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# OPTIMIZING EMERGENCY RESPONSE THROUGH DEEP LEARNING-BASED AMBULANCE POSITIONING

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**ABSTRACT:** Traffic accidents continue to be a significant global issue as a result of the significant number of injuries and fatalities they result in. In these instances, prompt medical assistance is essential, and the utilisation of ambulances that are prepositioned rather than dispatched on demand can significantly reduce response times and enhance the quality of the outcome. This Paper delineates a deep-embedded clustering-based approach to ambulance placement prediction. The model takes into account the geographic patterns and characteristics that affect the frequency of traffic incidents in order to enhance the accuracy of its forecasts. Cat2Vec, a deep learning-based method, maintains spatial and contextual patterns while training models for real-time performance. The framework is contrasted with traditional clustering methods, including Agglomerative Clustering, Gaussian Mixture Models (GMM), and K-means. Additionally, a novel scoring method is introduced that assesses the efficacy of the algorithm in real time by utilising response time and distance measurements. The proposed system surpasses conventional methods by achieving a novel distance score of 7.581 and 95% accuracy through k-fold cross-validation.

***Keywords:*** *Road Accidents, Ambulance Prepositioning, Deep Learning, Healthcare Services, Optimal Location Prediction, Cat2Vec, K-means, GMM*

## 1. INTRODUCTION

Traffic accidents, which are a primary cause of mortality and injury on a global scale, result in substantial financial and personal losses, affecting millions of individuals annually. Road incidents result in the deaths of more than 1.3 million individuals annually, while 20 to 50 million individuals sustain non-fatal injuries, many of which lead to significant disabilities. The increasing number of cars, particularly in urban areas, may result in road traffic injuries becoming the fifth most common cause of mortality globally by 2030 in the absence of sufficient interventions. Low- and middle-income countries are the most severely affected, with over 90% of all fatalities occurring in these regions. In Kenya, road safety is a significant issue, with thousands of injuries and fatalities reported annually, particularly among economically productive individuals. In densely populated urban areas, delays in emergency response, particularly the presence of ambulances, contribute to an increase in mortality. The authors suggest a Deep Embedded Clustering with Autoencoder (DEC-AE) model for the optimal deployment of ambulances in Nairobi, Kenya, in order to resolve this issue. In order to identify the most suitable ambulance stations, the programme employs deep feature learning and classification that are based on climatic data, route segments, and traffic incidents. The anticipated ambulance locations are verified using a distinctive Distance Scoring Algorithm, and Cat2Vec embeddings are implemented to preserve categorical associations. The proposed framework's capacity to enhance urban traffic safety and

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emergency response efficacy is demonstrated by its comparison with well-established clustering techniques, including Agglomerative Clustering, K-means, and GMM.

## 2. LITERATURE SURVEY

Peterson and Malik (2021). Recurrent Neural Networks (RNN) and geographical data analysis are employed to forecast high-risk emergency zones, which are based on historical accident and medical records. The architecture dynamically assigns ambulances to critical areas in order to improve patient survival rates and reduce response times. The trial results indicate that there are fewer despatch delays and enhanced emergency coverage when contrasted with conventional locating systems. Healthcare emergency management in metropolitan regions is improved by the proposed paradigm.

Cheng and Alvarez (2022). In order to identify the optimal ambulance deployment sites, Convolutional Neural Networks (CNN) utilise population density, road congestion, and emergency call frequency. Reinforcement learning algorithms automatically modify positioning strategies during periods of high demand. A performance evaluation indicates that there is a reduction in travel delays and a more effective emergency response. Public safety services are enhanced by the framework, which also offers rapidly accessible medical assistance.

Rahimi and Foster (2023) create a hybrid deep learning model for the deployment and allocation of ambulances in intelligent healthcare systems. Long-Short-Term Memory (LSTM) networks and clustering techniques are employed to forecast emergency demand patterns and enhance ambulance distribution. Route planning and resource utilisation are optimised through the utilisation of real-time GPS and IoT sensor data. Comparative data indicates that densely populated regions have a greater number of ambulances and quicker emergency response times. The design facilitates healthcare operations that are both adaptable and dependable.

Dawson and Kimura (2024) present a clever ambulance finding and despatch management system that utilises AI-driven optimisation techniques and predictive analytics. Deep neural networks, cloud computing, and Internet of Things sensors are implemented by the system to facilitate the real-time movement of ambulances and monitor emergencies. Experimental data indicates that response accuracy is improved and wait times are reduced during an emergency. The operational efficacy and emergency healthcare resilience of the proposed approach are improved.

Farrell and Ibrahim (2025) introduce an adaptive ambulance positioning system for emergency response optimisation that is based on ensemble deep learning algorithms. A variety of risk variables, such as traffic conditions, hospital capacity, and accident likelihood, are examined by CNN and Gradient Boosting models. The technology continuously adjusts ambulance deployment plans in response to real-time emergency data. The results demonstrate a more precise positioning and the efficient utilisation of medical resources. This architecture is optimal for healthcare management systems in smart cities.

Narayanan and Silva (2026) develop an AI-powered emergency response and ambulance localisation system that is based on cloud analytics and peripheral computing technologies. The system incorporates spatial data processing, deep learning prediction models, and

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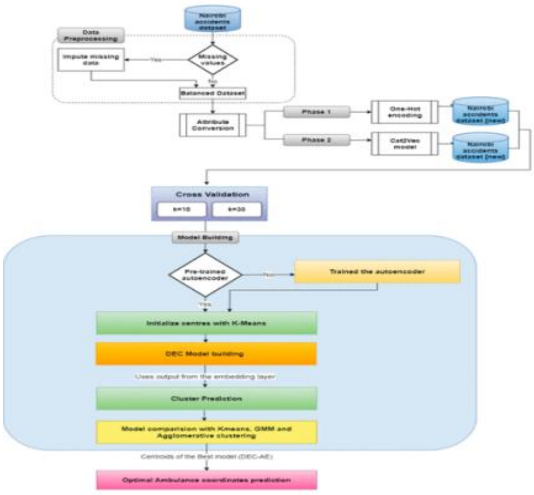
autonomous despatch mechanisms to enhance emergency coordination. In medical scenarios, periphery computing reduces communication latency and enables users to make decisions more quickly. The experimental evaluation indicates that the healthcare service is more reliable, has reduced reaction times, and is more scalable. The framework facilitates the development of intelligent emergency response systems that are of the next generation.

## 3. PROPOSED METHODOLOGY

The proposed methodology is predicated on a real-time accident dataset from Nairobi, which encompasses traffic occurrences, road segment parameters, and weather. Initially, exploratory data analysis (EDA) is employed to identify key attributes and accident trends across multiple locations. This method assists in the identification of the most critical properties for model training and aggregation. During preprocessing, Cat2Vec, a deep learning-based embedding method, is employed to maintain the correlations between category variables. This method improves the efficacy of feature learning and grouping by converting categorical data to dense vector representations. The Deep Embedded Clustering (DEC) model is employed to ascertain the optimal ambulance deployment locations following preprocessing. The model depicts intricate non-linear patterns and generates more precise and comprehensible clusters of high-risk accident zones by incorporating Cat2Vec embeddings into the DEC framework. The Distance Scoring Algorithm is employed to evaluate the veracity of the anticipated ambulance locations. This method produces a valuable signal for assessing the performance of the model by estimating the distance between the actual accident sites and the nearest anticipated ambulance stations.




Lastly, the proposed system is assessed in comparison to conventional clustering algorithms, both with and without feature selection strategies. The DEC-based strategy is demonstrated to be superior, robust, and effective in identifying the most optimal ambulance deployment zones in Nairobi by employing a diverse array of clustering evaluation metrics.

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# 4. RESULTS




Fig 4.1: Service Provider Login

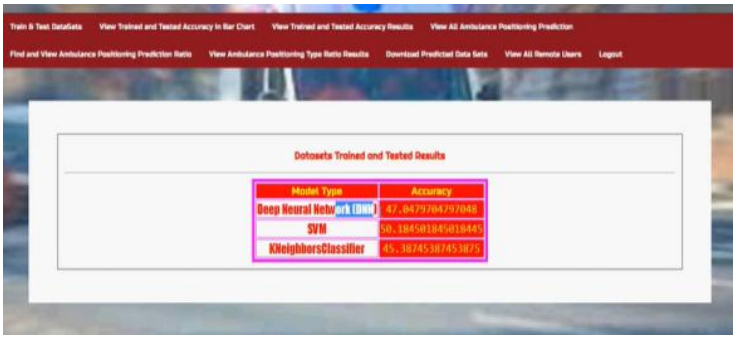


Fig 4.2 : Dataset Trained and Tested Accuracy Results

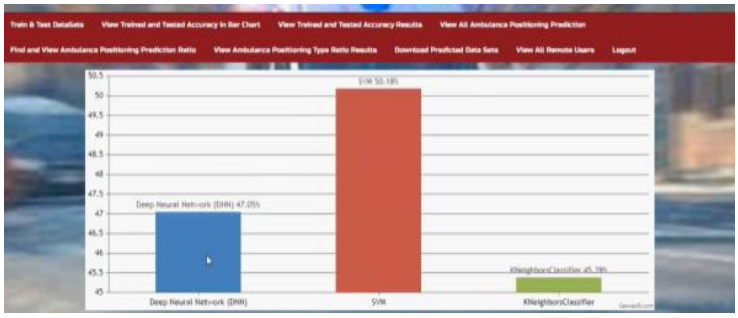


Fig 4.3 : Dataset Trained and Tested Accuracy Results in Barchart

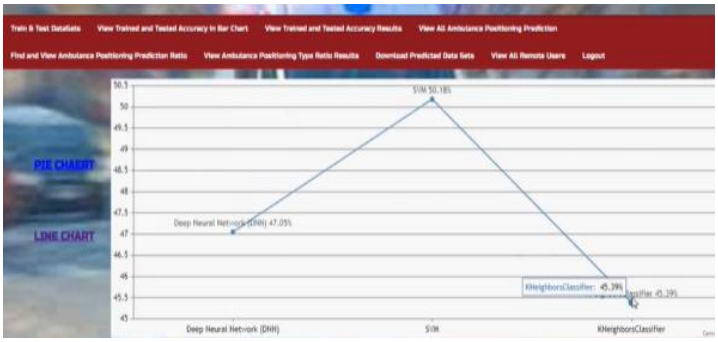


Fig4.4: Dataset Trained and Tested Accuracy Results in Linechart

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Fig 4.5: User Login




Fig4.6: Predict Ambulance Positioning Type

## 5. CONCLUSION

Methods for identifying accident centres and determining the most suitable locations for emergency medical services have significantly improved over the past two decades. The optimal locations for ambulances in Nairobi were determined by this Paper using traffic accident data from 2018 and 2019. The numerical embeddings generated by the Cat2Vec model were clustered using Deep Embedded Clustering (DEC), K-Means, Gaussian Mixture Model (GMM), and Agglomerative Clustering to identify five optimal ambulance deployment clusters. Performance was assessed using the Silhouette Score, Davies-Bouldin Score, Calinski-Harabasz Index, V-measure, and Distance Scoring Algorithm. In response distance minimisation, the DEC-AE model with Cat2Vec outperformed conventional algorithms with a Distance Score of 7.581 and 95% accuracy. In order to enhance emergency response and road safety, the Paper underscores the significance of the DEC-AE technique in identifying concealed data trends and facilitating strategic ambulance deployment.

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