An Intelligent Context-Aware Biometrics System Based on Agent Technology

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Abstract

Traditional biometric systems deal with each instance of identification in the same way irrespective of the circumstances in which the biometric samples were captured at different times or for different applications. Our main objective is to enhance the traditional biometric identification process and improve the decision making process. This is by giving biometric systems an intelligent and flexible identification mechanism using agent technology. Our aim is to develop a multiagent based framework to represent a context-aware adaptive biometric system with multimodalities.

1 Introduction

A typical biometric system includes five main steps to identify a person as we will describe them in details in section 4. Each one might be affected by multiple factors and particularly when a number of biometrics modalities work in the same system. Such factors that have to be considered when designing a biometric system include in general: the quality of sensors, illumination, noise and other such environmental conditions; the biometric modalities used; type of user's interaction with the system, the type of features and classifiers and the image processing techniques applied at each step of its processes. All these factors will affect the final objective of the system which is to accurately identify/verify the claimed identity of a person.

Traditional biometric systems essentially use specific biometric modalities and techniques at each of their five steps of the identification process irrespective of those techniques being the best one at that specific time or not. They use adaptive techniques to consider only one step/ factor and ignore the rest such as Sellahewa and Jassim [2010] who proposed adaptive techniques for quality-aware illumination normalisation and fusion for face recognition.

Agents based biometrics have been used to enhance such traditional mechanism and again in partial biometric system process steps such as in a classification module only [Abreu and Fairhurst, 2011]. Therefore, we propose to design a framework based on multiagents that consider all the steps and factors in a cooperative manner to support adaptive and intelligent solutions across all of these steps.

2 What are Context-aware and Adaptation?

Context-aware in biometrics means at any given instance of identification or identity verification, the system has the ability to find the best configuration information (awareness) for the requirements of its three main components (user, application, environment), which have a direct affect to make a final identification decision correct or not. Then, the system has to respond *adaptively* to achieve these requirements. The system works self-awareness and adaptation to get a set of requirements/ attributes for each one of its components by using agent technology as follows

Unidentified user context agent is either a cooperative user that gives his profile data and would either have a preferred choice of biometric data to be collected or does not have depending on the application conditions, or a non-cooperative user that does not have such choice at any application/scenario. This agent will determine what kind of user the system is supposed to work with.

Application context agent is based on the type of the application. Each one may require different level of cost, accuracy, convenience, usability, speed of process, privacy and security issues, error rates, etc. In addition, the type of extracted biometric modal(s) is either optional, compulsory or mixed. This agent determines which application we have, and what are the levels of conditions the system should get.

Environment context agent is concerned with the type of environmental conditions that the system is situated in. These conditions are varied such as illumination, quiet or noisy space, occlusion, indoor or outdoor scene, etc.

All these three components with their particular parameters are incorporated and formed the overall system context at a particular instance of identification.

2.1 Use Case: Remote Authentication Service

There is no one specific combination of requirements that works best every time for every biometric application. For example, ATMs are normally placed in controlled environments with cooperative users, whilst surveillance applications have opposite scenarios. These two applications can use the same framework of biometric system and the agent technology can figure out and adapt all the possible requirements based on the context of the given scenarios.

Figure 1 shows a biometric system that provides authentication services for different applications such as banks, and border control. For example, bank 'X' needs to authenticate its customers to offer its services (e.g. ATM, m-payment), with each service is required different levels of authentication accuracy and user/merchant convenience depend on the type, amount and location of the transaction. Accordingly, the system must be able to select the most appropriate biometric modal(s) based on the application context, sensor availability and environmental conditions.

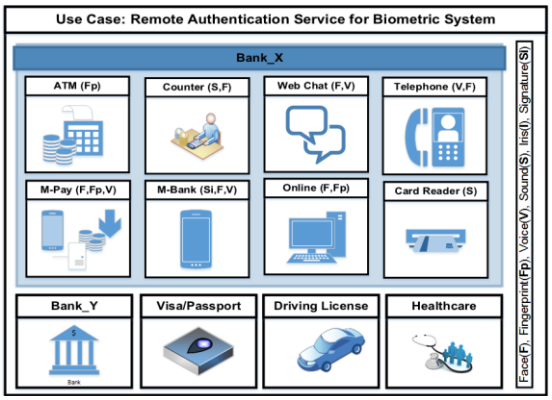

Figure 1: Remote Biometric Authentication Service.

Bank 'Y' or any other applications could have completely different set of requirements in authenticating their customers. Thus, the system has to be context-aware and adaptive to give such service to heterogeneous applications.

3 A Novel Framework for Adaptive Biometrics System Based-Multiagents

We propose a multiagent framework to represent a context-aware adaptive biometric system. The agents will help conduct the system's internal processes so that they are able to utilise the best approaches to identify an individual. The framework will include five sequential modules as follows:

1) *Sensing module* uses an appropriate sensor according to the required biometric sample. This can be done either with a user's agreement or remotely. Sensors that could capture biometric samples in a good quality will help to minimise the ratio of noise to clean and process these samples. An agent will check the sample's liveness and quality to decide to pass it on to the next module or to re-capture it, **2) *pre-processor module*** normalises the captured samples to a canonical form. It will remove the undesirable noise from these samples. Traditional biometric systems preprocess samples even when they are of good quality, but in our framework, an agent will decide the actual necessity when to do it, **3) *features extractor module*** processes the biometric data to generate a set of distinct features and either store them as templates database (in the enrolment) or send them forward to the next module (in the identification). Features are extracted based on the type of the modality. An agent will select the best feature(s) representation based on the application context and the sample quality determined by the previous module, **4) *classifier and matcher module*** compares between the extracted template of the new biometric sample during the identification process and all the stored templates in the database. An agent will determine which classifier to select based on the type of features extracted and the level of accuracy is required. This module generates a match score for each extracted feature from the biometric sample, and **5) *decision maker module***: an agent based score fusions approaches will be used to determine the best score fusion strategy for a given instance. As the framework accommodates multimodalities, therefore, this module will use agents to fuse scores at two sequential levels: 1) *an agent based sample score fusion* is to receive and fuse all the match scores of different samples (S_1, S_2, .. S_n) which are related to the same modality (M_i). There is one agent is concerned with one modality in order to handle all its samples' scores ($M_1\_S_1$, S_2, .. S_n; $M_2\_S_1$, S_2, .. S_n; $M_n\_S_1$, S_2, .. S_n), and 2) *an agent based modality score fusion* is to collect a number of results from these multiple agents according to the number of modalities in the system.

At the final step, another agent (i.e. a decision making agent) is used to present the final score to determine the predicted identification decision by the biometric system for a given user. After making the decision, there is a check by using a threshold comparison if template update is required. In addition, some applications (e.g. border control) has an operator who may update the stored templates if necessary.

At every step of the above five modules, there will be several options to select from (e.g. which classification method is most appropriate?) Multiagents will be used to determine the most appropriate solution adaptively based on the given scenario and awareness of the system's context. Agents will negotiate (e.g. game theory- and auction-based approaches [Wooldridge, 2002]) with each other, use their past experiences, and change opinions if necessary to arrive at an optimal result for the final identification decision.

4 Conclusion and Future Work

This paper proposed a conceptual framework for context-aware adaptive multimodal biometrics system using agents. Agents will be used at each of the key processing steps of a biometric system to determine the most suitable action to take based on the application, user and environment context at the time of identification. Our future work is to implement and evaluate the proposed framework.

References

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