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Multi-Time Series Forecasting for Regional Emergency Call Demand

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ABSTRACT

Accurate emergency call demand forecasting is essential for optimizing resource allocation and response times in Emergency Medical Services (EMS). Time series forecasting, a cornerstone of machine learning, plays a crucial role in predicting demand patterns. This research proposes a novel multi-series forecasting model for scenarios involving multiple independent time series, representing call data from distinct service areas. While previous research has explored multivariate time series and machine learning methods for EMS demand forecasting, this study focuses on comparing a simplified independent time series approach against the proposed multi-series model. By evaluating the accuracy of both methods in predicting future call volumes, the findings will provide insights into the most effective forecasting approach, ultimately contributing to improved resource allocation and enhanced patient care in EMS.

KEYWORDS

Multi Time Series Forecasting, Autoregressive Model, EMS

INTRODUCTION

Everywhere in the world, road accidents, fires, and crimes pose a constant threat to humans. Emergencies may emanate from incidents resulting in fatalities, bodily harm, or destruction of property. Emergencies have the potential to jeopardize public safety, health, and overall well-being. Furthermore, both natural and anthropogenic disasters can result in a significant number of injuries within a brief period (Hugelius et al., 2020). Emergency services play a pivotal role in healthcare, with demand for them surging significantly in recent years (Oberlin et al., 2020). Emergency Medical Services are crucial for delivering immediate medical care in cases of serious incidents or injuries outside the hospital setting. The presence of EMS stands as a fundamental element within an effective healthcare system due to its vital function in preserving lives and diminishing mortality and morbidity rates, particularly in instances involving grave accidents and acute illnesses (Aringhieri et al., 2017).

Furthermore, the objectives of Emergency Medical Services encompass prompt provision and delivery of care to patients (Nickel et al., 2016), Provision of out-of-hospital care services, coupled

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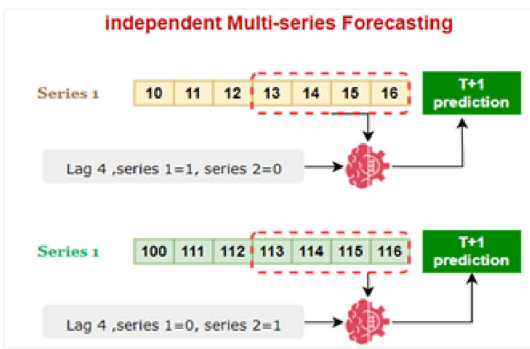
with the swift relocation of individuals to suitable healthcare establishments following instances of significant or moderate injuries or emergencies (Jánošíková et al., 2019). In other words, reducing ambulance response time is the primary measure of EMS performance worldwide (Al-Shaqsi, 2010).

Additionally, the positioning of the ambulance is crucial for the efficient functioning of Emergency Medical Services to alleviate distress and minimize injuries from accidents (Brotcorne et al., 2003). Hence, accurately predicting the requisite quantity of ambulances for every region along with their precise placement yields beneficial outcomes and enhances the effectiveness of service provision (Jaldell et al., 2014). Univariate and multivariate are the two primary categories of time series prediction models (Serin et al., 2021). The difference between them lies in the quantity of variables or characteristics utilized in the prediction process. Univariate models concentrate on forecasting future values of a single variable using its historical data, while multivariate models forecast multiple variables simultaneously based on their past values [10],[11].

But in another way, Multi Time Series (No Multivariate Time Series) This refers to a situation where you have multiple distinct time series datasets, each representing a different sequence of data. For example, you might have separate time series for stock prices, customer transactions, and website traffic, all unrelated to each other. These are separate time series, and they are not combined into a single multivariate time series dataset. It's crucial to differentiate multiple time series from multivariate time series. In multivariate analysis, we have a single time series dataset containing multiple variables measured at each time point. These variables are assumed to be interrelated, and the analysis focuses on modeling these relationships to understand the system's dynamics. In contrast, independent multiple time series datasets comprise separate sequences, and the focus of the analysis lies on understanding the individual characteristics and patterns within each series as in Figure. 1.

Figure 1. The independent multi series (no multivariate)



To clarify, if you are working with multiple independent series that are correlated but not dependent on each other (meaning past values of one series do not predict future values of another), it can be helpful to model them together as they may follow a similar pattern in terms of past and future value. Combining the series in a multi- series model is advantageous as it allows for the identification of intrinsic patterns that may be present in the past and future values of all the series (Atkinson et al., 2021). In This research, we investigate the demand for emergency ambulance services across five distinct geographical areas. Our objective is to develop resource deployment plans by forecasting future call volumes in each region and determining the optimal number of ambulances required. To achieve that, we conducted a comparative experiment utilizing machine learning techniques. We evaluate two forecasting strategies: (1) Individual Time Series, (2) Independent Multi-Series. Following the forecasting experiments, we perform a detailed analysis comparing the accuracy and effectiveness of each strategy in predicting future call volumes.

Artificial Intelligence-Empowered Chatbot for Effective COVID-19 Information Delivery to Older Adults

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