iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** VI **Month of publication:** June 2021

DOI: https://doi.org/10.22214/ijraset.2021.34952

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VI Jun 2021- Available at www.ijraset.com

Performance Evaluation of ANN based Hand Geometry Recognition

Anam Malik[1], Satnam Singh Dub[2]
[1,2]Department of ECE, SSCET, IKGPTU

Abstract: The research paper includes development of Application GUI for the ANN Hand Geometry based Recognition System with initial stages of Image Acquisition, Image Pre-processing and Feature Extraction and ANN Recognition using MATLAB. The application is to be tested on database for accuracy and performance and analytical comparisons are to be made on basis of testing. The research presents a method based on moment invariant method and Artificial Neural Network (ANN) which uses a four-step process: separates the hand image from its background, normalizes and digitizes the image, applies statistical features like Length and Width of the Fingers, Diameter of the Palm Perimeter Measurements, maxima and mini points and finally implements recognition and was successful in the verification as ANN was trained for seven neural net layers with 150000 iterations each. Neural network with MLP is highly efficient. The ANN is trained and tested on a total of 150 input palm images from CASIA Multi-Spectral Palmprint Image Database. The two different datasets are created for Left Palm Images and Right Palm Images. The Dataset1 includes 90 left palm images from 15 subjects with 06 images from each subject. The Dataset2 includes 60 right palm images from 10 subjects with 06 images from each subject.
Keywords: ANN, Hand Geometrics, MATLAB, CASIA, MLP

I. INTRODUCTION

This Hand geometry based identification systems utilize the geometric features of the hand like length and width of the fingers, diameter of the palm and the perimeter. Hand geometry depend on human hand, the human hand does not significantly change after a certain age. Unlike many other biometrics, the human hand is not unique therefore it considered as a life measure. The hand recognition systems are accurate for the verification purposes when combined with other features and measurements of fingers and hands. Hand geometry is based on the fact that nearly every person's hand is shaped differently and that the shape of a person's hand does not change after certain age. Hand geometry systems produce estimates of certain measurements of the hand such as the length and the width of fingers. Various methods are used to measure the hand. These methods are most commonly based either on mechanical or optical principle. Hand geometry is based on the palm and fingers structure. The human hand has a complex anatomical structure consisting of bones, muscles, tendons, skin, and the complex relationships between them. Analysis of human hand anatomical structures is important in various fields, including ergonomics, hand surgery, as well as computer animation. Hand geometry recognition systems are based on a number of measurements taken from the human hand, including its shape, size of palm, and lengths and widths of the fingers. Commercial hand geometry based verification systems have been installed in many locations around the world. The technique is very simple, relatively easy to use, and inexpensive. Environmental factors such as dry weather or individual anomalies such as dry skin do not appear to have any negative effects on the verification accuracy of hand geometry-based systems.

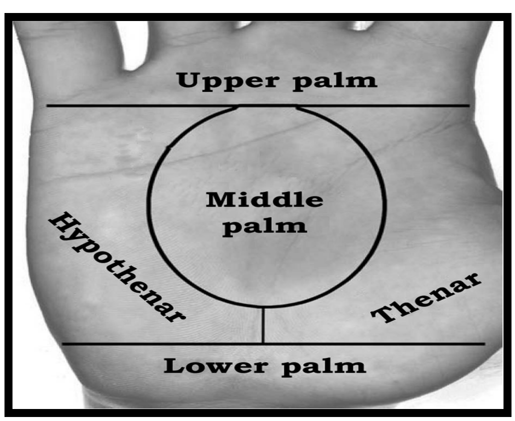


Fig.1 Palm Areas [1]

The geometry of the hand is not known to be very distinctive and hand geometry based recognition systems cannot be scaled up for systems requiring identification of an individual from a large population. Further, hand geometry information may not be invariant during the growth period of children. In addition, an individual's jewelry (e.g., rings) or limitations in dexterity (e.g., from arthritis), may pose further challenges in extracting the correct hand geometry information. The physical size of a hand geometry based system is large, and it cannot be embedded in certain devices like laptops. There are verification systems available that are based on measurements of only a few fingers (typically, index and middle) instead of the entire hand. Human hand contains enough anatomical characteristics to provide a mechanism for personal identification, but it is not considered unique enough to provide mechanism for complete personal identification. Hand geometry is time sensitive and the shape of the hand can be changed during illness, aging or weight changing. It is actually based on the fact that every person has differently formed hand which will not drastically change in the future.

Based on the data used for personal identification, technologies for reading human hand can be divided in three categories: Palm technology, Hand vein technology and Hand geometry and hand shape technology. The first category is considered the classic approach in the hand biometrics. The size, shape and flow of papillae are measured and minutiae are the main features in the identification process. Image preprocessing and normalization in this category gives us binary image containing papillae and their distances. Because of the different lightning when taking an image, the palm can be divided into five areas, although strictly medically speaking, if we consider the muscles, it has only three areas. The areas of the palm are: lower palm, middle palm, upper palm, thenar (thumb part) and hypothenar (little finger part).Second category uses similar approach for capturing hand image, but instead of using ordinary camera or scanner it rather uses specialized devices containing scanners with infrared light or some other technology that can be used for retrieving image of veins under the human skin. Hand vein biometrics is gaining popularity in the last years and it is likely that this will be one of the main biometric characteristics for the future. Using contactless approach for capturing the structure of human veins gives promising results in this field. Third category which is of the primary interest is hand geometry and hand shape [1].

II. LITERATURE REVIEW

Laura Gulyás Oldal et. al. propose a method for contactless hand geometry and palmprint-based authentication. The proposed method uses simple image processing algorithms and geometric relations for keypoint detection and palm image extraction. Morphological operations, averaging filters and different methods for noise filtering are used for palmprint principal line extraction. The corresponding points of palmprint images are detected by template-based matching which is followed by further filtering of matching points. With the use of hand geometry features and palmprint matching mechanism, the collected information of the hand and palm is suitable for authentication [2].

K. Přihodová et. al. publish that reliable authentication is a key factor in ensuring data security. Information systems requiring a high level of data security do not use passwords that are considered to be too insecure to verify the identity of the subject but instead often use different biometrics. Examples include user verification through fingerprints, keyboard dynamics, or hand-shaped biometrics. There are many approaches to hand authentication, each of which has strengths and weaknesses. There is currently no comparison of these approaches based on both quantitative and qualitative criteria in current scientific publications. The aim of this paper is therefore to compare the different methods of biometric authentication by hand geometry to identify current trends in this area and the need for future research [3]

Gagandeep Kaur states that biometrics has enormous role to authenticate or substantiate an individual's on the basis of their physiological or behavioral attributes for pattern recognition system. Multimodal biometric systems cover up the limitations of single/ uni-biometric system. In this work, the multimodal biometric system is proposed; iris and hand geometry features are fused at feature level. The iris features are extracted by using moments and morphological operations are used to extract the features of hand geometry. The Chaos-based encryption is applied in order to enhance the high security on the database. Accuracy is predicted by performing the matching process [4].

Kalsoom Fatima et. al. review different physical and behavioral biometric techniques that described in a different research paper in past decades; then analyze findings and future direction of different papers separately based on physical and behavioural biometric methods. Authors provide a comparative analysis of all biometric techniques it will help out readers to get a better idea about different biometric technologies that which one will suit according to their needs and budget. They conclude that for identification, authentication, in healthcare sector there is a need of proper implementation of any of these biometric authentication techniques or the combination of different techniques properly, to provide advanced security and prevention from any security threats to patient records. Authors also publish that The development of technology has affected the performance of the healthcare system globally. There is no denying the way that security is fundamental in-patient consideration [5].

Johnson I Agbinya et. al. publish that palm print modelling and recognition systems have been extensively studied. Palm shape or palm geometry has had lesser attention paid to its study because of the difficulties associated with shape definitions and modelling. This paper reports on experimental determination of human palm geometry equations. Experimental determination of human palm geometry was undertaken using measurements of hands of 14 subjects drawn from a mixture of racial and gender backgrounds. By also analyzing scanned images of their hands, characteristic measurements of their palms were determined. Characteristic expressions describing the geometry of human hands are proposed [6].

A.Muthu Kumar et. al.state that Biometrics is a mode of popularity and identification affirmation that uses physical attributes of a particular person that are impossible or as a minimum hard to mask. Finger-Knuckle-Print and ear print are examined to be maximum reliable physiological bio metric methods. These days a Finger Knuckle Print authentication based totally bio metric system has been efficaciously applied in various sectors. These unique Finger Knuckle Print and ear print authentication offers in reveals its user image that matches with its very own template that is stored inside the database for verification. An ear print is a replica of the parts outside the ear which have impressed a particular surface. Many variants of local binary patterns are widely used for feature extraction process due to their satisfactory performance, for recognition purpose [7].

Shanmukhappa Angadi et. al. publish that the user's hand is represented as a weighted undirected complete connected graph and spectral properties of the graph are extracted and used as feature vectors. To reduce the complexity in representing the hand image as a complete connected graph and to achieve the higher identification rate, the hand image is sought to be represented as minimal edge connected graph. The experiments are conducted separately for 16 topologies of minimal edge connected graph selected empirically to investigate the performance of the hand-geometry system. The prominent edges of hand image graph are identified experimentally by computing the identification rate [8].

Neha Mittal et. al. state that owing to the ever increasing demand of privacy protection and security concerns, hand geometry based biometric system aimed at addressing these concerns is developed. In this study authors have developed an authentication system which is based on finger shapes. The shapes of fingers are considered as patterns for extracting features using Eigen vector method and discrete wavelet transform. There are four feature types that include (i) Frequency and power content using Eigen vector method, (ii) Pisaranko's method (iii) Wavelet entropy of individual fingers, and (iv) Specific area of finger [9].

Duo Lu; Dijiang et. al. present an in-depth analysis of the utilized features to explain the reason for the performance boost. Authors publish that on wearable and Virtual Reality (VR) platforms, user authentication is a basic function, but usually a keyboard or touch screen cannot be provided to type a password. Hand gesture and especially in-air-handwriting can be potentially used for user authentication because a gesture input interface is readily available on these platforms. However, determining whether a login request is from the legitimate user based on a piece of hand movement is challenging in both signal processing and matching, which leads to limited performance in existing systems. In this paper, authors propose a multifactor user authentication framework using both the motion signal of a piece of in-air-handwriting and the geometry of hand skeleton captured by a depth camera [10].

Md. Khaliluzzaman et. al. present a biometric system for person verification based on the hand geometric features. The hand geometric features are extracted from the upper palm including four fingers of the right hand. The main aim of this proposed system is to reduce the feature and database size and improve the performance of the system. For that, initially, top four fingertip points and two corner valley points from the right hand four fingers are estimated. After that, eight distance edges from these fingertip and valley points are computed. From these eight distance edges, three triangles are estimated. These three triangle areas are used as a three feature and stored in the database as the feature vector. Finally, the test candidate hand feature is compared with the predefine database feature vector through the Euclidian distance metric. Hand geometry which is the famous biometrics system is utilized in the various identification systems with different feature estimation methods. Hand geometry plays a vital rule in the biometric authentication and security application [11].

III.METHODOLOGY

Traditional hand geometry system always uses pegs to fix the placement of the hand. Two main weaknesses of using pegs are that pegs will definitely deform the shape of the hand silhouette and users might place their hands incorrectly. Hand geometry systems produce estimates of certain measurements of the hand such as the length and the width of fingers. Various methods are used to measure the hand. These methods are most commonly based either on mechanical or optical principle. The system proposes a fast and optimized algorithm for hand geometry recognition based on Neural Networks. Proposed approach does not require any particular hardware since extracted features are computed without assuming any fixed hand positioning from a database. The main objectives for development of system are given as under.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VI Jun 2021- Available at www.ijraset.com

A. To design hand geometry based recognition system that works by acquiring the image of a hand to determine the geometry and metrics of human hand to recognize a human subject.

B. To utilize an important aspect of hand geometry based approach is the assumption that an individual's hand does not drastically change after a certain age.

C. To use only some of the selected attributes which will not change significantly over short periods of time image from a database. Most of the existing systems use more number of attributes to describe a hand of which some like finger width may slightly vary over time.

D. To include attributes like length and width of the fingers, diameter of the palm and the perimeter in the process of distance metric along with ANN feature optimization and ANN Feature Classifier will notably increase the accuracy of the system during practical implementation.

E. To train and test the system using ANN and evaluate the system for accuracy and feature verification and identification.

A hand geometry recognition system consists of five important steps as discussed below:

1) *Image Acquisition:* The hand image is acquired from CASIA Multi-Spectral Palmprint Image Database in order to build a template database.

Fig.2 Example of an Image from Database

2) *Image Pre-processing:* The block diagram of the image pre-processing system is shown below.

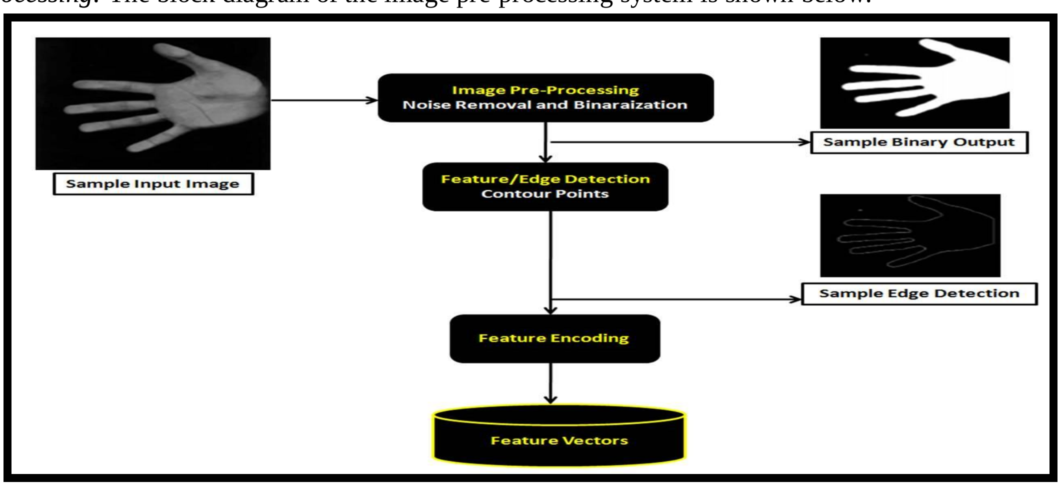


Fig.3 Image Pre-processing for Hand Geometry Recognition

If the original image is colored it is necessary first colored hand image convert in to gray scale image. The next step is operation called Binaraization. The image thresholding operation is to binarize the grayscale image from color image to obtain the binary hand shape images. The next step in image pre-processing is noise removal. It is necessary to remove the noise from the image because it may reduce the difference between the actual hand and the captured image using filters. The next step is edge detection as the image contains only edges to extract geometric features of the hand. Localization pixel intensity transactions are measure by the edge detection. An edge is a collection of connected high frequency points called contour points in an image. The goal is to find the limits between the hand and the background. For this purpose the algorithm detects the intensity changes, and marks a closed set of one pixel wide and length the perimeter of the hand. Edge points can be thought of as pixel locations of abrupt grey-level change. For example it can be defined an edge point in binary images as black pixels with at least one white nearest neighbour.

3) *Feature Extraction:* Hand geometry based identification systems utilize the geometric features of the hand like length and width of the fingers, diameter of the palm and the perimeter. The method for the geometric hand-palm features extraction is quite straightforward. From the hand image, the following main points are located: finger tips, valleys between the fingers and three more points that are necessary to define the hand geometry precisely. The geometric feature measurements are characterized by Location of Measure Points and Hand Measurements. The proposed system is a verification system which utilizes these hand geometry features for user authentication. The system accepts a pre-processed handprint from which it extracts features of hand geometry like the finger lengths, finger widths and perimeter. The first two points to be detected are the ones representing the thumb and the little finger. These points enable the extraction of most of the geometrical information and are detected based on the location of the thumb, and the little finger points respectively. Once these points are found, the location of the finger tips and the valleys between them are extracted. The procedures for detecting tips and valleys are very similar. For instance, in order to search for the index finger tip, the points with minimum ordinate found from the initial point have to be used. The minimum ordinate is searched in a clockwise direction. The process for locating a valley is the same. For example, to locate the valley between the heart and middle finger, the maximum ordinate points have to be found starting from the point middle finger. Finally, using all the main points previously computed, the geometric measurements are obtained. The following distances are taken: Length of the 5 fingers, distances between points and the valley between the thumb and first finger, perimeter etc. The feature vector contains ten geometric measurements extracted from the hand.. The geometric features which are measured are as under.

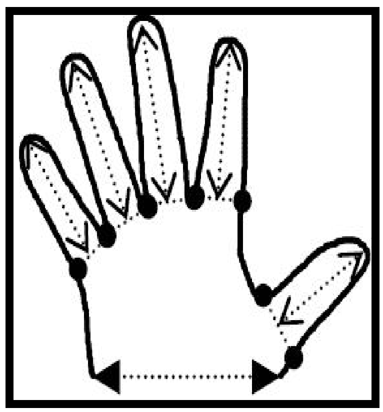


Fig.4 Measured Geometric features for Hand Geometry Recognition

4) *ANN Matching:* In this stage, the ANN is applied for recognize the features that has been extracted and saved in a database. The ANN that suggested is the most general used supervised learning of neural network.

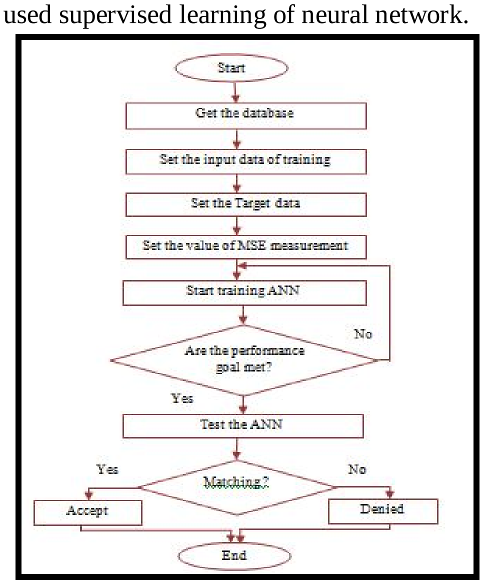


Fig.5 Flowchart of ANN based Hand Geometry Recognition Algorithm

The system process obtains one model from each training image by testing each input image against all the models inside the database and the model close to the input image using Mean Square Error (MSE) criterion indicates the recognized person. The ANN Classifier used is nearest neighbour classifier based on Mean Square Error (MSE) which will form the basis for weighted features vectors. The nearest neighbour neural net classifier is trained using a Multi-Layer Perceptron (MLP). Multilayer perceptron neural network (MLPNN) is considered as a widely used artificial neural networks architecture in predictive analytics functions. The architecture of an artificial neural network, that is, its structure and type of network is one of the most important choices concerning the implementation of neural networks as forecasting tools. The design of MLPNN is motivated by the structure of a biological neuron system capable of parallel processing like a human brain, but the processing elements of this machine learning tool has gone far from their biological inspiration. For this reason, MLPNN have been successfully used by most of the researchers in the field of forecasting, science and engineering to predict the behavior of both linear and nonlinear systems without the need to make assumptions that are implicit in most traditional statistical approaches.

5) *Decision:* The recognized id is shown according to the values returned on the basis of training done by ANN. An error-control learning system detects and possibly corrects the errors that occur when weighted features are transmitted through multiple layers of a MLP. To accomplish this, the MLP transmits not only the informative features, but also one or more redundant features. The MLP uses the redundant features to detect, and possibly correct, whatever errors occurred during transmission in hidden layers to the output layer of the neural network thus increasing the accuracy and speed.

IV. RESULTS

The The results are obtained for ANN Hand Geometry based Recognition System by development of a robust user-interface in MATLAB programmatically as well as using GUIDE. The application GUI's for ANN Hand Geometry based Recognition System using MLP neural networks with 7 layer training nets is developed and tested using database entry samples from two datasets from CASIA Multi-Spectral Palmprint Image Database.

A. Analysis Graph 1: Dataset1 (Left Palms) Vs. Dataset2 (Right Palms)

The Dataset1 (Left Palms) is created from CASIA Multi-Spectral Palmprint Image Database and consists of 90 palm images of left palm from 15 Classes with a number of 06 palm images per class and the Dataset2 (Right Palms) is also created from CASIA Multi-Spectral Palmprint Image Database and consists of 60 palm images of right from 10 classes with a number of 06 palm images per class.

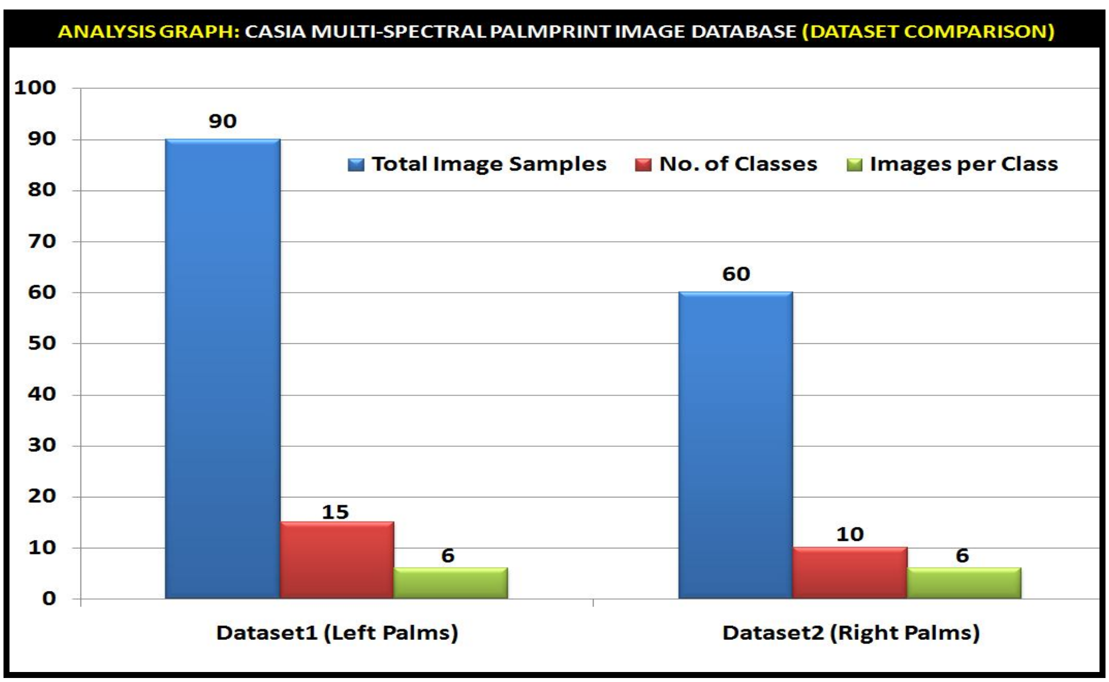


Fig.6 Hand Geometry Datasets Comparison and Evaluation: Dataset1 (Left Palms) Vs. Dataset2 (Right Palms)

B. Analysis Graph 2: Comparison of ANN Training Time Data

The Total ANN Training Time calculated for 150000 iterations for Dataset1 (Left Palms) with 90 images is calculated to be 1261 seconds with an average training time per neural net being 180.14 seconds. The Total ANN Training Time calculated for 150000 iterations per neural net for Dataset2 (Right Palms) with 60 images is calculated to be 605 seconds with an average training time per neural net being 86.42 seconds.

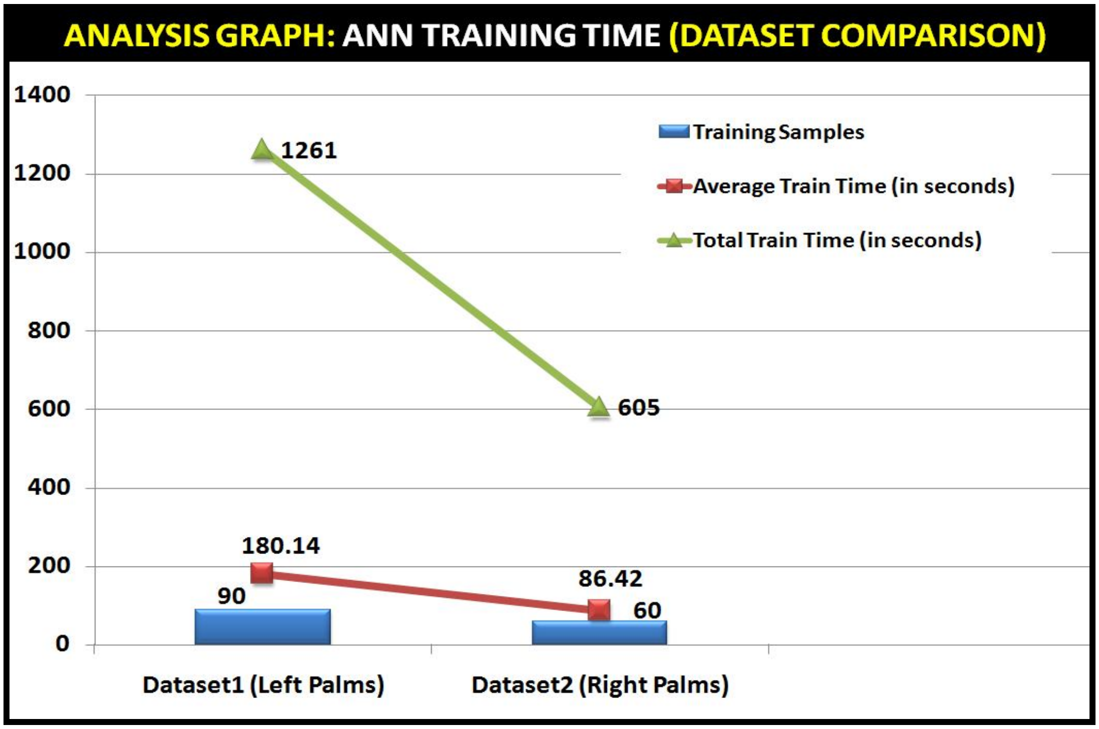


Fig.7 ANN Train Time (Total and Average) with respect to Training Set Size Comparison and Evaluation

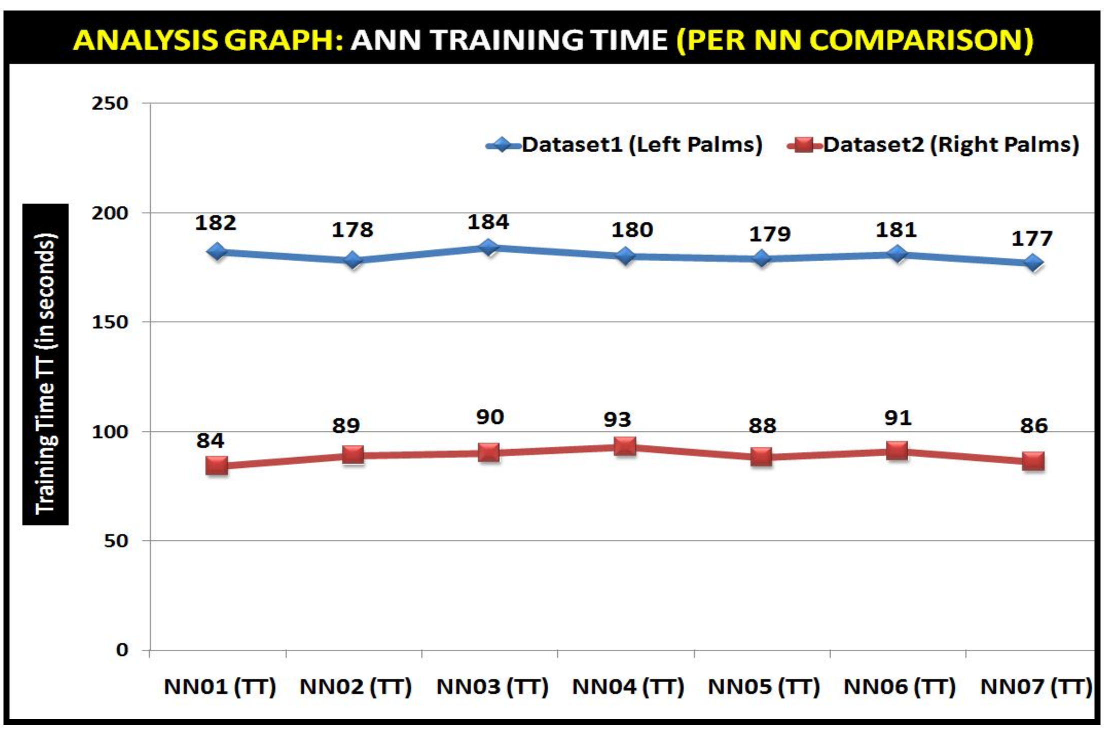


Fig. 8 ANN Train Time per Neural Net Layer Comparison and Evaluation

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VI Jun 2021- Available at www.ijraset.com

C. Analysis Graph 3: Comparison of ANN Recognition Time

ANN Recognition Time is the time taken by the ANN to recognize the input signature sample with the accurate sample in the database when the ANN performance is tested for accuracy and speed.

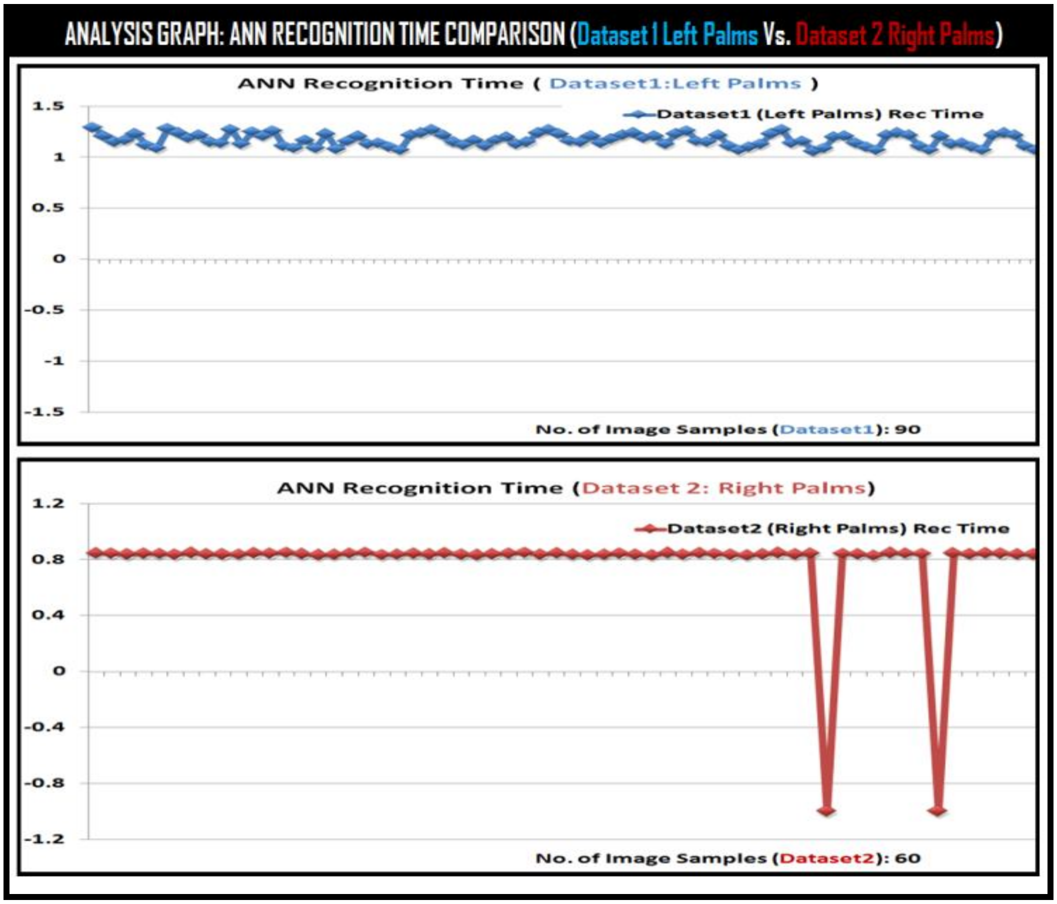


Fig.9 ANN Recognition Time Comparison and Evaluation

The average ANN recognition time for Dataset1 is calculated as 1.17 seconds which is higher than other dataset because of bigger dataset size. The ANN recognition time for Dataset2 is calculated to be 0.81 seconds.

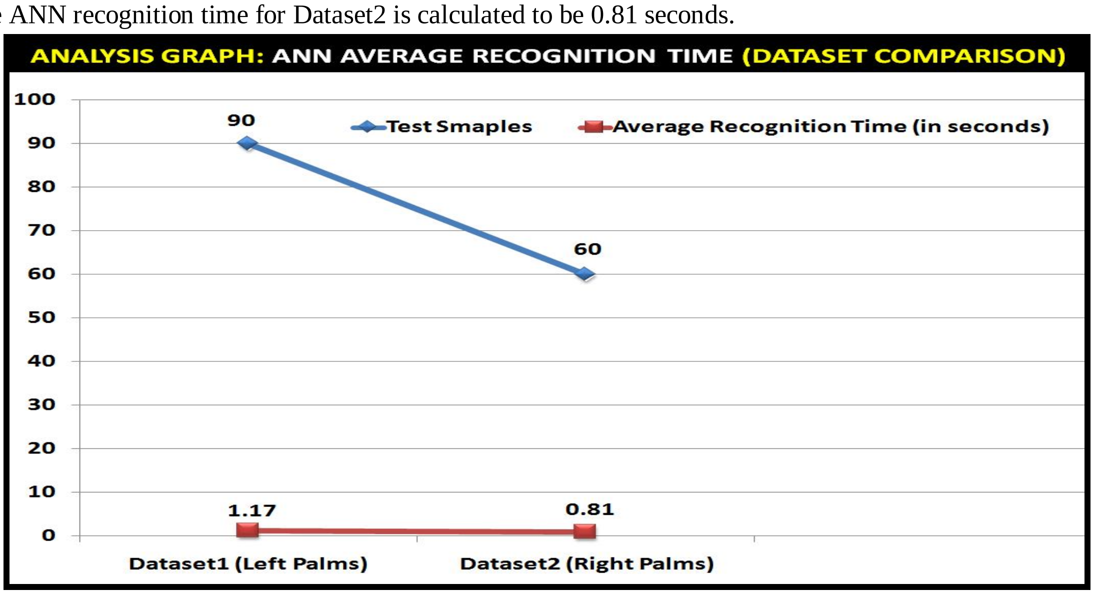


Fig.10 Average ANN Recognition Time Comparison and Evaluation

D. Analysis Graph 4: Application Performance Evaluation Accurate Matches Vs. Inaccurate Matches

The Dataset1 (Left Palms) has 90 accurate image class matches out of 90 and zero inaccurate matches. The Dataset2 (Right Palms) has 58 accurate image class matches out of 60.

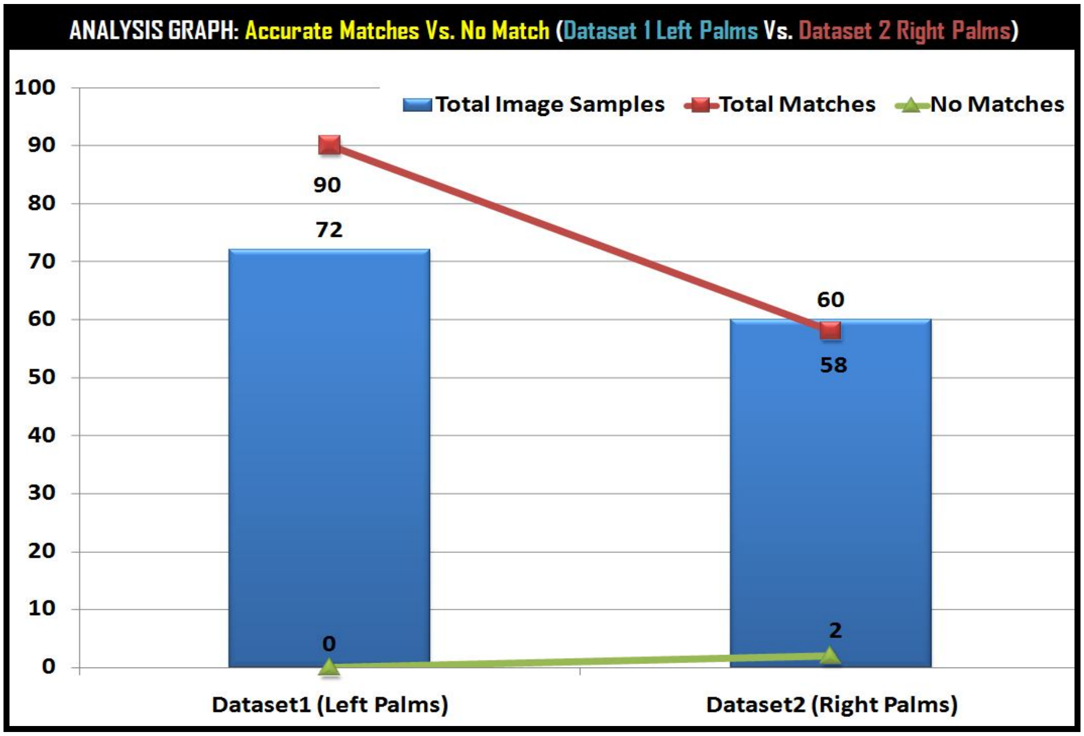


Fig.11 Performance Comparison and Evaluation (Accurate Vs. Inaccurate Matches)

E. Analysis Graph 5: Application Performance Evaluation %Accuracy per Class Vs. % Error per Class

The % accuracy per class and %error per class on the basis of number of images matched is calculated and show in the graph.

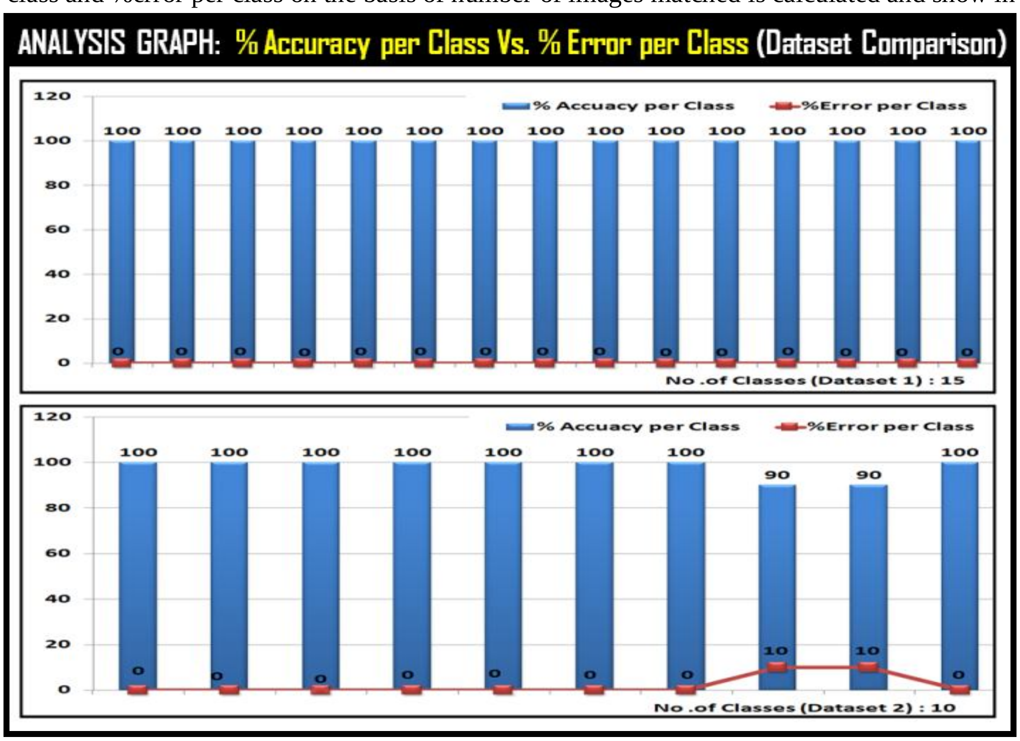


Fig.12 Performance Comparison (%Accuracy per class and %Error per Class)

F. Analysis Graph 6: Application Performance Evaluation %Accuracy Vs. % Error

The Dataset1 (Left Palms) has 90 correct image class matches out of 90 and zero incorrect matches leading to a high % accuracy performance of 100%. The Dataset2 (Right Palms) has 58 correct image class matches out of 60 and only 02 incorrect matches leading to a slightly lower % accuracy performance of 96.66% and a slightly higher %error of 3.34%.

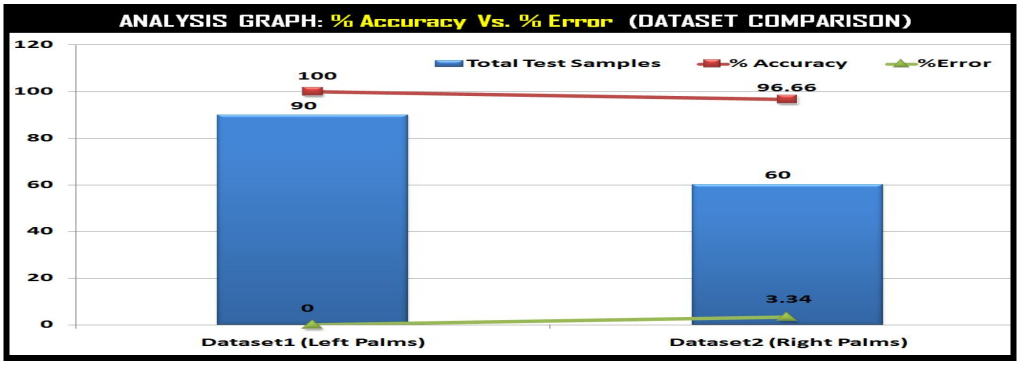


Fig.13 Performance Comparison and Evaluation (%Accuracy and %Error)

G. Analysis Graph 7: Application Performance Evaluation Overall Analysis

The comparison graph is shown for overall analysis for combined values of the two datasets. The Total number of combined images for testing the application performance is 150 including 72 images from Dataset 1 and 60 images from Dataset 2 out of which accurate matches are 148 including 90 images from Dataset 1 and 58 images from Dataset 2 with a total of 02 inaccurate matches from Dataset 2. Thus the overall % accuracy is calculated to be 98.66% and the overall % error is 1.34%.

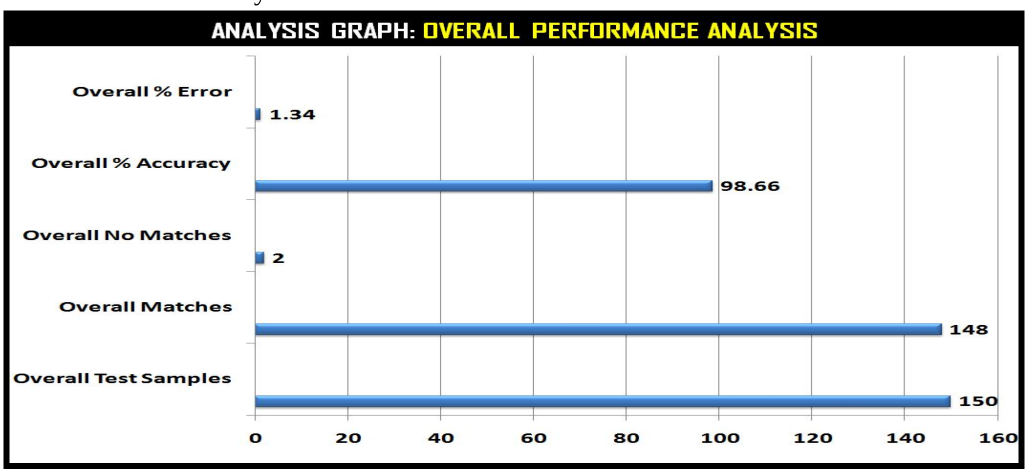


Fig.14 Performance Comparison and Evaluation (Overall Analysis)

V. CONCLUSIONS

The research presents a method based on moment invariant method and Artificial Neural Network (ANN) which uses a four-step process: separates the hand image from its background, normalizes and digitizes the image, applies statistical features like Length and Width of the Fingers, Diameter of the Palm Perimeter Measurements, maxima and mini points and finally implements recognition and was successful in the verification as ANN was trained for seven neural net layers with 150000 iterations each. Neural network with MLP is highly efficient. The ANN is trained and tested on a total of 150 input palm images from CASIA Multi-Spectral Palmprint Image Database. The two different datasets are created for Left Palm Images and Right Palm Images. The Dataset1 includes 90 left palm images from 15 subjects with 06 images from each subject. The Dataset2 includes 60 right palm images from 10 subjects with 06 images from each subject. The ANN Train Time Value is calculated and recorded for 90 images of Dataset1 is 1261s. For 60 images of Dataset2 the ANN Train Time is calculated to be 605s. The average ANN recognition time for Dataset 1 is calculated as 1.17s which is higher than other dataset because of bigger dataset size. The ANN recognition time for Dataset2 is calculated to be 0.81s. The Dataset1 has a high % accuracy performance of 100%.The Dataset2 has slightly lower % accuracy performance of 96.66% and %error of 3.34%. Thus the overall % accuracy is calculated to be 98.66% and the overall % error is 1.34%.

REFERENCES

[1] Nidhi Saxena, Vipul Saxena, Neelesh Dubey, Pragya Mishra (2013), “Hand Geometry: A New Method for Biometric Recognition”, International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-2, Issue-6, pp.192-196, 2013.

[2] L. G. Oldal and A. Kovács, "Hand geometry and palmprint-based authentication using image processing," 2020 IEEE 18th International Symposium on Intelligent Systems and Informatics (SISY), Subotica, Serbia, 2020, pp. 125-130, doi: 10.1109/SISY50555.2020.9217068.

[3] K. Přihodová and M. Hub, "Biometric Privacy through Hand Geometry- A Survey," 2019 International Conference on Information and Digital Technologies (IDT), Zilina, Slovakia, 2019, pp. 395-401, doi: 10.1109/DT.2019.8813660.

[4] G. Kaur, "Multimodal Biometrics Feature Level Fusion for Iris and Hand Geometry Using Chaos-based Encryption Technique," 2019 Fifth International Conference on Image Information Processing (ICIIP), Shimla, India, 2019, pp. 304-309, doi: 10.1109/ICIIP47207.2019.8985690.

[5] K. Fatima, S. Nawaz and S. Mehrban, "Biometric Authentication in Health Care Sector: A Survey," 2019 International Conference on Innovative Computing (ICIC), Lahore, Pakistan, 2019, pp. 1-10, doi: 10.1109/ICIC48496.2019.8966699.

[6] J. I. Agbinya, "Human Palm Geometry Modelling for Biometric Security Systems," 2019 Cybersecurity and Cyberforensics Conference (CCC), Melbourne, VIC, Australia, 2019, pp. 160-164, doi: 10.1109/CCC.2019.00011.

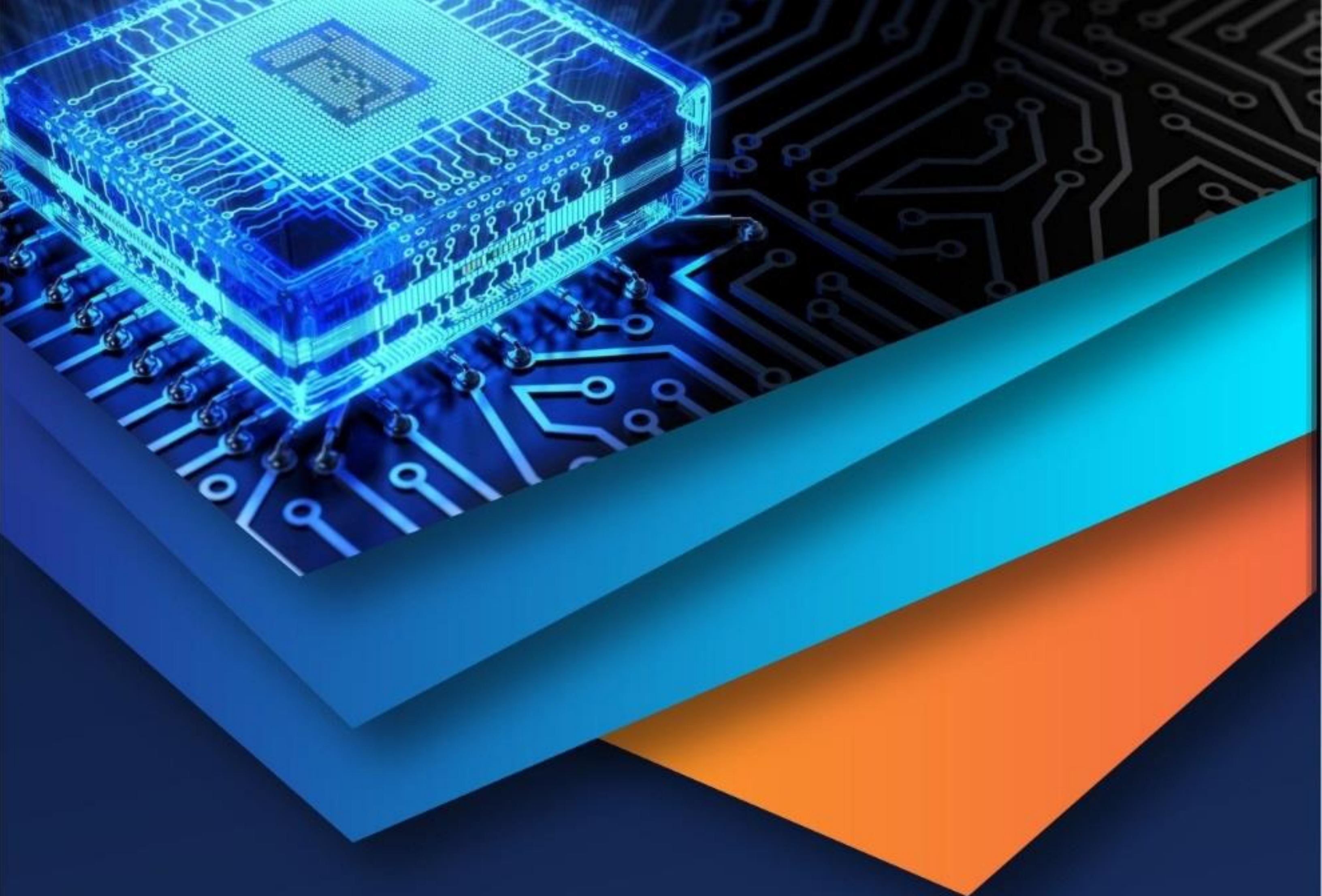
[7] A. M. Kumar, A. Chandralekha, Y. Himaja and S. M. Sai, "Local Binary Pattern based Multimodal Biometric Recognition using Ear and FKP with Feature Level Fusion," 2019 IEEE International Conference on Intelligent Techniques in Control, Optimization and Signal Processing (INCOS), Tamilnadu, India, 2019, pp. 1-5, doi: 10.1109/INCOS45849.2019.8951348.

[8] S. Angadi, S. Hatture, “Hand geometry based user identification using minimal edge connected hand image graph”, IET Comput. Vis., 2018, Vol. 12 Iss. 5, pp. 744-752 © The Institution of Engineering and Technology 2018.

[9] N. Mittal, M. Hanmandlu and S. Vasikarla, "An Authentication System based on Hybrid Fusion of Finger-Shapes & Geometry," 2018 IEEE Applied Imagery Pattern Recognition Workshop (AIPR), Washington, DC, USA, 2018, pp. 1-7, doi: 10.1109/AIPR.2018.8707382.

[10] D. Lu, D. Huang, Y. Deng and A. Alshamrani, "Multifactor User Authentication with In-Air-Handwriting and Hand Geometry," 2018 International Conference on Biometrics (ICB), Gold Coast, QLD, Australia, 2018, pp. 255-262, doi: 10.1109/ICB2018.2018.00046.

[11] M. Khaliluzzaman, M. Mahiuddin and M. M. Islam, "Hand Geometry Based Person Verification System," 2018 International Conference on Innovations in Science, Engineering and Technology (ICISET), Chittagong, Bangladesh, 2018, pp. 1-6, doi: 10.1109/ICISET.2018.8745620



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)