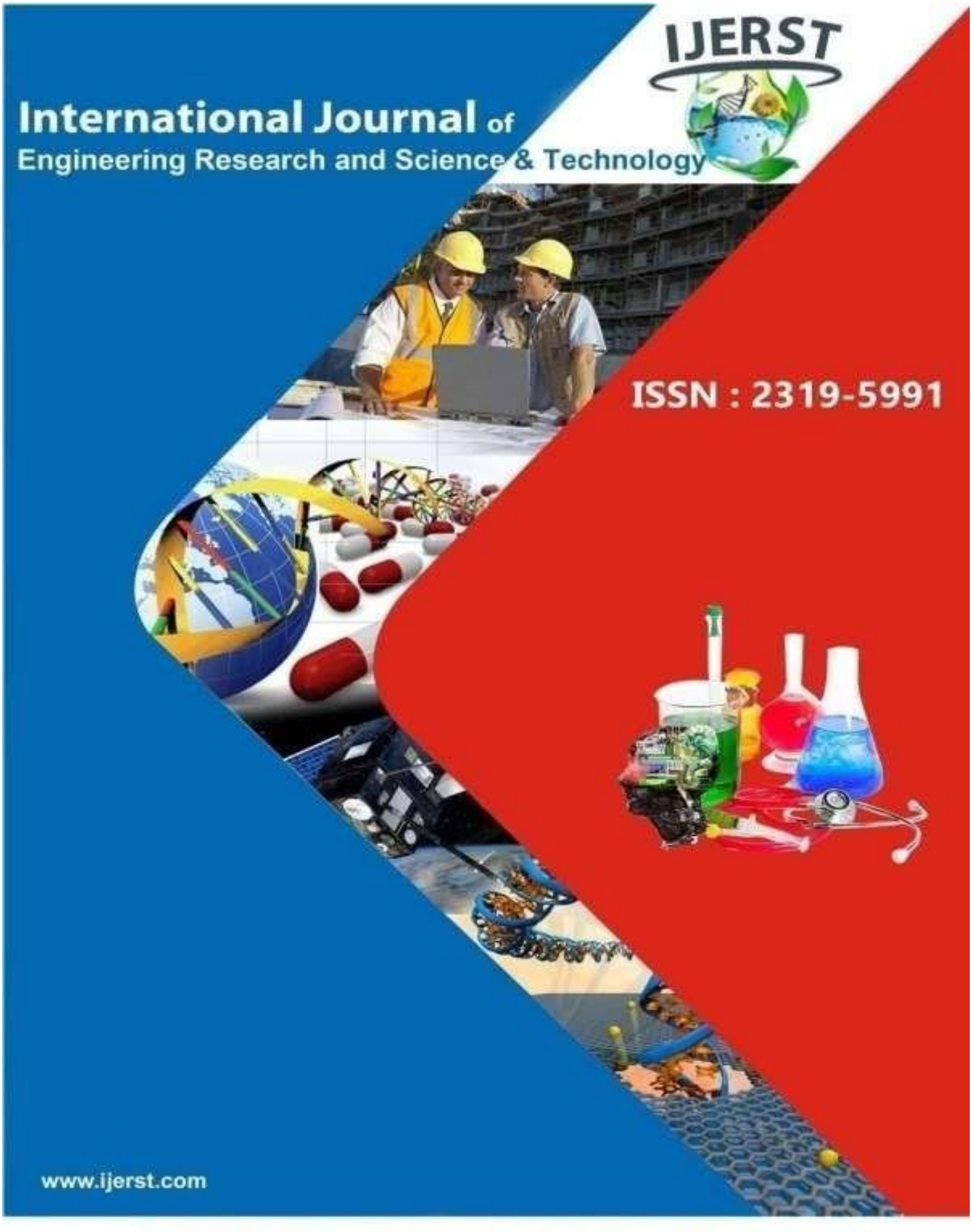


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International Journal of Engineering Research and Science & Technology

*ISSN 2319-5991 www.ijerst.com*

*Vol. 17, Issue 3, 2021*

# OPTIMAL AMBULANCE POSITIONING FOR ROAD ACCIDENTS WITH DEEP EMBEDDED CLUSTERING

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## ABSTRACT:

Improvements to road accident emergency response systems are the focus of the novel "Optimal Ambulance Positioning for Road Accidents with Deep Embedded Clustering" project. The need for strategic and rapid ambulance location to reduce response times and save lives is heightened by the fact that road accidents are a leading cause of death globally. By analysing accident data from the past, this program uses deep integrated clustering algorithms to optimise the deployment of ambulances in high-risk locations. This study uses deep embedded clustering to analyse road accident patterns in detail, finding clusters of accidents with high frequency and severity. When planning where to best station ambulances to guarantee quick response in high-need regions, these clusters are key places. The incorporation of geographical data and real-time traffic also makes the ambulance placement system more accurate and faster. In addition to taking into account variables including traffic patterns, time of day, and accident severity levels, this system's implementation seeks to minimise ambulance response times. This research aims to transform emergency response methods by using predictive models created by deep embedded clustering to strategically place ambulances. This might improve overall emergency medical services and reduce the effect of traffic accidents.

The overarching goal of this project is to improve ambulance location in the event of traffic accidents via the use of an intelligent and data-driven strategy. It has the potential to improve the efficacy and efficiency of emergency medical services by combining deep embedded clustering with real-time data processing, leading to the saving of more lives in life-threatening circumstances.

International Journal of Engineering Research and Science & Technology
ISSN 2319-5991 www.ijerst.com
Vol. 17, Issue 3, 2021

# I. INTRODUCTION

Road accidents present critical challenges to emergency response systems, often necessitating swift and strategic deployment of ambulances to mitigate casualties. The project on "Optimal Ambulance Positioning for Road Accidents with Deep Embedded Clustering" aims to revolutionize emergency medical services by leveraging advanced data analytics and machine learning techniques. By harnessing the power of deep embedded clustering algorithms, this initiative seeks to optimize ambulance positioning based on historical accident data, traffic dynamics, and accident severity levels. The proposed system intends to enhance the efficiency and effectiveness of emergency response strategies, ultimately improving outcomes for accident victims.

# II. LITERATURE REVIEW

1.Optimal Ambulance Positioning for Road Accidents With Deep Embedded Clustering, Dhyani Dhaval Desai; Joyeeta Dey; Sandeep Kumar Satapathy; Shruti Mishra; Sachi Nandan Mohanty, The number of casualties and fatalities brought on by road accidents is one of the most significant concerns in the modern world. Instead of dispatching ambulances only at the time of demand, pre-positioning them can reduce the response time and provide prompt medical attention. Deep learning techniques hold great potential and have proven to be essential for problem-solving and decision-making in the field of healthcare services. This study introduces a deep-embedded clustering-based approach to predict optimal locations for ambulance positing. Various factors and patterns in a geographical region greatly influence the occurrence of road crashes, hence understanding such relationships while model building is crucial. The present study also emphasizes the need of preserving such patterns during model building to ensure real-time results and implements them with the help of another deep-learning-based model, Cat2Vec. The proposed framework is also compared with traditional clustering algorithms like K-means, GMM, and Agglomerative clustering. Moreover, to calculate response time and distance in real time, a novel scoring function has also been introduced for the

ISSN 2319-5991 www.ijerst.com
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performance evaluation of various algorithms. The proposed ambulance-positing system exhibits remarkable performance, achieving an accuracy of 95% with k-fold cross-validation and a novel distance score of 7.581 proving the use of the proposed approach is better than all the other traditional algorithms used.

## III. EXISTING SYSTEM

Assi et al. and Xiong et al. pioneered the use of Machine Learning models for predicting accident vs. non-accident patterns in crash sites. Their approaches employed Gaussian Mixture models and Support Vector Machines (SVM) to discern these patterns. Additionally, they predicted the severity of crash injuries by clustering the crashes using Fuzzy C-Means, Feed Forward Neural Networks, and SVM. Ghandour et al. and Tiwari et al. developed a hybrid ensemble classifier utilizing decision trees and the MSO algorithm to identify risk factors contributing to fatal road accidents. Granberg et al. introduced a simulation-based predictive model for emergency ambulance demand using a multivariate regression model. Alkheder et al. proposed an approach using decision tree classifier, MLP, and Naïve Bayes to identify significant attributes impacting the prediction of accident severity. Hashmienejad et al. utilized decision trees and genetic algorithms, achieving superior accuracy compared to alternative methods such as ANN, SVM, KNN, and Naïve Bayes. Ghosh et al. and Sasaki et al. employed Bayesian networks to identify factors responsible for road accidents and predict severity. Taamneh et al. utilized Artificial Neural Networks (ANN) along with K-means to predict accident severity, showing higher accuracy. Dizaji et al. and Tian et al. used Auto-encoders for dimensionality reduction and K-means for clustering. Alqahtani et al. proposed an approach using embedded clustering layer in deep auto-encoders, optimizing feature representations and cluster assignments concurrently.

Disadvantages

• The complexity of data: Most of the existing machine learning models must be able to accurately interpret large and complex datasets to detect Ambulance Positioning.

• Data availability: Most machine learning models require large amounts of data to create accurate predictions. If data is unavailable in sufficient

International Journal of Engineering Research and Science & Technology
ISSN 2319-5991 www.ijerst.com
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quantities, then model accuracy may suffer.

• Incorrect labeling: The existing machine learning models are only as accurate as the data trained using the input dataset. If the data has been incorrectly labeled, the model cannot make accurate predictions.

## IV. PROPOSED SYSTEM

The dataset includes information on traffic accidents that occurred, road segment information, and weather details of Nairobi, Kenya. Performing Exploratory Data Analysis on the dataset of the road surveys, and weather dataset, the paper identifies possible features and attributes affecting the accidents and patterns of risk across the city. To preserve such relationships and patterns of the data we apply a deep learning-based embedding approach called Cat2Vec while converting categorical attributes in the data pre-processing stage. To validate the predicted locations using DEC, the distance from that crash site to the nearest ambulance locations predicted is calculated using a novel Distance Scoring Algorithm. For further evaluation of the algorithm, different clustering metrics have been used and compared with other traditional clustering algorithms.

• Exploratory Data Analysis (EDA) is performed on the real-time accident dataset through which the potential features and attributes which contribute towards accidents and patterns across the city are identified.

• A clustering-based approach using Deep Embedded Clustering (DEC) is developed to identify optimal ambulance positioning locations across Nairobi while preserving the feature relationships and patterns using Cat2Vec deep learning-based embedding technique which facilitates more accurate clustering.

• A novel Distance Scoring method is developed to validate the DEC model which calculates the distance between crash-site and the nearest predicted ambulance location, thus providing a quantitative measure of effectiveness.

• The performance of the proposed framework is then evaluated with and without the feature selection techniques and compared with existing clustering methods using various clustering metrics, which further validates the effectiveness of the DEC model.

Advantages:

ISSN 2319-5991 www.ijerst.com

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The proposed system proposes an approach (optimal ambulance positioning framework) for the automatic placement of paramedic help using Deep Embedded Clustering (DEC). To ameliorate the classification accuracy, this study utilizes Cat2vec(a deep learning-based model) to represent high cardinality categorical variables using low-dimension embedding while preserving the relationship and patterns obtained through exploratory data analysis between each of the categories. This study employs K-fold cross-validation for dividing the dataset into training and test sets.

## V. METHODOLOGY

The methodology for the "Optimal Ambulance Positioning for Road Accidents with Deep Embedded Clustering" project involves a systematic process beginning with the collection of comprehensive road accident data, encompassing location details, severity, and other pertinent attributes. After preprocessing and feature engineering, a deep learning model, such as an Auto-Encoder with an embedded clustering layer, is implemented for unsupervised learning. This model is trained on the preprocessed dataset to learn meaningful representations of key features, employing clustering techniques to group similar accident locations. Subsequently, an algorithm is developed to determine optimal ambulance positioning based on the learned patterns, considering factors like accident density, severity, and proximity to medical facilities. Evaluation metrics are defined to assess the performance of the optimal positioning algorithm, including response time reduction and overall effectiveness. The methodology includes a comparative analysis with existing methods and validation through separate datasets or cross-validation. The proposed approach aims to enhance emergency response systems by providing a data-driven strategy for optimizing ambulance deployment in the event of road accidents.

## VI. CONCLUSION

Last but not least, the effectiveness of traffic safety management programs now hinges on the methods that have emerged over the last 20 years for pinpointing accident hotspots and optimising paramedic deployments. Using the accident dataset from 2018-2019, this research aimed to develop and compare prediction models for the optimal placement of ambulances inside

International Journal of Engineering Research and Science & Technology
ISSN 2319-5991 www.ijerst.com
Vol. 17, Issue 3, 2021

Nairobi city. Five distinct groups were detected by combining the Cat2Vec model for categorical-to-numerical translation with Deep Embedded Clustering (DEC) and more conventional methods like K-Means, GMM, and Agglomerative clustering. We found the best places to park ambulances by locating the centres of these clusters. The DEC-AE model outperformed the others with an impressive 95% accuracy in k-fold cross-validation when tested using a variety of metrics, including Silhouette score, Calinski-Harbasz score, Davies Bouldin Score, V-measure, and the new Distance score. The DEC-AE model impressed with a Distance score of 7.581, which indicates that there is little distance between possible collision locations and ambulance placements. This result is higher than regular machine learning methods. The robustness and effectiveness of the DEC-AE model in correctly detecting data patterns are shown by its persistent outperformance across clustering measures. Policymakers may use the study's findings as a roadmap for improved emergency response system security and strategic investment.

## VII. FUTURE SCOPE

The exploration of optimal ambulance placements in Nairobi through DEC has unveiled several promising paths for future investigation. Primarily, enriching the dataset used in this study presents a key opportunity. By including additional variables—such as road type, construction details, speed limits, accident severity, driving behaviors, and road conditions—currently absent due to data limitations, a more comprehensive understanding of the factors influencing accidents can be attained. This augmentation promises enhanced accuracy in ambulance positioning models.

Extending the analysis beyond the constrained 2018-2019 timeframe offers prospects to uncover temporal trends and accident patterns. A broader timespan would capture seasonal fluctuations, evolving traffic patterns, and the impact of dynamic changes in road infrastructure or safety measures. Expanding the study to encompass cities with diverse urbanization levels and traffic dynamics would enable a deeper comprehension of model performance across varied settings. This longitudinal approach stands to yield insights into the

*ISSN 2319-5991 www.ijerst.com*

*Vol. 17, Issue 3, 2021*

efficacy of safety interventions, policy implementations, and the shifting landscape of road accidents.

Furthermore, comparative studies leveraging datasets from cities of varying socio-economic contexts would shed light on the generalizability and resilience of the proposed methodology. This comprehensive analysis would elucidate the multifaceted factors contributing to accidents across different settings.

Moreover, delving into the examination of accident trends over time warrants exploration, recommending the utilization of time series analysis techniques. Integration of real-time data streams encompassing traffic flow, weather updates, and live accident reports presents an avenue to bolster the responsiveness and adaptability of ambulance positioning models. This integration would empower models to dynamically adjust ambulance placements based on evolving traffic conditions, emerging accident hotspots, and real-time demands, ensuring a more efficient emergency response system.

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