Design and Simulate an Efficient Algorithm for Biometric Recognition in Wireless Sensor Network Based on Hybrid Technique

Matheel E. Abdulmunem Ph.D (Asst.Prof.)* Fatima B. Ibrahim (Lecturer) **

Abstract

The need for a flexible and cost effective biometric security system is the inspired of this paper. Face recognition is a good contactless biometric and it is suitable and applicable for Wireless Sensor Network (WSN). Image processing and image communication is a challenges task in WSN due to the heavy processing and communication that reduce the life time of the network. This paper proposed a face recognition algorithm on WSN depending on the centralized algorithm principle that carry the load of the work to the sink node and compress the communication data to 87.5%. An efficient hybrid algorithm is proposed based on the benefit of wavelet decomposition to extract the most distractive features of the face and Eigen face method to classify faces according to the minimum distance with feature vectors on a flat architecture to the WSN with gossiping routing protocol. An Excellent recognition rate is achieved reaching to 100% with a minimum computation time.

Keywords: Wireless Sensor Network, Principle Component Analysis, Discrete Wavelet Transform, Haar family, Routing protocol.

* University of Technology
** Baghdad University

1- Introduction

Wireless Sensor Network (WSN) is modeled of tiny motes that have the ability to sense and extract the nearby environmental features; these features are processed locally with limited computing resources and wirelessly transmitted to the base station or sink [1, 2]. These sensors may measure scalar physical phenomena, like pressure, Infrared IR, humidity, gas temperature …etc. Most of these applications have low bandwidth demands and delay tolerant [1, 3].

This kind of WSN is called Wireless Scalar Sensor Network (WSSN), another stream branch is developed ,which is called Wireless Multimedia Sensor Network (WMSN), the data sensed to be more complex like a stream video [4], visual data forms give a well knowledge for the networks' environment [5]. The availability of Complementary Metal-Oxide Semiconductor (COMS) cameras and small microphones, which are inexpensive, make this trends possible and growth the area of the applications that are treated by the WSN as well as strengthen them like road traffic, surveillance, security, health care and many others [1, 3, 5].

WSN integrated with pattern recognition applications is employed in many fields like smart home. El-Basioni, Abd El-kader and Abdelmonim [6] proposed a wireless biometric smart home design employing WSN and biometrics as an authentication, their system is flexible and easy in installation but also have several limitations like frequently transmitted data.

Xiang [7] proposed a design for smart home based on WSN and the technology of Internet of Things, his work is a window on employing WSN applications to be monitored remotely.

Althobaiti, Al-Rodhaan and Al-Dhelaan [8] exploited the biometric recognition on WSN to exploit a biometric user authentication protocol for legitimately access control in WSN, they use the user iris to regenerate the user's key on-the-fly every time the user wants to be authenticated.

Park, Choi and Lee [9] developed a facial recognition system using a mobile terminals and smart phones; the whole face image is send to the PC server.

Arpra [10] utilized PCA using Eigen faces approach to develop a real time application of face recognition.

2- Wireless Sensor Network Architecture

The hardware technology progression in processors of low cost, low power and small size is the motivation of the development of WSN. An individual sensor node has some limitations in energy, memory, antenna and processing capability. Figure 1 shows the typical architecture of a sensor node [11]

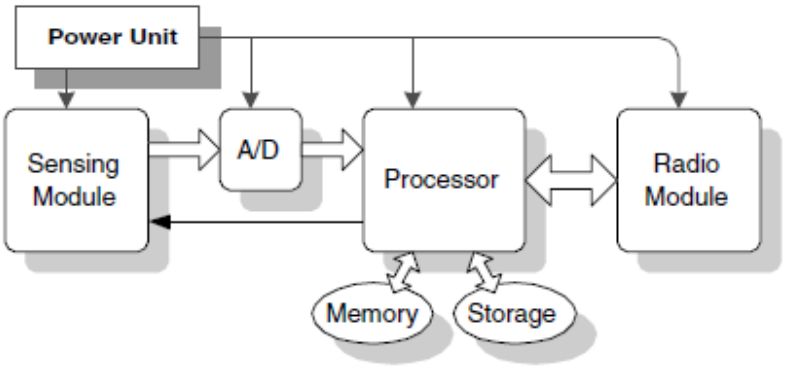

Figure 1 :Architecture of sensor node.

The important component of sensor node is the battery. Battery must be distributed properly that the life of the sensor node depends on it [12].

Fundamentally WMSN network architecture as shown in Figure 2 can be generally categorized into three classes relying on what is the natural of the application desired is, they are:[1, 3].

- Single-tier flat architecture having homogeneous sensors.
- Single-tier clustered architecture having heterogeneous sensors.
- Multi-tier heterogeneous architecture with heterogeneous sensors support.

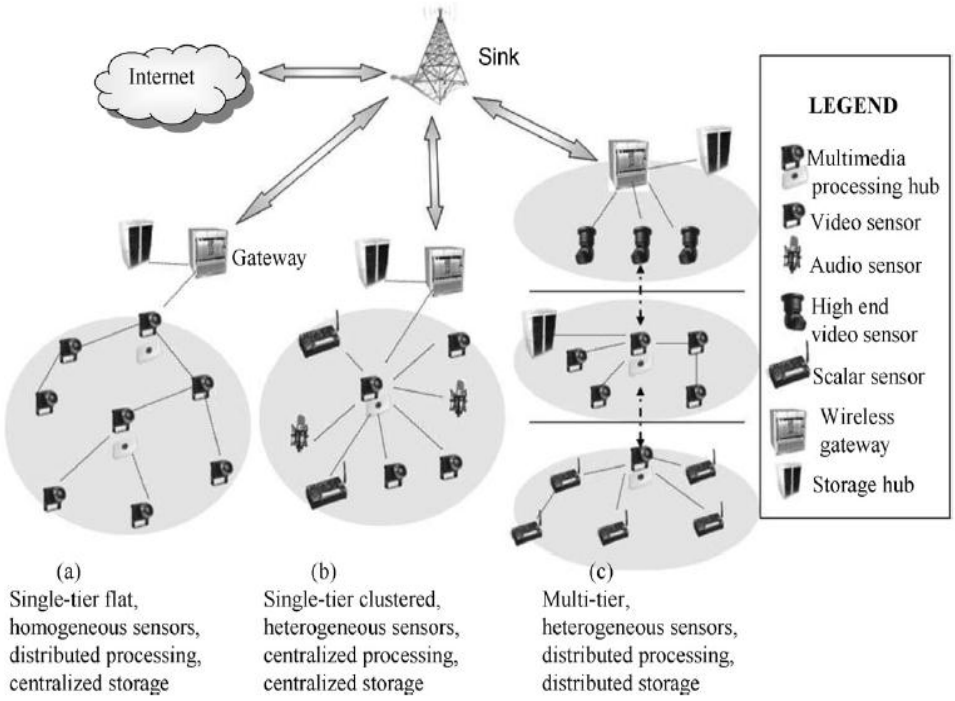

Figure 2: Architecture of WMSN**.**

Generally, routing in WSNs can be grouped into kinds of flat-based routing, hierarchical-based routing, and adaptive-based routing. In flat-based routing, all nodes in the network are assigned to the same roles or functions. In hierarchical-based routing, on the other hand, not all the network nodes are assigned to the same roles or function sin the network. In adaptive routing, definite system criteria's are considered in an attempt tobe suitable for the network's current circumstances and existing energy levels [11, 12, 13].

Flooding is the simplest routing technique which has been designed for multi-hop networks. In flooding, whenever a node receives a packet, it sends out the received packet to all of its neighbors. This routing technique has the flaws of implosion. To overcome the implosion problem the gossiping protocol was proposed. Gossiping protocol sends data to one randomly selected neighbor. The energy consumption of gossiping protocol is less than that of flooding as it avoids the replicated copies of packet [11, 13, 14].

Sensor networks must control in autonomous manner that is obviously clear to address the network challenges of new technological and optimization. Besides, with the intention of addressing low-energy, privacy, security, and scalability issues better,

wireless sensor networks will have need of new styles of algorithms that will usage least amounts of communication [11].

Centralized algorithms in wireless ad hoc sensor network are processes in which way that the whole entire information from all nodes in the network is first collected together at a single, particular, ordinarily predetermined, node. The problem is solved at this node and accordingly the consequences of the optimization are distributed to all nodes that demanded this information [11].

3- Face Recognition techniques

The standing face recognition algorithms are generally grouped into three categories depending on what are the features processed as holistic, local and hybrid. [15] Principle Component Analysis PCA is an operative method for holistic face recognition methods. It is proposed and developed by Turk and Pentland. PCA is depending on computation of Eigen values and Eigen vectors [16].

The accuracy of the face recognition system is influenced hardly by feature extraction way to characterize and classify the face image. It is significantly to reduce the dimensionality of the involved image [17]. Discrete Wavelet Transform DWT is efficient in this domain. In achieving a hybrid method, the benefit of both holistic and local methods is composed. This is motivated by the human recognition manner.

4- The proposed face recognition algorithm

The proposed system depends on moving the computation load to the base station (sink node) and to reduce the data that travel in the network as much as possible to send a useful data. The work is subdivided into two stages. **The first** is design the framework of the network. The workshop is considered to be a building with several entries each entry has a sensor node with camera that has the ability to capture the face image, and a sink node which is considered to be approximately in the center of the building with several other nodes. The gossiping routing protocol is selected to simulate this network. The assumption of the simulation parameters is shown in table 1. **The second** stage in the application level, hybrid face recognition algorithm is developed to appropriate the WSN challenges with work tends to centralized algorithms.

The overall procedure of the work from sensing the face image through the acknowledgment of accepting or refusing the face is described in Algorithm 1.

Algorithm 1: The proposed scenario algorithm

Input: The captured face image of the desired authenticated person.

Output: Acceptance /Refused authentication response for the desired face.

Begin

Step1: In the sensing node, the face image is capture.

Step2: In the sensing node, the face image is compressed by DWT up to five levels producing a small set of face features.

Step3: These small set of features is send from the sensing node to the sink node using the Gossiping routing protocol.

Step4: In the sink node, the set of the face feature is received.

Step5: In the sink node, the set of the face feature is applied to the PCA algorithm to produce the corresponding Eigen face.

Step6: In the sink node, Euclidean distance as distance measure is used to compute the similarity between the computed Eigen face and the stored Eigen faces in the database.

Step7: If the face is accepted, an accepted authentication response is send back to the sending node; else if it is not accepted a refused response is send back.

End.

The proposed recognition algorithm attains the benefit of DWT and PCA techniques as a compression and recognition techniques.

PCA algorithm is used as a good algorithm for face recognition that dealt with the whole face without needing to the knowledge of the geometry of the face. As well as it is not influenced with the factors of illuminations, shifting and rotation of the face and different facial expressions. So it is a good recognition technique.

Although this technique in its mathematical computations depends on reduction space principle, it has a heavy load of computations to compute the Eigen vector and Eigen value. To reduce this heavy load of computation, the data used in computation of Eigen vector and Eigen value must be reduced. The compression technique is used for this purpose. The face image is compressed with keeping the

main facial traits that are useful to recognize the face. DWT is used for this objective. DWT depends on subdividing the image into details and approximation sub-images. The approximation portion has the important and descriptive features of the face. Applying the face image to multilevel of DWT, reduce the data substantially and maintain the descriptive traits.

Finally, this feature which it is substantially smaller than the face image is used to find the Eigen face to recognize and classify the face.

Haar wavelet is chosen for its attributes of simplicity and speed. It is memory efficient, that it can be computed in place without temporary array [18]. Haar wavelet is defined by the formula [19]:

$$\Psi(t) = \begin{cases} 1 & for\ t\epsilon[0,\frac{1}{2}] \\ -1 & for\ t \in [\frac{1}{2},1] \\ 0 & otherwize \end{cases} \quad \ldots(1)$$

Energy is an important aspect of WSN. Receiving and sending a message is a cost operation for energy which takes the most energy of node. The proposed protocol takes the following arithmetic model to compute the power consumed:

$$E_nT(K) = E_{elec} * K + E_{amp} * K.d^2 \quad \ldots (2)$$

$$E_nR(K) = E_{elec} * K \quad \ldots (3)$$

Where E_{elec} is the transmitter electronic that the energy waste for receiving and transmitting per bit, E_{amp} is the transmit amplifier that the energy needed per bit per square meter to accomplish satisfactory Signal to Noise Ratio (SNR), d is the distance from sender node to receiver node, K is the packet size in bit [20].

First of all the system is designed to distribute thirty nodes in a building of 30m X 30m in a way that regard to put in every entry to the building a sensor node with a camera sensor. The sink node is considered to be in the center of the building. The limit of transmission of each node is 15m. The simulation parameters of the Gossiping routing protocol is listed in table 1.

Table 1: Simulation parameters of Gossiping routing protocol.

Parameter	value
Building Area (meter)	30mX30m
No. of nodes	25
Packet data size	2700 bit
No of transmission packets	100
Limit of transmission distance (meter)	15m
E_{elec}	50nj/bit
E_{amp}	100pj/bit/m^2

5- Experimental Results

The software to simulate and implement the proposed work is Matlab® 2010a. For testing the proposed hybrid face recognition algorithm the database FACES94 is used. The database has images of 123 individuals grouped to male, female and male_staff each has 20 image taken while he/she is spoken with a little variation to positon. The image resolution is 180×200.

At the first of all the system is trained offline on the base station. Different subsets from the database are used with different number of images.

Figure 3 shows the mean image for training 10 classes each with 10 training image using PCA with level 5 DWT method.

The network simulation parameters are shown in table 1 and the distribution of nodes in the network is shown in figure 4. The source node is sensed the face image which is considered 180X200, then apply 5 level DWT using Haar family making the facial value 7X6. This facial value is traveled in the network to reach the base station where the remaining computation is down and acknowledgment to accepting or refusing is stated.

The threshold value depending on Euclidean distance of the image from the stored weights as a similarity measure is small enough to enforce the system to reject unauthorized individuals. Figure 5 shows the Euclidean distance of a testing image by PCA with level 5 DWT. It is showing that the classes is discriminatory classified.

With this reduction of data and the distribution of the nodes the network lifetime is maintained. This is shown in figure 6 that reveal 23 nodes are still alive after sending 100 packets in the network. Figure 7 shows that the remaining average energy is above 0.36 that affects the efficiency of the proposed algorithm in power saving and maintaining network lifetime.

The cumulative simulation time of the network in the above parameters do not across 0.14 second which it is a good result. This is shown in figure 8. The network behavior in selecting multiple paths to deliver the packets is good to maximize the network time. This is clear in the number of hops used for end-to-end delay. Figure 9 shows end to end delay that has at most 2 hops.

Table 2 shows the details of the reduction of data transmitted and the corresponding recognition rate for face recognition in different DWT levels.

Figure 3 :mean image for training

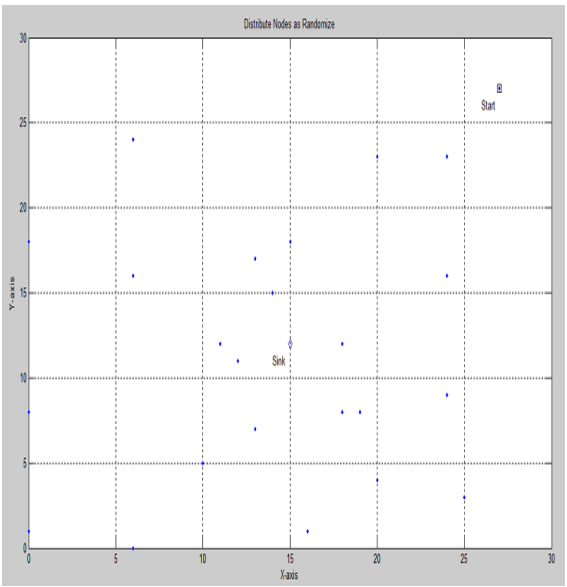

Figure 4: Network nodes distribution

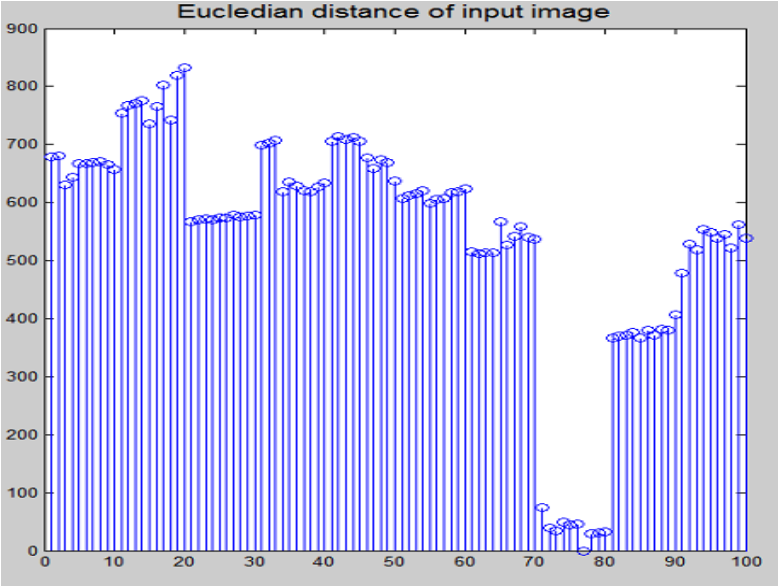

Figure 5: Euclidean distance of a tested image with Eigen faces of PCA with level 5 DWT method

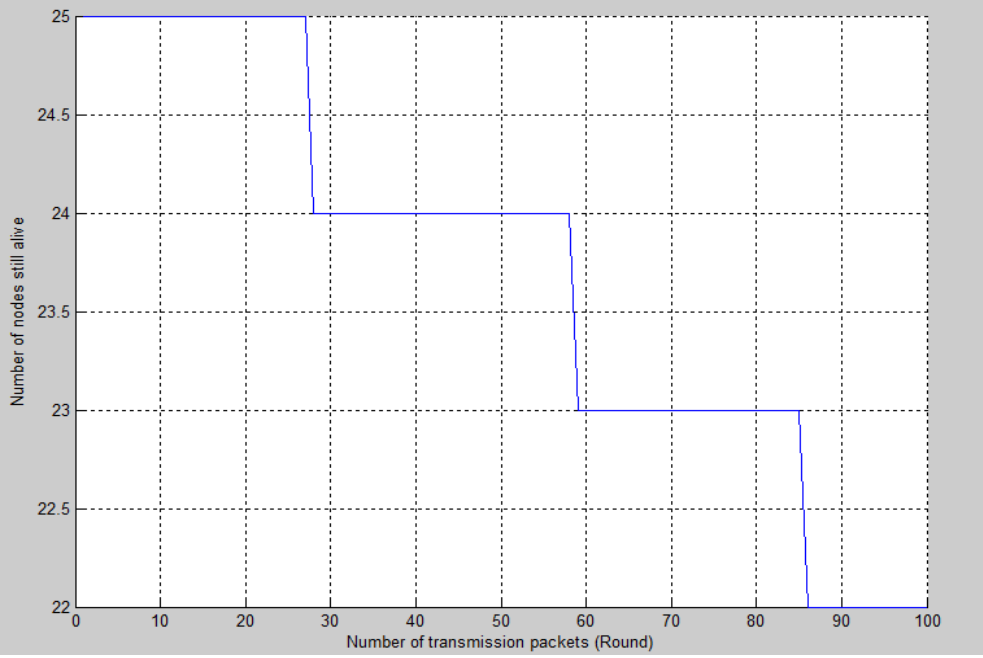

Figure 6: Number of still alive nodes.

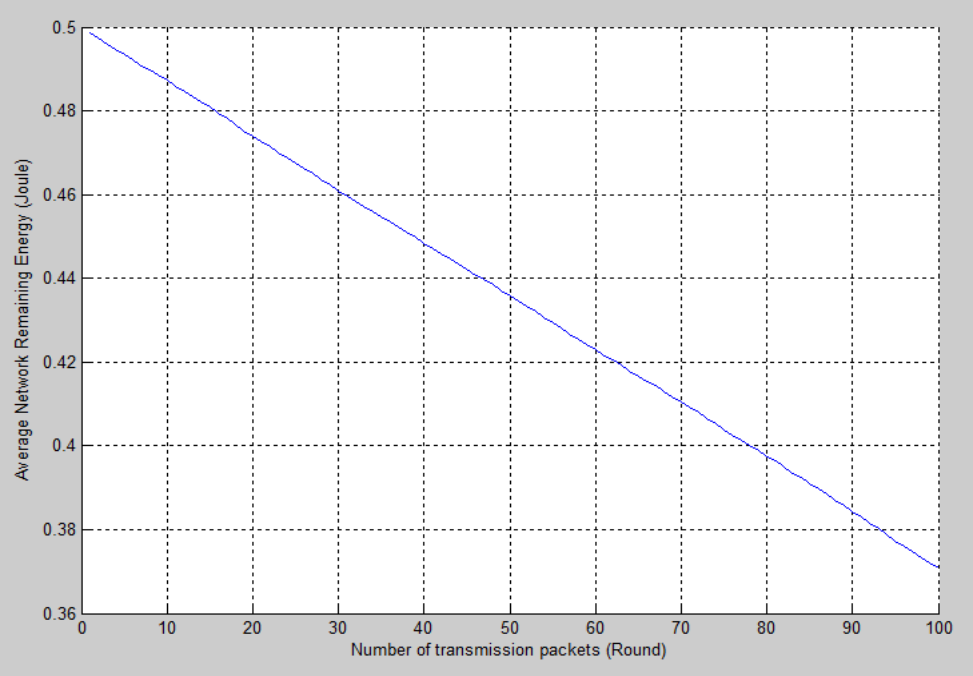

Figure 7: Average remaining network energy.

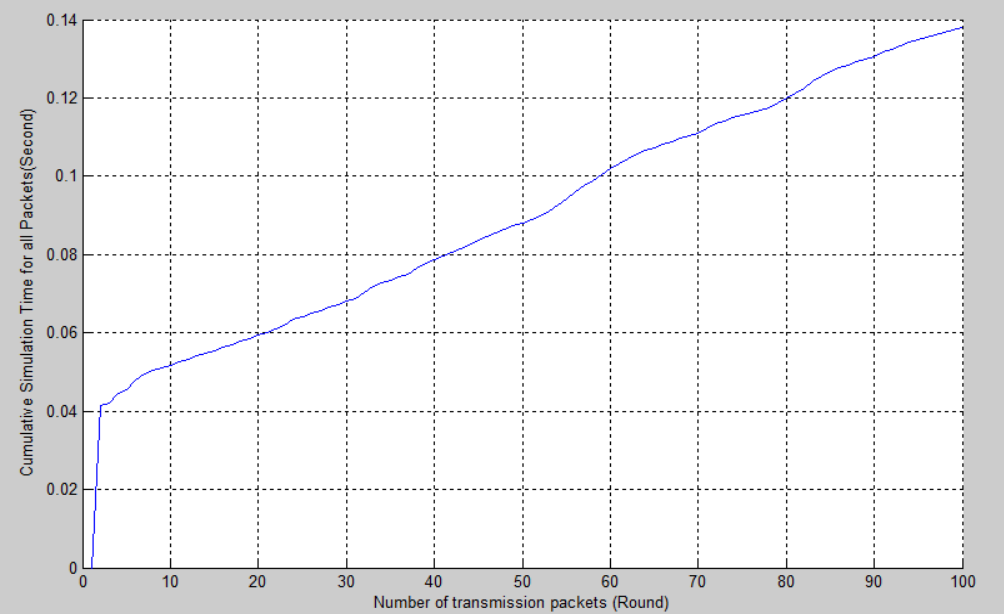

Figure 8: Cumulative network simulation time.

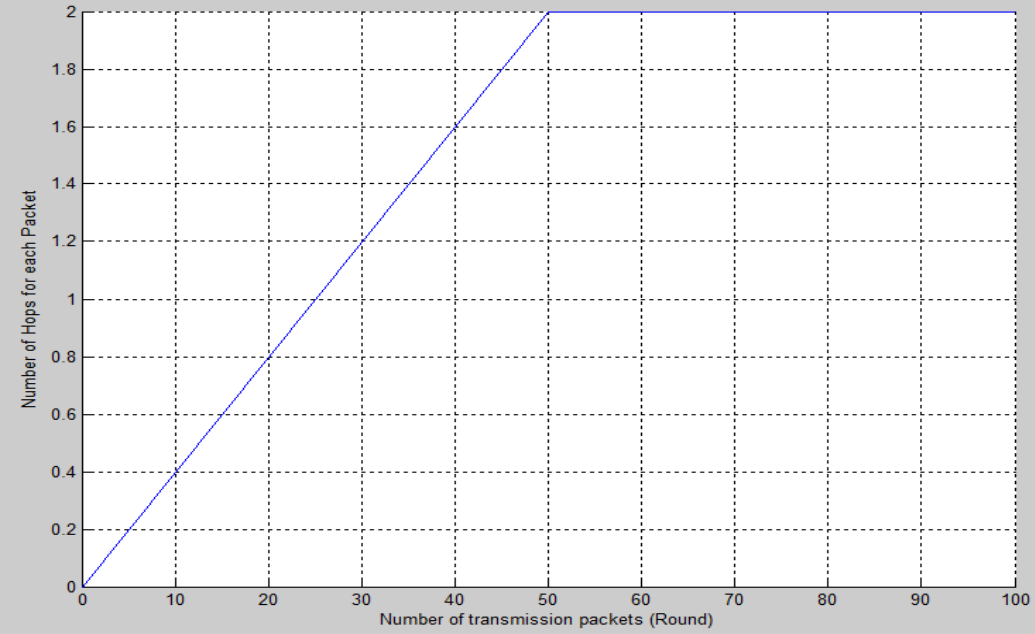

Figure 9: End to end network delay (number of hops).

6- Conclusions

This paper has presented a hybrid face recognition technique used on WSN. The system depends on centralized algorithm principle that move the load of the work to the base station which it is in fact has more facilities than other network nodes that seems to have less power challenges and faster hardware processor. Choosing Haar family is good due to its simplicity and memory efficiency use that leads to simplify the computation on the node to reduce the power consuming. As communication is the most power consuming part for the network, the algorithm stands to reduce the transmitted data up to 850 times. The computation time in the base station node becomes faster 87.5% than the particular PCA algorithm.

The simplicity and speed of the suggested hybrid algorithm with the strong recognition of 100% dives it the tendency to be implemented on a low cost hardware.

In future the algorithm can be evaluated with different challenges applications like real time environmental challenges. This algorithm also can be evaluated in a Biometric Authentication protocols in WSN.

Table 2: Transmission data size and training time for different levels of decomposing DWT.

	Data size	Transmitted data size in byte without header	Time to compute the Eigen faces	Recognition Rate
Original Image	200X180	36000	≅ 30.02 sec.	98%
After level 1 DWT	100X90	9000	≅ 12.01 sec.	98.8%
After level 2 DWT	50X45	2250	≅ 10.3 sec.	98.8%
After level 3 DWT	25X23	575	≅ 9.87 sec.	100%
After level 4 DWT	13X12	156	≅ 9.07 sec.	100%
After level 5 DWT	7X6	42	≅ 2.89 sec.	100%

7. References:

[1] Shafif, Atif. Potdar, Vidyasagar. Chang, Elizabeth. **2009**. *Wireless Multimedia Sensor Network Technology: A Survey*. 2009 7th IEEE International conference on Industrial Information (INDIN). pp: 606-613.

[2] Misria, ‘’satyajayant. Resslein, Martain. Xue, Guoliang. **2008**. **A Survey of Multimedia Streaming in Wireless Sensor Networks**. IEEE Communication surveys and tutorials. 10(4). pp: 20-39.

[3] Akyildiz, Ian F.Melodia, Tommaso. Chowdhury, Kaushik R.**2007**. *A survey on wireless multimedia sensor networks*. Computer Networks (Elsevier). 51.pp: 921-960.

[4] Gueuerrero-Zapata, Manal. Zilan, Ruken. Ordinas, Jose M. Blackci, Kemal. Tavli, Bulent. **2010**. *The future of security in Wireless Multimedia Sensor Networks*. Telecommunication System (Springer). 45(1). pp: 77-91

[5] Downes, Ian. Baghaei, Leli. Aghajan, Hamid. **2006**. *Development of a Mote for Wireless Image Sensor Networks.* In Proc. of Cognitive Systems and Interactive Sensors (COGIS). Paris.

[6] El-Basioni, Basma. El-Kader, Sherine. Abdelmonim, Mahmoud. **2013**. *Smart Home Design using Wireless Sensor Network and Biometric Technologies.* International Journal of Application or Innovation in Engineering and Management (IJAIEM). 2(3). pp: 413-429.

[7] Xiang, P. **2012**. *Design of smart home system based on the technology of Internet of things.* Research Journal of Applied Sciences, Engineering and Technology. 4(14). pp: 2236-2240.

[8] Althobaiti, Ohood. Al-Rodhhaan, Mznah. Al-Dhelaan, Abdullah. **2013**. *An Efficient Biometric Authentication protocol ffor wireless sensor Networss*.

International Journal of Distributed Sensor Networks (Hindawi). vol. 2013, Article ID 407971, 13 pages.

[9] Park, Yoon Young. Choi, YougKeum. Lee, KyungOh. **2014**. *A Study on the design and implementation of Facial recognition application system.* International Journal of Bio-Science and Bio-Technology. 6(2). pp: 1-10.

[10] Arora, Kandla. **2012**. *Real Time application of face recognition concept*. International Journal of soft computing and engineering (IJSCE). 2(5). pp: 191-196.

[11] Ilyas, Mohammed. Mahgoub, Imad. **2005**. *Handbook of sensor networks: compact wireless and wired sensing systems.* CRC PRESS.

[12] Jangra, Ajay. Swati. Richa. Priyanka. **2010**. *Wireless Sensor Network (WSN): Architectural Design issues and Challenges*. International Journal on Computer Science and Engineering (IJCSE). 2(9). pp: 3089-3094.

[13] Singh, Shio Kumar. Singh, M P. Singh, D K. **2010**. *Routing Protocols in Wireless Sensor Networks- A Survey.* International Journal of Computer Science and Engineering Survey (IJCSES). 1(2). pp: 63-83.

[14] Jain, Sanjolly. Grover, Amit. **2014**. *Routing Techniques in Wireless Sensor Networks*. International Journal of Computer Applications. 92(6). pp: 15-20.

[15] Cho,H. Roberts,R. Jung,B. Choi,O. Moon,S. **2014**. *An efficient Hybrid Face Recognition Algorithm Using PCA and Gabor wavelets.* International Journal of Advanced Robotic Systems.

[16] Turk,M. Pentland,A. **1991***. Eigenfaces for recognition*. Journal of Cognitive Neuroscience. 3(1) ,pp:71-86.

[17] Satone,M. Kharate,G. **2013**. *Comparative Study of multiresolution Analysis and Distance Measures for face recognition.* International Journal of Signal Processing Systems. 1(1), pp: 34-38.

[18] Tamboli, S. Udupi, V. **2013**.*Image Compression Using Haar Wavelet Transform.* International Journal of Advanced Research in Computer and Communication Engineering, 8(2), pp:3166-3170.

[19] Jain,s. Bhati,D. **2013***. Face Recognition Using ANN with Reduce Feature by PCA in Wavelet Domain.* International Journal of Scientific Engineering and Technology, 2(6), pp: 595-599.

[20] Heinzelman, W.R. Chandrakasan, Ananth. Balakrishnan, Hari. **2000**. *Energy-Efficient Communication Protocol for Wireless Microsensor Networks*. in Proc. Hawaii Int. Conf. Syst. Sci. (HICSS-33). 2. pp: 1-10.

[21] TheDatabase of FACES94, http://cmp.felk.cvut.ci/space lib/faces/faces94.html.

تصميم و محاكاة خوارزمية تتسم بالكفاءة للتعرف على العلامات الحيوية في شبكات الاستشعار اللاسلكية معتمدة على تقنية هجينة

أ.م.د.مثيل عماد الدين عبد المنعم* م. فاطمة بهجت ابراهيم **

المستخلص

إن الحاجة الى نظام امني مرن و فعال من حيث التكلفة يعتمد العلامات الحيوية هي الدافع لهذا البحث. إن تمييز الوجوه هي طريقة حيوية جيدة بدون تماس وهي مناسبة و قابلة للتطبيق على شبكات الاستشعار اللاسلكية. إن معالجة الصور و نقلها هي مهمة تتسم بالتحدي في شبكات الاستشعار اللاسلكية نظراً الى العمليات و الاتصالات الثقيلة التي تحتاجها و التي بدورها تقلل من مدة حياة الشبكة. في هذا البحث أُقترح خوارزمية لتمييز الوجوه مناسبة لشبكات الاستشعار اللاسلكية تعتمد على مبدأ الخوارزميات المركزية التي تقوم بنقل ثقل العمل الى العقدة المركزية و تضغط بيانات النقل الى 87.5%. اقترحت خوارزمية كفوءة هجينة, التي تعتمد على الاستفادة من خواص تحليل المويجات بإستخلاص اهم الصفات المميزة للوجه و طريقة القيم الذاتية للوجه و تصنيف الوجوه حسب أقل مسافة مع متجهات الصفات المميزة حيث طبقت على شبكات استشعار لاسلكية بمعمارية مستوية معتمدة برونوكول التوجيه Gossiping. و تم الحصول على نسبة تمييز ممتازة تصل الى 100% مع اقل وقت حسابات.

الكلمات المفتاحية: شبكات الاستشعار اللاسلكية , تحليل المكونات الاساسية , تحويلة المويجات المتقطعة , عائلة Haar , بروتوكولات التوجيه.

* الجامعة التكنلوجية
** جامعة بغداد