Online ISSN : 0975-4172
Print ISSN : 0975-4350
DOI : 10.17406/GJCST

Global Journal

of Computer Science and Technology: D

Neural & AI

Highlights

- Optimization of Frequency
- Evaluation of Hypervisor Schedulers
- Unveiling Customer Sentiments
- Use of Robust Artificial Neural Networks

Discovering Thoughts, Inventing Future

VOLUME 24 ISSUE 2 VERSION 1.0

Global Journal of Computer Science and Technology: D
Neural & Artificial Intelligence

Global Journal of Computer Science and Technology: D
Neural & Artificial Intelligence

Volume 24 Issue 2 (Ver. 1.0)

Open Association of Research Society

Incorporation No.: 0423089
License No.: 42125/022010/1186
Registration No.: 430374
Import-Export Code: 1109007027
Employer Identification Number (EIN):
USA Tax ID: 98-0673427

Global Journals Inc.

*(A Delaware USA Incorporation with "Good Standing"; **Reg. Number: 0423089**)*

Sponsors: Open Association of Research Society
Open Scientific Standards

Publisher's Headquarters office

Global Journals® Headquarters
945th Concord Streets,
Framingham Massachusetts Pin: 01701,
United States of America
USA Toll Free: +001-888-839-7392
USA Toll Free Fax: +001-888-839-7392

Offset Typesetting

Global Journals Incorporated
2nd, Lansdowne, Lansdowne Rd., Croydon-Surrey,
Pin: CR9 2ER, United Kingdom

Packaging & Continental Dispatching

Global Journals Pvt Ltd
E-3130 Sudama Nagar, Near Gopur Square,
Indore, M.P., Pin:452009, India

Find a correspondence nodal officer near you

To find nodal officer of your country, please email us at *local@globaljournals.org*

eContacts

Press Inquiries: *press@globaljournals.org*
Investor Inquiries: *investors@globaljournals.org*
Technical Support: *technology@globaljournals.org*
Media & Releases: *media@globaljournals.org*

Pricing (Excluding Air Parcel Charges):

Yearly Subscription (Personal & Institutional)
250 USD (B/W) & 350 USD (Color)

Editorial Board

Global Journal of Computer Science and Technology

Dr. Stefano Berretti

Ph.D. in Computer Engineering and Telecommunications, University of Firenze Professor Department of Information Engineering, University of Firenze, Italy

Dr. Abdurrahman Arslanyilmaz

Computer Science & Information Systems Department Youngstown State University Ph.D., Texas A&M University University of Missouri, Columbia Gazi University, Turkey

Dr. Lamri Sayad

Ph.d in Computer science, University of BEJAIA, Algeria

Dr. Tauqeer Ahmad Usmani

Ph.D in Computer Science, Oman

Dr. Hazra Imran

Ph.D in Computer Science (Information Retrieval), Athabasca University, Canada

Dr. Magdy Shayboub Ali

Ph.D in Computer Sciences, MSc in Computer Sciences and Engineering, BSc in Electronic Engineering, Suez Canal University, Egypt

Dr. Nurul Akmar Binti Emran

Ph.D in Computer Science, MSc in Computer Science, Universiti Teknikal Malaysia Melaka, Malaysia

Dr. Asim Sinan Yuksel

Ph.D in Computer Engineering, M.Sc., B.Eng., Suleyman Demirel University, Turkey

Dr. Anis Bey

Dept. of Computer Science, Badji Mokhtar-Annaba University, Annaba, Algeria

Alessandra Lumini

Associate Researcher Department of Computer Science and Engineering University of Bologna Italy

Dr. Rajesh Kumar Rolen

Ph.D in Computer Science, MCA & BCA - IGNOU, MCTS & MCP - MIcrosoft, SCJP - Sun Microsystems, Singhania University, India

Dr. Rajneesh Kumar Gujral

Ph.D in Computer Science and Engineering, M.TECH in Information Technology, B. E. in Computer Science and Engineering, CCNA Certified Network Instructor, Diploma Course in Computer Servicing and Maintenance (DCS), Maharishi Markandeshwar University Mullana, India

Dr. Aziz M. Barbar

Ph.D. IEEE Senior Member Chairperson, Department of Computer Science AUST - American University of Science & Technology Alfred Naccash Avenue Ashrafieh, Lebanon

Dr. Federico Tramarin

Ph.D., Computer Engineering and Networks Group, Institute of Electronics, Italy Department of Information Engineering of the University of Padova, Italy

Dr. Chutisant Kerdvibulvech

Dept. of Inf. & Commun. Technol., Rangsit University Pathum Thani, Thailand Chulalongkorn University Ph.D. Thailand Keio University, Tokyo, Japan

Dr. Pranit Gopaldas Shah

MTech CE, BECE, MPM, FCSRC, Master of Technology in Computer Engineering, Parul University, India

Contents of the Issue

Global Journal of Computer Science and Technology: D
Neural & Artificial Intelligence
Volume 24 Issue 2 Version 1.0 Year 2024
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Use of Robust Artificial Neural Networks and ARIMA in Detecting Brief Anomalies in Gas Consumption

By Azizul Hakim Rafi

Abstract- This paper introduces an innovative system for outlier detection that combines the strengths of an Auto-regressive Integrated Moving Average (ARIMA) model and an Artificial Neural Network (ANN). While ARIMA is traditionally used for linear predictions and ANNs for non-linear forecasting, this study demonstrates their synergistic capabilities in capturing complex, non-linear relationships between meteorological forecast variables and gas consumption patterns. The resulting system can identify anomalies, aiding building managers in reducing energy waste in HVAC systems. The process comprises two phases: first, it predicts short-term gas consumption patterns using historical data, and then it identifies outliers by detecting deviations from expected values. Remarkably, this outlier detection process doesn't require predefined labeled examples, thanks to the system's highly accurate gas consumption forecasts, characterized by a root mean square error (RMSE) ranging from 8 m3 to 2.5 m3.

Keywords: energy forecasting, time series, robust artificial neural networks, arima models, anomaly detection, outlier detection, gas consumption prediction, energy forecast.

GJCST-D Classification: LCC Code: QA76.9.D343

Strictly as per the compliance and regulations of:

Use of Robust Artificial Neural Networks and ARIMA in Detecting Brief Anomalies in Gas Consumption

Azizul Hakim Rafi

Abstract- This paper introduces an innovative system for outlier detection that combines the strengths of an Auto-regressive Integrated Moving Average (ARIMA) model and an Artificial Neural Network (ANN). While ARIMA is traditionally used for linear predictions and ANNs for non-linear forecasting, this study demonstrates their synergistic capabilities in capturing complex, non-linear relationships between meteorological forecast variables and gas consumption patterns. The resulting system can identify anomalies, aiding building managers in reducing energy waste in HVAC systems. The process comprises two phases: first, it predicts short-term gas consumption patterns using historical data, and then it identifies outliers by detecting deviations from expected values. Remarkably, this outlier detection process doesn't require predefined labeled examples, thanks to the system's highly accurate gas consumption forecasts, characterized by a root mean square error (RMSE) ranging from 8 m3 to 2.5 m3.

Keywords: energy forecasting, time series, robust artificial neural networks, arima models, anomaly detection, outlier detection, gas consumption prediction, energy forecast.

I. Introduction

Energy utilization in structures is perhaps one of the quickest developing areas. Roughly 41% of the all-out energy in Europe is consumed by structures (families and administrations) [1]. Studies and states' mandates about limiting energy utilization and utilizing sustainable power expanded consistently with the decrease of petroleum derivatives, the line contacts with eastern nations like Russia, and the increment of different natural issues. In light of this, the European association, with a new order [2], has the objective to raise EU energy utilization created from sustainable assets to 20%, to lessen by 20% the EU ozone-depleting substance discharges and to improve by 20% the EU's energy productivity. This implies speculations to re-qualify old structures, new nation regulations, and energy analysis, yet in addition, new productivity frameworks from the pre-owned apparatuses.

Determining energy requests has become one of the significant exploration fields in the energy divisions since it can assist with gassing utility organizations and families. Gas utilities purchase gas from pipeline organizations on an everyday basis, so they need to know the necessities ahead of time to be cutthroat. Organizations and families have the point of decreasing energy utilization and increment effectiveness.

Lately, enormous organizations like Google have also shown their premium in this new market, creating indoor regulators that consequently control the house environment and putting together choices with respect to the client's timetable. Home, an organization procured by Google, pronounced that clients saved the 11.3% of AC-related energy use without compromising solace [3], because of the programmed learning carried out in their indoor regulators. On the off chance that, on the one hand, the programmed indoor regulator program setting in light individuals conduct can assist them with setting aside cash, peculiarity location can diminish the energy utilization. It is displayed by [4] and [5], that business structures consume from 15% to 30% more energy than needed due to ineffectively kept up with, corrupted, and inappropriately controlled hardware. These inconsistencies can turn out to be simply fixable issues with a dependable shortcoming location and conclusion (FDD) framework.

In this paper, an automatic outlier detection system is proposed, where days/hours with abnormally high and low gas consumption are labeled and reported to the building manager. He can further analyze and fix the HVAC system, minimizing the energy waste caused by the outliers. Gas consumption is very irregular and not easily predictable with classic methods. The outlier detection system presented is based on predictions made by a hybrid ARIMA-ANN, which can model linear and non-linear behavior of the data with very reliable results and a comparison between the predicted value/trend and the actual one to find outliers.

Since the definition of outlier is highly application dependent, in section II they are defined. In the same section, ANNs and ARIMA are briefly explained because they will be lately used in the proposed solution (section IV), based on a gas consumption forecaster. In section III some related works are discussed. In section V, some experiments on synthetic and real data are shown. Section VI presents some future ideas for the readers based on techniques that the author didn't have the time to apply.

Author: e-mail: azizulhakimrafi4@gmail.com

II. Background

a) What is an outlier

An exception, by definition [6], is a perception that goes astray fundamentally from different perceptions, so it makes doubt that various elements made it. Regardless of this overall definition, the more fitting approach to characterizing exceptions is exceptionally application-subordinate since even similar situations might require various judgments of anomalies.

In this paper, exceptions are firmly connected with the issue of time-series gauging since anomalies are proclaimed based on deviations from expected (or estimated) values. In this unique circumstance, a worth is viewed as an exception due to its relationship to its connected information (*contextual* exception [7] or contingent oddities [8]). An unexpected pinnacle (fig. 1) in a period series is a *contextual* exception in light of the fact that its worth is totally different from the upsides of its nearby items.

At the point when a gathering of focuses are proclaimed exceptions, it is alluded as *collective* peculiarity or anomaly [7]. It initially shows up at a point, and afterward, it influences the qualities promptly close to it. Sooner or later, this impact vanishes, passing on the time series to a typical way of behaving. This situation is normally difficult to identify. Outliers can have distinct main reasons:

1. Defective system (e.g., a defective heater in a room).
2. Bad human behavior (e.g., people who leave open the window in a room while the system is trying to heat it).
3. Defective monitoring system, where the system monitors different values from the real one due to a malfunction, computing process errors, or recording negligence.

In literature, outliers are also referred to as abnormalities, deviants, novelties or anomalies.

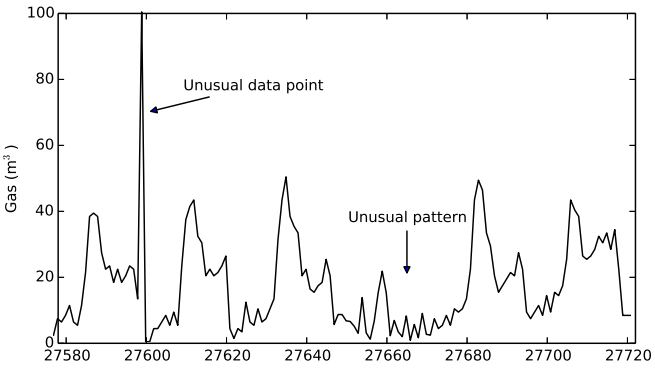


Fig. 1: Different Types of Outliers. On the Left an Unusual Data Point is Presented, on the Right an Unusual Pattern of Changes can be Recognized if Compared to the other Days Shape

b) Artificial Neural Networks

Counterfeit Brain Organizations (ANNs) were initially evolved to impersonate the mind's usefulness. There is definitely not a broadly acknowledged definition yet by [9]: "A brain network is a circuit made out of an extremely huge number of straightforward handling components that are neurally based. Every component works just on nearby data. Moreover, every component works nonconcurrently; in this manner, there is no general framework clock. " From section II-B, it is feasible to see a completely associated ANN with five sources of info, 3 neurons on the secret layer (purported on the grounds that the ANN resembles a black box), and one result. The data sources are additionally called elements, and they address the attributes to portray the result.

The secret neurons will plan this connection. Every association has an initiation that addresses the significance (weight) of the associated neuron. ANNs with something like a 1-stowed away layer can plan non-direct relations.

The hidden neurons are usually represented with logistic sigmoid units, which internally calculate the sigmoid function of the inputs, but also with a hyperbolic tangent. Recent findings argued that rectifier units seem to be more biologically plausible [10], and they also seem to perform better in ANNs.

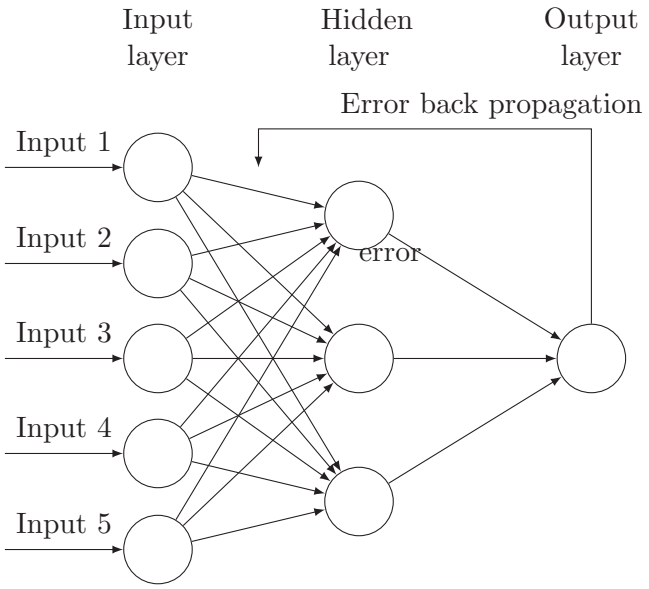


Fig. 2: Artificial Neural Network with *Backpropagation*. Example with 5 Inputs, 3 Hidden Neuron in the First Hidden Layer, and One Output (in the Case of This Paper, the Gas Consumption Value)

The ANNs are commonly applied with the *Stochastic Gradient Descent* algorithm, which tries to find the right weights of each connection to have the right output value. It is usually combined with the *Backpropagation* algorithm which calculates the error in the output layer and then backpropagates it to the previous layers in order to adjust the weights [11]. More information can be found in [12].

Nowadays, ANNs are a state-of-the-art technique that has many applications.

c) Autoregressive Models

Let $X_1, X_2, \ldots X_t$ be the values in an univariate time-series. In the *Auto-Regressive Moving Average* model, the value of X_t is defined in terms of the values of the last window of length p and q moving average terms.

$$X_t = \sum_{i=1}^{p} \varphi_i X_{t-i} + \sum_{i=1}^{q} \theta_i \varepsilon_{t-i} + c + \varepsilon_t.$$

The left-hand part is called the auto-backward part since it relies upon the past (slacked) values $X_{t-1}, X_{t-2}, \ldots X_{t-p}$, the right-hand part is called moving normally in light of the fact that the blunder at time t is the direct mix of the past mistakes $\varepsilon_{t-1}, \varepsilon_{t-2}, \ldots, \varepsilon_{t-q}$.

These techniques are applied to *stationary* time-series, alleged when the mean, fluctuation, and autocorrelation structure don't change over the long run. Tragically, many time series make occasional impacts or patterns. Specifically, arbitrary strolls, which describe many sorts of series, are non-fixed. Differencing the information focuses can frequently change a non-fixed time series into a fixed one. In view of the Crate Jenkins models of the 1970s, ARIMA models are separate, where a series with deterministic patterns ought to be differentiated first, and then an ARMA model is applied. ARIMA models are typically referenced as ARIMA (p, d, q), to show the ARMA boundaries and the *d* request of difference. ARIMA models are likewise fit for displaying a lot of information.

$$\mathrm{ARIMA}(p,d,q)(P,D,Q)_m$$

where m is the quantity of periods per season. The capitalized documentation is utilized for the occasional pieces of the model, and the lower-case documentation for the nonoccasional pieces of the model.

The decision of the boundaries p, d, q is exceptionally application ward, and it depends on a hypothesis that is past the extent of this paper. More data can be found in [13].

III. Related Work

Since this paper declares outliers based on deviations from the expected (or forecast) value, this section is divided into related work in forecasting and outlier detection.

a) Outlier Detection

Outlier detection systems are a wide range of areas, from introduction detection systems to fraud detection systems, law enforcement systems to earth science anomaly detection systems.

Outlier detection can be supervised when available data is labeled indicating previously known examples of anomalies, semi-supervised, where only examples of normal data or anomalies are available, or unsupervised, where previous examples of interesting anomalies are not available. Typically, most of the unsupervised outlier mechanisms use a measure of

outlierness of a data point, such as sparsity of underlying region, nearest neighbor distance, or the fit to underlying distribution [7]. In these cases, a data point is unusual due to one or more variables rather than a specific one (like in the supervised methods).

In energy consumption outlier detections, literature is usually based on the Gaussian error theory, stating that when the measurement accord with normal distribution, the probability that the residual falls in three times the variance is more than 99.7%. Therefore, the residuals falling outside can be considered outliers. In [14], the author further improved this system by considering a rolling window median, which seems to improve the results when the distribution is not fixed. Supervised methods are usually based on classifications using trees, ANNs, and other different algorithms, thanks to the presence of previous examples of anomalies. In the energy consumption field, unsupervised methods are usually based on clustering, where an algorithm tries to find similarities between points/trends and cluster them into groups, calculating the distance between them. A cluster is considered good when the intra-cluster distance is minimized, and the intra-cluster distance is maximized. Popular methods in this group are *k*means, one-class SVM, and self-organizing maps.

For example, in [15], some clustering methods, like CART, *k*-means, and DBScan, were applied to detect outliers in the office lighting energy consumption. The author showed different techniques applied with the Generalized Extreme Studentized Deviate (GESD) and listed some irregularities found. He also stated that the clustering methods were not able to detect faults strongly related to time variables.

Clustering methods are very difficult to apply in timeseries data, and the results are usually poor. For this reason, this paper will build a prediction algorithm, where outliers are declared based on deviations from expected (or forecast) values. The more accurate the predictor, the more abnormal data points will be detected.

b) Forecasting

Traditionally, several techniques have been used for energy use forecasting, but short-term, medium-term, and long-term energy forecasting needs to be differentiated. The former usually refers to prediction with a horizon of hours or days; the second refers to weeks, and the latter refers to a monthly or annual horizon. Long-term forecasting usually deals with data that rarely presents significant distortions and irregularities, so they have a small effect on the overall value. On the contrary, short-term forecasting has to deal with irregularities and sudden changes in values (due to weather changes, human behavior, etc.).

There are essentially five types of prediction models [16]: Engineering methods, Statistical methods, Artificial Neural networks, Support Vector Machines, and Grey models. Engineering methods use physical principles to calculate thermal dynamics and energy behavior of the building, Statistical methods build empirical models to apply a regression to a time series of values, Neural networks try to predict energy using an artificial intelligence network of interconnected neurons, Support vector machines are based in a machine learning algorithm and Grey models apply a mixture of the models. All the principal methods are extensively reviewed in [16] and [17].

Several techniques have been traditionally applied for energy use forecasting, and among the statistical methods, Kalman filtering and ARIMA/ARMAX time-series techniques are the most famous.

The first reports about applications of Artificial Neural Networks (ANNs) were published in the early 1990s [18]. Since then, the number of publications increased steadily. Kalogirou et al. [19] used back propagation neural networks to predict the required heating load of 225 buildings; Ekici and Aksoy used the same model to predict building heating loads in three buildings. Nizami and Al-Garni [20] tried a simple feed-forward NN and related the electric energy consumption to weather data and population, Taylor and Buizza [21] used an ANN with weather data (51 variables) to predict load of 10 days ahead. Gonzales [22] built an ANN to predict hourly energy consumption. Some researchers tried to specialize the ANNs: Neto and Fiorelli [23] compared generic ANNs with working days ANNs and week-end ANNs, Lazzerini and Rosario [24] specialized them to predict electric lighting with weather data.

Some researchers have also tried to apply a hybrid model to increase the performance of the ANN. One example above all is [25] which applied a hybrid ARIMA and neural network model to forecast electricity use, another one is [26] who improved the previous one. This paper is based also on his work.

Until now, only electric forecasting was presented because the majority of the existing forecasters are related to electric forecasting. There are only a few of them are about natural gas forecasting: Brown et al.[27] built one of the first predictors for natural gas consumption, and Khotanzad et al. [28] developed a two-stage system ANN with very good results.

Even if ANNs might outperform traditional methods, the researchers are still not convinced about the results of ANNs in this field. Nevertheless, it is also stated that “a significant portion of the ANN research in forecasting and prediction, lacks validity” [29] and that most of the papers seem misspecified models that had been incompletely tested (no standard benchmarks, no synthetic data, etc.) [17]. This paper will try to avoid these mistakes.

It also needs to be pointed out that ANNs are *multistep ahead* forecasters, while Auto-Regressive methods are potentially useless in long ahead data points.

IV. Proposed Solution

As stated before, this paper proposes a regression algorithm in which outliers are declared based on deviations from the expected (or forecast) value.

A time-series is a sequence of data-points typically measured at successive points of a uniform time interval *t* (eq. (1)).

$$\{x(t_0), x(t_1), \ldots x(t_i), x(t_{i+1}) \ldots\} \quad (1)$$

where *x* is the value and *t* the time.

Time-series forecasting is about predicting future values given past data (eq. (2)).

$$\hat{x}(t+s) = f\left(x(t), x(t-1) \ldots\right) \quad (2)$$

where *s* is the step size. A *multivariate* time-series is a ($n \times 1$) vector of *n* time-series variables.

It can be seen that in academic and industry research, linear regression-based systems are the standard "de facto" of energy forecasting, and in recent works, this problem is treated by combining weather forecast data. However, this relationship is clearly non-linear [17]. Consequently, even if some papers have acceptable results with measured datasets, these systems cannot adequately capture the relationship in all the situations and data. Since ANNs are the state-of-the-art technique of many machine learning problems where there is complex nonlinear hypotheses, the proposed solution is composed of a *multilayer feed-forward* neural network with *backpropagation*.

Table I: Buildings used

Building name	Date interval	Number of rows
HvA 740 - NTH	01/2008 - 03/2014	54.725
Hva 761 - KMH	01/2009 - 09/2013	40.407
Hva 882 - WBW	01/2008 - 03/2014	54.647

a) Experimental Data

Ebatech gathers the energy utilization datasets utilized in various structures of the Hogeschool van Amsterdam. The Universiteit van Amsterdam gave these datasets to this undertaking. These structures are situated in Amsterdam, the capital city of The Netherlands. This city has a sea environment like Britain, firmly impacted by the North Ocean. Winters are genuinely cold, and summers are seldom sweltering, according to European guidelines. Amsterdam is described by the normal presence of downpours and wind, and the weather patterns change frequently.

Ebatech gathered various sorts of elements in every structure, with various granularity. For this undertaking, three structures are utilized: *HvA 740 - NTH*, *Hva 882 - WBW*, and *Hva 761 - KMH*. In these structures, the organization gathered the energy utilizations and the gas utilizations as different factors. It should be noted that gas is utilized exclusively to warm the structures.

The weather data was collected by KNMI [1] in Schipol, the Amsterdam airport 16 km far from the tested buildings. The dataset, findable on the website, consists of over 21 variables collected hourly. The proposed solution only uses a few of them, as explained in the section IV-B, and they are used as forecast values: the measured weather conditions are linked to the previous hour of energy consumption. It is necessary to consider that there will be an error in the built model since the weather data is collected in a different location from the building's positions, and in practice, the error will be larger than those obtained in this simulation due to the effect of the weather forecast uncertainty [30], [31]. The advice is to keep it in mind before applying the methods contained in this paper with days forecasting.

1. *Data Analysis:* The energy consumption dataset covers a very large period ranging more than 5 years, allowing us to see similar patterns even with different yearly/season behavior (one year could be different from another one for external factors like weather or building use). It is very rich (with more than 50 variables) but also sparse because the monitored variables are not the same in all the buildings. For this reason, only common variables, such as total electric and gas consumption, were used in this paper. In this way, it is possible to generalize and compare the models.

The gas consumption data is highly seasonal: daily and weekly cycles are quite perceptible, as it can be seen from fig. 4 and fig. 3. From the latter, the weekly behavior is clear: the last two days of the week (Saturday and Sunday) are completely different from the others, and Monday seems a bit different from the rest of the days. Every day, around 4:00-5:00 AM, the system seems to react by turning on the heating system, whereas in the previous hours of the night, it seems only to keep a minimum temperature. The system reveals to us that after a couple of hours, it decreases the consumption again. In fig. 4 the Temperature has a clear daily/hourly relation with the gas consumption while in fig. 5 the electric consumption is shown to be very smoothed and more regular than the gas one.

[1] Koninklijk Nederlands Meteorologisch Instituut http://www.knmi.nl

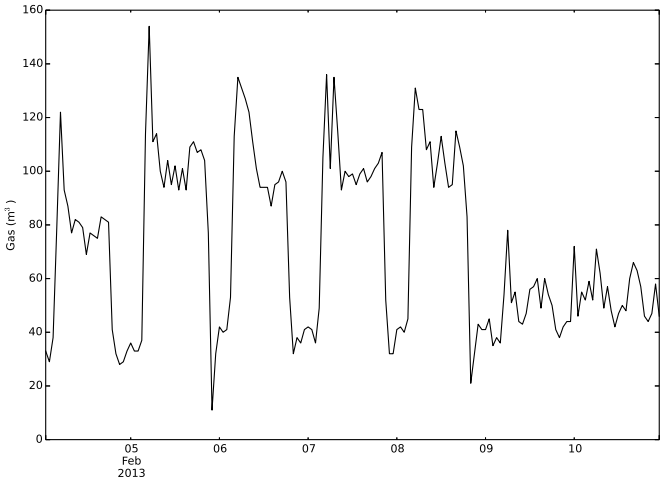


Fig. 3: Typical weekly and daily gas consumption behavior in building 740NTH. The weekly pattern can be noticed by observing that the last two days of the week (Saturday and Sunday) have a completely different shape than the others. During the week, the daily behavior is very similar, with one peak around 4:00-5:00 AM

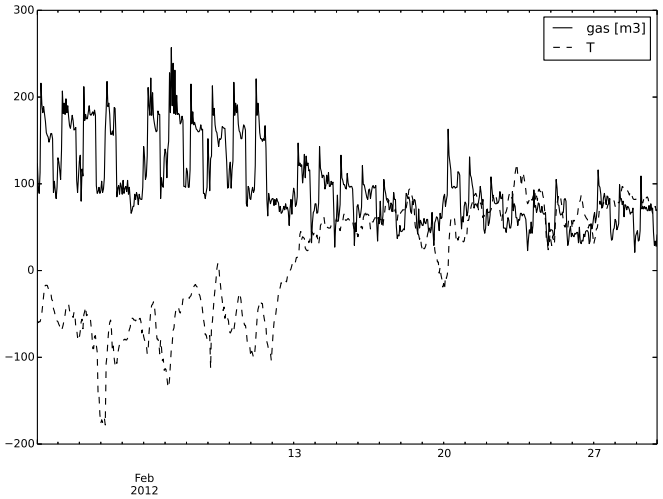


Fig. 4: Typical Monthly gas Consumption Behaviour in Building 740-NTH and its Relation with the Temperature on Building 740-NTH

2. *Data Cleaning:* The data presented some irregularities like repeated and missing data points. Although the first one may not influence the performance of the ANN, it could lead to problems when other algorithms are used (like ARIMA in this paper). Repeated data points were deleted, keeping only the last one, while missing data points were reconstructed by linear interpolation. Cubic and spline interpolation were also considered, but the performance was heavily affected by these methods.

Missing and repeated data points represent some problems in the data collection that will be further investigated.

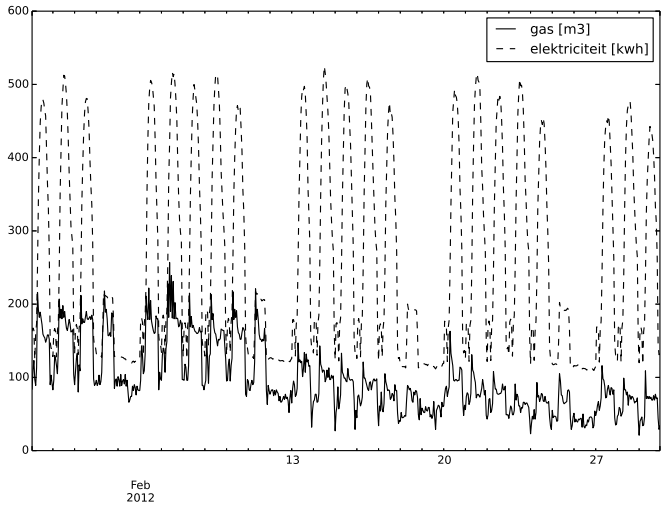


Fig. 5: Relation between Electric and Gas Consumption in Building 740-NTH

b) Artificial Neural Network Forecaster

Time series are characterized by more or less complex dependencies: Known dependencies like date-time dependencies. Hidden dependencies include the behavior of the HVAC system (when it starts, when it raises the temperature, etc). Short/long -term dependencies between variables.

Data scientists and experts are focused on known dependencies, while the proposed ANNs will be focused on the hidden ones. The short/long-term dependency is realized by a moving window containing a "memory" of the previous states for the interesting variables, using a *Tapped delay line memory* [32].

These memories form a new set of states-

$$\{\bar{x}_1(t), \bar{x}_2(t), \ldots \bar{x}_n(t)\}$$

from the original states

$$\{x(1), x(2) \ldots x(n)\}$$

where $\bar{x}_i(t) = x(t-i+1)$. The window types will be explained later in this section.

Since the value to predict is time-dependent, the first element to consider is adding the time feature. Energy consumption depends on the hour of the day but also on the day of the week and the seasonality of the year (month and day of the year) (as explained in section IV-A1, fig. 4 and fig. 3). The day of the week is a number from 0 to 6, where 0 is Monday and 6 is Sunday. Since the behavior of the holidays was considered similar to the weekends (particularly similar to Sundays), a function encoded all the holidays as weekend days[2]. In the future, this can be improved by asking for a timetable list for the buildings, indicating when these are closed. The day of the year is a number between 0 and 366, and the first one is the first of January. All these date-time features by means of their sine and cosine values as usual, reported in literature [33], [34], [22]. This transforms the time component into a cyclic feature that spans a fixed length (a single day for the hour), and it is bounded in $[-1, 1]$.

Another added feature was the current system load, which is the energy consumption at the k state when the load at $k+1$ needs to be predicted. This was believed to be an important measure for determining building usage and holidays.

Many elements influence the energy needs of structures. These variables can be separated into three principal bunches, specifically the *physical environmental*, the *artificial planning parameters*, and the *human warm discomfort*. The first is made out of weather conditions related to boundaries like open-air temperature, wind speed, sun-powered radiation, and so forth. The *artificial planning parameters* are connected with the structure development: straightforwardness proportion, direction, and so on [35]; however, these factors were inaccessible in the dataset. The *human impression of warm discomfort* is connected not exclusively to the temperature but also to different factors, for example, relative stickiness, illumination, and wind speed. Regardless of whether this large amount of information was accessible, the main climate factors found were the temperature and the breeze speed.

The framework utilization was accepted to be connected with the distinction of the open air temperature between two moments (eq. (3)), addressing a positive/negative difference in the outer natural circumstances.

$$\Delta T_{k+1} = T_{k+1} - T_k \tag{3}$$

where T_{k+1} is the predicted temperature for the period $k + 1$ and T_k is the value measured in the instant k. It needs to be noted that the real behavior of the system was unknown, so it was not possible to know if this

[2] Thanks to an Open source Dutch weekend list https://github.com/PanderMusubi/dutch-holidays

change would have an immediate effect on the HVAC system and/or its reaction time. Gas usage has a daily cycle but there are also secondary weekly and annual cycles that the ANN may not be able to capture. Gas usage $u(t)$ is defined as $u(t) = s(t) + f(t) + r(t)$

$$u(t) = s(t) + f(t) + r(t)$$

where $s(t)$ is the seasonality at time t, $f(t)$ is the trend and $r(t)$ is called *remainder*, irregular component or difference. The time series were analyzed by the STL decomposition by LOESS [36](fig. 6), which decomposes a time series into seasonal, trend, and irregular components by an additive method. Since the ANN is interested in the *remainder* and the trend can be found from the historical part, the daily, weekly, and yearly remainders were added as features. For the same reason also, the Temperature, the wind speed, and the electric consumption were decomposed by the STL decomposition, resulting in a stationary time series added to the input.

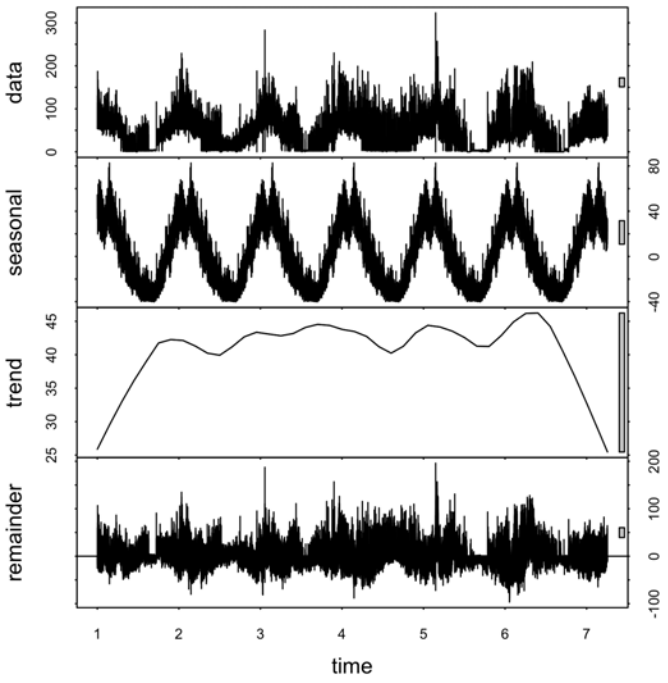


Fig. 6: Yearly STL Decomposition by LOESS in Building 740-NTH

In Zhang et al. [37], it is expressed that ANN models truly enjoy benefits while managing a lot of verifiable burden information with non-direct trademarks. Yet, the scientists ignored the straight relations, including the information. Hence a cross breed approach is proposed, where the ANN will be helped in direct guaging by the famous strategy ARIMA (autobackward coordinated moving midpoints), generally known as the Container Jenkins approach. To apply ARIMA, the time series was handled iteratively with a moving window of 21 days where the ARIMA model was fitted. After the fitting, the upsides of the following 24 hours were determined prior to moving the window and doing the same for the following day. The occasional ARIMA fitting was finished by the assistance of the Figure R bundle [38] and its *auto.arima* technique, which finds the best ARIMA $(p,d,q)(P,D,Q)_m$ boundaries by looking at the *Akaike data criterion* (AIC) of the tried models. Only for the peruser interest, the most fitted model was ARIMA $(3,0,3)(2,0,1)_{24}$. An ARIMA model with temperature sham factors was tried. However, it did not advance the ANN: the least complex models were liked.

Taking into account the points made in this section, the ANN is predicting the gas consumption "seeing" without knowing its shape and its behavior in the previous hours/days. This limit is surpassed by some rolling windows, which will somehow simulate the Recurrent neural networks' behavior. Two rolling windows were created for the gas consumption, memorizing the sum and the peak load of the previous five hours, and two moving rolling windows were created for the STL yearly residuals, memorizing sum and peak of them.

Table II: Ann Features

Variable	Data
Electricity load	$E(t)$
Hour	$sin(2\pi(h)/24)$; $cos(2\pi(h)/24)$
Week day	$sin(2\pi(wDay)/6)$; $cos(2\pi(wDay)/6)$
Month	$sin(2\pi(mon)/12)$; $cos(2\pi(mon)/12)$
Year day	$sin(2\pi(d)/366)$; $cos(2\pi(d)/366)$
Temperature	$T(t)$
Gas peak′	$\max_{1\leq k\leq 5} G(t-k)$
Gas sum′	$\sum_{i=1}^{5} G(t-i)$
Gas mean′	$\frac{1}{288}\sum_{i=1}^{288} G(t-i)$
Gas peak″	$\max_{1\leq k\leq 24} G(t-k)$
Gas sum″	$\sum_{i=1}^{24} G(t-i)$
Electricity peak″	$\max_{1\leq k\leq 5} E(t-k)$
Electricity sum″	$\sum_{i=1}^{5} E(t-i)$
Temp peak	$\max_{1\leq k\leq 5} T(t-k)$
Temp sum	$\sum_{i=1}^{5} T(t-i)$
Wind speed	$FH(t)$
ΔT_{k+1}	$T_{k+1}-T_k$
ARIMA forecast	$forecast(\text{ARIMA}(3,0,3)(2,0,1)_{24})$
STL year res.	$YearRes(t)$
STL day res.	$DayRes(t)$
STL E res.	$Res(E(t))$
ARIMA peak′	$\max_{1\leq k\leq 5} \text{ARIMA}(t-k)$
ARIMA sum′	$\sum_{i=1}^{5} \text{ARIMA}(t-i)$

All the features that were not between the limits $[-1,1]$ were scaled to have a faster convergence [39] of the *Stochastic Gradient Descent* (eq. (4)).(4)

$$x_i' = \frac{x_i - \frac{max(x)+min(x)}{2}}{\frac{max(x)-min(x)}{2}} \tag{4}$$

where x_i is the original value and x'_i is the scaled one. Many practical tricks like the shuffling of the elements, the normalization and initialization were taken from [39], [40].

All the process described so far is also called *feature engineering* and was done almost iteratively, cumulatively introducing and removing features from the model and comparing the performance.

Choosing a number of hidden units for the ANN is always a tricky task. As stated by [41], [42], using *early stopping* in an oversized *Backpropagation* ANN, where the number of hidden neurons is higher than the number of the features, makes it easier to find the global optimum and avoid bad local optima. For this reason, the number of hidden units was chosen to be greater than $2 \times |features|$ and then test-driven, and the training was early stopped to prevent *overfitting*.

Architecture: ANNs are trained trying to minimize a cost function of the form

$$E = \frac{1}{N}\sum_{i=1}^{n} p(r_i)^2$$

where the error function p is symmetric and continuous, $r_i = Y_i - \hat{Y}_i$ is the residual between the actual value and the forecast one, and N is the number of training patterns.

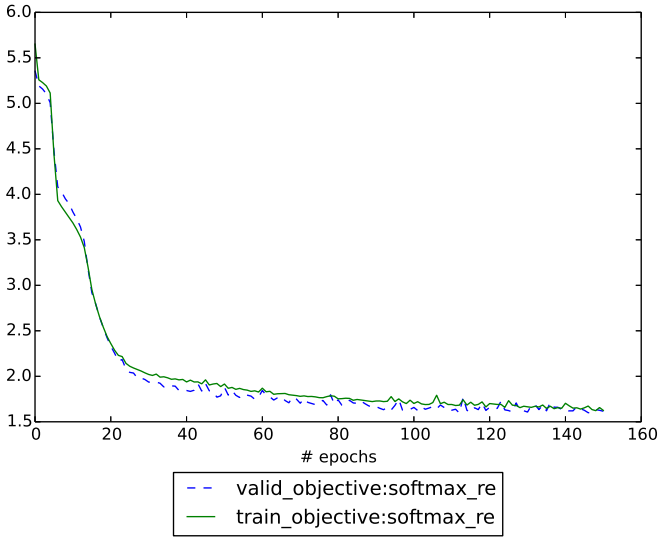


Fig. 7: Training Curve of the Hybrid Model with 80 Hidden Neurons

Using the notations defined above, the most used cost function is based on the Mean Squared Error (MSE), commonly, known in data modeling as the Least Mean Squares (LMS) method. The basic idea of LMS is to optimize the fit of a model with respect to the training data by minimizing the square of residuals

$$p(r) = \frac{1}{2}r^2$$

but it is greatly influenced by outliers [43]. In order to control the damage caused by outliers, in this paper the Least Mean Log Squares (LMLS) method (eq. (5)), presented by [43] is used. The ANN will try to minimize the Mean Log Squared Error (MLSE).

$$p(r) = \log(1 + \frac{1}{2}r^2) \tag{5}$$

The ANN is a 1-hidden-layer *Multilayer Feedfoward* ANN with a feedback structure, called *Backpropagation*. This ANN is composed by *Rectifier* neurons and one output linear node. Training is done by the *Stochastic Gradient Descent* algorithm with 10 batch size and is characterized by a learning rate of 0.003 and fixed by a Momentum of 0.05, which could help to increase the speed, avoiding local minima.

This project used Python and *pandas* for the data analysis, *Pylearn2* [44] to construct and test the ANN and the R system with the *zoo* [45] and the *Forecast* [38] packages for the ARIMA process.

c) Outlier Detection

According to Chebschev's theorem [46], almost all the observations in a data set of system states falls into the interval $[\mu - 3\sigma, \mu + 3\sigma]$, where μ and σ are respectively the mean and standard deviation of the data set, and the data points outside this interval are declared outliers. In this paper the ANN is used to predict the gas consumption, for this reason a point will be considered outlier if it will fall outside the 95% confidence interval[3] [3] expressed for the RMSE. If it is assumed that the difference between the actual values x_i and the predicted value $\hat{x}_i$ have:

$$\hat{x}_i - x_i \sim \mathcal{N}\left(0, \sigma^2\right) \tag{6}$$

- mean zero.
- follow a Normal distribution (it is assumed that it holds for the large amount of data utilized).
- and all have the same standard deviation σ.

$$\hat{x}_i - x_i \sim \mathcal{N}\left(0, \sigma^2\right) \tag{7}$$

it is possible to say that eq. (7) follows a χ^2_n distribution with n degrees of freedom. Which means:

$$P\left(\chi^2_{\frac{\alpha}{2},n} \leq \frac{n\mathrm{RMSE}^2}{\sigma^2} \leq \chi^2_{1-\frac{\alpha}{2},n}\right) = 1 - \alpha \tag{8}$$

$$\Leftrightarrow P\left(\frac{n\mathrm{RMSE}^2}{\chi^2_{1-\frac{\alpha}{2},n}} \leq \sigma^2 \leq \frac{n\mathrm{RMSE}^2}{\chi^2_{\frac{\alpha}{2},n}}\right) = 1 - \alpha \tag{9}$$

$$\Leftrightarrow P\left(\sqrt{\frac{n}{\chi^2_{1-\frac{\alpha}{2},n}}}\mathrm{RMSE} \leq \sigma \leq \sqrt{\frac{n}{\chi^2_{\frac{\alpha}{2},n}}}\mathrm{RMSE}\right) = 1 - \alpha. \tag{10}$$

[3] For the following description user *fabee* of *CrossValidated* needs to be mentioned: http://tinyurl.com/l9gvz65.

Therefore

$$\left[\sqrt{\frac{n}{\chi^2_{1-\frac{\alpha}{2},n}}}\text{RMSE}, \sqrt{\frac{n}{\chi^2_{\frac{\alpha}{2},n}}}\text{RMSE}\right] \quad (11)$$

V. Experimental Evaluation

The ANN has been prepared with early halting, with a decent number of preparing ages (stages) or halting the preparation when the approval blunder rate was expanding. Every one of the outcomes showed is obtained from k-crease cross-approval strategies, where the organization was prepared *k* times, each time leaving out a subset of information from preparing to test the ANN. The consequences of the *k* tests were partitioned by *k*. The organization is constantly prepared with 70% of the information, 15% is utilized for approval and the other 15% for testing.

Albeit most of the Mean Outright Rate Blunder (MAPE) is viewed as a norm for looking at the nature of the model expectation of energy load, it is a satisfactory mistake measure provided that the misfortune capability were direct and ongoing investigations exhibited it isn't [19][47]. Besides, the rate of blunder is limitless on the off chance that there are no qualities on the series, continuous in discontinuous information and in utilization information, and it puts a heavier punishment on certain mistakes than on regrettable mistakes [48]. In light of these impediments, this paper will just consider the minimization of the Root Mean Square Mistake (RMSE), which punish huge blunders, as proposed in [49]. As recommended in [17], for each analysis, likewise the Mean Outright Blunder (MAE) will be determined.

$$\text{MAPE}^4 = \frac{1}{n}\sum_{i=1}^{n}\frac{|Y_i - \hat{Y}_i|}{Y_i} \times 100 \quad (12)$$

$$\text{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(\hat{Y}_i - Y_i)^2} \quad (13)$$

$$\text{MAE} = \frac{1}{n}\sum_{i=1}^{n}\left|\hat{Y}_i - Y_i\right| \quad (14)$$

where $\hat{Y}$ is the vector of the *n* predictions and *Y* is the vector of the true values.

a) Synthetic Experiments

The strategy is tried using engineered information. Twoday exceptions were created using various calculations. In the first, the genuine utilization was changed by an irregular worth, recreating the framework estimation/control breakdown, which makes the utilization bobbing all over (see eq. (15)). The second artificially made day was made by adding $50m^3$ of gas utilization to the genuine one, making an example that recreates a weird way of behaving as well as a glitch of the warming framework (see eq. (16)).

$$G(t) = G(t) + v * 30 \quad (15)$$

where

$$v \sim \mathcal{N}(0, \sigma^2)$$

$$G'(t) = G'(t) + 50 \quad (16)$$

The two outliers were correctly detected, as it can be seen in fig. 8.

b) Measured Data Experiments

The method is also tested with measured data coming from a different type of day. For example, the gas consumption of a weekend was placed in a weekday, simulating a holiday. The purpose of this test was to show that an unusual pattern was detected. In fig. 9 it can be seen that the outlier mechanism works perfectly when the Sunday gas consumption is placed in a weekday.

The outlier was correctly detected, as it can be seen in fig. 9. The robustness of the design was proved with different building, listed in section IV-A1.

Excluding this little experiment, some interesting behaviors were found through this work: Occasions: Paying little mind to at whatever point the school was functional, the main tests showed that the Ebatech framework was typically warming the structures (Christmas, on Tuesday, December 25, 2012, was warmed like an ordinary Tuesday regardless of whether

[4]MAPE errors will be calculated only on the non-zero values, to avoid the problems described before the structure was surely shut). This causes avoidable waste. Utilization skips In fig. 10 an odd crisscross way of behaving should be visible for building 740-NTH. It appears to be that the framework is squandering energy, and this shape is entirely unexpected from the standard one (fig. 3). This goes on for quite a long time, and obviously, likewise, the ANN preparation is impacted by this exception-like way of behaving. Tops: Around the underlying long periods of September, there is an immense amount of utilization (up to multiple times more than the maximal utilization of the year). Is it a test? In building 761-KMH, sporadic tops were tracked down each day during April 2013, likely while the warming framework was turned on. August with radiators in building 740-NTH, during August 2009 and August 2011, the warmers were dynamic even with the absence of a clear summer virus. Exceptions A few different exceptions are viewed, yet they Time need to be affirmed by the chiefs, ideally after checking the recently referenced ways of behaving.

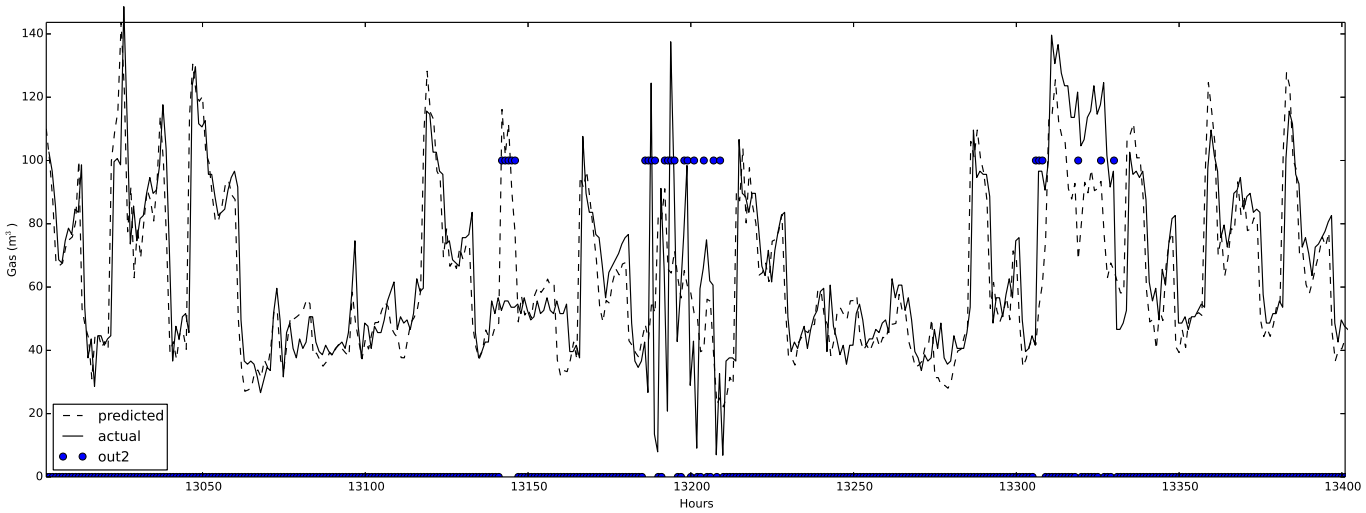


Fig. 8: Outlier Detection with Synthetic Generated Data. The Circle Represents the Hours Where an Outlier is Detected

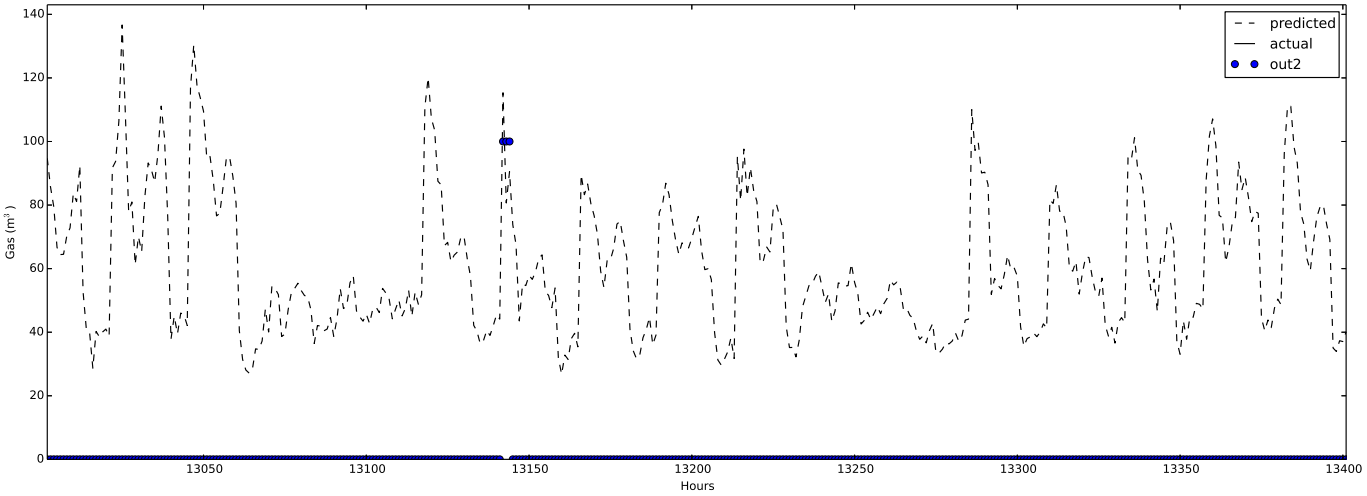


Fig. 9: Outlier Detection Where A Sunday One Replaced the Gas Consumption of A Weekday. The (Three) Circles Represent the Outliers Detected by the System

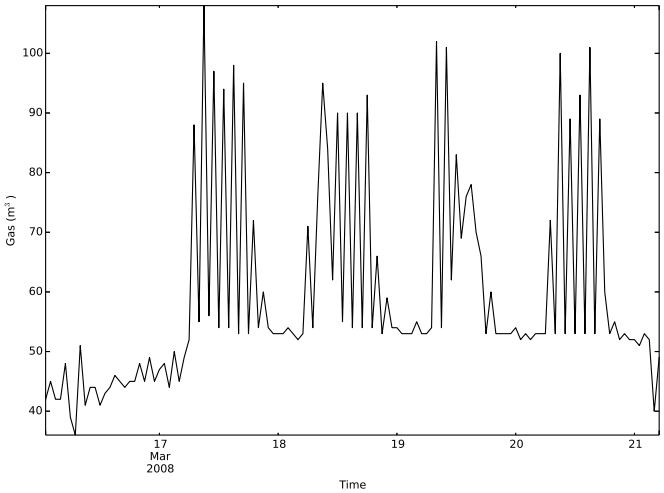


Fig. 10: Strange Zig-Zag Behaviour Found by the Algorithm

Table III: Best Selected Results in Building 740-Nth, to Compare the Arima, ANN and Hybrid Model. Hymse is the Hybrid Model with MSE Cost Function, While Hymlse is the Same Model with MLSE Cost Function

Model	neurons	epochs [4]	RMSE	MAPE	MAE
ARIMA[5]	-	-	88.50	117.27	22.52
ANN	80	15	11.95	34.78	8.52
HyMSE	80	70	9.4	27.66	6.90
HyMLSE	150	140	10.02	30.05	7.26

Table IV: Best Selected Results for All the Buildings

Model	neurons	epochs [7]	RMSE	MAPE	MAE
740-N TH	150	140	10.02	30.05	7.26
761- KMH	150	140	2.49	18.30	1.00

An ANN with the standard cost function MSE was also trained, apparently resulting in a smaller RMSE error in a faster way (section V-B). Although this can be true, the Hybrid MLSE model was more precise and better at detecting possible outliers. They contributed the most to the error.

In section V-B the results in the different buildings can be read.

VI. Future Work

ARIMA models can't detect more than one seasonality, but it can be helped with Fourier terms and ARIMA *dummy variables* to produce reasonable forecasts. When multi-seasonality is present, an algorithm like TBATS can overpass the ARIMA one and detect it. This non-parametric model described in [50] could be substituted for the ARIMA one as a feature of the ANN. At the moment, it is very slow, but it is very recent, so it will probably be improved.

The daily pattern could be seen in the transformed Fourier space applying the Modified Discrete Cosine Transform (MDCT) [51]. In theory, this could help as well to understand the pattern, but it was only applied once by [52], with scarce results.

ANNs are sensitive to missing values and irregularities, but it was not possible to contact the building managers in order to confirm/identify previously known outliers. For this reason the ANN training was done with not entirely perfect data, and this probably affected the performance. It is necessary to contact these building managers to further help with the training of this algorithm.

The input variables were scaled, standardizing them to a midrange 0 and range $[-1,1]$. It is also possible to normalize them to have mean 0 and standard deviation 1. In this case, Robust estimates of location and scale are desirable if the inputs contain outliers. Some examples are [53] and the recent [54], which can be the basis of a future refinement of the ANN inputs.

In future work, it is possible to break down the contrast between the MSE and the MLSE costs in the forecast and in the exception recognition.

Before 2006, ANN was quite often connected with the *Backpropagation* calculation and with the 1-stowed away layer design. The issue with these designs is that they stall out in unfortunate neighborhood optima. In 2006, there was an enormous advancement principally began by [55], which is called *Deep learning*, and it addresses the new design of ANNs in light of multi-stowed away layers and new calculations. Future enhancements can be founded on Repetitive Brain Organizations (RNNs) and Limited Boltzmann Machines (RBMs), which were, as of late, ended up being fascinating in time-series gauging [52], [56], [57]. The *Pylearn2* [44] RNN structure is being worked on.

VII. Conclusion

No model can treat all circumstances precisely for a lot of verifiable burden information. The unpredictable variance of the gas utilization was not really unsurprising, thus the ANN model was assisted with powerful expense capability and with the notable ARIMA model. Although different papers introduced comparative models to figure out electric utilization, the mixture model introduced here is practically interesting on the grounds that it centers around estimating momentary gas utilization, which is extremely sporadic and not effectively unsurprising with exemplary techniques. Since the indicator is exceptionally precise (with RMSE from 8 m^3 in building 740-NTH to RMSE 2.5 m^3 in building 761KMH), the anomaly component can undoubtedly distinguish weird ways of behaving characterizing an edge esteem in the certainty stretch without the need to have past instances of anomalies. The aim of this paper is to determine the profoundly sporadic gas utilization time series. Yet, it is accepted that comparable outcomes could likewise be acquired with the electric utilization time series. It is trusted that this could prompt another examination of the energy utilization in open structures.

References Références Referencias

1. E. C. Eurostat, *Energy balance sheets - 2010-2011 - 2013 edition*. Luxembourg: Publications Office of the European Union, 2013.
2. [Online]. Available: http://epp.eurostat.ec.europa.eu/portal/page/portal/ product _details/ publication? p product code=KS-EN-13-001 [2] European Parliament and Council of the European Union, "Directive 2009/28/EC," Brussels, 2009.

[4] epochs to converge
[5] Calculated iteratively as described in section IV-B
[7] epochs to converge

3. Nest, "Energy savings from nest white paper preview, "https://nest.com/downloads/press/documents/efficiency-simulation-white-paper.pdf, 2014.
4. S. Katipamula and M. R. Brambley, "Review article: methods for fault detection, diagnostics, and prognostics for building systems—a review, part i," *HVAC&R Research*, vol. 11, no. 1, pp. 3–25, 2005.
5. S. Wu and J.-Q. Sun, "Cross-level fault detection and diagnosis of building hvac systems," *Building and Environment*, vol. 46, no. 8, pp.1558–1566, 2011.
6. D. Hawkins, "Identification of outliers," *London: Chap*, 1980.
7. C. C. Aggarwal, *Outlier analysis*. Springer, 2013.
8. X. Song, M. Wu, C. Jermaine, and S. Ranka, "Conditional anomaly detection," *Knowledge and Data Engineering, IEEE Transactions on*, vol. 19, no. 5, pp. 631–645, 2007.
9. C. M. Bishop *et al.*, "Neural networks for pattern recognition," 1995.
10. X. Glorot, A. Bordes, and Y. Bengio, "Deep sparse rectifier networks," in *Proceedings of the 14th International Conference on Artificial Intelligence and Statistics. JMLR W&CP Volume*, vol. 15, 2011, pp. 315–323.
11. D. E. Rumelhart, G. E. Hinton, and R. J. Williams, "Learning internal representations by error propagation," DTIC Document, Tech. Rep., 1985.
12. C. M. Bishop *et al.*, *Pattern recognition and machine learning*. springer New York, 2006, vol. 1.
13. P. J. Rousseeuw and A. M. Leroy, *Robust regression and outlier detection*. John Wiley & Sons, 2005, vol. 589.
14. H. Ferdowsi, S. Jagannathan, and M. Zawodniok, "A neural network based outlier identification and removal scheme," in *Prognostics and Health Management (PHM), 2013 IEEE Conference on*. IEEE, 2013, pp. 1–6.
15. I. Khan, A. Capozzoli, S. P. Corgnati, and T. Cerquitelli, "Fault detection analysis of building energy consumption using data mining techniques," *Energy Procedia*, vol. 42, pp. 557–566, 2013.
16. H.-x. Zhao and F. Magoules, "A review on the prediction of building` energy consumption," *Renewable and Sustainable Energy Reviews*, vol. 16, no. 6, pp. 3586–3592, 2012.
17. H. S. Hippert, C. E. Pedreira, and R. C. Souza, "Neural networks for short-term load forecasting: A review and evaluation," *Power Systems, IEEE Transactions on*, vol. 16, no. 1, pp. 44–55, 2001.
18. T. Czernichow, A. Piras, K. Imhof, P. Caire, Y. Jaccard, B. Dorizzi, and A. Germond, "Short term electrical load forecasting with artificial neural networks," *Engineering Intelligent Systems for Electrical Engineering and Communications*, vol. 4, no. LRE-ARTICLE-1996-003, pp. 85–99, 1996.
19. S. A. Kalogirou, "Artificial neural networks in energy applications in buildings," *International Journal of Low-Carbon Technologies*, vol. 1, no. 3, pp. 201–216, 2006.
20. S. J. Nizami and A. Z. Al-Garni, "Forecasting electric energy consumption using neural networks," *Energy Policy*, vol. 23, no. 12, pp. 1097 – 1104, 1995. [Online]. Available: http://www.sciencedirect.com/science/article/pii/0301421595001166
21. J. W. Taylor and R. Buizza, "Neural network load forecasting with weather ensemble predictions," *Power Systems, IEEE Transactions on*, vol. 17, no. 3, pp. 626–632, 2002.
22. P. A. Gonzalez and J. M. Zamarre´ no, "Prediction of hourly energy˜ consumption in buildings based on a feedback artificial neural network," *Energy and Buildings*, vol. 37, no. 6, pp. 595–601, 2005.
23. A. H. Neto and F. A. S. Fiorelli, "Comparison between detailed model simulation and artificial neural network for forecasting building energy consumption," *Energy and Buildings*, vol. 40, no. 12, pp. 2169–2176, 2008.
24. E. D' Andrea, B. Lazzerini, and S. L. del Rosario, "Neural networkbased forecasting of energy consumption due to electric lighting in office buildings," in *Sustainable Internet and ICT for Sustainability (SustainIT), 2012*. IEEE, 2012, pp. 1–5.
25. G. P. Zhang, "Time series forecasting using a hybrid arima and neural network model," *Neurocomputing*, vol. 50, pp. 159–175, 2003.
26. M. Khashei and M. Bijari, "An artificial neural network (p, d, q) model for timeseries forecasting," *Expert Systems with Applications*, vol. 37, pp. 479–489, 2010.
27. R. H. Brown and I. Matin, "Development of artificial neural network models to predict daily gas consumption," in *Industrial Electronics, Control, and Instrumentation, 1995., Proceedings of the 1995 IEEE IECON 21st International Conference on*, vol. 2. IEEE, 1995, pp. 1389–1394.
28. A. Khotanzad, H. Elragal, and T.-L. Lu, "Combination of artificial neural-network forecasters for prediction of natural gas consumption," *Neural Networks, IEEE Transactions on*, vol. 11, no. 2, pp. 464–473, 2000.
29. M. Adya and F. Collopy, "How e! ective are neural networks at forecasting and prediction? a review and evaluation," *J. Forecasting*, vol. 17, pp. 481–495, 1998.
30. A. P. Douglas, A. M. Breipohl, F. N. Lee, and R. Adapa, "The impacts of temperature forecast uncertainty on bayesian load forecasting," *Power Systems, IEEE Transactions on*, vol. 13, no. 4, pp. 1507–1513, 1998.

31. D. K. Ranaweera, G. G. Karady, and R. G. Farmer, "Effect of probabilistic inputs on neural network-based electric load forecasting," *Neural Networks, IEEE Transactions on*, vol. 7, no. 6, pp. 1528–1532, 1996.
32. M. C. Mozer, "Neural net architectures for temporal sequence processing," 2007.
33. M. B. Ohlsson, C. O. Peterson, H. Pi, T. S. Rognvaldsson, and B. P. Soderberg, "Predicting system loads with artificial neural networks–methods and results from" the great energy predictor shootout"," *ASHRAE Transactions-American Society of Heating Refrigerating Airconditioning Engin*, vol. 100, no. 2, pp. 1063–1074, 1994.
34. R. H. Dodier and G. P. Henze, "Statistical analysis of neural networks as applied to building energy prediction," *Journal of solar energy engineering*, vol. 126, no. 1, pp. 592–600, 2004.
35. B. B. Ekici and U. T. Aksoy, "Prediction of building energy consumption by using artificial neural networks," *Advances in Engineering Software*, vol. 40, no. 5, pp. 356–362, 2009.
36. R. B. Cleveland, W. S. Cleveland, J. E. McRae, and I. Terpenning, "Stl: A seasonal-trend decomposition procedure based on loess," *Journal of Official Statistics*, vol. 6, no. 1, pp. 3–73, 1990.
37. G. Zhang, B. Eddy Patuwo, and M. Y Hu, "Forecasting with artificial neural networks:: The state of the art," *International journal of forecasting*, vol. 14, no. 1, pp. 35–62, 1998.
38. R. J. Hyndman and Y. Khandakar, "Automatic time series for forecasting: the forecast package for r," Monash University, Department of Econometrics and Business Statistics, Tech. Rep., 2007.
39. Y. A. LeCun, L. Bottou, G. B. Orr, and K.-R. Muller, "Efficient¨ backprop," in *Neural networks: Tricks of the trade*. Springer, 2012, pp. 9–48.
40. L. Bottou, "Stochastic gradient descent tricks," in *Neural Networks: Tricks of the Trade*. Springer, 2012, pp. 421–436.
41. S. Lawrence, C. L. Giles, and A. C. Tsoi, "What size neural network gives optimal generalization? convergence properties of backpropagation," 1998.
42. W. S. Sarle, "Stopped training and other remedies for overfitting," in
43. *Proceedings of the 27th Symposium on the Interface of Computing Science and Statisfi (.'. _\'. pp. 352-360. Interface Foundation of North America, Fairfax Station. VA, USA*, 1995.
44. K. Liano, "Robust error measure for supervised neural network learning with outliers," *Neural Networks, IEEE Transactions on*, vol. 7, no. 1, pp. 246–250, 1996.
45. I. J. Goodfellow, D. Warde-Farley, P. Lamblin, V. Dumoulin, M. Mirza, R. Pascanu, J. Bergstra, F. Bastien, and Y. Bengio, "Pylearn2: a machine learning research library," *arXiv preprint arXiv:1308.4214*, 2013.
46. A. Zeileis and G. Grothendieck, "zoo: S3 infrastructure for regular and irregular time series," *arXiv preprint math/0505527*, 2005.
47. B. G. Amidan, T. A. Ferryman, and S. K. Cooley, "Data outlier detection using the chebyshev theorem," in *Aerospace Conference, 2005 IEEE*. IEEE, 2005, pp. 3814–3819.
48. S. Kajl, M. Roberge, L. Lamarche, and P. Malinowski, "Evaluation of building energy consumption based on fuzzy logic and neural networks applications," in *Proc of CLIMA*, 2000, p. 264.
49. R. J. Hyndman, "Another look at forecast-accuracy metrics for intermittent demand," *Foresight: The International Journal of Applied Forecasting*, vol. 4, no. 4, pp. 43–46, 2006.
50. R. Yao and K. Steemers, "A method of formulating energy load profile for domestic buildings in the uk," *Energy and Buildings*, vol. 37, no. 6, pp. 663–671, 2005.
51. A. M. De Livera, R. J. Hyndman, and R. D. Snyder, "Forecasting time series with complex seasonal patterns using exponential smoothing," *Journal of the American Statistical Association*, vol. 106, no. 496, pp. 1513–1527, 2011.
52. H. S. Malvar, *Signal processing with lapped transforms*. Artech House, 1992.
53. E. Busseti, I. Osband, and S. Wong, "Deep learning for time series modeling," Technical report, Stanford University, Tech. Rep., 2012.
54. B. Iglewicz, *Robust scale estimators and confidence intervals for location*. New York: Wiley, 1983.
55. I. Mizera and C. H. Muller, "Location–scale depth,"¨ *Journal of the American Statistical Association*, vol. 99, no. 468, pp. 949–966, 2004.
56. G. Hinton, S. Osindero, and Y.-W. Teh, "A fast learning algorithm for deep belief nets," *Neural computation*, vol. 18, no. 7, pp. 1527–1554, 2006.
57. G. W. Taylor and G. E. Hinton, "Factored conditional restricted boltzmann machines for modeling motion style," in *Proceedings of the 26th annual international conference on machine learning*. ACM, 2009, pp. 1025–1032.
58. I. Sutskever, "Training recurrent neural networks," Ph.D. dissertation, University of Toronto, 2013.

This page is intentionally left blank

Global Journal of Computer Science and Technology: D
Neural & Artificial Intelligence
Volume 24 Issue 2 Version 1.0 Year 2024
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Harnessing the Capabilities: The Synergistic Potential of Quantum Computing in Addressing Limitations of Artificial Intelligence

By Stevie A. Burke & Ammara Akhtar

Abstract- With the rapid advancement in technological fields, two major domains including Quantum computing and artificial intelligence are substantially transforming the internet world. Although AI has fundamentally made rapid progress, it still has many limitations that are hindering its full potential to efficiently deal with intricate challenges. QC, on the other hand, is an emerging field that has the potential to efficiently handle and minimize these limitations, thereby opening new doors of success for artificial intelligence applications. This article explored the capacity of QC in alleviating the limitations of AI and thus unfolding novel opportunities in the world of technology. It further explored the advantages of quantum computing over classical computing methods. The findings suggested that quantum computing can replace classical computing in various computational tasks. Moreover, it holds significant potential in addressing complex problems and minimizing the challenges associated with artificial intelligence

Keywords: *quantum computing, artificial intelligence, algorithms, quantum neural networks (QNNS), encryption.*

GJCST-D Classification: *LCC Code: QA76.889, QA76.9.A43, QA76.27*

Harnessing the Capabilities: The Synergistic Potential of Quantum Computing in Addressing Limitations of Artificial Intelligence

Stevie A. Burke [α] & Ammara Akhtar [σ]

Abstract- With the rapid advancement in technological fields, two major domains including Quantum computing and artificial intelligence are substantially transforming the internet world. Although AI has fundamentally made rapid progress, it still has many limitations that are hindering its full potential to efficiently deal with intricate challenges. QC, on the other hand, is an emerging field that has the potential to efficiently handle and minimize these limitations, thereby opening new doors of success for artificial intelligence applications. This article explored the capacity of QC in alleviating the limitations of AI and thus unfolding novel opportunities in the world of technology. It further explored the advantages of quantum computing over classical computing methods. The findings suggested that quantum computing can replace classical computing in various computational tasks. Moreover, it holds significant potential in addressing complex problems and minimizing the challenges associated with artificial intelligence.

Keywords: quantum computing, artificial intelligence, algorithms, quantum neural networks (QNNS), encryption.

I. Background

Artificial intelligence is playing a vital role in diverse aspects of our daily lives. There are still many shortcomings of artificial intelligence in terms of its reliability including safety, information security, and privacy issues that require immediate attention in diverse fields for example robotics, banking, entertainment, healthcare, and surveillance. These issues further cause biases, lack of robustness, insufficient data, security issues, and compatibility problems [1]. When it comes to the role of quantum computing in artificial intelligence, it would not be wrong to say that "Modern problems require modern solutions". In 1980, two scientists Benioff and Feynman first proposed the idea of QC, highlighting the superiority of quantum mechanics over classical computing in dealing with intricate problems [2].

Classical neural networks analyze and send data by mimicking the structure of the human brain and are made up of artificial neurons present in the form of interconnected layers [3]. These classical neural networks have been quite successful in various industries, but as the problems become more complex, the need for advanced computations rises exponentially, thereby posing several challenges for classical computing methods [4].

Quantum computing can be employed to reshape and enhance artificial intelligence applications. For example, it can be utilized to train neural networks that are employed in machine learning. Quantum neural networks (QNNs) exhibit a unique integration of two cutting-edge technologies including artificial neural networks and quantum computing [5]. QNNs utilized the principles of quantum mechanics to process data. These neural networks possess tremendous potential in transforming diverse domains ranging from machine learning (ML) to optimization to dealing with complex data.

Machine learning is an artificial intelligence-based technology that enables computers to acquire knowledge from experience without the need for direct programming [6]. Moreover, QC can improve the capabilities of machine learning by developing novel learning algorithms and frameworks that can handle and execute bulk data and intricate computations more effectively resulting in more authentic predictions [7].

Quantum computing works on the principles of quantum mechanics including quantum entanglement, interference, and quantum superposition (Figure 1). Entanglement is a quantum property that combines multiple quantum states, thereby allowing the computational speed to rise exponentially [8]. Quantum superposition plays an integral role in storing all the values on one qubit simultaneously in the quantum state. Interference is another property associated with quantum algorithms. It enhances the probabilities of desired outcomes of algorithms and decreases the possibilities of unwanted outcomes. These features allow quantum computers to solve complex problems more effectively [9].

Author α σ: Clean Community Inc.
e-mails: Stevie@cleancommunityinc.com, ammaraakhtar3@gmail.com

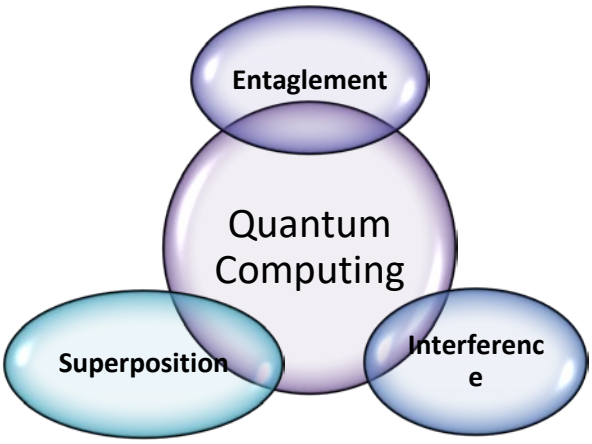


Figure 1: Introduction to Quantum Computing

This study aimed to explore the potential of quantum computing in minimizing the limitations of artificial intelligence.

II. Methodology

A systematic review analysis was done by going through previously available literature. An extensive review of hundreds of articles was done from the Scopus database to extract relevant information. Furthermore, a search was made on Google Scholar to identify the articles highlighting the role of quantum computing in advancing artificial intelligence. The main focus of this review was to cover the articles published in the years above 2000. While scrutinizing, major attention was put to identify the complex relationship between both computing methods and how they can synergistically act together to transform the world of technology.

III. Results and Discussion

a) The Synergistic Potential of Quantum Computing in Artificial Intelligence

Quantum algorithms are generally based on quantum circuits that mainly contain quantum gates. These gates are designed to execute operations on qubits [10]. Quantum circuits play a significant role in QC and are used to design novel quantum algorithms that hold immense potential in various artificial intelligence applications including algorithm optimization, natural language processing, cryptography, image recognition area, information security, and simulation (Figure 2).

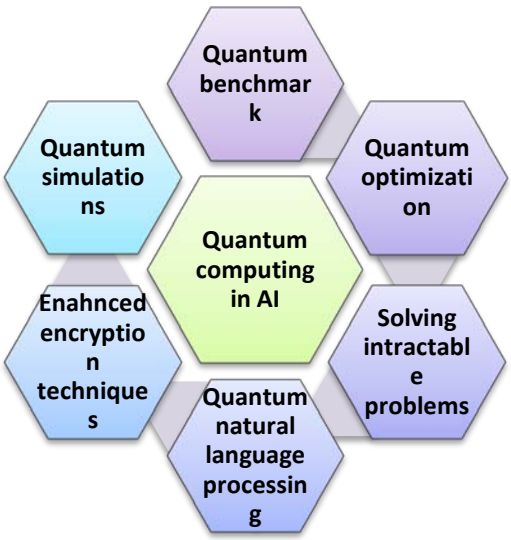


Figure 2: Quantum Computing in Improving AI

b) Strengthening Encryption Techniques

The internet has become an indispensable need of the modern world [11]. With the digital advancements in the last few years, personal data is no longer personal. Due to the substantial rise in data breaches and cyberattack cases, there is a growing need to protect sensitive information and personal data [12]. Encryption techniques are widely used in artificial intelligence-based systems for protecting highly confidential data. Most conventional encryption techniques use Advanced Encryption Standard (AES) or Rivest-Shamir- Adleman (RSA) algorithms that are dependent upon factoring large numbers to provide data confidentiality. Nonetheless, with the tremendous progression of AI, there is a constant increase in cyberattack cases [13]. Innovative solutions are fundamentally needed to bring improvements in the cryptography system.

Quantum computing maintains the integrity of data by allowing the inspection of the anonymized data. This function allows various businesses and industries to analyze personal data without decrypting it, thereby maintaining the individuals' privacy. The main idea behind the application of homomorphic encryption in QC is to execute the encrypted computational data while ensuring the privacy of the individual [14].

Quantum key distribution (QKD) based on quantum mechanics can be employed to deal with cybersecurity and encryption issues by providing an unsurpassed degree of security [15]. QKD maintains the confidentiality of the data by identifying and rejecting all attempts to interrupt or change the keys. It further ensures the identity of the user by employing quantum signatures to avoid impersonation attacks. Moreover, factoring large numbers can be easily done with the help of QC by using Shor's algorithms, which otherwise would be quite challenging for classical computers. The Shor algorithm was first proposed by Shor in 1994 for large factor integration. Factoring of large prime numbers is an NP-hard problem in the security cryptosystem. By employing the ability of QC to perform complex computations, the potential of AI systems for the development of resilient encryption techniques can be enhanced, thereby providing much greater protection of confidential data [16].

c) Solving Intractable Problems

The Turing machine was a mathematical model developed by Alan Turing in 1936 to describe the concepts of computability. This abstract machine contains an infinitely long tape divided into cells. It can read, write, or remove symbols. Today, digital computers have a vast array of applications, but there are still many limitations that require superior solutions. These limitations signify the importance of developing new computing types also known as post-Turing computing. This term refers to the different computing methods that surpass the limitations of classical computers according to the Turing machine model [17]. Quantum computers fundamentally have the potential to lie in the category of post-Turing computation. As compared to Turing machines in classical computers, quantum computers are based on quantum Turing machines with their performance strengthened by qubits and quantum gates [1].

Instead of using bits, QC is based on the work of qubits that have the potential to generate novel logic gates allowing the development of new algorithms that could have been quite difficult to construct while using classical computing methods. One such example is Shor's prime factorization algorithm [18]. The power of classical and quantum computing can be distinguished by the breaking speed of an algorithm that has revolutionized the development of QC, known as the Rivest–Shamir–Adleman (RSA) algorithm. Classical computing methods can take billions of years to solve this computational problem while QC has the potential to solve it within a day [19].

Quantum computing offers potential solutions to various intractable problems in artificial intelligence and classical computing that are considered unmanageable. The bit in classical computing can only take a single binary value, either 0 or 1 values, while the qubits in quantum computing can take both values in a superposition state at a time, thereby allowing several operations to run simultaneously. In classical computing, the record of three bits is equal to 8 possible values, and particles can only employ one of these at a time. In QC, the qubits are allowed to be present in multiple states, so we can use all eight values at a time. This means that three qubits can lead to the running of eight operations simultaneously due to its property known as quantum superposition [20]. This feature can help speed up the training process of AI-based models, improving their decision-making abilities and tackling complicated computational issues that would otherwise be deemed impossible to resolve.

Currently, most of the research is focusing on the use of quantum computing in improving AI searching techniques. One of the challenges in AI search techniques is managing decision problems including integer factorization, search issues, and machine learning problems. Quantum search is considered one of the best techniques of QC that can play a crucial role in artificial intelligence. QC can exponentially solve decision problems that are represented in the form of decision trees. In this regard, the Grover search algorithm [21] has shown that QC can act much faster as compared to other classical approaches in searching an element from the unsorted database [22]. Many AI researchers have faith that quantum search can prove to be one of the most prominent techniques to play a crucial role in artificial intelligence [23].

Bernstein and Vazirani, [24] studied a class of complex decision problems known as BQP (bounded-error quantum polynomial) that have been reported to be easily solved by QC employing polynomial numbers of quantum gates. They proposed that similar problems like BQP can be quite difficult to solve with classical computers. Another example is Simon's problem which is solved by searching for a hidden string based on the black box function. QC can easily solve Simon's problems by employing a polynomial number, while even the top classical computers will require an exceeding number of queries thereby implying that quantum algorithms have the exponential speedup potentials as compared to the classical algorithms.

d) Quantum Natural Language Processing (QNLP)

Natural language processing (NLP) is an artificial intelligence-based machine learning technology that enables the manipulation and comprehension of human languages by computers [25]. QNLP has surpassed the capabilities of classical NLP methods by providing language modeling, text summarization, speech processing, question answering, and machine translation more efficiently and accurately. In classical NLP methods, these tasks can be quite power-intensive, but quantum computers can speed up the process with less power consumption, thereby allowing AI models to work more efficiently. QNLP further reduces the training time for data-intensive artificial intelligence models. By transforming the languages into more logical formats with the help of string diagrams, quantum computing further simplifies natural language processing designs on quantum hardware [26].

Quantum-based artificial intelligence systems have the potential to improve natural language generation-related tasks including chatbots, and automated storytelling by providing better insight into human languages [27]. Widdows et al. [28] successfully described a quantum-based approach to bigram modeling for developing and distributing the sequences of words and sentences by employing a quantum circuit known as the Born machine. This approach was used in the verb-noun composition by utilizing one qubit rotation for nouns while two-qubit rotation was used for verbs.

Social media is widely employed for connecting, sharing information, promoting businesses, learning, and education purposes [29]. Usually, text used in social media is based on code-mixed languages. Part of speech (POS) tagging is one of the principal tasks used in social media for different AI-based natural language processing applications. It involves assigning a POS tag automatically to all the words present in a text. Pandey et al., [22] studied the impact of quantum machine learning (QML) on different NLP applications. He performed the POS tagging on a dataset with mixed codes by employing classical long short-term memory (LSTM) and quantum-based long short-term memory (QLSTM). The data was priorly processed and sorted into several batches for each experiment. The results showed that the outcomes of QLSTM surpassed the classical LSTM in terms of performance.

The common theoretical model used in all QNLP methods is the Categorical Distributional Compositional (DisCoCat) model [30]. DisCoCat model employed in natural languages fundamentally presents the encoding meaning of sentences and phrases in the form of quantum circuits on specialized hardware. Overall, all QNLP algorithms come up with diverse benefits and can be applied successfully on all NLPs. One current challenge is the limited accessibility of these quantum hardware on a small scale. A hybrid approach can be used by integrating the operations of classical computers with quantum mechanics-based operations.

e) Quantum Benchmark

Benchmarks consist of a set of operations or inputs that are used to assess the performance of computer systems. They provide valuable insights and metrics to determine roadmaps and technological maturity [31]. There are three different types of benchmarks including aggregation, physical, and application-level benchmarks. Physical benchmarks focus on the physical properties of QC, while aggregation assists in determining the performance of quantum processors. Application-centered benchmarks are based on the metrics acquired by testing real-world problems while using quantum processors [3].

Currently, there is a scarcity of application-centered benchmarks exhibiting good hardware performance in conventional computing and artificial intelligence. This has led to several difficulties for users in comprehending the performance of these benchmarks. By using quantum benchmarks, a comparison of different quantum solutions can be made to bring improvements on all layers of the quantum computing stack. One such example of an application-centered benchmark is the "ImageNet" benchmark Deng et al., [32] which has led to breakthroughs in AI by creating specialized hardware. Another example is "Glue" [33] which is a natural language understanding system and has been proven to be highly useful in improving the performance of machine learning by providing standardized datasets that allow active comparisons. These types of benchmarks can also assist in developing hardware protocols and converging applications for diverse AI tools.

f) Quantum Simulations

One of the most promising applications of QC lies under the category of quantum simulations. QNNs can help simulate and comprehend complex quantum systems. Quantum systems include microscopic particles, molecules, and materials that are related to quantum chemistry and modern material sciences. QC

can revolutionize the world of molecular simulations by authentically predicting the outcomes of different complex chemical reactions at a much faster speed than other classical computational methods.

Through the synergistic action of AI and QC, quantum simulation can be used to develop cheaper reliable batteries. Improved version of batteries is high in demand in the electric vehicles industry. Quantum computing in combination with artificial intelligence is used in battery production for searching the suitable and safer materials. To find the best, more powerful, long-lasting, and cost-effective developing materials for batteries, the use of QC has been proven to be highly essential.

Quantum simulation can be used in simulating various industrial catalysis processes. With the ever-growing population, there is a need for the expansion of world resources. One of the examples is the production of natural nitrogen fixation catalysts, ammonia, which is widely used in plant fertilizers. In the ammonia production process, researchers are trying to simulate the exact natural mechanism of ammonia. Researchers have predicted that a quantum computer can correctly simulate the different catalytic stages of the nitrogen fixation process. The predictive models generated can be further used to identify new molecules with little energy consumption. These new molecules will be further screened to find the best-suited ones for the nitrogen fixation catalytic process [34].

Engineering simulations are widely used in the manufacturing sector. These simulations are for example used in aerodynamics and automotive industries to reduce the efforts of designing and testing physical prototypes. One of the most used numerical simulations, also known as the finite-element method (FEM) is employed to simulate intricate processes including structural dynamics, operating power, and aerodynamics. For example, AIRBUS is investigating the potential of QC or synergistic potential of AI and QC in reducing the usage of computational resources needed to test the behavioral features of airflow in computational fluid dynamics [35] (Airbus, 2019, Andreas et al., 2021).

g) Managing Optimization Problems

One of the greatest challenges in artificial intelligence is related to solving optimization problems. AI uses machine learning methods (ML) and optimization algorithms to identify and withdraw patterns from bulk data. Quantum neural networks (QNNs) have excelled in managing optimization problems by making use of adiabatic computation, quantum approximate optimization algorithm (QAOA), Quadratic unconstrained binary optimization (QUBO), and quantum annealing to look for solutions within a big and intricate search space [36]. Quantum approximate optimization algorithm (QAOA) is a highly quantum-based algorithm that is designed to solve optimization problems that would otherwise be unsolvable by classical computers. QUBO is another quantum model that is efficient in solving combinational optimization problems. The importance of these optimization models cannot be ignored in artificial intelligence and machine learning applications [37].

Quantum computers are known to give polynomial speedup as compared to classical computers. It means that the time needed for solving the problem polynomially reduces as the size of the problem increases. This ability of QC empowers the AI system to get in-depth insight into the larger data and exhibit greater prediction accuracy. These neural networks have revolutionized the world of optimization algorithms, and thus have opened new avenues in diverse scientific fields to tackle intractable real-world problems [38].

IV. Conclusion

Quantum computing is an emerging field that has diverse potential in various industries. The findings in this paper prove that the convergence of AI with quantum computing can offer tremendous opportunities in the fast-growing technological industries. QC has the potential to offer unique processing capacity, optimize ML methods, strengthen encryption techniques, and simulate complex systems, thereby mitigating the hurdles encountered by AI. By employing this integrated approach, a multitude of unprecedented benefits can be achieved in promoting groundbreaking progress across several fields in future. There is a need for more exploration to find the potential of this synergistic integration of quantum computing in artificial intelligence. This interaction can substantially transform the world of technology and move us toward a bright future filled with tremendous opportunities.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Availability of data and material

None

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Acknowledgement

None

References Références Referencias

1. A. Bacho, H. Boche, and G. Kutyniok, "Reliable AI: Does the Next Generation Require Quantum Computing?," *arXiv preprint arXiv:2307.01301,* 2023.

2. D. Joseph *et al.*, "Transitioning organizations to post-quantum cryptography," *Nature,* vol. 605, no. 7909, pp. 237-243, 2022.
3. J. Wang, G. Guo, and Z. Shan, "Sok: Benchmarking the performance of a quantum computer," *Entropy,* vol. 24, no. 10, p. 1467, 2022.
4. J. F. Torres, A. Troncoso, I. Koprinska, Z. Wang, and F. Martínez-Álvarez, "Deep learning for big data time series forecasting applied to solar power," in *International Joint Conference SOCO'18-CISIS'18-ICEUTE'18: San Sebastián, Spain, June 6-8, 2018 Proceedings 13*, 2019: Springer, pp. 123-133.
5. M. Schuld, R. Sweke, and J. J. Meyer, "Effect of data encoding on the expressive power of variational quantum-machine-learning models," *Physical Review A,* vol. 103, no. 3, p. 032430, 2021.
6. J. Biamonte, P. Wittek, N. Pancotti, P. Rebentrost, N. Wiebe, and S. Lloyd, "Quantum machine learning," *Nature,* vol. 549, no. 7671, pp. 195-202, 2017.
7. S. K. Abd, M. M. Jaber, S. Y. Ali, and M. H. Ali, "Artificial intelligence for cancer diagnosis," in *Artificial Intelligence in Cancer Diagnosis and Prognosis, Volume 1: Lung and kidney cancer*: IOP Publishing Bristol, UK, 2022, pp. 10-1-10-11.
8. M. Gupta and M. J. Nene, "Quantum computing: An entanglement measurement," in *2020 IEEE International Conference on Advent Trends in Multidisciplinary Research and Innovation (ICATMRI)*, 2020: IEEE, pp. 1-6.
9. X. Gu, L. Chen, and M. Krenn, "Quantum experiments and hypergraphs: Multiphoton sources for quantum interference, quantum computation, and quantum entanglement," *Physical Review A,* vol. 101, no. 3, p. 033816, 2020.
10. J. Van de Wetering, "Constructing quantum circuits with global gates," *New Journal of Physics,* vol. 23, no. 4, p. 043015, 2021.
11. S. A. Burke, "Internet addiction: A summary towards an Integration of Current Knowledge and broad Perspectives," *Open Journal of Psychology,* pp. 84-96, 2022.
12. M. Conti, T. Dargahi, and A. Dehghantanha, *Cyber threat intelligence: challenges and opportunities*. Springer, 2018.
13. S. A. Burke and A. Akhtar, "The shortcomings of artificial intelligence: A comprehensive study," 2023.
14. J. B. Bernabe, J. L. Canovas, J. L. Hernandez-Ramos, R. T. Moreno, and A. Skarmeta, "Privacy-preserving solutions for blockchain: Review and challenges," *IEEE Access,* vol. 7, pp. 164908-164940, 2019.
15. S. Pirandola *et al.*, "Advances in quantum cryptography," *Advances in optics and photonics,* vol. 12, no. 4, pp. 1012-1236, 2020.
16. A. Djenna, A. Bouridane, S. Rubab, and I. M. Marou, "Artificial Intelligence-Based Malware Detection, Analysis, and Mitigation," *Symmetry,* vol. 15, no. 3, p. 677, 2023.
17. L. De Mol, "Turing machines," 2018.
18. B. Wang, F. Hu, H. Yao, and C. Wang, "Prime factorization algorithm based on parameter optimization of Ising model," *Scientific reports,* vol. 10, no. 1, p. 7106, 2020.
19. H. T. Sihotang, S. Efendi, E. M. Zamzami, and H. Mawengkang, "Design and implementation of Rivest Shamir Adleman's (RSA) cryptography algorithm in text file data security," in *Journal of Physics: Conference Series*, 2020, vol. 1641, no. 1: IOP Publishing, p. 012042.
20. V. Moret-Bonillo, "Can artificial intelligence benefit from quantum computing?," *Progress in Artificial Intelligence,* vol. 3, pp. 89-105, 2015.
21. L. K. Grover, "A fast quantum mechanical algorithm for database search," in *Proceedings of the twenty-eighth annual ACM symposium on Theory of computing*, 1996, pp. 212-219.
22. S. Pandey, N. J. Basisth, T. Sachan, N. Kumari, and P. Pakray, "Quantum machine learning for natural language processing application," *Physica A: Statistical Mechanics and its Applications,* vol. 627, p. 129123, 2023.
23. G. Acampora, "Quantum machine intelligence: Launching the first journal in the area of quantum artificial intelligence," vol. 1, ed: Springer, 2019, pp. 1-3.
24. E. Bernstein and U. Vazirani, "Quantum complexity theory," in *Proceedings of the twenty-fifth annual ACM symposium on Theory of computing*, 1993, pp. 11-20.
25. N. G. Canbek and M. E. Mutlu, "On the track of artificial intelligence: Learning with intelligent personal assistants," *Journal of Human Sciences,* vol. 13, no. 1, pp. 592-601, 2016.
26. E. R. Miranda, R. Yeung, A. Pearson, K. Meichanetzidis, and B. Coecke, "A quantum natural language processing approach to musical intelligence," in *Quantum Computer Music: Foundations, Methods and Advanced Concepts*: Springer, 2022, pp. 313-356.
27. A. Karamlou, M. Pfaffhauser, and J. Wootton, "Quantum natural language generation on near-term devices," *arXiv preprint arXiv:2211.00727,* 2022.
28. D. Widdows, A. Alexander, D. Zhu, C. Zimmerman, and A. Majumder, "Near-term advances in quantum natural language processing," *arXiv preprint arXiv:2206.02171,* 2022.
29. S. A. Burke, A. Mahoney, A. Akhtar, and A. Hammer, "Public Perspective on the Negative Impacts of Substance Use-Related Social Media Content on Adolescents: A Survey," *Open Journal of Psychology,* pp. 77-83, 2022.
30. R. Lorenz, A. Pearson, K. Meichanetzidis, D. Kartsaklis, and B. Coecke, "QNLP in practice:

Running compositional models of meaning on a quantum computer," *Journal of Artificial Intelligence Research,* vol. 76, pp. 1305-1342, 2023.
31. J. R. Finžgar, P. Ross, L. Hölscher, J. Klepsch, and A. Luckow, "QUARK: A framework for quantum computing application benchmarking," in *2022 IEEE International Conference on Quantum Computing and Engineering (QCE)*, 2022: IEEE, pp. 226-237.
32. J. Deng, W. Dong, R. Socher, L.-J. Li, K. Li, and L. Fei-Fei, "Imagenet: A large-scale hierarchical image database," in *2009 IEEE conference on computer vision and pattern recognition*, 2009: Ieee, pp. 248-255.
33. A. Wang, A. Singh, J. Michael, F. Hill, O. Levy, and S. R. Bowman, "GLUE: A multi-task benchmark and analysis platform for natural language understanding," *arXiv preprint arXiv:1804.07461,* 2018.
34. M. A. Metawei, H. Eldeeb, S. M. Nassar, and M. Taher, "Quantum Computing Meets Artificial Intelligence: Innovations and Challenges," in *Handbook on Artificial Intelligence-Empowered Applied Software Engineering: VOL. 1: Novel Methodologies to Engineering Smart Software Systems*: Springer, 2022, pp. 303-338.
35. B. Andreas *et al.*, "Industry quantum computing applications," *EPJ Quantum Technology,* vol. 8, no. 1, 2021.
36. K. Beer, D. List, G. Müller, T. J. Osborne, and C. Struckmann, "Training quantum neural networks on nisq devices," *arXiv preprint arXiv:2104.06081,* 2021.
37. J. Choi, S. Oh, and J. Kim, "The useful quantum computing techniques for artificial intelligence engineers," in *2020 International Conference on Information Networking (ICOIN)*, 2020: IEEE, pp. 1-3.
38. R. Jozsa and N. Linden, "On the role of entanglement in quantum-computational speed-up," *Proceedings of the Royal Society of London. Series A: Mathematical, Physical and Engineering Sciences,* vol. 459, no. 2036, pp. 2011-2032, 2003.

This page is intentionally left blank

Global Journal of Computer Science and Technology: D
Neural & Artificial Intelligence
Volume 24 Issue 2 Version 1.0 Year 2024
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Optimizing Real-Time Intelligent Traffic Systems with LSTM Forecasting and A* Search: An Evaluation of Hypervisor Schedulers

By Azizul Hakim Rafi

Abstract- This research explores an Intelligent Traffic System (ITS) designed for real-time optimal routing using traffic forecasting and an A* search algorithm. Leveraging a pre-trained Long Short-Term Memory (LSTM) neural network, I predict traffic flow based on historical data to inform heuristic functions, ensuring optimal route calculations. The heuristic is constructed to be permissible and consistent by incorporating predicted traffic flow and average speed measurements. The experimental setup involves a messaging virtual machine (VM) and a real-time VM within a Xen hypervisor environment, utilizing Apache Kafka and Apache Flink for data flow and processing. I empirically evaluate the latency performance of the ITS under three different Xen schedulers: RTDS, Credit, and Credit2. My findings indicate that the RTDS scheduler provides superior latency guarantees, making it suitable for applications requiring ultra-low latency, whereas the Credit and Credit2 schedulers offer better median performance. These insights highlight the impact of hypervisor scheduler choice on the efficiency and responsiveness of real-time ITS applications.

GJCST-D Classification: *FOR Code: 080108*

Strictly as per the compliance and regulations of:

Optimizing Real-Time Intelligent Traffic Systems with LSTM Forecasting and A* Search: An Evaluation of Hypervisor Schedulers

Azizul Hakim Rafi

Abstract- This research explores an Intelligent Traffic System (ITS) designed for real-time optimal routing using traffic forecasting and an A* search algorithm. Leveraging a pre-trained Long Short-Term Memory (LSTM) neural network, I predict traffic flow based on historical data to inform heuristic functions, ensuring optimal route calculations. The heuristic is constructed to be permissible and consistent by incorporating predicted traffic flow and average speed measurements. The experimental setup involves a messaging virtual machine (VM) and a real-time VM within a Xen hypervisor environment, utilizing Apache Kafka and Apache Flink for data flow and processing. I empirically evaluate the latency performance of the ITS under three different Xen schedulers: RTDS, Credit, and Credit2. My findings indicate that the RTDS scheduler provides superior latency guarantees, making it suitable for applications requiring ultra-low latency, whereas the Credit and Credit2 schedulers offer better median performance. These insights highlight the impact of hypervisor scheduler choice on the efficiency and responsiveness of real-time ITS applications.

I. Introduction

Intelligent Transportation Systems (ITSs) are one of the most anticipated smart city services and have already seen widespread adoption. The Sydney Coordinated Adaptive Traffic System (SCATS) is a fully adaptive urban traffic control system that optimizes traffic flow and currently operates in more than 37,000 intersections worldwide. Optimizing traffic flow conditions not only shortens travel times but can also reduce the carbon emissions generated from road vehicle activity [5]. Unfortunately, city-wide traffic control models are difficult to study using realworld data. While it is possible to develop a model of an ITS using historical data, it is difficult to determine its effectiveness because traffic conditions would morph under the use of the ITS. Therefore, instead of considering city-wide coordination, this research focuses on intelligent routing based on real-time prevailing traffic conditions, similar to the service provided by Google Maps.

Traditional traffic flow models rely on shallow learning algorithms and only a few conditions to predict traffic flow. While these models have been moderately successful, they fail to capture the deeper relationship between their features and also fail to adapt to changing conditions quickly [17]. Deep learning methods, on the other hand, have drastically improved the state-of-the-art in a variety of fields, such as speech recognition and object detection. Deep learning's success is largely based on its ability to discover intricate structures and relationships between features in large datasets [9]. The evolution of traffic flow over time is dynamic and non-linear, which makes it a perfect candidate for deep learning methods. With the advent of the Internet of Things (IoT), wireless sensors are able to capture a variety of real-world conditions such as traffic accidents, weather, and external events like sports games. ITSs are then able to aggregate these features to build hybrid multimodal methods for traffic flow forecasting using deep learning [7,10].

However, this data transmission and analysis must be performed at ultra-low latency and in real time in order to have the intended effect of optimizing the operations of a smart city. The combination of compute-intensive workloads and latency-sensitive applications motivates the use of real-time cloud computing. [8] have recently introduced a framework for efficient edge and cloud computing specifically designed for ITSs but do not provide empirical results to substantiate their claims. Moreover, current clouds lack service level agreements on latency; these clouds provision resources and not latency. Such a service level agreement is critical for applications like ITSs.

In this paper, I empirically study the latency performance of a simplified ITS on a real-time cloud. The rest of this paper is organized as follows. Section II presents related work. In Section III, I provide relevant background information for the technologies used. Section IV covers design and implementation strategies. Section V presents my empirical study using a real traffic dataset and evaluates the latency of the application on a real-time cloud. Finally, Section VI offers conclusions and directions for future research.

II. Related Work

Traffic flow forecasting has a long history in transportation literature, and many techniques have been proposed to address this problem. [17] introduce an autoregressive integrated moving average (ARIMA) process for estimating traffic flows. While the ARIMA

Author: e-mail: azizulhakimrafi4@gmail.com

model has the benefit that it is easy to interpret, it is not able to accurately capture the non-linear, stochastic nature of traffic flow evolution. [13] have utilized an efficient Bayesian particle filter for tracking traffic flows and demonstrated its effectiveness on a dataset from the I-55 highway system in Illinois. The authors then used the same dataset to evaluate a deep neural network with ℓ_1 regularization and applied this model to predict traffic flows during a baseball game accurately [14]. [11] develop a novel model, called LC-RNN, that combines both convolutional and recurrent neural networks in order to learn the time-series and spatiotemporal nature of traffic patterns more meaningfully.

While deep-learning, specifically time-series-based approaches, have seen the greatest empirical success, it is apparent that no single method works best for every situation. In general, the most successful methods are hybrid methods that can combine techniques to improve the accuracy of prediction under the prevailing traffic conditions [4].

a) Traffic Flow

Traffic flow forecasting is a challenging problem in the space of intelligent traffic management. In this paper, I consider traffic flow in a macroscopic context. That is, instead of considering each vehicle in a traffic stream individually, I rather think of the traffic flow as a measurement at a single fixed location in space. The traffic flow forecasting problem is thus formally defined as follows. At time T, I seek to predict the future traffic flow q_{T+1} at time $T + 1$ or q_{T+n} at time $T + n$ based on the history of traffic data.

Flow may be considered a temporal measurement and is usually expressed in terms of units over a period of time. For a single lane of traffic, I can define the flow q in region R as

$$q = \frac{N}{T}, \tag{1}$$

where N is the number of vehicles observed crossing region R during timespan T [12]. For multiple-lane traffic, I can sum the partial flows across each of the L lanes

$$q = \sum_{l=1}^{L} q_l = \frac{1}{T} \sum_{l=1}^{L} N_l, \tag{2}$$

where N_l is the number of vehicles that passed a detector's site in lane l. I also define the mean speed of the traffic stream, expressed in terms of miles (or kilometers) per hour. In this paper, I consider the time-mean speed, which is calculated as the arithmetic average of the vehicles' instantaneous speeds in the region R_t. The time-mean speed is denoted by $\bar{v}_t$

$$\bar{v}_t = \frac{1}{N} \sum_{i=1}^{N} v_i, \tag{3}$$

where v_i is the instantaneous speed of the ith vehcile [12].

b) Vanishing Gradient

The vanishing gradient problem as described in [3] is particularly prevalent in training recursive neural networks. Most neural networks learn weight parameters through some gradient-based optimization method, such as backpropagation through time. For deep or recursive neural networks, backpropagation yields lengthy update equations in which gradients may become vanishingly small, effectively preventing the weight from ever updating its value. There are many methods to combat the vanishing gradient problem in recurrent neural networks, namely the introduction of long short-term memory networks.

c) Long Short-Term Memory Networks

Given their capacity to memorize long-term dependencies, long short-term memory (LSTM) neural networks have special advantages for traffic flow prediction. LSTMs are a specific type of recurrent neural network. Recurrent neural networks are comprised of memory cells; memory cells add a loop to the traditional perceptron model of a neural network. These loops make the network recursive, thereby allowing information to persist. Recurrent neural networks have been notable in language modeling, speech-to-text transcript, and other applications with time-series patterns. Whereas traditional recurrent neural networks suffer from the vanishing gradient problem during training, LSTM networks are specifically designed to address the vanishing gradient problem [15]. Just like recurrent neural networks, LSTMs are comprised of many memory cells. LSTM networks combat the vanishing gradient problem through the use of forgetting gates, which are special structures added to the memory cell designed to allow the cell to forget certain information. The typical structure of an LSTM memory cell is shown in Figure 1.

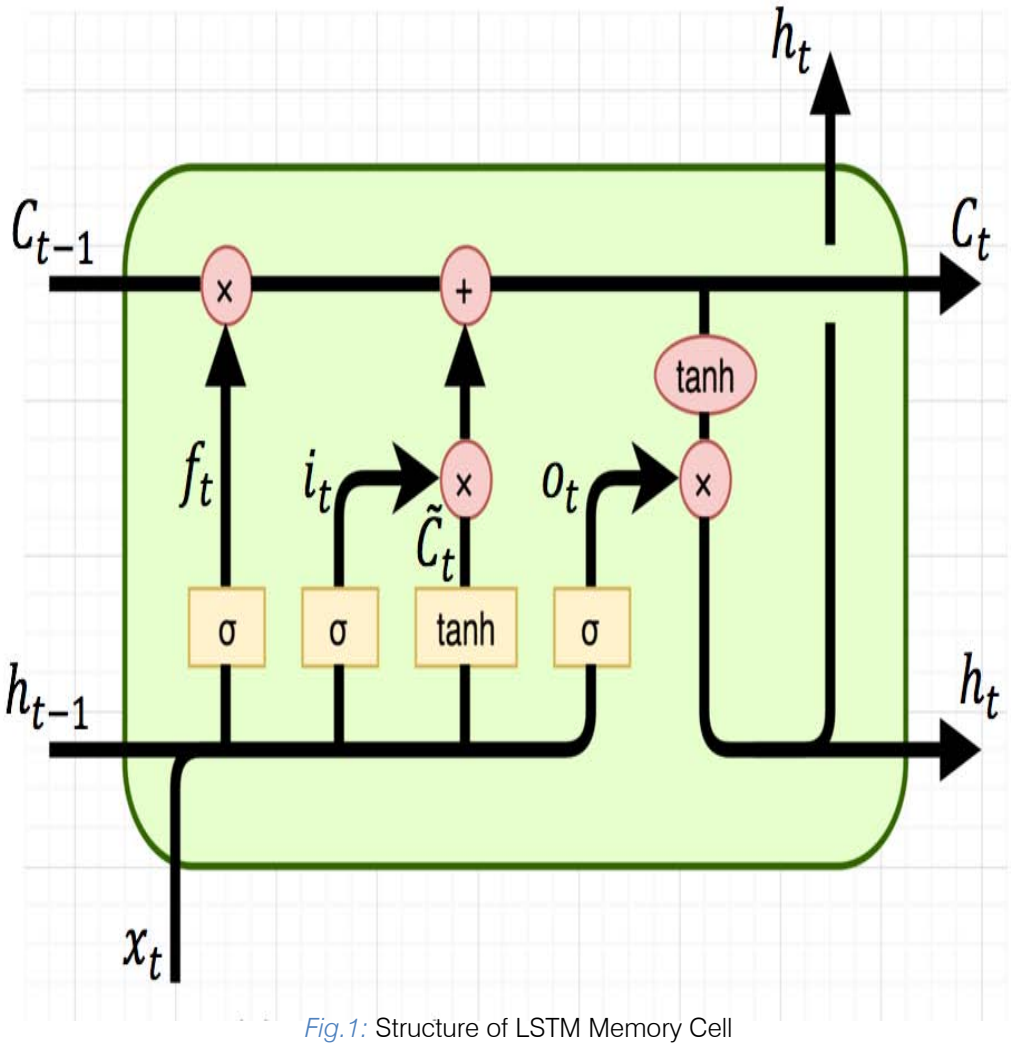


Fig.1: Structure of LSTM Memory Cell

[15] describes the information flow for a typical LSTM memory cell– an LSTM memory cell has three gates: an input gate, a forget gate, and an output gate. Each of these gates is a way to let information flow optionally and is comprised of a sigmoid activation function. The sigmoid function squashes values between the range of [0,1], representing how much information to let through a given gate. At the *t*th timestep, the output from the previous LSTM memory cell, h_{t-1}, is fed into the forget gate, which determines how much information from the previous gate to keep, f_t. The output of the forget gate is then multiplied by the previous cell state. The input gate determines how much information from the most recent observation, x_t, to include in the cell state. The current cell state, C_t is first passed through the *tanh* activation function and then multiplied with the output from the input gate, i_t, yielding $\tilde{C}_t$. Finally, the current cell state, C_t is updated:

$$C_t = f_t * C_{t-1} + i_t * \tilde{C}_t \tag{4}$$

The updated cell state, C_t, is then fed into the output gate, which determines the output from the current cell state using the sigmoid function, producing o_t. The memory cell applies the *tanh* activation function to the current cell state to squash the values between $[-1,1]$ and multiplies the result with o_t, producing:

$$h_t = o_t * tanh(C_t) \tag{5}$$

While training LSTM networks takes a very long time, stacking many of these LSTM memory cells produces an extremely powerful model capable of learning long-term dependencies, which is particularly useful for predicting traffic flow [10].

d) A Star Search

The A Star Search Algorithm (*A**) is an algorithm used in graph traversal to find the optimal path between any pair of nodes. In my case, I can express a city's roads and freeways as a directed graph in which intersections are nodes, and the roads are edges. I can use *A** to find the optimal path between any two points in the city. *A** is an informed search algorithm that makes use of heuristics to decide which path to consider next. *A** determines which path to consider next by minimizing

the cost of the current path to the next node and the estimated cost from the next node to the end. Mathematically, this is expressed as-

$$f(n) = g(n) + h(n), \tag{6}$$

where $g(n)$ is the cost from the start node to node n, and $h(n)$ is a heuristic that estimates the cost from node n to the end. In order for A^* to be optimal, this heuristic must satisfy two properties: admissibility and consistency. An admissible heuristic is any such heuristic that does not overestimate the true cost of traveling to the next node. A consistent heuristic is any such heuristic that supports the following inequality for any two adjacent nodes, x and y

$$h(x) \leq dist_{x,y} + h(y) \tag{7}$$

III. Background

This section provides background on the Xen hypervisor and the scheduling framework in Xen. It also describes a stream-processing engine, Flink, and real-time messaging middleware, Kafka.

a) Xen

Xen [2] is a popular open-source virtualization platform that allows multiple virtual machines to share conventional hardware in a safe and resource-managed fashion. Xen serves as a virtual machine monitor (VMM) that lies between the hardware and guest operating systems. Xen controls a special domain called *domain 0*, which is responsible for managing all other guest domains. Each guest domain acts as a virtual machine (VM) and can specify its resource requirement in terms of the number of virtual CPUs (VCPUs). The typical Xen architecture is shown in Figure 2. Each VM has a guest operating system, which is responsible for scheduling tasks on to VCPUs. Xen is not only responsible for providing virtual resource interfaces to the VMs but is also responsible for scheduling the VMs onto physical CPUs (PCPUs). There are currently three different schedulers in Xen: Credit, Credit2, and RTDS. Credit is the default scheduler; it is a generalpurpose weighted fair share scheduler. Credit2 is the evolution of the default credit scheduler; it is still based on a general purpose, a weighted fair share scheme, but it is more scalable and efficient with latency-sensitive workloads. RTDS is the real-time deferrable server scheduler that is specifically designed to handle real-time and latency-sensitive workloads [18].

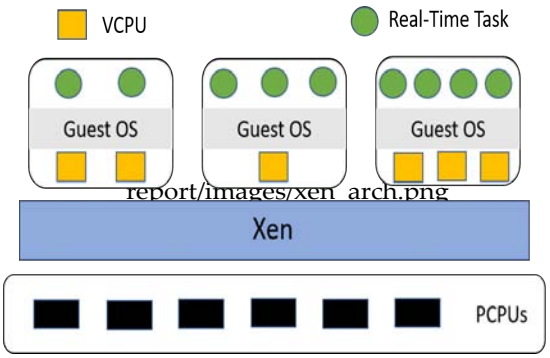


Fig. 2: Architecture of a Xen System

Credit Under the Credit scheduler, each VM specifies a weight and optional cap. The weight corresponds to the share of CPU a VM will have relative to other VMs, and the cap encodes the maximum CPU resource a VM can receive. The scheduling algorithm itself is implemented with a partitioned queue: each PCPU maintains a local run queue of VCPUs, sorted by VCPU priority. While a VCPU is scheduled onto a PCPU, it burns credits; once the VM is preempted, VCPU priorities are recalculated based on the weight, cap, and amount of credits consumed. By default, Credit uCreditwork stealing load-balancing scheme: if a PCPU has no VCPUs in its run queue, it will steal VCPUs from other cores.

Credit2 The Credit2 scheduler is similar to the default Credit scheduler in that it focuses on fairness, but Credit2 also aims to address issues of latency and scalability. Credit2 uses a similar weighting scheme as Credit Credit, assigning a weight to each VM. Credit2, however, does not have support for caps like Credit credit and is also not CPU mask-aware. As a result, a VM cannot pin its workload to specific CPUs.

RTDS Under the RTDS scheduler, each VM specifis a budget and period. While a VCPU is scheduled onto a PCPU, it consumes its budget until the budget is exhausted. The end of the period marks the deadline for a VCPU; at this time, any remaining budget is discarded, and then the budget is replenished. The scheduling algorithm is implemented using a global run queue sorted by VCPU deadline. This event-driven approach differs from the quantum-based approach used by the Credit and Credit2 schedulers. As

a result, this avoids invoking the scheduler unnecessarily, which should reduce overhead.

b) Apache Flink

Apache Flink is a distributed stream-processing engine that provides data distribution, communication, and fault tolerance for distributed computations over data streams. Flink's programming model is a generalization of the MapReduce paradigm. The Flink API offers a set of useful transformation operations, such as join and filter, in addition to the traditional map and reduce functions. Applications specify a series of lazy transformations to an unbounded data stream, which are connected to sources and sinks. The Flink engine then uses a cost optimizer to determine an efficient execution plan called a dataflow. This dataflow is internally represented as a directed acyclic graph from sources to sinks with transformation operators in between. Sinks trigger the execution of the necessary lazy transformations [1].

c) Apache Kafka

Apache Kafka is a distributed streaming platform that provides data pipelines and fault tolerance for streams of records across topics. Kafka makes use of two core APIs: the producer API allows an application to publish a stream of records to one or more topics, and the consumer API allows an application to subscribe to one or more topics and process the stream of records produced to them. Multiple producers may send streams of records on the same topic, and numerous consumers can also subscribe to the same topic. Each topic is spread over a cluster of Kafka brokers, with each broker holding at least one partition of the topic. Kafka uses Apache Zookeeper to help coordinate these services. Kafka is designed to meet high throughput and low latency requirements, making it an extremely suitable choice for real-time streaming applications.

IV. Design and Implementation

The previous section provided an overview of background information relevant to this paper's methodology. This section explores specific design and implementation choices.

a) Dataset

In order to create a model of an ITS, I needed historical traffic data to train and test a predictive model as well as data to use to study the latency of the application empirically. The California Transportation Performance Measurement System (PMS) collects real-time data from nearly 40,000 individual detectors across the freeway system in the state of California. PeMS provides data at a granularity of 5-minute intervals and includes features such as flow and average speed. These features are available across each lane and as aggregates for a given detector station. The raw data that comes from the single lanes is recorded every 30 seconds and then aggregated after every 5 minutes. While the real-time 30second granularity data is not made publicly available, the 5-minute granularity data is. For this research, I have downloaded data for March 2018 at 5-minute granularity. The data includes the timestamp, flow, and average speed (across individual lanes as well as aggregates); the data were taken from six different detector locations in southern California. Table 1 describes the detector locations and provides their latitude and longitude.

Table 1: Detector Locations

Detector Number	Canonical Name	Primary Freeway	Intersection	Latitude	Longitude
1	El Segundo	405S	105E	33.928621	-118.368522
2	Wilmington	405S	Wilmington	33.825757	-118.24005
3	Long Beach	405S	710S	33.824173	-118.207084
4	Athens	105E	110N	33.928478	-118.284031
5	Lynwood Gardens	105E	710S	33.914156	-118.184451
6	East Rancho Dominguez	710S	East Rancho Dominguez	33.877433	-118.192776

b) Model of ITS

I seek to create a model of an ITS that will predict future traffic flows and use this prediction to provide optimal routing using the A^* algorithm. First, I must create a model that can forecast future traffic flows based on historical data.

Evaluation Metric Given that this is a regression problem, I choose to train my models to minimize the mean squared error loss (MSE). MSE is defined as-

$$L = \frac{1}{N}\sum_{i=1}^{N}(h_i - y_i)^2, \tag{8}$$

where h_i is the predicted flow for the ith test data point and y_i is the true flow. Recall that the MSE loss metric is very sensitive to outliers and noise. To reduce this sensitivity, I preprocess my data by scaling non-time features between the range of 0 and 1. Once the network has been trained and I use it to predict traffic

flows, I will transform the prediction back to its original scale. Algorithms 1 and 2 describe how I scale the data down before feeding input into the network and then transform the data back to its original scale to evaluate the network's performance.

Algorithm 1: Preprocess Data

$min \leftarrow X.min$;
$max \leftarrow X.max$;
$X_{scaled} \leftarrow (X - min)/(max - min)$;
return X_{scaled};

Algorithm 2: Transform Data to Original Scale

$X_{original} \leftarrow X_{scaled} * (max - min) + min$;
return $X_{original}$;

Comparison of Methods I chose to evaluate five different regression methods and select the model that gave the lowest MSE. I aggregate data across all six detector locations into one cumulative dataset and use this dataset to create a predictor. This cumulative dataset is used to develop a predicted model and empirically study the latency of my application on a real-time cloud. I split this dataset into training and testing sets; I used 80% of the data for training and 20% of the data for testing. Once the models had been trained, I measured their performance on the unseen test data again using MSE as a metric. Table 2 presents the MSE (on the original scale) as well as the mean absolute percentage error and R^2 value for each regressor. Although all models appear to perform extremely well on the dataset, I chose the LSTM neural network for two reasons. First, it is the model that has the lowest score. Second, as I have mentioned in Section II, LSTM neural networks are the state-of-the-art prediction method for forecasting traffic flows. In order to create the most realistic workload, I should select the model that is most likely to be used in a real-world context.

Table 2: Model Scores

Model	MSE	MAPE	R^2
LSTM Neural Network	985.455275	23.091062	0.962043
Linear Regression	1013.644990	23.702992	0.960957
Random Forest	1083.919621	24.140704	0.958250
Gradient Boosting Decision Tree	1151.047555	25.586357	0.955664
Decision Tree	1988.652076	32.951715	0.923402

LSTM I have implemented the LSTM neural network in Python using TensorFlow. Existing studies, such as [9], have shown that stacked LSTM layers in a neural network can lead to higher levels of representation of time-series data, which increases the effectiveness of the model. I adopted this architectural choice when I was working on the architecture. In order to prevent overfitting, I utilize dropout– a technique that randomly drops units and their connections during training [16]. The stacked LSTM layers are then connected to two fully connected layers. Recall that I preprocess the data and scale it to a range of 0 and 1, which is why the last layer only has one unit. I use the default activation function for the stacked LSTM layers, *tanh*, but select the rectified linear unit (ReLU) function in fully connected layers. ReLU is defined as

$$ReLU(x) = max(0,x) \tag{9}$$

ReLU provides two primary benefits. First, it is very easy to compute relative to other activation functions like the sigmoid function or *tanh*, which speeds up training time. Furthermore, ReLU helps prevent the vanishing gradient problem during training. Table 3 summarizes neural network architecture.

The network receives a 12x1 vector of scaled traffic flows as input, corresponding to the previous 12 observations of traffic flows, scaled between a range of 0 and 1, at 5-minute intervals. This vector represents the past hour's worth of traffic data. The network predicts the next value of flow, corresponding to traffic flow five minutes in the future.

I can see from Table 2 that the trained LSTM neural network performs extremely well on test data.

Since the network has been trained, I have used it as a predictor in my experiments.

Table 3: LSTM Neural Network Architecture

Layer Shape	Dropout	Activation
LSTM 256	N/A	tanh
LSTM 128	0.2	tanh
Dense 64	0.4	ReLU
Dense 1	N/A	ReLU

Heuristic Recall that I use traffic prediction as a means of creating a heuristic for search algorithms. In order for the *A** search algorithm to be optimal, the choice of heuristic must be admissible and consistent.

I make use of the average speed measurement as well as the predicted flow in order to create a heuristic function. Consider the case in which I only use predicted flow in heuristic. A very low prediction for flow might indicative that I expect a lot of heavy, slow-moving traffic, in which case only a few vehicles actually cross the inductor loop. On the other hand, the low value of precited flow might indicate that it is not a busy time on the highway, such as early in the morning. Therefore, I hypothesize that the heuristic would be most informed using information about the predicted flow and average speed. To enforce admissibility, I bound heuristic so that it is no greater than the true distance. Because I have the latitude and longitude coordinates, I am able to calculate the true distance along the freeway between any pair of detectors. We, therefore, define heuristic as

$$h(n) = min(0, min(dist_n, (70 - \bar{v}) * q)), \quad (10)$$

where $dist_n$ is the true distance to node n in the graph, $\bar{v}$ is the average speed across the previous 12 observations, and q is the forecasted flow. Notice that I subtract the average speed from 70, the speed limit on the freeways. This associates a higher cost with very slow-moving traffic and a lower cost for conditions without traffic congestion. Observe that the heuristic is both permissible and consistent by construction, so the *A** search algorithm is optimal.

c) Experimental Setup

I create two VMs on a server running Xen to handle the dataflow and workload of the experiment. One VM is responsible for producing messages to a Kafka input topic and consuming messages from another Kafka output topic. The other VM is responsible for running a Flink application that will consume messages from the Kafka input topic, pass these records through the pre-trained LSTM neural network to create a prediction, run *A** search with this prediction, and then publish results to the Kafka output topic. I denote the former VM as the messaging VM, whereas the latter VM is the real-time VM. The messaging VM is responsible for measuring latency, which will be discussed shortly. Figure 3 describes the experimental setup.

Hardware and Resource Provisioning This configuration resides on a server with an 8-core Intel Xeon ES-2620 CPU and 64 GB of memory. The server is

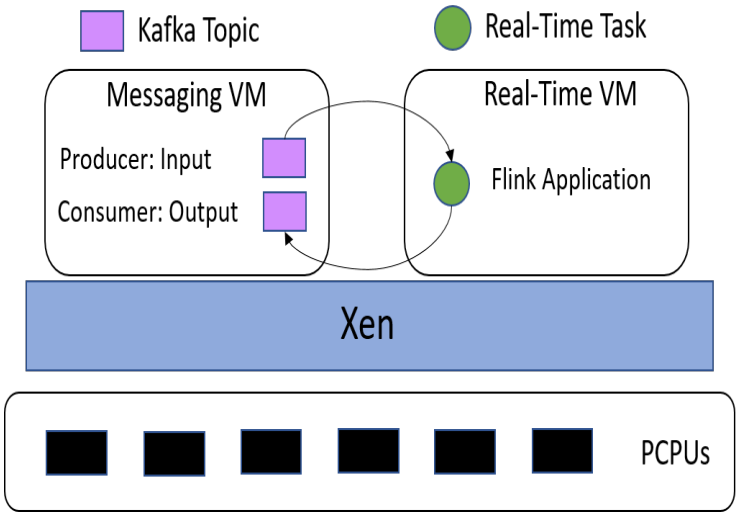


Fig. 3: Experimental Setup

configured with Xen 4.10 as the hypervisor and Ubuntu 16.04 as the *domain*0 operating system. Each of the guest domains also run Ubuntu 16.04.

Within the messaging VM, I created Kafka producers for each detector location for a total of six producers. I made one consumer for the output topic. Recall that Kafka also requires Apache Zookeeper to help coordinate services. Since I want to be able to pin each of these processes to a specific VCPU, the messaging VM requires eight cores. I allocated 16GB of memory to this machine since it will be responsible for running many services. Within the real-time VM, I will

only run the Flink application. I allocate this VM only two cores and 8GB of memory.

Flink Application The Flink application provides the workload whose latency I will empirically study. At initialization, the application loads the pre-trained LSTM neural network from memory and initializes a directed graph. The directed graph consists of nodes representing the detector locations and edges representing the freeways. As a source, the Flink application consumes from the Kafka input topic. Each record contains four fields: a detector location, average speed, traffic flow, and a timestamp. The average speed and traffic flows are both 12x1 vectors of the raw data at 5-minute intervals as captured by the detector. As soon as the application receives a new record, it parses this information and scales the measured flows into the range [0,1]. The application then feeds these scaled flows into the LSTM neural network and creates a prediction, which is immediately transformed back to its original scale. The application then uses this heuristic to run the *A** search algorithm to find the optimal path between the El Segundo and Long Beach detectors. Finally, the application creates a new record of the following information: detector location, average speed, traffic flows, timestamp, predicted flow, and path returned by *A**. As a sink, the Flink application publishes these new records to the Kafka output topic.

Latency Calculation It is well known that traditional timestamping methods, such as the C routine *dogettimeofday*(), are unreliable in virtual environments [6]. To remedy this issue, I created a custom Python module that utilizes timestampcounter scaling in order to measure time precisely. This module provides an API to read the current value of the timestamp counter into the ex: tax registers and return this value. Once I have this value, I can convert it into nanoseconds by dividing it by the clock frequency of the CPU, assuming the clock frequency is constant. To enforce a continual clock frequency, I change the power settings in the system's BIOS. Although the CPU can optimize its power consumption through different p-states (performance states) and minimize power consumption through c-states, these create variability in the clock frequency of the CPU. By disabling these features, I fix the clock frequency. In this case, I fixed the clock frequency to 2.1GHz. I implement highly precise latency calculations in the messaging VM using this method.

Each producer calls the custom module just before sending the message and appends the nanosecond timestamp to the record. When the consumer receives a record, it has access to this original timestamp. Therefore, the consumer can call the custom module and timestamp as soon as it receives a new record; the difference between these two timestamps represents the application's latency in nanoseconds.

V. Evaluation

I empirically evaluate the latency of the Flink application on each of the three schedulers within Xen. One experiment corresponds to sending 20,000 records through the Flink application and recording the latencies for a given configuration. Each of the six producers sends a message from their detector location once every 100ms. Although real-world data comes only every 5 minutes, I accelerate the rate in order to achieve a suitable workload.

a) RTDS

Recall that within the RTDS scheduler, each VM must specify a budget and a period. Given that producers are sending messages once every 100ms, I set the period of the real-time VM to 100ms. Initially, I provide the real-time VM with access to the entire PCPU- that is, I set the budget to be equal to the period of 100ms. An ECDF curve of this configuration is shown in Figure 4. I can also specify a budget less than the value of the period, effectively giving the real-time VM partial access to the CPU or a "partial CPU." The benefit of not consuming the entire period is that the system may reclaim idle clock cycles and improve overall efficiency. If I keep the period the same, then I can discover a budget that gives the same latency performance as if the real-time VM had exclusive access to the CPU. I do so by first allocating a very small budget and then incrementally increasing the budget until the ECDF curves overlap. In nearly all cases, the budget was smaller than the period, and the maximum latency of the partial-CPU experiments was greater than those of the full-CPU counterpart. Table 4 summarizes these results. When I set the budget to 777500,

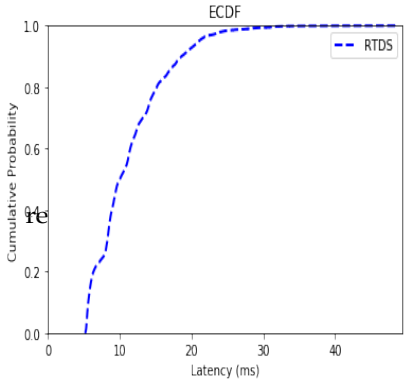


Fig. 4: ECDF of Latency Distribution RTDS Scheduler

Table 4: Maximum Latencies for RTDS Experiments Scheduler Budget (μs) Period (μs) Maximum Latency (ms)

Scheduler	Budget (μs)	Period (μs)	Maximum Latency (ms)
RTDS	100000	100000	48.52186857142857
RTDS	80000	100000	55.77778047619047
RTDS	77500	100000	38.0649180952381
RTDS	76750	100000	49.31550476190476
RTDS	76000	100000	61.50309523809524
RTDS	75000	100000	55.69025428571428

I actually observed an improvement in the maximum latency observed. On the other hand, almost all of the partial-CPU experiments yielded ECDF curves that indicated a critical majority of the latencies were smaller than those of the full-CPU counterparts. Consider Figure 5, which shows the ECDF curves of the full-CPU and budget=77500 experiments.

Not only does this experiment have a smaller maximum latency and, therefore, can provide a better service-level agreement, but the ECDF curve also lies above that of the full CPU experiment. This behavior is also exhibited in the other experiments with budgets greater than 76750. The experiment with the budget set to 76750 showed near equivalent performance both in terms of maximum latency, as seen in Table 4, but also with respect to their ECDF curves, as seen in Figure 6.

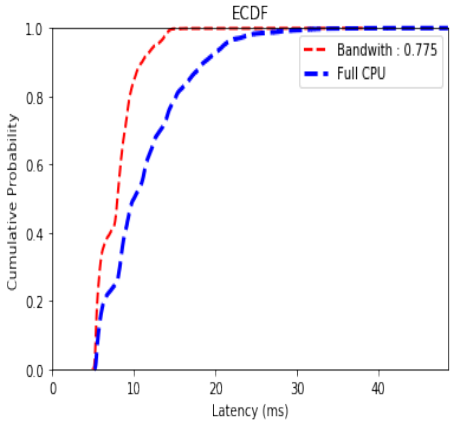


Fig. 5: ECDF Latency Distribution Partial CPU (0.775) vs. Full CPU RTDS Scheduler

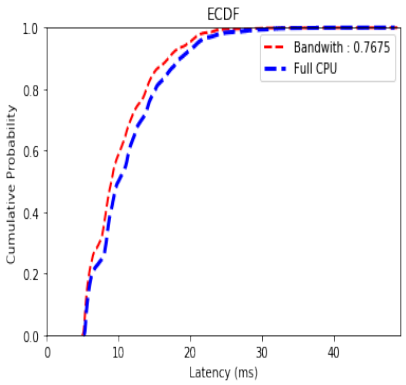


Fig. 6. ECDF Latency Distribution Partial CPU (0.7675) vs. Full CPU RTDS Scheduler

b) Credit

Under the default Credit scheduler, each VM can specify a weight and optional cap. The cap is expressed in terms of the number of VCPUs. While it is not a direct equivalence, I can vary the cap parameter for the real-time VM to achieve a similar effect as the partial CPU cases that were discussed with RTDS above. We, therefore, conduct two experiments: one without any caps and one with a cap. Recall that the partial-CPU experiment that was most similar to the full-CPU experiment using the RTDS scheduler had a budget of 76750 and a period of 100000. Therefore, since the real-time VM had two cores, it effectively made up of $\frac{76750}{100000}$ *2 = 153% of a single PCPU. Because the cap parameter in Credit iCreditessed in terms of the percentage of CPUs, I set the cap of the real-time VM to be 153 for the partial-CPU Credit experiment. Table 5 Creditizes the experimental results.

Figure 7 shows the ECDF curves for the full CPU experiments using Credit and RTDS schedulers. The full-CPU Credit scheduler distribution exhibits characteristics similar to those of the partial-CPU RTDS experiments. The majority of the Credit ECDF curve lies above that of the RTDS, and it has a higher maximum latency. Figure 8 shows the ECDF curves for the partial CPU experiments using Credit and RTDS schedulers. Observe that the green line corresponding to the Credit Partial CPU ECDF curve trails off of the plot. This is because the partial-CPU credit experiment's maximum latency was abysmally large—over a second. If the plot were to show the entire graph, the two curves would be indistinguishable, so I limit the X-axis for readability.

Table 5: Maximum Latencies for Credit Experiments

Scheduler	Cap	Maximum Latency (ms)
Credit	0 (None)	116.94941476190476
Credit	153	1040.939347142857

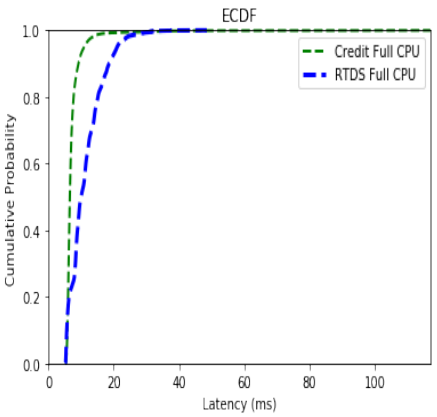


Fig. 7: ECDF Latency Distribution Full CPU Credit vs. Full CPU RTDS

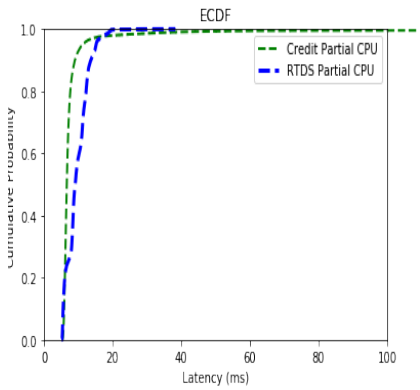


Fig. 8: ECDF Latency Distribution Partial CPU Credit vs. Partial CPU RTDS

c) Credit2

Although Credit2 is the evolution of the Credit scheduler, it does not yet support a cap feature. As a result, I cannot run experiments that limit the CPU of a VM. We, therefore, only run one experiment, which is equivalent to the full-CPU scenarios described above. Table 6 summarizes the experimental results.

Table 6: Maximum Latencies for Credi2t Experiments

Scheduler	Maximum Latency (ms)
Credit2	951.1479685714286

Credit2 suffered from the same behavior that was observed under the default credit scheduler– the maximum latency was tremendously large even though a significant portion of the records were processed faster than in RTDS. Figure 9 shows the ECDF curves for all three full-CPU experiments. Observe that I limited the X-axis of this plot for readability due to the same reasons discussed above: the large maximum latency would otherwise make the graphs indistinguishable.

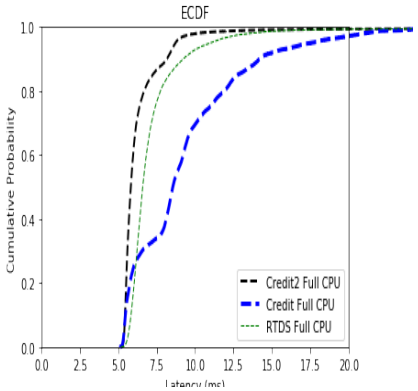


Fig. 9: ECDF Latency Distribution Full CPU Credit2 vs. Full CPU Credit vs. Full CPU RTDS

It is readily apparent that the choice of hypervisor is largely dependent on the use case. For applications that require ultra-low-latency service level agreements, the RTDS scheduler is the clear choice. For other applications that are more concerned with median performance, the Credit and Credit2 schedulers seem to provide better performance. Although I artificially accelerated the input rate of the producers to achieve a more critical workload, this workload demonstrates the performance benefits and drawbacks of each scheduler.

VI. Conclusion

I have developed a model of an ITS that provides real-time optimal routing through the use of traffic forecasting. I have used this model as a workload to empirically study the effect that the choice of scheduler has on the latency of the application. It is evident from these experiments that the choice of scheduler largely depends on the application's use case. The RTDS scheduler provides excellent latency guarantees, whereas the Credit and Credit2 schedulers are more general-purpose. It is important to note that I have sacrificed a few real-world conditions in order to create a viable workload. First, I have statically defined the start and end locations for the *A** search algorithm. In contrast, in the real world, they would certainly be more dynamic, and the network graph would be significantly larger in order to represent the roads and freeways of

the surrounding area accurately. Additionally, I have artificially increased the rate of input in order to achieve a critical workload and demonstrate the effectiveness of the three schedulers. Although most cities do not currently have real-time traffic data, the advent of self-driving cars and other IoT devices has significant implications for the amount of data being transmitted and computed. This work creates several future research opportunities in a variety of different areas. It may be useful to examine the source code to understand better why the RTDS scheduler lacks some aspects of efficiency relative to Credit and Credit2. This work may also be extended to compare the effects of different architecture choices, such as the choice of a different messaging middleware. Lastly, although this work provides a basic model of an ITS with routing capabilities, there are many possible features to integrate into this model to make it more applicable to the real world.

References Références Referencias

1. Akil, B., Zhou, Y., Röhm, U.: Technical report: On the usability of hadoop mapreduce, apache spark & apache flink for data science. CoRR abs/18 03.10836 (2018), http://arxiv.org/abs/1803.10836.
2. Barham, P., Dragovic, B., Fraser, K., Hand, S., Harris, T., Ho, A., Neugebauer, R.,
3. Pratt, I., Warfield, A.: Xen and the art of virtualization. ACM SIGOPS Operating Systems Review (2003).
4. Bengio, Y., Simard, P., Fransconi, P.: Learning long-term dependencies with gradient descent is difficult. IEEE Transactions on Neural Networks 5 (1994).
5. Chen, Y., Guizani, M., Zhang, Y., Wang, L., Crespi, N., Lee, G.M.: When traffic flow prediction meets wireless big data analytics. CoRR abs/1709.08024 (2017), http://arxiv.org/abs/1709.08024.
6. Chong-White, C., Millar, G., Johnson, F., Shaw, S.: The scats and the environment study: introduction and preliminary results (2011).
7. Corporation, I.: Timestamp-counter scaling (tsc scaling) for virtualization (2015).
8. Du, S., Li, T., Gong, X., Yu, Z., Horng, S.: A hybrid method for traffic flow forecasting using multimodal deep learning. CoRR abs/1803.02099 (2018), http:
9. //arxiv.org/abs/1803.02099.
10. Ferdowsi, A., Challita, U., Saad, W.: Deep learning for reliable mobile edge analytics in intelligent transportation systems. CoRR abs/1712.04135 (2017), http:// arxiv.org/abs/1712.04135.
11. LeCun, Y., Bengio, Y., Hinton, G.: Deep learning. Nature (2015).
12. Lv, Y., Duan, Y., Kang, W., Li, Z., Wang, F.: Traffic flow prediction with big data: A deep learning approach. IEEE Transactions on Intelligent Transportation Systems, 2015, 16(2):865-873 (2015)
13. Lv, Z., Xu, J., Zheng, K., Yin, H., Zhao, P., Zhou, X.: Lc-rnn: A deep learning model for traffic speed prediction. IJCAI (2018).
14. Maerivoet, S., Moor, B.D.: Traffic flow theory. CoRR abs/0507126 (2005).
15. Polson, N., Sokolov, V.: Bayesian particle tracking of particle flows. CoRR abs/1411.5076 (2015).
16. Polson, N., Sokolov, V.: Deep learning for short-term traffic flow prediction. CoRR abs/1604.04527 (2017).
17. Sherstinsky, A.: Fundamentals of recurrent neural network (RNN) and long shortterm memory (LSTM) network. CoRR abs/1808.03314 (2018), http://arxiv.org/abs/1808.03314.
18. Srivastava, N., Hinton, G., Krizhevsky, A., Sutskever, I., Salakhutdinov, R.: Dropout: A simple way to prevent neural networks from overfitting. Journal of Machine Learning Research 15, 1929–1958 (2014), http://jmlr.org/papers/v15/srivastava14a. html.
19. Williams, B.M., Hoel, L.A.: Modeling and forecasting vehicular traffic flow as a seasonal arima process: Theoretical basis and empirical results. Journal of Transportation Engineering (2003).
20. Xi, S., Xu, M., Lu, C., Phan, L.T., Gill, C., Sokolsky, O., Lee, I.: Real-time multi-core virtual machine scheduling in xen. ACM International Conference on Embedded Software (2014).

Global Journal of Computer Science and Technology: D
Neural & Artificial Intelligence
Volume 24 Issue 2 Version 1.0 Year 2024
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Unveiling Customer Sentiments: A Comprehensive Analysis of Product Reviews on Amazon

By Azizul Hakim Rafi

Abstract- This research delves into the multifaceted implications of customer feedback within the e-commerce landscape, focusing on product reviews on Amazon. The study meticulously examines over 1,400 unique product reviews to decipher patterns, extrapolate trends, and offer actionable recommendations for the evolving e-commerce paradigm. The dataset comprises 16 distinct features, including product ratings, textual reviews, prices, and discounts. Preliminary data exploration reveals a prevalence of high ratings, indicative of an overarching positive sentiment among Amazon's clientele. Furthermore, features related to pricing and discounts hint at the intricate interplay between economic factors and customer feedback. Through data preparation techniques, including numeric extraction and missing data handling, the research ensures the dataset's readiness for advanced statistical and machine learning analyses. Leveraging the CRISP-DM methodology, the study uncovers insights into customer satisfaction, the impact of pricing strategies, and the significance of in depth reviews.

GJCST-D Classification: *DDC Code: 658.872*

Strictly as per the compliance and regulations of:

Unveiling Customer Sentiments: A Comprehensive Analysis of Product Reviewson Amazon

Azizul Hakim Rafi

Abstract- This research delves into the multifaceted implications of customer feedback within the e-commerce landscape, focusing on product reviews on Amazon. The study meticulously examines over 1,400 unique product reviews to decipher patterns, extrapolate trends, and offer actionable recommendations for the evolv- ing e-commerce paradigm. The dataset comprises 16 distinct features, including product ratings, textual re- views, prices, and discounts. Preliminary data explo- ration reveals a prevalence of high ratings, indicative of an overarching positive sentiment among Amazon's clientele. Furthermore, features related to pricing and discounts hint at the intricate interplay between economic factors and customer feedback. Through data prepa- ration techniques, including numeric extraction and missing data handling, the research ensures the dataset's readiness for advanced statistical and machine learning analyses. Leveraging the CRISP-DM methodology, the study uncovers insights into customer satisfaction, the impact of pricing strategies, and the significance of in- depth reviews. These findings provide actionable insights for e-commerce platforms and vendors, underscoring the importance of understanding customer sentiments for informed decision-making and cultivating positive customer relationships.

I. Introduction

The digital age has ushered in an era where vast amounts of data are at the fingertips of organizations [1]. For businesses [2], especially in the financial sector, this data is a goldmine, offering insights into customer behaviors, preferences, and patterns. Among the various data types, credit card transaction data is particularly intriguing, encapsulating a user's spending habits, preferences, and financial behaviors.

Segmenting users based on this data can unveil distinct groups with unique characteristics, enabling businesses to tailor their services, offers, and mar-keting strategies accordingly [3], [4]. This research navigates this segmentation journey, harnessing the power of the KDD process and clustering techniques.

II. Data Understanding

The dataset under scrutiny encapsulates the behav- iors of 8950 active credit card users, spanning 18 behavioral variables. These variables range from basic metrics like balance and credit limit to more intricate ones like purchase frequency and cash advance trans- actions.

A cursory exploration of the dataset reveals:

- A diverse range of balances, with some users maintaining high balances and others minimal amounts.
- Various purchasing behaviors, with certain users inclined towards one-off purchases and others towards installment-based ones.
- Discrepancies in credit limits, indicating differing creditworthiness among users.
- Missing data points in certain columns necessi- tating preprocessing steps before deeper analysis.

III. Data Preparation

A rigorous data preparation phase was undertaken to ensure the dataset's suitability for clustering. This phase is pivotal in the KDD process [5], [6] as it sets the stage for effective data mining. Key steps included:

- *Missing Value Imputation:* Credit card data often contains missing values, either due to errors or omissions. The CREDIT LIMIT and MINI- MUM PAYMENTS columns, which had missing values, were addressed by imputing the mean of the respective columns. This strategy ensured that the overall distribution of these columns remained unaffected while providing a reasonable estimate for the missing values.
- *Standardization:* Given the varying scales and units of the dataset's features, a standardization step was crucial. This ensured that each feature contributed equally to the clustering process, pre- venting any single feature from dominating the clustering due to its scale.
- *Dimensionality Reduction:* With a multitude of features, reducing dimensionality can sim- plify the clustering process and make visual- izations feasible. Employing Principal Compo- nent Analysis (PCA), the dataset's dimension- ality was reduced, making it more manageable and visualization-friendly. The first two principal components, which captured a significant portion of the dataset's variance, were retained for sub- sequent steps.

Author: e-mail: azizulhakimrafi4@gmail.com

IV. Modeling

The modeling phase is a pivotal step within the Knowledge Discovery in Databases (KDD) process. It entails applying data mining algorithms to extract patterns or knowledge from the prepared dataset[7]. The overarching goal of this phase was to segment credit card users based on their behavioral patterns.

a) Optimal Cluster Determination

Before proceeding with clustering, it's imperative to determine the optimal number of clusters. This ensures that the granularity of segmentation is neither too broad nor too specific.

For this purpose, the elbow method was employed, a technique that identifies the number of clusters at which the reduction in within-cluster variance starts to show diminishing returns.

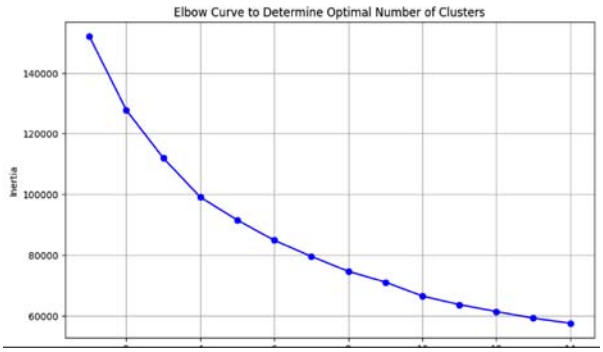


Fig. 1: Elbow Plot for Determining Optimal Number of Clusters

From the elbow plot, the inflection point around four clusters suggested that segmenting users into four distinct groups would be the most effective.

b) Clustering with K-Means

K-means was the algorithm of choice for clustering due to its effectiveness in partitioning datasets into non-overlapping subgroups. The algorithm works by:

1. Initializing k centroids randomly.
2. Assigning each data point to the nearest centroid.
3. Recomputing the centroid of each cluster based on its constituent data points.
4. Repeating the assignment and recomputation steps until cluster assignments no longer change or a set number of iterations is reached.

Upon application to the standardized dataset, users were segmented into the previously identified four clusters. Each of these clusters represents a distinct group of users, differentiated by their credit card usage behaviors.

V. Evaluation

The evaluation phase provides a critical assessment of the clusters formed, ensuring they are interpretable, actionable, and aligned with the initial objectives of the research.

- *Cluster Characteristics:* Each cluster was examined to understand the dominant behaviors of its members. For instance, one cluster might consist predominantly of users with high one-off purchase values, suggesting a pattern of infrequent, high-value shopping behaviors. Another cluster might be characterized by frequent cash advances, indicating users who might be facing financial challenges or have immediate liquidity needs.
- *Cluster Visualization:* Visualizing the clusters, especially in reduced-dimensional space (e.g., using the first two principal components), provides an intuitive grasp of how distinct the clusters are and how they relate to each other in the feature space.
- *Inter-cluster Analysis:* By examining the centroids of the clusters, one can derive insights into the "average" behavior of each segment. This is crucial for businesses aiming to tailor marketing strategies for each segment.
- *Intra-cluster Analysis:* Within each cluster, the variance or spread of data points was analyzed. A tighter cluster indicates members with very similar behaviors, while a more dispersed cluster suggests a broader range of behaviors within that segment.

Through this comprehensive evaluation, it was evident that the clusters formed are distinct and insightful. Each cluster offers a unique lens into a segment of credit card users, providing businesses with granular insights into user behaviors and preferences.

VI. Conclusion

The application of the KDD process in segmenting credit card users has demonstrated the profound potential of data mining in unveiling hidden patterns within datasets. By methodically progressing

through data understanding, preparation, modeling, and evaluation, this research has segmented credit card users into discernible clusters, each echoing unique behavioral patterns.

Such segmentation provides businesses with a deeper understanding of their customer base, enabling them to devise personalized marketing strategies, offers, and services. In an era where enterprises strive for personalization and meaningful customer engagement, the insights derived from this study are of paramount importance.

Furthermore, this research underscores the signifi- cance of a structured approach to data analysis, empha-sizing the importance of each phase in the KDD pro- cess. As the field of data mining continues to evolve, methodologies like KDD will remain instrumental in transforming raw data into actionable knowledge.

References Références Referencias

1. T. C. Redman, *Data driven: profiting from your most important business asset*. Harvard Business Press, 2008.
2. H. Chen, R. H. Chiang, and V. C. Storey, "Business intelligence and analytics: From big data to big impact," *MIS quarterly*, pp. 1165–1188, 2012.
3. F. Provost and T. Fawcett, *Data Science for Business: What you need to know about data mining and data-analytic thinking*. " O'Reilly Media, Inc.", 2013.
4. R. W. Hoerl and R. D. Snee, *Statistical thinking: Improving business performance*. John Wiley & Sons, 2020.
5. V. Plotnikova, M. Dumas, and F. Milani, "Adaptations of data mining methodologies: A systematic literature review," *PeerJ Computer Science*, vol. 6, p. e267, 2020.
6. A. Shehadeh, H. ALTaweel, and A. Qusef, "Analysis of data mining techniques on kdd-cup'99, nsl-kdd and unsw-nb15 datasets for intrusion detection," in *2023 24th International Arab Conference on Information Technology (ACIT)*. IEEE, 2023, pp. 1–6.
7. M. Almseidin, "Fuzzy automaton-based early detection model," Ph.D. dissertation, University of Miskolc, Hungary, 2020.
8. J. Li, H. Izakian, W. Pedrycz, and I. Jamal, "Clustering-based anomaly detection in multivariate time series data," *Applied Soft Computing*, vol. 100, p. 106919, 2021.

This page is intentionally left blank

Global Journal of Computer Science and Technology: D
Neural & Artificial Intelligence
Volume 24 Issue 2 Version 1.0 Year 2024
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Optimization of Frequency Reconfigurable Antenna Parameters Design using Genetic and PSO Algorithms based on Neural Networks

By Rajaa Amellal & Mr. Habibi Mohamed

Ibn Tofail University

Abstract- In this paper, we propose a novel mixed-integer optimization formulation for the optimal design of a reconfigurable antenna inspired by methodology to design frequency reconfigurable patch antennas using multi-objective genetic algorithms (MOGA) genetic algorithm trained by recurrent neural networks and nondominated sorting genetic algorithm II (NGSA-II) improve global optimization capability by diversity detection operation to surrogate a model optimized. Experimental validation of Pareto-optimal set miniaturized multiband antenna designs is also provided, demonstrating a new optimization technique. The oriented design here is practiced for improving reflection coefficient S11, and gain specifications at the frequency band that is achieved by sizing the design parameters using our proposed method in the author's way the performance parameters were predicted by an iterative process of particle swarm optimization based on feed-forward neural networks (FFNN).

GJCST-D Classification: *DDC Code: 621.382*

Strictly as per the compliance and regulations of:

Optimization of Frequency Reconfigurable Antenna Parameters Design using Genetic and PSO Algorithms based on Neural Networks

Rajaa Amellal [α] & Mr. Habibi Mohamed [σ]

Abstract- In this paper, we propose a novel mixed-integer optimization formulation for the optimal design of a reconfigurable antenna inspired by methodology to design frequency reconfigurable patch antennas using multi-objective genetic algorithms (MOGA) genetic algorithm trained by recurrent neural networks and nondominated sorting genetic algorithm II (NGSA-II) improve global optimization capability by diversity detection operation to surrogate a model optimized. Experimental validation of Pareto-optimal set miniaturized multiband antenna designs is also provided, demonstrating a new optimization technique. The oriented design here is practiced for improving reflection coefficient S11, and gain specifications at the frequency band that is achieved by sizing the design parameters using our proposed method in the author's way the performance parameters were predicted by an iterative process of particle swarm optimization based on feed-forward neural networks (FFNN). The proposed optimization technique is successfully attracted as a problem solver for designers to tackle the subject of antenna design. which works in the frequency range from 200 MHz to 224.25MHz (50% impedance bandwidth at operated frequency 200 MHz) sequentially is obtained.

I. Introduction

With the increasing demand for smarter antenna design in advanced technology applications, Several antenna structures are suitable for the implementation of reconfigurable antennas, among patch antennas are beautiful structures for various types of reconfigurations.

There are two main domains to be researched for reconfigurable antennas; one is to reconfigure the radiation patterns at fixed operating frequencies, and the other is to reconfigure the operating frequencies with uniform radiation patterns [1]. However, the core of the desired characteristics of a modern reconfigurable antenna is that the design of the antenna has a high real-time requirement for the optimization algorithm to reconfigure the radiation patterns [2] and reduce the interferences over an extensive band. There is a large gap between the present research and the ultimate objective. Our method is illustrated using a miniaturized multiband antenna design example [2,3]. Miniaturized multiband antennas and accelerated automated design optimization of antenna structures using variable-resolution computational models are highly desirable in modern wireless communications.

Integrating the GA-RNN surrogate model with multi-objective genetic algorithms (MOGA) establishes a fast multi-objective inversed optimization framework for multi-parameter antenna structures based on NSGA. NSGA is a dominance-based multi-objective optimization algorithm developed on genetic algorithms, where NSGA-II overcomes some of NSGA's shortcomings [8].

And has excellent performance in 2–3 objective optimization. Finally, a Pareto-optimal set miniaturized reflection coefficient and Gain corresponding to optimized antenna design are presented, demonstrating that the proposed model provides better prediction performance and considerable computational savings [3].

It includes evolutionary algorithms such as the Genetic Algorithm (GA), and Particle Swarm Algorithm (PSO). The signal transmission and reception systems of reconfigurable antennae that increase various diversity methods to improve the quality of the signal and lessen interference in terms of time and frequency [5], further their remarkable advantages such as cost-effective, consolidated effortless fabrication process, conformable, satisfactory bandwidth (BW)[7-6].

The optimization parametric space corresponds to design configuration, and thus, only discrete optimization algorithms can be used and trained by artificial neural networks [4]. These methods have a slower convergence rate than local methods because they can't take advantage of the solution space regularity. Second, the newly added sample operators are well-fitted regarding the optimization objectives to speed up convergence [7].

This paper aims to briefly describe the algorithms and present their application to antenna design problems.

The rest of the paper is organized as follows. Section 2 formulates the data antenna concerning the space design problem. Section 3 presents the performance of the antenna parameters predicted by the model based on the PSO-FNN. Section 4 achieves

Author α: Physic Department, Laboratory Electronic Systems, Information Processing, Mechanic and Energetic, Ibn Tofail University, Kenitra, Morocco. email: amellalrajae@gmail.com
Author σ: Universite Ibn Tofail Laboratoire De Systeiemes Electroniques Traitement De L'information Mecanique Et Energetique Kenitra, Gharb-Chrarda-Beni Hssen, Morocco

the output and inputs for the GA-RNN model to estimate the desirable values of S11 and Gain accurately establishes the fast inversed multi-objective antenna optimization framework by combining the result of data antenna offering by HFSS and GA-RNN for the multi-objective optimization improved with NSGA2. Section 5, offers the result of the parameters surrogate the simple model of the patch antenna and gives the result of Pareto optimal design, secondly demonstrates the performance by simulating the fitness and accuracy of neural networks.

II. Methodology and Problem Description

In the first step of the GA process, the initial population is created and the fitness value of each individual in the population is calculated. Then, individuals selected from the population according to the fitness value are crossed and the two parents create a new individual from the individual's genetic codes [3-5]. The search space is expanded by making random changes in the individual's genes with the mutation in the next step.

The next step of Data generation. After confirming the initial antenna shape of the patch antenna, optimal design parameters must be determined. All the optimization processes are performed automatically [10]. For accurately modeling the antenna, a suitable amount of data set includes training, validation, and test data (XTrain, XVal, and XTest) [5], and corresponding desired outputs (YTrain, YVal, and YTest) of recurrent neural networks based on model sequential of Keras and weighting by genetic algorithm process.

MOGA optimization is used in the field of surrogate models mainly to design the characteristics of the patch-feed [5], width, and length with the objective of performance enhancement.

There are two objectives to be satisfied. The first is that the antenna should be impedance-matched over a frequency range [3], The second objective is acceptable to gain performance over the same, with the corresponding cost function as in Equation (1). The overall fitness function is given by Equation:

$$Ft1 = \frac{1}{N}\sum_{f2}^{f1} Ob1(f) \tag{1}$$

N is the total number of sampling frequencies

$$Ob1(f) = \begin{Bmatrix} -S11\ for\ S11 \geq -10db \\ 0\ for\ \ S11 < -10db \end{Bmatrix} \tag{2}$$

The second objective and fitness function given by

$$Ft2 = \frac{1}{N}\sum_{f1}^{f2} Ob2 \tag{3}$$

$$Ob2(f) = \begin{Bmatrix} 0\ for\ 0.5 \leq Gain(dB) \leq 5 \\ norm(Gain(dB)\ elsewere \end{Bmatrix} \tag{4}$$

the input reflection coefficient in dB, f1, and f2 are frequencies included in the range of BW, defining the operating band. N is the number of frequency samples taken between f1 and f2.

MOGA consists of n-size parameters in the antenna to be optimized; that is, each chromosome consists of n-size parameters in the antenna to be optimized; for each individual in the new generation represents a space of design parameters.

After determining the suitable antenna configuration, it is time to obtain the optimized design parameters as length (L) and width (W) ground (G). This part aims to enhance the fitness of reflection coefficient S11 within the BW [10]. Hence, advanced multi-objective optimization methods such as NSGA2 are required for multi-objective specifications and the diversity of solutions. When MOGA reaches the set number of iterations, the procedure ends, and the obtained Pareto Front is shown [5-4].

The theoretical values of W and L are given by:

$$W = \frac{c}{2f_r}\sqrt{\frac{2}{\epsilon_r + 1}}$$

$$L = \frac{c}{f_r\ \sqrt{\epsilon_{r,eff}}} - 2\Delta L$$

When f_r notes operating frequency and ϵ_r represented the dielectric constant, The efficient patch length is different and its length is increased through ΔL. In general, the multi-objective and multi-parameter antenna designs can be mathematically described as:

min $F(x)=[f1(x), f2(x)\ldots, fn(x)]$ Ts.t. $x\in X \quad X\subseteq Rm$

When

$fj(x)$, $(j=1, 2,\ldots., n)$ $fj(x)$,$(j=1,2,\ldots,n)$ are *n* objective functions to be optimized x present the parameters design x= {(W_s,L_s,W_p,L_p,W_k,,L_k,W_e,L_e)}

and F(x) is a vector of m objective functions ($g_i(x)$)

min y = f(x) s . t. g(x) = (g1 (x), g2 (x), …, gm(x)) ≤ 0 where x = (x1, x2, …, xn) ∈ x ,

x = {x| l ≤ x ≤ u} l = (l1, l2,…, ln), u = (u1, u2, …, un) (1)

U(x) = G(x) = 1

$$U(x) = \frac{1}{F}\int_{f1}^{f2} G(x,f)df \tag{5}$$

and U stands for the scalar merit function that quantifies the designer's view concerning the design quality Constraint:

$$|S11(x, f)| \leq -10 \text{ dB for f} \in F$$

$$UP(x) = U(x) + \beta 1 c1(x)^2 \tag{6}$$

were

$$c1(x) = \frac{\max(S11(x)+10}{10}$$

The functions c1(x) measure constraint violations, whereas β1 is the proportionality factor.

where x is the decision vector, l and u are the lower and upper bounds of x, f(x) is the objective function [7], and g(x) are constraints. A solution x is feasible if it satisfies all constraints g(x) ≤ 0, otherwise, it is infeasible, and y is the predicted value using the algorithm MOGA [5].

After constructing the initial configuration of the patch antenna, the optimized values for design parameters must be achieved. The brief definitions for this algorithm are as follows the steps:

1. Predefine the design space;
2. Determine the number of neurons in each layer of RNN and the antenna geometry vector *x*;
3. Sample design space using HFSS and acquire the response set y *construct the targets;*
4. Adjust the RNN_genetic algorithm mapping S11 and Gain by *the first iteration I1* of optimization;
5. Construct an I_1-MOGA surrogate model $R_s(x)$;
6. Optimize the population by MOGA with an *NSGA2* surrogate model;

The relative error is defined as ||R(x)-Rs(x)||/||R(x)||, where Rs stands for the surrogate.

The computational model R is simulated in HFSS and corresponds to the experiment parameters design of the patch antenna [8].

Enhanced genetic algorithm (RNN-GA), this redundant information is fed back into the GA's objective function via the recurrent neural network. The neural network learns the optimal weights of the objective function by identifying trends and optimizing weights.

The fitness value of each chromosome represents the accuracy of the network. to evaluate the antenna performance. After confirming the initial antenna shape, optimal design parameters must be determined. All the optimization process is performed automatically in the created platform constructed antenna surrogate model, which is a black box for mapping the relationship between the antenna structure parameters and performance indexes (reflection coefficient S11, gain resonant frequency) [5-8].

In another way, the PSO technique was applied to this problem due to its robust convergence for optimizing the weights [4]. It enhanced the model PSO-FNN for predicting the desirable reflection coefficient S11 in BW concerning the range frequency.

Problems that are multimodal, non-differentiable, and discontinuous. HFSS in conjunction with PSO-FNN is used to find the optimal values and targets for all the parameters specified.

a) Recurrent Neural Networks

Recurrent Neural Network (RNN) is a type of neural network where the output from the previous step is fed as input to the current step. In traditional neural networks, all the inputs and outputs are independent of each other, when it is required to predict the next word of a sentence, the previous words are required and hence there is a need to remember the words. Thus, RNN came into existence, solving this issue with the help of a hidden layer. Recurrent Neural Networks (RNNs) have become a popular technique for language modelling tasks such as speech recognition, machine translation, and text generation [11].

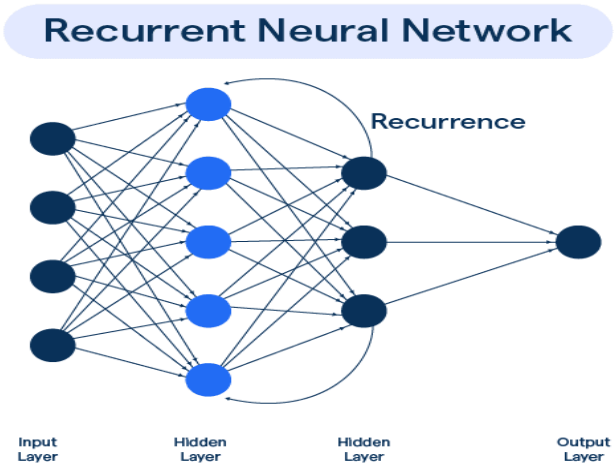


Figure 1: General View of the Architecture of RNN

b) *Artificial Neural Network based on PSO And Genetic Algorithm Used In Optimization Performance And Design Parameters Of Patch Antenna:*

The MOGA-HFSS process of the objective function converge results showed that the average fitness approaches the global best value, which is typically a good indication that the optimization run has converged, and no significant improvements are to be expected [6]. This can also indicate that the design tolerates our main objective, which is to obtain good impedance-matching _10dB over two specified frequency bands. the fitness of the design parameter set does not satisfy the constraint equations.

The boundaries and the constraints define the solution space and feasible space and thus account for all the geometrical aspects of the optimization. The aim is to find the optimal solution vector for decision variables. This solution vector must satisfy specific constraints. and non-dominated sorting genetic algorithm II (NGSA-II) to show the effectiveness of our improved MOGA [9].

The space of variables x is the randomly generated population. The population is mutated and crossover to get a new population in the MOGA algorithm. The best fitness value is compared with the desired value and the antenna parameter is updated for the next generation population.

The algorithm is initialized by creating a population of N random neural networks. the fitness functions that force to have a reflection coefficient less than -10 dB give a better bandwidth than those considered the reflection coefficient at the expected resonant frequency or over a frequency band. When multiple objectives in addition to the broadband performance are considered, the cost function needs to be modified by considering all the objectives [6-8]. Optimal design parameters must be determined after configuring the initial configuration of the antenna using HFSS. All the optimization processes are performed automatically in the inputs created concerning the gain and reflection coefficient for the RNN-genetic model.

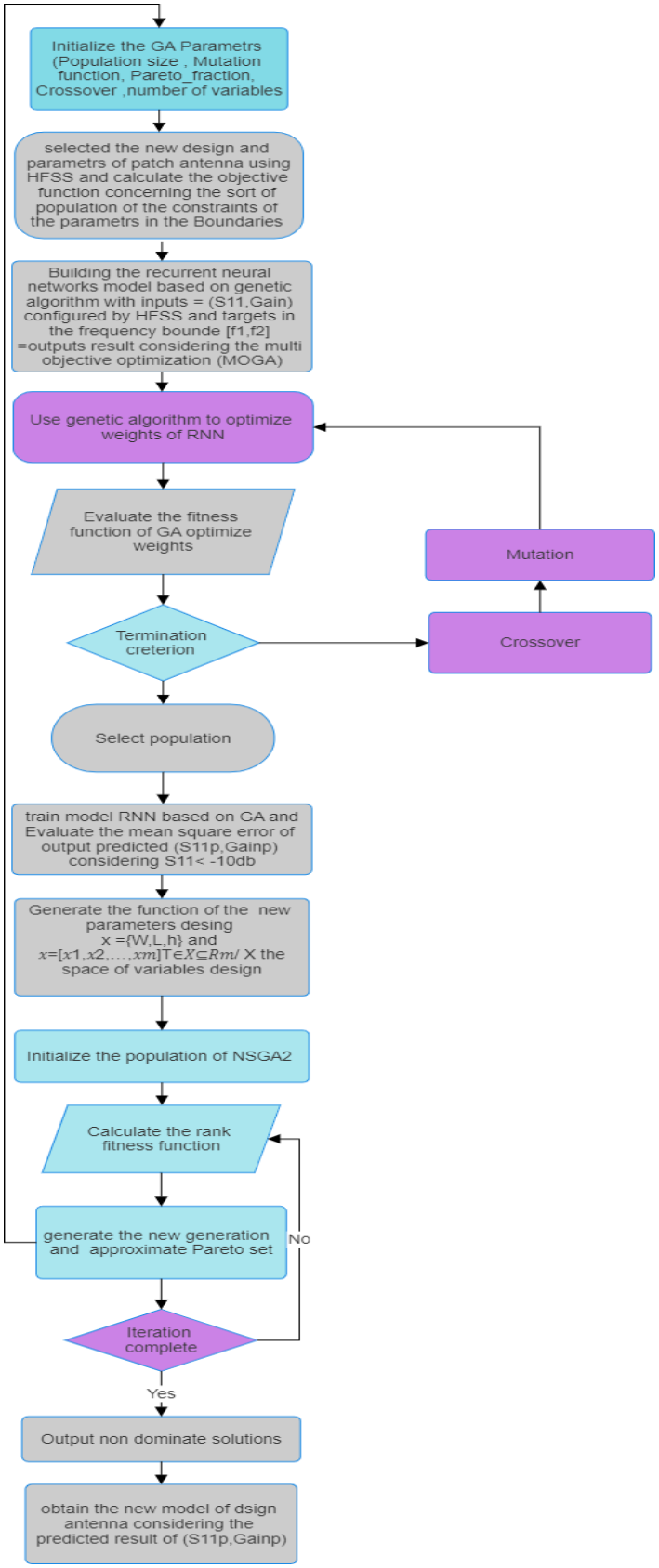


Figure 2: Flowchart of the Improved MOGA/NSGA2 with A Dynamically Updatable using GA_RNN Surrogate-Optimized Model

c) *Optimization Performance Parameters Antenna Using Feed-Forward Neural Networks Based on PSO Algorithm*

Maintain the Patch reconfigurable antenna. The boundaries and the constraints define the solution space and feasible space and thus account for all the performance parameters of the optimization [8].acquiring high directivity to obtain the optimal solution established on the action of the swarm that adopts the fitness function.

We have used double PSO optimization. the first time is for creating the NN model with the least error and the second time, while optimizing the NN_model to get the best output parameters [10]. The FFNN-PSO model behaves as The S11 and Gain operated by HFSS. Since the antenna had to be optimized, we have taken this NN model and optimized parameters by feeding different objectives and targets.

Algorithm1 PSO_FFNN:

Input: Input The parameters of the Result patch antenna (S11, Gain, frequency):
Outputs: Optimized value of (S11, Gain)
maximum iterations: Max, size of
swarm: begin and end, inertia weights: ωbegin and ωend,
acceleration constants: c1, c2 , maximum of velocity:
vmax
frequency variable f ('2.4,2.8') for each optimization set
Initialization of PSO algorithm:
Social and cognitive coefficients C1, C2;
Inertial weights W(i);
Update Velocity V(i);
Populations, Iterations;
1: Set iteration index k = 0. Initialize the velocities
and positions of n particles, ω ← ωbegin − k/Max ∗
(ωbegin − ωend).
2: For every particle in the swarm evaluate the fitness function
3: Obtain corresponding expectations of the parameter's performance of
the patch antenna.
4: Update the personal best position of each particle, the global best
position of the swarm Gbest(i), the local best position, and corresponding values. and best fitness
5: while k < Max do
6: For every Iteration do:
7: Obtain corresponding constraints of antenna parameters and update the objective function based on the result obtained using HFSS (S11, Gain).
8: if the Current position is the personal best position for this
particle then
9: Update its personal best position
10: Request result from HFSS (S11, Gain)

11: evaluate the objective function:

Fit = −FG − min (FG − 20, Gmin) + max (|S11|, 10dB)

Improve in-band matching within the

frequency range F

Ensure that in-band matching does not

exceed −10 dB in F

|S11(x, f) |≤ −10 dB for f ∈ F;

12: Evaluate targets for neural networks, Fit = Targets;

Inputs = {S11, Gmin, F}, net = outputs;

PSOFFNN_run_model (net, inputs);

ALGORITHM2 GA_RNN/MOGA_NSGA2 :

X: {XTRAIN, YTRAIN,}

1. GENERATE INPUTS AND OUTPUTS OF RNN

INPUTS = SIZE {S11, GAIN)

OUTPUTS = SIZE {TARGET (1)}

TARGETS = {$S11_{S,}$ $GAIN_S$};

NET= RNNETWORKS (NET, INPUTS, TARGETS);

2. INITIALIZATION OF GA ALGORITHM PARAMETERS

POPULATION SIZE;

MUTATION RATE, CROSSOVER

GENERATION

NUMBER OF VARIABLES

3. INITIALIZE LEARNING PARAMETERS

MUTATION POWER, POPULATION SIZE, TRUNCATION SIZE;

4. EVALUATE POLICYINITFNCTION

5. TRAIN NETWORK FOR THE PARAMETERS (M, POP, TS, I, O, TARGETS)

EVALOPTI = GA_RNNMODEL (NET, O)

COMPARE OBJECTIVE FUNCTION (|S11(X, F) |≤ −10 DB, FOR F ∈ F) OF EVALOPTI

6. EVALUATE THE NEW DESIGN OF THE PATCH ANTENNA USING AN INVERSE PROCESS OF MULTIOBJECTIVE GENETIC ALGORITHM (NSGA2) BASED ON THE RESULT OBTAINED USING THE RNN-GENETIC MODEL (S11, GMIN)

7. REQUEST THE RESULTS OF ANSYS HFSS

8. EVALUATE THE DECISION VARIABLES OF PARAMETERS BASED ON THE SPACE OF SOLUTIONS DESIGN PARAMETERS ∈∈∈ ⍰ ⊆⊆⊆.....

III. Simulation and Results

This section of the paper illustrates that 0.01 GHz increased the frequency of the optimized parameters design and simulation results.

All other values were kept to their default value during the simulation. The figure.1 shows the general structure of the microstrip patch antenna. The proposed antenna is simulated using HFSS Ansys simulation software.

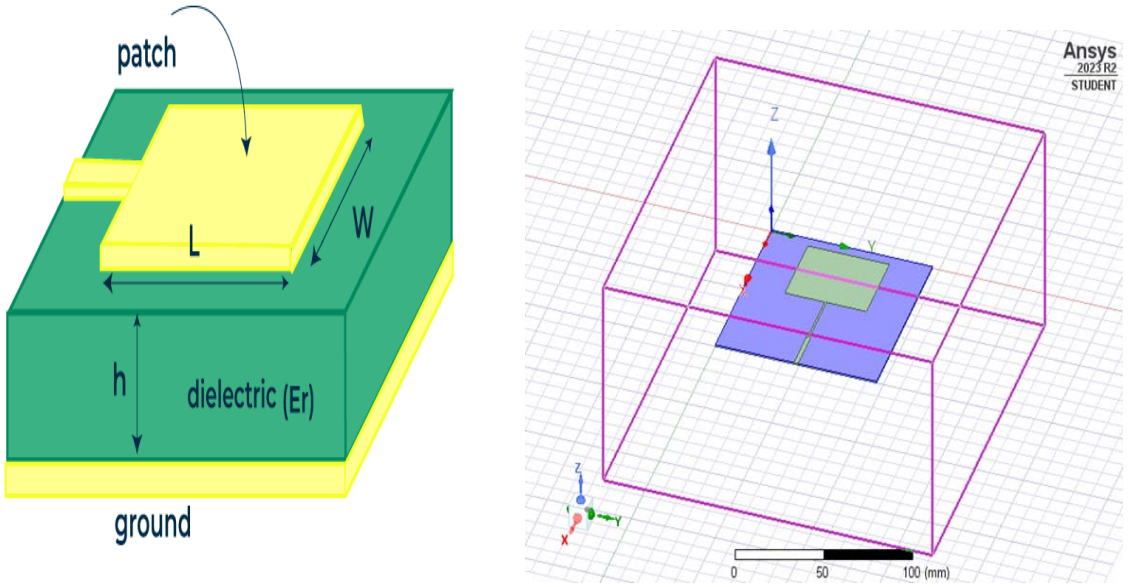
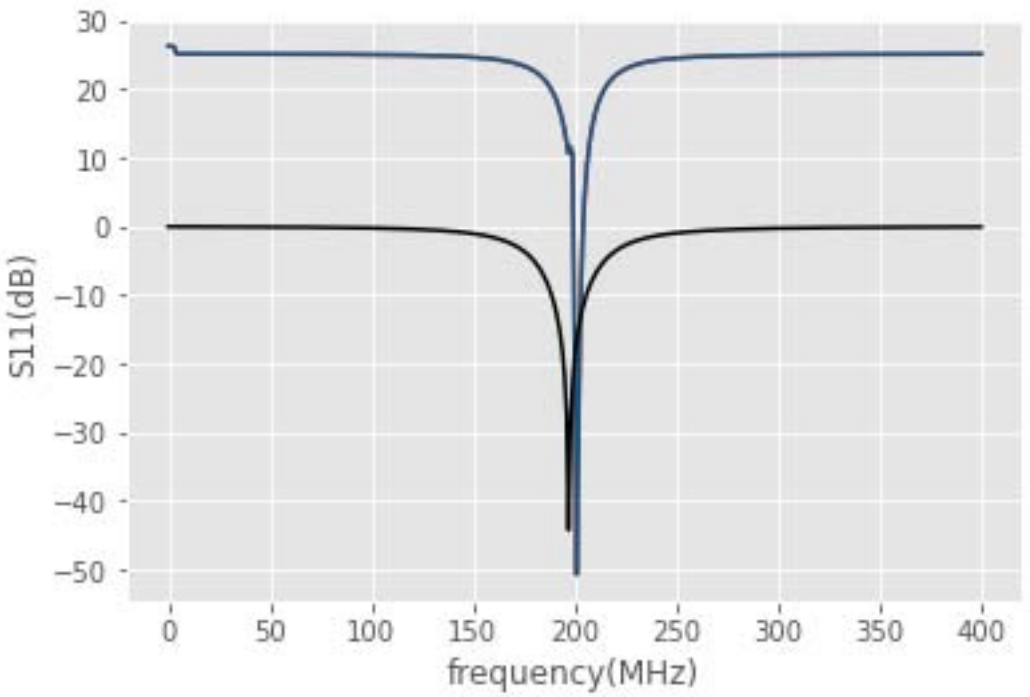


Figure 3: The General Structure of the Microstrip Patch Antenna and Simulated Model using HFSS Software

Consider the antenna structures paired in Fig. 1 along with their refection responses |S11|, obtained for different optimized parameter values.

Figure 2 shows the predicted S11 by optimization. The predicted S11 well matches the simulated S11 in the results optimized through FFNN based on the PSO algorithm.



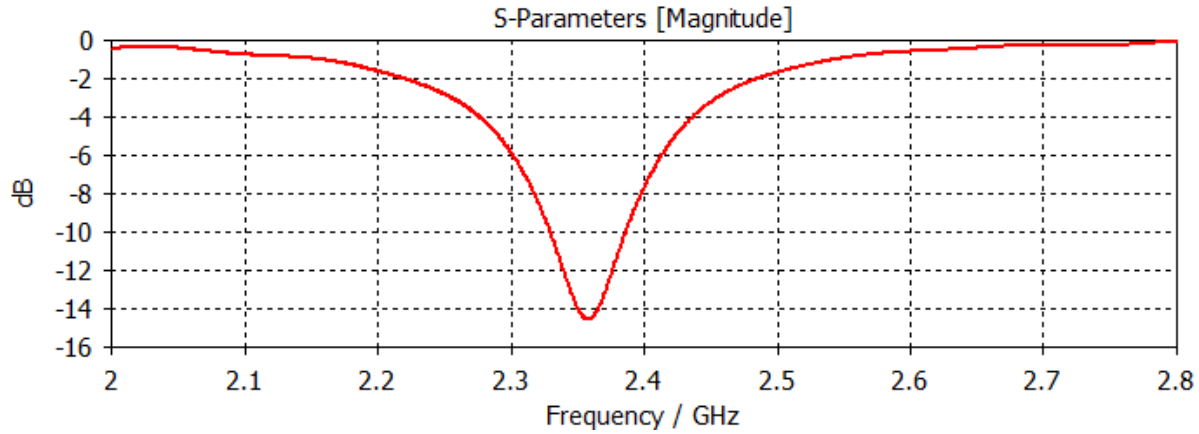


Figure 4: Reflection Responses of Predicted S11 Using PSO_FFNN and Simulated Results in the Dual-Band

Table 1 shows the detailed sizes of the patch antennas. within the range specified of frequency demonstrate the optimized parameters design, indicating that compared to predictive results of s11 and Gain.

Parameters Design(mm)	Boundaries	Optimized Parameters	Max |S11|(dB)	Gain (dB)	Frequency Range (MHz)
"Substrate dimension" W_s: 80	[45, 89]	87	-28.1798	9.10295	[196.87, 197]
"Substrate dimension L_s": 80	[45, 89]	87	-27.9522	9.09736	[197.75,197.12]
"Dielectric Height" h: 1.6	[1, 5.4]	1.3	-26.1151	8.96144	[198.12,197.87]
"Antenna patch dimension" W_p: 35	[19, 63]	38	-22.9891	8.83201	[198.5,200]
" Antenna patch dimension ": L_P:29	[16, 30]	29.4	-12.6065	8.82812	[201.5,210.33]
"Transmission line x" W_e: 2.98	[1.6, 5.3]	3.8	-9.25723	8.9755	[223.5,223.62]
"Inset dimension x": $W_{k:}$ 1.4	[1, 6.45]	1.52	-6.7947	7.90189	[223.87,224]
" Inset dimension y" L_k:7.16	[7,7.18]	6.7	-0.111962	6.76174	[224.12,224.25]

Changes in the location of the finder solution for particle swarm performance in the later stage of evolution, such as concurrent accuracy for two variables S11 and Gain examine probability for 4 generations.

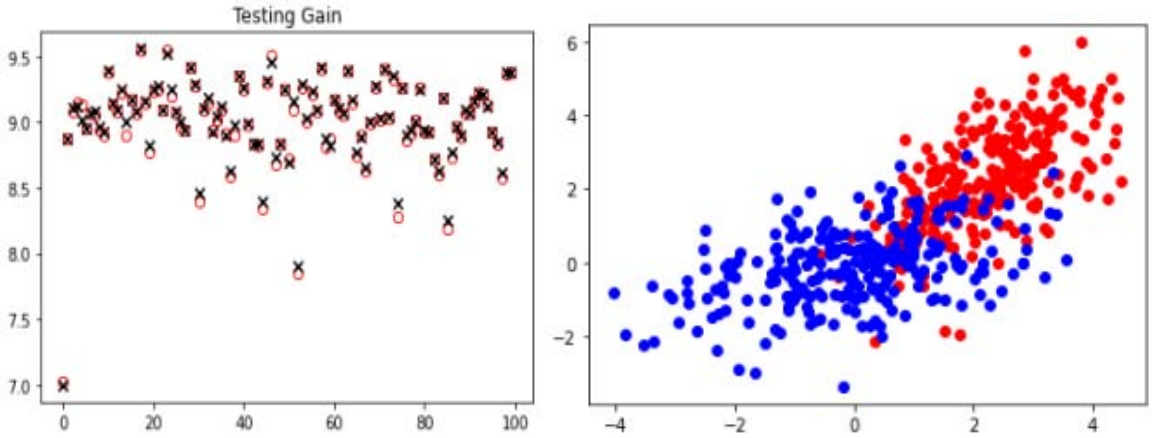


Figure 5: The Finder Solution for Particle Swarm Performance and Location in the Later Stage of Evolution, for two Variables S11 and Gain

Consider the antenna structures appaired in Fig. 3 along with their refection responses S11, obtained for different values of parameter optimized and experimented.

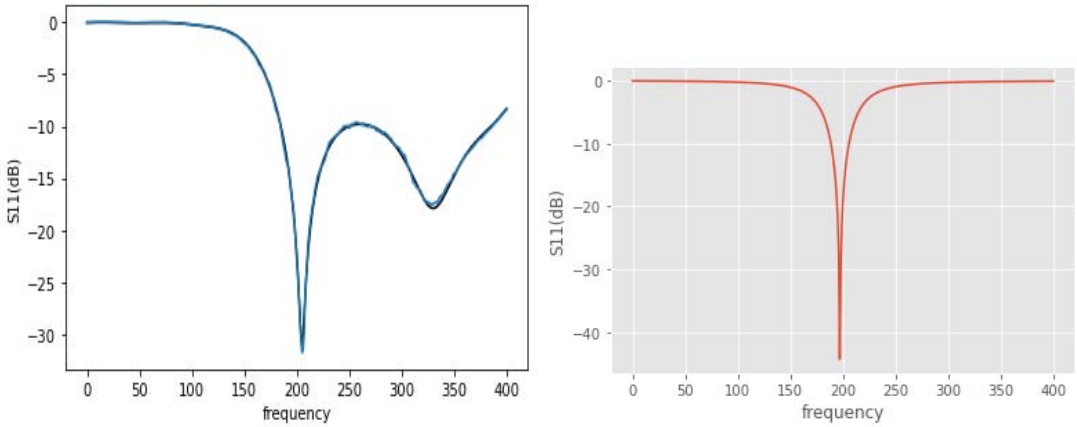


Figure 6: Reflection Responses of Optimized and Experimental Parameters in the Dual-Band Arranged the BW

Multi_objective genetic algorithm optimization is used in conjunction with the surrogate model and prediction of performance parameters of the antenna (S11, Gain, BW). The RA is capable of simultaneously steering its beam in different directions.

The radiation pattern for both parameters simulated and optimized for the patch antenna at two different frequencies has been achieved accordingly.

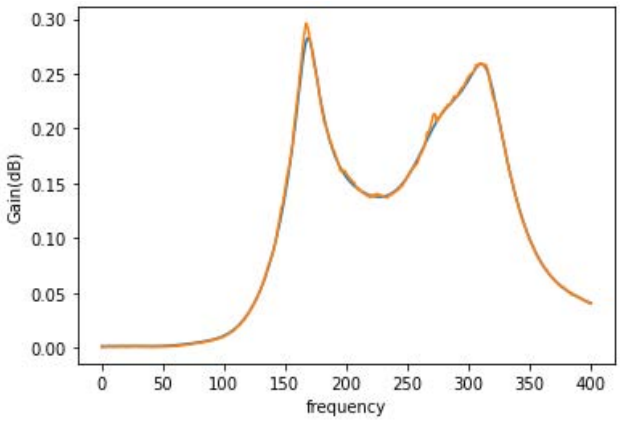


Figure 7: The Radiation Pattern for both Simulated and Optimized Parameters Designed for the Patch Antenna

The optimization process is stopped meaning that the desired antenna goals are obtained. At this time, the non-dominated solution set appeared. All solutions in the non-dominated solution set constitute the Pareto front (PF).

Initial Pareto set identified using MOGA executed NSGA2; evaluated the reflection coefficient S11 and Gain from the initial Pareto set, in next step obtained Pareto front in two-objective optimization using high-fidelity-based optimization, shown in Figure 9.

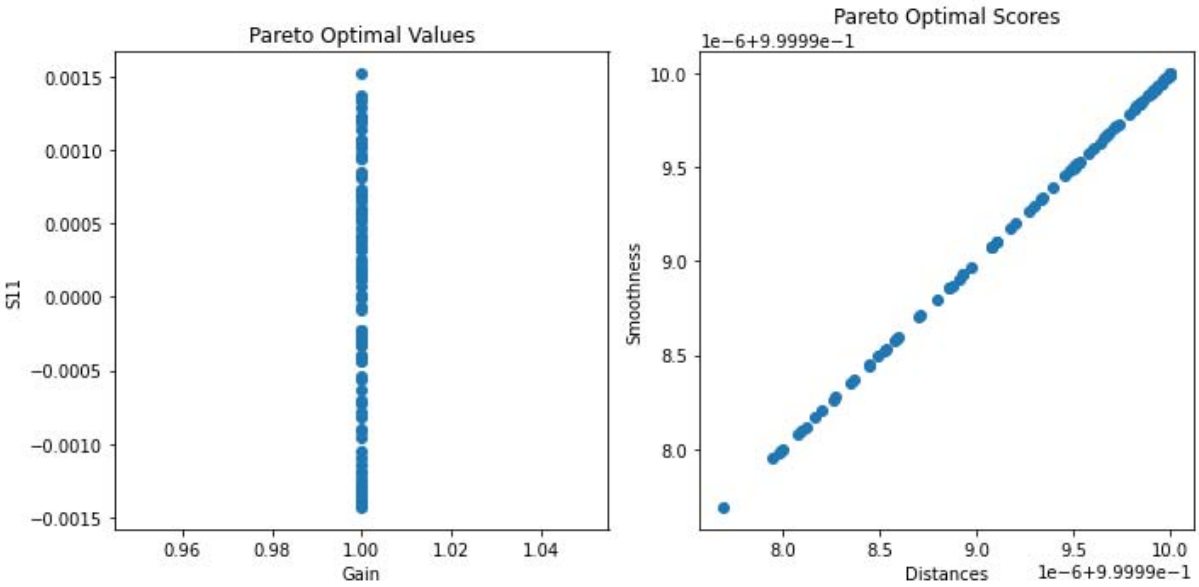


Figure 8: The Selected Pareto Optimal Designs' Reflection Coefficient and Realized Gain Characteristics

Initial Pareto set identified using MOGA executed with NSGA2 for 2 objective functions concerning the performance parameters on the space of design optimized

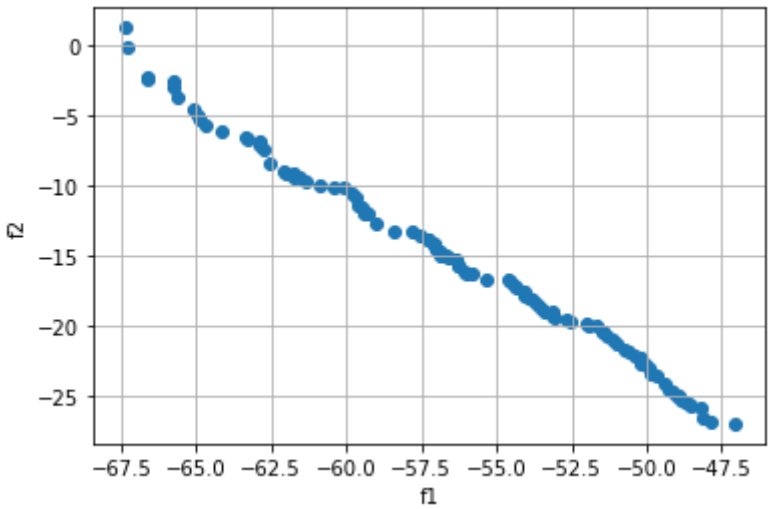


Figure 9: Example of Pareto Front in two-Objective Optimization for S11

Whereas Figure 10 provides a fitness function according to the generation of GA and illustrates a comparison of the simulated and measured reflection coefficient and realized gain characteristics.

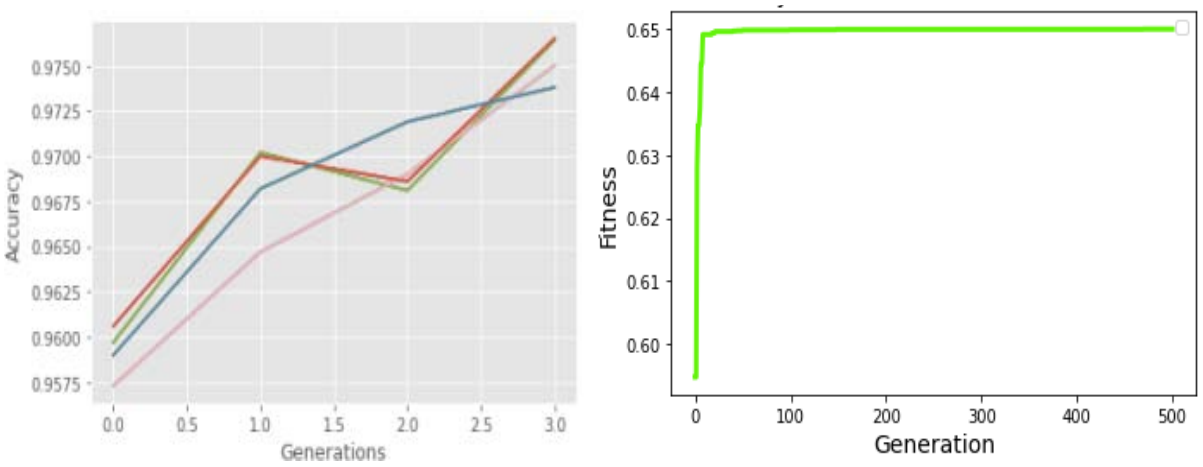


Figure 10: The Evolution of Fitness Functions for the GA Algorithm Accurately with Upgrade the Generation, Such as Concurrent accuracy for two Variables S11 and Gain, Examines Probability for 4 Generations

IV. Conclusion

The proposed method is then employed to optimize the antenna parameters and predict the reflection coefficient S11 and gain. At the same time, an additional branch is built to run the simulation tools (e.g., HFSS) and update the data set during the training process instead of constructing the targets for the RNN_GA model.

The results demonstrate that reconfigurable antennas can be designed using an efficient optimization method. We therefore need to combine the objective function with a suitable search procedure.

The main objective of this research is to explore the effectiveness of Artificial Neural Networks (ANN) Based on PSO and GA algorithms in designing and optimizing parameters of the reconfigurable patch antenna and identifying optimal antenna parameters such as S11 and Gain. The study aims to create a fully automated environment for antenna design to minimize the risk of errors and improve the overall efficiency of frequency reconfiguration.

The study aims to demonstrate that the NN-based evaluation algorithms approach can successfully optimize the antenna design process and produce antennas with improved performance.

In our method, two specifications gain and S11 are optimized, and broadside direction with radiation efficiency and optimization of reconfigurable polarization antenna design will be considered as the future work.

References Références Referencias

1. Nandana. P, Shefin Shoukhath "Design of MEMS Reconfigurable E-Shaped Patch Antenna Design for Cognitive Radio" y (IJERT) ISSN: 2278-0181, Published by, www.ijert.org, NCETET-2015 Conference Proceedings.
2. P. Gravas, D. Zaharis "Optimal Design of Aperiodic Reconfigurable Antenna Array Suitable for Broadcasting Applications", Electronics 2020, Vol 9, 818; www.mdpi.com/journal/electronics.
3. H.J. Mohammed, F. Abdulsalam; "Evaluation of Genetic Algorithms, Particle Swarm Optimisation, and Firefly Algorithms in Antenna Design", 2016 IEEE '13th International Conference on Synthesis, Modeling, Analysis and Simulation Methods and Applications to Circuit Design (SMACD)'.
4. Z.Wang, J. Qin; "Multi-Objective Antenna Design Based on BP Neural Network Surrogate Model Optimized by Improved Sparrow Search Algorithm", Appl. Sci. 2022, Vol: 12, Issue 12543, https://www.mdpi.com/journal/applsci
5. Farzad Mir, L.Kouhalvandi "Deep neural learning-based optimization for automated high-performance antenna designs", Scientific Reports | (2022) Vol:12 Issue:16801.
6. J. Dong, Yingjuan Li and Meng Wang "Fast Multi-Objective Antenna Optimization Based on RBF Neural Network Surrogate Model Optimized by Improved PSO Algorithm", Appl. Sci. 2019, Vol: 9, Isuue: 2589; www.mdpi.com/journal/applsci
7. S. Koziel, A. Pietrenko-Dabrowska "On nature-inspired design optimization of antenna structures using variable-resolution EM models", Scientific Reports (2023) Vol:13 Issue: 8373, www.nature.com/scientificreports/
8. S.Koziel, A.Pietrenko-Dabrowska "Rapid multi-objective optimization of antennas using nested kriging surrogates and single-fidelity EM simulation models", Engineering Computations Vol. 37 No. 4, 2020 pp. 1491-1512.
9. Y.Guo, Y.Wang "A New Optimization Design Method of Multi-Objective Indoor Air Supply Using the Kriging Model and NSGA-II", Appl. Sci. 2023,

Vol: 13, Issue: 10465, www.mdpi.com/journal/applsci
10. Sarbagya Ratna Shakya, Matthew Kube "A comparative analysis of the machine learning approach for optimizing antenna design", International Journal of Microwave and Wireless Technologies (Cambridge University Press) (2023), https://doi.org/10.1017/S1759078723001009
11. M. Haromainy, D.Prasetya "Improving Performance of RNN-Based Models With Genetic Algorithm Optimization For Time Series Data", TIERS Information Technology Journal Vol.4, No.1, June 2023, pp. 16~24.

This page is intentionally left blank

Global Journal of Computer Science and Technology: D
Neural & Artificial Intelligence
Volume 24 Issue 2 Version 1.0 Year 2024
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Vehicle Routing Optimization with ANT Colony Optimization Algorithm Integrated with Map Analyzer API

By Mashrure Tanzim

Bangladesh University of Professionals

Abstract- Ant colony optimization (ACO) algorithm can be used to solve combinatorial optimization problems such as the traveling salesman problem. In this work, an endeavor has been taken in finding the proper algorithm which could be used for routing problems in different real-life situations. Taking into due cognizance of the limitations of the existing routing system, the outcome of this work will facilitate a more convenient way of finding destinations for the users in term of accuracy and time over the existing routing systems. The cost of the program will also be lesser than contemporary systems. To accomplish this, a system has been built that can take a map image with source and destinations denoted; and find an optimal path for them. The work has been concluded with suggestions to future researchers who might look to build a system that can solve any type of routing problems using TSP.

Keywords: *swarm intelligence, vehicle routing, ant colony optimization.*

GJCST-D Classification: *LCC Code: QA76.9.A43*

Strictly as per the compliance and regulations of:

Vehicle Routing Optimization with ANT Colony Optimization Algorithm Integrated with Map Analyzer API

Mashrure Tanzim

Abstract- Ant colony optimization (ACO) algorithm can be used to solve combinatorial optimization problems such as the traveling salesman problem. In this work, an endeavor has been taken in finding the proper algorithm which could be used for routing problems in different real-life situations. Taking into due cognizance of the limitations of the existing routing system, the outcome of this work will facilitate a more convenient way of finding destinations for the users in term of accuracy and time over the existing routing systems. The cost of the program will also be lesser than contemporary systems. To accomplish this, a system has been built that can take a map image with source and destinations denoted; and find an optimal path for them. The work has been concluded with suggestions to future researchers who might look to build a system that can solve any type of routing problems using TSP.

Keywords: swarm intelligence, vehicle routing, ant colony optimization.

I. Introduction

Vehicle routing problems are one of the most basic problems for any traffic control system or delivery system; especially in an overpopulated and traffic congested country like Bangladesh, where traffic jam is a common phenomenon. Bangladesh has a massive population compared to other nations of similar size. Moreover, those populations are not evenly distributed in all parts of the territory. As a developing nation, it is only natural that most people gravitate towards the cities, be it for economic or social reasons. This also creates a demand for mass transportation, since a modern city can't function without it. Unfortunately in the case of Bangladesh, this was done haphazardly and without proper planning. This resulted in huge numbers of private transports and a distinct lack of mass public transit infrastructure. Thus, an application that can help regular people plan their routes more efficiently can mitigate the effect of traffic jam in Bangladeshi cities. Such an application has to be easy to use since it is meant to be used by the general populace, many of whom lack technical literacy.

It also presents a good opportunity for the stakeholders since there is no other alternative solution currently popular in the local market. The use of the application can cut down both time and fuel cost for the users. It is therefore, easy to believe that people will be willing to pay a small fee to access such a service. The users of such an application are most likely to be ordinary drivers and travelling salesmen or delivery boys. Such users tend to be in a hurry when plying their services. They don't tend to plan their routes in any way. They simply take a look at their map, choose the closest destination at hand and repeat the process till they complete their shift. Thus the application needs to be both efficient and simple to use. For that reason, Ant Colony Optimization algorithm has been chosen. As a regular user is unlikely to use more than 15-20 destinations per work shift, it can solve such small sets quickly compared to most other algorithms we tested. Thus, the algorithm should be a great fit for the purpose of this work. This service has been built in the context of Bangladesh, but can be used anywhere with similar problems. Traffic congestion is not only an annoyance. It has economic consequences. Due to sitting in traffic jam, the fuel cost of trips increase. It also wastes a lot of time for every trip. The average commuter in Dhaka city spends about 55% of his time sitting in traffic [1]. This causes a massive loss in working hours. According to a survey in 2018, the traffic congestion in Dhaka is wasting around 3.2 million working hours daily [2]. According to a study conducted in 2016, the total congestion cost for the Dhaka city is 12561.296 million USD. Considering the country's total population, per capita congestion cost is 78.50 USD and if we consider only Dhaka city's population, the per capita congestion cost stands 785.00 USD [3]. Previous work in this sector includes various applications in telecommunication network such as circuit and packet switch networks, mobile networks, industrial scheduling problems and assembly line balancing problems. The proposed work aims to fill the gap that exists here regarding vehicle routing problems in general. Preliminary testing shows that the algorithm can achieve up to 24% efficiency in distance cost. This work provides a framework on how such a service can be provided and some data on how it will help both the users and stakeholders economically. Future researchers can use this work as a template on building the proper digital infrastructure needed to alleviate the congestion from roads, not only

Author: Department of Information and Communication Technology, Bangladesh University of Professionals, Dhaka, Bangladesh. e-mail: tanzimndub@gmail.com

in Dhaka but any location that suffers from similar problems.

II. Constructing the Application

The algorithm needed an interface to be able to solve real life tsp problems. We built a web application by php language for that purpose. The application uses laravel framework. It receives data from an API simulated via another php library [4]. Both applications have to be run simultaneously for the simulation to work. We built up the input to be used for the API application. We first took a map of Dhaka city. The API recognizes nodes to be of a different colour from the map background. Thus, we picked a black and white map. We use the colour blue as the node colour. The specific RGB code for the colour is (0,163,232). This is important because the API has an option for specifying the colour of the nodes. If the colour does not match up, the data does not get properly rendered. A user can change the colour code according to his need. Or they can simply pick the option that says: "The colors of nodes on a graph are different from background color". This forces the API to analyze the image for background colour and any differences in the image. But this process is often not reliable and has been noted to fail during testing. User discretion is advised. The input image is then analyzed by the application. It can accept anywhere from 2 to 500 nodes. An average user is unlikely to need that many destination points. For that and also for the sake of simplicity, we chose 7 nodes over different parts of the map. The image would be used as a template by the algorithm to generate a second image. The newly generated image will have paths denoted between the nodes. The paths also have an approximate weight value calculated by the algorithm. The algorithm uses this new weighted graph format to calculate the most optimal path of travel for the user.

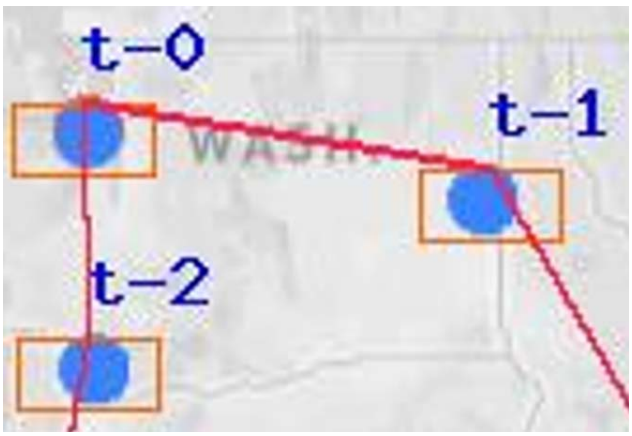


Fig. 1: Nodes and Weight Value Calculation

The starting node is denoted by zero. Each closest node is given a number of its own and denoted in numerical order. Each node represents a destination, with the node t-0 being an exception. It is considered to be the starting point of the journey. Subsequent nodes are denoted as t-1, t-2 etc. based on a rough estimation of the distance between them. As an example, a map with 7 nodes will have the following nodes: t-0, t-1, t-2, t-3, t-4, t-5 and t-6. Once the nodes and weight paths are calculated, the algorithm uses the data to internally construct a data matrix. It uses this data to calculate the most optimal path to travel from node t-0 to all the other nodes and then come back to t-0. It presents us with the result which includes the total distance covered by the vehicle and also which path is optimal to be travelled. The path should always start and end with the node 0. The distance between the nodes is not calculated in any specific unit, but a numerical value. That is because the algorithm does not have a sense of scale and can't find out the distance between two nodes by simply looking at the map. Attempts had been made to specify the distance between the first two nodes and use it as a scale for the rest, albeit unsuccessfully. This is one of the major limitations of the current work. However, it still informs a user which path is the most optimal. A user can compare the value of distance for multiple paths using the same map. It is not the smoothest way to compare routes, but it gets the job done. Another gap in the work is the inability of a user to update his path in the middle of a trip. In real life, the situation of the road changes with time. A road that was open moments ago can be clogged with traffic in minutes. This isn't even taking into accounts events like accidents or temporary closure of a road. In that case, the weight value of a chosen path should also change. But the system lacks any automatic update service that can alter the value of the trip once it has begun. To achieve that we would require a service that provides GPS update to the users in real time. It would also have to be compatible with the web application. We were unable to find such a service. The best way a user can achieve that goal is to manually input an image of the map after reaching every

destination. This is cumbersome for an average user. It would also slow down the trip as the web application would have to calculate the optimal path every time a destination is reached. So this work does not include such a feature. It has been left for future researchers to fill that gap. They can work in conjunction with companies that provide Geolocation service to develop an application that can receive data in real time. Or if they are ambitious enough, they can even develop their own geolocation service that has such a feature. In any case, such an endeavor is beyond the scope of our work. Currently services like google map calculate routes by measuring the shortest distance between two nodes. Any further destinations are measured only after reaching the first destination. Then the shortest distance to the next destination is calculated and thus it goes on and on. This format of travelling is called greedy best first search. And it gives suboptimal results in almost every case, since the user is just travelling without any consideration to future travel. As an example, we can consider the bays29.tsp dataset in order to find the most optimal algorithm for our system [5]. If we simply calculate the closest distance from one node to the next, then we get a distance of 6173 just to travel from the starting node to the final destination. In order to get back to the source, that distance is doubled, so the total distance travelled is 12346. Even if we calculate the total distance randomly from another starting point, the best result we can get is 4955, which if doubled amounts to a distance of 9910.

Table 1: Calculating Distance by Best First Search Method (Bays29.Tsp))

Distance	Distance
167	0
79	107
77	241
205	190
97	124
185	80
435	316
243	76
111	152
163	157
322	283
238	133
206	113
288	297
243	228
275	129
319	348
253	276
281	188
135	150
108	65
332	341
342	184
218	67
350	221
39	169
263	108
199	45
0	167
Total: 6173	Total: 4955

On the other hand, the ACO implementation of the same dataset generates a distance between the ranges of 9390 to 9612. These values were found by using a java program that takes a fixed dataset and calculates the shortest path. The program is fairly basic and has no option to process image files. It had been slightly modified to give time and memory cost as parts of the result. The original code can be found in the following link: https://github.com/LazoCoder/Ant-Colony-Optimization-for-the-Traveling-Salesman-Problem [6].

```
------------------ANT COLONY OPTIMIZATION------------------
Use the parameter '-p' for custom settings.
Otherwise the default values will be:
Ants per epoch:           100
Epochs:                   100
Evaporation Rate:         0.1
Alpha (pheromone impact): 1
Beta (distance impact):   5
Best Tour: 5 -> 21 -> 2 -> 20 -> 10 -> 13 -> 4 -> 15 -> 18 -> 14 -> 17 -> 22 ->
11 -> 16 -> 19 -> 25 -> 7 -> 23 -> 27 -> 8 -> 24 -> 1 -> 28 -> 6 -> 12 -> 9 -> 2
6 -> 29 -> 3 -> 5
Evaluation: 9390
-------------------------COMPLETE--------------------------
It took 6869 milliseconds
It took 56.2529296875 mbs
```

Fig. 2: ACO Run on Bays29.tsp (instance 1)

```
------------------ANT COLONY OPTIMIZATION------------------
Use the parameter '-p' for custom settings.
Otherwise the default values will be:
Ants per epoch:           100
Epochs:                   100
Evaporation Rate:         0.1
Alpha (pheromone impact): 1
Beta (distance impact):   5
Best Tour: 5 -> 21 -> 2 -> 20 -> 10 -> 13 -> 4 -> 15 -> 18 -> 14 -> 17 -> 22 ->
11 -> 16 -> 19 -> 25 -> 7 -> 23 -> 27 -> 8 -> 24 -> 1 -> 28 -> 6 -> 12 -> 9 -> 2
6 -> 29 -> 3 -> 5
Evaluation: 9390
-------------------------COMPLETE--------------------------
It took 6869 milliseconds
It took 56.2529296875 mbs
```

Fig. 3: ACO Run on Bays29.tsp (instance 2)

If we take 12346 as the highest range for greedy search, 9390 is 76.05% of that value. If we take 9910 as the lowest range for greedy search, 9612 is 96.99% of that value. This gives us an efficiency rating anywhere between 3% and 24%, depending on the situation. We are using a range instead of a flat number because there is a factor of randomness in ACO iterations. It may not always give the best results. But the risk is acceptable considering the benefits. So we can clearly see that even the worst result from ACO is better than the best result obtained by simply travelling blindly through the nodes. And it is obtained in a very small amount of time, 3-6 seconds. The memory consumption is also low, around 55-56 mbs. Thus, we can achieve an efficiency of 3-24%, just by spending a little bit of time and memory space. A 24% efficiency rating is unlikely to be replicated in real life due to issues like human error and fuel inefficiency inherent to every vehicle. So we considered 15% as a realistic estimate for calculating fuel cost efficiency in previous sections of the paper. Let the cost of travel for not using an algorithm be A. Let the cost of travel for using ACO be B. Let P be the percentage of reduced cost. Let C be the cost of fuel per unit. Let S be the saved cost in BDT. Thus the final formula for cost efficiency stands at:

((C/100)) x ((100 x B) / A)

III. Integration With the Web Application

The web application would serve as a user friendly interface for our system. Since our focus was on proving the usefulness of the system, the front end of the web application was designed to be fairly basic. A simple login and registration system at the top are the only usable part of the page. A user has to register himself with his name, email and password to access the system.

Fig. 4: Landing Page of the Web App

The dashboard page was designed to have only 2 menus; the dashboard itself and the map api. A user could also check his profile by clicking on the ribbon on the top right corner of the screen. He could edit his profile, change his password, log out or even delete his account from there. The map option was designed to take a user to a page with an input form. The input could accept image files and send it to the api part of the system. Once an image file was selected, a user would press the upload button. The interface would then send that image file to the API and also keep a copy of the file in its own storage. After the file is saved on the map api, the interface would automatically redirect itself to the path finding system.

Fig. 5: Map API

Once on the system, a user can check his previously uploaded maps on a list. The maps can be deleted if deemed unnecessary. New image files can also be directly uploaded by an input system on the right side of the page. The users can go back to the interface by clicking on the option “Go back to Main Page”. It would take them back to the dashboard page.

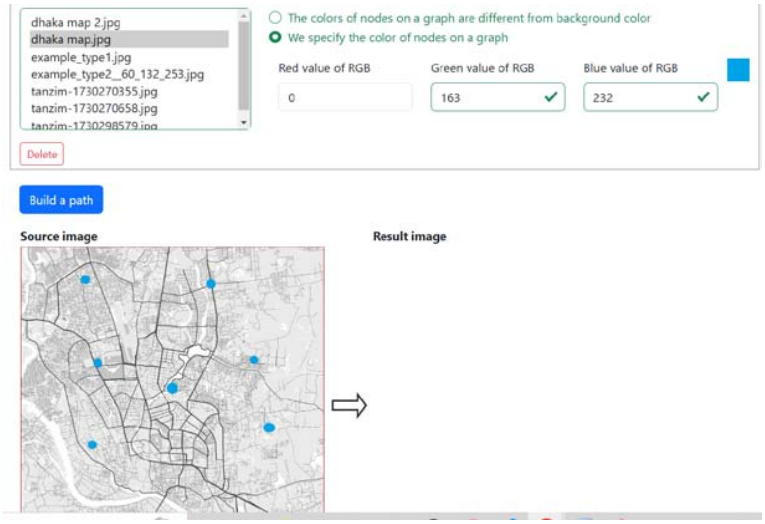


Fig. 6: Building an Optimal Path

The users can select a map from the stored files and specify how nodes would be detected on the image. If a user selects the option to specify the colour of the nodes, three additional input boxes would appear. They would take the RGB value of the colour the nodes are expected to represent. Once that is specified, clicking on the button “Build a path” would activate the algorithm and generate an optimal route through the nodes.

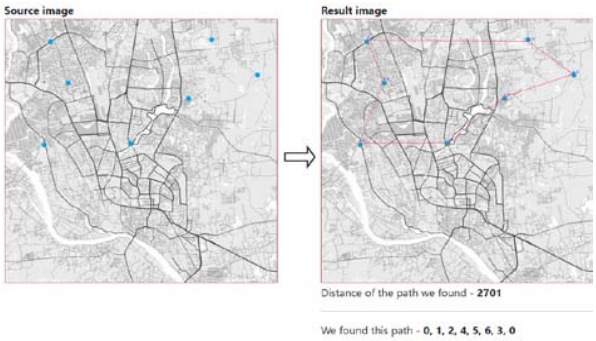


Fig. 7: Result of Path Calculation

Once the nodes and weight paths are calculated, the algorithm uses the data to internally construct a data matrix. It uses this data to calculate the most optimal path to travel from node t-0 to all the other nodes and then come back to t-0. It presents us with the result which includes the total distance covered by the vehicle and also which path is optimal to be travelled. The path should always start and end with the node 0. The distance between the nodes is not calculated in any specific unit, but a numerical value. That is because the algorithm does not have a sense of scale and can't find out the distance between two nodes by simply looking at the map. Attempts had been made to specify the distance between the first two nodes and use it as a scale for the rest, albeit unsuccessfully. This is one of the major limitations of the current work. However, it still informs a user which path is the most optimal. A user can compare the value of distance for multiple paths using the same map. It is not the smoothest way to compare routes, but it gets the job done. It has been left for future researchers to fill that gap. The interface was published in a public site. It was able to function with data inputs in real time. The codes for all the algorithms used for our testing was also published accordingly.

Web application interface code:

https://github.com/navintanzim/acov1

Map API code:

https://github.com/navintanzim/aco-php

A demonstration video showing the whole process step by step is located at:

https://github.com/navintanzim/acov2/blob/main/demo%20video.wmv

IV. Discussion and Analysis of Result

We calculated multiple distances of optimal paths by using ACO. We also calculated multiple distances without using any algorithm. We found that the highest distance measured for solving the bays29.tsp dataset without using any algorithm is 12346. And the lowest cost for the same dataset using ACO is 9390. Thus, the percentage of distance reduced becomes:

$$\text{Percentage} = (100/12346) \times 9390 = 76.0570225174\ \%$$

We then used the lowest distance value calculated with the algorithm and compared it to the highest distance value calculated without any algorithm. Using the same formula to calculate the percentage of reduced path, we got:

$$\text{Percentage} = (100/9910) \times 9612 = 96.9929364279\ \%$$

So, the best efficiency rating we could calculate was:

$(100 - 76.0570225174) = 23.9429774826\%$.

And the worst we could find was:

$(100 - 96.9929364279) = 3.0070635721\%$.

Since these are fringe values, we consider a middling 15% as a more realistic efficiency rating.

The java implementation of ACO was unsuitable for integration into a web framework. So a new implementation by php was built. This system consisting of a user interface and an API uses an image input to find the optimal path. It gives an optimal path in only a few microseconds. Such as:

Calculation Time (in microseconds) - 0.0024600029

The total time taken to calculate the shortest distance and generate a map for it was found to be anywhere from 4 to 7 seconds. From previous testing, we knew that the efficiency rating of using ACO was 15 on average. Using the formula for cost efficiency equation mentioned in chapter 2, we calculated the cost efficiency of fuel usage per litre of ocane. We used BDT 125 as the price point for a litre of octane according to the latest govt. mandated price [7]. The cost efficiency became:

$$\text{Cost efficiency} = (\text{cost per unit of fuel}/100) \text{ X efficiency rating} = (125/100) \times 15 = 18.75 \text{ taka/litre}$$

We could safely assume that the measurements taken were mostly correct. While not perfect, the ACO algorithm has been considered to be fairly accurate. It aids in extracting logical information from credit data with over 80% accuracy [8]. We also searched for how much fuel an average travelling salesman might use per day. Unfortunately, we found no available statistics on that. The best information found by visiting online forums was that a sedan running on natural gas might spend 1000 taka per day. But this is not sufficient to calculate a profit margin, simply because octane and natural gas have different mileage and there are all kinds of vehicles on the streets. A motorbike won't have the same fuel cost as a sedan. Without proper survey, it is not possible to calculate this. We leave it for future researchers to do so if they wish.

V. Conclusion

Traveling salesman problem is one of the most important problems faced by vehicle routing procedures. Choosing the appropriate algorithm for a situation is necessary. In real life, the condition on the road can change at any moment due to unforeseen circumstances. In that case, the proper algorithm must be implemented to find the quickest route efficiently. This paper is a step forward in the effort to find the most practical solution to resolve the issue of traffic congestion. It demonstrated a practical implementation of ACO to find the most optimal path for a travelling salesman. It can function as a blueprint for future services that can automatically update the routes based

on traffic congestion data received from satellites. However the work has certain limitations as well. The programs used in this work can handle only certain types of datasets. It can't use all forms of data as input. For that reason, the pool of available datasets was very limited and this research was forced to test the programs on only 2 different datasets. It also lacked the ability to update the routes based on traffic congestion automatically. The update had to be done manually by a user. Future researchers can work on these aspects to further improve the usefulness of the system.

References Références Referencias

1. Khaled, Khonika, Mustafizur & Syed, "Possible Causes & Solutions of Traffic Jam and Their Impact on the Economy of Dhaka City", Journal of Management and Sustainability, vol. 2, 2012.
2. "https://www.worldbank.org/en/news/press-release/2018/07/05/act-now-for-a-more-prosperous-and-livable-dhaka," September 23,10.30 p.m.
3. Sonjoy Chakraborty, "Traffic Congestion in Dhaka City and its Economic Impact," Dhaka University Journal of Business Studies, vol. 1, no. 1, 2016.
4. "https://github.com/mgrechanik/ant-colony-optimization," April 15,10.40 p.m.
5. https://github.com/pdrozdowski/TSPLib.Net/blob/master/TSPLIB95/tsp/bays29.tsp (March 3, 9.15 p.m)
6. https://github.com/LazoCoder/Ant-Colony-Optimization-for-the-Traveling-Salesman-Problem
7. "https://bpc.gov.bd/site/page/0d64c1df-2020-45fd-9e07-673d972e1bec/-," October 26, 1.30 p.m.
8. Cheng, Li. "Ant colony optimization algorithm in the design of international trade early warning system." 12609 (2023).:126092J-126092J. doi:10.1117/12.2671574

Global Journals Guidelines Handbook 2024

www.GlobalJournals.org

Memberships

Fellows/Associates of Computer Science Research Council

FCSRC/ACSRC Memberships

Introduction

FCSRC/ACSRC is the most prestigious membership of Global Journals accredited by Open Association of Research Society, U.S.A (OARS). The credentials of Fellow and Associate designations signify that the researcher has gained the knowledge of the fundamental and high-level concepts, and is a subject matter expert, proficient in an expertise course covering the professional code of conduct, and follows recognized standards of practice. The credentials are designated only to the researchers, scientists, and professionals that have been selected by a rigorous process by our Editorial Board and Management Board.

Associates of FCSRC/ACSRC are scientists and researchers from around the world are working on projects/researches that have huge potentials. Members support Global Journals' mission to advance technology for humanity and the profession.

FCSRC

Fellow of Computer Science Research Council

FELLOW OF COMPUTER SCIENCE RESEARCH COUNCIL is the most prestigious membership of Global Journals. It is an award and membership granted to individuals that the Open Association of Research Society judges to have made a 'substantial contribution to the improvement of computer science, technology, and electronics engineering.

The primary objective is to recognize the leaders in research and scientific fields of the current era with a global perspective and to create a channel between them and other researchers for better exposure and knowledge sharing. Members are most eminent scientists, engineers, and technologists from all across the world. Fellows are elected for life through a peer review process on the basis of excellence in the respective domain. There is no limit on the number of new nominations made in any year. Each year, the Open Association of Research Society elect up to 12 new Fellow Members.

Benefits

To the institution

Get letter of appreciation

Global Journals sends a letter of appreciation of author to the Dean or CEO of the University or Company of which author is a part, signed by editor in chief or chief author.

Exclusive Network

Get access to a closed network

A FCSRC member gets access to a closed network of Tier 1 researchers and scientists with direct communication channel through our website. Fellows can reach out to other members or researchers directly.They should also be open to reaching out by other.

Career | Credibility | Exclusive | Reputation

Certificate

Certificate, LoR and Laser-Momento

Fellows receive a printed copy of a certificate signed by our Chief Author that may be used for academic purposes and a personal recommendation letter to the dean of member's university.

Career | Credibility | Exclusive | Reputation

Designation

Get honored title of membership

Fellows can use the honored title of membership. The “FCSRC” is an honored title which is accorded to a person’s name viz. Dr. John E. Hall, Ph.D., FCSRC or William Walldroff, M.S., FCSRC.

Career | Credibility | Exclusive | Reputation

Recognition on the Platform

Better visibility and citation

All the Fellow members of FCSRC get a badge of "Leading Member of Global Journals" on the Research Community that distinguishes them from others. Additionally, the profile is also partially maintained by our team for better visibility and citation. All fellows get a dedicated page on the website with their biography.

Career | Credibility | Reputation

Future Work

Get discounts on the future publications

Fellows receive discounts on future publications with Global Journals up to 60%. Through our recommendation programs, members also receive discounts on publications made with OARS affiliated organizations.

Career | Financial

GJ Account

Unlimited forward of Emails

Fellows get secure and fast GJ work emails with unlimited forward of emails that they may use them as their primary email. For example, john [AT] globaljournals [DOT] org.

Career | Credibility | Reputation

Premium Tools

Access to all the premium tools

To take future researches to the zenith, fellows receive access to all the premium tools that Global Journals have to offer along with the partnership with some of the best marketing leading tools out there.

Financial

Conferences & Events

Organize seminar/conference

Fellows are authorized to organize symposium/seminar/conference on behalf of Global Journal Incorporation (USA). They can also participate in the same organized by another institution as representative of Global Journal. In both the cases, it is mandatory for him to discuss with us and obtain our consent. Additionally, they get free research conferences (and others) alerts.

Career | Credibility | Financial

Early Invitations

Early invitations to all the symposiums, seminars, conferences

All fellows receive the early invitations to all the symposiums, seminars, conferences and webinars hosted by Global Journals in their subject.

Exclusive

Publishing Articles & Books

Earn 60% of sales proceeds

Fellows can publish articles (limited) without any fees. Also, they can earn up to 70% of sales proceeds from the sale of reference/review books/literature/publishing of research paper. The FCSRC member can decide its price and we can help in making the right decision.

Exclusive | Financial

Reviewers

Get a remuneration of 15% of author fees

Fellow members are eligible to join as a paid peer reviewer at Global Journals Incorporation (USA) and can get a remuneration of 15% of author fees, taken from the author of a respective paper.

Financial

Access to Editorial Board

Become a member of the Editorial Board

Fellows may join as a member of the Editorial Board of Global Journals Incorporation (USA) after successful completion of three years as Fellow and as Peer Reviewer. Additionally, Fellows get a chance to nominate other members for Editorial Board.

Career | Credibility | Exclusive | Reputation

And Much More

Get access to scientific museums and observatories across the globe

All members get access to 5 selected scientific museums and observatories across the globe. All researches published with Global Journals will be kept under deep archival facilities across regions for future protections and disaster recovery. They get 10 GB free secure cloud access for storing research files.

ASSOCIATE OF COMPUTER SCIENCE RESEARCH COUNCIL

ASSOCIATE OF COMPUTER SCIENCE RESEARCH COUNCIL is the membership of Global Journals awarded to individuals that the Open Association of Research Society judges to have made a 'substantial contribution to the improvement of computer science, technology, and electronics engineering.

The primary objective is to recognize the leaders in research and scientific fields of the current era with a global perspective and to create a channel between them and other researchers for better exposure and knowledge sharing. Members are most eminent scientists, engineers, and technologists from all across the world. Associate membership can later be promoted to Fellow Membership. Associates are elected for life through a peer review process on the basis of excellence in the respective domain. There is no limit on the number of new nominations made in any year. Each year, the Open Association of Research Society elect up to 12 new Associate Members.

Benefits

To the institution

Get letter of appreciation

Global Journals sends a letter of appreciation of author to the Dean or CEO of the University or Company of which author is a part, signed by editor in chief or chief author.

Exclusive Network

Get access to a closed network

A ACSRC member gets access to a closed network of Tier 2 researchers and scientists with direct communication channel through our website. Associates can reach out to other members or researchers directly.They should also be open to reaching out by other.

Career | Credibility | Exclusive | Reputation

Certificate

Certificate, LOR and Laser-Momento

Associates receive a printed copy of a certificate signed by our Chief Author that may be used for academic purposes and a personal recommendation letter to the dean of member's university.

Career | Credibility | Exclusive | Reputation

Designation

Get honored title of membership

Associates can use the honored title of membership. The “ACSRC” is an honored title which is accorded to a person’s name viz. Dr. John E. Hall, Ph.D., ACSRC or William Walldroff, M.S., ACSRC.

Career | Credibility | Exclusive | Reputation

Recognition on the Platform

Better visibility and citation

All the Associate members of ACSRC get a badge of "Leading Member of Global Journals" on the Research Community that distinguishes them from others. Additionally, the profile is also partially maintained by our team for better visibility and citation.

Career | Credibility | Reputation

Future Work

Get discounts on the future publications

Associates receive discounts on future publications with Global Journals up to 30%. Through our recommendation programs, members also receive discounts on publications made with OARS affiliated organizations.

Career | Financial

GJ Account

Unlimited forward of Emails

Associates get secure and fast GJ work emails with 5GB forward of emails that they may use them as their primary email. For example, john [AT] globaljournals [DOT] org.

Career | Credibility | Reputation

Premium Tools

Access to all the premium tools

To take future researches to the zenith, associates receive access to all the premium tools that Global Journals have to offer along with the partnership with some of the best marketing leading tools out there.

Financial

Conferences & Events

Organize seminar/conference

Associates are authorized to organize symposium/seminar/conference on behalf of Global Journal Incorporation (USA). They can also participate in the same organized by another institution as representative of Global Journal. In both the cases, it is mandatory for him to discuss with us and obtain our consent. Additionally, they get free research conferences (and others) alerts.

Career | Credibility | Financial

Early Invitations

Early invitations to all the symposiums, seminars, conferences

All associates receive the early invitations to all the symposiums, seminars, conferences and webinars hosted by Global Journals in their subject.

Exclusive

Publishing Articles & Books

Earn 30-40% of sales proceeds

Associates can publish articles (limited) without any fees. Also, they can earn up to 30-40% of sales proceeds from the sale of reference/review books/literature/publishing of research paper.

Exclusive | Financial

Reviewers

Get a remuneration of 15% of author fees

Associate members are eligible to join as a paid peer reviewer at Global Journals Incorporation (USA) and can get a remuneration of 15% of author fees, taken from the author of a respective paper.

Financial

And Much More

Get access to scientific museums and observatories across the globe

All members get access to 2 selected scientific museums and observatories across the globe. All researches published with Global Journals will be kept under deep archival facilities across regions for future protections and disaster recovery. They get 5 GB free secure cloud access for storing research files.

Associate	Fellow	Research Group	Basic
$4800 **lifetime designation**	$6800 **lifetime designation**	$12500.00 **organizational**	APC **per article**
Certificate, LoR and Momento **2** discounted publishing/year **Gradation** of Research **10** research contacts/day **1 GB** Cloud Storage **GJ** Community Access	**Certificate,** LoR and Momento **Unlimited** discounted publishing/year **Gradation** of Research **Unlimited** research contacts/day **5 GB** Cloud Storage **Online Presense** Assistance **GJ** Community Access	**Certificates,** LoRs and Momentos **Unlimited** free publishing/year **Gradation** of Research **Unlimited** research contacts/day **Unlimited** Cloud Storage **Online Presense** Assistance **GJ** Community Access	**GJ** Community Access

Preferred Author Guidelines

We accept the manuscript submissions in any standard (generic) format.

We typeset manuscripts using advanced typesetting tools like Adobe In Design, CorelDraw, TeXnicCenter, and TeXStudio. We usually recommend authors submit their research using any standard format they are comfortable with, and let Global Journals do the rest.

Alternatively, you can download our basic template from https://globaljournals.org/Template.zip

Authors should submit their complete paper/article, including text illustrations, graphics, conclusions, artwork, and tables. Authors who are not able to submit manuscript using the form above can email the manuscript department at submit@globaljournals.org or get in touch with chiefeditor@globaljournals.org if they wish to send the abstract before submission.

Before and during Submission

Authors must ensure the information provided during the submission of a paper is authentic. Please go through the following checklist before submitting:

1. Authors must go through the complete author guideline and understand and *agree to Global Journals' ethics and code of conduct,* along with author responsibilities.
2. Authors must accept the privacy policy, terms, and conditions of Global Journals.
3. Ensure corresponding author's email address and postal address are accurate and reachable.
4. Manuscript to be submitted must include keywords, an abstract, a paper title, co-author(s') names and details (email address, name, phone number, and institution), figures and illustrations in vector format including appropriate captions, tables, including titles and footnotes, a conclusion, results, acknowledgments and references.
5. Authors should submit paper in a ZIP archive if any supplementary files are required along with the paper.
6. Proper permissions must be acquired for the use of any copyrighted material.
7. Manuscript submitted *must not have been submitted or published elsewhere* and all authors must be aware of the submission.

Declaration of Conflicts of Interest

It is required for authors to declare all financial, institutional, and personal relationships with other individuals and organizations that could influence (bias) their research.

Policy on Plagiarism

Plagiarism is not acceptable in Global Journals submissions at all.

Plagiarized content will not be considered for publication. We reserve the right to inform authors' institutions about plagiarism detected either before or after publication. If plagiarism is identified, we will follow COPE guidelines:

Authors are solely responsible for all the plagiarism that is found. The author must not fabricate, falsify or plagiarize existing research data. The following, if copied, will be considered plagiarism:

- Words (language)
- Ideas
- Findings
- Writings
- Diagrams
- Graphs
- Illustrations
- Lectures

- Printed material
- Graphic representations
- Computer programs
- Electronic material
- Any other original work

Authorship Policies

Global Journals follows the definition of authorship set up by the Open Association of Research Society, USA. According to its guidelines, authorship criteria must be based on:

1. Substantial contributions to the conception and acquisition of data, analysis, and interpretation of findings.
2. Drafting the paper and revising it critically regarding important academic content.
3. Final approval of the version of the paper to be published.

Changes in Authorship

The corresponding author should mention the name and complete details of all co-authors during submission and in manuscript. We support addition, rearrangement, manipulation, and deletions in authors list till the early view publication of the journal. We expect that corresponding author will notify all co-authors of submission. We follow COPE guidelines for changes in authorship.

Copyright

During submission of the manuscript, the author is confirming an exclusive license agreement with Global Journals which gives Global Journals the authority to reproduce, reuse, and republish authors' research. We also believe in flexible copyright terms where copyright may remain with authors/employers/institutions as well. Contact your editor after acceptance to choose your copyright policy. You may follow this form for copyright transfers.

Appealing Decisions

Unless specified in the notification, the Editorial Board's decision on publication of the paper is final and cannot be appealed before making the major change in the manuscript.

Acknowledgments

Contributors to the research other than authors credited should be mentioned in Acknowledgments. The source of funding for the research can be included. Suppliers of resources may be mentioned along with their addresses.

Declaration of funding sources

Global Journals is in partnership with various universities, laboratories, and other institutions worldwide in the research domain. Authors are requested to disclose their source of funding during every stage of their research, such as making analysis, performing laboratory operations, computing data, and using institutional resources, from writing an article to its submission. This will also help authors to get reimbursements by requesting an open access publication letter from Global Journals and submitting to the respective funding source.

Preparing your Manuscript

Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

Format Structure

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, “What words would a source have to include to be truly valuable in a research paper?” Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

Tips for writing a good quality Computer Science Research Paper

Techniques for writing a good quality computer science research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of computer science then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10.Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

Criterion for Grading a Research Paper (Compilation) by Global Journals Inc. (US)

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals Inc. (US).

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

INDEX

save our planet

Global Journal of Computer Science and Technology

Visit us on the Web at www.GlobalJournals.org | www.ComputerResearch.org
or email us at helpdesk@globaljournals.org

ISSN 9754350