TreatmentFlow – Finding the optimal patient triage system for hospital usage

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ABSTRACT

The average wait times in the Ontario emergency departments are 2.2 hours. Triage is the sorting mechanism that hospitals use to see which patient they need to care for first ensuring patients needing urgent care wait the least for treatment. In Ontario patients are assigned a priority number from 1-5 based on urgency. Triage nursing is known to be one of the most stressful positions a nurse, therefore, to address this we propose *TreatmentFlow* an AI-based algorithm for optimizing the flow of patients through the emergency room. We examine three problems in triage and apply AI techniques including Deep Learning, constrain optimization and Bayesian Networks to solve them.

I. Introduction

In December 2024, the Ontario healthcare system published their average wait time to first assessment by a doctor in the emergency department to be 2.2 hours [1]. This time could however vary based on how urgent the patients' symptoms are. Triage is the sorting mechanism that hospitals use to see which patient they need to care for first. This is determined by their conditions when entering the hospital. This ensures that patients needing urgent care wait the least for treatment. In Ontario patients are assigned a priority number from 1-5 based on urgency; level 1 indicating extremely urgent (resuscitation) to level 5 indicating non-urgent. Triage nurses check vital signs and listen to patients' symptoms and history to assess where they fit on this priority list. This is known to be one of the most stressful positions a nurse can have in the hospital [2]. These days technology has been more common in the hospital to aid with triage and relieve some of this stress on nurses with Artificial intelligence (AI) and machine learning (ML) becoming novel topics for triage. We propose *TreatmentFlow* an AI-based algorithm for optimizing the flow of patients through the emergency room. We examine three problems in triage and apply AI techniques to solve them.

We aim to automate the assignment of patient priority using triage symptom information relieving the pressure of making bad decisions. The method presented to solve this is to use a Deep Learning approach meaning we will use a type of machine learning that uses artificial neural networks to learn from data to be able to solve problems.

We also aim to optimally assigning patients to beds based on patient priority, simplifying the decision-making tasks of the nurses. This is done by minimizing the sum of each bed's total priority squared. The method presented to solve this is using constraint optimization and

constrain satisfaction problem which is a set of objects whose state must satisfy a number of constraints and limitations.

Doctors in the emergency ask for each others opinions to ensure minimizing the risk of misdiagnosis. This is important but can waste time and can sometimes be ineffective, therefore, we propose a solution for is to predict possible diagnoses for a doctor-aimed bedside document to aid in the correct diagnosis for the patient, therefore the doctor can validate their hypothesis ensuring that patients get admitted to the hospital more frequently if needed and discharged if care is not needed. The method presented to solve this is using Bayesian Networks which is a probabilistic graphical model that represents a set of variables and their dependencies.

II. Methodology

Data sets containing patient symptom information were used to train *TreatmentFlow*. *Hospital Triage and Patient History Data* and *SymbiPredict* are the data sets which were found on Kaggle [3] and Mendeley [4] respectively. *Hospital Triage and Patient History Data* is data found in a study of admission and discharge data found at Yale New Haven Health system between March 2014 and July 2017; it contains 972 variables, including patient information and symptoms and about 50,000 rows of patients. This data was cleaned and processed by reducing the size of the file from 103.45 MB to 19.8 MB by converting the rdata file into a csv file and only taking every 75^{th} row. The *SymbiPredict* file is a csv file containing almost 5,000 rows of symptoms and the given prognosis. This file was not processed and did not need to be cleaned since it is only 1.32 MB and already in the csv format.

A. Constraint Satisfaction

The Constraint Satisfaction portion of *TreatmentFlow* is an optimization-based hospital bed assignment based on incoming patients and available resources.

To manage patient assignments efficiently, the system will sort the list of patients by arrival time, potentially maintaining a running list that updates as new patients arrive. If multiple patients share the same arrival time, they will be sorted by priority. Beds will be assigned using a greedy method, where the next available bed is allocated to the next highest priority patient. This approach requires maintaining a running list of patients waiting to be served. If a new patient arrives with a higher priority than those currently waiting, they will be assigned a bed first. However, this method poses a potential issue of low-priority patients experiencing starvation, as they may be continually bypassed by higher-priority arrivals.

python -m pip install ortools

pip install pandas pyreadr

B. Deep Learning

Deep Learning-based patient priority assignment through an automated triage system
pip install pandas

python -m pip install -U pip

python -m pip install -U matplotlib

pip install -U scikit-learn

pip install sklearn

C. Bayesian Networks

Bayesian Network-based diagnostic tools to produce bedside documents for doctors only, which display the probabilities of certain conditions based on symptom inputs

III. Results

Tables and figures (graphs)

IV. Discussion

V. Conclusion

A. Constraint Satisfaction

B. Deep Learning

C. Bayesian Networks

References

[1] https://www.hqontario.ca/System-Performance/Time-Spent-in-Emergency-Departments?utm_source=Ontario.ca&utm_medium=Referral&utm_campaign=WT%20Referral

[2] https://thedailyscan.providencehealthcare.org/2018/11/emergency-room-triage-how-does-it-work/

[3] https://www.kaggle.com/datasets/maalona/hospital-triage-and-patient-history-data

[4] mendeley