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# A novel noise-robust stacked ensemble of deep and conventional machine learning classifiers (NRSE-DCML) for human biometric identification from electrocardiogram signals

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ABSTRACT

*Background:* Biometric identification is advantageous over traditional authentication methods such as password, PIN (Personal Identification Number), and/or a token-based card. Electrocardiogram (ECG) signals show unique behavioral characteristics for persons due to their heart morphology and structure which make them more appropriate for human identification. ECGs are safe and more reliable. Related previous models for human identification from ECG signals can be divided into conventional machine learning and deep learning models. In this study, a novel noise-robust stacked ensemble of deep and conventional machine learning models (NRSE-DCML) is proposed for human identification from ECG signals.

*Methods:* NRSE-DCML includes an ensemble of deep convolutional neural networks in the first layer, an ensemble of support vector machines in the second layer and a perceptron classifier with Softmax activation function in the third layer. This study takes advantages of both of conventional machine learning models and deep neural networks by combining them in NRSE-DCML. All heart beats are used to train the first, the second and the third layers of the proposed stacked ensemble classifier. The first and the second layer try to identify noisy heart beats and increase their weights to reduce their misclassification error. PTB-Diagnostics ECG signals for 152 healthy and patient persons from PhysioNet database are used for evaluating and validating NRSE-DCML.

*Results:* Experimental results show that NRSE-DCML achieves the Accuracy of 99.02, FAR of 0.95 and FRR of 1.02 using 5-fold Cross-Validation strategy using 1-second segments which is comparable with other state-of-the art methods.

*Conclusions:* The main advantages of our proposed method is its ability to detect unknown persons as unauthorized class and considering both healthy and patient groups. Finally, our proposed model enhances the accuracy of the biometric identification for noisy heart beats.

## 1. Introduction

Human identification from biometric data has some advantages over traditional human authentication methods such as passwords, identification cards or encryption keys [1]. For traditional authentication methods, several concerns such as their loss or unauthorized copy can reduce their security [2].

Biometric data is a safe method for human identification with enhanced security without risk of duplication, fake data, and using them by unauthorized persons [3]. Many different types of biometrics have been used for recognizing individual's identity in the previous studies such as fingerprints, faces, speech, voice, iris and gaits [4]. Although, they can be counterfeited [5]. For example, fingerprint can be compromised using gelatin [1].

Electrogardiogram (ECG) signals capture heart electrical signals. ECGs as a biometric modality show unique behavioral characteristics for persons according to their heart morphogy and structure [2]. The previous studies have shown that the main advantage of using ECG as a biometric is achieving to high accuracy even in abnormal heart beats [6]. Duplication and copying ECG signals are difficult and even impossible because of its uniqueness and intrinsic property for each subject [1]. Moreover, they have the ability for liveliness detection. According to the previous studies, different physiological and geometric properties and various heart position and size have been detected for different

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