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Propose an Efficient Face Recognition Model in WSN Based on Zak Transform

Matheel Emaduldeen Abdulminuim
Department of Computer Science, University of Technology, Baghdad, Iraq.

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 principles of the unique algorithm that hold the capacity of the network to the sink node and compress the communication data to 89.5%. An efficient hybrid method is introduced based upon the advantage of Zak transform to offprint the farthest different features of the face and Eigen face method to assort acceding to the minimum value of the 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, Zak Transform, Routing protocol.

افتراض موديل لتمييز الوجوه في شبكات التحسس اللاسلكية بالاعتماد على النقل زاك

مثيل عمادالدين عبد المنعم

قسم علوم الحاسوب، الجامعة التكنولوجية، بغداد، العراق.

الخلاصة

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 89.5%. اقترحت خوارزمية كفوءة هجينة، التي تعتمد على الاستفادة من خواص النقل زاك بإستخلاص اهم الصفات المميزة للوجه و طريقة القييم 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.

Email: matheel_74@yahoo.com

Introduction

Wireless Sensor Network (WSN) is modeled of tiny motes that have the ability to sense and extract the nearby environmental features [1]; these features are processed locally with limited computing resources and wirelessly transmitted to the base station or sink [2, 3]. 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 [4, 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.

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].

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 can be generally categorized into three classes relying on what is the natural of the application desired is, they are [13, 14]:

- Single-tier flat design with similar sensors.
- Single-tier collect design having diverse sensors.
- Multi-tier collect design with diverse sensors upholding.
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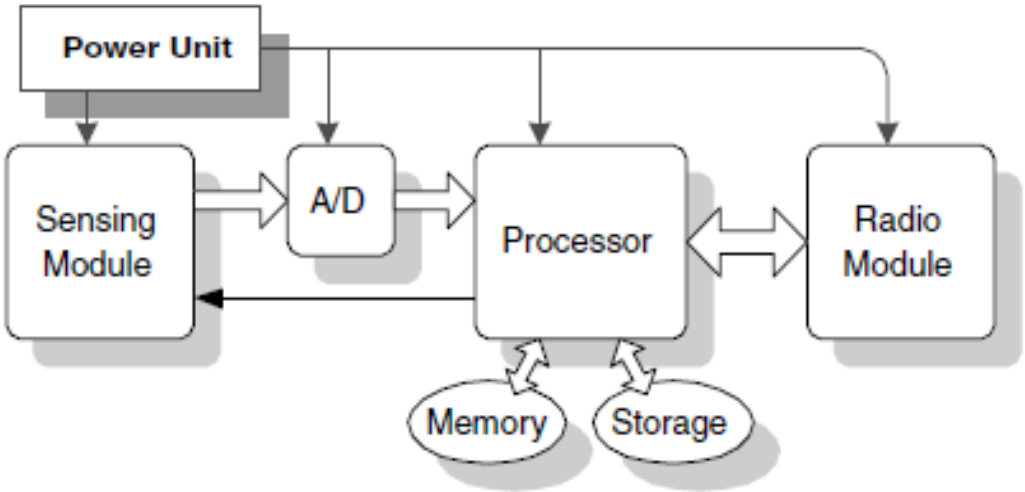

Figure 1 - Architecture of sensor node.

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 [15].

Face Recognition (FR) Techniques

The blockdiagram represents the essence of FR system that is appeared in Figure- 2; this is without using the wireless sensor NWs. Besides, the faces of the recorded users are treated into molds of hand drawn by special steps to the FR system, and these molds are saved. The molds has an ability to observe as the converted user portraits coded using conformable transformation strategies. The transformation strategies and the molds are detected at the same time[16].

In investigation step, the FR system extradites a brand new image; this image is store the new image by an equivalent formula, and matches to the models. The choice methodology would possibly incorporate every kind of classifiers. If the classifier could also be a learning formula and its structure ought to be trained a bit like the neural network or theorem network, the enrollment information is in addition split into a try of elements, one for constructing the templates, and one for learning the classifier structure [17, 18].

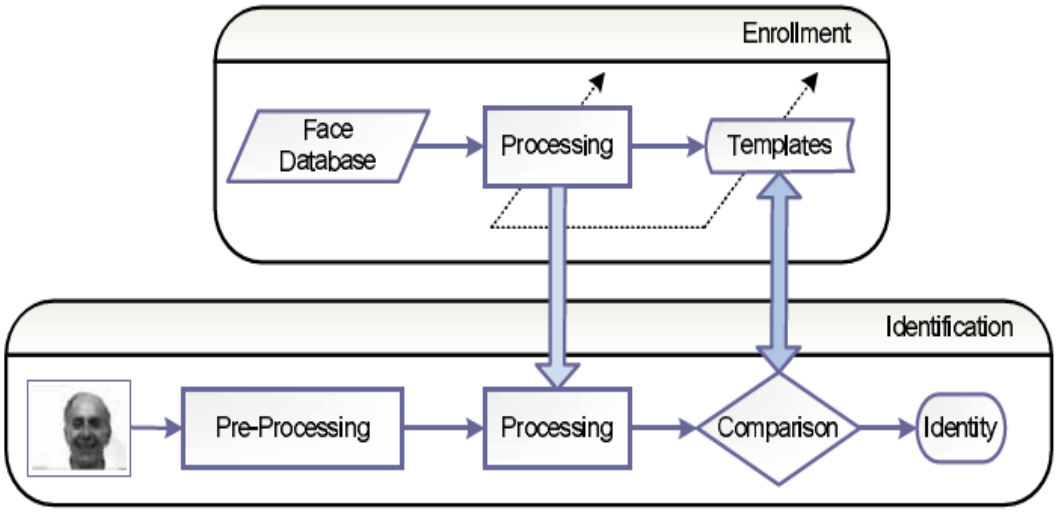

Figure 2-The block diagram of the initial face recognition strategy.

FR methodologies are often roughly classified into the subsequent classes [19-21]:

- Template based: A typical template-based technique is PCA based Manfred Eigen face technique, that uses holistic info of the face.
- Feature based: this area unit characterization or measurements of native face expression like mouth, lips, eyes and nose for immediate rapprochement.
- Rule based: A learning rule, like Support Vector Machine (SVM), call tree, neural network or Bayesian network, is trained on the gettable dataset that constitutes a certain or implicit set of rules.
- Module based: Facial modules unit of measurement equally printed or detected as native choices, but modules unit of measurement analyzed as independent components. The choices, scores or picks from modules are going to be put together combined on to attain a amalgamate result. The fusion at every score level and decision level is shown to reinforce the recognition performance.

Zak Transform

In arithmetic, the Zak remodel may be a sure operation that takes as input a perform of 1 variable and produces as output a perform of 2 variables. The output perform is named the Zak remodel of the input perform.

The remodel is outlined as associate degree infinite series within which every term may be a product of a dilation of a translation by associate degree number of the perform associate degreed an exponential. In applications of Zak remodel to signal process the input perform represents a

symbol and therefore the remodel are a mixed time–frequency illustration of the signal. The signal is also real valued or complex-valued, outlined on a nonstop set (for example, the important numbers) or a separate set (for example, the integers or a finite set of integers). The Zak remodel may be a generalizationofthe separate Fourier remodel [22].

The Zak remodel had been discovered by many individuals completely different in several numerous fields and was referred to as by different names. It had been referred to as the "Gel'fand mapping" as a result of I.M. Gel'fand introduced it in his work on Manfred Eigen perform expansions. The remodel was rediscovered severally by J. Zak in 1967 United Nations agency referred to as it the "k-q representation". There looks to be a general consent among consultants within the field to decision it the Zak remodel, since Zak was so the primary to consistently study that remodel in a very additional general setting and acknowledge its quality. Within the following it'll be assumed that the Zak remodel has the subsequent properties [22]:

1. Linearity

Let *a* and *b* be any real or complex numbers. Then:

$$Z[af + bg](t, w) = aZ[f](t, w) + bZ[g](t, w) \quad (1)$$

2. Periodicity

$$Z[f](t, w + 1) = Z[f](t, w) \quad (2)$$

3. Quasi-periodicity

$$Z[f](t + 1, w) = e^{2\pi wi} Z[f](t, w) \quad (3)$$

4. Conjugation

$$Z[\bar{f}](t, w) = \overline{Z[f]}(t, -w) \quad (4)$$

5. Symmetry

If $f(t)$ is even then $Z[f](t, w) = Z[f](-t, -w)$ (5)

If $f(t)$ is odd then $Z[f](t, w) = -Z[f](-t, -w)$ (6)

6. Convolution

Let * denote convolution with respect to the variable *t*.

$$Z[f \star g](t, w) = Z[f](t, w) \star Z[g](t, w) \quad (7)$$

The Zak transform has been used with success employed in physics in quantum theory, in engineering science in time-frequency illustration of signals, and in digital knowledge transmission. The Zak transform has conjointly applications in arithmetic. For instance, it's been employed in the Dennis Gabor illustration downside [23].

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 is the proposed face recognition algorithm that 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 the following proposed procedure steps.

Input: Color face image to the authorized user.
Output: Accept or reject the authorized user face response.
Begin
Step1: In the sensing node, the camera captures the face image.
Step2: In the sensing node, Zak transform was used to computer Gabor coefficients of images to produce image features.
Step3: The features calculated from step 2 are transmitted 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 and reconstruct images from those coefficients.
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 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, associate degree accepted authentication response is remit to the causing node; else if it's not accepted a refused response is remit.
End.

The proposed recognition algorithm attains the benefit of Zak transform to compute the coefficients efficiently as one see to its properties and using PCA techniques as a recognition technique. Figure- 3 describe the steps of adding Zak transform.

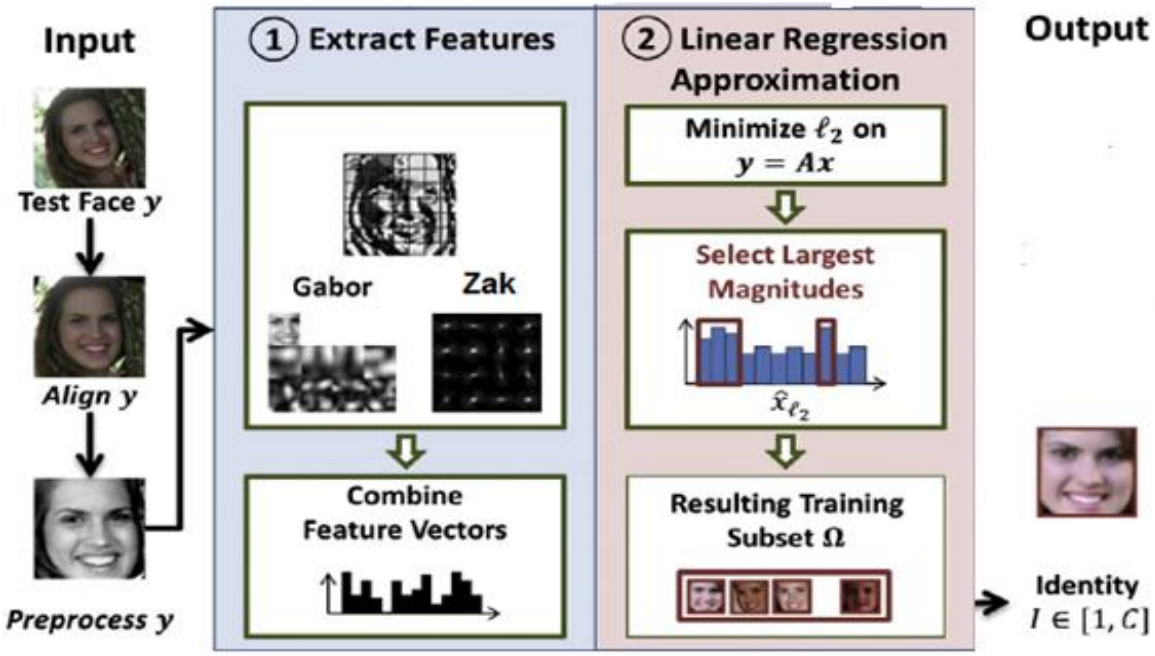

Figure 3-The Block diagram of the proposed procedure.

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. 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.

Energy is a vital side of WSN. Receiving and causation a message could be a price operation for energy that takes the foremost energy of node. The projected protocol takes the subsequent arithmetic model to calculate the ability consumed:

$$E_nT(K) = E_{elec} * K + E_{amp} * K.d^2 \quad (8)$$

$$E_nR(K) = E_{elec} * K \quad (9)$$

Where E_{elec} is that the transmitter electronic that the energy waste for receiving and transmission per bit, E_{amp} is that the transmit electronic equipment that the energy required per bit per area unit to accomplish satisfactory Signal to Noise Ratio (SNR), d is that the distance from sender node to receiver node, K is that the packet size in bit.

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

Experimental Results

For testing the projected hybrid face recognition algorithmic program the database that are used is FACES94 [24] is employed. The information has pictures of 123 individual's classified to male, feminine and male employees everyone has twenty pictures taken whereas he/she is spoken with slightly variation to position. 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.

The network simulation parameters are shown in Table-1. The source node is sensed the face image which is considered 180X200, the features that are extracted using Zak transform 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- 4 shows the Euclidean distance of a testing image by PCA algorithm. 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- 5 that reveal 23 nodes are still alive after sending 100 packets in the network. 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. 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.

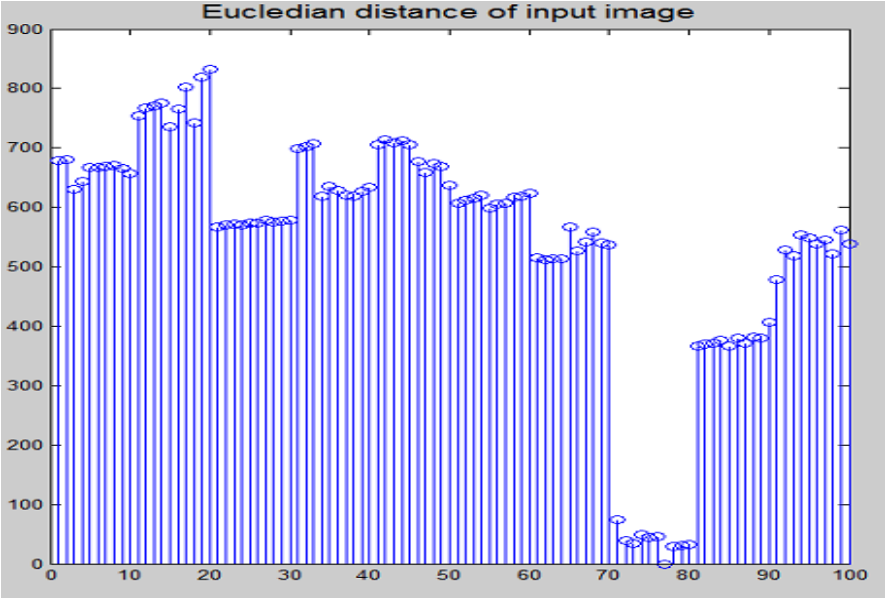

Figure 4- The tested image upon Euclidean distance with Eigen faces of PCA.

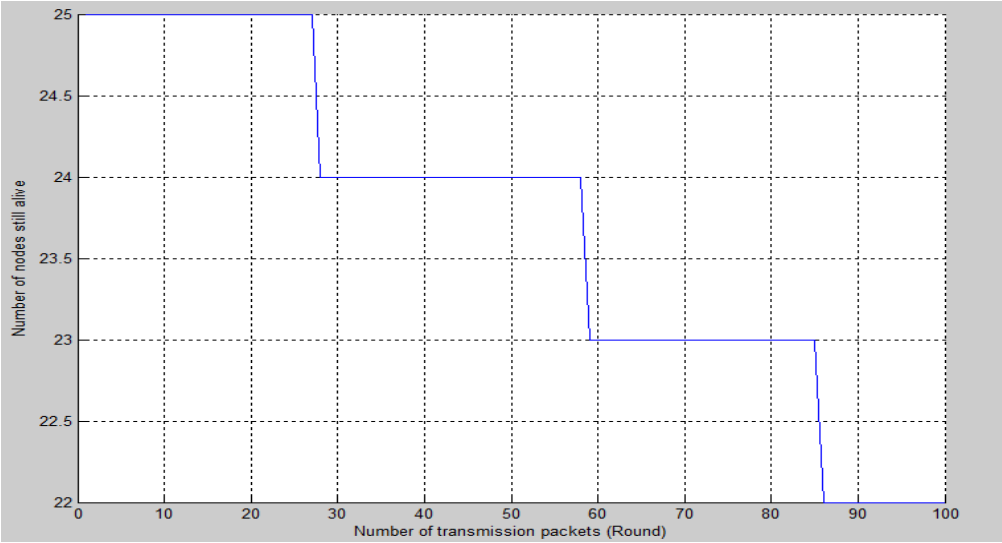

Figure 5- Number of still alive nodes.

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.

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