METHODS FOR DETERMINING THE DEGREE OF HEART RATE INSTABILITY IN DIFFERENT TYPES OF FIBRILLATION USING ARTIFICIAL INTELLIGENCE

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The development and optimisation of methods for assessing the degree of heart rate instability in different types of fibrillation (mainly atrial fibrillation) using advanced artificial intelligence (AI) tools to improve accuracy, speed of diagnosis and prediction of complication risk is a pressing issue today.

Atrial fibrillation is the most common type of arrhythmia, accompanied by a chaotic electrical impulse in the atria and irregular ventricular activity. This form of rhythm disorder considerably increases the risk of thromboembolism, stroke and heart failure. Traditional electrocardiography (ECG), despite its effectiveness, does not always allow rapid and accurate classification of the degree of CP destabilisation, especially in dynamic conditions.

Current heart rate analysis methods are based on a combination of statistical measures (e. g. SDNN, RMSSD), spectral analysis of heart rate variability and geometric approaches. However, artificial intelligence tools are increasingly used to detect complex fibrillation patterns that cannot be classified linearly.

In this study, the following methods are investigated and applied:

- Neural networks (CNN, LSTM) for real-time ECG signal processing and instability detection;
- Cluster analysis algorithms to divide ECG segments into typical rhythmic states (stable/instable/transient); - Deep learning to identify latent features of ECG segments;
- Deep learning to identify latent features that are difficult to detect manually;
- Explainable Artificial Intelligence (XAI) — to visualise the reasons for the decisions made by the models and give doctors confidence.

Of particular note is the creation of the Heart Rate Instability Index (HRI), an integral measure based on a combination of frequency, time and morphological characteristics of the ECG signal analysed by artificial intelligence models. HRI enables transient fibrillation states to be detected and their evolution predicted.

Modelling results based on open datasets (e. g. the MIT-BIH atrial fibrillation database) show that the use of AI increases the accuracy of fibrillation classification by 15-20% compared with conventional methods. This enables non-invasive real-time monitoring using portable devices.

Thus, the integration of AI into cardiac fibrillation analysis methods opens up new possibilities for early diagnosis, personalised prognosis and automated monitoring of the patient's condition.