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A Novel PPG-Based Biometric Authentication System Using a Hybrid CVT-ConvMixer Architecture with Dense and Self-Attention Layers

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Abstract: Biometric authentication is a widely used method for verifying individuals' identities using photoplethysmography (PPG) cardiac signals. The PPG signal is a non-invasive optical technique that measures the heart rate, which can vary from person to person. However, these signals can also be changed due to factors like stress, physical activity, illness, or medication. Ensuring the system can accurately identify and authenticate the user despite these variations is a significant challenge. To address these issues, the PPG signals were preprocessed and transformed into a 2-D image that visually represents the time-varying frequency content of multiple PPG signals from the same human using the scalogram technique. Afterward, the features fusion approach is developed by combining features from the hybrid convolution vision transformer (CVT) and convolutional mixer (ConvMixer), known as the CVT-ConvMixer classifier, and employing attention mechanisms for the classification of human identity. This hybrid model has the potential to provide more accurate and reliable authentication results in real-world scenarios. The sensitivity (SE), specificity (SP), F1-score, and area under the receiver operating curve (AUC) metrics are utilized to assess the model's performance in accurately distinguishing genuine individuals. The results of extensive experiments on the three PPG datasets were calculated, and the proposed method achieved ACCs of 95%, SEs of 97%, SPs of 95%, and an AUC of 0.96, which indicate the effectiveness of the CVT-ConvMixer system. These results suggest that the proposed method performs well in accurately classifying or identifying patterns within the PPG signals to perform continuous human authentication.

Keywords: biometric authentication; internet of things; photoplethysmography (PPG); deep learning; ConvMixer model; feature extraction; attention mechanisms; secure identification; authentication systems

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1. Introduction

Biometric authentication is an essential aspect of identity verification systems, offering a secure and reliable means of confirming individuals' identities [1]. Traditional biometric methods, such as fingerprint or iris recognition, have been widely adopted [2]. However, the integration of emerging technologies, such as Photoplethysmography (PPG) and deep learning (DL), presents exciting opportunities to enhance biometric authentication systems [3]. PPG is a non-invasive optical technique that measures blood volume changes in tissues. It involves the use of light sensors to capture the reflected light from the tissue, providing insights into cardiovascular activity and physiological characteristics. PPG signals can be obtained from various parts of the body, including the fingertip, wrist, or earlobe [4].