Development of a Versatile and Fast Method for The Optimal Ship Routing

[1]Dr. G. Balram, [2] Smruti Rekha Pradhan , [3]Gade Sathwik , [4]Ganta Mihika

[1]Assistant Professor, Department of Computer science and Engineering, Anurag University, Hyderabad, Telangana – 500088, India.
[2] UG Student, Department of Computer science and Engineering, Anurag University, Hyderabad, Telangana – 500088, India.
[3] UG Student, Department of Computer science and Engineering, Anurag University, Hyderabad, Telangana – 500088, India.
[4] UG Student Department of Computer science and Engineering, Anurag University, Hyderabad, Telangana – 500088, India.

[1]*balaramcse@anurag.edu.in*
[2]*21eg105d62@anurag.edu.in*
[3]*21eg105d18@anurag.edu.in*
[4]*21eg105d19@anurag.edu.in*

Abstract. Maritime transportation is a crucial component of global trade, necessitating efficient route optimization to enhance operational efficiency, minimize costs, and ensure timely deliveries. Traditional maritime route planning methods rely on heuristics that often fail to account for dynamic factors such as weather conditions, fuel type, and real-time sea traffic. These conventional approaches, while effective to some extent, lack the adaptability required to handle sudden changes in maritime conditions. As a result, vessels may face delays, increased fuel consumption, and suboptimal routing decisions that negatively impact overall efficiency.

To overcome these limitations, this study proposes a machine learning-based approach that leverages a Random Forest Regressor model trained on synthetic maritime data to predict optimal travel routes with greater accuracy. Additionally, Dijkstra's Algorithm is employed to determine the shortest and most efficient paths between ports, dynamically adjusting for changing conditions. By incorporating real-time weather updates, historical data, and predictive analytics, the system enables more informed decision-making, reducing operational costs and fuel consumption. The proposed model demonstrates high accuracy and adaptability, making it a valuable tool for modern maritime logistics. With the increasing demand for efficient and sustainable shipping solutions, this data-driven approach enhances navigation efficiency, reduces risks, and improves the overall reliability of maritime transportation networks.

Keywords. Maritime route optimization, Machine learning, Random Forest, Transportation efficiency, Travel time prediction, Cost prediction, Dijkstra's algorithm

INTRODUCTION

Maritime transportation is the backbone of global trade, facilitating the movement of goods across continents with efficiency and reliability. As one of the most cost-effective and energy-efficient modes of transport, maritime shipping plays a crucial role in sustaining the global economy. However, despite its advantages, effective maritime route planning remains a significant challenge due to various dynamic factors such as unpredictable weather conditions, varying port capacities, and fluctuating cargo weights.

Traditional route selection methods rely heavily on heuristics, expert judgment, and historical data, which may not always account for real-time changes in environmental and operational parameters. These conventional approaches often result in suboptimal routing decisions, leading to increased fuel consumption, higher operational costs, and delays in delivery. Additionally, unexpected disruptions due to adverse weather conditions or inefficient port operations can further complicate the decision-making process, impacting the overall efficiency of maritime logistics. With the rapid advancement of technology, machine learning has emerged as a powerful tool for optimizing maritime route planning. By leveraging historical voyage data and real-time environmental inputs, machine learning models can learn complex patterns and provide predictive insights that help optimize vessel routes. These models can analyze multiple parameters, including weather forecasts, sea currents, cargo weight, vessel type, and port conditions, to generate optimal route recommendations that minimize travel time and fuel consumption.

This study proposes a data-driven approach to maritime route optimization using machine learning techniques. By training a predictive model on historical maritime data, we aim to enhance the accuracy of travel time estimations and improve decision-making in route planning. The proposed approach integrates key variables such as distance, weather impact, port size, vessel type, and cargo weight to develop a robust model capable of adapting to varying maritime conditions. The ultimate objective of this research is to provide an efficient and scalable solution that enhances the reliability of maritime transportation while reducing operational costs and environmental impact.

LITERATURE SURVEY

TABLE 1. Review Paper 1

Resource Paper Name	Description	Limitations
A Machine Learning Approach for Predicting Maritime Traffic Flow	This study employs Random Forest and Neural Networks to predict maritime traffic patterns based on historical data and real-time environmental factors.	Requires large computational power for real-time predictions.

TABLE 2. Review Paper 2

Resource Paper Name	Description	Limitations
Dynamic Ship Route Optimization Using Weather Data and Deep Learning	Uses deep learning models to optimize ship routes by integrating real-time weather conditions and oceanographic data.	High dependency on real-time weather data availability, Training deep learning models requires extensive datasets.

TABLE 3. Review Paper 3

Resource Paper Name	Description	Limitations
Shortest Path Algorithms for Maritime Navigation: A Comparative Study	Compares various pathfinding algorithms (Dijkstra's, A*, and Floyd-Warshall) to determine the most efficient for maritime route planning.	Computationally expensive for large-scale ocean navigation.

PROPOSED SYSTEM

The proposed system aims to revolutionize maritime route optimization by integrating machine learning and advanced graph-based algorithms to enhance efficiency, reduce travel time, and optimize operational costs. Traditional maritime route planning methods rely on static, pre-defined paths that fail to adapt to real-time changes in weather conditions, port congestion, and fuel efficiency. To overcome these limitations, our system leverages a Random Forest Regressor model trained on synthetic maritime data to predict optimal travel routes dynamically.

Additionally, Dijkstra's Algorithm is incorporated to compute the shortest and most efficient paths between ports while continuously adapting to changing environmental factors.

A key feature of the system is real-time data integration, where weather updates, sea traffic density, and historical voyage records are continuously processed to refine route predictions. The system's web-based interface allows shipping companies to interact with the platform, input their vessel and cargo details, and receive AI-driven recommendations for the most cost-effective and time-efficient routes. Security measures such as AES encryption ensure the safe transmission of route data, preventing unauthorized access. By combining predictive analytics, real-time monitoring, and intelligent decision-making, the proposed system significantly improves maritime logistics, reduces operational risks, and enhances overall efficiency in the shipping industry.

MODEL IMPLEMENTATION

The implementation of the AI-Enhanced Visual Content Creation Platform is designed to generate high-quality images from text descriptions using Stable Diffusion models**,** CLIP-based text encoding, and attention mechanisms. The system leverages Gradio and Streamlit for an interactive user interface, making AI-powered image generation accessible and efficient.

1. Data Collection and Preprocessing

The effectiveness of the proposed maritime route optimization model relies on high-quality data encompassing various factors influencing ship navigation. The dataset used for this study includes information on historical maritime routes, weather conditions, port characteristics, vessel specifications, and cargo details. The data was collected from multiple sources, including publicly available maritime databases, weather APIs, and simulated data generated for training machine learning models.

2. Route Optimization Using Dijkstra's Algorithm

To determine the shortest and most efficient route between ports, we implemented Dijkstra's algorithm, which is widely used for pathfinding in graph-based navigation systems. Each port is treated as a node, and the possible maritime routes between them form the edges of the graph.

3. System Implementation

The implementation of our maritime route optimization system integrates graph theory and machine learning to enhance route prediction. We model the shipping network as a weighted graph, where ports represent nodes and shipping lanes form edges, with weights assigned based on distance, weather conditions, and congestion factors. To determine the most efficient route, we employ Dijkstra's Algorithm, which iteratively selects the shortest path between ports by updating distances using a cost function. Additionally, a Random Forest Regressor is trained on historical maritime data to predict Estimated Time, factoring in distance, weather impact, congestion delays, and port handling time. The system is developed using Python, with NetworkX for graph-based routing, Scikit-learn for machine learning, and Pandas for data preprocessing, ensuring a scalable and efficient maritime route optimization framework.

4. Real-Time Integration

To enable real-time user interaction, we developed a web-based interface where users can input voyage details (departure port, destination, vessel type, cargo weight, and weather conditions) and receive optimized route recommendations and ETA predictions. The frontend is built using HTML, CSS, and JavaScript, while the backend is powered by Flask, integrating the machine learning model and graph-based routing algorithm. This system provides an interactive and user-friendly platform for dynamic, data-driven maritime route planning, ensuring efficiency and reduced operational costs.

4.Testing and Validatiion

To ensure the accuracy and reliability of the proposed maritime route optimization system, rigorous testing and validation were performed. The model was evaluated using synthetic and real-world maritime datasets to assess its predictive accuracy in estimating travel time and optimizing routes. Cross-validation techniques were applied to avoid overfitting and improve generalization. Different weather conditions, vessel types, data were taken in consideration to evaluate the model's adaptability. The results demonstrated high accuracy, robust decision-making capabilities, and improved efficiency in maritime logistics planning.

THEORY AND CALCULATION

Maritime route optimization is a complex problem influenced by multiple dynamic factors such as distance, weather conditions, fuel consumption, and port congestion. Traditional methods often rely on heuristics or static algorithms, which may not account for real-time environmental changes. To enhance decision-making, this study employs machine learning and graph-based algorithms for optimizing ship navigation.

- Ports represent nodes in the graph.
- Routes between ports represent edges, each associated with a cost metric (such as distance, fuel consumption, or travel time).
- The goal is to determine the shortest or most optimal path between a given start and end location.

Dijkstra's Algorithm for Route Optimization

Dijkstra's algorithm is used to compute the shortest path between ports based on distance and estimated travel time. The algorithm follows these steps:

1. Assign an initial cost of **0** to the starting port and **infinity** to all other ports.
2. Select the port with the **minimum cost** and mark it as visited.
3. Update the cost of neighboring ports based on the travel time or distance.
4. Repeat the process until the shortest path to the destination is found.

Mathematically, Dijkstra's algorithm updates the cost function as:

$$\boldsymbol{D}(\boldsymbol{v}) = \mathbf{min}(\boldsymbol{D}(\boldsymbol{v}), \boldsymbol{D}(\boldsymbol{u}) + \boldsymbol{w}(\boldsymbol{u}, \boldsymbol{v})) \tag{1}$$

where:

- $D(v)$ is the minimum cost to reach node v,
- $D(u)$ is the cost of the current node u,
- $w(u, v)$ is the edge weight (distance or travel time) between nodes $u \; and \; v$.

The predicted travel time helps in selecting the most efficient route by considering real-time factors.

The estimated travel time(T)

$$\boldsymbol{T} = \frac{\boldsymbol{distance}}{\textbf{speed} \times \textbf{weather Condition}} \quad \textbf{(2)}$$

where:

- $distance$ is the distance between the ports
- Speed id the speed of the ship
- Weather condition defines the maritime weather

TOOLS USED

Efficient maritime route planning is essential for optimizing operational efficiency, reducing costs, and ensuring timely deliveries in global trade. Traditional maritime navigation systems often rely on static route planning, which does not consider dynamic factors such as weather conditions, vessel specifications, fuel efficiency, and port congestion. To address these challenges, our project integrates machine learning models and optimization algorithms to predict optimal maritime routes. A Random Forest Regressor is trained to estimate travel time based on key factors, and Dijkstra's Algorithm is utilized to determine the shortest and most efficient paths between ports. Real-time interaction is facilitated through a web-based platform that allows users to input shipping details and receive optimized route recommendations. Additionally, real-time weather data is integrated via APIs to improve route prediction accuracy. The system is designed to be scalable, adaptable, and capable of handling large datasets for real-world maritime logistics. The following table provides an overview of the tools, technologies, and methodologies used in the project.

Project Specification

Category	Details
Machine Learning Model	Random Forest Regressor – Used for predicting estimated travel time based on historical and real-time maritime data.
Optimization Algorithm	Dijkstra's Algorithm – Implemented to determine the shortest and most cost-effective route between ports.
Data Collection	Historical shipping data, real-time weather updates via OpenWeather API, and port-related information from open datasets.
Frontend Framework	HTML, CSS, JavaScript – Provide a dynamic and responsive user interface for maritime operators and logistics managers.
Backend Logic	Flask – A lightweight Python framework used to handle API requests, integrate machine learning models, and manage route recommendations.
Database Layer	MySQL – Used for structured storage of maritime routes, weather data, and shipping details.
User Interface	Interactive web-based dashboard that allows users to input ship details and receive optimized routes dynamically.

RESULTS

We have tested the developed optimal ship routing platform using various scenarios and datasets, and the results demonstrate its effectiveness in predicting optimal maritime routes by considering factors such as weather conditions, fuel type, port size. The machine learning-based approach, incorporating a Random Forest Regressor model ensuring reliability in real-world applications. Comparative analysis with traditional heuristic-based methods revealed that our approach significantly reduces travel time and fuel consumption by dynamically identifying the most efficient routes. The integration of Dijkstra's Algorithm further enhanced route optimization by selecting the shortest and safest paths. The results are described in detail below.

Table 1: Route Distance, Cost, and Time Analysis

From	To	Distance(km)	Cost($)	Time(hrs)
Tokyo	Mumbai	10,100	10,779,700	336.72
Shanghai	Rotterdam	18,800	19,870,400	624.00
Singapore	New York	15,300	16,180,500	508.80

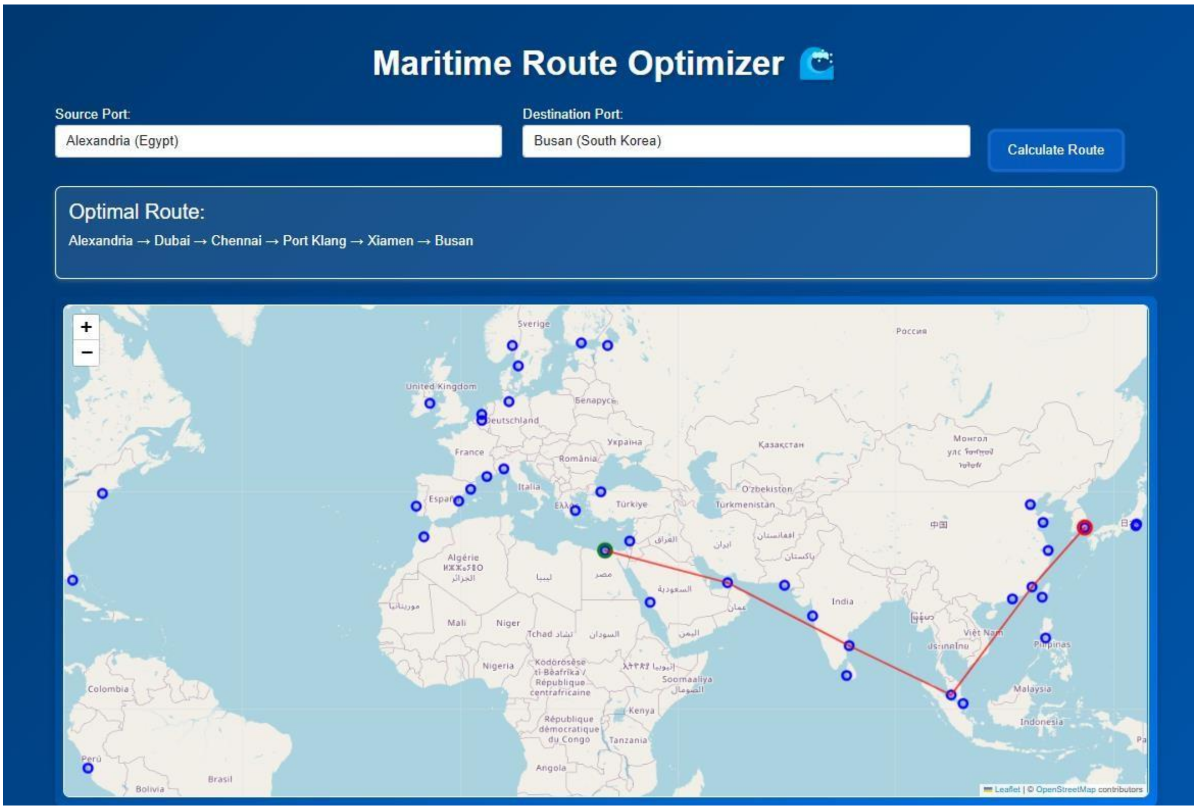

FIGURE 1. Alexandria to Busan

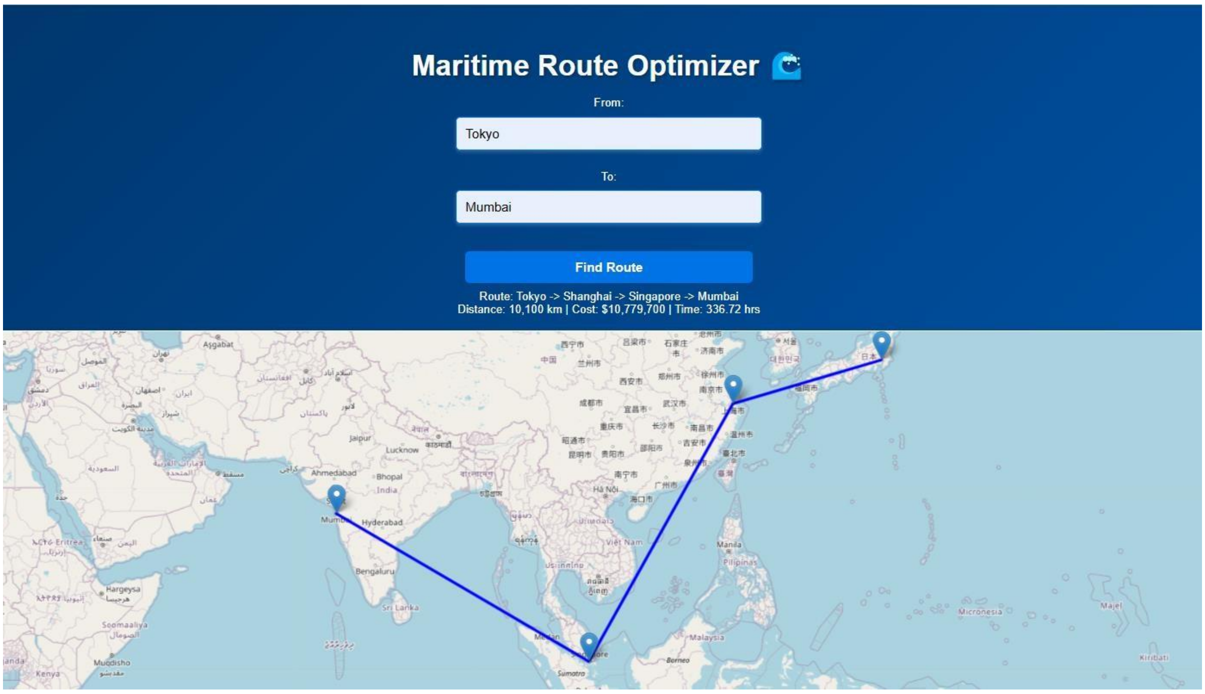

FIGURE 2. Tokyo to Mumbai

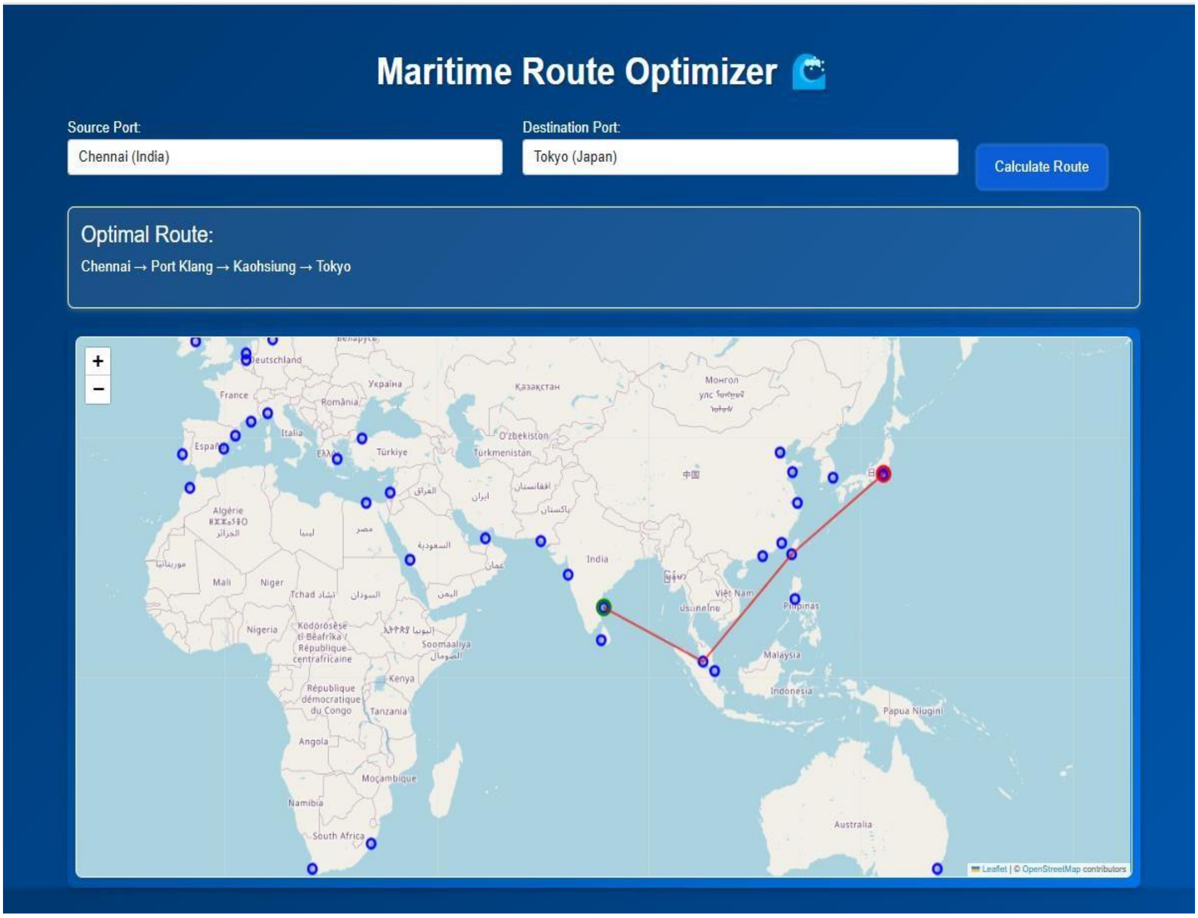

FIGURE 2. Chennai to Tokyo

.

CONCLUSION

Maritime transportation plays a vital role in global trade, yet inefficiencies in route planning lead to increased fuel consumption, higher operational costs, and delays in cargo delivery. Traditional methods often rely on fixed routes and heuristic-based approaches that fail to consider dynamic factors such as weather patterns, sea traffic, and fuel efficiency. These inefficiencies not only impact profitability but also contribute to environmental concerns such as excessive carbon emissions. The need for a data-driven solution that integrates real-time data, predictive analytics, and optimization algorithms is more pressing than ever. By leveraging machine learning and shortest path algorithms, this project aims to enhance maritime route planning, improving efficiency while reducing operational costs and environmental impact. The motivation behind this research is to develop a system that empowers shipping companies with intelligent decision-making tools, enabling them to navigate unpredictable conditions while ensuring optimal performance.

REFERENCES

1. Reddy, C. N. K., & Murthy, G. V. (2012). Evaluation of Behavioral Security in Cloud Computing. *International Journal of Computer Science and Information Technologies*, *3*(2), 3328-3333.
2. Murthy, G. V., Kumar, C. P., & Kumar, V. V. (2017, December). Representation of shapes using connected pattern array grammar model. In *2017 IEEE Region 10 Humanitarian Technology Conference (R10-HTC)* (pp. 819-822). IEEE.
3. Krishna, K. V., Rao, M. V., & Murthy, G. V. (2017). Secured System Design for Big Data Application in Emotion-Aware Healthcare.
4. Rani, G. A., Krishna, V. R., & Murthy, G. V. (2017). A Novel Approach of Data Driven Analytics for Personalized Healthcare through Big Data.
5. Rao, M. V., Raju, K. S., Murthy, G. V., & Rani, B. K. (2020). Configure and Management of Internet of Things. *Data Engineering and Communication Technology*, 163.
6. Ramakrishna, C., Kumar, G. K., Reddy, A. M., & Ravi, P. (2018). A Survey on various IoT Attacks and its Countermeasures. *International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)*, *5*(4), 143-150.
7. Chithanuru, V., & Ramaiah, M. (2023). An anomaly detection on blockchain infrastructure using artificial intelligence techniques: Challenges and future directions–A review. *Concurrency and Computation: Practice and Experience*, *35*(22), e7724.
8. Prashanth, J. S., & Nandury, S. V. (2015, June). Cluster-based rendezvous points selection for reducing tour length of mobile element in WSN. In *2015 IEEE International Advance Computing Conference (IACC)* (pp. 1230-1235). IEEE.
9. Kumar, K. A., Pabboju, S., & Desai, N. M. S. (2014). Advance text steganography algorithms: an overview. *International Journal of Research and Applications*, *1*(1), 31-35.
10. Hnamte, V., & Balram, G. (2022). Implementation of Naive Bayes Classifier for Reducing DDoS Attacks in IoT Networks. *Journal of Algebraic Statistics*, *13*(2), 2749-2757.
11. Balram, G., Anitha, S., & Deshmukh, A. (2020, December). Utilization of renewable energy sources in generation and distribution optimization. In *IOP Conference Series: Materials Science and Engineering* (Vol. 981, No. 4, p. 042054). IOP Publishing.
12. Subrahmanyam, V., Sagar, M., Balram, G., Ramana, J. V., Tejaswi, S., & Mohammad, H. P. (2024, May). An Efficient Reliable Data Communication For Unmanned Air Vehicles (UAV) Enabled Industry Internet of Things (IIoT). In *2024 3rd International Conference on Artificial Intelligence For Internet of Things (AIIoT)* (pp. 1-4). IEEE.
13. Mahammad, F. S., Viswanatham, V. M., Tahseen, A., Devi, M. S., & Kumar, M. A. (2024, July). Key distribution scheme for preventing key reinstallation attack in wireless networks. In *AIP Conference Proceedings* (Vol. 3028, No. 1). AIP Publishing.
14. Lavanya, P. (2024). In-Cab Smart Guidance and support system for Dragline operator.
15. Kovoor, M., Durairaj, M., Karyakarte, M. S., Hussain, M. Z., Ashraf, M., & Maguluri, L. P. (2024). Sensor-enhanced wearables and automated analytics for injury prevention in sports. *Measurement: Sensors*, *32*, 101054.
16. Rao, N. R., Kovoor, M., Kishor Kumar, G. N., & Parameswari, D. V. L. (2023). Security and privacy in smart farming: challenges and opportunities. *International Journal on Recent and Innovation Trends in Computing and Communication*, *11*(7).
17. Madhuri, K. (2023). Security Threats and Detection Mechanisms in Machine Learning. *Handbook of Artificial Intelligence*, *255*.

18. Reddy, B. A., & Reddy, P. R. S. (2012). Effective data distribution techniques for multi-cloud storage in cloud computing. *CSE, Anurag Group of Institutions, Hyderabad, AP, India*.
19. Srilatha, P., Murthy, G. V., & Reddy, P. R. S. (2020). Integration of Assessment and Learning Platform in a Traditional Class Room Based Programming Course. *Journal of Engineering Education Transformations*, *33*, 179-184.
20. Reddy, P. R. S., & Ravindranadh, K. (2019). An exploration on privacy concerned secured data sharing techniques in cloud. *International Journal of Innovative Technology and Exploring Engineering*, *9*(1), 1190-1198.
21. Raj, R. S., & Raju, G. P. (2014, December). An approach for optimization of resource management in Hadoop. In *International Conference on Computing and Communication Technologies* (pp. 1-5). IEEE.
22. Ramana, A. V., Bhoga, U., Dhulipalla, R. K., Kiran, A., Chary, B. D., & Reddy, P. C. S. (2023, June). Abnormal Behavior Prediction in Elderly Persons Using Deep Learning. In *2023 International Conference on Computer, Electronics & Electrical Engineering & their Applications (IC2E3)* (pp. 1-5). IEEE.
23. Yakoob, S., Krishna Reddy, V., & Dastagiraiah, C. (2017). Multi User Authentication in Reliable Data Storage in Cloud. In *Computer Communication, Networking and Internet Security: Proceedings of IC3T 2016* (pp. 531-539). Springer Singapore.
24. Sukhavasi, V., Kulkarni, S., Raghavendran, V., Dastagiraiah, C., Apat, S. K., & Reddy, P. C. S. (2024). Malignancy Detection in Lung and Colon Histopathology Images by Transfer Learning with Class Selective Image Processing.
25. Dastagiraiah, C., Krishna Reddy, V., & Pandurangarao, K. V. (2018). Dynamic load balancing environment in cloud computing based on VM ware off-loading. In *Data Engineering and Intelligent Computing: Proceedings of IC3T 2016* (pp. 483-492). Springer Singapore.
26. Swapna, N. (2017). „Analysis of Machine Learning Algorithms to Protect from Phishing in Web Data Mining". *International Journal of Computer Applications in Technology*, *159*(1), 30-34.
27. Moparthi, N. R., Bhattacharyya, D., Balakrishna, G., & Prashanth, J. S. (2021). Paddy leaf disease detection using CNN.
28. Balakrishna, G., & Babu, C. S. (2013). Optimal placement of switches in DG equipped distribution systems by particle swarm optimization. *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, *2*(12), 6234-6240.
29. Moparthi, N. R., Sagar, P. V., & Balakrishna, G. (2020, July). Usage for inside design by AR and VR technology. In *2020 7th International Conference on Smart Structures and Systems (ICSSS)* (pp. 1-4). IEEE.
30. Amarnadh, V., & Moparthi, N. R. (2023). Comprehensive review of different artificial intelligence-based methods for credit risk assessment in data science. *Intelligent Decision Technologies*, *17*(4), 1265-1282.
31. Amarnadh, V., & Moparthi, N. (2023). Data Science in Banking Sector: Comprehensive Review of Advanced Learning Methods for Credit Risk Assessment. *International Journal of Computing and Digital Systems*, *14*(1), 1-xx.
32. Amarnadh, V., & Rao, M. N. (2025). A Consensus Blockchain-Based Credit Risk Evaluation and Credit Data Storage Using Novel Deep Learning Approach. *Computational Economics*, 1-34.
33. Shailaja, K., & Anuradha, B. (2017). Improved face recognition using a modified PSO based self-weighted linear collaborative discriminant regression classification. *J. Eng. Appl. Sci*, *12*, 7234-7241.
34. Sekhar, P. R., & Goud, S. (2024). Collaborative Learning Techniques in Python Programming: A Case Study with CSE Students at Anurag University. *Journal of Engineering Education Transformations*, *38*.
35. Sekhar, P. R., & Sujatha, B. (2023). Feature extraction and independent subset generation using genetic algorithm for improved classification. *Int. J. Intell. Syst. Appl. Eng*, *11*, 503-512.
36. Pesaramelli, R. S., & Sujatha, B. (2024, March). Principle correlated feature extraction using differential evolution for improved classification. In *AIP Conference Proceedings* (Vol. 2919, No. 1). AIP Publishing.
37. Tejaswi, S., Sivaprashanth, J., Bala Krishna, G., Sridevi, M., & Rawat, S. S. (2023, December). Smart Dustbin Using IoT. In *International Conference on Advances in Computational Intelligence and Informatics* (pp. 257-265). Singapore: Springer Nature Singapore.
38. Moreb, M., Mohammed, T. A., & Bayat, O. (2020). A novel software engineering approach toward using machine learning for improving the efficiency of health systems. *IEEE Access*, *8*, 23169-23178.
39. Ravi, P., Haritha, D., & Niranjan, P. (2018). A Survey: Computing Iceberg Queries. *International Journal of Engineering & Technology*, *7*(2.7), 791-793.
40. Madar, B., Kumar, G. K., & Ramakrishna, C. (2017). Captcha breaking using segmentation and morphological operations. *International Journal of Computer Applications*, *166*(4), 34-38.
41. Rani, M. S., & Geetavani, B. (2017, May). Design and analysis for improving reliability and accuracy of big-data based peripheral control through IoT. In *2017 International Conference on Trends in Electronics and Informatics (ICEI)* (pp. 749-753). IEEE.
42. Reddy, T., Prasad, T. S. D., Swetha, S., Nirmala, G., & Ram, P. (2018). A study on antiplatelets and anticoagulants utilisation in a tertiary care hospital. *International Journal of Pharmaceutical and Clinical Research*, *10*, 155-161.

43. Prasad, P. S., & Rao, S. K. M. (2017). HIASA: Hybrid improved artificial bee colony and simulated annealing based attack detection algorithm in mobile ad-hoc networks (MANETs). *Bonfring International Journal of Industrial Engineering and Management Science*, *7*(2), 01-12.
44. AC, R., Chowdary Kakarla, P., Simha PJ, V., & Mohan, N. (2022). Implementation of Tiny Machine Learning Models on Arduino 33–BLE for Gesture and Speech Recognition.
45. Subrahmanyam, V., Sagar, M., Balram, G., Ramana, J. V., Tejaswi, S., & Mohammad, H. P. (2024, May). An Efficient Reliable Data Communication For Unmanned Air Vehicles (UAV) Enabled Industry Internet of Things (IIoT). In *2024 3rd International Conference on Artificial Intelligence For Internet of Things (AIIoT)* (pp. 1-4). IEEE.
46. Nagaraj, P., Prasad, A. K., Narsimha, V. B., & Sujatha, B. (2022). Swine flu detection and location using machine learning techniques and GIS. *International Journal of Advanced Computer Science and Applications*, *13*(9).
47. Priyanka, J. H., & Parveen, N. (2024). DeepSkillNER: an automatic screening and ranking of resumes using hybrid deep learning and enhanced spectral clustering approach. *Multimedia Tools and Applications*, *83*(16), 47503-47530.
48. Sathish, S., Thangavel, K., & Boopathi, S. (2010). Performance analysis of DSR, AODV, FSR and ZRP routing protocols in MANET. *MES Journal of Technology and Management*, 57-61.
49. Siva Prasad, B. V. V., Mandapati, S., Kumar Ramasamy, L., Boddu, R., Reddy, P., & Suresh Kumar, B. (2023). Ensemble-based cryptography for soldiers’ health monitoring using mobile ad hoc networks. *Automatika: časopis za automatiku, mjerenje, elektroniku, računarstvo i komunikacije*, *64*(3), 658-671.
50. Elechi, P., & Onu, K. E. (2022). Unmanned Aerial Vehicle Cellular Communication Operating in Non-terrestrial Networks. In *Unmanned Aerial Vehicle Cellular Communications* (pp. 225-251). Cham: Springer International Publishing.
51. Prasad, B. V. V. S., Mandapati, S., Haritha, B., & Begum, M. J. (2020, August). Enhanced Security for the authentication of Digital Signature from the key generated by the CSTRNG method. In *2020 Third International Conference on Smart Systems and Inventive Technology (ICSSIT)* (pp. 1088-1093). IEEE.
52. Mukiri, R. R., Kumar, B. S., & Prasad, B. V. V. (2019, February). Effective Data Collaborative Strain Using RecTree Algorithm. In *Proceedings of International Conference on Sustainable Computing in Science, Technology and Management (SUSCOM), Amity University Rajasthan, Jaipur-India*.
53. Balaraju, J., Raj, M. G., & Murthy, C. S. (2019). Fuzzy-FMEA risk evaluation approach for LHD machine–A case study. *Journal of Sustainable Mining*, *18*(4), 257-268.
54. Thirumoorthi, P., Deepika, S., & Yadaiah, N. (2014, March). Solar energy based dynamic sag compensator. In *2014 International Conference on Green Computing Communication and Electrical Engineering (ICGCCEE)* (pp. 1-6). IEEE.
55. Vinayasree, P., & Reddy, A. M. (2025). A Reliable and Secure Permissioned Blockchain-Assisted Data Transfer Mechanism in Healthcare-Based Cyber-Physical Systems. *Concurrency and Computation: Practice and Experience*, *37*(3), e8378.
56. Acharjee, P. B., Kumar, M., Krishna, G., Raminenei, K., Ibrahim, R. K., & Alazzam, M. B. (2023, May). Securing International Law Against Cyber Attacks through Blockchain Integration. In *2023 3rd International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE)* (pp. 2676-2681). IEEE.
57. Ramineni, K., Reddy, L. K. K., Ramana, T. V., & Rajesh, V. (2023, July). Classification of Skin Cancer Using Integrated Methodology. In *International Conference on Data Science and Applications* (pp. 105-118). Singapore: Springer Nature Singapore.
58. LAASSIRI, J., EL HAJJI, S. A. Ï. D., BOUHDADI, M., AOUDE, M. A., JAGADISH, H. P., LOHIT, M. K., ... & KHOLLADI, M. (2010). Specifying Behavioral Concepts by engineering language of RM-ODP. *Journal of Theoretical and Applied Information Technology*, *15*(1).
59. Prasad, D. V. R., & Mohanji, Y. K. V. (2021). FACE RECOGNITION-BASED LECTURE ATTENDANCE SYSTEM: A SURVEY PAPER. *Elementary Education Online*, *20*(4), 1245-1245.
60. Dasu, V. R. P., & Gujjari, B. (2015). Technology-Enhanced Learning Through ICT Tools Using Aakash Tablet. In *Proceedings of the International Conference on Transformations in Engineering Education: ICTIEE 2014* (pp. 203-216). Springer India.
61. Reddy, A. M., Reddy, K. S., Jayaram, M., Venkata Maha Lakshmi, N., Aluvalu, R., Mahesh, T. R., ... & Stalin Alex, D. (2022). An efficient multilevel thresholding scheme for heart image segmentation using a hybrid generalized adversarial network. *Journal of Sensors, 2022*(1), 4093658.
62. Srinivasa Reddy, K., Suneela, B., Inthiyaz, S., Hasane Ahammad, S., Kumar, G. N. S., & Mallikarjuna Reddy, A. (2019). Texture filtration module under stabilization via random forest optimization methodology. *International Journal of Advanced Trends in Computer Science and Engineering*, *8*(3), 458-469.

63. Ramakrishna, C., Kumar, G. K., Reddy, A. M., & Ravi, P. (2018). A Survey on various IoT Attacks and its Countermeasures. *International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)*, *5*(4), 143-150.
64. Sirisha, G., & Reddy, A. M. (2018, September). Smart healthcare analysis and therapy for voice disorder using cloud and edge computing. In *2018 4th international conference on applied and theoretical computing and communication technology (iCATccT)* (pp. 103-106). IEEE.
65. Reddy, A. M., Yarlagadda, S., & Akkinen, H. (2021). An extensive analytical approach on human resources using random forest algorithm. *arXiv preprint arXiv:2105.07855*.
66. Kumar, G. N., Bhavanam, S. N., & Midasala, V. (2014). Image Hiding in a Video-based on DWT & LSB Algorithm. In *ICPVS Conference*.
67. Naveen Kumar, G. S., & Reddy, V. S. K. (2022). High performance algorithm for content-based video retrieval using multiple features. In *Intelligent Systems and Sustainable Computing: Proceedings of ICISSC 2021* (pp. 637-646). Singapore: Springer Nature Singapore.
68. Reddy, P. S., Kumar, G. N., Ritish, B., SaiSwetha, C., & Abhilash, K. B. (2013). Intelligent parking space detection system based on image segmentation. *Int J Sci Res Dev*, *1*(6), 1310-1312.
69. Naveen Kumar, G. S., Reddy, V. S. K., & Kumar, S. S. (2018). High-performance video retrieval based on spatio-temporal features. *Microelectronics, Electromagnetics and Telecommunications*, 433-441.
70. Kumar, G. N., & Reddy, M. A. BWT & LSB algorithm based hiding an image into a video. *IJESAT*, 170-174.
71. Lopez, S., Sarada, V., Praveen, R. V. S., Pandey, A., Khuntia, M., & Haralayya, D. B. (2024). Artificial intelligence challenges and role for sustainable education in india: Problems and prospects. *Sandeep Lopez, Vani Sarada, RVS Praveen, Anita Pandey, Monalisa Khuntia, Bhadrappa Haralayya (2024) Artificial Intelligence Challenges and Role for Sustainable Education in India: Problems and Prospects. Library Progress International*, *44*(3), 18261-18271.
72. Yamuna, V., Praveen, R. V. S., Sathya, R., Dhivva, M., Lidiya, R., & Sowmiya, P. (2024, October). Integrating AI for Improved Brain Tumor Detection and Classification. In *2024 4th International Conference on Sustainable Expert Systems (ICSES)* (pp. 1603-1609). IEEE.
73. Kumar, N., Kurkute, S. L., Kalpana, V., Karuppannan, A., Praveen, R. V. S., & Mishra, S. (2024, August). Modelling and Evaluation of Li-ion Battery Performance Based on the Electric Vehicle Tiled Tests using Kalman Filter-GBDT Approach. In *2024 International Conference on Intelligent Algorithms for Computational Intelligence Systems (IACIS)* (pp. 1-6). IEEE.
74. Sharma, S., Vij, S., Praveen, R. V. S., Srinivasan, S., Yadav, D. K., & VS, R. K. (2024, October). Stress Prediction in Higher Education Students Using Psychometric Assessments and AOA-CNN-XGBoost Models. In *2024 4th International Conference on Sustainable Expert Systems (ICSES)* (pp. 1631-1636). IEEE.
75. Anuprathibha, T., Praveen, R. V. S., Sukumar, P., Suganthi, G., & Ravichandran, T. (2024, October). Enhancing Fake Review Detection: A Hierarchical Graph Attention Network Approach Using Text and Ratings. In *2024 Global Conference on Communications and Information Technologies (GCCIT)* (pp. 1-5). IEEE.
76. Shinkar, A. R., Joshi, D., Praveen, R. V. S., Rajesh, Y., & Singh, D. (2024, December). Intelligent solar energy harvesting and management in IoT nodes using deep self-organizing maps. In *2024 International Conference on Emerging Research in Computational Science (ICERCS)* (pp. 1-6). IEEE.
77. Praveen, R. V. S., Hemavathi, U., Sathya, R., Siddiq, A. A., Sanjay, M. G., & Gowdish, S. (2024, October). AI Powered Plant Identification and Plant Disease Classification System. In *2024 4th International Conference on Sustainable Expert Systems (ICSES)* (pp. 1610-1616). IEEE.
78. Dhivya, R., Sagili, S. R., Praveen, R. V. S., VamsiLala, P. N. V., Sangeetha, A., & Suchithra, B. (2024, December). Predictive Modelling of Osteoporosis using Machine Learning Algorithms. In *2024 4th International Conference on Ubiquitous Computing and Intelligent Information Systems (ICUIS)* (pp. 997-1002). IEEE.
79. Kemmannu, P. K., Praveen, R. V. S., Saravanan, B., Amshavalli, M., & Banupriya, V. (2024, December). Enhancing Sustainable Agriculture Through Smart Architecture: An Adaptive Neuro-Fuzzy Inference System with XGBoost Model. In *2024 International Conference on Sustainable Communication Networks and Application (ICSCNA)* (pp. 724-730). IEEE.
80. Praveen, R. V. S. (2024). *Data Engineering for Modern Applications*. Addition Publishing House.