Constructing an Efficient Wireless Face Recognition System by Swarm Intelligence

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ABSTRACT

This research was inspired by the need to increase the flexiblity and cost efficiency of a face recognition system by utilizing wireless sensor network for data transmission. Swarm intelligence is used to optimize routing in distributed time varying network by maintaining the required bit error rate for varied channel conditions while consuming minimal energy. Simulation shows the energy efficiency and accuracy of such a system.

1. INTRODUCTION

Face recognition system (FRS) usually has a centralized processing unit, and FRS gains great flexiblility if placing remote image acquisition devices near the region of interest (ROI) and accessing remote databases. However, wireless channels introduce bit errors from the channel fading etc, which must be taken into account. A successful face recognition system should tolerate the intra-personal variations while distinguishing the inter-personal variations; thus accurate and efficient data transmission is crucial in fulfilling this task. In this paper, a robust wireless face recognition system is constructed while optimizing the network transmission limited by constraints. These transmissions may require a single or multi hop wireless sensor network depending on the communication ranges and transmission powers.

Swarm Intelligence (SI) is very competitive in our particular application due to its discrete nature, fast convergence and global optima reachability, comparing with Genetic Algorithms (GA), Simulated Anealing (SA) etc. [1]. Therefore, SI is utilized to construct an efficient and accurate data routing scheme.

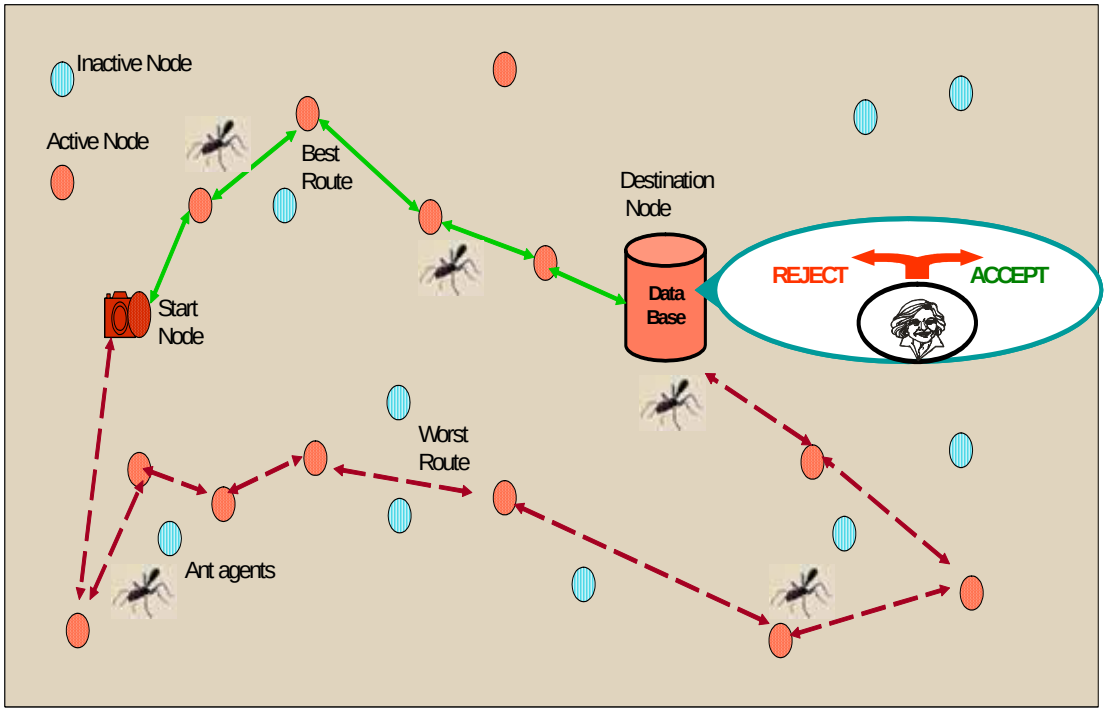

Fig. 1. Face Recognition System Using Wireless Sensor Network For Data Transmission.

2. SIMULATION RESULTS

A sensor network with 16 nodes is considered in this simulation run. Agents are randomly placed on the nodes. It is evident that more ant agents leads to less computation time and higher performance. To ensure fairness, the network consists of equal number of agents and nodes. The total hops for all simulations is assumed to be the same as the number of nodes in the network, that is 16. The actual number of hops is user defined, which varies depending on the problem assigned.

The predicted BER (bits/sec), energy and distance helps in making a decision whether the nodes in the current route are capable of communicating with its peers on the next iteration. The memory of the sensor nodes are very limited hence, the messages are limited to 10 per stack.

After the images are transformed by wavelets of contourlets for compression, the details coefficients are assigned higher priority to ensure more accurate transmission. The performance of prioritized transmission is evaluated by the mean square error of the reconstructed images. The performance is averaged over 1000 trials. The performance of coefficients v.s. original images is evaluate by the face recognition rate based on the distorted coefficients and images with manually added error, where the BER is ensured by the ant system transmission. After the transmission, the data (either coefficients or original images) are thresholded by Stein's thresholding method [2] for denoising.

Table I lists the mean square error of the reconstructed images with or without the prioritization setup. It also compares the contourlet compression and the wavelet compression [3]. The result shows that the contourlet compression is quite competitive to the wavelet compression, and it's slightly better in both cases [4]. Meanwhile, the prioritization of the coefficients realized by the ant system can decrease the MSE in both cases.

TABLE I.MSE COMPARISON OF THE COEFFICIENTS TRANSMISSION WITH OR WITHOUT PRIORITIZATION

	Prioritization	
Coefficients	**With**	**Without**
Contourlets	4.1349	4.3653
Wavelets	4.7108	4.9863

Table II lists the rank-1 face recognition rates based on different transmission schemes. The transmission of coefficients, either contourlets or wavelets, is more robust than transmitting the original images, because the compression compacts the information in fewer coefficients, and less prone to channel error; meanwhile, the prioritization preserves the most important information more accurately, and it improves the performance further. The contourlets scheme is slightly more robust.

Figure 2 shows the BER of DSSS-BPSK model for image coefficients with three different priority levels. The normalized BER for high priority coefficients is given by red circles, the normalized BER for the medium priority coefficients is denoted by yellow '+' and the normalized BER for the low priority coefficients is denoted by green '*' symbols respectively.

The BER achieved for high priority coefficients is much less compared to messages of low priority coefficients. Therefore the limited network resources are allocated more on the more important data and less distortion is exerted on the original message by channel.

TABLE II.**RANK-1 FACE RECOGNITION RATES BASED ON THE TRANSMITTED COEFFICIENTS AND IMAGES**

Contourlets		**Wavelets**		**Image**
With Prioritization	Without Prioritization	With Prioritization	Without Prioritization	
91.7949%	90.2564%	91.2821%	89.7436%	89.2308%

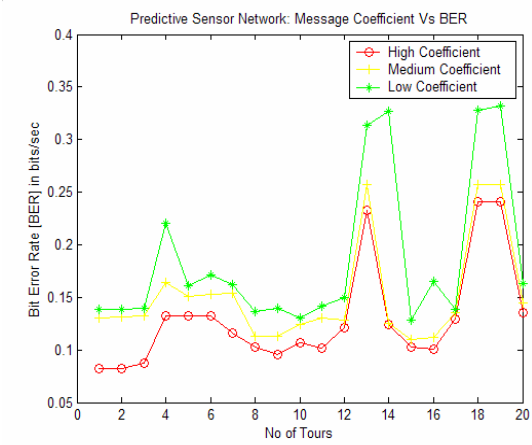

Fig. 2. BER v.s. Msg Coefficient: Routing in WFRS

After the analysis of the data transmission in the wireless sensor network, Figure 3 shows the classification performance of the face recognition system based on the transmitted wavelet coefficients. The contourlet coefficients achieve the same performance as the wavelet coefficients, therefore the curve is not shown.

In the traditional wired face recognition system, the data transmission is expected to be more reliable than the wireless transmission, and the 1st ranking face detection rate based on eigenface method is 94%. This paper proposes to use a wireless sensor network for data transmission to make the face recognition system more flexible in watching the dynamic region of interest, in the specific deployment of devices, and in sharing the face database. But with the extra link of wireless fading channel, the imperfect data transmission is lowering the 1st ranking detection rate down to 88% as shown by the blue dashed line in Figure 3.

However, if the contourlet or wavelet coding is first implemented to transform the image into coefficients to assign different priorities in transmission, more channel source is allocated to the more important data, and final 1st ranking detection rate can be still maintained at 94% as shown by the red solid line in Figure 3. The face recognition system provides not only the rank-1 candidate, but also other lower-rank possible identities. This property is useful for pre-screening and multiple combination with other modalities.

3. CONCLUSION AND FUTURE WORK

This paper proposes to use the ant system for routing the contourlet or wavelet coefficients of the face images to the processing center with minimum energy consumption and reliable transmission, thus the performance of the wireless face recogni-

tion system achieves 94% accuracy, the same performance of a wired system, with a short response time. Meanwhile, the wireless channel make the face recognition system more flexible, more efficient and still robust. Jamming attacks can make a sensor unsuitable for any kind of transmission, hence choosing FHSS and DSSS helps in avoiding denial of service attacks (DoS) to an extend.

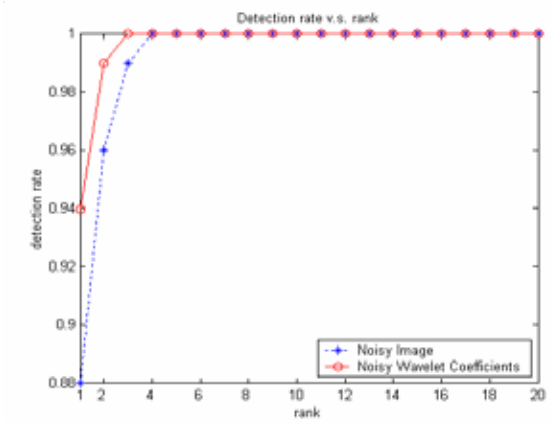

Fig. 3. Face Detection Rate v.s. Ranking

In the future, diversity schemes can be used for higher transmission accuracy. A combination of artificial intelligence and evolutionary algorithm increases the performance of the system. Hence, Bayesian network could be introduced to enhance the learning ability of the ant system. The sensor nodes considered here are assumed to be under a secure environment, which is not true in reality. Secure transmission of messages under worm hole and sybil attack[5] need to be considered as future work. Knowledge of different jammers and predicting the attacks keeps the network efficient and reliable. This security feature will also be added to the Wireless Face Recognition System, making the network secure, reliable and efficient.

4. REFERENCES

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