



## **UNDERGRADUATE THESIS**

# **CLASSIFICATION OF ARRHYTHMIAS USING A CNN-PATCH TIME SERIES TRANSFORMER VIA ECG SIGNALS**

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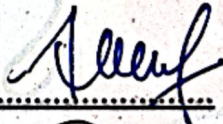


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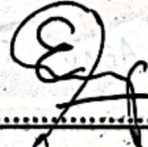


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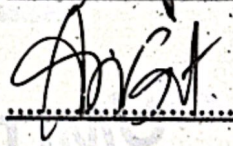
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SERIES TRANSFORMER VIA ECG SIGNALS**

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## ABSTRACT

Student Name / : Humam Maulana Tsubasanofa Ramadhan /  
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Thesis Title : Arrhythmia Classification Using CNN-Patch Time  
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Advisor : 1. Achmad Junaidi, S.Kom., M.Kom.  
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Arrhythmia, or cardiac rhythm disorder, is one of the cardiovascular conditions that can lead to stroke, heart failure, and sudden cardiac death. Traditional arrhythmia identification is performed through manual observation of electrocardiogram (ECG) signal recordings, encompassing analysis of rhythm, duration, orientation, and waveform morphology. This process is time-consuming and prone to interpretation errors, prompting the development of various machine learning models to assist clinicians in detecting and classifying ECG waveform patterns. Deep Learning techniques such as CNN and RNN have demonstrated potential in automating ECG analysis, yet each carries notable limitations: CNNs often struggle to capture global temporal dependencies, while RNNs are susceptible to vanishing gradient problems on long sequences. This study explores the application of a hybrid end-to-end CNN-PatchTST architecture, where the CNN handles local morphological feature extraction from ECG signals before being processed by PatchTST, which leverages a patching mechanism to overcome the quadratic complexity of self-attention and efficiently capture long-range temporal dependencies. The model was evaluated on five arrhythmia classes — Atrial Fibrillation (AF), First-degree Atrioventricular Block (IAVB), Normal Sinus Rhythm (NSR), Sinus Bradycardia (SB), and Sinus Tachycardia (STach) — using multiple public ECG datasets with varying look-back window configurations ( $L=336$  and  $L=512$ ) and patch configurations ( $\text{patch\_length}=16/\text{stride}=8$  and  $\text{patch\_length}=32/\text{stride}=16$ ). Experimental results show that the best configuration,  $L=336$  with  $\text{patch\_length}=32$  and  $\text{stride}=16$  at a 70:20:10 split ratio, achieves an accuracy of 88.8%, macro sensitivity of 84.3%, macro specificity of 96.3%, and macro F1-score of 82.5%. Look-back window  $L=336$  consistently outperforms  $L=512$  in both classification performance and training efficiency, reducing training time by up to 77% under the same patch configuration. Per-class analysis reveals significant performance variation, with NSR and AF achieving the highest F1-scores of 93% and 91% respectively, while IAVB and SB obtain the lowest at 70% and 73%, reflecting the inherent challenge of distinguishing classes with high morphological similarity.

**Keywords:** Arrhythmia, Electrocardiogram, Convolutional Neural Network, PatchTST, Transformer

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This thesis addresses the classification of cardiac arrhythmias using electrocardiogram (ECG) signals, applying a hybrid deep learning architecture that combines Convolutional Neural Networks (CNN) with the Patch Time Series Transformer (PatchTST). The author hopes this work can contribute, even modestly, to the development of automated ECG diagnostic support systems and to the broader field of biomedical signal processing.

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The author is fully aware that this thesis is still far from perfect, given the limitations in knowledge and experience. Therefore, constructive criticism and suggestions are warmly welcomed for future improvement. It is the author's sincere hope that this thesis will be useful and provide meaningful contributions to readers, particularly in the fields of machine learning.

Surabaya, July 11, 2026

Author

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