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Neural & AI

Artificial Heart Neural Networks

Controlled System for Mobile Robot

Highlights

Vehicular Traffic Control System

IP-Based Remote Controlled System

Discovering Thoughts, Inventing Future

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Detailed Analysis and Identification of Key Factors Resulting in Motor Accidents across the UK

By Harshita Garg
Birkbeck University

Abstract- Motor accidents across the globe amount to a large number of deaths every year. The collisions result in not just the personal injury to people involved but also in the loss of money to the motor insurance companies, trauma to the people involved, and added pressure on the emergency services. With the help of data analytics techniques, this project aims to identify critical factors that might contribute to the accidents. Upon investigating the temporal features and geo-spatial features of the motor accident locations, we tried to establish a correlation between the accident intensity and its key factors. For this exploratory analysis, we also considered weather conditions and daily average traffic flow data. We then trained Supervised learning models on the data to find out the best performing multi-label classification model.

Keywords: *supervised learning; accident analysis; multilabel classification.*

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Detailed Analysis and Identification of Key Factors Resulting in Motor Accidents across the UK

Harshita Garg

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Keywords: supervised learning; accident analysis; multi-label classification.

I. Introduction

Around the world, every year, more than 1.25 million people are killed and 50 million are injured in road traffic accidents. (Source – Express, road safety facts [1]) The source claims that "Every day, on average, five people are killed and 64 seriously injured on UK roads." Driving is considered the most dangerous activity we do every day.

Several factors contribute to road accidents. Some of these are – severe weather conditions, the distraction of driver, failure to give or understand appropriate signals, reduced motor skills due to old age, or alcohol consumption.

If there was a way to find the key factors responsible for motor accidents happening on the roads, lots of these effects could be minimized. If the hotspots for accidents could be identified, emergency services could be put on high alert in those areas, increasing the response time and potentially reducing the loss of life. If we can predict the likelihood of a crash in real-time, the driver could be warned of potential danger. The government can issue advisory to all the motorists on the accident's hotspots or put signboards to notify the road users.

Author: Birkbeck University, London.
e-mail: Harshita.garg@hotmail.com

II. Literature Review

Accidents dataset for the UK region, which is available at the government of UK website [2], is an immensely popular dataset and many academicians have based their research on this, with some variations.

Jinning You et al. attempted to calculate the crash likelihood in [3]. They used web crawling techniques to obtain live weather data and oversampling to solve the problem of inherent imbalance in the dataset and applied random forest and SVM classifier algorithms on the training dataset. SVM classifier performed better for them when used with the web crawling techniques.

The relationship between road accidents and traffic on the roads has got a lot of attention in recent years. Salifu [4] used a similar approach for the accident prediction for unsignaled urban junctions in Ghana. He combined accident data with the Annual Average Data Flow and analyzed the effect on different kinds of junctions like signaled junctions, unsignaled junctions, T- junctions, X- junctions etc.

Traffic data visualization is another approach that researchers have studied extensively to discover patterns and make clusters amongst traffic accidents. In the research paper [5], authors Chen et al. state that "Data visualization is an efficient means to represent distributions and structures of datasets and reveal hidden patterns in the data. "

This project builds upon many of the approaches described above and draws a parallel with the model developed by You et al [4] but is different in the sense that it involves not only the accident, and traffic data but also the detailed demographics of the driver and the vehicle involved.

III. Secondary Data

I obtained the data for accidents from the government of the UK website [2]. Statistics on road safety in Great Britain are based on accidents reported to the police in a form submitted by the attending officer.

To quantize the accident severity, many factors were considered. One of the significant variables for this model was the volume of traffic flowing on the road at the accident time. Taner J.C. [6] explained that the traffic volume and crash data follows the model $Y = \alpha F\beta$,

where Y is crash count, F is traffic volume, and α and β are calibration coefficients. In other words, the crash count is directly proportional to the amount of traffic on the road. Annual average daily flow(AADF) data is available on the government of the UK website [7]. This dataset gives the estimated annual average of the flow of traffic on most of the major and minor UK roads.

The data for the vehicles involved in road accidents is from the same source as the accidents dataset [2]. Vehicles dataset includes the details of the vehicles involved in accidents.

IV. Methodology

a) Data Preparation

Many columns in the dataset had missing values. Columns with more than 20% missing values were dropped. We also decided to drop the features that were not considered important in the classification problem at hand. After combining the Accident dataset with vehicles and the AADF table, many records for AADF were found to have missing values. The missing data was because not all the accident spots had AADF values available. This trend was more common in the minor roads, mainly B, C, and U roads. The final data frame had nearly 50% of values missing.

We created a linear regression model to calculate the value of traffic based on the variable's latitude, longitude, road class, and road type. All the records with a valid AADF value in the combined data frame were used as the training dataset, and all the records with missing AADF values were used as a test dataset. Performance of the model was about 70%, which was okay.

The machine learning models try to derive a meaningful relationship between the features present and the target variable. The ability of a model to predict the outcome successfully depends mainly on the types of features present in the dataset. This is where feature engineering comes into the picture. We engineered different features from the existing ones to increase the predictive powers of the models. We converted Hour of the day into a cyclic feature such that hour 0 is closer to hour 24. Data distribution after conversion of time into cyclic feature is plotted below.

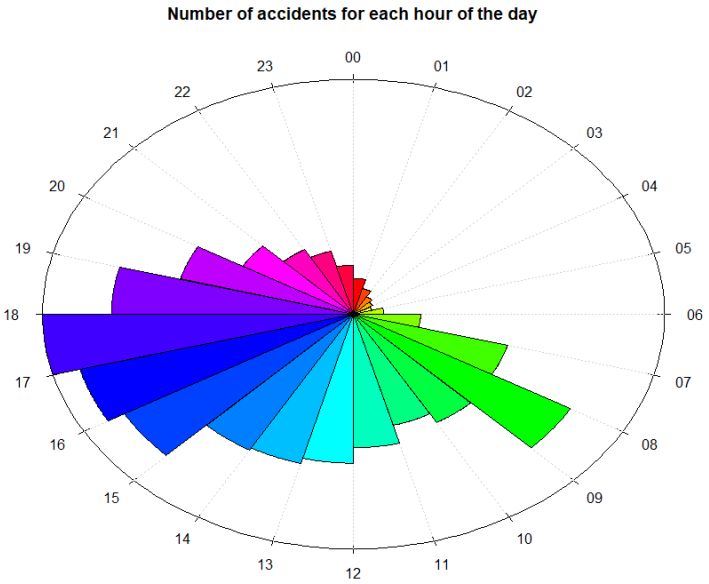

Figure 1: Number of accidents by hour

The graph indicates the relation between peak hours and the number of accidents. It shows that the maximum accidents happen at the times 5-6 pm, followed by 4-5 pm with the morning rush hour 8-9 am following closely behind.

Mean encoding is encoding categorical features based on the ratio of occurrence of positive class in the target variable. For the problem at hand, the target variable is Accident Severity, and the positive class is the 'fatal' class. Thus, we converted the categorical variable 'road name' to mean encoded value which better represented the target variable accident severity. Two problems were solved here in one go – categorical variable with an unmanageable number of levels was converted to a quantitative one, and the target values were embodied into the feature, thus increasing the predictive power of the model.

b) Exploratory Data Analysis

A layered analysis was done for the exploratory variables to fully understand the dataset and the impact every variable had on the severity of accidents. We plotted the distribution of the number of accidents concerning some predictor variables and accident severity.

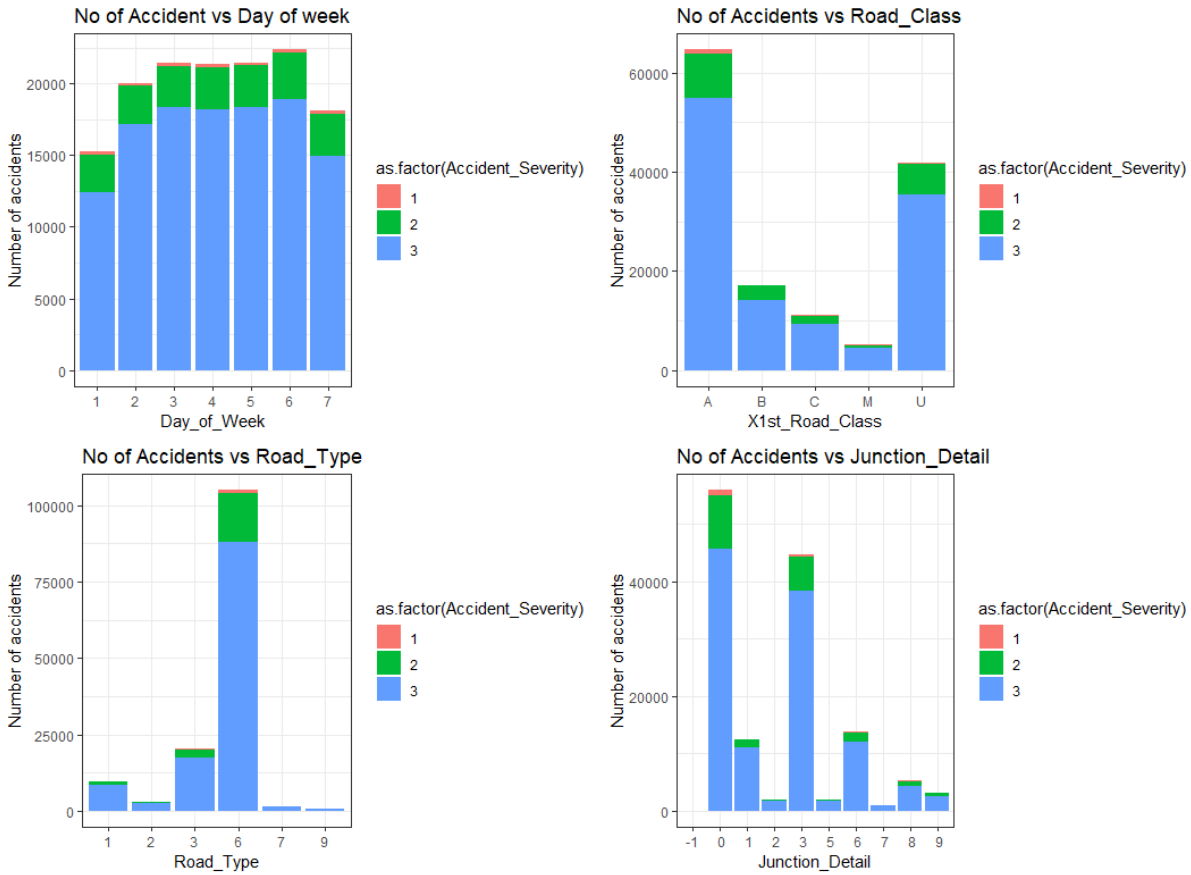

Figure 2: Number of accidents by different variables in Accident dataset

The first graphs show that more accidents tend to happen on the weekdays rather than on the weekends. A maximum number of accidents seem to take place on day 6(Fridays). The third plot shows that most accidents happen on road type 6, which stands for single carriageway. According to the last graph, most accidents happen at junction 0(not a junction) and 3(T or staggered junction).

The second plot indicates that maximum accidents occur on A roads, followed by the unclassified 'U' category roads. Also, the maximum number of fatal accidents happen on the A roads.

We can identify accident hotspots by doing the geospatial analysis of accidents data. A number of accidents was plotted on the UK map based on their location information, and we obtained the following plot.

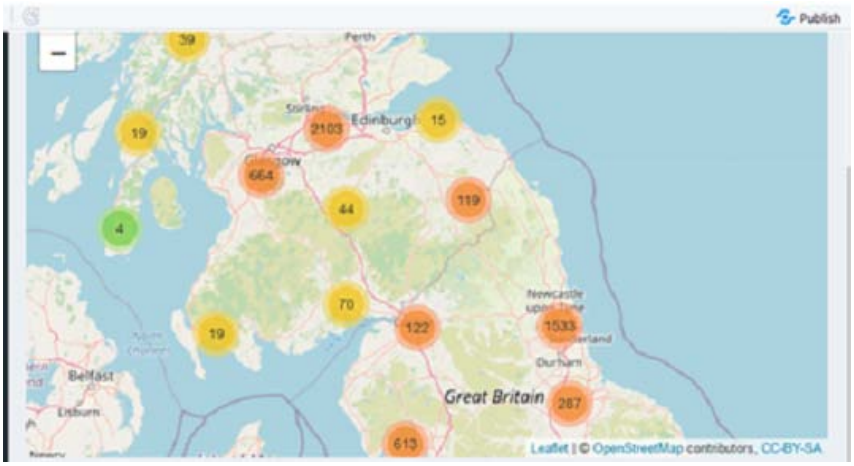

Figure 3: Accident hot spots on the UK map

To thoroughly understand the distribution of the flow of traffic amongst different types of vehicles, ratios of AADF values to the types of vehicles were calculated. The following graph was obtained:

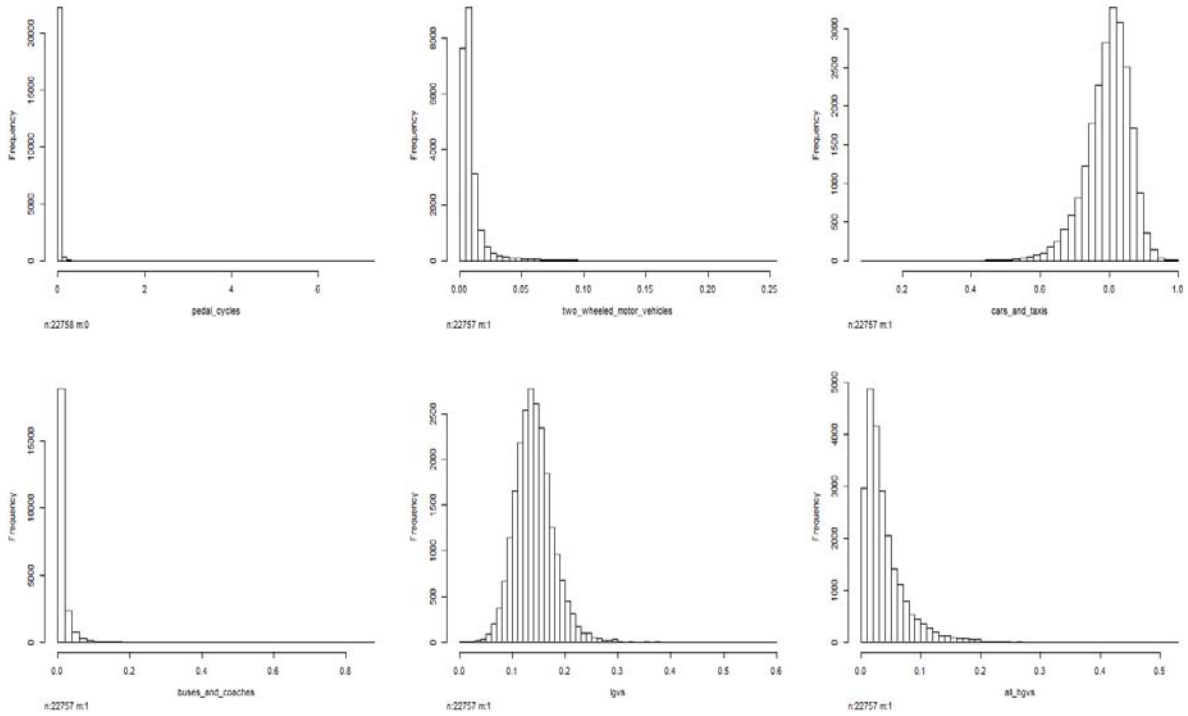

Figure 4: Ratio of AADF to vehicle types

The above plot shows that the ratio of pedal cycle, two-wheelers and buses and coaches is centered more towards 0, suggesting that there are fewer roads that have a high distribution of these vehicles on average. The distribution of ratios for large goods vehicles(LGVs) is between 0 to 0.3, and that for heavy goods vehicles (HGV) is between 0 and 0.2. We get the maximum ratio for the cars and taxis(between 0.6 to 1.0), which is the trend that one would typically expect on any UK road.

We visualized the distribution of accident-severity concerning the age and sex of the driver available in the vehicle dataset.

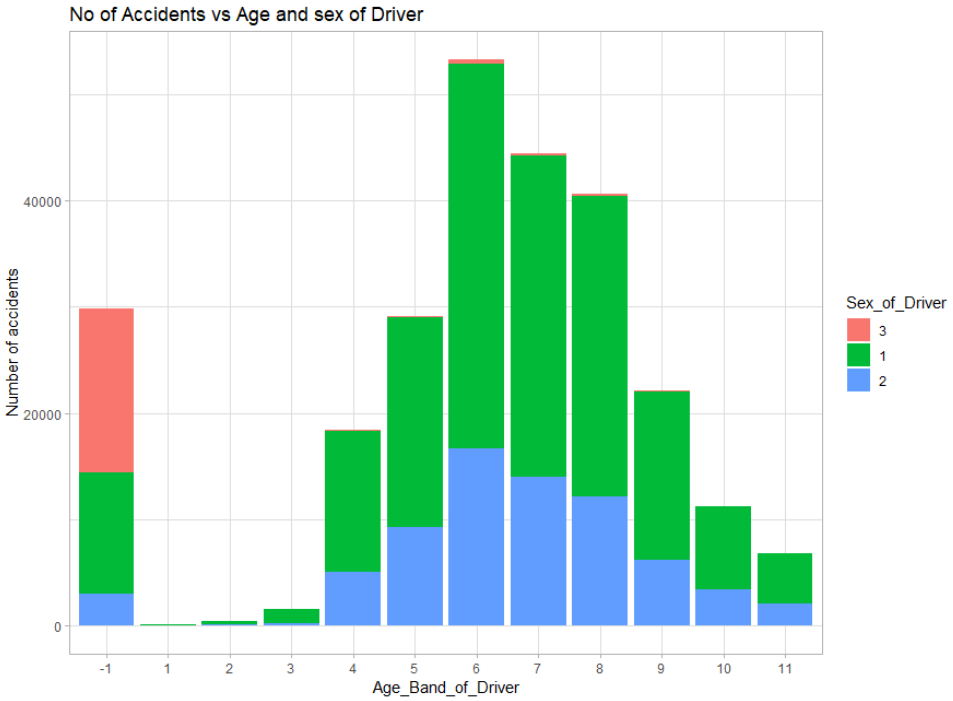

Figure 5: Number of accidents by age and sex of the driver

Here 1(green) represents male drivers, 2(blue) represents female drivers, and 3 is unknown gender. This graph clearly shows that male drivers are more likely to be involved in motor accidents than female drivers. The graph peaks at the age band 6, which represents the age range 26-35 years, showing that this age range is more likely to be involved in accidents than the other age bands.

c) Modeling

After the exploratory analysis of the dataset, some models were created in Python and evaluated for their performance. Before starting the modeling process though, some important decisions were taken.

Choice of Metric: A classifier is only as good as the metric used to evaluate it. A wrong metric misleads into believing that the classifier is working fine. Standard performance metrics treat all the classes in a multiclass problem as equally important. Whereas, in imbalanced classification problems, minority classes are often more important than the majority classes.

Following the general guidelines given by Jason Brown in his book [8], we decided to use F2- measure as a metric for model evaluation. In this case, False Negatives are more costly than False Positives. Meaning that if there is a likelihood of an accident happening at some location and we reported as negative (False Negative), it could be dangerous. On the other hand, if there is less probability of accidents happening and is flagged as an accident (False Positive), it was okay because it would warn the driver to be more cautious while driving. We calculated F2 measure as

$$\text{F2-measure} = \frac{(1+2^2)\ \text{X Precision X Recall}}{2^2\ \text{X Precision} + \text{Recall}}$$

Generalization of F-beta score is calculated with the value of beta being equal to 2. Beta value 2 means that more emphasis is given on Recall than Precision.

Spot Checking the Algorithms: Spot-checking machine learning algorithms means evaluating a suite of different machine learning algorithms with minimum hyper tuning. Thus, giving each algorithm a fair chance to perform under comparable conditions. Spot-checking helps us decide which algorithms to use for the final model.

We used the following framework for spot-checking: -

Linear Algorithms: We checked the following linear algorithms.

- Logistic Regression
- Linear Discriminant Analysis
- Naïve Bayes

Non-Linear Algorithms: Nonlinear algorithms tend to perform better when the problem is inherently non-linear.

- Decision Trees
- Support Vector Classifier

Ensembles: Ensembles are the group of algorithms, whose predictions are combined to give a better performance. Models tested here were:-

- Random Forest
- Bagging
- Adaboost

Sampling: Sampling is the process that attempts to reduce the class imbalance by decreasing the number of samples in the majority class(also called under-sampling) or by increasing the number of samples in the minority class(also known as over-sampling).

Cost-sensitive learning: Normal algorithms treat all the classes as equal. We can change this trend by enforcing cost-sensitive learning, in which we applied a cost to penalize the model if it does not predict the minority class correctly.

V. Model Evaluation and Testing

a) Linear and Non-linear Models

All the linear, non-linear, and ensemble models were trained on the training set using the 10-fold cross-validation method. The models were beyond the computing capacity of the laptop they were training on. Hence we decided to do the training on the cloud "floydhub". Floydhub is an extremely easy to use and intuitive platform for running python scripts on the cloud. We then recorded the average of the F2-scores and standard deviation.

Table 1: Performance of linear and non linear models

Name of the Model	Average of f2 Scores	Standard Deviation of scores	Time taken
Linear Regression	0.804	0.000	10s
Linear Discrminant Analysis	0.801	0.001	5s
Naïve Bayes	0.795	0.001	3s
Decision Tress	0.804	0.000	5s
Linear SVC	0.804	0.000	25s
Bag	0.806	0.000	16m48s
Random Forest	0.806	0.000	3m32s
Adaboost	0.805	0.000	3m41s

Performance of the above models was compared using a box and whisker plot.

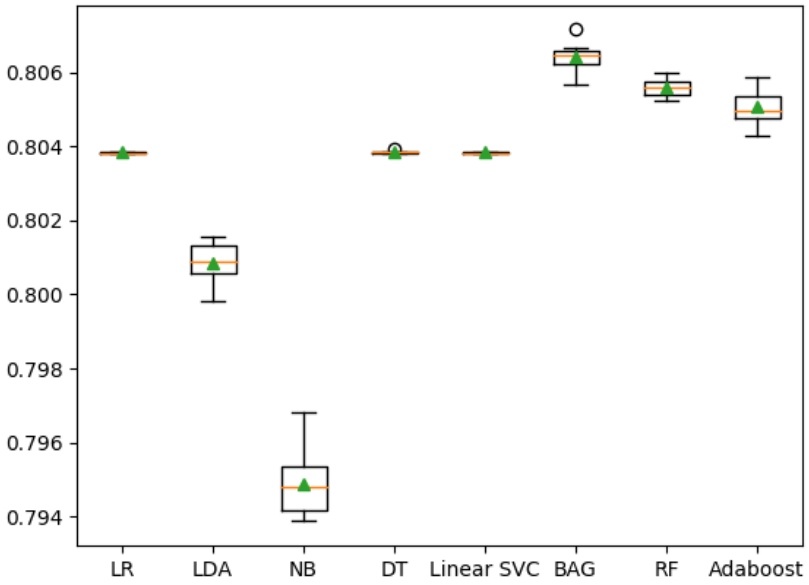

Figure 6: Box and whisker plot comparing performance of models

As expected, ensemble models have better f2-scores than the rest of the models. The bagging model has the best F2 value for the training set. Random Forest comes a close second. In terms of consistency, linear regression model, Decision trees, and Linear Support Vector Classifier performed uniformly across the folds. Naïve Bayes gave the worst performance of all, but it was the fastest to train. In terms of training time, the bagging algorithm was the most expensive one, giving only marginal improvements over some other algorithms.

After comparing the Precision and Recall values and the overall weighted f2-score,we decided to investigate the final four models further - Linear Regression, Naïve Bayes, Random Forest, and Adaboost.

b) Sampling Methods

The distribution of observations across different classes (accidents severity):-

1	2	3
3382	41947	231842

The above table showed that the data distribution was highly skewed amongst the three classes with the 83% of the total accidents belonging to class 3(mild), nearly 16% belonging to class 2(serious) only 1% of the accidents belonging to class 3 that represents the fatal accidents.

Most machine learning algorithms are designed such that they perform the best if trained on the problems with equal class distribution throughout the dataset. When this is not the case, models learn to conclude that very few minority class instances exist. Hence, they are not critical and can be ignored. But this is far from true.

For this project, we investigated under-sampling methods and the combination of under-sampling and over- sampling method. In the combination method, we oversampled Class 1 using SMOTE(Synthetic Minority Over Sampling Technique) by the ratio of 4. The other two classes were under-sampled using random under-sampling. The ratio of the three classes 1:2:3 was 4:0.8:0.4. In this technique, the number of samples of minority class was increased, and that of majority class was decreased, while maintaining the imbalance, thus training the model on more realistic data.

After the sampling, we trained the four best-performing models on this data and tabulated their results. Sometimes the training error gives optimistic results, but the model does not perform well on the test dataset. Hence we also tested these models on the test set, and included their F2 scores in the table.

Table 2: Performance of models on sampled data

Name of the model	Average of Training f2 scores	Standard deviation	Test F2 score
Under-sample LR	0.788	0.000	0.804
SMOTE LR	0.601	0.000	0.804
Under sample NB	0.779	0.001	0.794
SMOTE NB	0.608	0.002	0.778
Under sample RF	0.791	0.000	0.804
SMOTE RF	0.707	0.003	0.804
Under sample Adaboost	0.789	0.000	0.803
SMOTE Adaboost	0.683	0.002	0.802

Sampling failed to produce any better results. Hence it was decided to drop sampling and proceed with training on the unsampled data.

c) Merging two classes

The classification problem that we were trying to solve here is a multiclass classification with three classes- Fatal, Serious, and Mild. For the accident dataset, accidents that involved deaths were defined as fatal accidents and accidents that involved a serious injury to the driver or passengers were classified as severe accidents. From a driver's point of view, whether he gets a red warning for a fatal accident or an amber alert for a severe accident, it should not make much of a difference. Moreover, in the multiclass classification models trained above, we saw that most of the classifiers ignored class 2. And for class 2, the recall value was relatively low in most of the models examined.

One way to deal with this problem was by combining the classes fatal and severe. The multi-classification problem now became a binary classification problem with two classes – minority(serious + fatal) and majority(mild).

We then trained the best performing algorithms, chosen earlier on the data with two classes and we plotted their performance in following box and whisker plot.

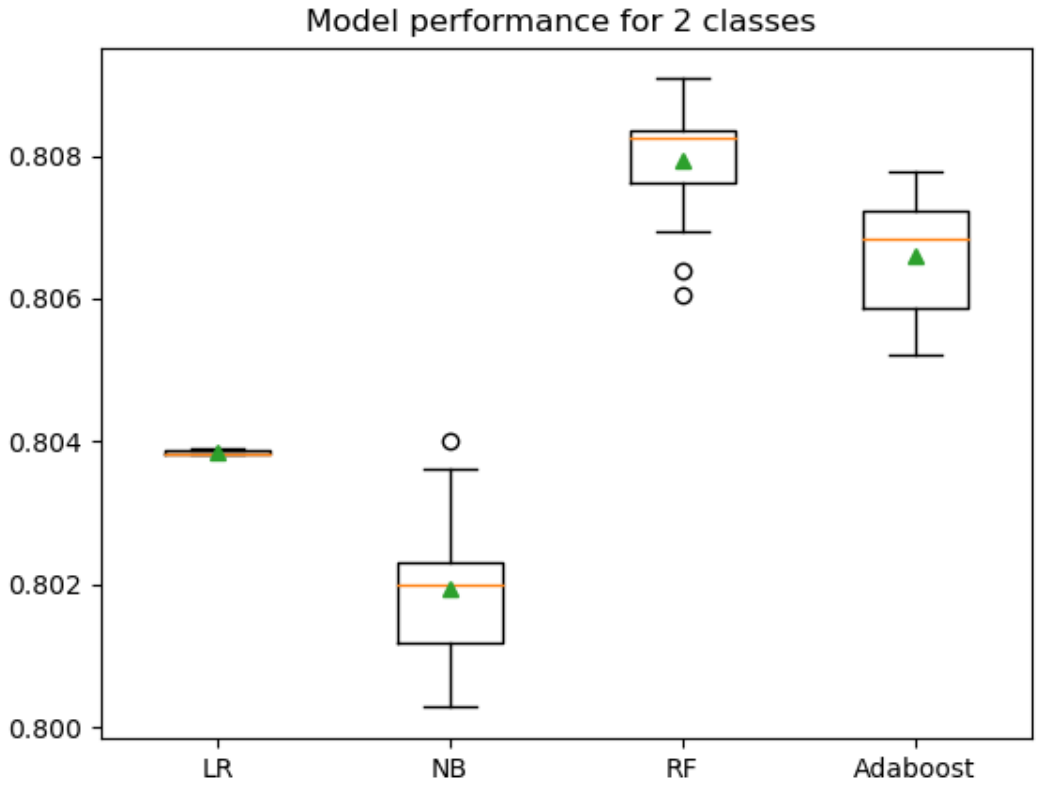

Figure 7: Performance comparison for binary classification

F2 measure of Random Forest algorithm went up on a 2-class version of data. Random Forest also gave the best recall for class 1(minority class).

Out of all the models investigated thus far, the random forest had the best f2- score and the recall value for minority class - class 1. We then tuned the random forest model with different parameter values and performed weighted learning. In the weighted learning, a model is penalized for misclassifying the minority class. The resulting random forest performed well both on training as well as testing data. The best recall for class 1 obtained for this model is 0.71. The accuracy of the model was found to be 0.83, and the confusion matrix obtained:

[43996 1151]
[7931 958]

VI. Conclusion

This project attempted to identify the key factors responsible for motor accidents happening across the UK and created models to correctly classify the accidents by their severity level. The historical records of accidents datasets were analyzed to understand the trends and to see if any critical factors could be identified while classifying accidents into 3 different classes- Mild, Serious, and Fatal. Different types of predictor variables were analyzed concerning the frequency of accidents. The variables included temporal variables like time of the day, month etc. A strong correlation was found between the time of the day and the number of accidents.

Geo-spatial factors were studied to see if they contribute to the severity of the accidents. A graph between the road class and accident severity revealed that the maximum number of accidents happen on A-class roads and not on the motorways, where the speed limit is usually more. Weather data, which was initially thought to be an important contributor in accidents, surprisingly did not emerge as a critical factor. More than 80% of the accidents happen on bright days with no heavy rains/ snow.

Coming to the question –' What are the key factors responsible for accidents?' On examining the feature importance of our chosen random forest model, the following plot was obtained.

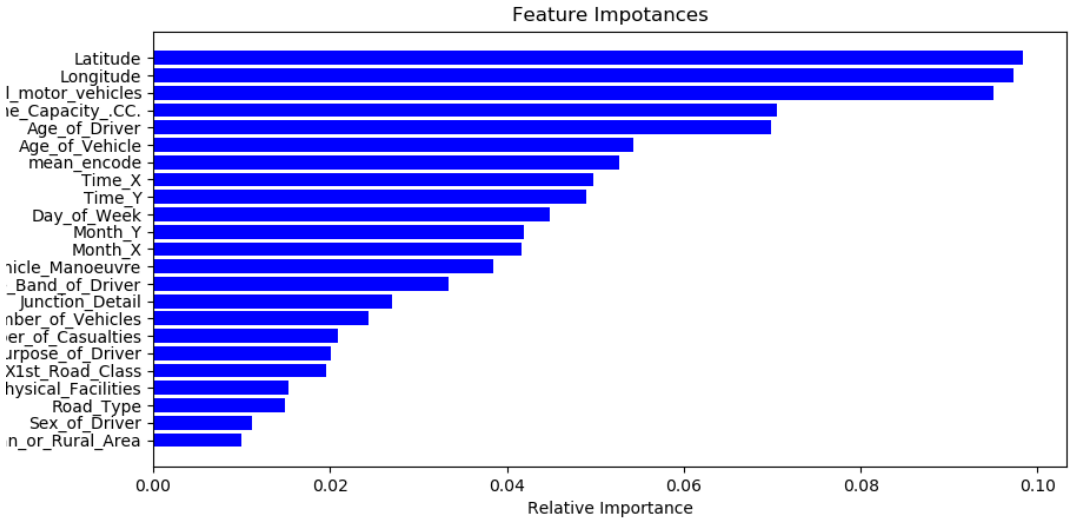

Figure 9: Feature Importance plot of all the features

From the features point of view, the geographical position is an essential feature in determining the accident probability. The latitude and longitude values were used to find the accident hotspots across the UK. The traffic flow data was the third most crucial feature in classifying accidents. Some of the engineered features proved to be particularly important from a classification point of view. Time features like month; day of the week proved to be important as well.

Accident prediction is inherently a difficult problem to solve and this project is a small step forward in facilitating progress on the same. With the systematic approach presented here, we introduced a model that gave promising results and classified accidents with an excellent f2 score estimate and a good recall score for the accident class. With more time, it would be a good idea to explore other possibilities for the ensembles in modeling the data. Ensembles generally tend to perform better than the individual classifiers. A warning system could be developed to warn the drivers in real-time using the model developed here.

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Intelligent Vehicular Traffic Control System using Priority Longest Queue First Model

By Samuel S. Udoh, Francis B. Osang, Olutola O. Fagbolu & Michael E. Isang

University of Uyo

Abstract- Traffic congestion of vehicles at road intersections is a growing problem in many developing countries of the world, especially in large urban areas. This stems from a continuous increase in the human population, poor road networks and the proliferation of vehicles for transportation of humans and goods from one location to another towards the performance of civil, social and economic activities. These vehicles often meet at road intersections and desire the Right-of-Way (RoW) towards their destination. This situation always results in race competition, traffic jam and gridlock condition with its attendant effects on time, fuel wastages as well as accident and fire outbreak which often results to loss of lives and property. The conventional traffic light control system which employs a static time cycle for issuance of RoW to each lane at the intersection lacks human-like intelligence and traffic situational awareness.

Keywords: intelligent system, priority longest queue, vehicular traffic, interval type-2 fuzzy logic.

GJCST-D Classification: I.2.0

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Intelligent Vehicular Traffic Control System using Priority Longest Queue First Model

Samuel S. Udoh [α], Francis B. Osang [σ], Olutola O. Fagbolu [ρ] & Michael E. Isang [ω]

Abstract- Traffic congestion of vehicles at road intersections is a growing problem in many developing countries of the world, especially in large urban areas. This stems from a continuous increase in the human population, poor road networks and the proliferation of vehicles for transportation of humans and goods from one location to another towards the performance of civil, social and economic activities. These vehicles often meet at road intersections and desire the Right-of-Way (RoW) towards their destination. This situation always results in race competition, traffic jam and gridlock condition with its attendant effects on time, fuel wastages as well as accident and fire outbreak which often results to loss of lives and property. The conventional traffic light control system which employs a static time cycle for issuance of RoW to each lane at the intersection lacks human-like intelligence and traffic situational awareness. It is incapable of giving preferential treatment to signals from vehicles on critical-missions such as hospital ambulances carrying accident victims, fire service vehicles on critical rescue missions and security patrol vehicles on time-dependent operations. The conventional system does not also consider the queue density on each lane to determine the proportion of time allotment for RoW. This paper proposes a Priority Longest Queue First(PLQF) model for the assignment of RoW to vehicles at traffic intersections. The PLQF model was formulated using mathematical equations. Time allotment strategy was incorporated using interval type-2 fuzzy logic model. Inputs to the model were queue density, average waiting time and vehicle priority, while time allotted for RoW served as the output. The system was simulated using Java Development Toolkit (JDK) 8.0 and tested using traffic data collected from heavy traffic intersections at Uyo, Nigeria. Results showed superior performance of PLOF model over the conventional traffic system in terms of selection of lane and dynamic allotment of time for right-of-way.

Keywords: intelligent system, priority longest queue, vehicular traffic, interval type-2 fuzzy logic.

I. Introduction

Traffic congestion constitutes serious problems and a threat to road users with its attendant effects on grid lock, noise pollution, long waiting hours, wastage of fuel, time and money as well as accident which might result in loss of lives and property. In large urban cities, intelligent traffic signal controller plays an important role in improving the efficiency of vehicles and traffic congestion thereby reducing travel time, noise pollution, carbon dioxide emission and amount of fuel used (Javed *et al.* 2015). Conventional traffic controller comprises a constant cycle of actions to be carried out based on received signals whose output are displayed in colours for instance red (stop), yellow (get-ready) and green (go) (Lee *et al*. 2002). Conventional traffic controller also grants equal allotment of time to each of the traffic routes (Maslekar *et al.* 2011). Equal time allotment to all routes is fair if all the routes have equal traffic density. This is seldom true in real-life traffic situations. At a given traffic intersection, there could be lanes with very high traffic density while others might have very low density. Marco (2014) opined that the strategies employed in conventional models' light control such as the use of constant cycle time for traffic control do not consider the traffic densities and analysis of situations at traffic intersections, thereby lacking adequate knowledge needed for dynamic response to complex and time-varying traffic scenarios. The static scheduling models grant cyclical permission and RoW to vehicles at intersections with no recourse to high traffic density routes or emergencies. This problem could be solved by incorporation ofthe Priority Longest Queue First (PLQF) model at the traffic controller. The PLQF model evaluates the density of each lane as well as the emergency signal to select the lane for traffic flow. Incorporation of an intelligent tool such as interval type-2 fuzzy logic for traffic pattern evaluation facilitates dynamic time allotment based on queue parameters. Fuzzy Logic (FL) developed in (Zadeh1975) as a mathematical tool for dealing with imprecision and uncertainty has been successfully applied in (Obot 2007; Inyang 2014; Udoh 2016, Udoh *et al.*2017, Udoh *et al.* 2019) for pattern classification and derivation of definite conclusions from vague and ambiguous information. In this work, PLQF was formulated for the selection of lanes for RoW. The data (queue density, average waiting time, number of priority vehicles) of the selected lane served as input to interval type-2 fuzzy logic module for pattern classification to guide traffic time allocation. In the remaining parts of this paper, reviews of some related works on vehicular control models are presented in section 2. The concept of PLQF model for traffic control is presented in section 3. Sections 4 and 5 contain results of simulations of the

Author α ω: Department of Computer Science, University of Uyo, Uyo, Nigeria. e-mails: samueludoh@uniuyo.edu.ng, mikeisang@yahoo.com
Author σ: National Open University of Nigeria, Abuja, Nigeria. e-mail: fosang@noun.edu.ng
Author ρ: Department of Mathematics and Statistics, Fourah Bay College, University of Sierra Leone, Freetown, Sierra Leone. e-mail: fagbolu.olutola@usl.edu.sl

PLQF model and the conclusion of the work respectively.

II. Related Works

Tubaishat et al. (2007), investigated vehicular traffic control system using wireless sensors. The sensors were installed at designated locations at the traffic intersection. The number of vehicles between two sensors at each lane of the intersection formed the queue density for that lane. Results showed that the distance between two sensors on the same lane had no significant effect on traffic volume. The average waiting time of vehicles was not compared with other traffic control models to ascertain the performance of the proposed system. The work in (Zhou *et al.* 2010) developed an adaptive traffic light control algorithm that adjusted both the sequence and length of the traffic light in accordance with the real-time traffic situation. The algorithm selected the sequence of phases among a set of conflict-free situations according to multiple criteria: traffic volume, priority vehicles, waiting time, starvation degree and queue lengths. Results showed that traffic throughput was maximized and average waiting time was minimized. However, the algorithm was based on the assumption that all vehicles were of the same type and run at the same speed. This is rarely true in a typical traffic scenario. Osigwe, *et al.*(2011) presented a hybrid methodology obtained from the crossing of the structured system analysis and fuzzy logic-based design methodologies. An analysis of current traffic systems in Nigeria was carried out which necessitated the design of an intelligent traffic control system. Java software was used for the simulation of the system. The fuzzy logic provided better performance in terms of total waiting time and total moving time. Emergency and high-priority vehicles were not captured in the design. The work in (Prajakta *et al.* 2011)surveyed multi-agent techniques for traffic congestion management. Limitations of existing non-multi-agent-based congestion management techniques were found to include lack of robustness, coordination and adaptivity which predominantly stem from factors such as lack of communication between elements of the traffic control system. This limits the capability of existing systems to act autonomously and respond to fast-changing traffic conditions. In (Harpel *et al.* 2012), an intelligent traffic light based on Radio Frequency Identification (RFID) was proposed. The work gave priority to emergency vehicles but did not consider high-density lanes. Lack of consideration of high-density lanes led to increase in traffic jams and average waiting time at traffic intersections. The work in (Escalera *et al.* 2013) employed a fuzzy type-1light controller to control the phase-splits of the traffic light at road intersections. The system provided better performance in terms of total waiting time but lacked the capacity for adequate handling of uncertainties in traffic input parameters. In (Rajeswaran and Rajasekaran 2013),Cellular Automata (CA) model was explored to model traffic flow. The traffic intersection was mathematically idealized with vehicles and time viewed as discrete quantities. The CA model was applied to a single-lane highway with a ring topology and a two-lane traffic flow intersection. Performance metrics were generally obtained through computer simulation of the evolution of the cellular automaton over time. Anuran *et al.*(2014) proposed an Intelligent Traffic Control Systems (ITCS) using Radio Frequency Identification (RFID). The ITCS comprised a set of two RFID readers, separated by some distance, in each direction of a road crossing and a Central Computer System (CCS) to control them. As a vehicle passed by a reader, it tracked the vehicle through the RFID tag attached to the vehicle and retrieved its electronic product code data which primarily consisted of a Vehicular Identification Number (VIN). Through a table look-up procedure, the VIN was matched against individual vehicle records and details such as type, weight, length, registration, pollution control status and the owner's identification were retrieved. The data was sent to the CCS for computation. The CCS employed a central database processing system for computing vehicular data and a decision-making section for controlling the traffic signals. The system was implemented in real-time. It helped in tracking stolen vehicles as well as vehicles booked for violating traffic rules. Peculiarities for high-priority vehicles were envisaged for preferential allotment of right-of-way. An interrupt handler was suggested to suspend normal automation in case of emergency. Human-like intelligent tools were not incorporated to handle dynamic time allotment on the lanes. Pati (2016) proposed an intelligent traffic control system based on K-mean algorithm. The system considered high-priority vehicles such as ambulance and fire service vehicles. Tools were not incorporated for dynamic allotment of time for RoW to the traffic lane. Analysis of traffic scenario was carried out using a single lane hence could not capture the ideal situation at multi-lanes traffic intersection. In (Uthara and Athira, 2018), image processing technique was employed in the design of density-based traffic control system. A webcam was used in each lane of the traffic light in order to take pictures of the roads where traffic was bound to occur. Counting of vehicles was carried out using image processing tools in Mat Lab environment. Different timings were allocated for RoW on the lanes based on the counts. The design of a smart traffic controller for vehicles and pedestrians was implemented in Adnan *et al.* (2018) using fuzzy logic tools in a Mat Lab environment. The system allotted different time signals for RoW at different lanes based on queue density. Considerations were not given to high-priority vehicles like ambulance, fire service, police patrol teams, and so on. This hindered the human-like

preferential considerations at traffic intersections. Zhuzhou *et al.* (2019), used Simulation of Urban Mobility (SUMO), an open-source, microscopic and multi-modal traffic simulation software to extract vehicle density at the traffic intersection in Vehicular Adhoc Network (VANET) environment. The Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) interaction technologies created better conditions for collecting the whole time-space and refined traffic data. A real-time traffic density extraction method was proposed to cater for lane density and road network density. The extracted traffic densities could be employed for efficient traffic management at traffic intersections.

III. Methodology

The conceptual architecture of the Intelligent Vehicular Traffic Control System (IVTCS)is presented in figure1. The architecture comprises the component of the IVTCS and the relationship among them.

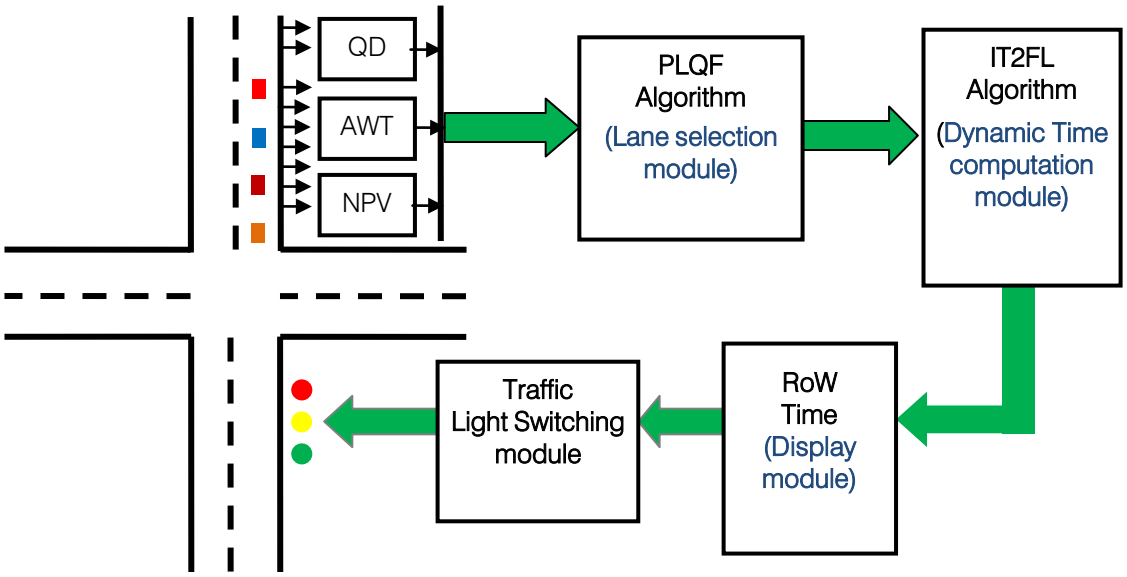

Figure 1: Conceptual Architecture of Intelligent Vehicular Traffic System

The proposed system framework is shown in Figure 1 consists of the following components:

1. Inputs: These are parameters used in selecting the optimal lane as well as computing the traffic time. These traffic parameters are Queue Density (QD), Average Waiting Time (AWT) and Number of Priority Vehicles (NPV).
2. Priority Longest Queue First (PLQF) model is proposed in this work to determine the optimal lane at any given instance.
3. Interval Type-2 Fuzzy Logic (IT2FL) algorithm is used to evaluate the traffic time based on the input parameters (called crisp input).
4. Right-of-Way (RoW) Time value – This is the output of the fuzzy logic algorithm (the crisp output), the value is used in allotting time for right-of-way for the selected lane,
5. Traffic Light Switching module – This is the interface that switches the traffic lights based on the lane selected by PLQF and time allotted by IT2FL algorithm.

a) Formulation of Priority Longest Queue First (PLOF) Model

The formulation of the PLOF model using mathematical equations is presented as follows:
Let the traffic function λ at the moment m_t at a traffic intersection with lanes *r* be modeled by equations 1 to 22

$$\lambda = m_t(\bar{x}_r\ ,\ p_r\ ,\ q_r) \quad \big|(t,\ r\ \in \mathbb{Z}^+) \tag{1}$$

$$\bar{x}_r = \frac{\sum_{i=1}^{n}(x_{r,i})}{n} \tag{2}$$

$$\varphi_r = \omega\big(\alpha(p_r)\big) \tag{3}$$

$$f(\varphi_r(p_r;[a_1,a_2],b,[c_1,c_2])) = \begin{cases} 0, & p_r \le [a_1,a_2] \\ \frac{p_r-[a_1,a_2]}{b-[a_1,a_2]}, & [a_1,a_2] \le p_r \le b \\ \frac{[c_1,c_2]-p_r}{[c_1,c_2]-b}, & b \le p_r \le [c_1,c_2] \\ 0, & [c_1,c_2] \le p_r \end{cases} \quad (4)$$

$$f(\varphi_r(q_r;[a_1,a_2],b,[c_1,c_2])) = \begin{cases} 0, & q_r \le [a_1,a_2] \\ \frac{q_r-[a_1,a_2]}{b-[a_1,a_2]}, & [a_1,a_2] \le q_r \le b \\ \frac{[c_1,c_2]-q_r}{[c_1,c_2]-b}, & b \le q_r \le [c_1,c_2] \\ 0, & [c_1,c_2] \le q_r \end{cases} \quad (5)$$

$$f(\varphi_r(\bar{x}_r;[a_1,a_2],b,[c_1,c_2])) = \begin{cases} 0, & \bar{x}_r \le [a_1,a_2] \\ \frac{\bar{x}_r-[a_1,a_2]}{b-[a_1,a_2]}, & [a_1,a_2] \le \bar{x}_r \le b \\ \frac{[c_1,c_2]-\bar{x}_r}{[c_1,c_2]-b}, & b \le \bar{x}_r \le [c_1,c_2] \\ 0, & [c_1,c_2] \le \bar{x}_r \end{cases} \quad (6)$$

$$\tau_r = f(\varphi_r(p_{r,}\ q_{r,}\ \bar{x}_r) \quad (7)$$

where

$\bar{x}_r$ is the average waiting time of vehicles starting at point (s_1) and stopping at point (s_2) at r^{th} lane of the intersection.

$x_{r,i}$ is the arrival time of i^{th} vehicle at r^{th} lane of the intersection.

p_r is the number of priority vehicles at r^{th} lane of the intersection

$q_{r,}$ is the queue length of vehicles at r^{th} lane of the intersection, obtained by counting the number of vehicles in the section within points ($s_{1,}$ s_2)

$\mathbb{Z}^+$ is the set of positive integers

α is the priority comparison function

ω is the priority ordering function

φ_r is the lane priority selection function.

$f(\varphi_r(p_r))$ is the interval type 2 fuzzy function for lane priority

$f(\varphi_r(q_r))$ is the interval type 2 fuzzy function for queue length of the selected lane

$f(\varphi_r(\bar{x}_r))$ is the interval type 2 fuzzy function for mean arrival time of the selected lane

a is the left leg of the triangular membership function,

b is the center of the membership function (it is constant for both upper and lower membership functions)

c is the right leg of the membership function, $[a_1,a_2]$ is the left leg of the lower and upper membership function, and $[c_1,c_2]$ is the right leg of the lower and upper membership functions.

τ_r is the dynamic time allotment function for right-of-way to r^{th} lane of the intersection

b) The Karnik Mendel Algorithm

The Karnik Mendel (KM) Algorithm is employed for interval type-2 fuzzy logic reduction. The algorithm seeks to find switch points (L, R), leftmost point (y_l) and the rightmost point (y_r)as expressed in equations 8 and 9 respectively

$$\underline{y}^L \leq y_l \leq \underline{y}^{L+1} \quad (8)$$

$$\bar{y}^R \leq y_r \leq \bar{y}^{R+1} \quad (9)$$

KM Algorithm for Computing y_l

Step 1: sort $\underline{y}^n$ (n = 1, 2, … , N) in increasing order and call the sorted $\underline{y}^n$ by the same, but now $\underline{y}^1 \leq \underline{y}^2 \leq \cdots \leq \underline{y}^N$. Match the weights $F^n(X')$ with their respective $\underline{y}^n$and renumber them so that their index corresponds to the re-numbered $\underline{y}^n$.

Step 2: Initialize f^n by setting

$$f^n = \frac{\underline{f}^n + \bar{f}^n}{2} \quad n = 1,2,\ldots,N \quad (10)$$

And then compute

$$y = \frac{\sum_{n=1}^{R} \underline{y}^n f^n}{\sum_{n=1}^{R} f^n} \quad (11)$$

Step 3: Find the switch point $k\ (1 \leq k \leq N-1)$ such that

$$\underline{y}^k \leq y \leq \underline{y}^{k+1} \quad (12)$$

Step 4: Set $f^n = \begin{cases} \bar{f}^n, n \leq k \\ \underline{f}^n, n > k \end{cases}$ (13)

And compute

$$y' = \frac{\sum_{n=1}^{N} \underline{y}^n f^n}{\sum_{n=1}^{N} f^n} \quad (14)$$

Step 5: Check if $y' = y$. If yes, stop and set $y_l = y$ and L = k. if no, go to Step 6.

Step 6: Set $y = y'$ and go to Step 3

KM Algorithm for Computing y_r

Step 1: Sort $\bar{y}^n$ (n = 1, 2, … , N) in increasing order and call the sorted $\bar{y}^n$ by the same, but now $\bar{y}^1 \leq \bar{y}^2 \leq \cdots \leq \bar{y}^N$. Match the weights $F^n(X')$ with their respective $\bar{y}^n$and renumber them so that their index corresponds to the re-numbered $\bar{y}^n$.

Step 2: Initialize f^n by setting

$$f^n = \frac{\underline{f}^n + \bar{f}^n}{2} \quad n = 1,2,\ldots,N \quad (15)$$

And then compute

$$y = \frac{\sum_{n=1}^{N} \bar{y}^n f^n}{\sum_{n=1}^{N} f^n} \quad (16)$$

Step 3: Find the switch point $k\ (1 \leq k \leq N-1)$ such that $\bar{y}^k \leq y \leq \bar{y}^{k+1}$

Step 4: Set $f^n = \begin{cases} \underline{f}^n, n \leq k \\ \bar{f}^n, n > k \end{cases}$

And compute

$$y' = \frac{\sum_{n=1}^{N} \bar{y}^n f^n}{\sum_{n=1}^{N} f^n} \quad (17)$$

Step 5: Check if $y' = y$. If yes, stop and set $y_r = y$ and R = k. if no, go to Step 6.

Step 6: Set $y = y'$ and go to Step 3

The algorithm to find the leftmost and the rightmost points are given in Equations18 and 19

$$y_l = \min_{L \in [1,N-1]} \frac{\sum_{n=1}^{L} \bar{f}^n \underline{y}^n + \sum_{n=L+1}^{N} \underline{f}^n \underline{y}^n}{\sum_{n=1}^{L} \bar{f}^n + \sum_{n=L+1}^{N} \underline{f}^n} \quad (18)$$

$$y_r = \max_{R \in [1,N-1]} \frac{\sum_{n=1}^{R} \underline{f}^n \bar{y}^n + \sum_{n=R+1}^{N} \bar{f}^n \bar{y}^n}{\sum_{n=1}^{R} \underline{f}^n + \sum_{n=R+1}^{N} \bar{f}^n} \quad (19)$$

where: $\bar{f}^n$is Upper Firing Strength, $\underline{f}^n$is Lower Firing Strength, $\bar{y}^n$ is Upper Consequent Set, $\underline{y}^n$ is Lower Consequent Set, *N* is Number of Firing Rules

c) Inference Engine

A Mamdani type inference mechanism is used to evaluate the rules in the rule-base against the fuzzy set. This is done using Equations (20) – (22)

$$F^i(x') = \left[\underline{f}^i(x'), \overline{f}^i(x')\right] \equiv \left[\underline{f}^i, \overline{f}^i\right] \mathrm{E} \quad (20)$$

$$\underline{f}^i(x') = \underline{\mu}_{\tilde{F}_1^i(x')} * \ldots * \underline{\mu}_{\tilde{F}_1^i(xp')} \quad (21)$$

$$\overline{f}^i(x') = \overline{\mu}_{\tilde{F}_1^i(x')} * \ldots * \overline{\mu}_{\tilde{F}_1^i(xp')} \quad (22)$$

where:

$\underline{f}^i(x')$ is the antecedent set of lower membership function

$\overline{f}^i(x')$ is the antecedent set of upper membership function

$\underline{\mu}_{\tilde{F}_1^i(x')}$ is the fuzzy set of lower membership function

$\overline{\mu}_{\tilde{F}_1^i(xp')}$ is the fuzzy set of upper membership function

i is the rule number

d) Algorithm implementing PLQF

The pseudo code implementing the PLQF algorithm is given as follows:

1. PLQF (m_t, $\bar{x}_r$, p_r, q_r)
2. BEGIN
3. // traffic parameters
4. m_t is the moment of traffic capture at intersection; $t \in \mathbb{Z}^+$// $\mathbb{Z}^+$is a set of positive integers
5. *r* is number of lanes at traffic intersection; $r \in \mathbb{Z}^+$
6. $\bar{x}_r$is the average waiting time of vehicles at specified section of r^{th} lane
7. p_r is the number of priority vehicles at r^{th} lane of the intersection

8. q_r is the queue length of vehicles at r^{th} lane of the intersection
9. sis traffic controlsignal // (s = 0: means continue; s = 1: means stop control)
10. Initialize; s = 0
11. DO WHILE s = 0
12. At moment m_t the traffic function (λ) at the intersection depends on: $(\bar{x}_r\ ,\ p_r\ ,\ q_r)$
13. Call the priority comparison function (α) to compare the priorities of vehicles p_r
14. Call the priority ordering function (ω) to sort the lanes based on ascending order of p_r
15. For r = 1 to n
16. Select the lane for issuance of the right-of-way based on the order obtained in step 14
17. In each selected lane (φ_r), implement interval type-2 fuzzy logic on: $(\bar{x}_r\ ,\ p_r\ ,\ q_r)$
18. Apply KM Algorithm in Equations (8) - (19) for Type Reduction and Equations (20)– (22) for inferencing in Step 17
19. Determine the time $(\tau_r)$for right-of-way based on the output in step 17
20. Next r
21. IF stop traffic signal is received Then
22. Go To step 28
23. Else
24. s = 0
25. $m_t = m_{t+1}$
26. Go To step 11
27. END IF
28. END DO
29. END //end Algorithm PLQF

IV. Results and Discussion

The PLQF algorithm was programmed using Java Development Toolkit (JDK) 8.0. In order to assess the practical function of the program, the system was simulatedusing1020 traffic data scenarios collected from three (3) traffic intersection sat Uyo, Akwa Ibom State, Nigeria. Data attributes collected were: Average Waiting Time (AWT) of vehicles on each lane, Queue Density (QD) and Number of Priority Vehicles (NPV) on each lane. The PLQF program employed data captured at traffic intersection as input to the system. The data was processed to facilitate the selection of lanes for RoW. Time for RoW in each lane was computed using interval type-2 fuzzy strategy. The traffic simulation interface is presented in Figure 2. It shows, RoW given to the East lane. The traffic patterns for 20 traffic instances extracted from 1020scenarios observed at traffic inter sections are depicted in Figure 3. Time for RoW was found to covary strongly with QD and AWT. There by showing the ability of the PLQF system to allot time to traffic lane with human-like intelligence.

Figure 2: Right-of -Way given to East Lane

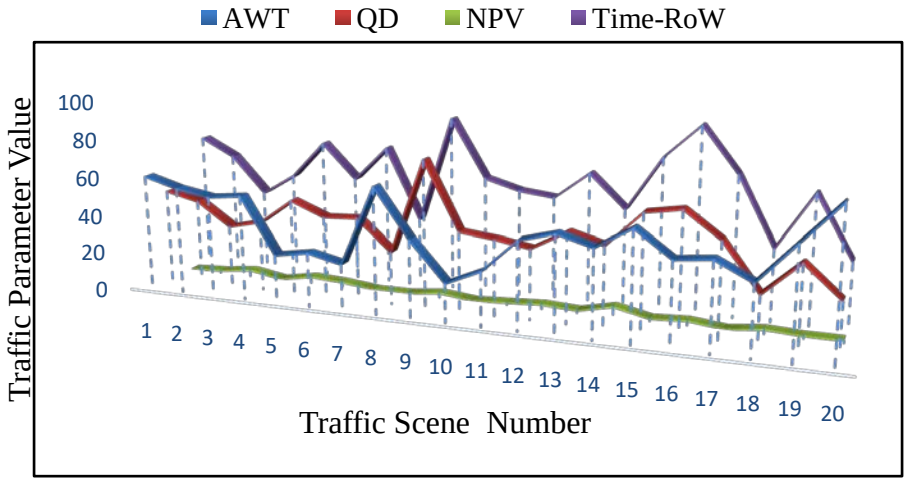

Figure 3: Traffic Pattern at Intersection

An instance of traffic parameters and the RoW decisions obtained from the PLQF system is depicted in Table 1.

Table 1: Traffic parameter instance and decision

Traffic Parameters				PLQF Traffic decisions		
Lane	AWT	QD	NPV	RoW Priority	Lane	Time
North	60	47	0	1	East	46
West	55	44	1	2	West	61
East	52	33	3	3	North	70
South	54	35	0	4	South	53

The traffic parameters segment captures the average waiting time, queue density and number of priority vehicles on each lane. For instance, in the North lane, the system captured 47 vehicles with an average waiting time of 60 seconds, the lane had no priority vehicle as at the time of capturing. The West lane had 1 priority vehicle in a total queue of 44 vehicles with an average waiting time of 55 seconds. The East lane had 3 priority vehicles in a total queue of 33 vehicles with an average waiting time of 52 seconds. The 35 vehicles in the South lane had an average waiting time of 54 seconds with no priority vehicle. The PLQF-based system employed the captured data to assign the RoW to the traffic lane as shown in the traffic decisions segment. Although the North lane had more vehicles in the queue with the highest average waiting time, followed by the West and the South lanes, the East lane had the RoW first because it had 3 priority vehicles in the queue. The fuzzy component of the system utilized the QD, AWT and NPV to allocate the time of 46 seconds for the RoW. Similarly, 61, 70 and 53 seconds were allocated as the time of RoW to West, North and South lanes respectively. A comparison of the PLQF model with the conventional pre-timed control system results at the traffic intersection is depicted in Table 2. The correlation coefficient and standard error of the PLQF model are shown in Table 3.

Table 2: Comparison of Traffic parameter instance and decision

Traffic Parameters				Pre-timed Traffic model decision			PLQF Traffic decision (Current study)		
Lane	AWT	QD	NPV	RoW Priority	Lane	Time	RoW Priority	Lane	Time
North	60	47	0	1	North	45	1	East	46
West	55	44	1	2	West	45	2	West	61
East	52	33	3	3	East	45	3	North	70
South	54	35	0	4	South	45	4	South	53

Table 3: PLQF parameters correlation and standard errors

Traffic Parameters	Correlation	Standard Error
Time_RoW versus QD	0.94	0.004
Time_RoW versus AWT	0.83	0.008
Time_RoW versus NPV	0.71	0.09
Average	0.826	0.034

As shown in Table 2. The pre-timed model is static in its operation. It follows the First-Come-First-Serve (FCFS) strategy and assigns a static time of 45 seconds for RoW to any lane, irrespective of traffic patterns, whereas the PLQF model decision for RoW selection and time allotment is dynamic based on QD, AWT and NPV. The interpolation of QD, AWT and NPV with time for RoW in the PLQF model is depicted in Figures 4 to 6.

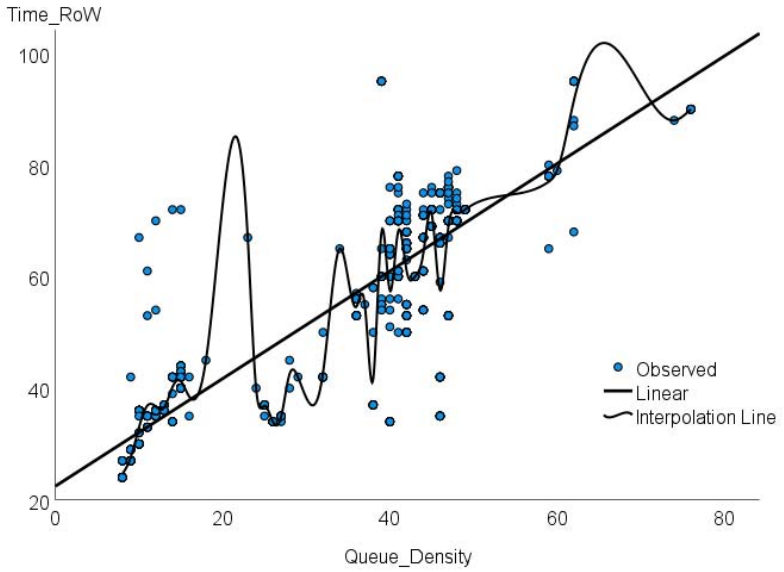

Figure 4: Interpolation of Queue Density with Time for RoW

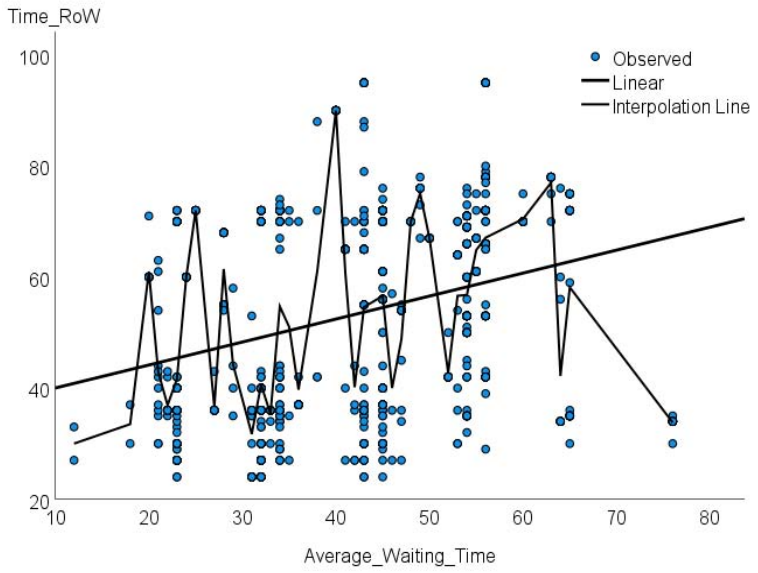

Figure 5: Interpolation of Average Waiting Time with Time forRoW

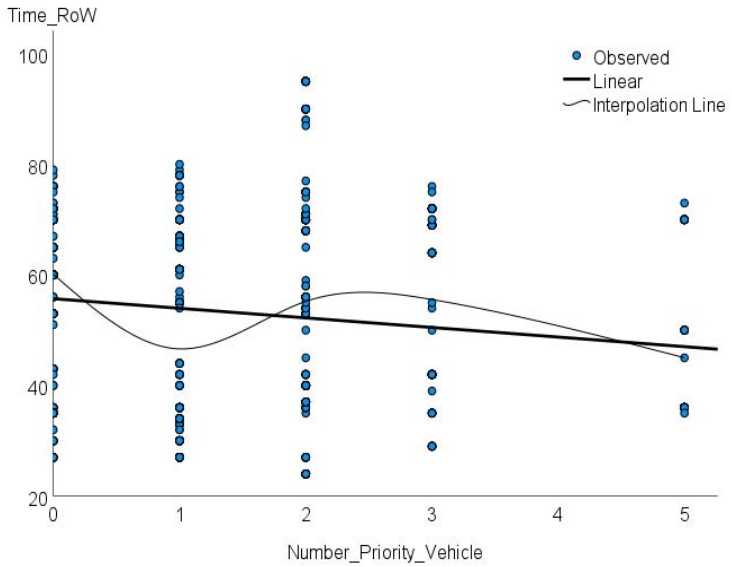

Figure 6: Interpolation of Number of Priority Vehicles with Time for RoW

Computation of correlation coefficient on 1020 instances of traffic patterns at the intersection resulted in correlation values of 0.94, 0.83 and 0.71between QD versus time for RoW, AWT versus time for RoW and NPV versus time for RoW respectively. Computation of standard error resulted in the values of 0.004, 0.008 and 0.09between QD versus time for RoW, AWT versus time for RoW and NPV versus time for RoW respectively. Mean correlation and standard error of 0.826 and 0.034 respectively were observed for traffic parameters (QD, AWT and NPV).The highest correlation value of 0.94 and lowest standard error value of 0.004were observed between QD and time for RoW. This implies that the PLQF algorithm has human-like intelligence for dynamic allotment of time for right-of-way based on traffic patterns that covary very strongly with queue density at the intersection.

V. Conclusion and Recommendation

This paper has developed a PLQF algorithm for the control of vehicular traffic at road intersections. Time allotment strategy was incorporated using interval type-2 fuzzy logic model. Inputs to the model were average waiting time, queue density and number of priority vehicles, while time allotted for RoW served as the output. PLQF model was formulated using mathematical equations. The system was simulated using Java Development Toolkit (JDK) 8.0 and tested using traffic data collected from heavy traffic intersections at Uyo, Nigeria. Results showed superior performance of PLQF model over the conventional traffic system in terms of selection of lane and dynamic allotment of time for right-of-way. The results from PLQF model invariably alleviate the sufferings of road users, maintain intelligent fairness, reduce traffic congestion, offer rational solutions to diverse situations on specific traffic lanes depending on queue density, average waiting time, emergencies and needs. Future work would critically investigate and compare the average turn-around-time of the PLQF model with other intelligent vehicular traffic models for traffic management at intersections.

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Artificial Heart Neural Networks – An Idea

By Satish Gajawada, Arun Kumar, Dr. Maria Celestina Vanaja
& Baby Supriya Sri Valikala

Indian Institute of Technology Roorkee

Abstract- Artificial Neural Networks Field (ANN Field) is an exciting field of research. ANN field took its inspiration from Human Brain. The heart and Brain are very important for the survival of Humans. Research Scientists published many articles by giving importance to Brain. But scientists have not yet explored much on the Heart which is another important part in addition to the Brain. The primary purpose of publishing this article is to show a path to ANN field Research Scientists by introducing the concept of "Heart" into Artificial Neural Networks. In this paper, we coined and defined "Artificial Heart Neuron," which is the basic part of Artificial Heart Neural Networks Field (AHNN Field) in addition to Artificial Neuron. This work takes its inspiration from both Heart and Brain.

Keywords: brain, artificial neural networks, ANN, heart, artificial heart neural networks, AHNN, artificial neuron, artificial heart neuron.

GJCST-D Classification: I.2.6

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Satish Gajawada [α], Arun Kumar [σ], Dr. Maria Celestina Vanaja [ρ] & Baby Supriya Sri Valikala [ω]

Abstract- **Artificial Neural Networks Field (ANN Field) is an exciting field of research. ANN field took its inspiration from Human Brain. The heart and Brain are very important for the survival of Humans. Research Scientists published many articles by giving importance to Brain. But scientists have not yet explored much on the Heart which is another important part in addition to the Brain. The primary purpose of publishing this article is to show a path to ANN field Research Scientists by introducing the concept of "Heart" into Artificial Neural Networks. In this paper, we coined and defined "Artificial Heart Neuron," which is the basic part of Artificial Heart Neural Networks Field (AHNN Field) in addition to Artificial Neuron. This work takes its inspiration from both Heart and Brain.**

Keywords: brain, artificial neural networks, ANN, heart, artificial heart neural networks, AHNN, artificial neuron, artificial heart neuron.

I. Definition of Artificial Heart Neural Networks Field

Artificial Neural Networks are made up of Artificial Neurons. Similarly, all algorithms which are made up of "Artificial Heart Neurons" will come under the "Artificial Heart Neural Networks" Field (AHNN Field). The fifth section of this article explains "Artificial Heart Neuron."

II. Opportunities in the New Artificial Heart Neural Networks Field

There are many opportunities for Artificial Intelligence Research Scientists and Students in this new "Artificial Heart Neural Networks" Field (AHNN Field). Some opportunities are listed below:

1. International Institute of Artificial Heart Neural Networks, Italy
2. Indian Institute of Technology Roorkee Artificial Heart Neural Networks, IIT Roorkee
3. Foundation of Artificial Heart Neural Networks, New York, USA.
4. IEEE Artificial Heart Neural Networks Society.
5. ELSEVIER journals in Artificial Heart Neural Networks
6. Applied Artificial Heart Neural Networks – A New Subject
7. Advanced Artificial Heart Neural Networks – A New Course
8. Invited Speech on "Artificial Heart Neural Networks" in world-class Artificial Intelligence Conferences
9. A Special Issue on "Artificial Heart Neural Networks" in a Springer published Journal
10. A Seminar on "Artificial Heart Neural Networks" at Technical Festivals in colleges
11. International Association of Artificial Heart Neural Networks
12. Transactions on Artificial Heart Neural Networks
13. International Journal of Artificial Heart Neural Networks
14. International Conference on Artificial Heart Neural Networks
15. www.ArtificialHeartNeuralNetworks.com
16. B.Tech in Artificial Heart Neural Networks Field
17. M.Tech in Artificial Heart Neural Networks
18. Ph.D. in Artificial Heart Neural Networks
19. Post Doc in Artificial Heart Neural Networks
20. IBM the Artificial Heart Neural Networks Labs
21. To become the "Father of Artificial Heart Neural Networks" field.

III. Artificial Neural Networks

Deep Learning is the current trend in Artificial Neural Networks. According to Wikipedia, the definition of Deep Learning is shown below in double-quotes as it is:

"Deep Learning is part of a broader family of machine learning methods based on Artificial Neural Networks with representation learning. Deep Learning architectures such as deep neural networks, Deep belief networks, recurrent neural networks, and convolutional neural networks have been applied to many fields including computer vision, machine vision, etc" [1]. Hence from the definition, it is clear that Deep Learning is related to Brain-Inspired Computing.

IV. Literature Review

There are many Artificial Neural Networks papers published in the literature. But there is not even a single paper that is based on Artificial Heart Neural Networks. The World's First Artificial Heart Neural Networks method is created in this article. For the sake of completeness, references [2] to [5] show Artificial

Author α: Independent Inventor and Scientist (2012-2020). Alumnus, Indian Institute of Technology Roorkee. Fellow of Computer Science Research Council, OARS, USA. Founder and Father of Artificial Human Optimization. Inventor of Artificial Soul Optimization and Artificial God Optimization. Designer of Nature++ Inspired Computing. The Creator of Artificial Satisfaction. Inventor of Deep Loving Field. The Designer of Artificial Heart Neural Networks Field.
e-mail: satish.gajawada.iit@gmail.com
Author σ: Independent Machine Learning Researcher.
e-mail: arunk.recs.cse@gmail.com
Author ρ: PhD, Senior Scientist - Human Genetics Hyderabad, Telangana, India.
Author ω: Graduate Student Ambassador and Graduate Student Assistant. Stevens Institute of Technology.
e-mail: bvalikal@stevens.edu

Neural Networks field articles. You can easily find references for Artificial Neural Networks on websites like deeplearning.net. We just showed four references for Artificial Neural Networks for completeness.

V. Artificial Heart Neuron

This section explains "Artificial Heart Neuron." Figure 1 shows Artificial Heart Neuron. "Artificial Neuron" and "Artificial Heart Node" are the building blocks of Artificial Heart Neuron. When the input is passed to "Artificial Heart Neuron," it goes to Artificial Neuron. The Artificial Neuron processes the input and sends it to Artificial Heart Node. The Artificial Heart node controls the input it receives and outputs the controlled input to the other Artificial Heart Neurons.

The input vector [1, 4, 5, 2] is passed to Artificial Heart Neuron. The input goes to Artificial Neuron present inside Artificial Heart Neuron. Artificial Neuron processes the input vector [1, 4, 5, 2] in the same way as it does when Artificial Neuron in Artificial Neural Networks (ANN). It sends the output to Artificial Heart Node. Let's say Artificial Neuron outputs 2.5 to Artificial Heart Node. The Artificial Heart Node receives 2.5 and multiplies it with Heart Controlling Factor and outputs to another Artificial Heart Neuron connected to this Artificial Heart Neuron. If Heart Controlling Factor is 1.2, then 2.5 is multiplied by 1.2, and the output is sent to the connected Artificial Heart Neuron in the next layer.

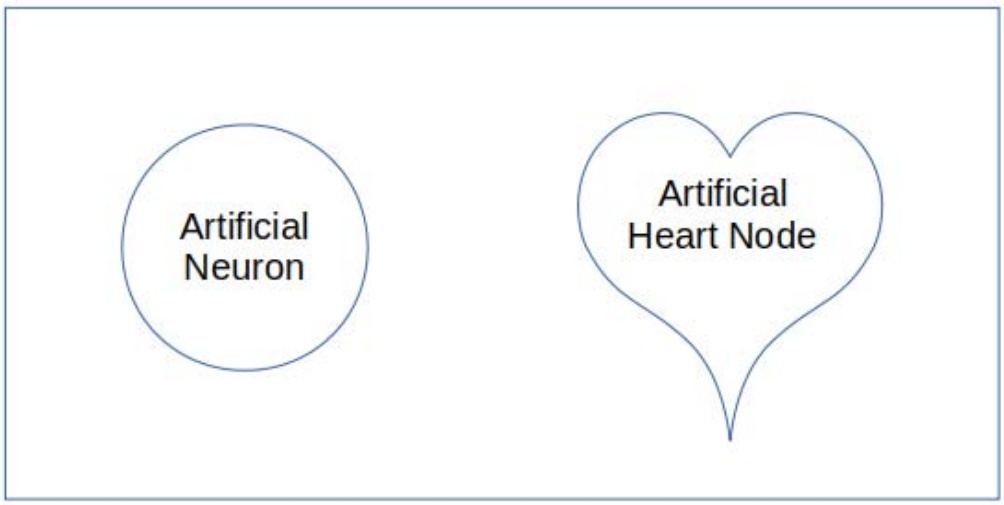

Figure 1: Artificial Heart Neuron

VI. Conclusions

A new field titled "Artificial Heart Neural Networks (AHNN)" is designed in this article. The concept of "Heart" is introduced into Artificial Neural Networks for the first time in Research Industry History in this article. The purpose of this work is to show a path to Artificial Neural Networks Field Scientists and Students so that they will create more and more complex algorithms from scratch following in this path for getting better results. Many opportunities for Artificial Intelligence field Scientists are shown in this paper. Implementing AHNN algorithms and comparison of results with ANN algorithms will be part of our future work.

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We would like to thank everyone (and everything) who directly or indirectly helped us to reach the stage where we are now today.

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Development of a Portable IP-Based Remote Controlled System for Mobile Robot

By Daramola O. A., Obe O. O. & Oriolowo A.

Federal University of Technology Akure

Abstract- The use of Mobile Robots to interact with objects in remote locations has proved to be useful in areas not easily accessible or too dangerous for humans. Various means have been used to remotely operate or control Mobile Robots. These range from wired connection to Wireless connection like radio frequency signal and more recently internet controlled Mobile Robot using the TCP/IP protocol stack. However, the problem of remote control dependence on the Mobile Robot Platform or configuration has made it difficult to switch controllers between Mobile Robots. In this work, a portable IPbased remote control system has been designed and implemented to remove the constraint imposed by the Mobile Robot's platform in choosing the control interface. The system developed was built on three loosely coupled components working together to ensure a high degree of Control interface portability. The Mobile Robot Gateway component was used to receive and send data from the Mobile Robot.

Keywords: mobile robot, remote control, command hub, rest architecture, TCP/IP, IP-based.

GJCST-D Classification: I.2.9

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Keywords: mobile robot, remote control, command hub, rest architecture, TCP/IP, IP-based.

I. Introduction

Mobile robots were defined by Posadas et al (2008) as physical agents that move and interact continuously while embedded in a dynamic environment. A mobile robot is also described as a situated and embodied agent endowed with mobility (Obe and Dumitrache, 2012). Control of mobile robots is categorized into three types namely, autonomous control, semi-autonomous control, and Tele operation. Autonomous control implements various control algorithms that control mobile robots in their environment without human intervention. Semi-autonomous control allows a user to instruct the mobile robot on what to do but the robot decides how the task is carried out. This mode of control is supervisory. In a Tele operated control, the mobile robot is entirely controlled by the user. Oxford dictionary (2015) defines "remote control" as the control of a machine or apparatus from a distance utilizing radio or infrared signals transmitted from a device. Teleoperation is often used in place of Remote control in research or technical environments. Teleoperation means controlling or doing work at a distance (Wichmann et al, 2014). The meaning of the distance, however, can vary. The distance can be physical, such as an operator controlling a robot at a remote location. The distance could also be a change in scale, for example, a surgeon using teleoperation to conduct surgery at the microscopic level. In 2014, Wichmann et al. reported that teleoperation systems are designed using a master-slave system model where the control system depends heavily on the mobile robot platform.

Various communication technologies have been used to achieve teleoperation for a mobile robot. These technologies include Bluetooth, Infrared, WIFI, GSM, Internet of Things (IoT) (Chikurtev, 2019), and Internet (Luimula et al., 2007). While some of these technologies impose a constraint on the range of operation, GSM and the Internet have proven to overcome such barriers (Chin et al, 2003, Ankit, 2014 and Juang&Juang, 2016). The Internet which is based on TCP/IP enables connectivity of billions of devices worldwide, giving access to communication, data, pictures, videos, and even real images of distant environments (Siegwart and Saucy, 1999). The advancement in the development of internet applications has made it the ideal testing ground for sophisticated new applications, such as video-conferencing and remote control systems (Oboe & Fiorini, 1997). However, only a few examples of real physical interaction with distant places are available at the moment. Goodrich and Schultz (2007) defined two categories of interaction, remote and proximate. Remote interaction refers to the situation where the human and the robot are separated spatially or even temporally (i.e., Opportunity Mars rover), while with proximate interaction the humans and the robots are collocated.

This research work aims at creating a portable IP-based remote-controlled system for mobile robot interaction. According to James (1997), a software unit is portable (exhibits portability) across a class of environments to the degree that the cost to transport and adapt it to a new environment in the class is less than the cost of re-development. Portability in general

Author α σ ρ: Federal University of Technology Akure, Ondo State Nigeria. e-mails: ooobe@futa.edu.ng, oadaramola@futa.edu.ng, adeoriolowo@gmail.com

terms is the usability of an object or component of the system in multiple environments without any modification in the internal structure.

Internet Protocol (IP) is a protocol in the Internet Layer of Transport Control Protocol/Internet Protocol (TCP/IP) model. It hides the underlying physical network by creating a virtual network view (Lydia et al, 2006). It is an unreliable, best-effort, and connectionless packet delivery protocol. Best-effort means that the packets sent by IP might be lost, arrive out of order, or even be duplicated. IP was designed with the assumption that a higher layer of the protocol will address these anomalies. According to Lydia et al., (2006), one of the reasons for using a connectionless network protocol was to minimize the dependency on specific computing centers that used hierarchical connection-oriented networks. Available remote control systems require specialized hardware and software that are heavily dependent on the mobile robot's platform or architecture. In this work, an architecture is proposed to eliminate the dependency of the remote control system on the robot's platform.

There are issues with existing mobile robot remote control systems which include but are not limited to, operation range, portability, and the multi-interface option of the system. Various researchers have addressed some of these problems, however, the problem of switching a remote control system from one mobile robot to another with little or no reconfiguration has not been dealt with. In Chin et al. (2003), a Real-Time Remote Control Architecture Using Mobile Communication was proposed. GPS, GSM, and GIS were applied in the development of real-time communication for remote data transfer which solved the range of operation problems, but the system lacked portability. Jose et al. (2004) illustrated a Java/Matlab-Based Environment for Remote Control System Laboratories. Matlab/Simulink and the Quanser Win Con environment were used to develop a control system using the HTTP server to process client requests. The client program is a java applet written in Java. The range of operation issue was eliminated by the architecture but failed to address portability and multi-interface options. In Mobile Robot Temperature Sensing Application via Bluetooth, Abdullah and Poh (2011) developed a control system using the KC-21 Bluetooth module and PIC16F877A microcontroller for remote temperature sensing. The system has a limited range of operations. Ankit et al. (2014) in Controlling of Remote Robot through mobile phone using DTMF Signal, developed a remote control system using microcontroller, CDMA modem, and DTMF signal. The system lacks portability and multi-interface options. Almali et al. (2015) developed a Wireless Remote control for Mobile robots operating in dangerous or narrow places for human beings. A 433MHz RF transceiver module was used to establish a connection between the mobile robot and the computer controlling it. The system has a limited operating range and also lacked portability.

This research work addresses the issue of portability and multi-interface options for mobile robot remote control systems. This will facilitate the use of one remote control system with a multi-interface for different mobile robots on several platforms, this will give room for using a robust interface for the control system at a particular time.

II. Related Literature

Oboe and Fiorini, 1998 in "A design and control environment for internet-based telerobotics describe the environment for the design, simulation, and control of internet-based force-reflecting telerobotics using a segment of the network to connect the master to the slave. Simulation of the complete telerobotic system and emulation using a planar force-reflecting master and a virtual slave uses a MatLab-Simulink program interfaced with a set of dedicated routines for internet modeling. The issues in the variable time-delay system were addressed by using the delay parameters acquired from the network probe to design the controller. However, the work does not address multiple interfaces that could be used as the master or controller. Lung et al., 2002; designed an internet-based human-assisted robotic controller system but the security of the web page was not considered as anyone that stumbles on the web application can control the robot. Chin et al., 2003 adopted the use of G3 (global positioning system (GPS), global system for mobile (GSM), and geographic information system (GIS)) system in developing real-time communication and remote control systems for robot real-time remote control, navigation, and surveillance. The designed system is not portable as it was only implemented on a Windows platform. Visual Basic, which is the choice of programming language, is not supported on other operating systems. Jose et al., 2004; developed a Java/Matlab-Based Environment for Remote Control System Laboratories, illustrated with an Inverted Pendulum - a novel environment that provides 24-hours-a-day access to a Web-based lab for the remote control of different didactic setups. A detailed description of an environment for the teleoperation of real Lab via the Internet, was achieved however, the design cannot be replicated on robots with different platforms due to the heavy dependence on Matlab/Simulink.

Abdullah & Poh, 2011; Mobile Robot Temperature Sensing Application via Bluetooth developed a Bluetooth-based control system for remote measurement of temperature from the robot's surrounding environment. The range of operation is limited to ten (10) meters. Esteller-Curto et al, 2012; in the Proposal of a REST-based architecture server to control a robot proposed the use of a REST-based

architecture server for the control of a robot. The use of proprietary protocol between the robot and the server limits the portability of the control architecture to other robot platforms. Pravin and Shalini, 2013 developed a remote control system based on the hand gesture of the user. The gesture is captured by an accelerometer sensor capable of tracking coordinate values of X, Y, and Z axes as the sensor are tilted. Radiofrequency 433Mz is used as a communication link. The remote control has a limited range of about 100 meters radius. A remote control system for mobile robots using DTMF tone from mobile phones was developed by Ankit et al., 2014. The system has no visual feedback to enable the user to monitor the movement and position of the robot within its environment. Adamides et al., 2014; worked on the development of a suitable user interface for teleoperated agricultural spray robots using multiple camera feedback, keyboard, and PS3 gamepad. The communication link is based on RF signals and has a limited range of operations. The interface design was restricted to the keyboard and Human Interface device (Gamepad) for robot control. Dutta and Zielinska, 2015 identified the challenges concerning IoT-aided robotic applications, with particular reference to their technological and scientific implications. The work is entirely theoretical. No implementation is discussed for the proposed architecture.Amali et al., 2015; in Wireless Remote control of a Mobile Robot designed a mobile robot serving dangerous and narrow areas for humans. The mobile robot consists of a mobile platform and a 4-DoF robot arm with a gripper. This work established the development of a mobile robot with teleoperation capability however, operation range is limited and integration with other platforms was not considered.

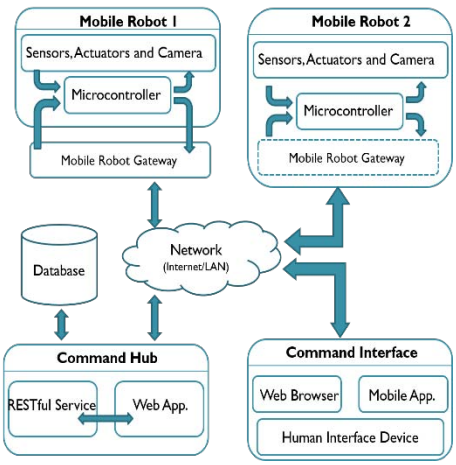

Figure 1: The System Architecture

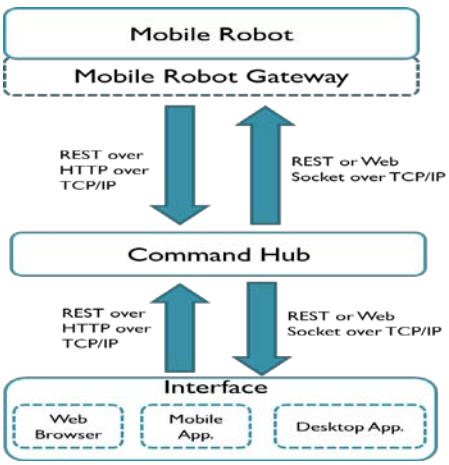

Figure 2: The System Communication Protocol

III. Method

a) System Overview

The proposed portable IP-based remote control system for Mobile Robots is aimed at solving two basic problems usually encountered with common Mobile Robot remote control systems. The first problem is the communication range between the Mobile Robot and its remote control interface. This range limit is entirely dependent on how far the communication link can transmit or receive data sent from both ends (usually 10 Meters for Bluetooth, 100 Meters for WIFI). The second problem is the portability of control interfaces with different platforms to provide different user interfaces that can be used to control different Mobile Robots. To solve the above-mentioned problems, the new system is divided into three functional parts namely: Command hub, Control Interface, and Mobile Robot Gateway.

b) System Architecture

Figure 1 shows the entire architecture of the Mobile Robot Remote Controlled System. The system components run separately on different devices, performing different roles in achieving the overall goal of the system. The components are also loosely coupled to ease upgrade and maintenance without affecting the operation of the other ones.

i. Command Hub Design

The Command Hub is at the center of the entire Remote control system for mobile robots. It is one of the three components required to develop the full system as shown in figure 2. This component acts as the major middleware between the Control Interface and the Mobile Robot Gateway. It is responsible for handling communication between the Gateway and the Control Interface. Digging deep into what made up the Command Hub, it is a REST-Based Service that runs a remote Webserver. It exposes a REST API and resources which can be accessed through Uniform Resource Identifier (URI) and corresponding HTTP Verbs (i.e. GET, POST, PUT, and DELETE). Every action performed by the user on the Control Interface is mapped by an HTTP request to the command Hub. The Command Hub then receives the request, processes it, and responds appropriately. From the request received

to the response given, there are three different modules responsible for carrying out the tasks required to transform the request to a corresponding response as shown in figure 3. The modules are:

Input/output module: This module is the first and the last point of contact for both Control Interface and Mobile Robot Gateway. It is responsible for intercepting any request made to the Command Hub, determine the resources that are requested, and then pass control to the appropriate controller fit to handle such requests. The module is also responsible for taking results from any controller and generates the output response which is either a stream of byte when using Web Socket or JSON/XML data format whenever web Socket is not available.

Command Controllers: This module carries out various important tasks required to correctly and efficiently process all the requests received from both the control interface and the gateway. This module is made up of different controllers to handle different requests coming from the input/output module. Controllers available in the module include Command controller (responsible for generating commands based on the type of request received), Motor Controller (handles requests related to Robot's movement control), Proximity controller (governs the request related to proximity sensors), and vice versa. All the controllers present in the module interact with the data access layer to get, insert, update, or delete records from the database. This module is also responsible for constructing the appropriate response to be sent back to the client's requests. Responses are delivered in two ways which are determined by the module. The module makes use of Web Socket to push new or updated content to the client (Control Interface and Gateway), if the client supports Web Socket, a push notification is used to stream the response back to the client. If the client does not support Web Socket, the traditional HTTP response is used to have a payload of either JSON or XML depending on the content negotiation from the client.

Data Access Layer: This module interface directly with the database. It contains all the necessary stored procedures and SQL statements required to retrieve, update, insert, and delete any record from the database. This module is entirely controlled by the controllers.

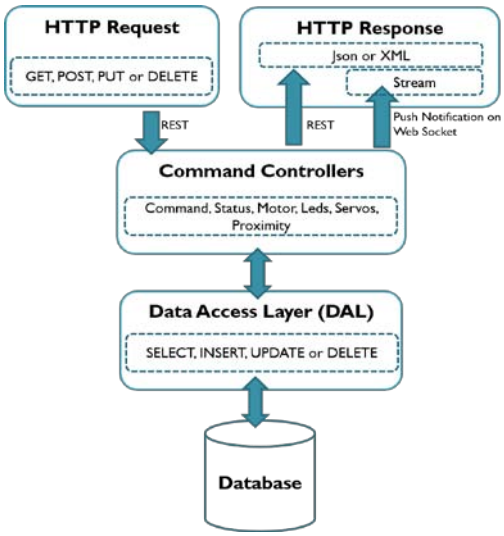

Figure 3: Command Hub Architecture

ii. *Control Interface Design*

The control interface component in the system is the one that interacts with the user and based on the operation performed on it, it will create and send an appropriate HTTP request to the command hub respectively. The control interface performs two basic functions. The first function is to take users' actions and transform them into a valid HTTP request required by the command hub. The second function is getting telemetry data from the command hub to create visual feedback for the users. The structure of this component is therefore organized along with its functions. Two modules are provided, one to constantly fetch new or updated data from the command hub to update the telemetry view of the mobile robot's vitals while the other module handles user interactions with the control interface and makes appropriate HTTP requests to the command hub.

Different Control Interfaces are designed based on the two modules explained earlier to expand the choice of control for each Mobile Robot in the system. Available control interface includes:

Cross-Platform Mobile Interface: This type of interface is meant for users that prefer to control their Mobile robots from a smartphone. The interface wasdesigned with Apache Cordova, HTML 5, CSS 3, and JavaScript. This ensures that the resulting interface can be used on Windows Phone, Android Phone, and iPhone as well.

Web Application Interface: This type of interface is available to users that want to control their Mobile Robots through a web browser. The web browser is used to access Web applications deployed alongside the command hub to provide the control interface. This Control interface is designed with ASP.Net MVC 4, HTML 5, CSS 3, and JavaScript. A variety of web browsers are supported.

Desktop Interface: In this type of control interface, the traditional Desktop application is used to provide the interface to the users. C# programming language is used to develop this interface.

iii. *Mobile Robot Gateway Design*

This is the component that interfaces directly with the Mobile Robot. It plays a major role in connecting the robot to the remote control interface through the command hub. There are two different types of Mobile Robot Gateway namely, Internal Mobile Robot Gateway and External Mobile Robot Gateway. The internal Mobile Robot Gateway runs locally on the robot's operating system. This type of Gateway is only supported by Mobile Robots capable of running scripts, executable programs and whose hardware supports networking and direct connectivity to the Internet. The Gateway is implemented as part of the required software running locally on the robot's platform. The Gateway runs directly on the Mobile Robot's control board as shown by Robot 2 in figure 1. External Mobile Robot Gateway does not run on the robot platform, it runs on a remote computer connected to the Mobile Robot through Bluetooth or a WIFI device. This type of Gateway is meant for Mobile Robots that do not have shields or devices to directly connect to the Internet thereby using the remote computer's Internet connectivity for its operation. In the case of External Mobile Robot Gateway, a remote computer connected to the Internet is placed within the communication range of the Mobile Robot, the computer shares its internet connection with the Mobile Robot. The Gateway is also executed on the remote computer to serve as the conduit through which communication is established with the control interface via the command hub. Robot 1 in figure 1 makes use of the External Mobile Robot Gateway.

Gateway Operation Circle

The Mobile Robot Gateway operates in a circle of three operations namely Sense/Listen, Think, and Act. Figure 4 shows the interaction of Gateway operations in a single circle.

- Sense/Listen Operation:- in this operation, the Gateway awaits new commands from the command hub through an active Web Socket if available or through an HTTP request to the REST API exposed by the command hub. If the Mobile Robot is in autonomous or semi-autonomous mode, values from the proximity sensors are fetched by the Gateway. Any data acquired from this operation is then passed on to the THINK operation in the circle.
- Think - analysis of data passed from the Sense/Listen operation is carried out during this operation. It is mainly responsible for command interpretation and conversion into a simpler form that could be handled on the Mobile Robot easily. After the interpretation and conversion task has been carried out, the result is sent to the ACT operation to take necessary action.
- Act: - this part is responsible for generating the control sequence based on the input received from the THINK operation. It determines the destination of the resulting control sequence (i.e. Mobile Robot or Command hub). The control sequence now determines the behavior the Mobile Robot will exhibit. This operation is also responsible for sending telemetry data to the command hub. After this operation is carried out, control is returned to the Sense/Listen operation

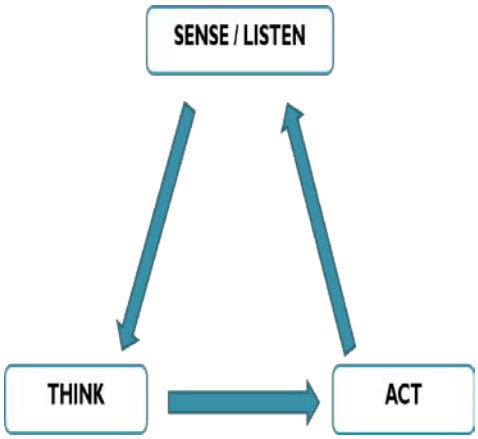

Figure 4: Mobile Robot Gateway Operation Circle

iv. *Command Design*

One of the roles of the Command Hub is the generation of commands to be sent to the Mobile Robot. These commands are generated based on the interaction of the users with the control Interface. Each action performed by the user on the control interface corresponds to a specific command meant for the Mobile Robot to execute. When an action is performed on the control interface, a request is sent to the REST API (Application Programming Interface) exposed by the Command Hub. The Command Hub now maps the request to the corresponding command to be generated and sent to the Mobile Robot. For example, if the user presses the "Move Forward" Button on the Control Interface, an HTTP POST request is sent to http://Command-Hub-DomainName/api/move/1, then "f" command is generated and sent to the Mobile Robot. The "Command-Hub-DomainName" is the domain name of the server hosting the Command Hub. Table 1 shows the comprehensive list of all Uri, HTTP verbs, and associated commands mapped to them.

Table 1: Command-Uri Mapping

URI	HTTP VERB	COMMAND	DESCRIPTION
/api/move	GET	W	Get Wheels State
/api/move/1	POST	F	Move forward
/api/move/2	POST	b	Move Backward
/api/move/3	POST	r	Move Right
/api/move/4	POST	l	Move Left
/api/move/5	POST	s	Stop
/api/speed	GET	v	Get Robot Speed
/api/speed/value	POST	v,value	Set Robot Speed to value
/api/leds	GET	d	Get all LED Status
/api/leds/id	GET	d,id	Get the Status of LED id
/api/leds/id/status	POST	d,id,status	Set the state of LED id with status
/api/servo	GET	c	Get Status of all Servo
/api/servo/id	GET	c,id	Get state of Servo id
/api/servo/id/pos	POST	c,id,pos	Set the position of Servo id to position
/api/motor	GET	m	Get the state of all Motor
/api/motor/id	GET	m,id	Get state of motor id
/api/motor/id/pwm	POST	m,id,PWM	Set the PWM signal of Motor id
/api/prox	GET	p	Get state of all proximity sensor
/api/prox/id	GET	p, id	Get state of proximity sensor id

v. *Mobile Robot Design and Configuration*

At the hardware level, two robots were designed to validate the workability of the remote control system whose architecture was shown in figure 1. These Mobile Robots have different platforms and configurations each of which corresponds to the two types of Mobile Robots in figure 1. The Mobile Robots are:

SleekBot V1: This was designed to use Arduino Nano R3 as its main control board. All other actuators and sensors are connected to the main control board. In this configuration, a Bluetooth module is used to communicate with an external Mobile Robot Gateway. Figure 6 shows the breadboard schematics of the robot's hardware configuration.

SleekBot V2: This is the second Mobile Robot, it was designed to use Raspberry Pi 2 Model B as its main control board while Arduino Nano R3 was used as a slave control board. In this configuration, a USB camera with a two degree of freedom is connected to the mainboard and Internal Mobile Robot Gateway was used because the main control board is capable of running executable programs and it is also capable of connecting to the internet directly. Figure 7 shows the breadboard schematics of SleekBot V2.

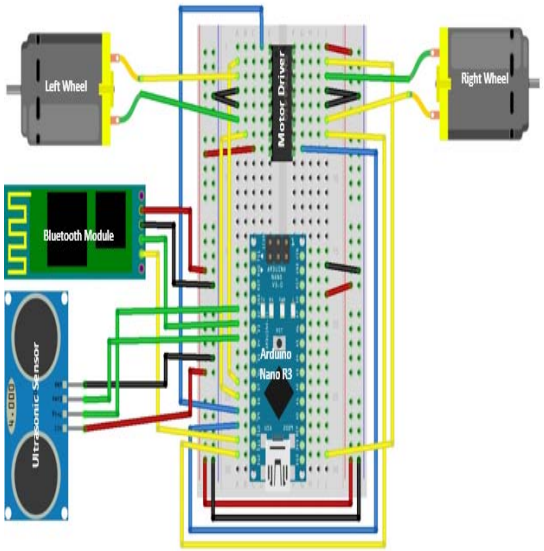

Figure 6: SleekBot V1 Breadboard schematics

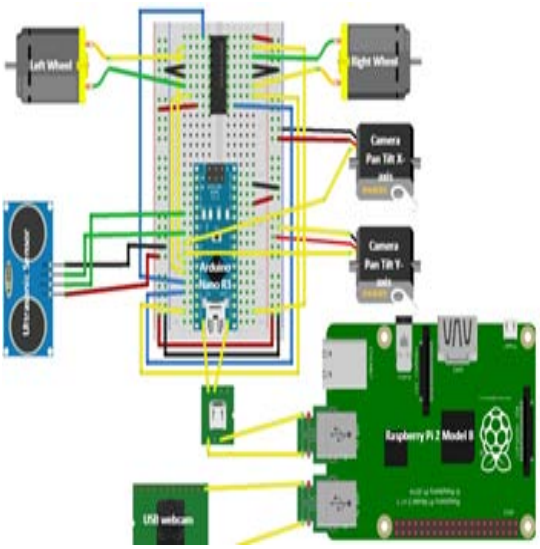

Figure 7: SleekBot V2 Breadboard Schematics

IV. Result and Discussion

a) System Implementation

The system was implemented in three stages, each stage corresponds to the deployment of each component that made up the system.

i. *Mobile Robot Gateway Stage*

Two types of Mobile Robot Gateway were implemented. The specific implementation used was determined by the robot's ability to connect directly to the internet. In a scenario where the Mobile Robot can connect directly to the internet, a python program was used to implement the Gateway. The second implementation was used when the Mobile Robot connects to the internet through another computer. A desktop application written in C# was used to implement the Gateway on the computer with internet connectivity.

ii. *Command Hub Stage*

At this stage of implementation, a web API written in C# was used to implement a REST-Based service that acts as the command hub for the system. The service was deployed to Internet Information Service (IIS) with MS SQL Server 2012 to act as the backend storage for the system.

iii. *Command Interface Stage*

HTML 5, JavaScript, and CSS 3 were used with Apache Cordova and Ionic framework to create a cross-platform mobile application for Mobile Robot remote control. Also at this stage, a web application written in C# and ASP.Net MVC 4 was used to implement a web-based Remote control Interface

b) Implementation Tools

i. *Hardware*

Arduino Nano R3: this is a programmable development board based on the ATmega328 microcontroller chip. It has 32 KB flash Memory, 2 KB SRAM, 1 KB EEPROM, 14 digital I/O pins of which 6 provide PWM (Pulse Width Modulation output), 8 analog input pins, and 16 MHz clock speed. It was used to develop the SleekBot V1 Mobile Robot.

Raspberry Pi 2 Model B: this is a credit card size computer capable of running a trim-down version of the Linux operating system. It has a quad-core processor with a clock speed of 900 MHz, 1 GB RAM, and 40 GPIO (General-purpose Input Output) pins. This was used with Arduino Nano R3 to develop SleekBot V2 Mobile Robot

ePuck Mobile Robot: this a differential drive educational mobile robot based on a dsPIC30F6014A microcontroller chip running at 60 MHz clock speed. It has 8 KB RAM, 144 KB flash Memory, 3D accelerometer, VGA camera, 8 infra-red sensors, Bluetooth for wireless communication with a computer, speaker and LED. It was used as one of the Mobile Robots used in testing the workability of the developed remote control system.

Software

Programming Languages: C, C#, Python, JavaScript
Interface Design: HTML 5, CSS 3, Win form
Backend: MS SQL Server 2012
Framework: .Net Framework, Apache Cordova, Ionic Framework
Web Server: Internet Information Service (IIS) 8

ii. *User Interface Documentation*

Home Page

For web interface users, the system provides a landing page where navigation to other modules is accessed. Figure 8 shows the home page layout.

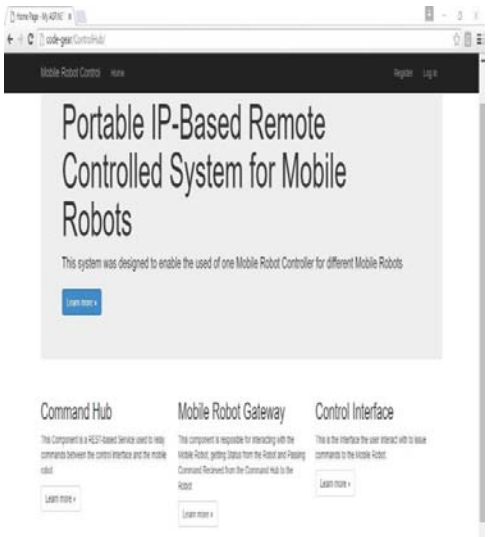

Figure 8: Home Page

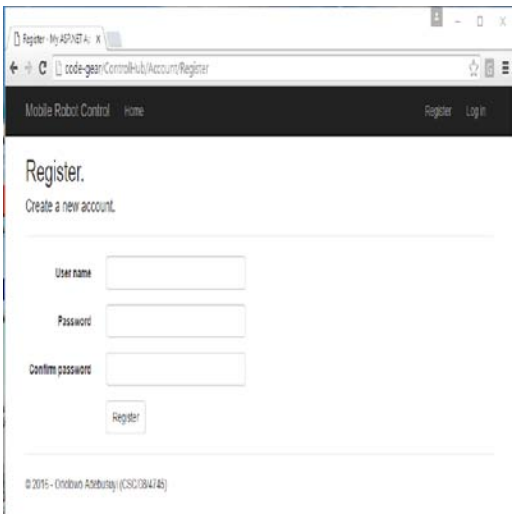

Figure 9: Web Registration Interface

User Registration

This module is used to register all users making use of the control platform. All valid users of the system need to be authenticated before they are granted access to control any mobile robot remotely. Figure 9 shows the user registration interface for web interface users while figure 10 shows the registration interface for mobile users.

Figure 10: Mobile Registration Interface

User Login

This module is used for authenticating all users making use of the system. All users must pass through this module to use the system. Figure 11 and figure 12 show the login user interface (UI) for web and mobile users.

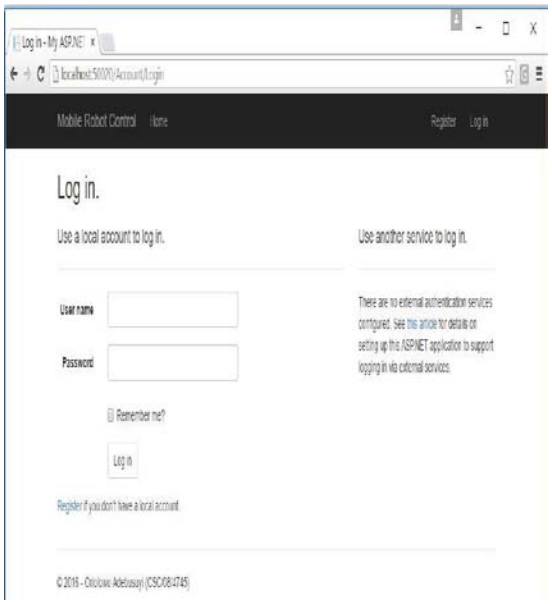

Figure 11: Web UI

Figure 12: Mobile UI

Main Menu

The main menu provides navigation to important modules the user can use to perform different tasks in the system. Figure 13 shows the main menu for mobile interface users

Figure 13: Main menu

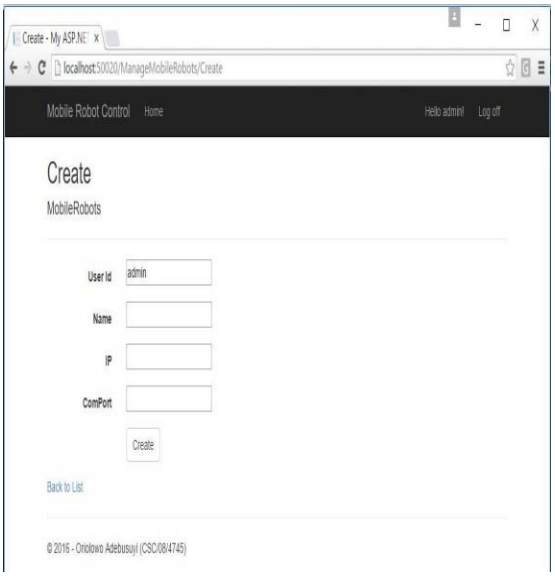

Figure 14: Mobile Robot Registration

Mobile Robot Registration

To make use of any robot on the platform, the user needs to register the robot. Figure 14 shows the interface dedicated to the registration. After registration, all registered Mobile Robots by the user is displayed in the Mobile Robot List as shown in figure 15.

Figure 15: Registered Mobile Robots

Figure 16: Settings Interface

Settings

The settings module is used to configure the parameters required for the interface to work properly. Figure 16 shows a settings Interface for mobile Users

Remote Control Interface

This interface provides the necessary widget to remotely control mobile robots. Actions performed on this interface translate to a command to be executed on the mobile robot. Figure 17 and figure 18 show the remote control interface for web and mobile interface users.

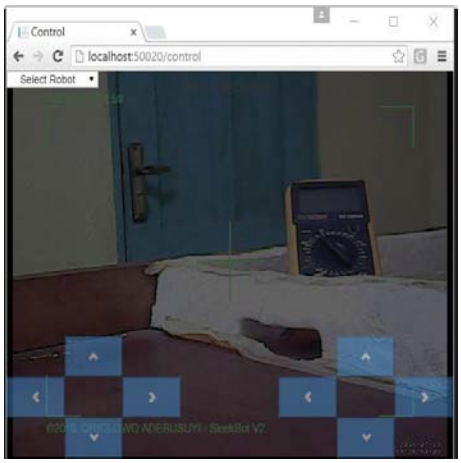

Figure 17: Remote control for web UI

Figure 18: Remote Control for Mobile UI

c) System Evaluation

Algorithm for Command Hub

Initialize Command Hub
While interrupt NOT available
    Get HTTP request from client
    Map request to command controller
    Construct response message
    Return response message
End While

Time Complexity of Command Hub algorithm

Number of Operation = 1 + 1 + N(1 + 1 + 1+ 1)
= 2 + N(4)
= 2 + 4N
Number of Operation = 2 + 4N
In Big O notation, the algorithm executes in linear time i.eO(n)

Algorithm for Command Interface

Initialize Command Interface
While UserAction != null
    Construct command object
    Send command object to Command Hub using HTTP Request
    Get Response for the HTTP Request
    If Response != null
        Process Response
        Update Interface
    End If
End While
While Interrupt NOT available
    Get Status from Command Hub
    Update Interface
End While

Time Complexity of Command Interface algorithm

Number of Operation = 1 + 1 + N(1 + 1 + 1+ 1 + 1) + N(1 +1)
= 2 + N(5) + N(2)
= 2 + 4N + 2N
Number of Operation = 2 + 6N
In Big O notation, the algorithm execute in linear time i.eO(n)

Mobile Robot Gateway Algorithm

Initialize Gateway
While new Command IS available

```
            Get Command from Command Hub
            If Command != null
                  Map command to the Mobile Robot Kinematics
                  Execute Command
            End If
      End While
      While Interrupt NOT available
            Get Mobile Robot Status
            Send Status to Command Hub
      End While
```

Time Complexity of Mobile Robot Gateway algorithm

Number of Operation = 1 + N(1 + 1 + 1) + N(1 + 1)
= 1 + N(3) + N(2)
= 1 + 3N + 2N
Number of Operation = 1 + 5N
In Big O notation, the algorithm executes in linear time i.eO(n)

The Time Complexity of the Entire System

Number of Operations = 2 + 4N + 2 + 6N + 1 + 5N
= 5 + 15N
Number of Operations = 5 + 15N
The Time Complexity of the entire system expressed in Big O notation = O(n)

V. Conclusion

The goal of this research work to develop a portable IP-based multi-interface remote-controlled system for mobile robots was achieved. The system offers the use of a single remote control device across different mobile robots and the use of a multi-interface for a single mobile robot.

The solution architecture is based on three loosely coupled components performing various tasks at different levels to collectively achieve a single aim of having a portable control system. At the core of the system is a REST-based web service handling communication between the user interface and the mobile robot. Various programming languages were used at different levels to achieve the overall goal of the system. A cross-platform mobile application, Web application, and the desktop client was developed to serve as the system's user interface.

Implementation of the system was carried out on three different mobile robots based on different platforms. The system was evaluated based on the time complexity of the algorithm used in its components. The result shows that the system time of execution is linear (O (n)).

The system developed is not without its weakness, hence the need to improve some parts that are currently inefficient in its mode of operation. These include:

1. The visual Feedback(Video Streaming) uses Motion Jpeg standard which has unacceptable lag time for network connection speed lower than 256 Kbps
2. iWeb Control UI does not work well with the Internet Explorer web browser
3. Better implementation algorithm to reduce the system time complexity from O(n) to O(1)

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Artificial Excellence - A New Branch of Artificial Intelligence

By Satish Gajawada

Indian Institute of Technology Roorkee

Abstract- "Artificial Excellence" is a new field which is invented in this article. Artificial Excellence is a new field which belongs to Artificial Human Optimization field. Artificial Human Optimization is a sub-field of Evolutionary Computing. Evolutionary Computing is a sub-field of Computational Intelligence. Computational Intelligence is an area of Artificial Intelligence. Hence after the publication of this article, "Artificial Excellence (AE)" will become popular as a new branch of Artificial Intelligence (AI). A new algorithm titled "Artificial Satish Gajawada and Durga Toshniwal Algorithm (ASGDTA)" is designed in this work. The definition of AE is given in this article followed by many opportunities in the new AE field. The Literature Review of Artificial Excellence field is shown after showing the definition of Artificial Intelligence. The new ASGDTA Algorithm is explained followed by Results and Conclusions.

Keywords: artificial excellence, artificial human optimization, evolutionary computing, computational intelligence, artificial intelligence, artificial satish gajawada, artificial durga toshniwal, artificial satish gajawada and durga toshniwal algorithm, asgdta algorithm, particle swarm optimization algorithm, PSO algorithm.

GJCST-D Classification: I.2

Strictly as per the compliance and regulations of:

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Satish Gajawada

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Keywords: artificial excellence, artificial human optimization, evolutionary computing, computational intelligence, artificial intelligence, artificial satish gajawada, artificial durga toshniwal, artificial satish gajawada and durga toshniwal algorithm, asgdta algorithm, particle swarm optimization algorithm, PSO algorithm.

I. Definition of Artificial Excellence Field

The basic entities in Particle Swarm Optimization, Artificial Soul Optimization and Artificial God Optimization are Artificial Birds, Artificial Souls and Artificial Gods respectively. Similarly, the basic entities in Artificial Human Optimization field algorithms are Artificial Humans. "Artificial Excellence (AE)" is a sub-field of Artificial Human Optimization field. Hence the basic entities in AE field are also Artificial Humans only. But there is a difference. Artificial Human Optimization is about imitating Humans in general. There is no concept of imitating particular Human beings. AE is based on imitating particular Human beings. The basic entities in AE field algorithms are particular Human beings. Every Human is different. Hence imitating Humans in general (Artificial Human Optimization) and imitating particular Human beings (Artificial Excellence) will yield different results. If we take particular Human being (Say Ankush Mittal) then we can design algorithm "Artificial Ankush Mittal Algorithm" where the search space consists of Artificial Ankush Mittals and this Ankush Mittal Algorithm belongs to Artificial Excellence (AE) field. Section 5 of this article designs and describes world's first AE field algorithm. This algorithm is named as "Artificial Satish Gajawada and Durga Toshniwal Algorithm (ASGDTA Algorithm)". The basic entities in ASGDTA Algorithm are Artificial Satish Gajawadas and Artificial Durga Toshniwals. Just like Satish Gajawada and Durga Toshniwal move in real world and solves problems. Similarly, Artificial Satish Gajawadas and Artificial Durga Toshniwals move in search space and solves optimization problems.

II. Opportunities in the New Artificial Excellence Field

There are many opportunities in the new Artificial Excellence field. Some of them are shown below:

1. International Institute of Artificial Excellence, Hyderabad, INDIA
2. Indian Institute of Technology Roorkee Artificial Excellence Labs, IIT Roorkee
3. Foundation of Artificial Excellence, New York, USA.
4. IEEE Artificial Excellence Society
5. ELSEVIER journals in Artificial Excellence
6. Applied Artificial Excellence – A New Subject
7. Advanced Artificial Excellence – A New Course
8. Invited Speech on "Artificial Excellence" in world-class Artificial Intelligence Conferences
9. A Special Issue on "Artificial Excellence" in a Springer published Journal
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11. International Association of Artificial Excellence
12. Transactions on Artificial Excellence
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15. www.ArtificialExcellence.com
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17. M.Tech in Artificial Excellence
18. Ph.D. in Artificial Excellence
19. PostDoc in Artificial Excellence

Author: Alumnus, Indian Institute of Technology Roorkee, Uttaranchal, India. Independent Inventor and Scientist. Founder and Father of Artificial Human Optimization. Inventor of Artificial Soul Optimization and Artificial God Optimization. The Creator of Artificial Satisfaction. Inventor of Deep Loving Field. The Designer of Nature Plus Plus Inspired Computing. The Creator of Artificial Heart Neural Networks Field. The Inventor of Artificial Excellence Field.
e-mail: satish.gajawada.iit@gmail.com

20. IBM the Artificial Excellence Labs
21. To become "Father of Artificial Excellence" field

III. Artificial Intelligence

The following is the definition of Artificial Intelligence according to Investopedia shown in double quotes as it is:

"Artificial intelligence (AI) refers to the simulation of human intelligence in machines that are programmed to think like humans and mimic their actions. The term may also be applied to any machine that exhibits traits associated with a human mind such as learning and problem-solving" (Investopedia, 2020).

IV. Literature Review

Lot of research was done in Artificial Intelligence field till date. But Artificial Excellence (AE) field invented in this article is not yet explored. The world's first AE algorithm is "Artificial Satish Gajawada and Durga Toshniwal Algorithm" which is designed and developed in this article. For the sake of completeness, articles (Al-Awami, A.T.; Zerguine, A.; Cheded, L.; Zidouri, A.; Saif, W., 2011), (Al-Shaikhi, A.A., Khan, A.H., Al-Awami, A.T. et al, 2019), (Anita, Yadav A., Kumar N., 2020), (C. Ciliberto, M. Herbster, A.D. Ialongo, M. Pontil, A. Rocchetto, S. Severini, L. Wossnig, 2018), (Deep, Kusum; Mebrahtu, Hadush, 2011), (Dileep, M. V., & Kamath, S., 2015), (Gajawada, S., 2016), (Gajawada, S., and Hassan Mustafa, 2019a), (Gajawada, S., & Hassan Mustafa., 2019b), (Gajawada, S., & Hassan Mustafa., 2020), (H Singh, MM Gupta, T Meitzler, ZG Hou, KK Garg, AMG Solo, LA Zadeh, 2013), (Imma Ribas, Ramon Companys, Xavier Tort-Martorell, 2015), (Kumar, S., Durga Toshniwal, 2016), (Martínek, J., Lenc, L. & Král, P, 2020), (M. Mitchell, 1998), (P Kumar, A Mittal, P Kumar, 2006), (S Chopra, R Mitra, V Kumar, 2007), (S Das, A Abraham, UK Chakraborty, A Konar, 2009), (S Dey, S Bhattacharyya, U Maulik, 2014), (Whitley, D, 1994), (W. Hong, K. Tang, A. Zhou, H. Ishibuchi, X. Yao, 2018) and (Zhang, L., Pang, Y., Su, Y. et al, 2008) show research articles under Artificial Intelligence field. For the sake of simplicity we are showing same articles under Artificial Intelligence as shown in article "Artificial Satisfaction - The Brother of Artificial Intelligence" published by Satish Gajawada et al in 2020 year. The focus of this paper is on designing AE field and describing AE field algorithms rather than on showing Artificial Intelligence literature. Hence we saved time by showing Artificial Intelligence field literature from a previous paper by Satish Gajawada et al.

V. The Artificial Satish Gajawada and Durga Toshniwal Algorithm

This section explains Artificial Satish Gajawada and Durga Toshniwal Algorithm (ASGDTA). Figure 1 shows ASGDTA. All Artificial Satish Gajawadas and Artificial Durga Toshniwals are initialized in line number 1. The iterations count is set to zero in line number 2. The local best and global best of all particles are found in line number 3 and line number 4 respectively. In line number 6, if the random number generated is less than Durga Toshniwal Probability then the Artificial Human is identified as Artificial Durga Toshniwal and hence Velocity and Position of Artificial Durga Toshniwal are updated in line number 7 and line number 8 respectively. On the other hand if the random number generated in line number 6 is greater than Durga Toshniwal Probability then the Artificial Human is identified as Artificial Satish Gajawada. Artificial Satish Gajawada has two possibilities. Either Artificial Satish Gajawada receives help from Artificial Durga Toshniwal or not. This is decided by Help of Durga Toshniwal Probability. In line number 10, if the random number generated is less than Help of Durga Toshniwal Probability then Artificial Satish Gajawada receives help from Artificial Durga Toshniwal and hence Artificial Satish Gajawada updates Velocity and Position in line number 11 and line number 12 respectively. On the other hand if the random number generated in line number 10 is greater than Help of Durga Toshniwal Probability then Artificial Satish Gajawada doesn't receive help from Artificial Durga Toshniwal and hence Artificial Satish Gajawada doesn't update Velocity and Position in line number 14. The generations or iterations count is incremented by 1 in line number 18. If termination condition reached is not true in line number 19 then the control goes back to line number 3 and the algorithm continues. If the termination condition reached is true in line number 19 then the algorithm terminates.

1) All Artificial Satish Gajawadas and Artificial Durga Toshniwals are initialized
2) Set iterations or generations count to zero
3) Find local best of all Artificial Satish Gajawadas and Artificial Durga Toshniwals
4) Find global best of all Artificial Satish Gajawadas and Artificial Durga Toshniwals
5) for each particle i do
6) if (generate_random_number (0,1) < DurgaToshniwalProbability) then // Durga Toshniwal
7) Update Velocity of Artificial Durga Toshniwal
8) Update Position of Artificial Durga Toshniwal
9) else // Satish Gajawada
10) if (random(0,1) < HelpOfDurgaToshniwalProbability) then // Satish Gajawada with Help
11) Update Velocity of Artificial Satish Gajawada
12) Update Position of Artificial Satish Gajawada
13) else // Satish Gajawada without help does nothing
14)
15) end if
16) end if
17) end for
18) generations (iterations) = generations (iterations) + 1
19) while (termination_condition not reached is true)

Figure 1: Artificial Satish Gajawada and Durga Toshniwal Algorithm (ASGDTA)

VI. Results

The benchmark functions are taken from article (Gajawada, S., and Hassan Mustafa, 2019a). The ASGDTA and PSO are applied on 5 benchmark functions shown in figure 2 to figure 6.

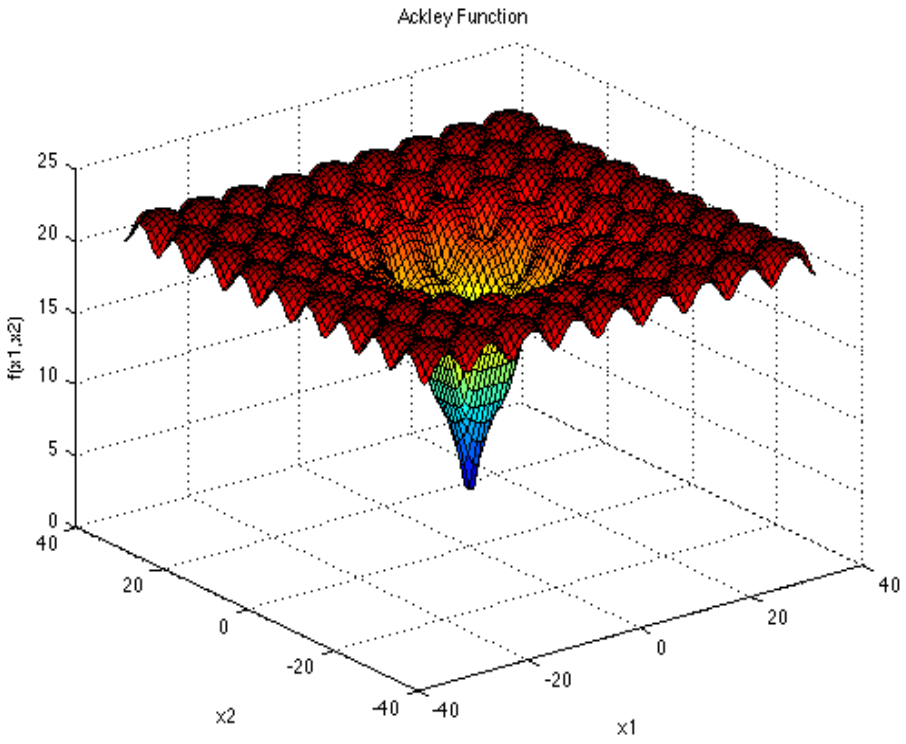

Figure 2: Ackley Function

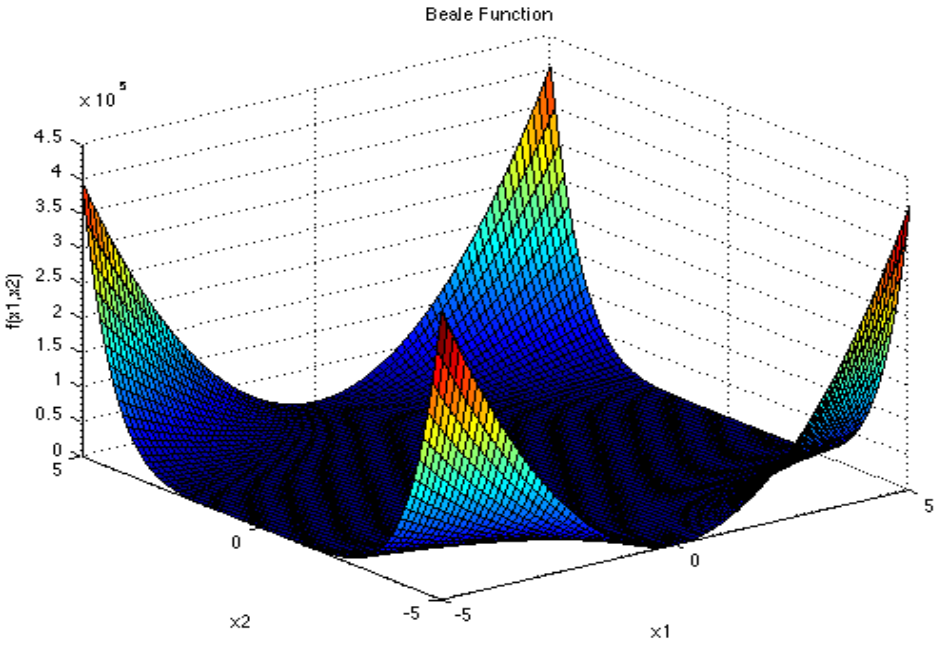

Figure 3: Beale Function

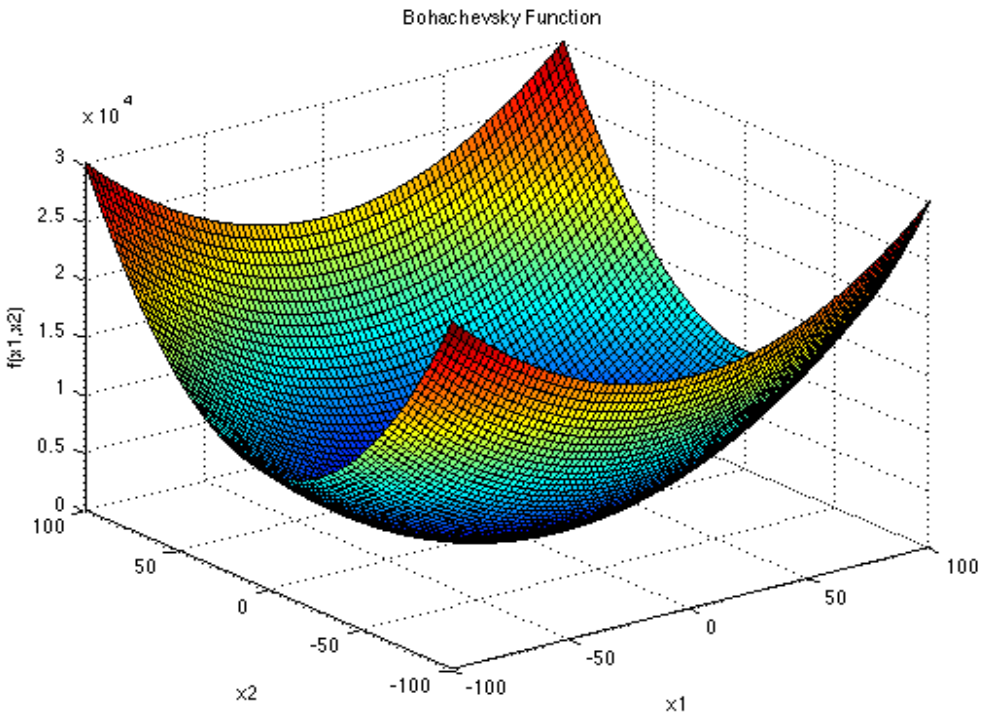

Figure 4: Bohachevsky Function

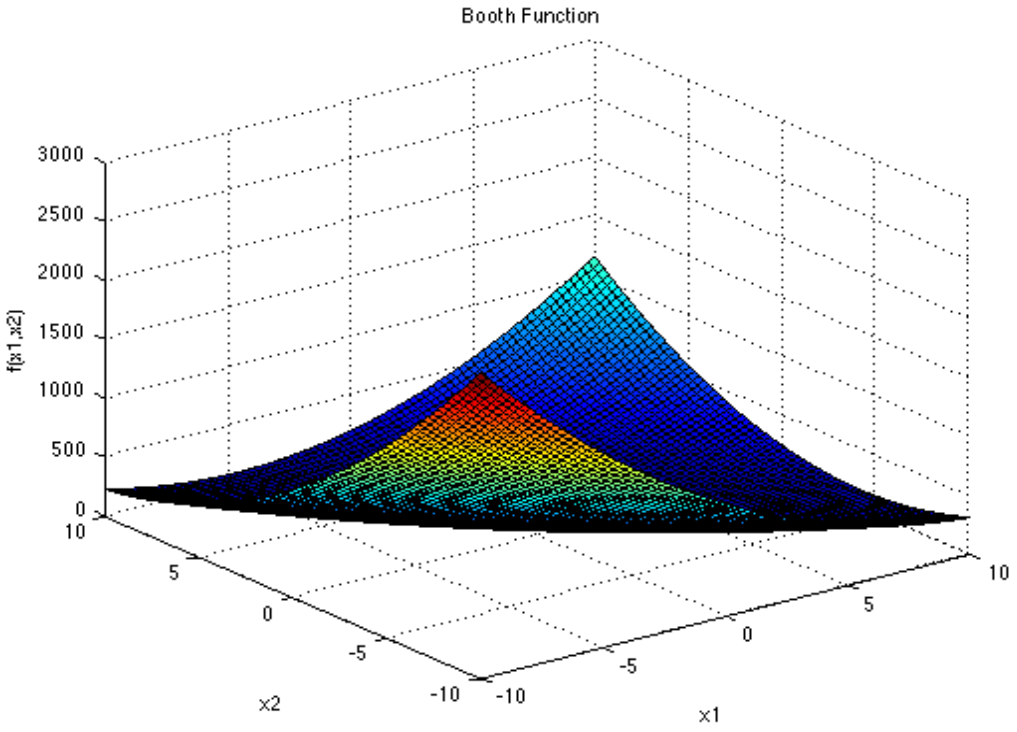

Figure 5: Booth Function

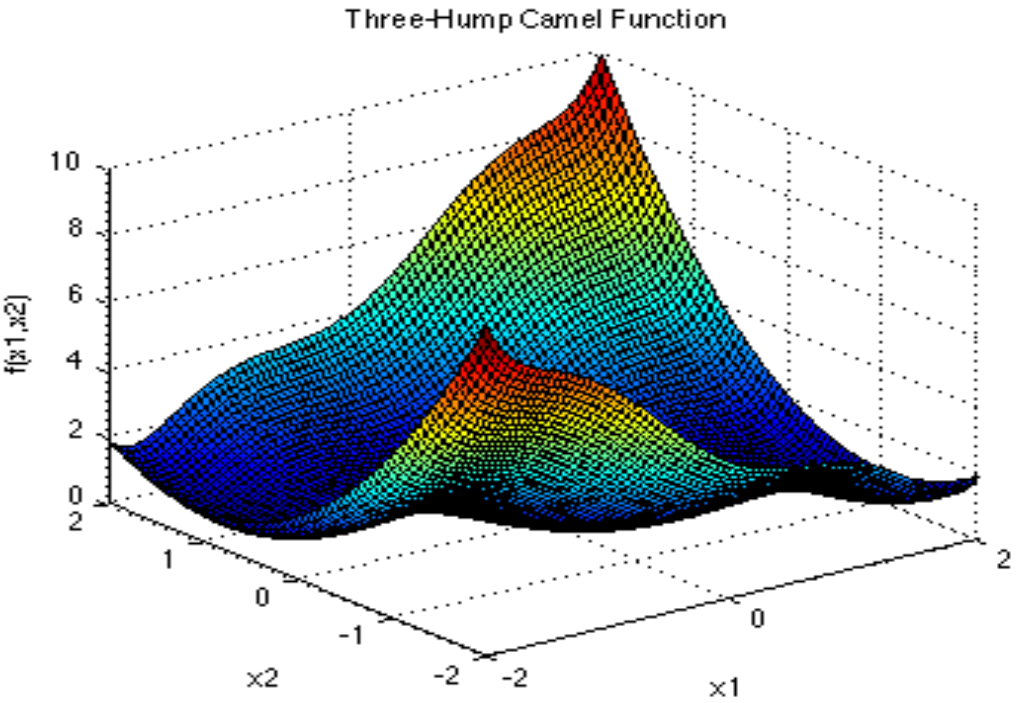

Figure 6: Three-Hump Camel Function

Table 1 shows the results obtained. Green represents performed well. Red represents not performed well. Blue represents performed between well and not well. From Table 1, we can see that all cells are green in color which means the PSO algorithm and developed ASGDTA performed well on all benchmark functions.

Table 1: Obtained Result

Benchmark Function / Algorithm	Artificial Satish Gajawada and Durga Toshniwal Algorithm (ASGDTA)	PSO Algorithm
Ackley Function		
Beale Function		
Bohachevsky Function		
Booth Function		
Three-Hump Camel Function		

VII. Conclusions

A new field titled "Artificial Excellence (AE)" is invented and defined in this work. Researchers in Artificial Intelligence field can follow the path shown in this paper and create algorithms like "Artificial Narendra Modi Algorithm", "Artificial Abdul Kalam Algorithm", "Artificial Mahatma Gandhi Algorithm", "Artificial Mother Teresa Algorithm" and "Artificial Raju Algorithm" by imitating particular humans like Narendra Modi, Abdul Kalam, Mahatma Gandhi, Mother Teresa and Raju respectively. If there are 100 crores population then we can imitate all these population and create more than 100 crores algorithms. If there are 20 people in a project solving real world problems. Then we can create a AE field algorithm imitating these particular 20 people. If we have particular Humans Raju and Rani in real world and AE field algorithm size is 20 then there will be multiple particular Artificial Humans in search space like 10 Artificial Rajus and 10 Artificial Ranis. Hence from this article it is clear that there are INFINITE articles and INFINITE opportunities possible in the new AE field invented in this work.

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- 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.

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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

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