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

Global Journal of Computer Science and Technology: D

Neural & AI

Highlights

- Advancing Real-Time Crime
- Leveraging Deep Machine Learning
- Classification in Pre-Crime Scenes
- Intelligent Ticket Assignment System

Discovering Thoughts, Inventing Future

VOLUME 25 ISSUE 1 VERSION 1.0

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

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

Volume 25 Issue 1 (Ver. 1.0)

Open Association of Research Society

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

Global Journals Inc.

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

Sponsors: *Open Association of Research Society*
Open Scientific Standards

Publisher's Headquarters office

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

Offset Typesetting

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

Packaging & Continental Dispatching

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

Find a correspondence nodal officer near you

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

eContacts

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

Pricing (Excluding Air Parcel Charges):

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

Editorial Board

Global Journal of Computer Science and Technology

Contents of the Issue

Global Journal of Computer Science and Technology: D
Neural & Artificial Intelligence
Volume 25 Issue 1 Version 1.0 Year 2025
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Advancing Real-Time Crime Weapon Detection and High-Risk Person Classification in Pre-Crime Scenes: A Comprehensive Machine Vision Approach Utilizing SSD Detector

By Taiwo. M. Akinmuyisitan, John Cosmas & Yusuff Adeniyi Giwa

Abstract- The application of state-of-the-art in deep learning detection algorithms, such as You Only Look Once (YOLO) and Single Shot MultiBox Detector (SSD), presents a significant opportunity for enhancing crime prevention and control strategies. This research focuses on leveraging the SSD algorithm to detect common crime weapons on individuals in both pre-crime video scenes and real-world crime scenarios. By thoroughly understanding the operational principles of the SSD algorithm, we adapted it for the identification of dangerous weapons commonly associated with violent crimes. Our detection model, which targets both weapons and individuals, establishes a robust foundation for an artificial intelligence (AI) system that accurately predicts individuals at high risk. The model first identifies the presence of a person and subsequently checks for any of the specified weapons. If a weapon is detected, the system further analyzes the individual's movement and speed within the frame of reference. Should the individual exceed a predetermined movement threshold, the system flags them as high risk.

Keywords: *single shot multipledetection (SDD), convolutional neural networks (cnn), deep learning, weapon detection. artificial intelligence, computer vision, image classification, machine learning, object detection, mean average precision.*

GJCST-D Classification: *LCC Code: HV8079.C65*

ADVANCINGREALTIMECRIMEWEAPONDETECTIONANDHIGHRISKPERSONCLASSIFICATIONINPRECRIMESCENESACOMPREHENSIVEMACHINEVISIONAPPROACHUTILIZINGSSDDETECTOR

Advancing Real-Time Crime Weapon Detection and High-Risk Person Classification in Pre-Crime Scenes: A Comprehensive Machine Vision Approach Utilizing SSD Detector

Taiwo. M. Akinmuyisitan [α], John Cosmas [σ] & Yusuff Adeniyi Giwa [ρ]

Abstract- The application of state-of-the-art in deep learning detection algorithms, such as You Only Look Once (YOLO) and Single Shot MultiBox Detector (SSD), presents a significant opportunity for enhancing crime prevention and control strategies. This research focuses on leveraging the SSD algorithm to detect common crime weapons on individuals in both pre-crime video scenes and real-world crime scenarios. By thoroughly understanding the operational principles of the SSD algorithm, we adapted it for the identification of dangerous weapons commonly associated with violent crimes. Our detection model, which targets both weapons and individuals, establishes a robust foundation for an artificial intelligence (AI) system that accurately predicts individuals at high risk. The model first identifies the presence of a person and subsequently checks for any of the specified weapons. If a weapon is detected, the system further analyzes the individual's movement and speed within the frame of reference. Should the individual exceed a predetermined movement threshold, the system flags them as high risk. For this study, the SSD model utilized a VGG16 backbone and was trained on a dataset comprising 3,317 images, featuring four distinct weapon categories: handgun, shotgun, rifle, and knife. The dataset was collected from UCF, via Kaggle and complimented with additional weapons from Google download all, all the sources are secondary, open sources and loyalty-free. We achieved a mean average precision of 84.19% across five classes after training for 59 epochs The findings of this research demonstrate the effectiveness of the SSD algorithm in crime prevention and control, contributing to the ongoing discourse surrounding the application of detection algorithms for crime prediction. This work aims to provide technological innovations that can assist local law enforcement agencies in their operational duties. Additionally, the insights gained from this study may enhance the detection of abnormal behavior within the broader field of artificial intelligence.

Keywords: single shot multipledetection (SDD), convolutional neural networks (cnn), deep learning, weapon detection. artificial intelligence, computer vision, image classification, machine learning, object detection, mean average precision.

I. Introduction

The alarming rise in crime rates globally, particularly in developing nations, poses significant challenges to public safety, peaceful assembly, and social stability. These issues undermine the fundamental right to protection of life and the maintenance of order. However, advancements in technology, especially in emerging fields such as artificial intelligence, offer innovative solutions to address security gaps and bolster support for local law enforcement agencies [1]. The evolving nature of criminal activities has necessitated the development of sophisticated techniques to assist police in their duty to safeguard citizens and uphold social stability [2].

In recent years, the application of machine learning and computer vision for identifying crime hotspots, analyzing weapons of mass violence, and examining crime scenes has gained traction within academic circles, technology-driven nations, and various industries [3]. Among these techniques, the integration of computer vision and artificial intelligence for crime prediction has emerged as a promising approach. Single Shot Detection (SSD) has become one of the most effective model architectures for object detection, offering high accuracy and speed while adapting precision for real-time applications [4].

Single Shot Detection (SSD) is an object detection algorithm similar to You Only Look Once (YOLO), both of which utilize convolutional neural networks (CNN) in their architecture. It may be true to state that SSD is an advanced form of convolutional neural network (CNN) [5]. SSD facilitates efficient processing of images and videos (3D/4D tensors), making it particularly suitable for analyzing crime scenes and weapons, as well as beig useful in manipulating the predicting of potential crime hotspots, including those that have yet to occur. Crime prediction is a sensitive endeavor that demands a high level of accuracy in representing observed situations; in many real-world scenarios, time is of the essence, and precise detection and representation are crucial [6].

This paper explores the adoption of single-shot detection (SSD) algorithms for crime prediction by leveraging extensive datasets of real-world crime footage, weapons, and reported incidents. The aim is to train an artificial intelligence (AI) model capable of predicting criminal activities through the analysis of visual data patterns. SSD has the potential to identify

Author: e-mail: taiwo.akinmuyisitan@brunel.ac.uk

Global Journal of Computer Science and Technology (D) XXV Issue I Version I Year 2025

potential criminal activities and alert law enforcement agencies, facilitating proactive measures. Its speed and accuracy make SSD particularly promising for real-time applications in this context

The study demonstrates the efficiency and effectiveness of single-shot detection (SSD) in various security-related domains, including license plate recognition, traffic monitoring, crime scene analysis, and real-time anomaly detection. However, its application specifically in crime hotspots and crime prediction, as well as its potential for identifying individuals at high public risk, remains largely unexplored, presenting significant opportunities for innovation and improvement. This paper aims to investigate the use of SSD for crime prediction, with a focus on its implementation and performance. Additionally, the research develops a Python scripts to leverage SSD as an advanced detection algorithm for classifying individuals deemed to be at significantly high risk.

The rest of the paper is organized as follows: Section II provides related work in crime prediction and object detection technologies. Section III describes the methodology used in this study, including data collection, preprocessing, and the SSD model architecture. Section IV presents the experimental results, analysis, and discussions of our findings. Finally, Section V presents our conclusion and recommendation including the research limitations and future work.

II. Related Work

SSD remains an emerging research area for the prediction and detection of crime. This emerging research area is looking to build on the capacity of the single-shot multi-box algorithm, its performance, its success in object detection, and more noticeably its capabilities in striking a balance between speed, performance, and real-time application [4]. Single shot detection(SSD) is one of the most popular deep learning object detection frameworks that is known for its balance between speed and accuracy, it could be considered a fit for real-time applications for crime detection and prediction [1].

Recent research on SSD has been on achieving an increased speed while still improving its speed in detecting small objects; speed and accuracy are important in real-time applications and they are also very important parts of surveillance systems. For example, SSD’s multi-scale feature maps and its default bounding boxes make it easy for it to handle different sizes and aspect ratios which are critical in detecting however small representation of scenes in criminal situations [9].

SSDs have shown great promise in crime prediction when used directly or indirectly with data sources such as close circuit TV (CCTV) and other sensory instruments for the identification of crime hotspots, analysis of crime scenes, and prediction of crimes and criminal activities[10]. In a research carried out by [11], the author used SSD together with machine learning algorithms to analyze the patterns captured in surveillance footage and predict suspicious behaviors and people that present possible threats; this research demonstrates great promise in adopting object detection algorithms for crime prediction, especially in an urban environment where many events are happening simultaneously, synchronously and in real-time.

Moreover, SSD's architecture has been adapted to address the specific challenges of crime prediction, such as the need for high accuracy in detecting small objects (e.g., weapons) and the ability to process video streams in real time [4]. These adaptations include the use of advanced feature extraction techniques and the integration of SSD with other neural network models to improve its robustness and accuracy in challenging environments [12].

III. Materials and Methods

This section outlines the methodologies used to achieve the results detailed in Section IV. The approaches are centered on the Single Shot MultiBox Detector (SSD) framework, which leverages a single deep neural network to predict bounding boxes and classify objects in images. Due to the specific nature of the study, our model was trained from near-scratch using a custom dataset designed to reflect real-world crime scenarios. This section further describes the hardware configurations, processes, and techniques involved in constructing custom object detectors specifically aimed at crime prediction.

a) Performance Metrics

Generally, measuring the performance of the object detector used mean average precision (mAP). The mean Average Precision (mAP) is a broadly used performance measures for evaluating the accuracy of object detection models in computer vision models. It combines three important aspects: precision, recall and F1, providing a comprehensive measure of a model's ability to locate and classify objects within an image. To compute mAP, precision-recall curves constructed for each class of objects in our dataset. These curves plot precision against recall at different confidence score thresholds. The area under the curves then averaged across all object classes, resulting in the mean average precision. The mean Average Precision is a valuable metric for assessing the accuracy of object detection models. It offers a balanced evaluation by considering precision and recall, making it particularly suitable for object detection and classification problems.

The mean average precision calculated with equation (1).

$$\mathrm{mAP} = N\_^{1} \sum\nolimits^{N}_{i=1} AP_{\mathrm{i}} \qquad (1)$$

- N is the total number of object classes of the dataset
- AP_i is the average precision for each class i.

i. *Precision*

Precision measures the proportion of correctly identified positive detections out of all the detections made by the model. It assesses the model's accuracy in predicting true positives while minimizing false positives.

$$\text{Precision} = \frac{TP}{TP+FP} \qquad (2)$$

TP= True Positive, which are the instances that are true objects and are positive by the model.

FP = False Positive, which are instances that are not true objects of a class but positive for the model

ii. *Recall*

It calculates the proportion of true positives detected by the model out of all the ground truth objects present in the image. It measures the model's ability to find all relevant objects, minimizing false negatives.

$$\text{Recall} = \frac{TP}{TP+FN} \qquad (3)$$

Here,

FN= False Negative. These are instances where the object is positive (criminal), but the model wrongly predicted (failed to identify the criminal).

iii. *System F1 Value*

The F1 score is the harmonic mean of precision and recall and provides a balance between the two metrics.

It is calculated as:

[F1 Score = 2 \times \frac {Precision \times Recall}
{Precision + Recall}]
{2(precision*Recall)}/precision+Recall) eqn (4)

For simplicity,

- Precision focuses on the accuracy of positive predictions.
- Recall focuses on the proportion of actual positives that correctly identified.
- F1 score provides a balance between precision and recall, especially when there is an uneven class distribution.

b) Data Collection and Processing

i. *Data Acquisition*

Implementing an SSD-based crime prediction model necessitates a substantial and carefully curated dataset. For the training of this system, a secondary video dataset was used, simulating a live-action.

These scenarios were crafted to replicate real-world criminal behavior, enabling the model to be trained and tested on its ability to generalize across diverse threatening situations. The dataset was enhanced by sourcing images and videos of weapons from online platforms and integrating real-world crime data from the UCF-Crime dataset, which includes video clips labeled with tags such as "assault" and "robbery" [14]

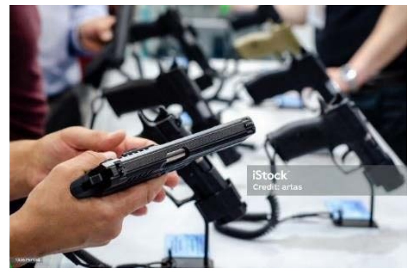


Fig. 1: Shotgun Sample

Fig. 2: UCF-Dataset [14]

ii. *Data Annotation*

Accurate data labeling is crucial for training deep learning models with SSD. In this study, manual annotation was performed using *labelImg* which ensures precise bounding box placement and class labels. At every labeling instance i.e an object (Image), a corresponding XML file is automatically created which contains the object metadata as follows;

- Class Name
- Bounding box Coordinates (xmin, ymin, xmax, ymax)
- Object Dimensions (width, height) The design covered five classes of interest:
- Person
- Handgun
- Shotgun
- Knife
- Rifle

This structured data enabled SSD to detect and classify these objects during training [15].

While YOLOv4 has its annotation in a .txt file, Pascal annotation standard format is in .xml, Fig 3.0

```
▼<annotation>
  <folder>shegun</folder>
  <filename>person.jpeg</filename>
  <path>/home/shegun/person.jpeg</path>
 ▼<source>
    <database>Unknown</database>
  </source>
 ▼<size>
    <width>234</width>
    <height>215</height>
    <depth>3</depth>
  </size>
  <segmented>0</segmented>
 ▼<object>
    <name>Rifle</name>
    <pose>Unspecified</pose>
    <truncated>0</truncated>
    <difficult>0</difficult>
   ▼<bndbox>
      <xmin>18</xmin>
      <ymin>11</ymin>
      <xmax>103</xmax>
      <ymax>183</ymax>
    </bndbox>
  </object>
 ▼<object>
    <name>Shotgun</name>
    <pose>Unspecified</pose>
    <truncated>0</truncated>
    <difficult>0</difficult>
   ▼<bndbox>
      <xmin>171</xmin>
      <ymin>77</ymin>
      <xmax>197</xmax>
      <ymax>131</ymax>
    </bndbox>
  </object>
 ▼<object>
    <name>Person</name>
    <pose>Unspecified</pose>
    <truncated>0</truncated>
    <difficult>0</difficult>
   ▼<bndbox>
      <xmin>54</xmin>
      <ymin>59</ymin>
      <xmax>211</xmax>
      <ymax>205</ymax>
    </bndbox>
  </object>
</annotation>
```


Fig. 3: SDD Sample Dataset Image .XML Annotation file Format

In preparing a dataset for training, a folder named "SSD Custom" created then inside this folder, three folders created namely.

1. Annotations
2. Imageset
3. JPEGImages

c) System Framework

SSD, known for its efficiency in real-time object detection, processes entire images in a single forward pass through the network. This framework predicts multiple bounding boxes and associated class scores for each object, using feature maps extracted at different scales. The advantage of SSD lies in its speed and ability to detect objects of various sizes simultaneously, making it ideal for applications where rapid response is essential, such as crime prediction [16].

The system architecture shown in Figure 4.0 utilizes SSD with vgg16 as the backbone network. The input data-drone-captured videos-are fed into the SSD, where the frames are divided into grids. Each grid cell then predicts bounding boxes and class scores, enabling the detection of objects relevant to criminal activities.

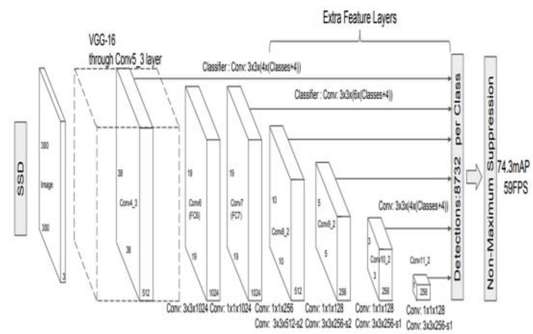


Fig. 4: SSD System Architecture [16]

d) Model Setup

We used SSD with vgg16 as the backbone. The Vgg16 was selected as the backbone model because of the depth of its architecture; Vgg16 has a depth of 16 convolutional layers which makes it easily learn complex and hierarchical features of our training dataset [19]. Additionally, vgg16 has done incredibly well in several image recognition tasks, it has achieved a very high accuracy over image classification tasks [17].

In this paper, we used mutlibox loss which has in its regression and classification loss. The regression loss measures the accuracy of the bounding box while classification predicts the performance of the model over the classes.

Training Configuration:

- *Batch Size:* There is a need to balance memory constraints and model convergence, therefore a small batch size of 10 was used .
- *Epochs:* The model is set for 100 epochs, with validation performed every epoch to monitor performance and avoid overfitting.
- *Checkpointing:* Models are saved at regular intervals, enabling the recovery of the best-performing model.
- *Optimization:* The model used stochastic gradient descent (SGD) which helps speed model convergence.

e) Evaluation

The primary evaluation metric is mean average precision which measures the model accuracy over all classes [18]. mAP is computed at different Intersections over Union (IoU) thresholds to provide a comprehensive assessment of the model's detection capabilities.

IV. Results and Discussion

The entirety of the research was jointly conducted on p2.xlarge AWS GPU and core i5 HP pavilion 16GB RAM with a 4GB Nvidia VRAM. The p2.xlarge instance was connected to a local machine. The research was implemented with a single shot multi-box detection, the VGG16 was selected as the backbone for this research due to its performance and accuracy on image classification tasks where object localizations are of utmost importance. The dataset was a mix of data from a UCF dataset of known criminals, and open-source data of images of guns, knives, and persons. The dataset was a mix of data from a UCF dataset of known criminals, and open-source data of images of guns, knives, and persons. The object dimension(Width, Height), coordinates and class they belong to were determined during the annotation of the dataset. The total dataset was 3317 and was divided into train, test, and evaluation in the 80:10:10 ratio. The dataset was loaded into the training in batches of 10 to ensure adequate memory usage and was trained over 62 epochs. The model performance (mean average precision, mAP) is shown in Fig. 5.0 while Fig 5.1 shows the training loss.

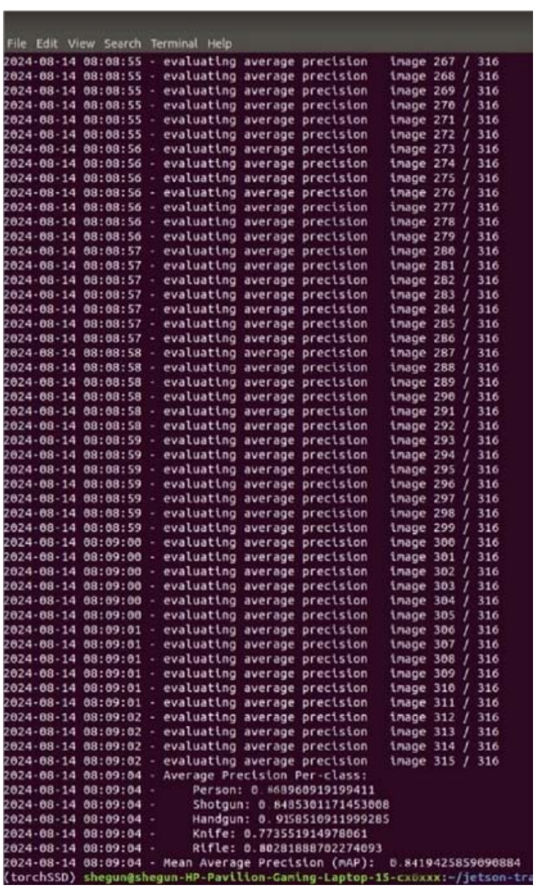


Fig. 5: Mean Average Precision (mAP)

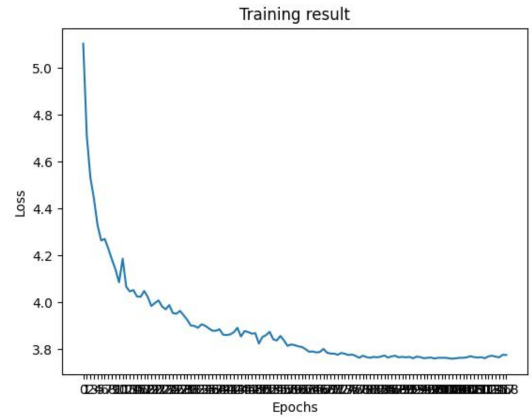


Fig. 5.1: Training Loss

The model was trained and initially set at 100 epochs. However, at about 62 epochs, the model began to overfit, an indication that the model isn't learning anything again. As such, it was ended. The best model performance therefore achieved at 59 epochs with a mean average precision of 0.84%. The inference was conducted on the data shown in Fig. 5(a) and the result of this is shown in Fig. 5(b).

Fig. 5(a): Sample Inference data

Fig. 5(b): Inference result

Table 1.0: SDD Class by Class Performance

Class	AP
Person	86.89
Shotgun	84.85
Handgun	91.58
Knife	77.35
Rifle	80.28

For our result, a confidence threshold of 0.25 was set, this threshold means an object to be detected, must first cross a 25% detection threshold for example for a class "Shotgun" to be said to be in a scene, the model must have seen the class crossed 25% initial detection threshold. This is to ensure that less confidence predictions are filtered out which therefore ensures a reliable detection mechanism.

In Fig 5.0, the model achieved a mean average precision of 84.19%. The high average precision (AP) for weapons mostly associated with violent crimes is of great significance to this research. To detect a person of high risk, it was important to have a model that would be able to pick features from scenes that may suggest whether or not a person detected is a person of high risk. The high precision results recorded in this phase (detection) were very instrumental in building a model that detects persons of high risk.

The High-Risk Detection System functions by identifying and flagging individuals who display potentially dangerous behavior or possess hazardous objects, utilizing a combination of speed analysis and object detection techniques. The process begins with the detection and tracking of "Person" instances within a video stream, where bounding boxes are drawn around each identified individual. The system uses Deep-SORT multiple object tracking algorithm. It calculates the speed of movement for each detected person by comparing their positions across consecutive frames. If an individual's speed exceeds a predefined threshold (set at 0.35 in the design Python script), they are flagged as "High Risk." Furthermore, the system also assesses the presence of specific high-risk objects, such as firearms (e.g., rifles, shotguns, handguns) and knives, associated with the detected "Person" in the precrime video footage.

Fig. 6(a): CCTV Crime Footage

Fig. 6(b): High Risk Prediction

The SSD (Single Shot MultiBox Detector) results demonstrate the efficacy of this approach. With an average precision (AP) of 86.89% for detecting "Person" instances, the model reliably identifies individuals, which is crucial for accurately determining whether someone should be flagged as high risk based on their behavior or the objects they carry. The model also shows strong performance in detecting specific weapons, with APs of 84.85% for "Shotgun" and 91.58% for "Handgun," which enhances the system's ability to identify individuals carrying these dangerous items. Fig. 6(a) and 6(b) show respectively the sample footage used for inference and the result. The footage is a real-life robbing scene captured by CCTV.

This model achieved high average precision (AP) scores for objects like "Handgun" (91.58%) and "Shotgun" (84.85%), However, other studies suggested that models like YOLOv4, which were fine-tuned for specific tasks and utilized additional enhancements, outperform our SSD in precision metrics, particularly for smaller objects [19]

V. Conclusion

This research focused on the application of the Single Shot Multi-Box Detection (SSD) algorithm for the prediction and prevention of violent crimes. It utilized a local HP Pavilion gaming machine with specific hardware specifications, alongside a p2.xlarge GPU instance on AWS, and a dataset comprising 3,317 instances from various sources, including the UCF Crime Open Dataset. We successfully developed a system capable of identifying individuals at high risk based on the presence of weapons and the speed at which these individuals are moving, indicating potential abnormal behavior.

To achieve the results presented in this paper, the datasets were meticulously annotated and divided into three distinct subsets: training, validation, and testing. The model was initially set to run for 100 epochs but was terminated at 62 epochs to prevent overfitting. Peak performance was achieved at 59 epochs, with a mean average precision of 84.19%.

In this study, we successfully employed the SSD algorithm to create a system for predicting high-risk individuals. This high-risk model relied heavily on the SSD model's performance in detecting weapons associated with violent crime. Upon optimization, our detection model demonstrated competitive results compared to the Yolov4 detection outcomes reported by [20], using the same dataset and classes.

The significance of our findings extends beyond the immediate results. Our model's ability to predict highrisk scenarios is particularly valuable in real-world surveillance applications, providing a robust tool for enhancing security measures. By successfully integrating advanced deep learning techniques, our study contributes to the literature on anomaly detection, especially concerning crime-related behaviors captured in surveillance videos.

However, our study is not without limitations. The dataset, while diverse, may still not cover all possible real-world scenarios, affecting the model's generalizability. Additionally, computational constraints limited the scale of our experiments. Future research could focus on expanding the dataset, improving annotation techniques, and exploring more powerful computational resources to further enhance model performance.

References Références Referencias

1. W. Liu et al., "SSD: Single Shot MultiBox Detector," in *Proceedings of the European Conference on Computer Vision (ECCV)*, 2016, pp. 21-37.
2. Y. Chen, Y. Zhu, C. Ke, and F. Chen, "Crime prediction using deep learning," *IEEE Access*, vol. 7, pp. 150503-150510, 2019.
3. S. Zhang, R. Benenson, and B. Schiele, "CityPersons: A Diverse Dataset for Pedestrian Detection," in *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, 2017, pp. 4457-4465.
4. "What Is SSD & How It Improved Computer Vision Forever," *Analytics India Magazine*, 2024. [Online]. Available: https://analyticsindiamag.com. Accessed: Aug. 12, 2024.
5. BlazeFace: Sub-millisecond Neural Face Detection on Mobile GPUs," *ar5iv.org*, 2024. [Online]. Available: https://ar5iv.org/abs/1907.05047. Accessed: Aug. 12, 2024.
6. G. C. Oatley and B. W. Ewart, "Crimes analysis software: 'pins in maps', clustering and Bayes net prediction," *Expert Systems with Applications*, vol. 25, no. 4, pp. 569-588, 2003.
7. O. Z. Apene, N. V. Blamah, and G. I. O. Aimufua, "Advancements in Crime Prevention and Detection: From Traditional Approaches to Artificial Intelligence Solutions," *European Journal of Applied Science, Engineering and Technology*, vol. 2, no. 2, pp. 285-297, 2024.
8. L. Aziz, M. S. B. H. Salam, U. U. Sheikh, and S. Ayub, "Exploring deep learning-based architecture, strategies, applications and current trends in generic object detection: A comprehensive review," *IEEE Access*, vol. 8, pp. 170461-170495, 2020.
9. L. Cheng, Y. Ji, C. Li, X. Liu, and G. Fang, "Improved SSD network for fast concealed object detection and recognition in passive terahertz security images," *Scientific Reports*, vol. 12, no. 1, p. 12082, 2022.
10. R. Shenoy, D. Yadav, H. Lakhotiya, and J. Sisodia, "An intelligent framework for crime prediction using behavioural tracking and motion analysis," in *2022 International Conference on Emerging Smart Computing and Informatics (ESCI)*, 2022, pp. 1-6.
11. R. M. Saji and N. V. Sobhana, "Real Time Object Detection Using SSD For Bank Security," in *IOP Conference Series: Materials Science and Engineering*, vol. 1070, no. 1, p. 012060, Feb. 2021, IOP Publishing.
12. Y. J. Hwang, J. G. Lee, U. C. Moon, and H. H. Park, "SSD-TSEFFM: New SSD using trident feature and squeeze and extraction feature fusion," *Sensors*, vol. 20, no. 13, p. 3630, 2020.
13. A. Juneja, S. Juneja, A. Soneja, and S. Jain, "Real time object detection using CNN based single shot detector model," *Journal of Information Technology Management*, vol. 13, no. 1, pp. 62-80, 2021.
14. W. Sultani, C. Chen, and M. Shah, "Real-World Anomaly Detection in Surveillance Videos," in *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, 2018, pp. 6479-6488.
15. T. Y. Lin, M. Maire, S. Belongie, J. Hays, P. Perona, D. Ramanan, P. Dollár, and C. L. Zitnick, "Microsoft COCO: Common Objects in Context," in *Proceedings of the European Conference on Computer Vision (ECCV)*, Cham, Switzerland: Springer, 2014, pp. 740-755.
16. W. Liu, D. Anguelov, D. Erhan, C. Szegedy, S. Reed, C. Y. Fu, and A. C. Berg, "SSD: Single Shot MultiBox Detector," in *Computer Vision – ECCV 2016: 14th European Conference, Amsterdam, The Netherlands, October 11–14, 2016, Proceedings, Part I*, Cham, Switzerland: Springer International Publishing, 2016, pp. 21-37.
17. K. Simonyan and A. Zisserman, "Very Deep Convolutional Networks for Large-Scale Image Recognition," in *Proceedings of the International Conference on Learning Representations (ICLR)*, 2015.
18. R. Padilla, S. L. Netto, and E. A. Da Silva, "A Survey on Performance Metrics for ObjectDetection Algorithms," in *Proceedings of the 2020 International*

Conference on Systems, Signals and Image Processing (IWSSIP), 2020, pp. 237-242.

19. K. Tran and N. D. Tran Pham, "Comparative Analysis of Image Processing Object Detection Models: SSD MobileNet and YOLO for Guava Application," in *The International Conference on Sustainable Energy Technologies*, Singapore, Nov. 2023, pp. 443-451. Springer Nature Singapore.
20. Taiwo Akinmuyisitan and John Cosmas(2024) Enhanced Crime Prediction with Computer Vision: YOLOv4 Approach. Global Journal of Computer Science and Technology, Massachusset, USA Vol 24 issue(1).

Global Journal of Computer Science and Technology: D
Neural & Artificial Intelligence
Volume 25 Issue 1 Version 1.0 Year 2025
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

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

By Rajaa Amellal & Mr. Habibi Mohamed

Ibn Tofail University

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

GJCST-D Classification: *DDC Code: 621.382*

Strictly as per the compliance and regulations of:

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

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

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

I. Introduction

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

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

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

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

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

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

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

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

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

Global Journal of Computer Science and Technology (D) XXV Issue I Version I Year 2025

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

II. Methodology and Problem Description

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

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

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

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

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

N is the total number of sampling frequencies

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

The second objective and fitness function given by

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

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

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

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

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

The theoretical values of W and L are given by:

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

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

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

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

When

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

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

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

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

U(x) = G(x) = 1

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

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

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

$$UP(x) = U(x) + \beta 1 c1(x)^2 \quad (6)$$

were

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

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

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

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

1. Predefine the design space;
2. Determine the number of neurons in each layer of RNN and the antenna geometry vector *x*;
3. Sample design space using HFSS and acquire the response set y *construct the targets;*
4. Adjust the RNN_genetic algorithm mapping S11 and Gain by *the first iteration I1* of optimization;
5. Construct an l_1-MOGA surrogate model $R_s(x)$;
6. Optimize the population by MOGA with an *NSGA2* surrogate model;

The relative error is defined as ||R(x)-Rs(x)||/||R(x)||, where Rs stands for the surrogate. The computational model R is simulated in HFSS and corresponds to the experiment parameters design of the patch antenna [8].

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

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

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

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

a) Recurrent Neural Networks

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

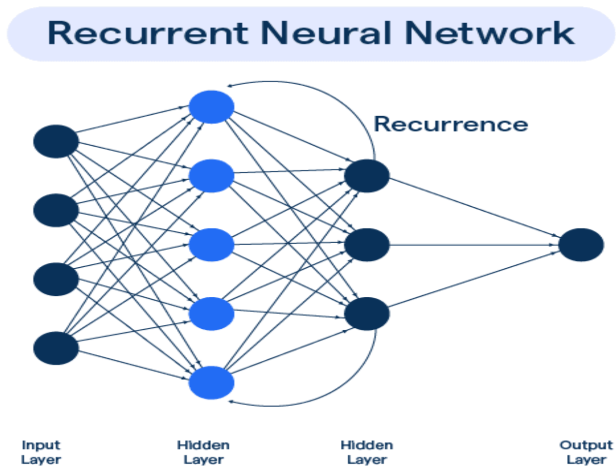


Figure 1: General View of the Architecture of RNN

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

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

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

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

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

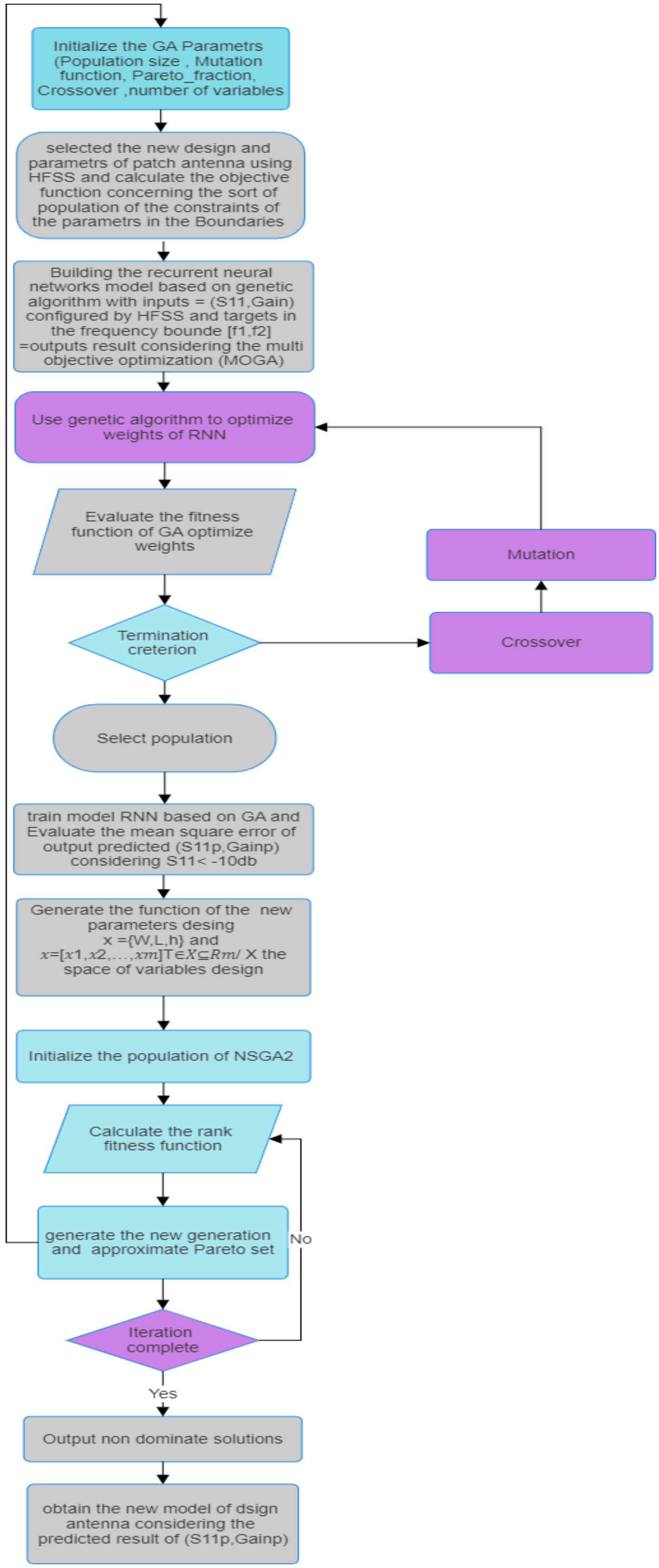


Figure 2: Flowchart of the Improved MOGA/NSGA2 with A Dynamically Updatable using GA_RNN Surrogate-Optimized Model

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

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

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

Algorithm1 PSO_FFNN:

Input: Input The parameters of the Result patch antenna (S11, Gain, frequency):

Outputs: Optimized value of (S11, Gain)

maximum iterations: Max, size of

swarm: begin and end, inertia weights: ωbegin and ωend,

acceleration constants: c1, c2 , maximum of velocity:

vmax

frequency variable f (‘2.4,2.8’) for each optimization set

Initialization of PSO algorithm:

Social and cognitive coefficients C1, C2;

Inertial weights W(i);

Update Velocity V(i);

Populations, Iterations;

1: Set iteration index k = 0. Initialize the velocities

and positions of n particles, ω ← ωbegin − k/Max ∗

(ωbegin − ωend).

2: For every particle in the swarm evaluate the fitness function

3: Obtain corresponding expectations of the parameter’s performance of

the patch antenna.

4: Update the personal best position of each particle, the global best

position of the swarm Gbest(i), the local best position, and corresponding values. and best fitness

5: while k < Max do

6: For every Iteration do:

7: Obtain corresponding constraints of antenna parameters and update the objective function based on the result obtained using HFSS (S11, Gain).

8: if the Current position is the personal best position for this

particle then

9: Update its personal best position

10: Request result from HFSS (S11, Gain)

11: evaluate the objective function:

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

Improve in-band matching within the

frequency range F

Ensure that in-band matching does not

exceed −10 dB in F

|S11(x, f) |≤ −10 dB for f ∈ F;

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

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

PSOFFNN_run_model (net, inputs);

ALGORITHM2 GA_RNN/MOGA_NSGA2 :

X: {XTRAIN, YTRAIN}

1. GENERATE INPUTS AND OUTPUTS OF RNN

INPUTS = SIZE {S11, GAIN)

OUTPUTS = SIZE {TARGET (1)}

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

NET= RNNETWORKS (NET, INPUTS, TARGETS);

2. INITIALIZATION OF GA ALGORITHM PARAMETERS

POPULATION SIZE;

MUTATION RATE, CROSSOVER

GENERATION

NUMBER OF VARIABLES

3. INITIALIZE LEARNING PARAMETERS

MUTATION POWER, POPULATION SIZE, TRUNCATION SIZE;

4. EVALUATE POLICYINITFNCTION

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

EVALOPTI = GA_RNNMODEL (NET, O)

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

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

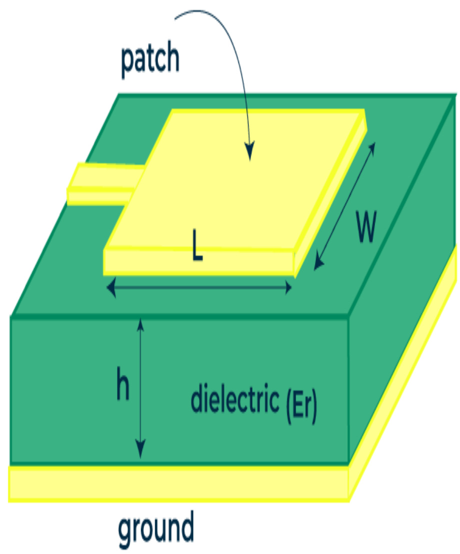
7. REQUEST THE RESULTS OF ANSYS HFSS

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

III. Simulation and Results

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

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



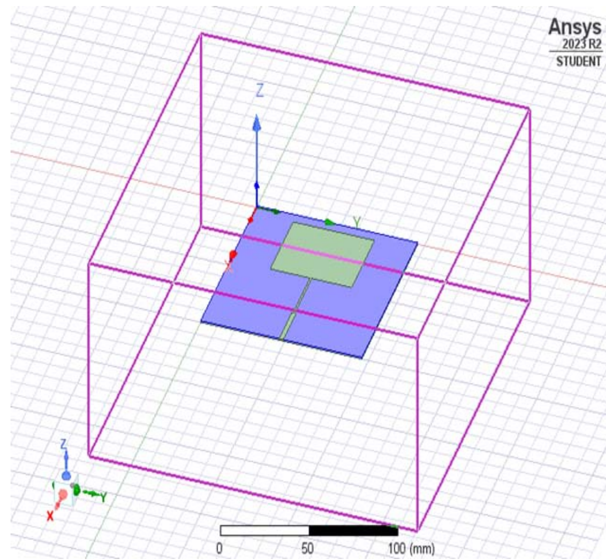
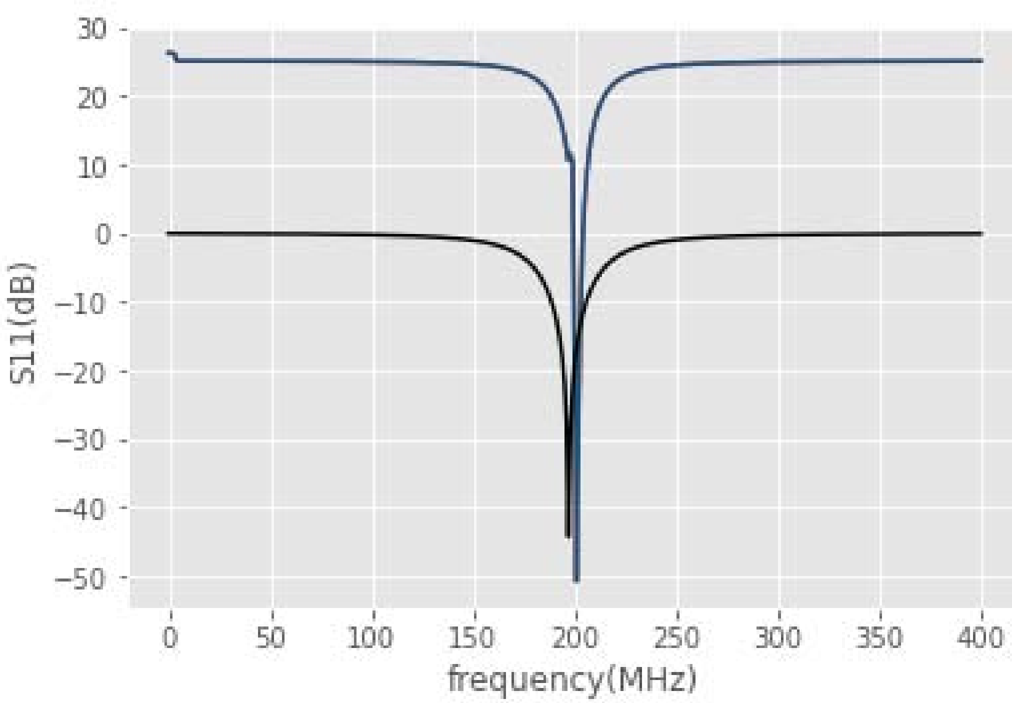


Figure 3: The General Structure of the Microstrip Patch Antenna and Simulated Model using HFSS Software

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

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



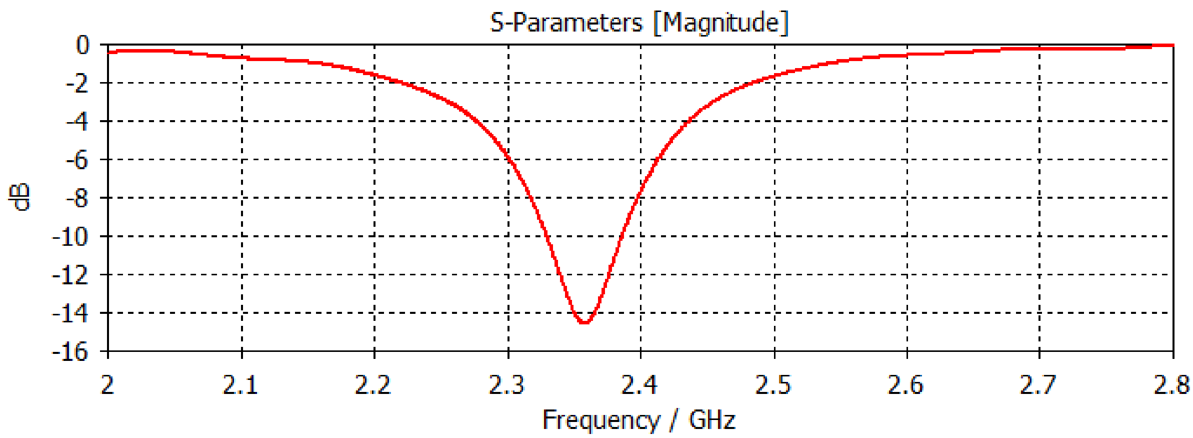


Figure 4: Reflection Responses of Predicted S11 Using PSO_FFNN and Simulated Results in the Dual-Band

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

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

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

Global Journal of Computer Science and Technology (D) XXV Issue I Version I Year 2025

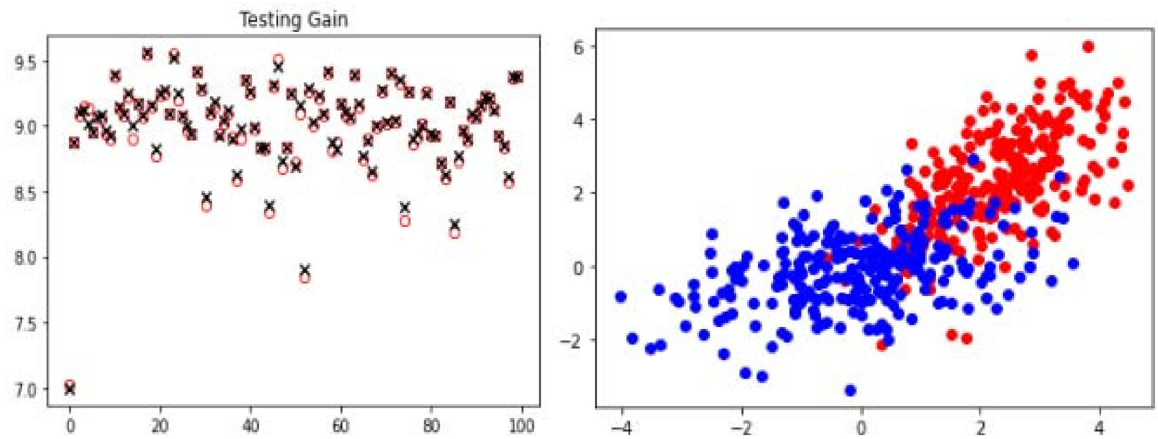


Figure 5: The Finder Solution for Particle Swarm Performance and Location in the Later Stage of Evolution, for two Variables S11 and Gain

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

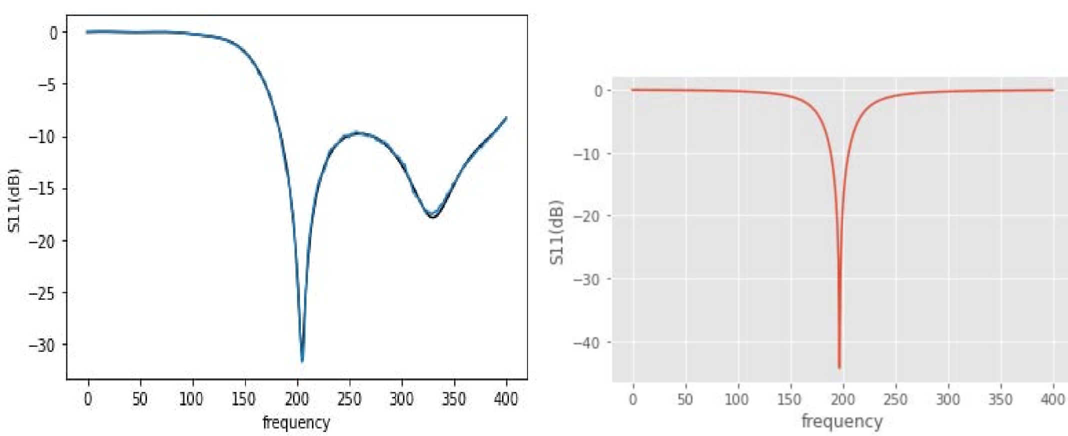


Figure 6: Reflection Responses of Optimized and Experimental Parameters in the Dual-Band Arranged the BW

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

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

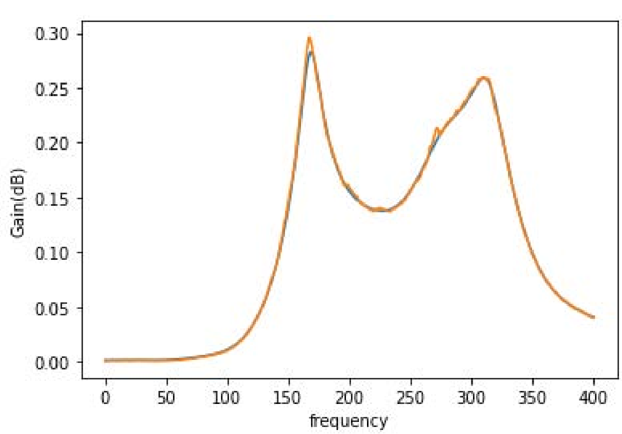


Figure 7: The Radiation Pattern for both Simulated and Optimized Parameters Designed for the Patch Antenna

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

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

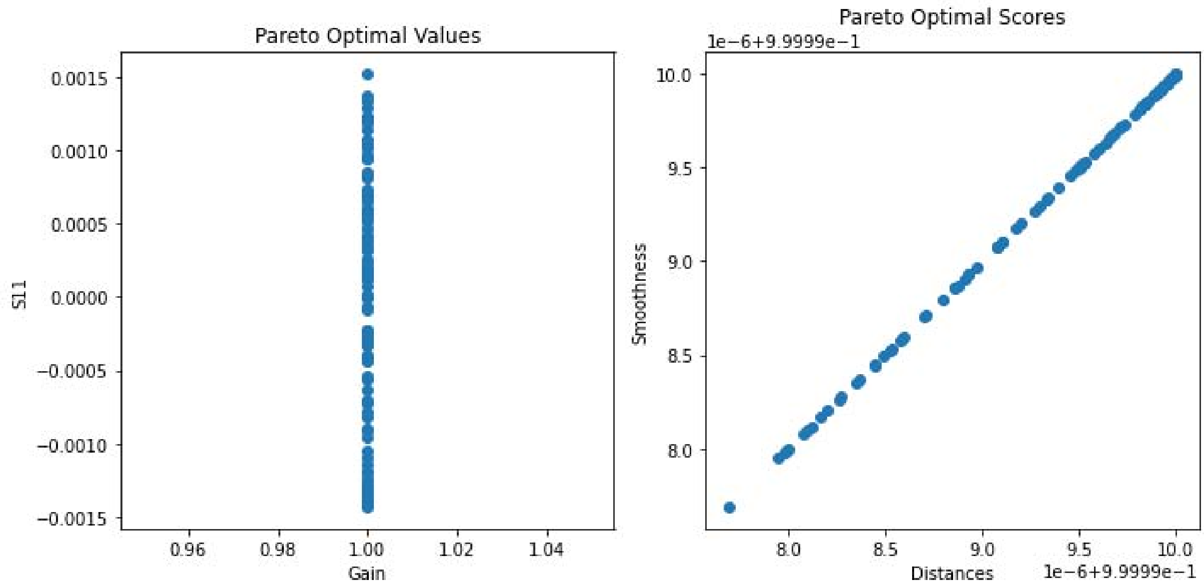


Figure 8: The Selected Pareto Optimal Designs' Reflection Coefficient and Realized Gain Characteristics

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

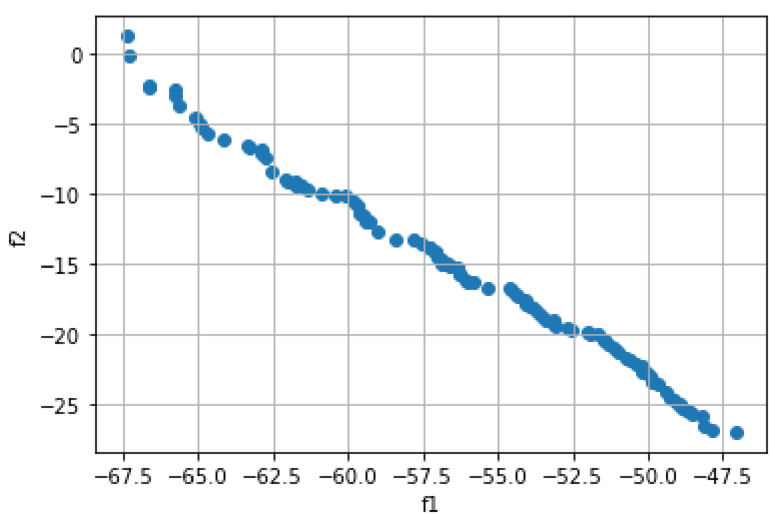


Figure 9: Example of Pareto Front in two-Objective Optimization for S11

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

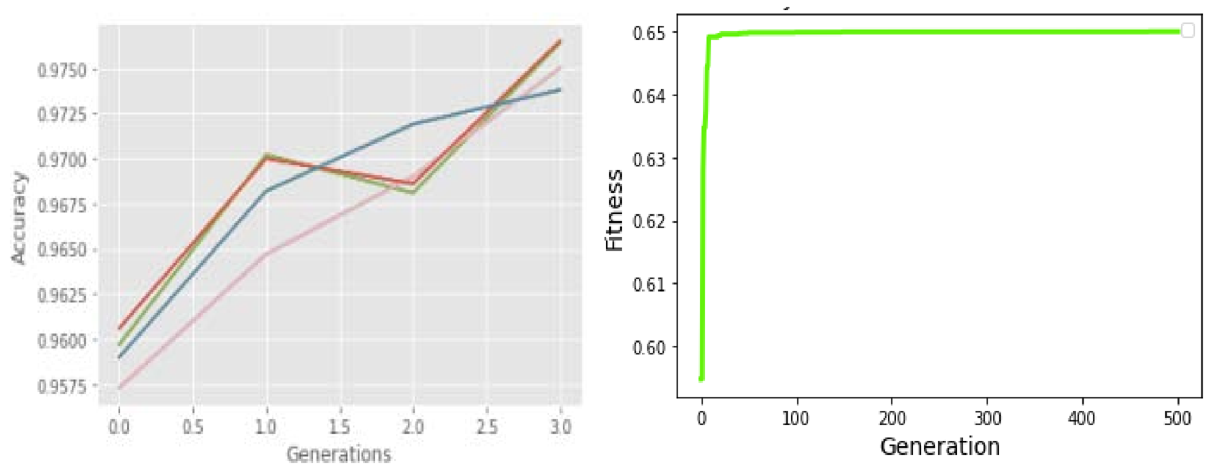


Figure 10: The Evolution of Fitness Functions for the GA Algorithm Accurately with Upgrade the Generation, Such as Concurrent accuracy for two Variables S11 and Gain, Examines Probability for 4 Generations

IV. Conclusion

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

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

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

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

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

References Références Referencias

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

Vol: 13, Issue: 10465, www.mdpi.com/journal/applsci

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

This page is intentionally left blank

Global Journal of Computer Science and Technology: D
Neural & Artificial Intelligence
Volume 25 Issue 1 Version 1.0 Year 2025
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Intelligent Ticket Assignment System: Leveraging Deep Machine Learning for Enhanced Customer Support

By Yusuff Adeniyi Giwa, Taiwo Akinmuyisitan, Jacob Sanni, Adebesin Adedayo, Boluwaji Benard Akinmuyisitan & Nosakhare Ikponmwosa

Teesside University

Abstract- In the evolving customer support domain, traditional ticketing systems struggle to meet increasing demands for speed and accuracy. This study presents an intelligent ticket assignment system leveraging BERT, Graph Neural Networks (GNN), and Prototypical Networks to enhance classification and routing efficiency. The methodology includes comprehensive preprocessing of historical ticket data, feature extraction using natural language processing (NLP), and model evaluation based on accuracy, precision, recall, and F1-score. Results indicate that BERT achieves the highest accuracy (89.4%), precision (88.7%), recall (90.2%), and F1-score (89.4%), outperforming GNN (87.6%) and Prototypical Networks (86.8%) by notable margins. A comparative analysis with Random Forest (85.3%) further demonstrates a 4.1% improvement in accuracy.

Keywords: e-ticketing AI system, machine learning, predictive model, bert algorithm, data preprocessing, prototypical networks, graph neural networks, natural language processing, feature extraction, ticket classification.

GJCST-D Classification: LCC Code: QA76.73.N37

INTELLIGENTTICKETASSIGNMENTSYSTEMLEVERAGINGDEEPMACHINELEARNINGFORENHANCEDCUSTOMERSUPPORT

Strictly as per the compliance and regulations of:

Intelligent Ticket Assignment System: Leveraging Deep Machine Learning for Enhanced Customer Support

Yusuff Adeniyi Giwa [α], Taiwo Akinmuyisitan [σ], Jacob Sanni [ρ], Adebesin Adedayo [ω], Boluwaji Benard Akinmuyisitan [¥] & Nosakhare Ikponmwosa [§]

Abstract- In the evolving customer support domain, traditional ticketing systems struggle to meet increasing demands for speed and accuracy. This study presents an intelligent ticket assignment system leveraging BERT, Graph Neural Networks (GNN), and Prototypical Networks to enhance classification and routing efficiency. The methodology includes comprehensive preprocessing of historical ticket data, feature extraction using natural language processing (NLP), and model evaluation based on accuracy, precision, recall, and F1-score. Results indicate that BERT achieves the highest accuracy (89.4%), precision (88.7%), recall (90.2%), and F1-score (89.4%), outperforming GNN (87.6%) and Prototypical Networks (86.8%) by notable margins. A comparative analysis with Random Forest (85.3%) further demonstrates a 4.1% improvement in accuracy. The analysis demonstrates both performance strengths and real-life practicality and scalability characteristics of the system when managing high traffic volumes. Stability and predictive accuracy improved through the application of noise filtering alongside SMOTE oversampling and weighted loss functions for addressing data quality problems and class imbalance and model integration complexities. The research demonstrates how machine learning changes the way customer service operations work while showing AI models can boost service quality and operational effectiveness.

Keywords: e-ticketing AI system, machine learning, predictive model, bert algorithm, data preprocessing, prototypical networks, graph neural networks, natural language processing, feature extraction, ticket classification.

Author α: Innovarie, Stockton-on-Tees.
e-mail: UKy.giwa@innovarie.com
Author σ: Department of Computer Science, Global Banking School, London. e-mail: Takinmuyisitan@globalbanking..ac.uk
Author ρ: Department of Computing, Teesside University, Avaso Technologies, Newcastle, United Kingdom.
e-mail: Sannijay2709@gmail.com
Author ω: Department of Physics and Engineering Physics, Obafemi Awolowo University, ile-ife, Nigeria.
e-mail: adebesindedayo@gmail.com
Author ¥: Business Management, Postgraduate School, University of Bolton, Greater Manchester. e-mail: UK ba1res@bolton.ac.uk
Author §: Business Management Dept, Global Banking School, London. e-mail: nikponmwosa@globalbanking.ac.uk

I. Introduction

Customer support stands as a fundamental business tool which boosts client satisfaction followed by brand loyalty while securing business superiority. Customer question resolution efficiency functions as a business success indicator that shapes how many customers will stay with the company [1]. Businesses need to evolve from solving problems after they occur to implementing ahead-of-time customer engagement approaches to stay competitive [2]. The growing complexity of customer interactions becomes worse because customers use a range of communication channels from social media to email and live chat and mobile applications [3]. The contemporary buying public requires assisted service that provides integrated personalised support throughout all its multiple interaction channels so organisations must adopt flexible data-based solutions to handle these platforms efficiently.

Current business operations still use basic support systems which base their ticket processing exclusively on human intervention. The outdated systems create multiple operational problems and performance issues which render services below contemporary consumer demands [4]. The ability to scale remains problematic due to human agents facing challenges in handling large numbers of tickets which generates delays and dissatisfied customers and backlog cases. Service quality issues persist in support centres because inconsistent ticket routing and prioritisation causes resolution times to vary by 25% for similar issues according to research [5]. The present constraints demonstrate an immediate requirement for intelligent automated solutions in customer service operations.

Global Journal of Computer Science and Technology (D) XXV Issue I Version I Year 2025

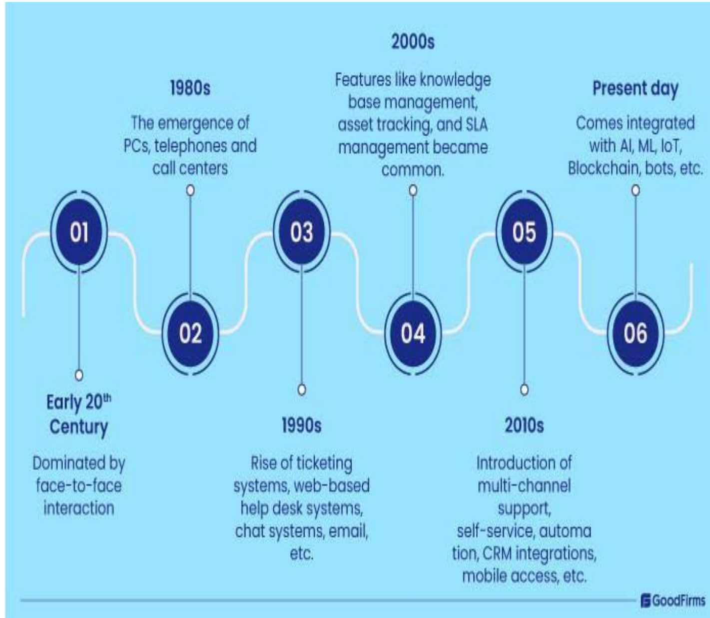


Figure 1: Evolution from Manual to AI-Powered Customer Support Systems. Adapted from [4]

Figure 1 demonstrates the fundamental shift in support systems from manual to AI-powered solutions which addresses these challenges as shown in Figure 1. The traditional support approaches do not satisfy contemporary customer demands because they depend on human staffing and contain error possibilities which limit their effectiveness. AI-based systems that use automation enhance ticket classification and prioritization and assignment speed while improving precision to deliver faster responses and better resource distribution [6]. Machine learning models trained with historical data enable predictive analytics to forecast both ticket urgency and complexity levels which businesses use to provide more accurate and data-based services [7]. Modern business practices remain hindered by existing scalability problems and inconsistent service quality since many organisations have not embraced AI-driven solutions.

This paper addresses these challenges by developing an intelligent ticket assignment system leveraging machine learning. The study aims to:

- Automate the categorisation and assignment of customer support tickets using machine learning techniques.
- Utilise historical data to predict the urgency and complexity of incoming tickets.
- Improve ticket assignment accuracy and response times compared to traditional, manual systems.

By implementing this intelligent AI-driven approach, businesses can overcome the limitations of manual ticketing systems, enhancing both scalability and service efficiency. This study highlights how AI-enabled solutions can transform customer service operations, allowing organisations to effectively meet the increasing demands of modern consumers.

II. Related Work

The development of customer care systems started with manual engagement before adding semi-automated solutions and finally implementing AI-based intelligent systems. Modern customer expectations regarding rapid precise service delivery create an increasing market need for scalable flexible accurate ticket-handling systems. Most organisations currently experience difficulty with traditional methods that depend on human agents to classify and assign support tickets when they expand their customer engagement through social media platforms and email and live chat channels. These operational systems succeed in limited situations but struggle to scale adequately nor operate with the desired speed and precision which creates service delays and incorrect ticket routing while generating service quality flaws [8]. The legacy systems restrict true-time capability and analytical analysis which reduces customer trend detection along with proactive customer involvement [9].

Recognising these limitations, early machine learning models such as Support Vector Machines (SVMs) and Logistic Regression were introduced to automate ticket classification. Such models required extensive feature engineering while achieving good results in structured environments without sufficient ability to handle complex context-rich questions [10]. Ensemble methods like Random Forest addressed non-linear relationships more effectively and improved classification accuracy; however, they remained insufficient for processing nuanced natural language interactions, particularly in cases involving sarcasm,

Global Journal of Computer Science and Technology (D) XXV Issue I Version I Year 2025

industry-specific terminology, or ambiguous phrasing [11]. The introduction of deep learning and graph-based approaches marked a significant shift in customer service automation by enabling models to extract context, identify relationships between tickets, and classify inquiries with greater precision [7].

BERT, a transformer-based model, advanced ticket classification by leveraging bidirectional contextual learning, allowing for improved semantic understanding. Advanced linguistic patterns within ticket classifications achieved better processing accuracy with this technology specifically in cases involving informal language and technical terminology [12]. However, despite its effectiveness, BERT remains computationally demanding, limiting its practicality for real-time deployment in high-volume service environments [13]. Graph Neural Networks (GNNs) introduced another layer of refinement by modelling customer inquiries as interconnected nodes, improving routing accuracy by identifying relationships between similar tickets. Real-time scalability of these models faces limitations because they need extensive hyperparameter tuning while requiring large resource usage [14][15].

Few-shot learning methods, such as Prototypical Networks and MAML, have emerged as an alternative solution for handling rare or novel ticket types. These methods leverage limited examples to adapt quickly to new customer inquiries [18][19]. These models are instrumental in dynamic service environments where new issues frequently arise, requiring rapid adjustments without extensive retraining. However, their reliance on specialised architecture and high computational costs has restricted widespread adoption, particularly in enterprise applications with resource constraints [23].

Despite these advancements, modern AI-driven models continue to present challenges. BERT, while highly effective in capturing linguistic nuances, struggles to generalise across domains with unfamiliar terminology, requiring extensive domain adaptation techniques to maintain performance [22]. GNNs, despite their ability to identify ticket relationships, demand significant processing power, making real-time implementation difficult [15]. Few-shot learning models offer adaptability but require computationally intensive architectures that limit their feasibility for large-scale deployment [23]. Bias and fairness also persist across these models, as imbalanced datasets can lead to disproportionate classification outcomes, potentially resulting in service inconsistencies [23].

Traditional systems' limitations have been well-documented in industry case studies, highlighting the pressing need for AI adoption. Large-scale e-commerce platforms have reported significant misrouting rates, leading to prolonged response times exceeding 24 hours and customer dissatisfaction [1]. Similarly, telecommuni-cations providers handling a number of daily inquiries have experienced severe service disruptions due to the inability of rule-based ticketing systems to scale effectively [28]. A UK financial institution, National Savings & Investments (NS&I), saw a 37% surge in complaints, reaching 33,655 in a year, as outdated technology and poor service led to long wait times and online access issues, diminishing customer trust [30]. On the other hand, companies like Amazon that are adopting BERT-based ticketing solutions have seen classification accuracy improve by 18%, reducing resolution times by 35% [29]. These findings underscore the need for AI-driven customer support frameworks that integrate scalable, efficient, and adaptive machine learning techniques.

While deep learning and graph-based models have revolutionised customer service automation, ongoing research must focus on mitigating computational constraints, improving domain generalisation, and addressing ethical concerns in AI-driven ticketing systems. Optimisation strategies such as model quantisation, hybrid AI architectures, and fairness-aware algorithms offer promising pathways for enhancing the scalability and real-time efficiency of machine learning applications in customer support [6]. The transition towards fully automated, intelligent support systems is an ongoing process, requiring continued refinement to ensure that AI-driven solutions meet the evolving demands of modern businesses and consumers.

III. Problem Statement and Motivation

Studies from 2011 indicated that 75% of customers did not like how long it took contact centres to respond [31]. When processing happens manually the response times get delayed and customers become dissatisfied along with their satisfaction measures decreasing. Ticket misclassification leads to incorrect routing that makes operational challenges and delay times steadily increase [32]. The correct routing of tickets requires longer procedural time when they travel through several departments before reaching their destination which results in service quality deterioration and higher operational costs. The lack of predictive analytics capabilities in these systems prevents businesses from forecasting upcoming customer difficulties at the same time as preventing peak load increases [24]. Organizations implement advanced machine learning (ML) models BERT and GNNs to address the limitations they face in their ticket processing systems. BERT processes information from both forward and backward text directions which provides contextual understanding of language topics to overcome traditional keyword classification limitations [12]. BERT uses its deep learning capabilities to detect word-to-word connections which results in fewer incorrect assignments when ticket categories are determined [13]. Through its deep bidirectional learning ability BERT recognises the difference between product defect reports and usage inquiries that use similar wordings so it helps speed up ticket routing and resolution time.

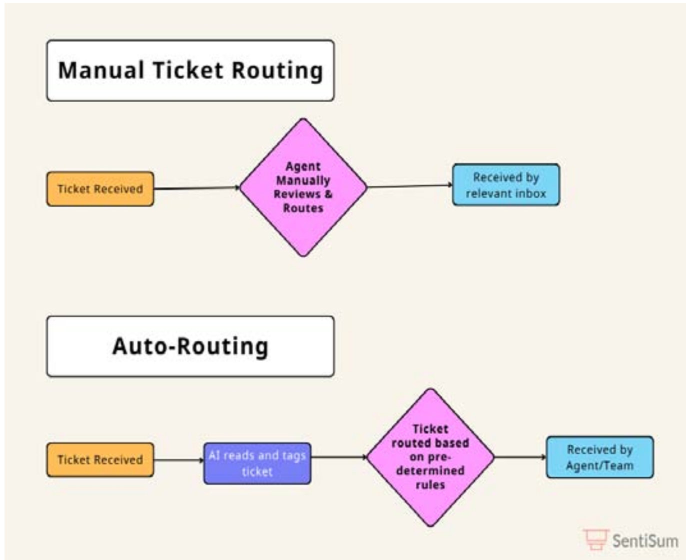


Figure 2: Manual Ticket Routing Process Vs. AI-Driven Automation Workflow. Adapted from [26]

BERT enhances semantic understanding but GNNs bring a network-based routing system for tickets particularly when multiple tickets show mutual connections. GNN technology applies mathematical graph algorithms to tickets so it can enhance both ticket grouping and routing operations and reduce ticket processing time. Operational classification organised by context enables organisations to handle interrelated problems which reduces customer contact duplications and optimises agent allocation throughout service departments. The combination of BERT with GNNs allows real-time decision automation and enhances scalability which modernises support systems to develop adaptive proactive services tools.

GNNs work together with BERT by analysing supportive ticket network relationships to provide better routing capabilities and categorization functionalities. The attributes of issue type and customer history serve as the basis for GNN models to establish edges between tickets while treating each ticket as a node in a graph format [14]. The system achieves group management abilities for connected tickets through this format allowing it to select appropriate tasks for specialised teams to reach faster resolution times. AI solutions like those presented in SentiSum's automatic versus manual routing test showcase how GNNs together with BERT achieve enhanced efficiency through minimised human involvement and rapid processing of numerous tickets [25]. The analysis systems train their comprehension by learning data constantly while simultaneously enhancing their predictive accuracy and minimising operational expenditures through lower technical support team staffing needs [14]. Customer satisfaction grows substantially together with proactive customer concern trend detection from machine learning insights through the combination of BERT contextual analysis with GNN relational modelling which prevents ticket misdirection and resolves all support requests [23]. BERT and GNNs establish their position as essential tools for achieving scalable high-precision data-based customer service operations that provide immediate customised support.

IV. Proposed Solution

The proposed system uses BERT alongside GNNs and Meta-learning capabilities to improve traditional customer support systems by resolving their current inefficiencies. BERT delivers better classification results through its context understanding capabilities which reduces the wrong decisions made by keyword-based methods. GNN operates to enhance routing performance by discovering ticket linkages which allows similar requests to automatically find the appropriate routing path for speedy resolutions. Meta-learning systems maintain their adaptability to process new and infrequent ticket types after small training sessions and this feature brings adaptive capabilities to changing service environments. The complete support system operates through an integrated pipeline that enables data preprocessing of unstructured inputs for BERT ticket classification then GNN processing of decisions and continuous adaptation delivered by Meta-learning mechanisms.

The system needs two key features to handle growing demands and perform instant processing requirements. The system achieves maximum

Global Journal of Computer Science and Technology (D) XXV Issue I Version I Year 2025

performance by using asynchronous processing and GPU acceleration and distributed computing methods to maintain speed for rising customer demand volumes. Many enterprise needs are addressed through this system which reduces workload requirements and accelerates service delivery and strengthens customer confidence in the process. This system represents a modern and effective automatic customer support solution through the integration of BERT linguistic skills and GNN relational analytics and Meta-learning adaptive features.

V. Methodology

a) Data Collection

This intelligent support ticket assignment system uses primary dataset information obtained from Kaggle to solve financial support requests. The chosen dataset attained selection because it provides substantial size along with varied subject matter which directly relates to financial support operations. The dataset contains various financial inquiries about billing disputes and technical banking platform faults and loan processing delays and account protection measures which serve as an optimal foundation for testing machine learning-driven classification and routing systems. This dataset encompasses different real-world data obstacles which include unbalanced class distributions along with diverse ticket wording and contains noisy information to supply a dependable setting for performance assessment and model adaptation testing.

The dataset contains several key fields that play critical roles in model training and ticket classification.

- *Ticket Description:* The text field carries extensive customer complaints that NLP functions primarily on for processing. Before BERT-based classification begins the text input needs preprocessing steps which include tokenisation and stop-word removal and lemmatisation to normalise the text input.
- *Customer Issue Type:* A categorical variable (e.g., technical, billing, service-related) that aids in prioritising and directing tickets to the appropriate departments. Model training requires this variable to be converted into one-hot encoding for usage purposes.
- *Resolution Status:* A binary variable indicating whether a ticket is closed or still open, used to track the efficiency of the support process. This feature helps in supervised learning models by acting as a label in training predictive models for resolution likelihood.
- *Time to Resolution:* A numerical field representing the time taken to resolve each ticket, crucial for performance evaluation and predictive modelling of response times. Normalising processes these data points first to eliminate abnormal results before standardising time values across various ticket types.

Extensive preprocessing and cleaning steps were applied to ensure data quality and enhance model accuracy. The data preparation process included handling missing values through imputation and removing system text along with duplicate entries to maintain data quality. Exceptional character removal and text normalisation techniques were implemented to refine textual data, ensuring better input consistency for NLP models. These preprocessing steps were critical in enhancing classification accuracy, enabling BERT, GNNs, and Meta-learning techniques to operate efficiently on structured and well-prepared data.

b) Source of Data

The datasets were sourced using Kaggle, a popular platform for seeking public datasets on any machine learning task. The data presented includes real-world ticket information, making it the best data to train models to respond to actual customer service queries. With such a diversity of data types, text, categorical, and numerical, this dataset is well suited for a multi-face machine learning approach. This also combines natural language processing with classification and time prediction.

Table 1: Dataset Overview

Field	Description
Ticket description	Textual description of customer issues
Customer issue Type	Categorical classification of issue type (e.g., billing, technical)
Resolution Status	Binary indicator of whether the issue was resolved or not
Time to Resolution	The numerical value indicates the time taken to resolve the issue.

Table 1 summarises the key fields in the dataset. These fields are the basis of training in machine learning models such as BERT and GNN. Rich, well-structured data is required to produce accurate classifications and predictions from these models.

c) Data Preprocessing

An essential part of these steps is data preparation because it cleans raw ticket data and prepares it for models such as BERT, GNN, or Prototypical Networks. In this section, the researcher

Global Journal of Computer Science and Technology (D) XXV Issue I Version I Year 2025

discusses how they cleaned and transformed the textual data for extraction of features, graph-based analysis, and few-shot learning, which can be conducted on novel or uncommon ticket types. Prototypical Networks classify tickets based on a few samples whenever new ticket types appear. GNN captures the relationship between comparable tickets, and BERT extracts contextual characteristics from the ticket descriptions.

d) Text Preprocessing

The following procedures below are ideal for the preparation of textual data from the support tickets for activities involving natural language processing (NLP):

- *Lowercasing:* All text is converted to lowercase to ensure uniformity, reducing the complexity introduced by case sensitivity.
- *Tokenisation:* The text is tokenised, breaking down the ticket scriptions into individual words or tokens. This allows the model to process the text at a word level.
- *Stop-word Removal:* Common words that do not carry significant meaning (e.g., "and," "the") are removed from the text. This helps focus the analysis on the more essential terms.
- *Lemmatisation:* Words are lemmatised, meaning they are reduced to their base or root form (e.g., "running" becomes "run"). This step reduces linguistic variability and improves model performance by treating similar words as the same entity.

e) Feature Extraction using TF-IDF

Once the text has been preprocessed, feature extraction is performed using the Term Frequency-Inverse Document Frequency (TF-IDF) method. TF-IDF transforms the text data into numerical features by weighing the importance of words based on their frequency in the document and across the dataset.

The TF-IDF formula is defined as follows:

Where:

- TF(t, d) is the frequencyof the term$t$ in document d.
- N is the total number of documents in the dataset.
- $|\{d \in D : t \in d\}|$ is the number of documents containing the term$t$.
- Figure 3 illustrates the TF-IDF feature extraction process.

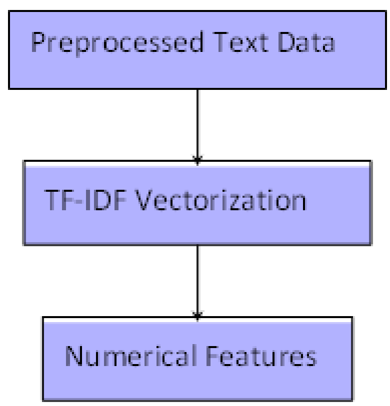


Figure 3: TF-IDF Feature Extraction Process: The Preprocessed Text is Converted into Numerical Features using TF-IDF Vectorisation

f) Graph Representation for GNN

For Graph Neural Networks (GNN) application, the ticket data is again transformed into graph representation. One ticket is represented by the following:

- *Nodes:* Cosine similarity or other similarity measurements establish the similarity among tickets, and this is the basis upon which Edges between nodes.
- The graph structure enables the GNN to reason about the connections between tickets and learn patterns that can be used to better route and classify tickets.

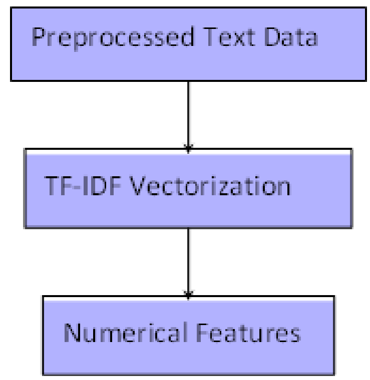


Figure 4: Graph Representation for GNN: Tickets are Represented as Nodes, and Edges are Created based on Ticket Similarity

g) Feature Engineering

Feature engineering is one of the crucial processes in converting raw text data into a numerical format that can be used for any machine learning model. To this end, two feature engineering techniques are applied to this intelligent support ticket assignment system: the graph representation using Graph Neural Networks (GNNs) and the text representation using BERT and TF-IDF.

h) Text Representation for BERT and TF-IDF

In order to successfully convert preprocessed text input into numerical features, the 'Term Frequency-Inverse Document Frequency' (TF-IDF) approach is adopted. This makes it possible for machines to focus on important words when performing classification tasks. The weighting system in this method provides higher importance to words that are important in a piece of text and rare across the whole dataset [27]. A particular document's weight value stands as the last element in each entry from the TF-IDF transformation matrix. The numerical representation generated by TF-IDF helps Random Forest and SVM models to execute ticket classification and prioritisation tasks.

The ticket descriptions benefit from deep contextual features extraction using Bidirectional Encoder Representations from Transformers (BERT). BERT generates one vector feature for each token which results from splitting the preprocessed ticket descriptions into their smallest linguistic units. This feature vector contains everything in each ticket record since it combines sequential word content from before and after the textual data. BERT works as a bidirectional system which enables it to interpret complex linguistic patterns. Translators (BERT) show exceptional ability in processing complicated and unclear ticket contents.

Algorithm for Preprocessing

Algorithm 1: Text Preprocessing Algorithm for BERT Input
The following are steps for preparing raw ticket descriptions for BERT feature extraction using the preprocessing algorithm.

Algorithm 1: Text Preprocessing for BERT Input

Input: Raw ticket descriptions

Output: Preprocessed text and TF-IDF vectors

1. *Result:* At this point, the preprocessed text and feature vectors are fed into BERT for feature extraction.
2. *Convert Text to Lowercase:* The next step is to tokenise the text into words. Stop words such as "and", "the", etc. are also removed, after which Lemmatization is performed to reduce words to their base forms. Lastly, TF-IDF vectorisation is applied to convert the text into numerical features.

Algorithm 2: Graph Preprocessing Algorithm for GNN Input

This algorithm outlines the basic steps for converting ticket descriptions into a graph representation for use with a Graph Neural Network (GNN).

Algorithm 2 Graph Preprocessing for GNN Input

Input: Preprocessed ticket descriptions

Output: Graph with nodes and edges based on similarity

3. *Result:* The result here is that the graph is used for GNN analysis as well as the capturing of relational data that is usually between tickets.
4. Begin
5. Next, a node is created for each ticket to calculate the similarity between tickets using cosine similarity. The nodes are then connected with edges if their similarity exceeds a threshold. Normalise the graph structure if necessary

i) Model Selection and Training

In this section, we will describe the process of selection and training of each of the models used in the intelligent support ticket assignment system. BERT is used for text understanding [12], GNN is used for relational learning [14], and Prototypical Networks is used for handling new ticket types [18].

i. *BERT for Text Understanding*

BERT accepted a large corpus for training before we applied it to fine-tune our ticket description dataset [12]. The fine-tuning process allows BERT to acquire domain knowledge about ticket description content that strengthens its ability to handle linguistic context within text. The attention mechanism in BERT functions as the main driver behind data contextual relationship extraction that enables correct ticket classification according to description semantics.

BERT's Self-Attention Mechanism is computed as:

$$\text{Attention (Q, K, V)} = \text{softmax}\left(\frac{QK^T}{\sqrt{d_k}}\right)V \quad (1)$$

Where:

Q is the query matrix,

K is the key matrix,

V is the value matrix,

dk is the dimensionality of the key matrix.

This mechanism helps BERT focus on relevant parts of the input when predicting the ticket's category.

ii. *Graph Neural Networks (GNN) for Relational Learning*

Graph Convolutional Networks (GCNs) analyse ticket connections through evaluation of their relational patterns [14]. The system builds the analysis through nodes which represent tickets and show relation points between the nodes to indicate similarity measurements. The ticket classification together with routing gets better because GNNs analyse relational data that helps identify closely related tickets in terms of their descriptions and categories.

The graph structure enables GCN to establish node representations by having features move between network edges. The approach makes relational data accessible to the model so the decision-making process can be optimised.

iii. *Few-shot Learning with Prototypical Networks*

Prototypical Networks are employed for handling new or rare ticket types that the model has not seen before [18]. Few-shot learning is instrumental in dynamic environments where new types of customer issues emerge frequently. Prototypical Networks work by computing a prototype (mean embedding) for each class and assigning tickets based on the distance to these prototypes.

iv. *Random Forest for Baseline Comparisons*

In addition to the deep learning models, we use a Random Forest model as a baseline for comparison [11]. Random Forest is an ensemble learning method that constructs multiple decision trees during training and outputs the mode of the classes for classification tasks.

The equation for Random Forest is-

Where:

T is the number of trees,

ht(x) is the prediction from the t-th tree.

v. *Algorithm for Model Training*

Algorithm 3 Model Training Algorithm for BERT, GNN, and Random Forest

Input: Preprocessed ticket descriptions, preprocessed graph data

Output: Trained models (BERT, GNN, Random Forest)

BERT Training:

1. Initialize BERT with pre-trained weights [12].
2. Fine-tune the ticket dataset with tokenised and preprocessed text.
3. Use a classification head for categorising tickets.

GNN Training:

1. Construct the graph from ticket data [14].
2. Initialize the Graph Convolutional Network (GCN).
3. Train the GCN by propagating features across nodes and edges.

Few-shot Learning with Prototypical Networks:

1. Initialize the Prototypical Network [18].
2. Compute prototypes for each ticket type using the training set.
3. Classify new tickets based on distance to the nearest prototype.

Random Forest Training:

1. Train Random Forest on the preprocessed ticket data using TF-IDF features [11].
2. Validate performance using cross-validation. Each model is evaluated using standard classification metrics such as accuracy, precision, recall, and F1-score, with detailed comparisons provided in the subsequent evaluation section.

j) *Evaluation Metrics*

To evaluate the performance of the models in classifying and routing support tickets, we employ the following evaluation metrics:

Accuracy

Accuracy measures the proportion of correctly classified tickets out of the total tickets. It is defined as:

Where:

TP (True Positive): Correctly classified positive instances (e.g., correctly routed tickets).

TN (True Negative): Correctly classified negative instances (e.g., tickets correctly identified as not belonging to a particular class).

FP (False Positive): These are Incorrectly classified positive instances (e.g., tickets wrongly routed to a particular class).

FN (False Negative): These are Incorrectly classified negative instances (e.g., tickets not routed to the correct class).

Precision

Precision measures the proportion of correctly classified positive tickets out of all tickets classified as positive. It is defined as:

$$\text{Precision} = \frac{TP}{TP+FP}$$

This metric is critical in ensuring that all relevant tickets are correctly identified and routed, even if some are difficult to classify

Recall

Also known as sensitivity, recall measures the proportion of correctly classified positive tickets out of all actual positive tickets. It is defined as:

$$\text{Accuracy} = \frac{TP}{TP+FN}$$

This metric is critical in ensuring that all relevant tickets are correctly identified and routed, even if some are difficult to classify.

F1-Score

The F1-Score is the harmonic mean of Precision and Recall. It also provides a single metric that balances both. It is beneficial when the data is imbalanced. This means that one class has far more instances than another:

$$\text{F1-Score} = 2 \times \frac{\text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}$$

Confusion Matrix

Using a confusion matrix, we summarise the performance of the classification model. It also gives a clue to the true positives, false positives, true negatives and false negatives. Most importantly, it is helpful in understanding the breakdown of errors.

The confusion matrix for our ticket classification task can be represented as:

Evaluation Strategy

The most important metrics for each model (BERT, GNN, Prototypical Networks) are first calculated to achieve a complete evaluation. Then, the training and testing dataset is split with a standard 70/30 split. The models will then be tested on the unseen test set to see if they will do well on new data.

VI. Results

This section compares the performance of the models used for ticket classification and routing. These include BERT, GNN, and Prototypical Networks (Meta-learning). The models are evaluated using key metrics such as Accuracy, Precision, Recall, and F1-Score.

The following visualisations illustrate the results:

- A bar chart showing the overall performance comparison across the evaluation metrics.
- Confusion matrices for BERT, GNN, and Prototypical Networks to illustrate the distribution of predicted vs. actual classifications.

The results demonstrate the strengths of each model. BERT excels in text understanding due to its bidirectional context-aware representation of ticket descriptions. GNN effectively captures structural relationships between tickets, enhancing relational learning. Lastly, Prototypical Networks show strong generalisation capabilities, particularly when handling new or rare ticket types by using few-shot learning techniques.

a) *Performance Comparison*

The results of the model evaluation are shown in Table 3. Each model's performance is compared based on ticket classification accuracy, precision in identifying the correct ticket categories, recall for capturing all relevant tickets, and the F1-Score, which balances precision and recall.

Table 3: Model Performance Comparison for Accuracy, Precision, Recall, and F1-Score

Model	Accuracy	Precision	Recall	F1-Score
BERT	89.4%	88.7%	90.2%	89.4%
GNN	87.6%	85.9%	88.5%	87.2%
Prototypical Networks	86.8%	86.1%	87.5%	86.8%
Random Forest	85.3%	84.5%	86.1%	85.3%

Table 2 shows that BERT achieved the highest performance across all metrics, with an F1-Score of 89.4%. GNN closely followed it, while Random Forest performed slightly lower.

b) *Performance Comparison Bar Chart*

Figure 8 visually represents the comparison of Accuracy, Precision, Recall, and F1-Score for each model. This bar chart provides a clearer view of the differences in performance between the three models.

Global Journal of Computer Science and Technology (D) XXV Issue I Version I Year 2025

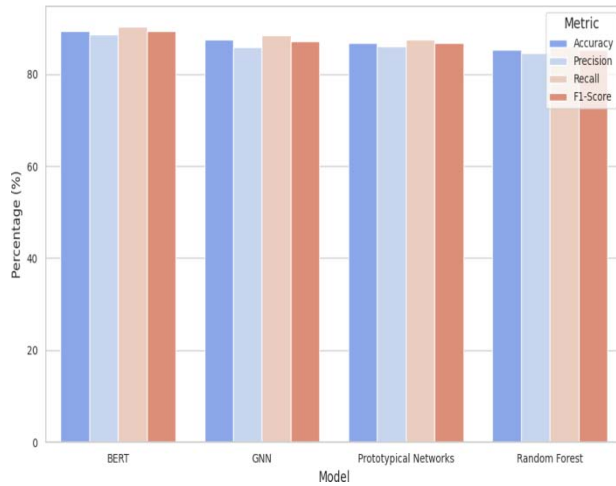


Figure 5: Performance Comparison Bar Chart for BERT, GNN, Prototypical Networks, and Random Forest

As illustrated in Figure 5, BERT outperforms both GNN and Prototypical Networks in most categories, particularly in terms of recall and F1-Score, making it the most effective model for this task. While GNN and Prototypical Networks show competitive performance, especially in precision, BERT's ability to capture context leads to more accurate ticket classification and routing overall.

c) Confusion Matrices

To further analyse the performance of the models (BERT, GNN, Proto-typical Networks, and Random Forest), we generated confusion matrices for each. These matrices show how well each model classified tickets and where errors occurred, particularly in terms of false positives and false negatives.

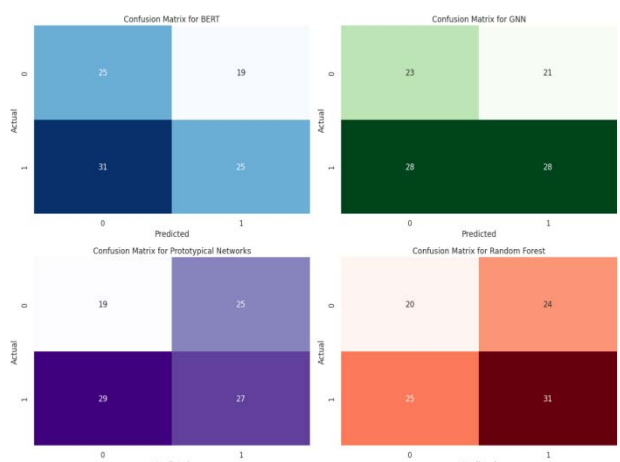


Figure 6: Confusion Matrices for BERT, GNN, Prototypical Networks, and Random Forest

Figure 6 shows the confusion matrices for all four models. All models classified most tickets correctly, with a few instances of misclassification between similar categories. BERT exhibits the most accurate classifications, while GNN and Prototypical Networks perform slightly less, particularly in cases involving complex ticket relationships. Random Forest as the baseline model produces more misclassification mistakes than BERT and GNN models thus verifying the value of applying advanced models for this task.

VII. Discussion

The results clearly demonstrate that advanced machine learning models, including BERT, GNN, and Prototypical Networks, outperform conventional models like Random Forest in ticket classification and routing tasks. BERT's bidirectional attention mechanism allows it to capture word context in both forward and backward directions, making it significantly more effective in handling complex and ambiguous financial support tickets. Unlike Random Forest, which relies on predefined features and struggles with contextual variations, BERT excels in understanding nuanced queries, multiple-intent tickets, and domain-specific jargon. Empirical results support this: BERT achieves an accuracy of 89.4% and an F1-score of 89.4%, compared to Random Forest's 85.3% accuracy and 85.3% F1-score, highlighting its superior ability to classify tickets with higher precision and recall (as seen in Table 3). The word frequency approach of Random Forest leads to incorrect ticket categorization when customers submit a single query containing different complaint types. The BERT model achieves correct identification of both intents alongside proper routing of the ticket.

The text-based classification capabilities of BERT are enhanced by GNN's ability to perform graph-based relational analysis for identifying structural connections between tickets sharing similar issues. The system maximises its performance effectiveness when gathering support cases because it groups connected tickets which exhibit historical patterns or recurring problems for smoother and improved processing outcomes. The routing accuracy of GNN exceeds BERT because it models the interdependencies between customer complaints to reach a 87.6% accuracy mark. Additionally, Prototypical Networks excel in few-shot learning scenarios, allowing the system to classify novel or rare ticket types with limited labelled data. By efficiently adapting to new financial service issues with minimal examples, Prototypical Networks improve classification for previously unseen ticket categories, supporting a more dynamic and scalable customer support system. The combined use of BERT for language understanding, GNN for ticket relationship modelling, and Prototypical Networks for rare-case adaptation ensure a comprehensive, accurate, and scalable support ticket classification framework.

a) Limitations

These sophisticated models offer substantial improvements in ticket classification and routing; however, they come with notable challenges. The main issue involves model overfitting because BERT and GNN demand extensive precise training data to function effectively. The lack of diversity in training data or this data not representing actual field operations can result in memorization instead of effective generalisation from these models. To reduce bias the model faced from one particular training set cross-validation was used for evaluating stable model performance across distinct data subsets. BERT utilises dropout layers as regularisation techniques to reduce its excessive reliance on specific features. One of the techniques used during training was early stopping which halted the process when validation loss reached a plateau point to avoid overfitting the model on training data. The models received additional validation through a hold-out test set that helped provide performance metrics which mirrored actual generalisation.

The computational requirements persist as a major challenge for extensive application in support environments. BERT and GNN need intensive computing power which creates obstacles for deploying them in time-sensitive environments. The implementation of model optimization methods called parameter pruning and quantisation minimised the model size yet maintained accuracy levels. Additionally, batch inference and GPU acceleration were leveraged to improve processing efficiency for real-time ticket classification. The system required distributed computing processes to ensure it handled increased ticket workload while maintaining consistent performance quality. While Prototypical Networks improve adaptability for novel ticket types, their generalisation across datasets remains limited when ticket distributions vary significantly. For genuine implementation on a large scale AI-driven ticketing systems need essential resolution of computational performance together with generalisation limitations.

b) Real-World Application

Such models demonstrate the ability to upgrade customer support systems by implementing a system that automatically classifies and routes problems quickly and accurately. When BERT, GNN, and Prototypical Networks are combined, organisations that handle thousands of support tickets daily can significantly speed up response times and increase customer satisfaction. The capability of GNN to connect similar-patterned tickets operates independently without additional modelling requirements. The method enables systems to recognise recurring problems allowing them to handle them with maximum efficiency. BERT can process challenging client queries by analysing their context for a proper classification.

VIII. Future Work

a) Improvements

Additional key improvements can enhance the existing models to achieve better performance. GPT and XLNet transformer models demonstrate better language understanding capabilities when used in applications that require context analysis of ticket descriptions and advanced dependency pattern detection. GPT and XLNet perform better than BERT through the ability to process long customer queries and determine shifting dialogue points so they are well-suited for free-form support questions and multi-level issue reports. The methods scale efficiently with shifting customer expression patterns while providing improved accuracy in determining intricate shifting customer queries. Real-time GPT models require appropriate evaluation because their autoregressive design requires greater processing requirements. Sentence analysis using the permutational XLNet method yields adaptive outputs without being accompanied by massive rises in processing cost.

Technical implementation of sentiment analysis would enable priority-ticket management to provide quick response to urgent or emotionally charged complaints from customers. The automated system implements a solution to detect emergency cases by scrutinizing tones in customer messages to accelerate response time. Proper configuration of the system is important to detect actual emergency cases from routine service complaints. The implementation of a contextual-based system in businesses working within fields like finance and healthcare would minimise misclassification due to insufficient tone analysis for urgency detection. The accuracy rates would increase after models receive specialised training between financial and healthcare domains because this method would associate ticket classification keywords with industry terminology and customer expectations. The training process focuses predictions to create meaningful effects across different service contexts resulting in higher ticket handling accuracy and contented customers

b) Deployment

Performance assessments need to be detailed enough for implementing scalable infrastructure in production environments through practical applications. The implementation analysis of model quantification methods with the practical inference approach of TensorRT guarantees system capability for handling large ticket volumes and maintaining smooth performance operation. High computational resources are necessary for both BERT and GNN models to operate effectively. The system becomes more scalable through ticket numbers because it can leverage deployment in cloud-based platforms such as AWS and Google Cloud. Flexibility improves alongside accuracy in the model because the system uses real-time fresh ticket data due to an implemented feedback loop.s

c) Ethics

Prior to applying this concept to manufacturing operations it becomes necessary to perform an ethical evaluation of infrastructure performance and optimization methods. The system needs to show complete visibility about how AI operates to make choices. Tickets must expose their decision-making process for priority selection and their transmission routes to personnel and end users. Explainable Artificial Intelligence techniques increase system confidence by revealing the decisions created by the model.

IX. Conclusion

a) Summary of Findings

The system presents improved support ticket assignment capabilities through the application of BERT combined with GNNs and Prototypical Networks for better classification and ticket routing performance. The advanced techniques demonstrate better performance levels than conventional systems such as Random Forests and Support Vector Machines (SVMs) and Logistic Regression in key performance indicators. BERT performed better than Random Forest as it achieved 89.4% classification accuracy and 89.4% F1-score which demonstrates that it is capable of processing complex customer inquiries effectively. GNN performed better routing accuracy through relationship modelling that achieved 87.6% precision. Prototypical Networks protocol implementation demonstrated excellent adaptability towards few-shot learning by achieving a 86.8% accuracy rate when processing tickets of unknown types. Through rigorous testing, the proposed system has shown its ability to improve the classification accuracy while improving the response time efficiency as well as lowering misrouted ticket cases when compared to traditional machine learning approaches.

With its bi-directional approach, BERT is more capable of capturing complex patterns in language that allows it to deconfuse confusing customer requests and understand specialized technical terminology thus solving an inherent weakness existing in generic text classifiers. Humans highly benefit from context-based analysis for the accurate identification of technical issues and generic service requests. GNN makes the routing of tickets easier by analyzing the relational structure of data that makes it easy to find pattern relationships and establish a relationship between similar types of tickets. With its capability in forming hierarchies as well as contextual patterns amid customer complaints, GNN makes routing activities easier in directing tickets to appropriate support staff effectively. This action results in limited support delays. Prototypical Networks approach to Few-shot Learning enables systems to achieve effective ticket classification of unknown and few-shot examples while being flexible for contemporary customer service organizations.

b) Impact on Industry

The IT sector gains competitive advantage in customer service through this innovation because it reduces the cost of operation while it speeds up the response time with more than ticket processing advantages. Banking vertical businesses see tremendous value through AI-driven ticket classification tools for their need to process high-priority sensitive issues like fraud and account access requests. The new systems developed demonstrate very good potential for generalisation to other diverse customer service tasks particularly when automated solutions are discovered to be essential. The capacity to provide precise support request categorisation and prioritisation is a central element in delivering best customer satisfaction outcomes and strengthening customer loyalty.

Acknowledgments

Appendix

Appendix A. Implementation Code

Implementation of the BERT model

from transformers import BertTokenizer, Bert For SequenceClassification import torch

Load pre-trained model

model=BertForSequenceClassification.from_pretrained('bert-base-uncased')

Tokenize input

tokenizer=BertTokenizer.from_pretrained('bert-base-uncased') inputs = tokenizer ("ticket description", return_ tensors="pt")

Get predictions

with torch.no_grad(): outputs = model(**inputs)

Appendix B. Ethical Considerations

Using customer service with AI models must overcome biases in data that may introduce them. Train models with biased data to generate unequal quality in service. Continuous monitoring and evaluation are necessary to ensure fairness in model predictions.

References Références Referencias

1. S. Winkler, M. Johnson, E. Zhang, Customer support in the digital era, Journal of Business and Technology 12 (3) (2023) 215–229.
2. S. Akter, S. F. Wamba, Big data analytics in e-commerce: A systematic review and agenda for future research, Journal of Business Research 70 (2016) 304–313.
3. S. Jackson, V. Ahuja, Impact of social media on customer support systems, Journal of Customer Relations 8 (2) (2016) 45–58.
4. Good Firms, Ultimate guide: Cost and feature comparison of top help desk software systems, accessed: Month Day, Year (2023). URL https://www.goodfirms.co/help-desk-software/blog/ultimate-guide-cost-feature-comparison-top-help-desk-software-systems
5. Fu, Min, Jiwei Guan, Xi Zheng, Jie Zhou, Jianchao Lu, Tianyi Zhang, Shoujie Zhuo, Lijun Zhan, and Jian Yang. "ICS-Assist: Intelligent customer inquiry resolution recommendation in online customer service for large E-commerce businesses." In *Service-Oriented Computing: 18th International Conference, ICSOC 2020, Dubai, United Arab Emirates, December 14–17, 2020, Proceedings 18*, pp. 370-385. Springer International Publishing, 2020.
6. Y. K. Dwivedi, L. Hughes, M. Wade, Ai and customer support systems: Emerging trends and prospects, Journal of Information Systems 40 (5) (2021) 345–362.
7. H. ElMaraghy, U. Schuster, A. Lee, Challenges of traditional customer support systems in a rapidly evolving digital environment, International Journal of Business Operations 9 (6) (2021) 612–628.
8. S. Falco, A. Rhodes, Limitations of traditional customer support systems in a digital age, Journal of Customer Service Management 7 (1) (2011) 12–21.
9. V. Botta-Genoulaz, P.-A. Millet, Business process improvement through intelligent ticketing systems, in: International Conference on Business Information Systems, Springer, 2006, pp. 222–228.
10. A. Y. Ng, Logistic regression as a classifier for support systems, Machine Learning for Customer Support Systems 42 (1) (2002) 345–350.
11. L. Breiman, Random forests, Machine learning 45 (1) (2001) 5–32.
12. J. Devlin, M.-W. Chang, K. Lee, K. Toutanova, Bert: Pre-training of deep bidirectional transformers for language understanding, arXiv preprint arXiv:1810.04805 (2018).
13. A. Vaswani, N. Shazeer, N. Parmar, et al., Attention is all you need, in: Advances in neural information processing systems, 2017, pp. 5998– 6008.
14. T. N. Kipf, M. Welling, Semi-supervised classification with graph convolutional networks, arXiv preprint arXiv:1609.02907 (2016).
15. J. Huang, L. Zhang, Graph neural networks in support systems: Challenges and prospects, Journal of AI Systems 14 (5) (2020) 189–200.
16. Z. Zhang, Y. Chen, J. Zhao, Graph neural networks for customer query classification, Journal of AI Research (2022).
17. J. Yoon, H. Lee, J. Kim, Leveraging graph neural networks for support ticket processing, International Journal of Information Management (2021).
18. J. Snell, K. Swersky, R. S. Zemel, Prototypical networks for few-shot learning, in: Advances in neural information processing systems, 2017, pp. 4077–4087.
19. C. Finn, P. Abbeel, S. Levine, Model-agnostic meta-learning for fast adaptation of deep networks, in: Proceedings of the 34th International Conference on Machine Learning-Volume 70, 2017, pp. 1126–1135.
20. Z. Gan, L. Li, Y. Wu, Few-shot learning in customer support with prototypical networks, IEEE Transactions on Neural Networks and Learning Systems (2021).
21. Z. Zhang, J. Li, Y. Wang, X. Chen, Meta-learning for customer support: A case study on support ticket classification, Journal of Machine Learning Research 22 (123) (2021) 1–30. URL http://www.jmlr.org/papers/volume22/21-123/21-123.pdf
22. S. Shalev-Shwartz, S. Ben-David, Understanding machine learning: From theory to algorithms, Cambridge University Press (2014).
23. N. Mehrabi et al., A survey on bias and fairness in machine learning, ACM Computing Surveys 54 (6) (2021) 1–35.
24. SympoQ, Support ticket categorisation and classification, SympoQ Blog (2022). URL

Global Journal of Computer Science and Technology (D) XXV Issue I Version I Year 2025

https://www.sympoq.com/blog/post/support-ticket-categorization-and-classification/
25. SentiSum, Automated ticket routing: Ai-driven support automation, https://www.sentisum.com/library/automated-ticket-routing. Accessed: 2024-10-12 (2024).
26. Sentisum, Automated ticket routing, accessed: Month Day, Year (2023). URL https://www.sentisum.com/library/automated-ticket-routing
27. G. Salton, C. Buckley, Term-weighting approaches in automatic text retrieval, Vol. 24, Elsevier, 1988.
28. Asres, Mulugeta Weldezgina, Million Abayneh Mengistu, Pino Castrogiovanni, Lorenzo Bottaccioli, Enrico Macii, Edoardo Patti, and Andrea Acquaviva. "Supporting telecommunication alarm management systems with trouble ticket prediction." *IEEE Transactions on Industrial Informatics* 17, no. 2 (2020): 1459-1469.
29. Huang, Xin. "Simplifying BERT-Based Models to Increase Efficiency, Capacity." Amazon Science, June 8, 2022. https://www.amazon.science/blog/simplifying-bert-based-models-to-increase-efficiency-capacity?
30. Nixon, George. "Why NS&I Is Falling out of Favour." Thetimes.com. The Times, August 9, 2024. https://www.thetimes.com/business-money/money/article/no-love-for-ns-and-i-why-the-complaints-are-mounting-up-99qlc80qg?utm_source=chatgpt.Com&region= global.
31. Quality Management Institute. "Customer Service Facts, Quotes & Statistics How Your Business Can Deliver with the Best of the Best an EBook By," 2011. https://www.qualitymanagementinstitute.Com/images/hrsolutions/Help-Scout-CustomerService.pdf.
32. Truss, Mario, and Stephan Boehm. "AI-based Classification of Customer Support Tickets: State of the Art and Implementation with AutoML." *arXiv preprint arXiv: 2406.01789* (2024).

Global Journal of Computer Science and Technology: D
Neural & Artificial Intelligence
Volume 25 Issue 1 Version 1.0 Year 2025
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

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

By Mashrure Tanzim

Bangladesh University of Professionals

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

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

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

VEHICLEROUTINGOPTIMIZATIONWITHANTCOLONYOPTIMIZATIONALGORITHMINTEGRATEDWITHMAPANALYZERAPI

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

Mashrure Tanzim

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

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

I. Introduction

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

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

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

in Dhaka but any location that suffers from similar problems.

II. Constructing the Application

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

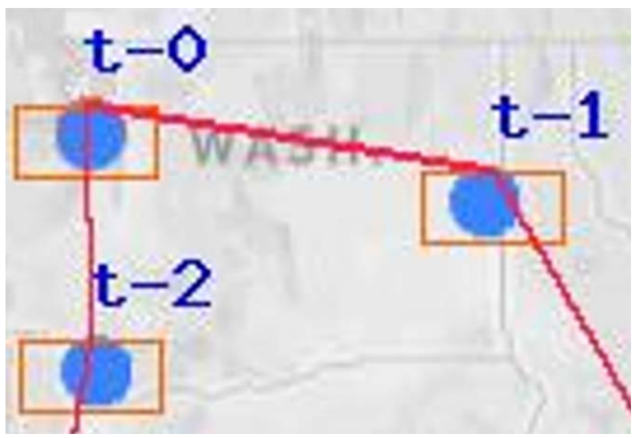


Fig.1: Nodes and Weight Value Calculation

The starting node is denoted by zero. Each closest node is given a number of its own and denoted in numerical order. Each node represents a destination, with the node t-0 being an exception. It is considered to be the starting point of the journey. Subsequent nodes are denoted as t-1, t-2 etc. based on a rough estimation of the distance between them. As an example, a map with 7 nodes will have the following nodes: t-0, t-1, t-2, t-3, t-4, t-5 and t-6. Once the nodes and weight paths are calculated, the algorithm uses the data to internally construct a data matrix. It uses this data to calculate the most optimal path to travel from node t-0 to all the other nodes and then come back to t-0. It presents us with the result which includes the total distance covered by the vehicle and also which path is optimal to be travelled. The path should always start and end with the node 0. The distance between the nodes is not calculated in any specific unit, but a numerical value. That is because the algorithm does not have a sense of scale and can't find out the distance between two nodes by simply looking at the map. Attempts had been made to specify the distance between the first two nodes and use it as a scale for the rest, albeit unsuccessfully. This is one of the major limitations of the current work. However, it still informs a user which path is the most optimal. A user can compare the value of distance for multiple paths using the same map. It is not the smoothest way to compare routes, but it gets the job done. Another gap in the work is the inability of a user to update his path in the middle of a trip. In real life, the situation of the road changes with time. A road that was open moments ago can be clogged with traffic in minutes. This isn't even taking into accounts events like accidents or temporary closure of a road. In that case, the weight value of a chosen path should also change. But the system lacks any automatic update service that can alter the value of the trip once it has begun. To achieve that we would require a service that provides GPS update to the users in real time. It would also have to be compatible with the web application. We were unable to find such a service. The best way a user can achieve that goal is to manually input an image of the map after reaching every destination. This is cumbersome for an average user. It would also slow down the trip as the web application would have to calculate the optimal path every time a destination is reached. So this work does not include such a feature. It has been left for future researchers to fill that gap. They can work in conjunction with companies that provide Geolocation service to develop an application that can receive data in real time. Or if they are ambitious enough, they can even develop their own geolocation service that has such a feature. In any case, such an endeavor is beyond the scope of our work. Currently services like google map calculate routes by measuring the shortest distance between two nodes. Any further destinations are measured only after reaching the first destination. Then the shortest distance to the next destination is calculated and thus it goes on and on. This format of travelling is called greedy best first search. And it gives suboptimal results in almost every case, since the user is just travelling without any consideration to future travel. As an example, we can consider the bays29.tsp dataset in order to find the most optimal algorithm for our system [5]. If we simply calculate the closest distance from one node to the next, then we get a distance of 6173 just to travel from the starting node to the final destination. In order to get back to the source, that distance is doubled, so the total distance travelled is 12346. Even if we calculate the total distance randomly from another starting point, the best result we can get is 4955, which if doubled amounts to a distance of 9910.

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

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

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

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

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

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

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

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

$$((C/100)) \times ((100 \times B) / A)$$

III. Integration With the Web Application

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

Fig. 4: Landing Page of the Web App

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

Fig. 5: Map API

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

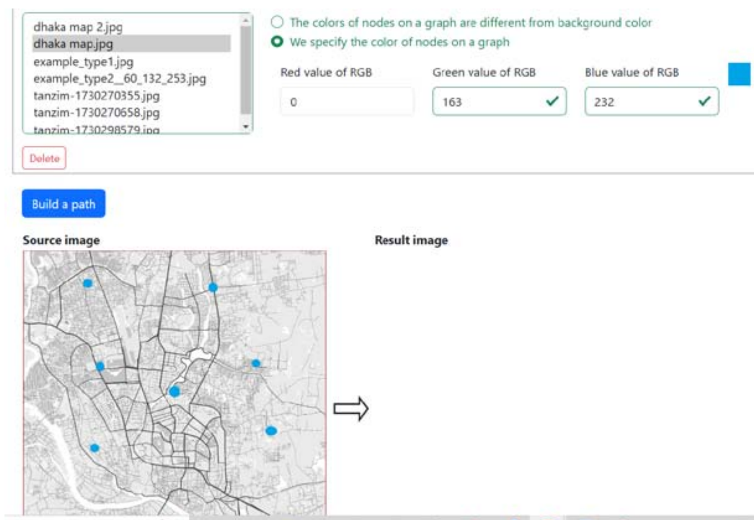


Fig. 6: Building an Optimal Path

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

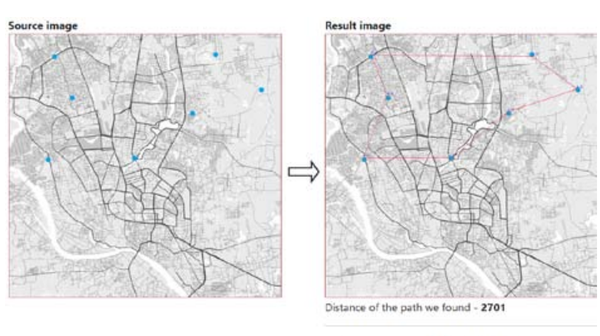


Fig. 7: Result of Path Calculation

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

Web application interface code:

https://github.com/navintanzim/acov1

Map API code:

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

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

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

IV. Discussion and Analysis of Result

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

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

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

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

So, the best efficiency rating we could calculate was:

(100 - 76.0570225174) = 23.9429774826%.

And the worst we could find was:

(100 - 96.9929364279) = 3.0070635721%.

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

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

Calculation Time (in microseconds) - 0.0024600029

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

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

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

V. Conclusion

Traveling salesman problem is one of the most important problems faced by vehicle routing procedures. Choosing the appropriate algorithm for a situation is necessary. In real life, the condition on the road can change at any moment due to unforeseen circumstances. In that case, the proper algorithm must be implemented to find the quickest route efficiently. This paper is a step forward in the effort to find the most practical solution to resolve the issue of traffic congestion. It demonstrated a practical implementation of ACO to find the most optimal path for a travelling salesman. It can function as a blueprint for future services that can automatically update the routes based on traffic congestion data received from satellites. However the work has certain limitations as well. The programs used in this work can handle only certain types of datasets. It can't use all forms of data as input. For that reason, the pool of available datasets was very limited and this research was forced to test the programs on only 2 different datasets. It also lacked the ability to update the routes based on traffic congestion automatically. The update had to be done manually by a user. Future researchers can work on these aspects to further improve the usefulness of the system.

References Références Referencias

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

Global Journals Guidelines Handbook 2025

www.GlobalJournals.org

Memberships

FELLOWS/ASSOCIATES OF COMPUTER SCIENCE RESEARCH COUNCIL

FCSRC/ACSRC MEMBERSHIPS

Introduction

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

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

FCSRC

FELLOW OF COMPUTER SCIENCE RESEARCH COUNCIL

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

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

Benefits

To the institution

Get letter of appreciation

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

Exclusive Network

Get access to a closed network

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

Career | Credibility | Exclusive | Reputation

Certificate

Certificate, LoR and Laser-Momento

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

Career | Credibility | Exclusive | Reputation

Designation

Get honored title of membership

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

Career | Credibility | Exclusive | Reputation

Recognition on the Platform

Better visibility and citation

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

Career | Credibility | Reputation

Future Work

Get discounts on the future publications

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

Career Financial

GJ Account

Unlimited forward of Emails

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

Career Credibility Reputation

Premium Tools

Access to all the premium tools

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

Financial

Conferences & Events

Organize seminar/conference

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

Career Credibility Financial

Early Invitations

Early invitations to all the symposiums, seminars, conferences

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

Exclusive

Publishing Articles & Books

Earn 60% of sales proceeds

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

Exclusive | Financial

Reviewers

Get a remuneration of 15% of author fees

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

Financial

Access to Editorial Board

Become a member of the Editorial Board

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

Career | Credibility | Exclusive | Reputation

And Much More

Get access to scientific museums and observatories across the globe

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

ACSRC

ASSOCIATE OF COMPUTER SCIENCE RESEARCH COUNCIL

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

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

Benefits

To the Institution

Get letter of appreciation

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

Exclusive Network

Get access to a closed network

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

Career | Credibility | Exclusive | Reputation

Certificate

Certificate, LoR and Laser-Momento

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

Career | Credibility | Exclusive | Reputation

Designation

Get honored title of membership

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

Career | Credibility | Exclusive | Reputation

Recognition on the Platform

Better visibility and citation

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

Career | Credibility | Reputation

Future Work

Get discounts on the future publications

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

Career | Financial

GJ Account

Unlimited forward of Emails

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

Career | Credibility | Reputation

Premium Tools

Access to all the premium tools

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

Financial

Conferences & Events

Organize seminar/conference

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

Career | Credibility | Financial

Early Invitations

Early invitations to all the symposiums, seminars, conferences

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

Exclusive

Publishing Articles & Books

Earn 30-40% of sales proceeds

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

Exclusive Financial

Reviewers

Get a remuneration of 15% of author fees

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

Financial

And Much More

Get access to scientific museums and observatories across the globe

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

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

Preferred Author Guidelines

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

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

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

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

Before and during Submission

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

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

Declaration of Conflicts of Interest

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

Policy on Plagiarism

Plagiarism is not acceptable in Global Journals submissions at all.

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

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

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

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

Authorship Policies

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

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

Changes in Authorship

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

Copyright

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

Appealing Decisions

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

Acknowledgments

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

Declaration of funding sources

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

Preparing your Manuscript

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

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

Manuscript Style Instruction (Optional)

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

Structure and Format of Manuscript

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

A research paper must include:

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

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

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

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

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

Format Structure

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

All manuscripts submitted to Global Journals should include:

Title

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

Author details

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

Abstract

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

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

Keywords

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

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

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

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

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

Numerical Methods

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

Abbreviations

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

Formulas and equations

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

Tables, Figures, and Figure Legends

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

Figures

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

Preparation of Eletronic Figures for Publication

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

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

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

Tips for writing a good quality Computer Science Research Paper

Techniques for writing a good quality computer science research paper:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Informal Guidelines of Research Paper Writing

Key points to remember:

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

Final points:

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

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

The discussion section:

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

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

General style:

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

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

Mistakes to avoid:

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

Title page:

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

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

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

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

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

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

Approach:

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

Introduction:

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

The following approach can create a valuable beginning:

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

Approach:

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

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

Procedures (methods and materials):

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

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

Materials:

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

Methods:

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

Approach:

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

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

What to keep away from:

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

Results:

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

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

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

Content:

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

What to stay away from:

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

Approach:

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

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

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

Figures and tables:

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

Discussion:

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

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

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

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

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

Approach:

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

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

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

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

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

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

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

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

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

Index

save our planet

Global Journal of Computer Science and Technology

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

ISSN 9754350