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Data mining in mobile ECG based biometric identification

Khairul Azami Sidek [a,*], Vu Mai [b], Ibrahim Khalil [b]

[a] Kulliyyah of Engineering, International Islamic University Malaysia, Kuala Lumpur, Malaysia
[b] School of Computer Science and Information Technology, RMIT University, Melbourne, Victoria, Australia

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ABSTRACT

This paper investigates the robustness of performing biometric identification in a mobile environment using electrocardiogram (ECG) signals. We implemented our proposed biometric sample extraction technique to test the usability across classifiers. Subjects in MIT-BIH Normal Sinus Rhythm Database (NSRDB) were used to validate the reliability and stability of the subject recognition methods. Discriminatory features extracted from the experimentations were later applied to different classifiers for performance measures based on the complexity of our proposed sample extraction method when compared to other related algorithms, the total execution time (TET) applied on different classifiers in various mobile devices and the classification accuracies when applied to various classification techniques. Experimentation results showed that our method simplifies biometric identification process by obtaining reduced computational complexity when compared to other related algorithms. This is evident when TET values were significantly low on mobile devices as compared to a non-mobile device while maintaining high accuracy rates ranging from 98.30% to 99.07% in different classifiers. Therefore, these outcomes support the usability of ECG based biometric identification in a mobile environment.

1. Introduction

In recent decade, the demand for improved security for personal data storage has been growing rapidly and among the potential alternative is employing innovative biometric identification techniques. Biometric has become a frontier in identity management systems which is gradually complementing traditional security mechanisms such as pin numbers and passwords. Biometric operation is reliant on pattern recognition approach by extracting unique and discriminative physical traits which are commonly known as biometric samples (recognition data) and matching these samples with datasets stored inside the identity management system (enrolment data). The identification process performs similarity analysis between these samples and estimates the equality using matching scores. Two biometric samples with high scores indicate that they come from the same individual. The operation is depicted as in Fig. 1.

Numerous biometric modalities have been proposed in the past such as keystroke, voice, iris, gait, face and fingerprint as shown in Fig. 2. However, these previous modalities are not reliable in terms of identification accuracy such as gait and keystroke. They are also not robust against falsifications such as voice which can be simply imitated, iris which can be duplicated by using contact lenses with copied iris features printed on it, face which is exposed to artificial disguise and fingerprint that can be faked by latex (gummy fingerprint). Recently, ECG which is the electrical representation of the heart emerged as one of the potential biometric modalities due to the uniqueness of its characteristics which integrates liveness detection, significantly preventing spoof attacks. The function of the ECG as a life indicator to the heart places itself superior as compared to other biometric modalities due to its suitability even for those who are visually impaired and amputees.

There exist substantial research entities pertaining to ECG based biometric as a person identification mechanism such as researches in Biel et al. (2001), Israel et al. (2005), Wang et al. (2008) and Sufi and Khalil (2011) including our previous works in Sidek and Khalil (2011a,b,c, 2013) and Sidek et al. (2011a,b, 2012). It encapsulates a variety of recognition techniques which include mobile biometric identification system (Poon et al., 2006; Agrafioti et al., 2011; Jurik and Weaver, 2011). The latter is due to rapid and dramatic improvements of mobile device features and performance with high processing power and large memory allocations such as smartphones. As a result, mobility has become an increasingly important element of mobile biometric. However, little has been said about the performance evaluation of mobile ECG based biometric identification. The feasibility of subject recognition techniques on mobile devices is significantly important because of the pressing need for better security to store personal and business data or connecting to corporate networks on mobile devices. Potential mobile ECG based biometric

* Corresponding author.
E-mail addresses: khairul.sidek@student.rmit.edu.au (K.A. Sidek), vuhuy.mai@rmit.edu.au (V. Mai), ibrahim.khalil@rmit.edu.au (I. Khalil).

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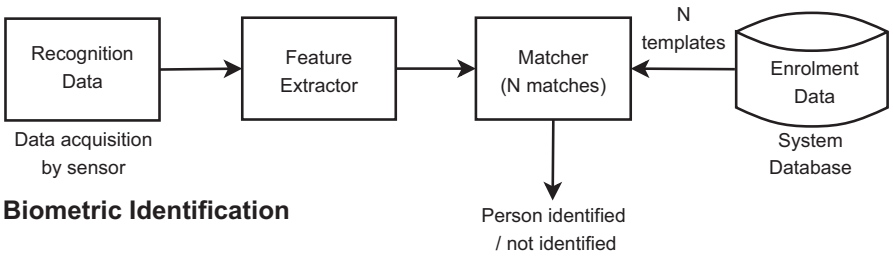

Fig. 1. Biometric matching operation between recognition and enrolment samples which produces score based on the similarity analysis.

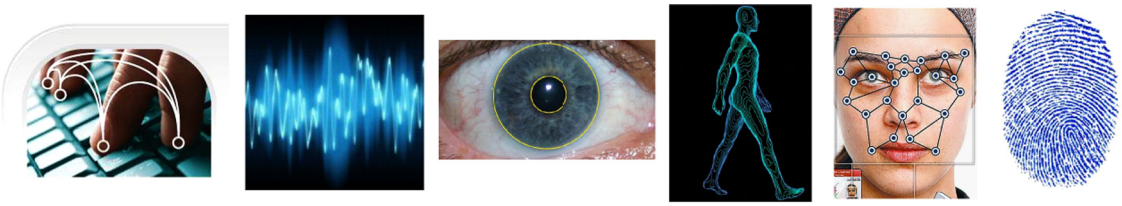

Fig. 2. Different types of biometric modalities such as keystroke, voice, iris, gait, face and fingerprint.

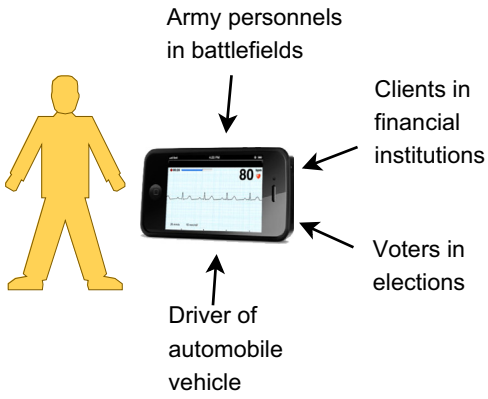

Fig. 3. Potential mobile ECG based biometric scenarios such as verifying army personnels in battlefields, identifying clients in financial institutions, validating voters in an election or even recognizing automobile drivers.

applications such as verifying army personnels in battlefields, identifying clients in financial institutions, validating voters in elections or even recognizing automobile drivers as shown in Fig. 3 are seen as possible future applications. These scenarios require reliable and easy to use recognition method to secure personal information and protect individual identity against unauthorized access. Moreover, Health Insurance Portability and Accountability Act (HIPAA) 1996, European Union Directive 2002/58/EC and Law of the People Republic of China on Medical Practitioners also recommend security procedures in a mobile environment to protect the confidentiality and privacy of electronic information being transmitted in the air (104th Congress, 1996; Directive 2002/58/EC, 2002; Law on Licensed Doctors of the People's Republic of China, 1999). Thus, in this study, we investigate the reliability of performing mobile ECG based biometric identification by applying different subject recognition techniques.

1.1. Motivation

Smartphone is a ubiquitous and internet-ready device used to facilitate daily activities. As an implication of this technological advancement, mobile users tend to store personal information such as credit card details, user passwords, email addresses or other credentials on their devices which may increase severity and risk of identity theft. Therefore, the ability to secure mobile phones determines the trustworthiness and reliability of subject recognition methods. In any related situation, the main objective is to create a seamless person identification mechanism. Thus, in order to achieve this aim, we recognize three important issues which should be dealt with:

- In consideration with resource scarcity of mobile devices, what will be the computational complexity of the proposed biometric sample extraction algorithm in order to maintain high accuracy rates?
- How long does it take to perform subject recognition using ECG signals in different mobile devices?
- Which data mining technique used for subject recognition suits a mobile environment using ECG signals?

These are among the most important highlights when we inquire about the reliability and robustness of mobile ECG based biometric identification system. Since mobile devices are not resource diversified as non-mobile systems, we investigate the computational complexity of our proposed method and suggest subject recognition techniques which suit mobile environment with the least amount of execution time. To the best of our knowledge, such research analysis has never been reported in previous literatures. Thus, this factor has motivated us to initiate and perform further investigations.

1.2. Contribution

In this paper, we evaluated three pertinent issues of mobile ECG based biometric identification which have been neglected in existing works, which are the following:

- performed ECG based biometric identification in three different mobile devices,
- proposed an innovative biometric sample extraction technique that reduces the computational complexity on mobile devices, and
- suggested data mining technique that achieved high accuracy rate and low execution time on mobile devices.

Thus, based on the experimentation results, subject recognition using ECG signals on mobile platform is possible by obtaining low TET values while still maintaining high identification accuracies. This is due to our proposed biometric sample extraction technique which simplifies the computational complexity in mobile environment. Additionally, the outcome of the mobile ECG based