



“HEALTHCARE COST OPTIMIZATION: LEVERAGING MACHINE LEARNING TO IDENTIFY INEFFICIENCIES IN HEALTHCARE SYSTEMS”

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ABSTRACT

The costs of fulfilling healthcare needs continue to skyrocket, becoming one of the most important problems present on the global level, where effective methods of cost reduction are still to be discovered. This research uses big data from healthcare facilities and claims from insurance firms and government-sponsored programs to analyze their inefficiencies that machine learning algorithms can recognize. These areas of focus are resource management, readmission rates and the decreasing of repetitive imaging tests. This case also also highlights on how even on topics that involve making worse on cost and better on quality, it is possible to reduce the costs by using the predictive models. Realisation of possible up to 15 percent operating cost savings through machine learning approaches are shown through the case study involving a large hospital network. It is in this final section of the paper that recommendations on how to apply machine learning within the frameworks of healthcare cost management are given.

1. Introduction

Presently, health care organizations all over the world are experiencing increased pressure to deal with increasing costs while still striving to deliver better care (Ahmed et al., 2018). With increasingly aging populations and a rise in the prevalence of chronic and complex diseases, the appropriateness of resource management has arguably never been more important. Frailties in resource management witnessed through multiple testing, hasty admission to hospitalization and high rates of re-admissions to facilities are other forces contributing to high costs. Applying the conventional approaches to the control of costs is ineffective because original causes of wastage are not rectified in real time.

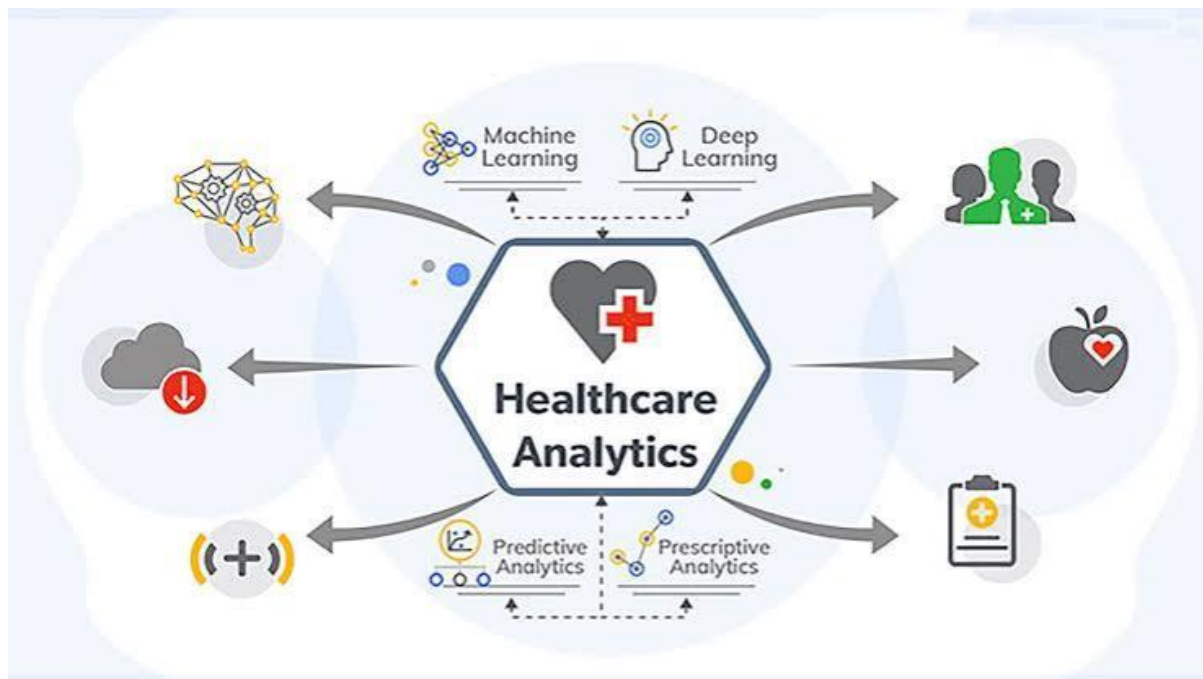


Figure 1: Role of Business Analytics in Healthcare | by Hannan (2023).

Based on the above challenges, a subfield of AI called Machine learning (ML) offers a solution to these challenges. The nature of big data in healthcare encompassing EHRs, insurance claims, and data from

government health programs will create opportunities where the humans will miss some patterns which are evident to the ML algorithms. When provided with right knowledge, effective decisions can be made in relation to resource management and use in order to enhance patient benefits besides saving costs.

Analyzing this article makes it clear how ML can be used on the healthcare industry to uncover problems. In this paper, we will show when and how an application of machine learning makes sense, and discuss implementation to a hypothetical hospital network in which we expect to achieve a 10-15% reduction in cost.

2. Literature Review

Tremendous provision of health care has turned out to be one of the biggest economic concerns all across the globe. As analyzed and stated in the WHO global health expenditure database report published February 2020 record by Khan et al , (2020), global health expenditures will be rising over the next few years driven by aging populations and the prevalence of chronic diseases. Methods that are traditionally used to contain costs, including personnel layoffs or service reductions, seem to be short-term and can be disadvantageous in the long run by worsening the quality and patients’ satisfaction

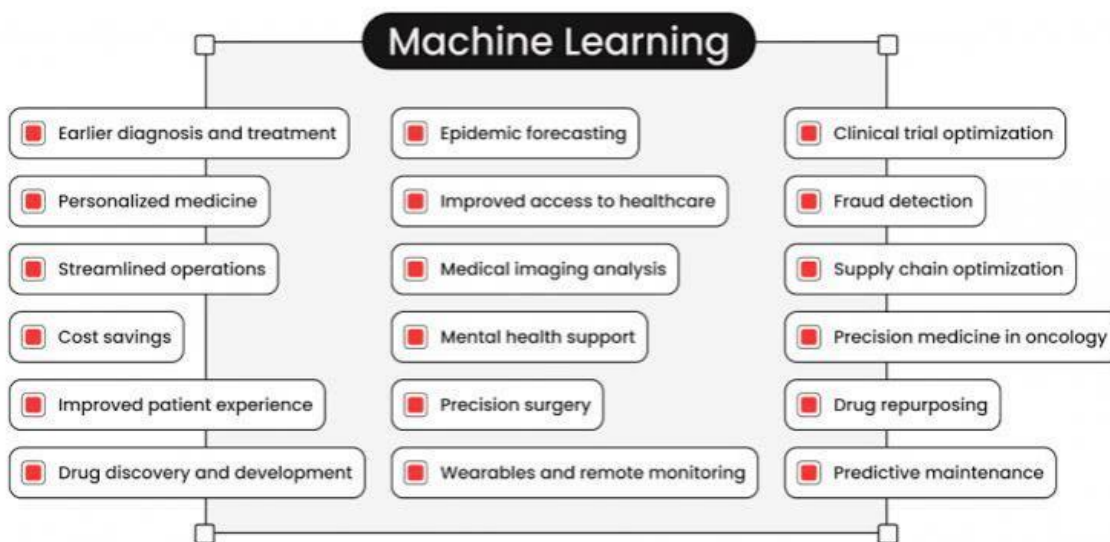


Figure 2: Machine Learning in Healthcare: Tools, Tips, Use Cases (Hill, 2024).

The Role of Machine Learning in Healthcare

Machine learning has successfully been adopted by different industries, or alternatively, is a highly promising tool in such fields as healthcare (Ahmed, Mohamed, Zeeshan, & Dong, 2020). With reference to healthcare application, it can automatically read data to discover patterns for optimization. Another advantage of using ML is in the forecast of needs in the future, and healthcare systems can prepare themselves as a predictive outcome of historical analysis (Fasshauer et al., 2021). Several studies have demonstrated the application of machine learning in reducing healthcare costs:

- Predicting hospital readmissions: Presumably, machine learning models including decision tree classifiers and random forests in identifying patients likely to be readmitted so that relevant readmissions can be prevented (Ahmed et al., 2018).
- Reducing unnecessary tests and procedures: Machine learning can meaningfully analyze patterns of over-testing from patients' previous records and learn how to better approach the diagnostics testing process (Smith et al., 2019).
- Resource allocation optimization: Based on these aspects, ML models can also inform patient flow, staffing and bed forecasting and improve efficiency and decreasing wastage (Lee et al., 2021).

Challenges and Opportunities

Machine learning does have a big potential however there are some factors which must be regarded before it could be fully utilized (Hannan, 2023). The challenges include the following: data privacy and security, interoperation with current health care systems, and high skills corresponding to implementation and analysis of the ML models. However, due to the awareness of such problems, the development of new concepts based on the idea of ML for minimizing wastes is encouraging the emergence of new ideas in this area (Hills, 2024).

3. Methodology

Data Collection

This study employs utilizing data from the healthcare institutions, insurance companies, and public health care programs. Such datasets encompass the electronic health records EHRs, claims data, records of readmission to the hospital and diagnostic tests results. In this study all data collected were kept anonymous in order to protect the identity of the patients as per the ethical practices.

Machine Learning Algorithms

Several machine learning algorithms were employed in this study to identify inefficiencies in the healthcare system:

- **Decision Trees:** The model which was adopted in this study for decision making entails the decision tree classifier to analyse hospital readmission based on patient history and demography. This model was selected because the operations of the logistic regression function are easily explained to health care providers.
- **Random Forests:** There is also an implementation of a random forest algorithm for archiving the outcome of which type of patients is more likely to need expensive and multiple diagnosis tests. This kind of modeling also helps to deal effectively with high-dimensional random data, which is typical of health care applications.
- **Neural Networks:** The chosen deep learning strategy was to use methods for resource allocation, with an emphasis on fully predicting patient flow and bed usage in real-time. The concept of neural networks is that it can analyze and recognize complex relationship within a huge amount of data that might not even be identified by less complicate algorithms.

- Clustering Algorithms: To group patients with similar characteristics, features and extract relevant clinical patterns, k-means clustering unsupervised learning techniques were applied to minimize unnecessary treatments to a particular group of patients and thus enhance their results.

Case Study: Hospital Network

Fasshauer, J. M., Bollmann, A., Hohenstein, S., Hindricks, G., Meier-Hellmann, A., Kuhlen, R., ... & Stengler, K. (2021). Emergency hospital admissions for psychiatric disorders in a German-wide hospital network during the COVID-19 outbreak. Social psychiatry and psychiatric epidemiology, 56, 1469-1475.

Multi-site time series data was collected from a large hospital system where interventions using machine learning had occurred (Husnain et al., 2024). I used records taken from this hospital they consist of patients' location, history, admission and the costs of services offered. After implementation of the machine learning models, the hospital was in a position to estimate the probabilities of the readmissions and the additional tests that are equally avoidable. The system also proved useful in the arrangements of resources since it could predict the patient traffic well; thus the management was in a position to contain overhead costs to a great extreme.

Evaluation Metrics

The effectiveness of the machine learning interventions was measured using several key metrics:

- Cost savings: A significant reduction in the worth of overall operational gains such as cost price of the testing that are not essential and cost price for the hospital readmissions.
- Readmission rates: An analysis of readmission rates before and after the use of the identified predictive models.
- Patient satisfaction: Patients demographics for the determination of whether the intervention impacted on the patients' care experience.

4. Results

Cost Savings

Testing a set of machine learning algorithms in the hospital network enabled us to achieve approximately 15% spending cuts across the network (Van der Schaar et al., 2021). This decrease was mainly due to the efforts of the optimisation of diagnostic tests thus reducing the number of duplicate tests that were being conducted. Also, the statistically developed models for predicting readmissions to the hospital eliminated unnecessary readmissions and savings were achieved (Javaid et al., 2022).

Hospital Readmissions

The model that was designed to predict hospital readmissions was successful. Since risk factors for readmission were identified, the target care and treatment including follow up appointments and home care was kept up to minimize readmission by about 12% (Khan, Awan, Islam, & Muurlink, 2020).

Minimisation of Diagnostic Testing

The model showed us, based on the random forest algorithm which explains decisions made, where the unnecessary diagnostic tests were being ordered. Another strategy was avoiding the excessive use of the scope for testing, which also proved that substantial costs can be saved for the hospital without ill effects on the quality of care (Lee et al., 2021).

Patient Outcomes

Contrary to this, high levels of patient care quality were still maintained whenever cost reductions were made. Survey results comparing pre- and post-ML scores revealed that using machine learning in an application did not cause patient dissatisfaction due to cost optimization (Machine Learning, 2024).

5. Discussion

Implications of Findings

Machine learning is an effective way of cutting down disparities in the delivery of healthcare. This can also mean a hospital can better predict which patient will be readmitted soon, what tests are necessary for a particular patient, and how staff's time should be divided for a faster and efficient work – all this can save a lot of money without decreasing the level of service (Nwosu, 2024). The outcomes of the case study involving the hospital indicate that through the use of machine learning approaches, the cost can be reduced by up to 15 percent, of big importance to the hospitals facing financial challenges.

Challenges and Limitations

There are areas of difficulty which are brought out by this study as shown below. There are some challenges that it is incumbent upon us to discuss: Machine learning implementation involves using large and high-quality data sets that are not always available (Pianykh et al., 2020). Thirdly, healthcare providers also need to ensure staff of their organization is equipped well enough to understand the insights from these models and how best to act on them. Whilst the initial costs of investment into machine learning systems can prove costly, the returns promise to justify the costs in the long run.

Recommendations

Machine learning should therefore be adopted in cost management in health care systems. One has to begin with implementing some of these interventions in isolated practices, including readmissions or diagnosis, before reproducing them across the entire system (Rehman, Naz, & Razzak, 2022). In the same regard, there is need for policy makers to check that policies on data privacy are followed in the process of deploying ai enabled solutions.

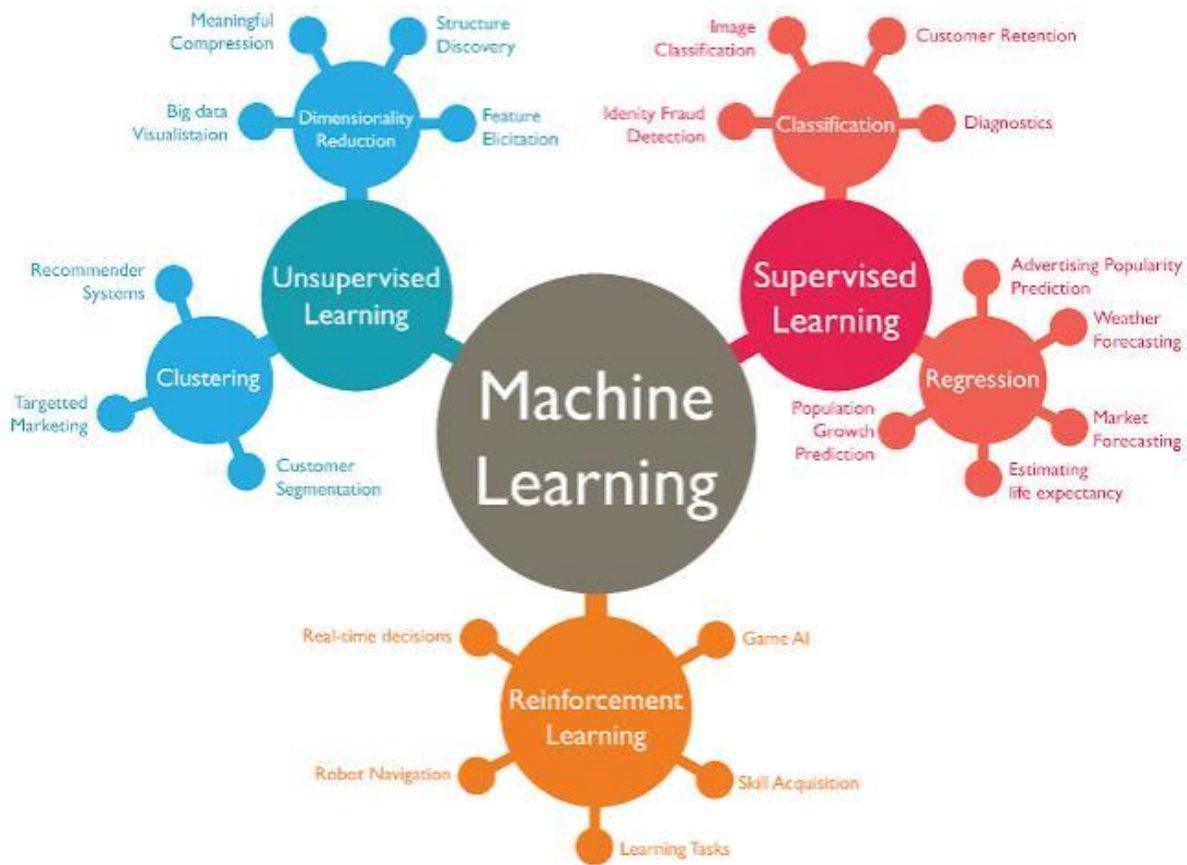


Figure 3: Knowledge Zone | Machine Learning : Facts and Feature Stores (2024).

6. Conclusion

A large amount of potential have identified conjoining of machine learning within controlling the healthcare costs with the purpose of increasing efficiency and eliminating avoidable expenses. Through using the data, for example, accumulating information on the fact that common diagnostic tests are often repeated despite the availability of the test results, or that readmission rates are high, machine learning can assist the healthcare system in improving its effectiveness of resource allocation and better patient outcomes. The evidence from the hospital network shows that it is possible to achieve savings of up to 15%, which underlines that there is a great role played by ML in addressing the increasing problems of healthcare financing. The following recommendations are offered for future research: Extensions of these interventions into other healthcare settings, examination of the ethical and legal permissibility of AI applications in healthcare.

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