IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 10, Issue 6, June 2020, ||Series -II|| PP 01-06

Multi-modal System based on IOMT Platform: A Survey

Saba Roohi[1], Dr. Shailendra Kumar[2]
M.Tech (Electronic Circuit and Systems), Integral University, Lucknow[1], Associate Professor, Integral University, Lucknow[2]
Received 10 June 2020; Accepted 27 June 2020

ABSTRACT: As digitalization increases nowadays the security system is widely based on the digital data and this increases the demand of biometric. For this the main concern always is the secure and accurate system. With the advancement in this area we come to the conclusion that the multi-biometric system is more reliable, accurate and secure in comparison to unimodal biometric system. So the focus for research is shifted to the multi-biometric systems. Multi-biometric system has different fusion levels and in this paper we present comparative analysis of different fusion levels. Multi-biometric systems are more reliable, secure and accurate than the unimodal systems. Here we use the face and fingerprint as the biometric traits. In this paper we found out the best fusion level for the particular biometric trait on the bases of accuracy of the system. Multi-biometrics have many applications in various areas among which the healthcare digital transformation is one of them. And with the advancement of technology in the area of healthcare the IOMT emerges as the new trend in the world of healthcare and multi-biometric give the security and accuracy which this area is needed.
KEYWORDS: Biometric, Fusion, Sensors, Match Score, FAR, FRR, FMR, ROC, EER, IOMT, MDI.

I. INTRODUCTION

Biometrics is the statistical and mathematical method, which uses human physical and behavioural characteristics to process, as the information data. These physical characteristics are called traits. And these traits included fingerprints, finger veins, palm, facial geometry iris pattern etc. Other than security purpose the biometric is used in various areas like medical applications, social science, natural science etc but it widely used in crime forensic and information. [1] As far as reliability concerned, Multi biometric systems are more reliable than the unimodal biometric system. These systems have greater matching accuracy, better reduction in noisy data, better fault tolerance, and better resistance in spoofing attack than the single biometric system. [2] Multi-biometric systems use multiple source of information and thus fusion is performed. This data fusion uses multiple integrated scenarios to process. When multiple sensors are used for capturing the particular biometric trait it is called multi-sensor system. When multiple traits are used for the identification the system called multi-modal system. When the multiple instances are given to the system as a biometric trait then the system is called multi-instance system. If multiple samples of same biometric characteristics are applied to the system then the system is called multi-sample system. When different algorithms are applied to the process the system called multi-algorithm system. And when more than one integration scenario is used the system is called hybrid system.

In this paper, the work is continued with multi-modal system. Multi-modal system uses multiple traits as the information data. The reason to use only the multi-modal system is due to the data regarding this system is easily available, the matching accuracy is high, the system is more robust to noise, provides higher security and better protection against spoof attacks. The multi-biometric is characterized into different fusion levels:

a) Sensor level fusion: In this, new biometric data is generated by combining the data in single unit at sensor level. This process is done by different algorithms and thus is the initial level of fusion, also called data level fusion.

b) Feature level fusion: In this, feature sets are used which are generated from the multiple information sources and thus produced new feature set. This feature sets extracted from different algorithm and passed to the matching module.

c) Decision level fusion: In this level, to obtain the final recognition decision the final Boolean results from every biometric subsystem is combined. For performing the fusion, decision output from different biometric matching components are used.

d) Score level fusion: In this level of fusion, for the final decision the match score which is provided by different matching indicating degree of similarity or differences between the input and enrolled templates are consolidated.

e) Rank level fusion: In this fusion level, the result is found out by assigning the rank to each enrolled identity and the rank from the biometric subsystem are combined and generate a new rank.

Now, for this paper these fusion methods are elaborated and give knowledge about the different methodology used for these fusion levels and also give the comparison between them.

II. IMPORTANCE OF BIOMETRICS IN HEALTHCARE DIGITAL TRANSFORMATION

Digitalization do magic in the world of healthcare department. The security of the patient's personal health and financial data is most important areas in the field of healthcare digital system. In developed countries, the patients undergo the medical identity theft issues. In which the benefits are not consumed by the genuine person if his personal ID or information are stolen or misplaced. This problem is solved by the biometrics as well as it provides high quality services and experience to the users. And in developing countries, the biometric system makes healthcare more convenient for citizens and replace the more resource required, easily manipulated and fragile paper based identity system. [16]

The safest and secure way to ensure the security of the healthcare system is Biometric Authentication. Two important areas of the healthcare system are patient identification and patient data. Now we observe how biometric helps to secure the healthcare system:

a) Patient identification and biometrics: determining the identity of the patient in the master patient index (MPI) database of the healthcare provider is refers as the patient identification. Patient's healthcare insurance is connected or linked to the patient ID in the MPI database. If any person with bad intensions has the some information of the genuine patient, and can act as a genuine person, he easily gets the healthcare benefits of the person. This act is called as the medical identity theft.

This did not happen if biometric patient identification system is placed. At the time f the authentication the biometric of the person also taken and stored in the data. Next time when the patient arrived the system compare the data on the bases of the biometric trait and stored template and when the data is match the health care benefits are provided. Biometric cannot be faked and spoofed if we use multi-biometric systems.

b) Patient data security and biometrics: most of the cases the password based system easily compromised the security of the user data. It happens unintentionally sharing the password to the employees of hospital or too many people know the password of the patient MPI database. If biometric are used as the security pin of the user account than it is difficult to steal the patient personal data from the healthcare systems.

Now as the advancement in the technology increases the concept of the IOMT emerges as the revolution in the medical department. For this purpose, first the patient's biometric data with personal and medical information is collected and any duplication is eliminated. After that the information data is stored in the hospital's cloud management system. With the use of this data doctors can access the information of patient in real time. If we are talking about the health insurance institution, the fraud billing is reduce and also avoiding assumptions of other's identity. Biometric is used for medical examination process such as blood transfusion, blood drawing. [15]

III. PERFORMANCE MEASURES

Performance measures for biometric system can be considered on two bases:

a) Based on performance of system and based on accuracy of the system. On the bases of performance, usually two error rates are used which are FAR and FRR. FAR refers to false acceptance rate, define as the error, emerging due to the biometric system incorrectly declared the match between two individuals. FRR refers to false rejection rate, define as the error makes by the biometric system which fails to identify an authorized person. For more accurate results the graph is plotted between the FAR an FRR. This graph shows the basic technical performance to compare one or more biometric systems and called receiver operating characteristics (ROC) curve.

b) On the bases of accuracy of the system EER and GAR are used. EER refers to the equal error rate, when the FAR is equal to the FRR on the ROC curve the point is called EER. Or can be say that when the threshold of the system is set so as the rate of false rejection is equal to rate of false acceptance. GAR refers to the genuine acceptance rate. It is measured by the rate at how many times the genuine user is accepted. Beside these there are some other errors FTE and FTA. FTE stands for failure to enroll which means the rate of unsuccessful attempts to create the template at input. Low quality inputs are the main cause.

IV. METHODOLOGY

Lots of work has been done on the different fusion levels using different modalities. This paper included the multi-modal system which is the combination of two traits which are face and fingerprint. Previous work defines that different fusion levels response is different with the particular combination of traits. But here only one combination is chose to know the performance of system at different fusion levels.

Here the fingerprint and face is chosen as the biometric traits to give the performance of the system at different fusion levels.

For this, first level of fusion is sensor level fusion in which the system performance is the concerned area in multi-modal scenario which uses fingerprint and face as the biometric traits.

a) Sensor Level Fusion Method: Sensor level fusion consolidate the raw biometric information, processed it thus biometric features are extracted for matching. It can be used in identification as well as in verification modes. As name suggested in this level the sensor captures the input data of same trait and gives the more accurate and efficient information about that trait. The input data for this level has to be multiple instance of the required trait. If we take the fingerprint and face recognition system then there has to be multiple sample of both traits. Then these samples are fused individually to form best sample and then both are combined to give the result. [3]

b) Feature Level Fusion: In this, with the help of feature extractor the information is extracted which comes from the sensors and on the basis of the modality this information further stored into vectors. The next step on this process is to combining the all individual vectors to form a joint feature vector. To form a single vector set various biometric algorithms are applied. For common domain vector the Min-max or median normalization is applied. And for reducing the dimension of vector the transformation techniques like forward sequential selection, PCA or sequential backward selection are used. [4]

Here face and fingerprint biometric modalities are used for decision making. For fingerprint Histogram of oriented gradient (HOG) descriptor has been used and for face the feature extraction is done by linear discriminant analysis (LDA) and feature reduction is done by principal component analysis (PCA). Here the face and fingerprint modalities are non-homogenous so here concatenation process is have to be done to found out the final fused vector. These fused vectors are given to the SVM (support vector machine) for further process. [5]

c) Score Level Fusion Method: In score level fusion, there are some steps are involved. The first step is normalization due the feature extraction is done by the different modalities and different domain. Here different modalities (face and fingerprint) are used.

In other words, when the different modalities are used and get the feature vectors from the feature extractor of individual modality then for the fused vector, normalization technique is used for the individual modality. After which two normalized vectors are obtained. And for the score fusion, the two normalized vectors are used to form a final decision. This is done either by the classification or by combination. In classification process the result is divided into the real and the imposter, thus it needed more space to store the data. In combination process, different results from the comparator are combined and give the final decision. [4] For the normalized vector, some normalization techniques are used and among them most common techniques are minima maxima (MM), hyperbolic tangent (HT), z-score (ZS). Above which likelihood ratios (LR) is most promising, in which for the predefined FAR the GAR is highest. [6]

d) Decision Level Fusion: After the feature extraction and matching score process the decision is done by in this level. The individual sub system gives the final decision of its own and by the some Boolean strategies the final accept/reject is done. Some common methods are AND, OR, weighted majority voting, majority voting, Bayesian Decision Fusion etc. [4]

e) Rank Level Fusion: Rank level fusion is the process in which the rank should be given to the different classifiers individually and then consolidates the results. This is done to improve the performance of the system. When multi-modal system is employed the ranking is given to the potential matches between the databases and samples, and creating the list of possible matches. There are some methods used for ranking.

i) The highest rank method, in which the user identity is discovered from the highest rank returned by the individual matcher. The possible user identity receives M ranks for each M matcher. Then the user identities are combined to obtain the new ranking from all M matchers. The drawback of this method is that the system does not properly work if there is large number of matchers are introduced.

ii) Borda count is the most favourable method for rank fusion. It sums up the assigned rank by individual matchers. [4] The consensus rank is obtained by using the following equation: CR= $\sum_{i=1}^{m} Ri$, where CR is consensus ranking sorted in ascending order.

V. LITERATURE SURVEY

i) T. B Long, L. H. Thai and T. Hanh [7] present the paper in which they used Zernike Moment (ZM) and Radial Basis Function (RBF) neural network as the algorithm for the fingerprint and face recognition. The FAR is 4.95% and FRR is 1.12% for the system and gives the great performance.

ii) K. Nguyen, S. Denman, S. Sridhaam and C Fookes [8] uses score level fusion method for face and fingerprint biometric traits as multi-modal system in which Dempstrshafer theory fusion is used to calculate the performance of the system and its EER is almost 1%.

iii) A. Rattani, D.R. kisku, M. Bicego, and M.Tistarelli [9] represented the feature level fusion of face and fingerprint, in their paper they use various techniques and methods and gives the results which are very impressive. There study shows that multimodal system has greater accuracy as compared to unimodal system. They shows in their experiment that using the multi modal system at feature level using Delaunay Triangulation Technique the system can achieve 98.5% accuracy and have the lowest FAR and FRR which are 1.025% and 1.95% respectively.

iv) Grace Wangari Mwaura, Prof. Waweru Mwangi, Dr. Calvins Otieno, [10] presented the comparison of the multimodal system to the unimodal system. They use fingerprint and face as the biometric trait and experiment on individual face unimodal system and fingerprint unimodal system and after that they proposes the multi modal system which has the combination of both face and fingerprint using the SIFT (scale invariant feature transform) algorithm for fusion and hamming distance theory for measure the distance from key points. Their experimental result shows that the multimodal system has higher accuracy (92.5%) in comparison with individual unimodal system which has the accuracy 90% for face and 82.4% for fingerprint unimodal system.

v) Ayman Abaza and Arun Ross, [11] represented in their paper that the system accuracy can also be increased by improving the rank of the system. For this they used two methods which are Borda count method and highest rank method. And they concluded that the Borda count method is more suitable with the multi biometric system to provide higher accuracy.

vi) Vinay Kumar, R.Srikantaswamy, [12] used different methodology at the decision level like logical AND, OR and binary operations. And gives the result which shows the system at this level gave 75% accuracy.

vii) Yang Xin, Lingshuang Kong, Zhi Liu, Chunhua Wang, Hongliang Zhu, Mingcheng Gao, Chensu Zhao, And Xiaoke Xu, [13] represented the feature level fusion for multibiometric system and its use in the IoMT platform. They proposed that in feature level fusion , for different biometric traits there is individual feature vector which is then processed, extracted and merging called fisher feature vector. And in this paper they carried out a simulation experiment with the proposed Fisher vector secondary feature fusion algorithm. And their result shows that with the secondary feature vector fusion the system accuracy is higher (93.3%) when we use less users and if we use more users then the accuracy is also higher (88%) in comparison with the unimodal biometric system.

VI. RESULT AND COMPARISON

TABLE I: *comparison of fusion levels*

Biometric Traits	**Level of fusion**	**Methodology**	**Performance**
Fingerprint and face	Feature level [9]	Face+Fingerprint at Feature level using Delaunay Triangulation Technique	The data represented the highest accuracy which is 98.51% can be acquired at this level of fusion along with 1.95% FRR and 1.02% FAR.
	Matching score level [8]	By using fusion with Dempstrshafer theory	The result shows the multimodal biometric system has better accuracy than unimodal system and calculated the EER which is almost 1%.
	Matching score level [10]	Used SIFT algorithm and hamming distance theory	The experimental result shows that the multimodal system at score level fusion has higher accuracy which is 92.5% than the individual unimodal system.
	Rank level [11]	Used Borda count and highest rank methods	The system uses fingerprint and face multimodal system. For improving the rank different algorithms are used and the performance of the system is based on the accuracy which is 92% to 95%.
	Decision level[12]	Used logical AND rule	The experimental result shows that at this level system accuracy is 75%.

i) For feature level, in this paper [9] there are various techniques are used for calculating the system performance. Among which the best techniques emerged is Delaunay Triangulation Technique. This technique is used after the feature reduction methods. Basically, the feature level gives the best performance if we are talking about the multimodal biometric system.

ii) For the score level, these papers include [8] [10] various techniques among which Dempstrshafer theory, SIFT algorithm and hamming distance theory are the best suited methods for calculating the fusion score. The score level fusion is good for the multimodal system but as compared to feature level it is less favourable.

iii) For the rank level fusion, this paper [11] describe that the higher accuracy can be achieved by improving the rank of the system.
iv) For the decision level fusion [12], in this level simplest techniques are used for making the decision. These include AND, OR logical methods. The system accuracy at this level is good but less than the above all levels.

VII. CONCLUSION

In the end, this paper concluded that the multi-biometric system have better accuracy than the unimodal system. And also there are multiple levels in multi-biometric systems. As it can be seen from the table the feature level fusion is most favorable and most important as compared to others. In Sensor level fusion sensors are suffers from the outside noise. In score level, fusion is done by collecting the scores from different classifiers thus sometime suffers the complexity of the process. Rank level fusion suffers from the assigning the rank individually thus become lengthy process. And decision level fusion not has the better accuracy rate. So, the Feature level fusion is best among all. As the performance of the fusion levels depends on the biometric traits which the system is used. Here the fingerprint and face are uses as biometric traits. And for these traits feature level fusion is best choice. Feature level fusion is also important in multi-biometric as if the multiple traits are used it is important to merge them in single vector because the different modalities have different feature vector. Feature level also useful for the internet of medical things (IOMT) platform [13]. If we are talking about the health insurance institution, the fraud billing is reduce and also avoiding assumptions of other's identity. Biometric is used for medical examination process such as blood transfusion, blood drawing, and medicine dispensing to ensure patient's safety and bring the misidentification errors to zero. Also if talking about the new technology some companies started to connect biometric to automated healthcare system such as medicine dispenser for safest and smartest way to manage medication. As a result, the workflow efficiency is improved and customer's satisfaction is increased. [15]

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Saba Roohi, et. al. " Multi-modal System based on IOMT Platform: A Survey." *IOSR Journal of Engineering (IOSRJEN),* 10(6), 2020, pp. 01-06.