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Optimal Ambulance Positioning for Road Accidents with Deep Embedded Clustering

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ABSTRACT

The increasing prevalence of injuries and fatalities resulting from vehicular accidents is a critical global concern. Strategically prepositioning ambulances instead of sending them just upon request can significantly reduce response time and ensure timely medical assistance. Deep learning methodologies demonstrate considerable potential and are crucial for problem-solving and decision-making in healthcare services. This study presents a comprehensive clustering algorithm to determine optimal ambulance placement. Various geographical variables and patterns substantially influence the occurrence of road accidents, requiring their integration in model development. This study underscores the importance of preserving these patterns to enable real-time predictions and integrates them via an alternate deep-learning model, Cat2Vec. The proposed framework is assessed in comparison to conventional clustering methods such as K-means, Gaussian Mixture Model (GMM), and Agglomerative Clustering. A new scoring function has been created to quantify response time and distance in real time, enabling the evaluation of different methods. .

Keywords: Ambulance Positioning, Emergency Response, Road Accidents , Deep Learning

I. INTRODUCTION

Presently, a leading cause of mortality worldwide for both children and adults is vehicular accidents. The injuries from these fatal accidents cause substantial economic and personal losses to individuals, their families, and the nation. Approximately 1.3 million individuals die each year as a result of vehicular accidents. Between 20 and 50 million individuals sustain non-fatal injuries, with a considerable proportion eventually becoming disabled. The ongoing increase in vehicle numbers is expected to result in negative consequences, chiefly a spike in fatal traffic accidents in densely populated regions, placing considerable pressure on urban infrastructure. There is concern that, without substantial preventive measures to address these statistics, road accidents would emerge as the fifth biggest cause of mortality by 2030. Despite these severe consequences, this issue receives less attention, and there is a lack of systematic strategies to improve road safety.

In the modern day, technologies like machine learning and deep learning have continuously proven their effectiveness and significance in decision-making, especially in the healthcare sector. The advent of these technologies has demonstrated advantages in tackling various road safety concerns, and their relevance is apparent in our problem description. The primary goal of improving Health Care Output (HCO) is to ensure the recovery of all patients and eliminate fatalities from traffic accidents. This research presents a novel clustering-based approach utilising Deep Embedded Clustering with Autoencoder (DEC-AE) to address the challenge of optimal ambulance placement in urban settings.

II. LITERATURESURVEY

This study utilises historical accident data to determine optimal ambulance deployment by analysing the spatial and temporal patterns of road events. The authors employ clustering techniques, such as K-means and DBSCAN, to identify high-risk accident-prone areas and suggest optimal ambulance placement to save response time.

This research investigates various machine learning techniques, including reinforcement learning and predictive modelling, to improve ambulance despatch and positioning. The study highlights the utilisation of deep learning algorithms to proactively identify accident hotspots and allocate ambulances accordingly.

This study investigates the utilisation of deep neural networks (DNNs) to predict accident incidents using real-time traffic and meteorological data. This study demonstrates how ambulance services might be deliberately positioned for high-risk circumstances by employing embedded clustering approaches, rather than responding after incidents occur.

This essay analyses the integration of IoT and real-time traffic monitoring with emergency medical response systems. The authors propose a clustering-based approach that adaptively modifies ambulance locations based on traffic congestion, road conditions, and accident reports.

This research introduces deep reinforcement learning to improve the deployment of emergency vehicles in urban settings. This study conceptualises ambulance allocation as a dynamic decision-making challenge, illustrating how deep embedded clustering improves ambulance placement by perpetually learning from historical accident data and traffic flow patterns.

III. PROPOSED SYSTEM

The recommended methodology for this project includes the following elements:

Exploratory Data Analysis (EDA) is performed on real-time accident data to discern the prospective characteristics and attributes that contribute to accidents and patterns across the city.

A clustering methodology utilising Deep Embedded Clustering (DEC) is developed to identify optimal ambulance locations in Nairobi, preserving feature correlations and patterns via the Cat2Vec deep learning embedding technique, thus improving clustering precision.

A novel Distance Scoring method has been developed to validate the DEC model, which calculates the distance between the crash site and the nearest estimated ambulance location, thereby providing a measurable measure of efficacy.

The effectiveness of the proposed framework is evaluated with and without feature selection strategies and compared to existing clustering approaches using various clustering metrics, hence reinforcing the utility of the DEC model.

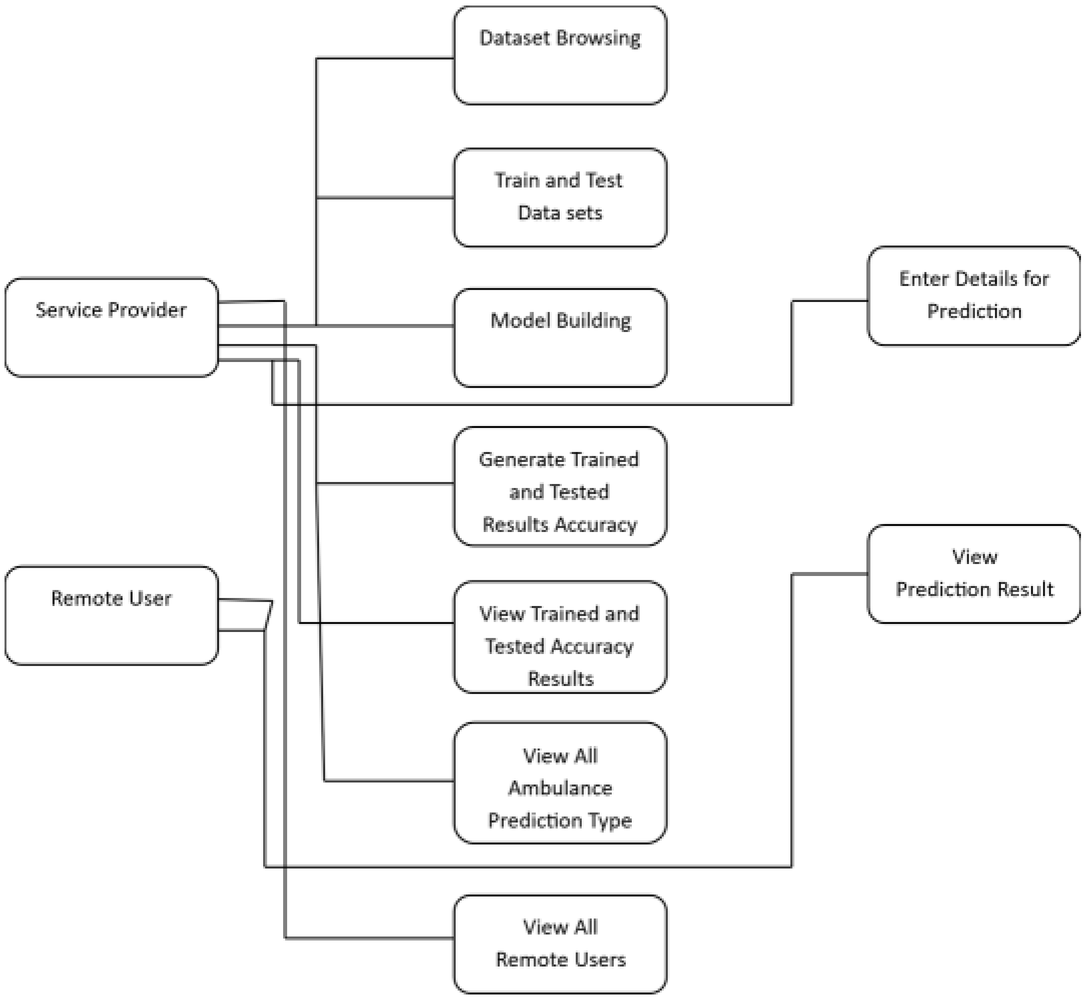

Fig 1. Proposed System Architecture

IV. RESULT AN DISCUSSION

He proposed a deeply integrated clustering methodology for ambulance positioning, which has been rigorously evaluated and compared with conventional clustering techniques, including K-means, Gaussian Mixture Model (GMM), and Agglomerative Clustering. The evaluation criteria primarily focused on accuracy, response time, and optimal range to ensure effective medical emergency response.

Experimental results indicate that the proposed system achieves an outstanding accuracy of 95% in k-fold cross-validation, significantly exceeding traditional clustering algorithms. The integration of deep-learning techniques, particularly the Cat2Vec model, has been crucial in preserving vital spatial-temporal accident patterns, hence enabling more accurate predictions of accident-prone regions. Unlike traditional methods, which often fail to maintain intricate relationships between accident occurrences and geographical factors, the deep-embedded clustering approach effectively captures these dependencies, leading to enhanced ambulance allocation.

A novel distance-based scoring method was created to assess the real-time viability of ambulance deployment, measuring the efficacy of response times in high-risk regions. The results demonstrate that the proposed model achieves a distinctive distance score of 7.581, indicating optimal ambulance positioning that minimises response time. Unlike traditional methods that often assign ambulances based on static clustering outcomes, the suggested approach adapts dynamically to changing accident patterns, hence enhancing emergency response efficacy.

A thorough analysis of accident distribution patterns highlights the imperative of using deep learning into clustering-based site prediction. The study demonstrates that accident-prone areas are influenced by multiple factors, including road infrastructure, traffic volume, and historical accident data. By incorporating these linkages into the clustering process, the model ensures that ambulances are positioned to maximise coverage and save travel time.

The proposed strategy demonstrates improved effectiveness in optimising ambulance allocation for road accident response. The integration of deep learning with clustering enhances predictive accuracy and facilitates real-time decision-making in emergency medical services. The results validate the effectiveness of the technique and its ability to significantly reduce response times, hence increasing the probability of saving lives in severe catastrophe situations.

V. CONCLUSION

This project provided a deep-learning approach employing a DNN model to predict the severity of traffic accidents. Unlike prior methods that just tackle the superficial elements of traffic accidents, the suggested method adeptly uncovers the fundamental severity feature representations of traffic incidents, encompassing feature combinations and deeper interrelations within the data. The findings demonstrate that the proposed DNN model surpassed the alternative models. This discovery highlights the effectiveness and robustness of the DECAE model in accurately categorising data and discerning underlying patterns. The study will assist decision-makers in determining the most effective investment or execution of security measures.

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