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Application of Machine Learning in Hospital Resource Allocation - A Survey

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Abstract: *One of the greatest challenges of any system is the efficient allocation of resources. During any pandemic, even well organized medical systems face many issues to facilitate patients in an appropriate way. This paper will present the survey for the usage of intelligent technologies in the allocation and management of resources in hospitals. It will conclude with the scope of technologies that can be used during COVID-19 for better hospital resource management.*

Keywords: *Artificial Intelligence (AI), Machine Learning (ML), Hospital Resource Management, COVID-19*

I. INTRODUCTION

As Artificial intelligence is a very hot topic nowadays in today's world that everywhere the world is going through various big technological advancement in terms of machine learning, deep learning, neural networks etc in almost every field day by day with a big hike in datasets Where a million billion bits of data is being created every second with an unexpected sharp growth of computational strength of machine can do unexpected things possible nowadays in today's world and yet more to occur which is enough to give almost everyone whether a person in particular or an Organisation, a very purposeful tool to achieve goals in the healthcare sector.

Machine learning is a branch of artificial intelligence. Its objective is to create an intelligent system that acts as human intelligence by learning from a lot of relevant data. Similarly, we can state that machine learning makes computer able to learn without being explicitly programming.

We need not write a program for any specific task. Only we have to collect experienced data belonging to the problem and apply some classification algorithms to produce the output depending upon the collected data.

Now the healthcare sector is also using these intelligent systems due to the massive amount of information that is impossible for human beings to analyze. Machine learning offers a solution to automatically extract the patterns and reason about data, which may enable healthcare management to use the resources effectively. Machine learning is getting popular day by day in the healthcare sector by helping clinicians, patients and hospital management in varied ways. The most common applications are automatic billing, allocation of beds, the automatic appointment system, diagnosis of disease and many more.

II. LITERATURE SURVEY

The literature survey is including published paper and articles regarding the role of intelligent technologies in the field of hospital resource management. The objective of this section is to present the survey for resource allocation in hospitals for efficient and effective usage of them.

In [1], the authors have a model which is helpful in predicting hospitals and emergency departments' utilization during COVID 19. They also launched a free publicly tool as COVID community vulnerability map which is used to identify populations that are likely to experience severe outcomes requiring hospitalization after exposure to the virus. This tool is also helpful in predicting the socioeconomic and environmental factors which affect patients to higher risk. To make the predictions, a proprietary decision tree methodology was performed. Age group, gender, and race are some socioeconomic features that were used to predict a patient's risk of admission.

The authors debated how artificial intelligence can help in managing human resources. AI may reduce costs in health care, making it faster and more efficient. It is leading a change in the medical profession that will involve more tasks related to creativity and critical thinking than time-consuming repetitions. But they also concluded that AI is not preparing substitutes for medical professional though it may act as assisting tools in health care [2].

In this paper, the authors had investigated the factors that impact on Length of Stay for Federal and Specialty care hospitals in Pennsylvania. They used real data set of 88 hospitals. They used three different machine learning techniques; Classification and Regression Tree (CART), Chi-Square Automatic Interaction Detection (CHAID) and Support Vector Regression (SVR). There is no significant difference in the performances of these three techniques.

However, a decision tree is resulted by CART that is easy to understand and interpret. The length of stay depends upon admission and bed staffed. They observed psychiatric care hospitals have a higher Length of Stay. While there is an increase in admissions in these hospitals, more resources need to be allocated to psychiatric care hospitals due to high LOS. For non-psychiatric care hospitals, LOS depends primarily on beds staffed. For large-size hospitals with beds staffed greater than 329, the expected LOS is about 13 weeks. Whereas, for small-size hospitals with beds staffed equal to 329 or less, the expected LOS is about 3 weeks [3].

The authors developed the COVID-19 Capacity Planning and Analysis System (CPAS), a machine learning-based system for hospital resource planning. They offered CPAS to individual hospitals and across regions in the UK in coordination with NHS Digital. CPAS is designed to serve the need of various groups of stakeholders involved in capacity planning at different levels of geographical and administrative resolution. CPAS models ICU demands on the (a) patient, (b) hospital, (c) regional and (d) national levels [4].

Ankrut and Vageesh Jain discussed opportunities and challenges for using machine learning techniques during COVID'19 in their article. They discussed about Cambridge Adjutorium system which is used to accurately predict the rate of mortality, ICU admission and the need for ventilation in hospitals with COVID-19. There is another ML-based electronic health record system that is used to analyze patient data and assign a severity score for his care [5].

There was another ML-based risk prioritization tool proposed by Fu-Yuan Cheng et al which is used in the identification of patients who need ICU transfer. The model shows the importance of respiratory failure, shock, inflammation, and renal failure in the progression of COVID-19. [6]

In the paper, the authors proposed an Artificial Intelligence-based prediction model for patient inflow for different departments. By using the help of this model, resources may be utilized efficiently. They used multilayer artificial neural network perception for the employment of the proposed model. The results showed that the model may be used for managing other resources like ambulance prediction for scheduling, disease, medical risk assessment prediction for diagnosis and so on [7].

There is a need to manage the ratio between patients and staff to provide quality health services. Overcrowding of patients in hospital waiting room forces them to leave the hospital without taking medical services. It is important to ensure the coordination for all patients to receive the required health care. In this paper, the authors proposed a model for coordinating to find the possible solution to manage the excess patient load. They used deep learning for employing a model that can predict future patient load.

The authors also proposed an approach for using the existing public transport system to support the timely delivery of health services. By using sensors and IoT, they developed a smart kit. These kits can be attached to the public transports which reply to the messages of patients and passengers for their time and location [8].

The data science team of Cedars-Sinai used a machine learning platform for the prediction of staffs. This platform is also being used for tracking the volume of local hospitals and the rate of confirmed cases of COVID-19. This model helps in preparing hospitals for an increasing number of patients suffering from COVID-19 with an 85%-95% degree of accuracy [9].

In this paper, the authors discussed a scoping review on the topic of decision making with the help of artificial neural networks in health care organization. By using this model the author has discussed the prominent integration of methodologies in healthcare delivery to patients for chronic disease management [10].

In this article, authors have discussed preventable methods for medical errors that happen during health care and treatment of patients which causes major injury and even death of patients. With the help of neural network models, authors have discussed identifying harm in clinical care. Authors have demonstrated their method which can remarkably better the performance in identifying harm safety cases over existing methods. With the help of these methods data analysis and reporting process prevent harm to patients' better precise resources to address safety incidents improve general patient care [11].

Authors have discussed in [12] how intelligently machine learning can be used and develop various better healthcare functions for patients effectively. In the paper, authors have also discussed various machine learning techniques like Support vector machine, deep learning, Logistic regression, discriminant analysis, decision tree, random forest, linear regression, naive Bayes, K nearest neighbour, hidden Markov, Genetic algorithm etc and, they did also put light on ethical and social issues related to healthcare privacy with effective balance.

Here in this article, the author's goal is to develop a sustainable model in the field of healthcare. The author had discussed about AI and signal processing driven health intervention fit relevant to global health research like- diagnosis, patient morbidity or mortality risk assessment, disease outbreak prediction, surveillance & health policy and planning in this Model [13].

In this review article, the authors have suggested that no application found in literature provides a comprehensive sustainable framework for strategic decision making. Which use a large amount of data health by various organizations within to inform both systems-wide and local strategic planning and coordination?

Authors have outlined the option for AI decision making which covered in the review in which search term included AI, specific AI component of machine learning, ANN, dimensionality reduction, deep learning, reinforcement learning, pattern recognition, prediction/classification, clustering, Markov decision methods, natural language processing, fuzzy systems/models, multi-agent systems and computational intelligence/prediction, combined with strategy, strategic decision-making, strategic planning and strategic management, and hospital or healthcare or health service organisation [14].

In this published article, authors have suggested the use of machine learning techniques such as naive Bayes, decision tree and logistic regression in association with the early DRG classification and resource allocation task more efficiently as compared to the use of a hospital's current approach using a DRG (Diagnosis~related group) grouper. The authors have pointed towards the need for several streams to be researched further in order to make the discussed model more applicable in hospitals in order to the allocation of hospital resources, through machine learning [15].

In this paper, the authors have used Weka freeware with the J48 classifier for the C4.5 algorithm of machine learning. which used in smart allocation algorithm using the modified C4.5 algorithm where the author has used five major attributes with their sub-attributes in order to do resource allocation for proposing the model that follows as- Picture archiving and communications system (PACS), Laboratory information system (LIS), Nursing information system (NIS), Pharmaceutical management information system (PMIS), Report information system (RIS) [16].

In this paper, the author is suggesting the usefulness of evidence-based prediction rule with increasing health data in today's pandemic time can guide hospital front liners and administrator like hospital staff, nurse, physicians, scientist and engineers helping to make an informed decision in the help of machine learning and artificial intelligence in a pandemic time while looking for thousands of covid-19 patients in terms of clinical healthcare and treatments [17].

III. CONCLUSION AND FUTURE SCOPE

It has been observed that Artificial Intelligence can work very efficiently in term of managing the hospital resources and their allocation better than professionals working in the field of medicine and Healthcare.

It could be concluded that Artificial intelligence making its roots in almost every sector and every field day by day. In today's world, AI is making human life easier like never before and providing services effortlessly and instantaneously. We may expect very important and necessary key roles yet to happen in the field of medicine and Healthcare. Therefore various machine learning, soft computing, deep learning and other techniques may use to propose new models for better hospital resource management.

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