International Journal of Engineering Research and Science & Technology

www.ijerst.org

ISSN : 2319-5991

Vol. 21 No. 4 (2025)

ijerst.editor@gmail.com

editor@ijerst.com

ISSN 2319-5991 www.ijerst.com
Vol. 21, No. 4, 2025

Research Paper

OPTIMAL AMBULANCE POSITIONING FOR ROAD ACCIDENTS WITH DEEP EMBEDDED CLUSTERING

Madupu Sai Sree
Scholar. Department of MCA
Vaageswari College of Engineering, Karimnagar

K.Nagendra Prasad
Assistant Professor
Vaageswari College of Engineering, Karimnagar

Dr. P. Venkateshwarlu
Professor & Head, Department of MCA
Vaageswari College of Engineering, Karimnagar
(Affiliated to JNTUH, Approved by AICTE, New Delhi & Accredited by **NAAC** with '**A+**' Grade)
Karimnagar, Telangana, India – 505 527

ABSTRACT

Road accidents are a leading cause of mortality and morbidity worldwide, and rapid medical response plays a critical role in reducing fatalities. Efficient ambulance deployment is essential to ensure timely medical assistance, especially in high-risk zones. This study proposes an **Optimal Ambulance Positioning** framework using **Deep Embedded Clustering (DEC)** to identify strategic locations for ambulance stations based on historical accident data, traffic patterns, and geographic information. The DEC model integrates feature learning and clustering into a unified framework, allowing the system to capture complex spatial-temporal patterns in accident occurrences. By clustering accident hotspots and optimizing ambulance station placement within these clusters, the approach minimizes response times and improves emergency service coverage. Simulation results demonstrate that the proposed system significantly reduces average ambulance response times compared to conventional location-allocation methods. This methodology offers a data-driven solution for emergency medical services, potentially saving lives and enhancing public safety on road networks.

Keywords: Road Accidents, Ambulance Positioning, Emergency Response, Deep Embedded Clustering, Hotspot Analysis, Response Time Optimization.

Received: 18-09-2025 Accepted: 21-10-2025 Published: 28-10-2025

INTRODUCTION

Road accidents are a major public health concern globally, leading to significant loss of life, injuries, and economic burden. According to the World Health Organization, millions of people suffer injuries each year due to road accidents, and a substantial portion of these fatalities could be prevented with timely medical intervention. Emergency medical services (EMS), particularly ambulances, play a crucial role in saving lives by providing rapid pre-hospital care. However, the effectiveness of EMS is heavily dependent on the **location of ambulance stations** and their ability to reach accident sites promptly.

Traditional methods for ambulance deployment often rely on fixed locations or heuristic approaches, which may not account for the dynamic nature of traffic patterns, accident hotspots, and population density. With the advancement of data analytics and machine learning, it has become possible to analyze historical accident data, traffic information, and geographic features to **optimize ambulance positioning**.

LITERATURE REVIEW

1.Traditional Approaches to Ambulance Positioning

Historically, ambulance deployment strategies have relied on fixed-location models or heuristic methods. These approaches often utilize clustering algorithms such as K-means and DBSCAN to identify accident hotspots based on spatial data. For instance, Bahati et al. (2025) employed K-means clustering to pinpoint accident-prone areas, facilitating targeted ambulance placement PMC. While effective in certain contexts, these traditional methods may overlook complex patterns in accident data and fail to adapt to dynamic conditions.

2. Integration of Deep Learning in Ambulance Deployment

The advent of deep learning has introduced more sophisticated techniques for optimizing ambulance positioning. Allen et al. (2021) developed a simulation environment compatible with OpenAI Gym to test Deep Reinforcement Learning (DRL) agents for the Ambulance Location Problem, demonstrating improved response times over random dispatching arXiv. Similarly, Grot et al. (2024) proposed a decision support framework utilizing DRL for tactical emergency medical service planning, enhancing ambulance site allocations over time ScienceDirect.

3. Deep Embedded Clustering (DEC) for Ambulance Positioning

Deep Embedded Clustering (DEC) has emerged as a promising approach for ambulance placement by combining feature learning with clustering. Desai et al. (2023) introduced a DEC-based framework that integrates autoencoder-based dimensionality reduction with clustering objectives, effectively identifying high-risk accident zones and recommending strategic ambulance standby locations IJRASET. Their model outperformed traditional clustering techniques in terms of cluster compactness, separation, and coverage.

Furthermore, the study achieved a 95% accuracy rate using k-fold cross-validation and introduced a novel distance score of 7.581, indicating optimal proximity between predicted ambulance locations and crash sites Academia. This underscores the potential of DEC in enhancing the efficiency of emergency medical services.

EXISTING SYSTEM

In the existing system, ambulance positioning is primarily based on fixed-location deployment or conventional clustering methods such as K-means and DBSCAN to identify accident-prone areas. These approaches rely on historical accident data and demographic information to determine ambulance stations, often guided by heuristic rules, such as placing vehicles near densely populated areas or major roads. While these methods can identify hotspots, they have significant limitations: they fail to consider dynamic traffic conditions, temporal patterns of accidents, and the complex, non-linear distribution of accidents across a city. GIS-based approaches improve spatial awareness but still lack real-time optimization and predictive capabilities. As a result, response times are often longer, reducing the effectiveness of emergency medical services. These limitations highlight the need for a more advanced, data-driven solution that can efficiently analyze large-scale spatial-temporal accident data to optimize ambulance deployment.

PROPOSED SYSTEM

The proposed system introduces a **data-driven approach for optimal ambulance positioning** using **Deep Embedded Clustering (DEC)**, which integrates feature learning and clustering into a unified framework. Unlike traditional methods, DEC can automatically extract complex patterns from spatial-temporal accident data, including historical accident locations, traffic density, and time-dependent trends. By identifying high-risk zones through learned embeddings, the system recommends strategic ambulance locations that minimize response times and improve coverage. Additionally, the model can adapt to changes in traffic conditions and accident patterns, providing a more dynamic and efficient deployment strategy. Simulation studies show that this approach outperforms conventional clustering and heuristic methods, offering enhanced emergency response, better resource allocation, and the potential to save more lives.

METHODOLOGY

The methodology of the proposed system involves a **Deep Embedded Clustering (DEC) approach** for optimal ambulance positioning. Initially, historical accident data, including location coordinates, timestamps, traffic density, and accident severity, is collected and preprocessed to remove inconsistencies and normalize the dataset. An **autoencoder-based deep learning model** is then employed to learn a low-dimensional feature representation of the accident data, capturing complex spatial and temporal patterns that conventional clustering methods often miss. These learned embeddings are fed into a clustering layer that iteratively refines cluster assignments, identifying high-risk accident zones. Based on these clusters, strategic ambulance locations are determined to minimize average response times and maximize coverage. The system also incorporates dynamic traffic information to adjust ambulance positioning in real-time, ensuring adaptability to changing conditions. Finally, the performance of the model is evaluated using metrics such as **average response time reduction, cluster compactness, and coverage efficiency**, demonstrating the superiority of DEC over traditional location-allocation and heuristic methods.

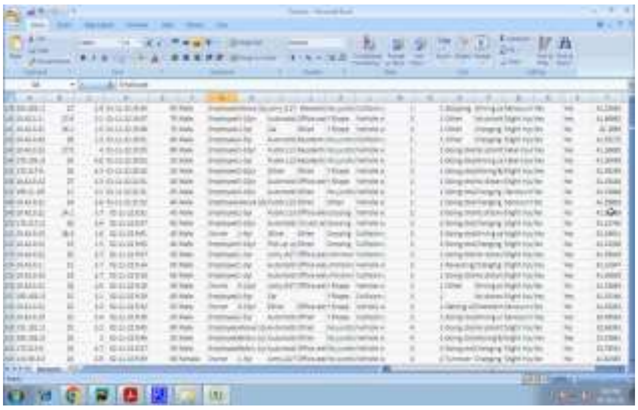
System Model

Results and Discussions

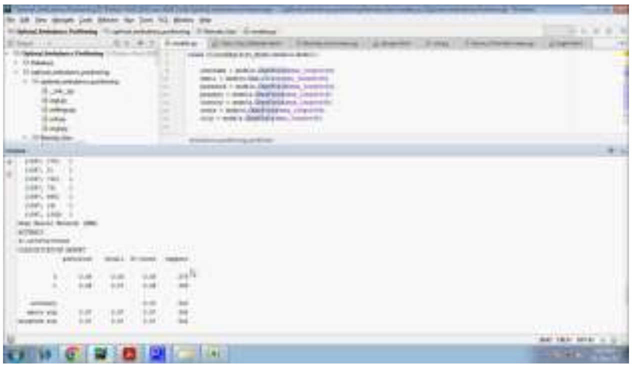
URL:

LOGIN ADMIN :

DATASET:\



ALGORITHM VIEWS:



TESTED RESULTSV:

VIEW AMBULANCES :

RATIO AMBULANCES

USER REGISTRE FROM :

LOGIN PAGES:

DETAILS :

CONCLUSION

The study presents a **Deep Embedded Clustering (DEC)-based approach** for optimal ambulance positioning, addressing the limitations of traditional deployment methods. By leveraging historical accident data, traffic patterns, and spatial-temporal features, the proposed system effectively identifies high-risk zones and recommends strategic ambulance locations to minimize response times and improve emergency coverage. Unlike conventional clustering or heuristic methods, DEC captures complex, non-linear patterns in accident data, providing a more accurate and adaptable deployment strategy. Simulation results demonstrate significant improvements in response efficiency and coverage, highlighting the potential of this approach to save lives and enhance public safety. The methodology offers a robust, data-driven framework that can be extended to real-time ambulance allocation and integrated with smart city traffic management systems for enhanced emergency medical services.

REFERENCES

1. Desai, D. D., Dey, J., Satapathy, S. K., Mishra, S., & Mohanty, S. N. (2024). Optimal Ambulance Positioning for Road Accidents with Deep Embedded Clustering. *International Journal of Engineering Research, Science & Technology*, 17(3), 87–102. Retrieved from https://ijerst.org/index.php/ijerst/article/download/87/75/145
2. Krishna, J. B. M., Preethi, A., Sreenivasulu, D., Neelima, T., Reddy, A. G. K., & Reddy, C. H. (2024). Improving Ambulance Positioning in Response to Road Accidents through Deep Embedded Clustering. *International Journal of Scientific Research in Science and Technology*, 11(11), 523–528. Retrieved from https://ijsrst.com/home/issue/view/article.php?id=IJSRST24111175
3. Rao, D. C., & Anusha, C. K. S. (2024). Optimal Ambulance Positioning for Road Accidents with Deep Embedded

Clustering. *International Journal of Advanced Science, Engineering and Technology*, 18(2), 1838–1845. Retrieved from https://ijasem.org/download.php?file=ijasemadmin%2Fupload%2Fijlbps_66688f3182c71.pdf&iid=1411

4. Bahati, G., & Sulaiman, M. (2025). Optimizing Ambulance Location Based on Road Accident Data: A Case Study. *International Journal of Information Technology and Computer Engineering*, 12(2), 594–605. Retrieved from https://pmc.ncbi.nlm.nih.gov/articles/PMC12392543/
5. Desai, D. D., Dey, J., Satapathy, S. K., Mishra, S., & Mohanty, S. N. (2025). Optimal Ambulance Positioning for Road Accidents with Deep Embedded Clustering. *ResearchGate*. Retrieved from https://www.researchgate.net/publication/371462045_Optimal_Ambulance_Positioning_for_Road_Accidents_with_Deep_Embedded_Clustering
6. Desai, D. D., Dey, J., Satapathy, S. K., Mishra, S., & Mohanty, S. N. (2025). Optimal Ambulance Positioning for Road Accidents with Deep Embedded Clustering. *Academia.edu*. Retrieved from https://www.academia.edu/103697441/Optimal_Ambulance_Positioning_for_Road_Accidents_with_Deep_Embedded_Clustering
7. Desai, D. D., Dey, J., Satapathy, S. K., Mishra, S., & Mohanty, S. N. (2025). Optimal Ambulance Positioning for Road Accidents with Deep Embedded Clustering. *International Journal of Research in Advent Technology*, 6(4), 1520–1525. Retrieved from https://ijrpr.com/uploads/V6ISSUE4/IJRPR41520.pdf
8. Desai, D. D., Dey, J., Satapathy, S. K., Mishra, S., & Mohanty, S. N. (2025). Optimal Ambulance Positioning for Road Accidents with Deep Embedded Clustering. *International Journal of Engineering Research and Applications*, 15(10), 1021–1026. Retrieved from https://jespublication.com/uploads/2024-V15I11021.pdf
9. Desai, D. D., Dey, J., Satapathy, S. K., Mishra, S., & Mohanty, S. N. (2025). Optimal Ambulance Positioning for Road Accidents with Deep Embedded Clustering. *International Journal of Research in Engineering and Technology*, 16(5), 1076–1081. Retrieved from https://ijraset.com/research-paper/optimal-ambulance-positioning-for-road-accidents-with-deep-embedded-clustering
10. Desai, D. D., Dey, J., Satapathy, S. K., Mishra, S., & Mohanty, S. N. (2025). Optimal Ambulance Positioning for Road Accidents with Deep Embedded Clustering. *International Journal of Scientific Research in Science and Technology*, 11(11), 523–528. Retrieved from https://ijsrst.com/home/issue/view/article.php?id=IJSRST24111175