Multi-Agent approach to Face Recognition in Border Control

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Abstract - In this paper, we have proposed a multi-agent approach to face recognition in border control. In today's unstable world, security is the most important aspect. Border criminals, frauds, and unauthorized immigrants are burning issue in Sri Lanka within the last few years due to the lack of proper identification system. Therefore, the efficiency and accuracy of the traditional face recognition system are not good enough to overcome this disaster. The face biometrics is an ideal solution for authentication as it has an advantage over conventional systems. The main objective of the research is to provide an automated and effective solution for face recognition using limited data and time-critical application. The face biometrics is the main ingredients of the proposed system and overall process done by using multi-agent system (MAS) to compare the latest face biometrics with a physical appearance at the border points. The face recognition algorithms, Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) are used as an agent within the multi-agent environment can be identified as the novelty of the proposed system. Less human intervention and smoothly adaption to the current system can be identified as an advantage of the system. The system has been analyzed with the traditional system and evaluated with authentic biometric samples and identified with 96% accuracy with comparing to the traditional system.

Keywords: Face Recognition, Multi-Agent Systems (MAS), Border Control System.

1. INTRODUCTION

The term "biometrics" is derived from the Greek words, "bio" is life and "metrics" is to measure [1]. Face biometric authentication systems have only become available over the last few years, due to significant advances in the field of computer security. Since the beginning of civilization, humans have used faces to identify known (familiar) and unknown (unfamiliar) individuals. Face appearance is biometric which is used every day by everyone as a primary means of recognizing other humans [2]. Face biometric does not need to be remembered and cannot be easily lost. This makes it much easier for the user. Furthermore, face biometric cannot be easily stolen or loaned to a friend.

During the last few years, unauthorized immigration and emigration dramatically increased in Sri Lanka. Consequently, drugs frauds, crimes are on the rise in an uncontrollable level. Hence, these threats have severely affected in many key sectors in the country ie, national security, finance, tourism. On the other hand, the Ministry of foreign affairs in Sri Lanka stated: "Illegal immigrants are a burning issue in Sri Lanka" [3]. The main reason for the issue can be identified as a lack of proper identification system at the border points. Manual face recognition and e-passports consider as a traditional border control system. Biometric capture is done at the visa granting process and the same candidate should be present at the airport with his/her passport during the time of arrival and departure [15]. The proposed system match both facial images using different recognition agents in a multi-agent environment.

There are three main parts of the overall system.

1) *Face detection phase in biometric capture*
2) *Face image stored in the database*
3) *Face recognition phase at the border*

After the empirical research, the system has been evaluated and identified more accurate than the conventional system with less time consumption in face recognition. MAS used for automating the overall process by matching faces with different agents as it has co-operation, co-ordination and negotiation features.

To discuss the aforementioned findings, this article is structured as follows: The next section offers a brief literature overview of the latest face recognin systems; the methodology is outlined in Section 4; this section includes approach, design, and implementation of the proposed system. Section 5 then offers a comparative analysis of the empirical findings in the proposed system; and finally, the article concludes by outlining the research conclusions, limitations, and future directions.

2. LITERATURE REVIEW

Many researchers have been conducted on face recognition with still face images. They have used popular techniques like principal component analysis (PCA), linear discriminant analysis (LDA) and backpropagation neural network which can be considered as higher accurate in face biometric domain. MAS gives less human intervention and emerging features to any complex system. In the following section, authors review the usage of the techniques mentioned above and how their contribution and limitation affect the final solution.

Marco Gamassi et al. described a multi-modal multi-paradigm agent-based approach to design Scalable distributed biometric systems in order to identification [4], recognition and monitoring, with a high level of privacy. The goal of the paper is to face the specific application by using flexible design by focusing on optimization, adaptively and evolvability. The paper has depicted the overall process by one example and conclude about one crucial aspect, which is biometric measurements can generate nonreversible code for security and privacy domain. However, authors are not involving implementation and evaluate the system with a considerable amount. The research will continue with further optimization, confidence, reliability, performances, security, and cost with real-world application.

A face detection algorithm based on deep learning has been proposed by Ming Li et al [5]. This paper has proposed a solution for partial occlusion and multi-pose using face detection algorithm based on deep learning. Experiment results show higher accuracy in case of occlusion and multi-pose with limitation in poor light condition. However, the author focuses on deep learning approach can be identified as a time consuming and computer power consuming system. Therefore, deep learning is not suitable for the time-critical environment as we expect time and accuracy both.

Fares Jalled has presented face recognition machine vision System using eigenfaces [6]. Eigenface approach is quite simple and efficient in a controlled environment such as one with less noise. The accuracy of the system has been measured by Euclidean distance between test faces and train faces. N-PCA has shown positive results than PCA over ORL face database. However, the main problem of the system is not combining or comparing with other face recognition algorithms. Face recognition in the real-time environment too has not been discussed within the study and they are identified as a weakness of the system.

M.C. Da Costa-Abreu et al. have analyzed the benefits of a novel multi-agent approach in a multimodal biometric identification task [7]. This paper influenced the versatile biometric-based system which can allow the deployment of more than one modality. According to the paper, if identification accuracy is the primary concern, a common alternative approach is to use a multiclassifier approach in order to build a more accurate system [8]. Multi-classifier has been widely used in a range of pattern recognition problems [7]. However, the optimal choice of a combination method which is most suitable for a specific application is a complicated process, often requiring the execution of exhaustive testing to choose the best implementation.

Nawaf Hazim Barnouti et al. have introduced face detection and recognition using Viola-Jones with PCA-LDA and square Euclidean distance [9]. The proposed system focuses on appearance-based features than local facial features. Face detection is the initial part of the process and the Viola-Jones face detection method is identified as highly accurate in detection. Feature extraction will be applied after the detection phase. PCA method is widely used in pattern recognition method and LDA used to overcome the limitation of PCA and the proposed method tested in three databases (MUCT, Face94, and Grimace). Eight individuals' one to three images are used from the database for testing the overall performance using Matlab software. The analysis shows that increasing the number of images from one to eight will give more accurate results and recognition time only a few seconds. However, they do not consider real-time face detection and recognition.

Adrian Kapczyński et al. discussed the simulation model of biometric authentication using a multi-agent approach [10]. The agent-based model which monitors the behavior of the authorized users. So, the agents are responsible for recording all actions of the authorized user and deliver all recorded data to the main agent for processing and decision making. In this approach, four models were created in NetLogo platform with agents playing different roles such as authenticator, authenticate and other with remain few future challenges.

Girija Chetty and Dharmendra Sharma presented a new approach to the application of agent technology to the problem of face recognition [11]. Multimodal biometric systems can produce more robust solutions for many real-world applications such as crime investigation, video oversight, and biomedical informatics applications, where there is a need to identify from less biometric data. This overall system has been developed in a distributed face recognition environment with embedded of intelligent multi-agent-based approach. Best and suited way to biometric security involves co-operation, coordination, and negotiation between agents. The architecture is based on adapting the

MARSE, a MAS framework, proposed by Intelligent Systems Group at the University of Canberra [11] for the distributed face recognition task.

Marco Tranquillin et al. discussed the usage of mobile agents for secure biometric authentication [12]. Authors have described important of hybrid solution (biometric and non-biometric) than fully AI transformation. The main goal of this paper is to present how biometric matching methods can be combining with the usual password/PIN. However, this paper highlighted fingerprint [13], which has less security biometric level. Furthermore, the author got stuck with an experimental phase due to not enough computational power of the smart-phones.

Malcolm Reid and Elhadi M. Shakshuki have implemented a MAS for recording and transmitting Biometric Information of elderly citizens [14]. The primary objective of this paper is to present the architecture and implementation of MAS design for elderly citizens. This paper more discussion about how recording and disseminating a group of patient's biomedical information to health-care professionals. Therefore, this paper address only about a particular group and how data transmitter to the health-care industry.

After a comprehensive study, the authors concluded that the best approaches for face recognition in time-critical applications are PCA and LDA with less training data in MAS. According to many past researchers, there is a need for a system to recognize the face in a time-critical environment in an effective way. Therefore, their proposed solution used past researchers' contribution to get an idea about the most suitable algorithms in each step.

3. PROPOSED METHODOLOGY

The face recognition process cannot be a success without face detection and the data storing phase. Therefore, the next section will briefly describe it as well. The overall system is based on MAS which include image processing agents and recognition agents. The different face recognition algorithms give different result in different conditions, therefore the proposed system used PCA and LDA face recognition algorithm [6] agents in the recognition phase. In this section, the authors focus on the agent-based approach, design, and implementation of the proposed system. Face images and personal details are the main input of the system and face recognition is the output. As mentioned above in the introduction, the proposed system consists of three phases,

1) *Face detection phase in biometric capture*
2) *Face image stored in the database*
3) *Face recognition phase at the border*

For the experiment purpose, this setup has been done by the same location for detection and recognition phase. First of all, look at the below figure to get an idea of the overall process in the system [16].

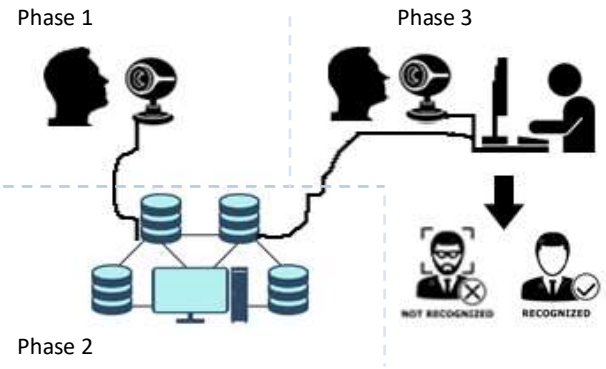

Figure 1- overview of the proposed system

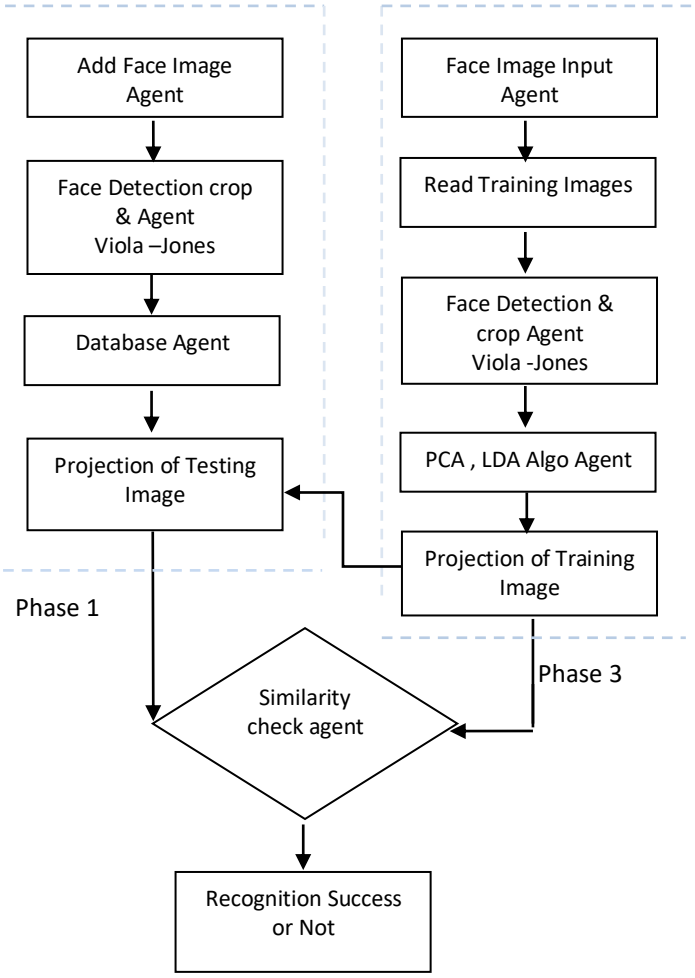

Figure 2- Proposed agent-based system

3.1 Face detection phase

Face detection can be considered a popular research topic in the biometric domain. The basic objective of detection is to find the object in the given image. Face detection is complex in real situations because it carries a lot of variations in the image such as lighting conditions, facial impressions, and head orientation. However, in border control application those obstacles are minimized because it has a specific location and environment to capture the front face image. This phase consists of few agents and behaviors such as,

addFaceImage Agent – start the add face behavior when clicking the start button.
faceDetectandCrop Agent – start crop image behavior
pauseAddFaceImage Agent – stop the image detection when clicking the pause button.
Clearfield Agent – will clear the fields in each attempt

faceDetectandCrop Agent used a famous face detection algorithm. In 2001, Paul Viola and Michael Jones introduced a technique to object detection known as "Viola-Jones object detection technique" [9]. This is known as the first object detection technique and possible to execute in real-time. Viola-Jones face detection technique needs four main ingredients Haar feature selection, integral image, AdaBoost and cascading to detect the face.

Figure3: Face detection phase.

Three consecutive face images have stored in the computer and more face images will enhance the recognition. This phase has been done by the visa granting process.

3.2 Face image and sensitive details stored in the database

Captured face images and sensitive data (passport id, name, address, mobile) have stored by database agent in MySql database. This database can be accessed in any destinations such as emigration/ immigration counters. 200 candidates have selected for the experiment and eight sample face images are shown below. Sources of the images are taken by authentic biometric samples in the embassy with permission.

Figure4: Eight candidates in the database. Sources: authentic biometric sample from the Embassy.

3.3 Face recognition phase

In this section, there are two important algorithms have used to face recognition; those are identified as PCA and LDA for feature extraction and dimension reduction respectively. There are few agents responsible in this phase.
faceDetect Agent – start to detect the face using webcam
imageRecognitionAgentPCA Agent – image recognition done by PCA algorithm
imageRecognitionAgentLDA Agent – image recognition is done by LDA algorithm
similerityccheck Agent – check the similarity using the distance function
dataLoder Agent – get the personal detail from database

As previously done in phase1 detection part will capture the image and filter it by using two recognition agents and check the similarity of images using Euclidian distance function.

Figure5: face recognition phase.

Face recognition has done by two algorithms as mentioned above; PCA and LDA Agents

A. *Principal Component Analysis (PCA) Agent*

Predictive analysis and explanatory data analysis used to transform high dimensional into low dimensional. Sizes of M x M training images are converted into low dimensional face images by applying PCA [9]. Principal components are known as correlated N variables into a set of uncorrelated k variables using a mathematical approach. This mathematical principle used to transform the set of correlated N face images into a set of uncorrelated K face images. This is called eigenfaces which used to represent the current and new faces.

B. *Linear Discriminant Analysis (LDA) Agent*

LDA is known as Fischer face method which can be used to reduce the limitation of PCA. Also, this method used for classification and discrimination [9]. LDA is an appearance-based method which can increase the recognition rate.

Both algorithm agents are used for face recognition and more accurate one selected by similarity agent. Similarity agent used most popular Euclidean distance function to check the similarity between testing image and training image [9].

4. RESULT AND DISCUSSION

Proposed system developed on the JADE framework as it can easy to develop and manage the agent behaviors in a comprehensive manner [17]. The proposed system has evaluated & compared with the traditional system and tested with 200 candidates who were applying for a visa for Schengen countries. All face images (300*300px) were captured by the same lighting condition and very less noise environment. Three face images are captured from each individual for training the system. Agents have done this in the face recognition phase with the help of OpenCV. OpenCV has been maximized to provide algorithmic efficiency especially for the processing of real-time applications.

4.1 Phase 1 results

Viola-Jones method was used to detect the image and cropping. After face detection results as follows:

Figure 6: after detecting face from images (intermediate step)

T= Traditional, M= Multi-agent, TP- True Positive, FP- False Positive, TN- True Negative, FN- False negative.

	Total face images	TP	FP	TN	FN	Detection Rate (%) TP/ TOTAL	Precision (%) TP/TP+FP	False Detection Rate (%) FP/TOTAL
T	200	121	13	8	58	60.5	97.58	6.5
M	200	171	12	5	12	85.5	93.44	6

Table 1 - Face Detection Results

Table 1 shows a higher number of detection rate using MAS than a traditional system. In the detection phase, both traditional and proposed systems are used the same algorithm but in a different way. Therefore, the detection rate more similar to traditional. Also, the authors are not expecting any improvements in the detection phase because it comes from the same algorithm. In practical, this has been done by visa grading process, which has even lighting condition and minimizes the facial expressions.

Authors have identified the reason behind the false rate due to the quality of webcam used in the practical scenario.

4.2 Phase 3 results

After the detected and cropped, images are ready for the recognition and this phase can be identified as a major part in the authentication process. PCA and LDA agents are used as face recognition and most accuracy agent will emerge from the system by the help of similarity Agent. Results and the intermediate face figures (eigenfaces) are shown in the below.

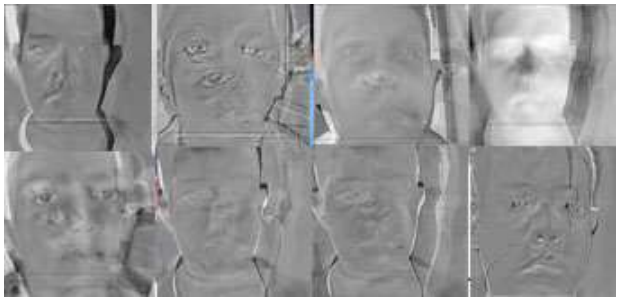

Figure 7: random eigenface images (intermediate step)

	Total images	TP	FP	TN	FN	Face Recog. Rate (%) TP/ TOTAL	Precision (%) TP/TP+FP	False face Recog. Rate (%) FP/TOTAL
T	200	171	10	1	18	85.50	94.76	5
M	200	191	4	2	3	95.50	96.44	2

Table 2 - Face Recognition results

Table 2 shows a higher number face recognition rate with the proposed system as predicted by authors. False-positive rates have identified the quality of webcam in practical.

	Total images	The average time is taken for face recognition (ms)
T	200	1230
M	200	560

Table 3 – Average Time taken for face recognition

The system itself calculates the average time consumption for face recognition and Table 3 shows significant improvement in the proposed system.

5. Conclusion

In this research paper, the researchers have proposed a multi-agent approach to face recognition in border control. The primary objective of this research was to provide an effective face recognition system to border control. In the above section, the researchers have brought into the attention of the reader, how to implemented the system and the accuracy in time-critical application. Viola-Jones algorithm was used to detect the face. PCA and LDA algorithm agents were used for face recognition phase. The overall system has been developed by MAS which can work with coordination and co-operation. It can be identified as the novelty of the system. After the implementation, accuracy was tested with comparing traditional system using 200 candidates. As observed in the experiment, MAS gives a higher rate of face recognition within a few seconds. The objectives of the research study were achieved to a significant level.

Although there may be some improvements, at the moment system works two face recognition algorithms. So the researchers willing to add more algorithm agents as it can give more accuracy in a time-critical environment.

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