AMERICAN ACADEMIC PUBLISHER

INTERNATIONAL JOURNAL OF MEDICAL SCIENCES

ISSN NUMBER: 2692 - 5206 Volume 5. No 11. November ,2025

ANALYSIS OF HEART RATE USING ARTIFICIAL INTELLIGENCE AND EARLY DISEASE DETECTION

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Annotation: This article scientifically examines the capabilities of artificial intelligence technologies in analyzing heart rhythm, particularly their effectiveness in early detection of arrhythmias. It discusses how cardiovascular diseases remain among the leading causes of death worldwide, the importance of early diagnostics, and the transformative impact of artificial intelligence on cardiology. The paper explains machine learning, deep learning, neural networks, and ECG signal processing technologies and evaluates modern scientific approaches in this field.

Keywords: artificial intelligence, heart rhythm, ECG, arrhythmia, early diagnosis, machine learning, neural networks

In recent years, cardiovascular diseases have been recognized as one of the most threatening factors to human health in the global medical system. According to statistics from the World Health Organization, disorders in heart function claim the lives of millions of people every year. In particular, changes in heart rhythm — arrhythmias — if not detected in time, can lead to serious complications such as heart failure, stroke, or sudden cardiac arrest. Although traditional diagnostic methods are highly accurate, many of them require time and resources and cannot always provide real-time monitoring. Therefore, in the context of scientific and technological progress, the integration of artificial intelligence technologies into cardiology has become one of the most relevant directions of modern medicine.

The development of artificial intelligence, especially machine learning and deep learning models, has formed a new paradigm in analyzing heart rhythm. Today it is possible to precisely interpret ECG signals, record complex rhythmic changes in real time, and even predict disease risks before clinical symptoms appear. The combination of human expertise and advanced technologies is elevating medical practice to a new level. This article analyzes these processes and highlights the methodology, practical outcomes, and future prospects of artificial intelligence in studying heart rhythm.

Artificial intelligence in heart rhythm analysis relies on two major technological layers:

1. Machine Learning (ML)

2. Deep Learning (DL)

AMERICAN ACADEMIC PUBLISHER
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Machine learning algorithms identify repetitive patterns in datasets. Since heart rhythm is a signal-based physiological process, the variations in ECG signals provide vast opportunities for ML models. These algorithms can learn micro-level fluctuations in thousands of ECG recordings, including amplitude and frequency shifts, R-peak analysis, and differences in PR and QT intervals, ultimately classifying them as normal rhythm or arrhythmia.

Deep learning, unlike classical ML, does not require manual feature extraction. Using convolutional neural networks (CNNs), recurrent neural networks (RNNs), and transformer models based on attention mechanisms, it processes raw ECG signals directly. As a result, even the most subtle signal features—those invisible to the human eye—can be detected. This significantly accelerates the detection of pacemaker-related issues, fibrillation, tachycardia, bradycardia, and other rhythm disorders compared to traditional ECG interpretation.

Artificial intelligence provides several advantages in the early detection of heart diseases:

Neural networks can detect rhythmic fluctuations unnoticed by the human eye by learning from large ECG datasets. Some studies show accuracy levels reaching 95–98%.

Smartwatches and heart monitoring devices integrated with AI allow continuous monitoring at home.

AI can predict the risk of heart disease months in advance, prompting timely medical consultation.

It enables personalized rhythm analysis for each patient.

Today, several AI-based cardiology systems have been developed, including:

EKG-NET deep learning model

Algorithms trained on the MIT-BIH arrhythmia database

SmartWatch monitoring systems

AI modules for real-time Holter monitoring

These systems significantly improve diagnostic accuracy in medical institutions and help reduce human error.

However, AI is not flawless. It has several limitations:

Insufficient or incorrectly annotated training data can lead to errors.

Legal and ethical questions regarding clinical responsibility remain unresolved.

AI cannot fully replace a physician’s medical judgment.

The quality of ECG sensors directly affects accuracy.

Artificial intelligence has revolutionized modern cardiology by enabling deep and accurate analysis of ECG signals, early detection of arrhythmias, and prediction of heart disease risks. In

AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES
ISSN NUMBER: 2692 - 5206 Volume 5. No 11. November ,2025

the future, the development of more precise AI models will contribute to even more effective and safer medical practice.

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