Using Multiagents for Context-Aware Adaptive Biometrics

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Abstract

This research is motivated by the need to design a biometric system that uses adaptive techniques relevant to a specific context to identify an individual with little or no interaction with the user. The aim of this research is to develop a framework for a context-aware adaptive multimodal biometric identification system using agent technology.

1 Research Problem

Due to the rapid increase in online activities, mobile transactions and the economic cost of identity theft as well as personal privacy, the necessity of being able to identify individuals accurately and efficiently under a variety of scenarios has become an important requirement.

Biometrics have made rapid progress over the past decade and have gained acceptance as being effective in person identification for a variety of applications. Each application may have its own set of requirements, such as the level of accuracy, security, usability and convenience. A typical biometric system processes through five steps: 1) capture or acquire biometric data; 2) pre-process the data; 3) extract features; 4) classify and match; and 5) present a final decision of identification or identity verification.

We propose a framework that will have the ability to make autonomous decisions in order to present the best solution for a given context. This is by choosing the most suitable data, techniques and parameters in each step of its identification process. Thus, the framework can be used to identify individuals under different conditions and for different applications with the highest possible accuracy.

2 Related Work

Biometric systems either work very well with high accuracy under certain scenarios (almost predefined and expected conditions) or result in poor/average accuracy in heterogeneous scenarios. Adaptive biometric systems have been considered to address some specific aspects of biometric systems so that they select the most suitable methods to identify a given test biometric sample.

Adaptive biometric systems have been looked at from different aspects; some dealing with ageing and others considering updating the reference template in order to reduce the error rates such as False Accept Rate and False Reject Rate. Adaptive solutions have been proposed to consider the factors of intra class variation in the new test biometric data as compared to the stored template data such as in [Sellahewa and Jassim, 2010; Poh *et al.*, 2012].

Agents have been used to improve the traditional approaches of making an identification decision in a classification module. An intelligent classification module that uses agents has been proposed in recent work [Abreu and Fairhurst, 2011]. Zhang *et al.*, [2008] proposed the use of multiagents for person identification based on fused results from geometric features of a human head.

The above examples demonstrate the successful use of agents in some of the processing steps of a biometric system. However, none of the previous work considered the use of multiagents across all the different steps or in a comprehensive manner as we propose to do.

3 Context-Aware Adaptive Biometric System

Context-aware means at every instance of identification or identity verification, the system is aware of its application's requirements (e.g. high-security or convenience) and the environment conditions that the system is working on (e.g. quiet or noisy background). Then the system has to work *adaptively* according to these requirements and environment conditions to achieve the best possible identification/ verification accuracy. This is different to traditional biometric systems that use specific (i.e. fixed) biometric modalities and techniques at each step of the identification process irrespective of those techniques being the best one at a given instance of identification or identity verification.

The context-aware and adaptation for a biometric system are based on a set of factors that include: the application (e.g. m-payment, tele-banking, border control), used techniques (e.g. pre-processing, feature extraction, classification), desired or pre-defined requirements (e.g. level of accuracy, convenience), operational environment (e.g. indoor, outdoor), and the chosen modality (e.g. face, signature). These factors are interlinked and might affect each other, hence the system has to work adaptively to achieve its overall aim based to its operational context. It is therefore important to develop an adaptive biometric system that takes into account all the aspects of its processing modules so the system is fully aware of its current context and takes actions adaptively and rationally to achieve the best result in heterogeneous environments.

4 Multiagent Framework for Context-Aware Adaptive Biometrics

We propose a multiagent framework to represent a context-aware adaptive biometric system. The agents will help conduct the system's internal processes in such a way that the system is able to utilise the best approaches to identify/verify an individual at a particular instance of time.

The proposed framework will include five key modules, each of which is controlled by at least one agent. These processes are represented by the *Intelligent Processing Agents* (IPA) module. The framework accommodates multimodalities. Each modality may contain more than one sample from a user. The sample is then processed individually by IPA module that represents the entire process for this particular sample so that this module receives input as a biometric sample and produces the output as a match score.

A result obtained from an IPA module will be sent to an agent (i.e. sample score fusion agent) for further processing. At this stage, this agent is to receive, process, arrange and fuse all the match scores of different samples ($S_1, S_2, .. S_n$) which are related to the same modality (M_i). Our proposed multimodal system (e.g. face, signature) will need to have multiple agents so that each agent is concerned with one modality in order to handle all its samples' scores ($M_1\_S_1, S_2, .. S_n; M_2\_S_1, S_2, .. S_n; M_n\_S_1, S_2, .. S_n$). In other words, an agent that is responsible for a modality will oversee the work of all agents that process this modality – hence the hierarchical multiagents.

In the next process, there is another agent (i.e. modality score fusion agent) to collect a number of results from these multiple agents according to the number of biometric modalities in the system. This agent will again fuse all the received results to produce one final score. In the final step, there is also another agent (i.e. decision making agent) as a decision maker to predict or verify the user's identity.

The final step is to check if template update is required. If for example the confidence level of the decision is greater or equal to t then the template is updated in the database, otherwise it would not update. In addition to the threshold comparison, some applications (e.g. border control) has an operator who may update the stored templates if necessary.

At every step of the above modules, there will be several options to select from. For example, which biometric modality should be captured? What is the best approach to remove noise and normalise a biometric sample? Which technique(s) will provide the most discriminant features? 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 interact and negotiate with each other, use their past experiences, and change opinions if necessary to arrive at an optimal result for the final identification or identity verification. Examples of negotiation methods are game theory-based approaches and auction-based approaches [Wooldridge, 2002].

The proposed framework will be tested with face data to begin with, followed by signature and fingerprint. The evaluation will include the use of multimodalities (e.g. face, signature, fingerprint), multi-samples for each modality (e.g. several face images), multiple normalisation techniques depend on the quality of biometric samples (e.g. face image quality is affected by illumination, sensor quality, and user cooperation), multi-features (e.g. geometrical, statistical, texture features for face images), multi-classifiers (e.g. K-Nearest Neighbour, Neural Networks, Convolutional Neural Networks), and score fusion (e.g. majority voting, weighted average). Since we are considering multimodalities, it is inevitable to explore fusion techniques at various levels of the system's process. A set of agents will be involved accordingly and added gradually to the system if necessary.

Each agent will be concerned with and aim to achieve its own local task (based on the five modules of biometric system) whilst maximising the outcome of the global task; accuracy of the final decision for the biometric system. Thus, agents will learn from their experiences of previous attempts – each agent will save in its own database all the decisions that have been made locally (previous states). This will help improve agents' ability and increase their confidence to make significantly fast and rational decisions which in turn will lead to improved accuracy rates.

5 Future Work

We presented a conceptual framework for context-aware adaptive biometrics. Although we are yet to demonstrate the effectiveness of the framework in practice, we have highlighted several examples from the literature that demonstrate the viability of the framework. Our future work is to implement and evaluate the framework.

References

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