Exploring the Use of Artificial Intelligence Aspects within the Framework of Cardiology

Artificial intelligence in Cardiology and the Influence of Stakeholders

A Thesis Prospectus

In STS 4500

Presented to

The Faculty of the

School of Engineering and Applied Science

University of Virginia

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science in Computer Science

By

Natalie Nieves

October 27, 2023

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

ADVISORS

Rider Foley, Department of Engineering and Society

Rosanna Vrugtman, Department of Computer Science

INTRODUCTION

The field of cardiovascular diseases is at the forefront of revolutionary advancements in healthcare. As we deal with the challenges of providing effective, accessible, and precise healthcare, artificial intelligence (AI) emerges as a transformative force with the potential to reshape how we diagnose and treat diseases.

Consider the alarming prevalence of cardiovascular diseases. Heart disease, for instance, is the leading cause of death for men, women, and people of most racial and ethnic groups in the United States with one person dying every 33 seconds in the United States from cardiovascular disease (CDC, 2023). The health field has faced challenges with decreasing the amount of cardiovascular related deaths in the United States. Additionally, as seen in Figure 1, there are numerous “missed opportunities to improve cardiovascular care and to avoid unnecessary costs in 6 major categories: risk factor modifications, patient engagement and involvement, correct diagnosis, adherence and proper use of first-line treatments, proper use of advanced treatments, and better use of supportive services” (McClellan et al., 2019). The adoption of AI in cardiology holds significant promise, addressing critical challenges and contributing to the overarching goal of enhancing the quality of life for patients. This thesis prospectus delves into the application of AI in the realm of cardiology and its implications for stakeholders. The primary objective is to explore the technical aspects of machine learning within the context of healthcare and its specific relevance to cardiovascular diseases.

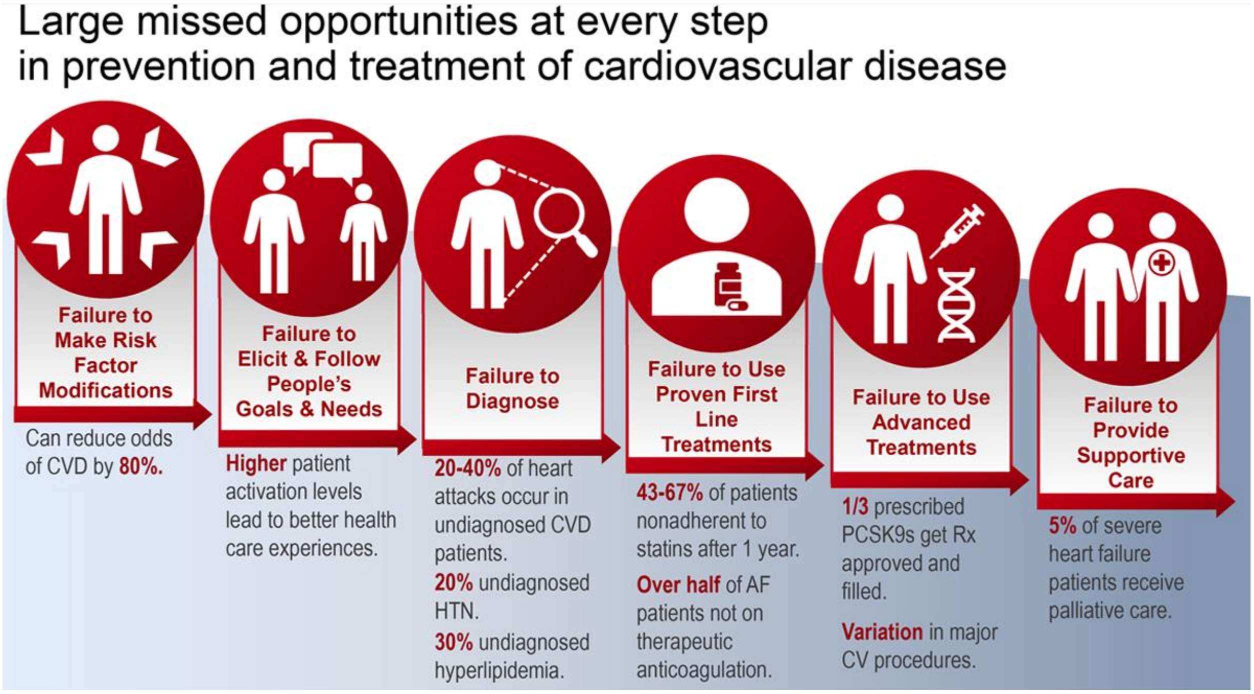

Figure 1: Cardiovascular care challenges waterfall showing the challenges at each stage of the disease continuum (Source: (McClellan et al., 2019)

ANALYSIS OF MACHINE LEARNING TECHNIQUES IN CARDIOLOGY

Artificial intelligence (AI) arises as a viable solution to combatting the current healthcare challenges in the cardiovascular field. To gain a comprehensive understanding of AI's potential to help achieve these goals, it's essential to explore the technical aspects of this technology and relate these aspects within the context of healthcare and cardiology. While AI is composed of various technologies, this paper's focus is on exploring the application of machine learning techniques for the identification and treatment of cardiovascular diseases.

Machine learning uses data to learn, predict, and make decisions. In the context of healthcare, machine learning "predict[s] what treatment protocols are likely to succeed on a patient based on various patient attributes and the treatment context" (Davenport & Kalakota, 2019). To facilitate this process, the technology uses supervised learning and unsupervised. learning to "teach computers to analyze vast datasets in a quick, accurate, and efficient way" (Romiti et al., 2020). Supervised learning "uses human labelled datasets, generally used to develop models that predict or classify future events or find the most relevant variables to the outcome” (Romiti et al., 2020). Unsupervised learning is used “to identify novel disease mechanisms, genotypes, or phenotypes from hidden patterns present in the data” (Krittanawong 2017).

Additionally, Machine learning offers a strong foundation for the analysis of extensive datasets in the cardiology domain. It “has shown significant promise over regression approaches in predicting CVD risk, incidence, and outcomes because of its improved flexibility and fewer assumptions” (Sun et al., 2023). In a case study done by Manish Motwani, Damini Dey, etc., they show how they used supervised learning techniques to “investigate the predictive ability of machine learning algorithms on structured data to predict 5-year mortality in a large population of 10030 patients with coronary artery disease in the Coronary CT Angiography Evaluation for Clinical Outcome (CONFIRM) study” (Kagiyama et al., 2019). First, they gathered patient information to “train the machine learning algorithm to predict mortality in each training set and tested the predictive ability using each validation set” (Kagiyama et al., 2019). Then they used a method called k-fold cross-validation, where “data is first partitioned into k equally (or nearly equally) sized segments or folds. Subsequently k iterations of training and validation are performed such that within each iteration a different fold of the data is held-out for validation while the remaining $k-1$ folds are used for learning” (Refaeilzadeh et al., 2009). After using this method to validate the accuracy of the machine learning algorithm, they concluded that “that the area under the receiver-operating-characteristic curves for prediction of 5-year mortality was significantly better with the machine learning algorithm (0.79) than other traditional risk scores (0.61–0.64)” (Kagiyama et al., 2019).

In a case study conducted at the National University of Sciences and Technology by Rao Liaqat and more, they used the method K-means, which is an unsupervised learning technique, to "find out the hidden cluster and pattern for heart patients" (Liagat, 2016). To facilitate this methodology, they first gathered data that was provided by the Armed Force Institute of Cardiology and selected specific attributes that are more likely to reveal hidden patterns and relationships within that data. Next, the data was then preprocessed to make it more compatible with the machine learning algorithm (Liagat, 2016). Then, the data was transformed, getting rid of useless or unimportant information, and then analyzed to discover hidden correlations within the data, using assumptions, such as universal standards, for better understanding and visualization of results (Liagat, 2016). This study successfully revealed the hidden patterns of cardiac patient information to factors such as age, BMI, LV-Myocardium, and LVEF.

The machine learning techniques, K-means (unsupervised learning) and k-fold validation (supervised learning) present significant promise to changing the field of cardiology for the better. Through predictive analysis, these methods have provided more accurate risk assessment and outcomes for cardiac patients. These two different case studies have shown to have a better accuracy and performance rate compared to some traditional approaches, providing better insights for healthcare practitioners to allow for more accurate diagnosis. Using machine learning techniques allows us to provide better quality of care for patients and address the challenges that are faced in the cardiology field today.

In "Application of Artificial Intelligence-Based Technologies in the Healthcare Industry: Opportunities and Challenges," the authors claim that although these technologies are great in detecting diseases, there are challenges contradicting its validity. They emphasize that AI may have trouble detecting different diseases even if it can detect one accurately. They stress that this is why AI is not a permanent replacement for healthcare professionals but more of a way to gain a different perspective and opinion on the diagnosis at hand (Lee & Yoon, 2021). Overall, while the technical aspects of AI in healthcare provide us with better accuracy and diagnosis in cardiovascular healthcare, this does not take away the significance of stakeholders and their role within the use of AI in cardiovascular health.

INVESTIGATING STS FRAMEWORKS IN CARDIOLOGY

Stakeholders play a crucial role in shaping patient care, AI technologies, and medical research. The stakeholders that affect the way that AI is used in cardiovascular healthcare include patients, doctors, AI developers, policies/laws, and values/ethics. An approach to exploring the how these stakeholders contribute to the shaping of AI in the cardiovascular field is by applying the framework presented in Pinch and Bijker's, "The Social Construction of Facts and Artifacts." Pinch and Bijker advocate for the Social Construction of Technology (SCOT) approach, which emphasizes that "It is people, not machines, that design, build, and give meaning to technologies and ultimately decide which ones to adopt and which ones to reject" (Pinch & Bijker, 1984, pp.107). In alignment with the SCOT approach, Latour emphasizes the Actor-Network theory in "Where Are the Missing Masses? The Sociology of a Few Mundane Artifacts," where "sociotechnical systems are developed through negotiations between people, institutions, and organizations" (Latour, 1992).

These frameworks highlight the relationship between stakeholders and AI, as AI is shaped by human values, perspectives, and social structures. Furthermore, AI development is shaped by human values and norms, which can yield both positive effects and negative effects. Since AI developers design and train these AI algorithms, the data that is provided to it significantly influences the patterns and biases within the AI algorithms. This is the reason why the authors of "Toward a Sociology of Artificial Intelligence" stress that one should critically examine the elements involved in shaping AI sociotechnical systems to lessen the inherent inequalities within these systems (Joyce et al., 2021). This is because AI practitioners often lack a sufficiently critical perspective when considering these elements. In Winter and Carusi's work, they emphasize the importance of involving all stakeholders at the beginning of the development process. (Winter & Carusi., 2022). This not only considers multiple perspectives in the development process but also helps build trust to help the relationship between technology and the workers to lessen their uncertainties. A solution provided by Makarius, et al. is to facilitate and analyze an assessment of uncertainty and "pre-entry knowledge" and use that to create a plan to integrate AI into their environment to help build this trust (Makarius et al., 2020).

In addition, it is the responsibility of humans to consider ethical principles when developing these algorithms to ensure that individuals have the right to provide consent for the use of their data, as well as guaranteeing a right to their privacy. Health data is the most private information about oneself whilst being the most valuable resource to improving wellbeing, defeating diseases, and supporting the elderly, those with disabilities and in social care (Bartoletti, 2019). Having this data compromised can lessen the trust that both patients and healthcare workers have towards AI, potentially leading to a rough adoption of AI in healthcare. In "The practical implementation of artificial intelligence technologies in medicine," the authors stress that privacy may need to be completely reimagined, as well as an increase in demand for cybersecurity protocols to reduce the risk of inaccurate data or the hacking to obtain patient Information. (He et al., 2019). Completely reimagining privacy will provide a viable solution to tackling privacy concerns because then there could be regulations put in place that also account for the use of AI in these healthcare fields.

Overall, AI’s role in cardiovascular healthcare is not just driven by the technology itself. but is guided by human knowledge and ethical considerations and is used as a viable tool to help treat and diagnose patients. However, humans make the final decision as they have the capacity to empathize and use their judgement based on circumstances that AI may not be able to understand. In addition, “AI is ready to support healthcare personnel with a variety of tasks from administrative workflow to clinical documentation and patient outreach as well as specialized support such as in image analysis, medical device automation, and patient monitoring” (Bohr & Memarzadeh., 2020).). It is important to note that AI and healthcare workers should have a mutual beneficial relationship, where one does not replace the other. Utilizing STS frameworks, such as SCOT and Latour’s perspective, can aid in understanding the relationship between the stakeholders and “non-human entities” in AI’s transition within the field of cardiology. These frameworks highlight the role of AI and its technical aspects, further emphasizing the impact that they have in society.

RESEARCH PROPOSAL: LONG-TERM MONITORING OF AI USE IN CARDIOLOGY

A research question that is proposed is: How can AI monitor patients with cardiovascular diseases to detect changes and improve disease management? The practice of long-term monitoring can provide many benefits such as providing early detection, generating prevention measures, and creating treatments that are specific patient-to-patient, and ultimately aiding in better quality care for patients.

To provide an analysis of this research question, the first step would be to evaluate previous studies and academic literature to gather existing research on the long-term use of AI in the field of cardiology. Literature review is important because “helps any researcher “join the conversation” by providing context, informing methodology, identifying innovation, minimizing duplicative research, and ensuring that professional standards are met" (Maggio et al., 2016). Then the use of it can be used to understand the current state of AI technologies in the field of cardiology. Additionally, the next step would be to facilitate a case study where data will be taken from cardiovascular patients who are already using AI technologies for long-term monitoring. This would help provide a wide range of data that comes from the real world. With the data received from both the literature review and case study, the data can then be interpreted by identifying certain patterns or correlations within the dataset to offer an insight at the effectiveness of long-term monitoring in relation to early disease detection, treatment effectiveness and accuracy, and prevention.

The intended research aims to address the long-term monitoring of cardiovascular diseases using AI. Through a structured approach, the incorporation of literature review and case studies within data analysis can contribute to providing more research on AI in the use of cardiovascular healthcare and its impact on disease management.

CONCLUSION

The incorporation of Artificial Intelligence in cardiology offers a viable solution to addressing the current problems in the field of cardiology in modern day healthcare. Utilizing machine learning techniques, such as supervised learning and unsupervised learning, provide the potential to improve diagnosis, treatment, and early detection. These technological advancements aid in the overall goal of proving effective and accurate treatment as well as a better quality of life for people who suffer with long-term cardiovascular diseases. In conclusion, this paper aims to not only provide insight on the adaptation of AI in the field of cardiology but provide an approach to understanding the significance that stakeholders have in the development and integration of AI in cardiology.

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