A Machine Learning Model for Real-Time Prediction of Patient Deterioration in ICUs

Background of the Invention:

[001]   Patient deterioration in intensive care units (ICUs) is a critical issue that requires continuous monitoring and timely intervention. Traditional methods of patient monitoring rely on manual assessments and periodic vital sign checks, which may delay the detection of deterioration. Early warning scores (EWS) have been developed to assist clinicians, but these methods often lack real-time predictive capabilities. Machine learning (ML) has shown promise in healthcare applications by leveraging vast amounts of patient data for predictive analytics. Integrating ML models into ICU settings can enhance early detection and improve patient outcomes.

[002]   Conventional approaches to ICU monitoring involve rule-based systems that depend on predefined thresholds for vital signs such as heart rate, blood pressure, and oxygen saturation. However, these approaches do not account for the complex interplay between multiple physiological parameters. The inability to capture nonlinear patterns in patient data results in high false-positive and false-negative rates. As a result, there is a growing need for advanced ML-driven solutions that can provide accurate and timely predictions of patient deterioration.

[003]   Recent advancements in artificial intelligence (AI) and deep learning have enabled the development of sophisticated models capable of analyzing real-time ICU data. These models utilize continuous streams of vital sign measurements, laboratory results, and clinical notes to detect early signs of deterioration. However, existing solutions often face challenges related to data integration, model interpretability, and real-world implementation. Addressing these challenges is crucial for developing a robust and reliable ML-based ICU monitoring system.

[004]   The implementation of ML models in ICUs necessitates seamless integration with electronic health records (EHRs) and real-time monitoring systems. Challenges such as

data preprocessing, feature selection, and model calibration must be carefully addressed to ensure high predictive accuracy. Additionally, ethical considerations, including patient privacy and data security, must be prioritized when deploying ML solutions in critical care environments.

[005] To overcome these limitations, this invention proposes a novel ML-based framework for real-time prediction of patient deterioration in ICUs. By leveraging advanced deep learning techniques, this framework aims to provide accurate and timely alerts to clinicians, thereby reducing the risk of adverse events and improving patient care outcomes.

Field of the Invention:

[006] The present invention relates to the field of healthcare technology and artificial intelligence. More specifically, it pertains to the development and implementation of a machine learning model for real-time prediction of patient deterioration in intensive care units (ICUs).

Background Technology of the Invention:

[007] Machine learning has emerged as a transformative technology in healthcare, enabling predictive analytics for early disease detection and prognosis. In critical care settings, real-time prediction of patient deterioration is essential for timely intervention and improved patient outcomes. Traditional monitoring systems rely on manually calculated early warning scores, which are often reactive rather than proactive.

[008] Recent developments in ML have led to the creation of predictive models that analyze large datasets from ICU patients, including continuous vital sign monitoring, laboratory results, and clinical notes. These models use techniques such as logistic regression, support vector machines (SVMs), and deep learning to identify high-risk patients. However, many existing models lack real-time processing capabilities, limiting their effectiveness in critical care settings.

[009] Deep learning techniques, such as recurrent neural networks (RNNs) and convolutional neural networks (CNNs), have been applied to ICU data analysis. These models can identify complex temporal patterns in patient data, leading to more accurate predictions. However, challenges related to data preprocessing, missing values, and model interpretability remain significant obstacles to widespread adoption.

[010] Integrating ML models with EHR systems has shown promise in improving patient monitoring and reducing clinical workload. However, the effectiveness of these models depends on the quality of input data and the ability to generalize across diverse patient populations. Addressing these challenges requires a comprehensive framework that incorporates advanced ML techniques and robust validation methodologies.

[011] This invention aims to bridge the gap between theoretical ML models and practical ICU applications. By designing a real-time predictive framework with high accuracy and interpretability, this invention seeks to enhance clinical decision-making and improve patient outcomes in critical care settings.

Summary of the Invention:

[012] The present invention proposes a machine learning-based framework for real-time prediction of patient deterioration in ICUs. The framework integrates real-time monitoring data, including vital signs, laboratory test results, and clinical notes, to provide accurate risk assessments. By utilizing advanced deep learning techniques, the model continuously learns from patient data to improve prediction accuracy. The invention ensures seamless integration with existing ICU monitoring systems and EHRs, offering timely alerts to healthcare professionals.

Objectives of the Invention:

1. To develop a machine learning model capable of real-time prediction of patient deterioration in ICUs.
2. To integrate the model with ICU monitoring systems and EHRs for seamless data processing.

3. To enhance prediction accuracy using deep learning techniques such as recurrent neural networks (RNNs) and convolutional neural networks (CNNs).
4. To ensure model interpretability and usability for healthcare professionals.
5. To improve patient outcomes by enabling timely intervention and reducing adverse events in ICUs.

Detailed Description of the Invention:

The invention comprises a machine learning model designed to predict patient deterioration in ICUs in real time. The model utilizes continuous vital sign monitoring data, laboratory test results, and clinical notes. It employs deep learning techniques, such as RNNs and CNNs, to analyze complex temporal patterns and generate risk scores for individual patients.

The model is trained on a large dataset of ICU patients, using feature engineering techniques to optimize predictive performance. The system continuously updates its predictions based on new patient data, ensuring real-time adaptability. The invention integrates with ICU monitoring systems through secure APIs, facilitating seamless data exchange and clinical implementation.

To enhance model interpretability, the invention incorporates attention mechanisms and explainable AI techniques. This ensures that healthcare professionals can understand the basis of predictions and make informed clinical decisions. The system is designed to comply with healthcare data privacy regulations, ensuring secure and ethical deployment.

Drawings
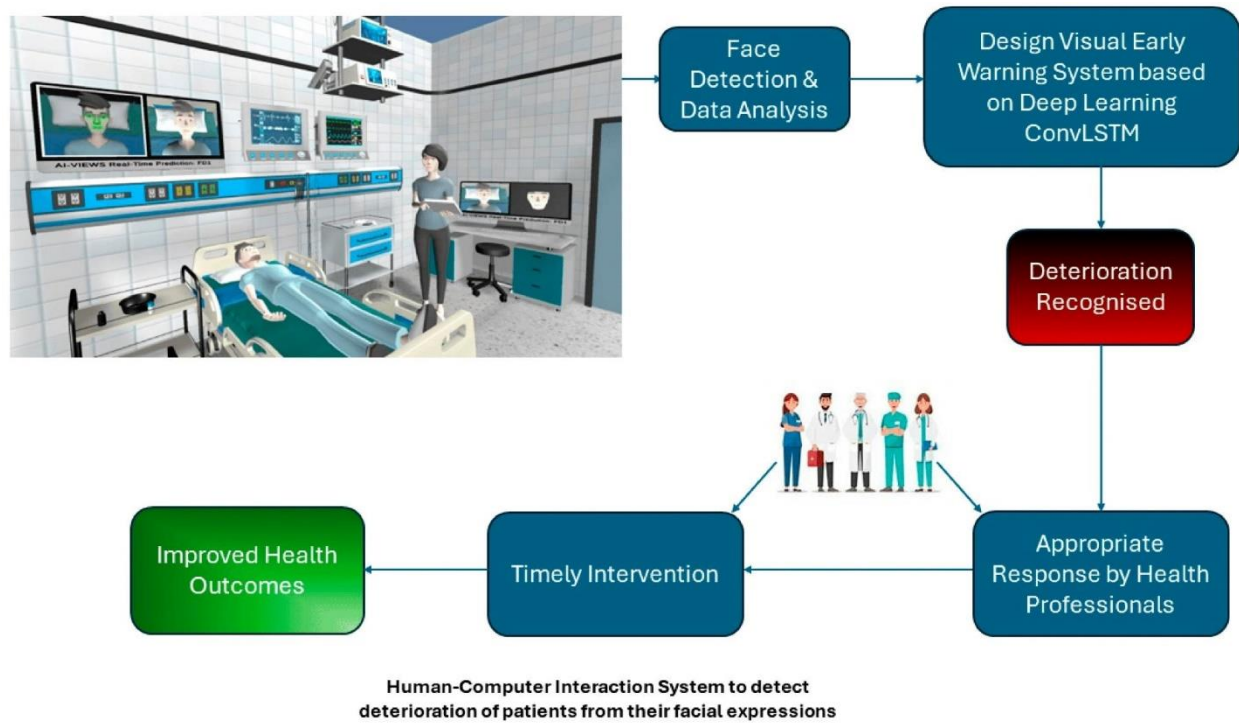
Fig.1. Concept diagram of the proposed invention
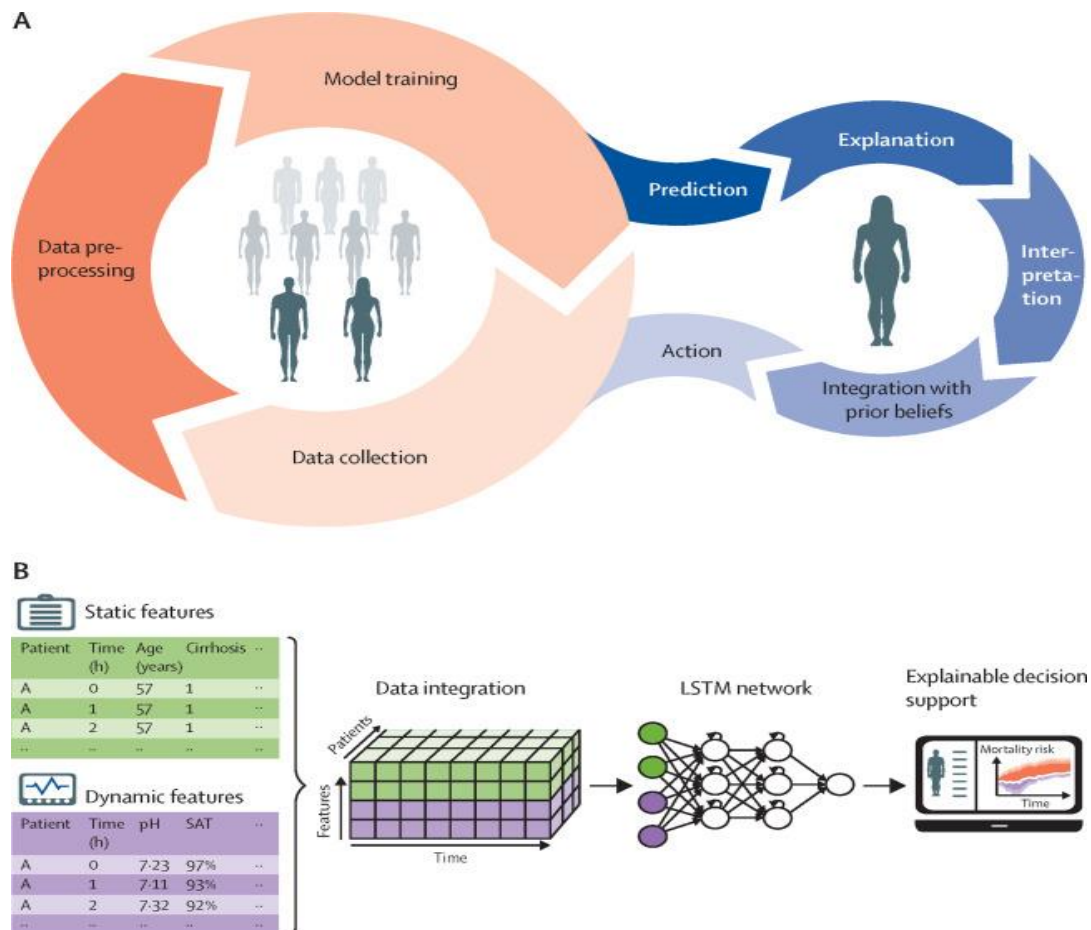
Fig.2. Workflow diagram of the proposed invention

Abstract:

The invention relates to a machine learning model for real-time prediction of patient deterioration in intensive care units (ICUs). The model integrates real-time monitoring data, including vital signs, laboratory results, and clinical notes, to generate risk scores for patient deterioration. Utilizing deep learning techniques such as recurrent neural networks (RNNs) and convolutional neural networks (CNNs), the model provides accurate and timely alerts to clinicians. The system seamlessly integrates with electronic health records (EHRs) and ICU monitoring systems, enhancing clinical decision-making and improving patient outcomes.

Claims:

1. A machine learning model for real-time prediction of patient deterioration in ICUs, comprising:
   - Data integration from real-time ICU monitoring systems and electronic health records;
   - Deep learning-based feature extraction and temporal pattern analysis;
   - Continuous learning and adaptation based on new patient data;
   - Secure API integration with ICU monitoring systems;
   - Explainable AI techniques for model interpretability.
2. The machine learning model of claim 1, wherein deep learning techniques such as recurrent neural networks (RNNs) and convolutional neural networks (CNNs) are utilized for analyzing patient data.
3. The machine learning model of claim 1, wherein the system generates risk scores and real-time alerts to notify clinicians of potential patient deterioration.
4. The machine learning model of claim 1, wherein the system ensures compliance with healthcare data privacy and security regulations.
5. The machine learning model of claim 1, wherein attention mechanisms and explainable AI techniques are implemented to enhance the interpretability of predictions for healthcare professionals.