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Machine Learning and Artificial Intelligence Models for Predicting Coronary Artery Disease Risk: Comparative Analysis of Performance and Interpretability

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Abstract

Coronary artery disease remains a leading cause of morbidity and mortality worldwide. With the rapid advancement of machine learning and artificial intelligence techniques, there has been an increasing interest in using these methods for CAD risk prediction. This study aims to provide a comprehensive comparative analysis of various ML and AI models for predicting CAD risk, considering both their performance and interpretability. A diverse dataset containing clinical, demographic, and diagnostic features was used to train and evaluate the models. The models' performance was assessed using standard evaluation metrics, including accuracy, precision, recall, F1-score, and area under the receiver operating characteristic curve. Additionally, model interpretability was evaluated using techniques such as feature importance analysis and SHAP (SHapley Additive exPlanations). Our findings indicate that while some complex models achieve higher predictive performance, simpler models also demonstrate competitive accuracy while maintaining higher interpretability. The trade-off between performance and interpretability is crucial, as interpretable models can offer valuable insights into the factors driving CAD risk. The study underscores the need to strike a balance between model complexity and clinical interpretability in CAD risk prediction applications.

Keywords: Coronary heart disease • Machine learning • Artificial intelligence

Introduction

Coronary artery disease remains a significant global health concern, leading to substantial morbidity and mortality rates. Early identification of individuals at high risk for CAD can facilitate timely intervention and personalized treatment strategies. Traditional risk assessment methods often rely on clinical risk factors and scoring systems. However, the advent of machine learning and artificial intelligence has opened up new avenues for improving CAD risk prediction by leveraging complex patterns and interactions within the data. A diverse dataset comprising clinical, demographic, and diagnostic information of patients was collected from multiple medical centers. The dataset included features such as age, sex, cholesterol levels, blood pressure, family history, and ECG results.

Data preprocessing involved handling missing values, normalizing numerical features, and encoding categorical variables. Feature selection techniques were also applied to reduce dimensionality and improve model generalization. A variety of ML and AI models were considered, ranging from simple models such as logistic regression and decision trees to more complex models like random forests, support vector machines, and neural networks. These models were chosen to represent a spectrum of complexity and interpretability. The models were evaluated using standard metrics including accuracy, precision, recall, F1-score, and the area under the receiver operating characteristic curve. These metrics provide a comprehensive view of the models' predictive capabilities. The study utilized a diverse dataset encompassing clinical, demographic, and diagnostic information of patients from multiple medical centers. The primary objective was to compare the performance and interpretability of various machine learning and artificial intelligence models in predicting CAD risk. This comparison is crucial as it addresses the dual challenge of achieving accurate predictions while maintaining the ability to understand and explain the factors contributing to these predictions [1-3].

Literature Review

The research methodology included rigorous data preprocessing to handle missing values, normalize features, and encode categorical variables. A selection of models, spanning from simple algorithms like logistic regression and decision trees to more complex ones like neural networks and support vector machines, were chosen to represent a spectrum of model complexity. The models were trained, validated, and evaluated using established performance metrics including accuracy, precision, recall, F1-score, and the area under the receiver operating characteristic curve.

Furthermore, the study delved into the critical aspect of interpretability, a topic gaining significant attention in the AI and medical communities. Techniques such as feature importance analysis and SHAP (SHapley Additive exPlanations) were employed to provide insights into the models' decision-making process. By identifying influential features and attributing predictions to individual features, the study assessed the extent to which each model's predictions could be understood by clinicians and healthcare professionals.

Discussion

The results of the comparative analysis showcased a trade-off between the complexity of models and their interpretability. While complex models demonstrated higher predictive accuracy, they were often less transparent, hindering their clinical application. Simpler models, on the other hand, exhibited competitive predictive performance while offering enhanced interpretability. This balance between predictive accuracy and interpretability is pivotal, as CAD risk prediction involves making actionable clinical decisions based on insights provided by the models [4,5].

The comparative analysis revealed a trade-off between model complexity and interpretability. Complex models like neural networks achieved high predictive performance, as evidenced by high AUC-ROC scores. However,

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these models lacked transparency, making it challenging to extract meaningful insights for clinical decision-making. Simpler models such as logistic regression and decision trees demonstrated competitive predictive accuracy while offering greater interpretability through feature importance analysis and SHAP values. The results highlight the importance of considering both performance and interpretability when selecting models for CAD risk prediction. While advanced ML and AI models can yield impressive predictive accuracy, their black-box nature limits their clinical utility. Interpretable models allow clinicians to understand the factors contributing to risk predictions, enabling better-informed decisions [6].

Conclusion

In the context of CAD risk prediction, striking a balance between predictive performance and interpretability is crucial. Clinically interpretable models provide insights into the underlying drivers of CAD risk, aiding medical professionals in making informed decisions. Future research should focus on developing hybrid models that combine the strengths of complex models with interpretability, ensuring effective CAD risk prediction and actionable insights.

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Conflict of Interest

Authors declare no conflict of interest.

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