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Effective Forecasting of Key Features in Hospital Emergency Department

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Abstract

Efficiently forecasting the demands within a hospital's Emergency Department (ED) is critical for optimal resource allocation and patient care management. This study focuses on leveraging deep learning techniques to predict various types of ED patient flows, facilitating informed decision-making by ED managers. The rising success of deep learning networks in modeling time-series data makes them a compelling choice for patient flow forecasting. In this context, we investigate and compare seven deep learning models-Deep Belief Network (DBN), Restricted Boltzmann Machines (RBM), Long Short-Term Memory (LSTM), Gated Recurrent Unit (GRU), combined GRU and Convolutional Neural Networks (CNN-GRU), LSTM-CNN, and Generative Adversarial Network based on Recurrent Neural Networks (GAN-RNN)—to accurately forecast patient flow within a hospital's emergency department. To enable traffic flow forecasting, a forecaster layer is introduced for each model. Real-world patient flow data spanning different ED services (biology, radiology, scanner, and echography) at Lille regional hospital in France serve as a case study to evaluate these models. Four effectiveness metrics are employed to assess and compare the forecasting methods. The outcomes demonstrate the superior performance of deep learning models in predicting ED patient flows compared to conventional shallow approaches like ridge regression and support vector regression. Significantly, the Deep Belief Network (DBN) stands out, achieving an averaged mean absolute percentage error of approximately 4.097.

Keywords: AI; Convolutional Neural Networks; Deep Reinforcement Learning; Deep Belief Network; Gated Recurrent Unit

Abbreviations: DBN: Deep Belief Network; ED: Emergency Department; GRU: Gated Recurrent Unit; LSTM: Long Short-Term Memory: GAN-RNN: Generative Adversarial Network based on Recurrent Neural Networks.

Introduction

Over the last decades, there has been an expanding demand for emergency department (ED) cares, including medical and surgical treatments worldwide [1]. Efficiently managing healthcare systems can significantly improve resources management in emergency departments (EDs) at a hospital where the number of visits is unpredictable [2]. The successful management of EDs is particularly sensitive because they are expected to provide immediate and often lifesaving of patients. In the US, in the period from 1993 to 2003, the EDs visits considerably raised by an average of 26; however, the number of EDs lowered by approximately 9 [3]. For instance, the demand for EDs services has been doubled within the period 1990 and 2014, and it is still continuously

increasing [4].

Related Work

In this study, the focus is on accurately forecasting daily visits in different departments of a Pediatric Emergency Department (PED). Such forecasts are crucial for optimizing appointment scheduling and resource allocation [5]. The study explores the potential of deep learning-driven methods in healthcare, particularly for predicting PED visits [6]. The authors examined seven deep learning models (including DBN, RBM, GRUCNN, LSTM-CNN, GAN-RNN, LSTM, and GRU) and two baseline models (SVR and RR) to forecast patient flow [7]. To prepare the data, multivariate PED visits data from various departments were preprocessed by smoothing and normalization [8]. The deep learning models were then trained on this data to predict daily PED visits at Lille Hospital in France. The results indicate that the DBN model outperformed the others, mainly due to its capacity for learning high-level features through hierarchical training [9]. While the deep learning models showed satisfactory results in patient flow forecasting, there is room for improvement [10]. One direction for enhancement is incorporating external factors like weather data and epidemic events to make the predictions more accurate [11]. Additionally, the study suggests designing an early detection system for overcrowding in Emergency Departments to enable proactive control, reducing the strain on resources and minimizing adverse consequences [12].

Sr No.	Authors	Title	Methods	Limitations
1	Yasser Zeinali and Seyed Taghi Akhavan Niaki [7]	Heart sound classification using signal processing and machine learning algorithms	TD3,FinBer	Complex Implementation, Data Dependency, Resource-Intensive
2	Yang, Liu, Zhong, and Walid [13]	Deep Reinforcement Learning for Automated Stock Trading: An Ensemble Strategy	Actor critic-based algorithms, Proximal Policy Optimization (PPO), Advantage Actor Critic (A2C),DDPG.	Limited period Evaluation, High Complexity, Uses limited data.
3	Vargas dos Anjos, Bichara, Evsukoff	Deep Learning for Stock Market Prediction Using Technical Indicators and Financial News Articles	Deep learning models, CNN, RNN, Technical Indicators	Involves significant data volume; however, historical stock market trends may not always correlate with future behavior.
4	Usha Manjunath,Mudunuri	Commodity and Forex trade automation using Deep Reinforcement Learning	Data collection, Data Pre-processing and Formatting, Training and testing of Agent.	Produce profits in short term only, Less effective in long trends.

Table 1: Comparison with Literature Data.

Declarations

Author Contributions

PMP: Conceptualization, Investigation, Writing-review & editing, Writing-review & editing, Supervision, Validation.

PPS: Conceptualization, Investigation, Writing-original draft, Writing-review & editing, Writing-original draft.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Ethical approval

Not applicable.

Consent to participate

Not applicable.

Consent to publication

Not applicable.

Availability of data and materials

Not applicable.

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