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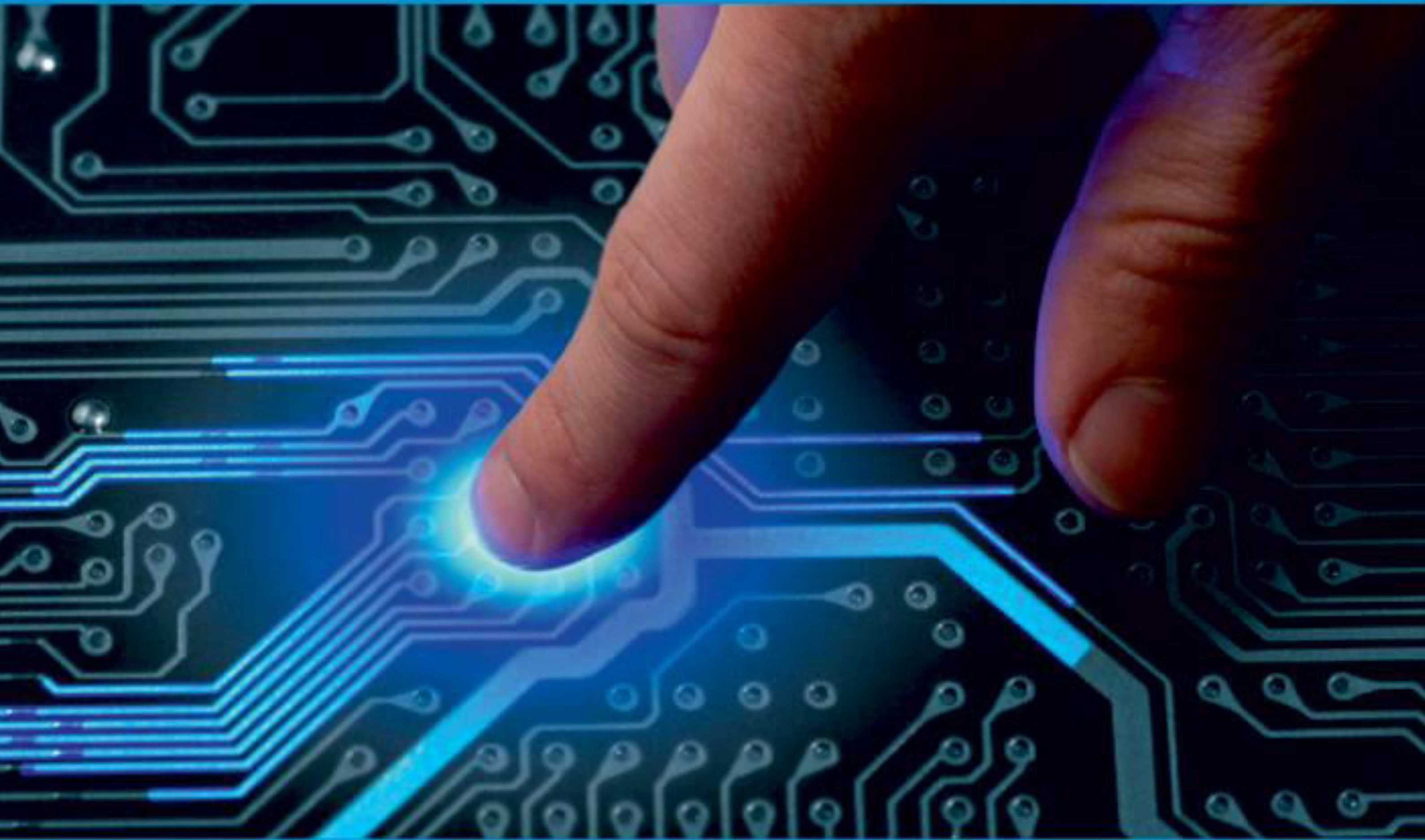

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Authentication using Hand Geometry

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ABSTRACT: Authentication is a critical aspect of ensuring secure access to systems and services. Traditional methods often involve passwords, which are susceptible to various security threats. This paper proposes a novel approach to authentication leveraging hand geometry, a biometric modality that captures unique physical characteristics of an individual's hand. Hand geometry authentication offers a combination of security and user convenience. The system extracts essential features from the hand, including finger length, finger base coordinates, and palm width, to create a personalized biometric template. A machine learning model, specifically a neural network, is employed for pattern recognition and authentication decision-making. The system adapts and learns from the user's hand geometry over time, ensuring robust and personalized authentication.

KEYWORDS: authentication, hand geometry, security, passwords, pattern recognition

I. INTRODUCTION

In the realm of securing digital spaces, the authentication of individuals plays a pivotal role in safeguarding sensitive information and resources. Traditional methods of authentication, such as passwords and PINs, have demonstrated vulnerabilities ranging from user forgetfulness to susceptibility to sophisticated cyber attacks. This has led to the exploration of innovative biometric authentication solutions that leverage unique physiological or behavioral characteristics of individuals. One such promising modality is hand geometry authentication, a method that capitalizes on the distinctive features of an individual's hand to establish a robust and user-friendly means of verifying identity. Experimental results demonstrate the effectiveness of the hand geometry authentication system in achieving high accuracy and reliability, paving the way for enhanced security in various applications, including physical access control, financial transactions, and digital identity verification.

Hand geometry authentication is grounded in the notion that the physical dimensions and proportions of an individual's hand are distinctive and largely unique. By capturing and analyzing key metrics such as finger length, finger base coordinates, and palm width, a personalized biometric template can be constructed. Unlike traditional passwords, which can be forgotten, shared, or compromised, hand geometry remains an intrinsic and unalterable aspect of an individual's identity. The utilization of machine learning, particularly neural networks, enhances the authentication process by enabling pattern recognition and adaptation to variations in hand geometry over time. At the core of ML in the context of authentication using hand geometry lies the concept of feature extraction — a process that distills meaningful information from the unique physical attributes of an individual's hand. The extraction of these features is a critical precursor to the training of ML models, where the system learns to discern patterns and relationships within the complex datasets generated by hand geometry measurements.

A key component within ML models applied to hand geometry authentication is the neural network. Inspired by the interconnected structure of the human brain, neural networks excel in capturing intricate patterns and nonlinear relationships inherent in biometric data. Through a training process, the neural network refines its parameters based on labeled datasets, gaining the capability to make informed decisions about the authenticity of an individual's identity.

This research paper embarks on a comprehensive exploration of the symbiotic relationship between ML and hand geometry authentication. Delving into the intricacies of feature extraction, neural network architecture, and the adaptive learning process, the subsequent sections unravel the technical nuances that underpin this innovative approach. As we harness the power of ML, we not only redefine the boundaries of secure access but also usher in an era of authentication systems that evolve alongside the dynamic nature of human biometrics.

II. LITERATURE SURVEY

As a part of the literature survey, 15 research papers have been reviewed. Every paper talks about using parameters from biometrics such as palm width, finger length and base coordinates.

Paper [1] explores the implementation of a hand geometry-dependent biometric system for identity authentication, presenting a method that extracts 21 features from the right hand to identify and authorize individuals. The system comprises two main parts: data collection and training/testing of three artificial neural networks—feed-forward backpropagation NN, Elman NN, and cascade forward neural network NN. The process involves image acquisition, pre-processing, and features extraction, with subsequent training and testing using the neural networks. The proposed system demonstrates a Recognition Rate (RR) of 95% for feed-forward backpropagation, 92% for Elman, and 88% for

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the cascade forward neural network. The authors highlight the advantages of hand geometry, emphasizing its cost-effectiveness, fast results, small template size, and user-friendliness. The paper positions hand geometry as a reliable biometric trait for security applications, utilizing neural networks for pattern recognition. Comparisons with related works indicate the proposed system's competitive recognition rates. The authors discuss the potential for multi-modal neural networks to further enhance system efficiency. In conclusion, the paper underscores the effectiveness of hand geometry for biometric authentication, offering a robust and cost-efficient solution with the integration of artificial neural networks.

In paper [2], the research introduces a method for contactless biometric authentication using hand geometry and palm prints through image processing. The goal is to create a low-cost system by combining features from both modalities for enhanced accuracy. The proposed approach involves several key steps. In hand geometry characteristic point detection, the preprocessing includes binarization, noise removal, and edge detection. Fingertip detection involves extracting contour lines, identifying fingertips, and determining hand orientation. Wrist point detection is essential for accurate hand geometry feature extraction, ensuring measurements are precise. Finger valley detection is crucial for finger length calculation and palm image extraction. The results indicate promising performance on a small dataset, with a defined acceptance threshold achieving a 0% False Acceptance Rate (FAR) and a 5.45% False Reject Rate (FRR). The proposed method combines the steadiness of palmprint matching with the accuracy of hand geometry, making it suitable for contactless biometric authentication. The paper suggests future improvements, such as persistent data storage and additional hand geometrical points, to further enhance the system's capabilities.

Paper [3] proposes a 3D hand geometry-based biometric authentication system integrated with an attendance management system. The motivation behind the system lies in the significance of discriminatory information offered by the combination of 2D and 3D features, its contactless and hygienic nature, improved performance, and resistance to forgery or counterfeiting. The objective is to introduce an affordable, robust, and user-friendly authentication system based on hand geometry features such as finger length, palm diameter, and perimeter. The conclusions of the paper summarize the contributions of the proposed system, emphasizing the simultaneous extraction and combination of 3D and 2D hand geometry features for more reliable personal authentication. The contact-free acquisition of hand images, incorporation of new representations like finger surface curvature and unit normal vector, and the combination of match scores from 3D and 2D hand geometry matchers are highlighted as key aspects.

In paper [4], the study proposes a system for personal authentication using hand geometry as a biometric identity. The aim is to build a low-cost, reliable verification system based on the analysis of hand shape. The system involves capturing a hand image, storing it in a database, and performing operations such as grayscale conversion, image segmentation, and feature extraction. Image segmentation is achieved using edge detection methods, specifically Sobel and Canny operators.The results include the conversion of RGB images to grayscale, Sobel and Canny edge detection, and extraction of region properties for two specimens. The results show that a variation in features leads to an "inauthentic" output, highlighting the potential of the proposed system for biometric identity verification.

Paper [5] presents a personal authentication system based on hand geometry, proposing two authentication methods: (1) machine learning, specifically the K-Nearest-Neighbor method, and (2) distance functions. Hand geometry involves measuring aspects such as finger lengths, palm width, etc., and is considered a non-invasive biometric suitable for middle and low-security requirements. The proposed system uses a standard document scanner as the image acquisition device. The paper acknowledges the limitations of the K-Nearest-Neighbor method in terms of time complexity and suggests the need for further testing, broader datasets, and potential merging of verification methods. The experimental results highlight the advantages and challenges of each method, paving the way for future research in improving algorithm performance and system reliability.

In paper [6], a peg-free hand geometry based authentication is proposed. Hand geometry has been a widely used biometric authentication Many hand geometry systems use pegs, which guide hand placement on the scanner. The system prompts the user to position the hand on the scanner several times and only captures when the current position is satisfied. In such a system, measurements are not very precise and this reduces accuracy during feature extraction. The system also has a higher false acceptance rate. This paper presents a peg-free hand geometry recognition system that does not depend on the orientation of the hand. Several features from test hand images are extracted and stored in the database, which are used to train an artificial neural network (ANN). To facilitate easy usage of the hand geometry verification system (peg-free), a GUI was developed using MATLAB software. The developed system was validated and the overall result shows that the system can be used for biometric verification using hand geometry where the orientation and placement of the hand are not a necessity. The results show that the developed system performed better with a relatively low false acceptance rate and false rejection rate of 0.01% and 0.02% respectively.

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Paper [7] discusses the development of a biometric identification system based on hand geometry that allows on-the-fly identification, eliminating the need for users to come to a standstill during scanning. The motivation for such a system is to overcome limitations in throughput and address hygiene concerns associated with current biometric systems, especially in scenarios where large numbers of people need to be processed, such as automated border gates or building entrances. The system demonstrates promising results, achieving a success rate of approximately 95.9% with a standard deviation of 19.76% in LOOCV and a success rate of 96.0% with a standard deviation of 1.46% in Repeated Stratified K-Fold Cross Validation. In summary, the paper presents a novel on-the-fly biometric identification system based on hand geometry, addressing limitations in throughput and hygiene concerns associated with existing systems. The proposed system shows promising performance in experimental evaluations.

Paper [8] presents a multimodal biometric recognition system based on the fusion of 3D ultrasound images of hand geometry and palm prints. The motivation behind this system lies in the advantages of ultrasound technology, which allows for volumetric imaging, providing a more accurate representation of anatomical features and enabling liveness detection. The proposed system extracts 2D features from ultrasound images at various depth levels and combines them to create 3D templates for both hand geometry and palm prints. In conclusion, the paper introduces a novel multimodal biometric recognition system based on 3D ultrasound images, combining hand geometry and palmprints. The proposed system shows promising results in terms of accuracy and security, making it a valuable contribution to the field of biometric authentication.

Research paper [9] proposes an approach for hand geometry recognition that considers both closed and separated fingers. Hand geometry is a biometric trait used for identification, and it is less intrusive as it can be captured without contact with the acquisition device. The challenge addressed in this paper is the restriction of hand placement during capture, where users are either instructed to keep their fingers separate or closed. The results and discussion section mentions the dataset used for testing and the training process. The SVM classifier is employed, and the optimized objective function and function evaluation for Manhattan distance features are presented. In summary, the paper proposes a finger geometry biometric system that can identify individuals using hand geometry, irrespective of whether their fingers are closed or separate.

In paper [10], emphasize the effectiveness of biometrics in addressing security challenges, leveraging physical and behavioral traits for unique identification. The paper reviews diverse biometric modalities, including fingerprint, facial landmarks, iris anatomy, speech recognition, and hand geometry. Cloud computing, with its benefits and security concerns, is introduced, and the authors discuss the limitations of traditional authentication methods, paving the way for the exploration of biometrics as a more reliable solution. The literature review encapsulates existing research on cloud security mechanisms, highlighting the necessity for robust authentication systems to counter identity theft threats in the cloud environment. Various proposed solutions are discussed, encompassing frameworks combining biometrics with cryptography, biometric lock apps for enhanced banking security, and integrated approaches using multiple biometric metrics. Overall, the paper underscores the potential of biometric authentication to contribute significantly to securing cloud environments against identity theft.

In paper [11], the author conducts experimental research to determine human palm geometry equations, utilizing measurements from a diverse group of 14 subjects. Scanned images of their hands are also analyzed to derive characteristic measurements. The proposed equations describe relationships between hand lengths and perimeters at fingertips and the base of fingers, leading to a unique expression termed the hand geometry equation. The paper provides a comprehensive exploration of human palm geometry for biometric security systems, offering valuable insights into its potential applications and contributions to individual recognition. The derived hand geometry equation presents a novel approach to modeling palm dimensions, contributing to the broader field of biometrics and security.

Paper [12] introduces a novel approach for human authentication based on hand radiographs, emphasizing the significance of biometric radiographs in the context of rising crime and disaster incidents. While traditional biometric methods such as fingerprint, iris, face, and palm prints may fail when external biometric parts are damaged due to various reasons, the paper proposes the use of radiographs of the skull, hand, and teeth as effective replacement methods. The review of related work in the paper indicates a growing interest in the application of deep learning techniques to various aspects of radiography, such as bone age assessment, rheumatoid arthritis detection, bone segmentation, human identification, and osteoporosis detection based on hand radiographs. The proposed method demonstrates promising results in comparison to conventional techniques, and the findings suggest its potential applicability in disaster victim identification and forensic scenarios.

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Paper [13] presents a hybrid feature-based approach for human recognition using dorsal hand vein patterns and dorsal geometry. The proposed system consists of four units: image acquisition, image preprocessing, feature extraction, and the identification process. The image acquisition unit utilizes an 850-nm wavelength light source to capture vein patterns without physical contact. The acquired images undergo preprocessing, including grayscale conversion, segmentation, and noise reduction. The paper underscores the importance of vein pattern recognition in biometrics, highlighting its potential applications in diverse fields such as security systems, internet access, healthcare, and more. The contactless and non-invasive nature of the proposed system enhances its practicality and user comfort

In paper [14], the research proposes a novel user authentication method called TouchPrint, designed to enhance the security of password-based authentication on mobile devices. The primary motivation is to address vulnerabilities in existing methods, such as PIN codes and patterns, which are susceptible to various side-channel attacks. The paper highlights three major challenges in designing TouchPrint: obtaining acoustic fragments during static finger positions, extracting fine-grained multipath effect features, and designing a reliable authentication method with limited training samples. The proposed method aims to overcome these challenges through careful consideration of finger static period estimation, multipath effect extraction, and feature-based verification. In summary, TouchPrint presents an innovative approach to user authentication based on geometry biometrics of touch gestures. The method leverages active acoustic sensing and touch trace analysis to enhance the security of password-based authentication on mobile devices, providing a reliable and user-friendly second-factor verification.

Paper [15] introduces a multifactor user authentication framework designed for wearable and VR platforms, addressing the challenge of user verification without traditional input methods like keyboards. It focuses on utilizing in-air-handwriting and hand geometry as authentication factors, captured by a depth camera. The proposed system combines motion signals from in-air-handwriting with hand skeleton geometry, aiming to enhance security. The authors present a novel signal matching algorithm, implement a prototype, and conduct experiments on a dataset of 100 users. The system achieves promising Equal Error Rates (EER), outperforming existing systems using the Dynamic Time Warping (DTW) algorithm. The paper emphasizes the revocable nature of the gesture passcode and discusses the contributions, including feature analysis and algorithm innovation, providing insights into user identity verification in gesture-based authentication systems.

III. PROPOSED SYSTEM

Existing system uses the Euclidean distance formula in order to detect key focus points on the hand to match them for authentication. This is straightforward and computationally efficient but these traditional authentication methods often face challenges such as password vulnerabilities and biometric spoofing. In response to this, the proposed system here combines the unique characteristics of hand geometry with the power of machine learning algorithms for accurate and efficient user authentication.

SYSTEM ARCHITECTURE

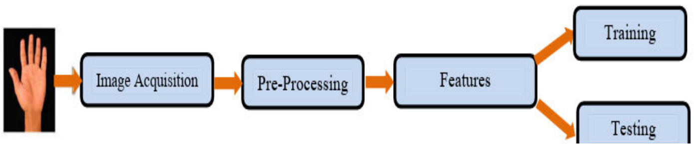

Fig 1: Block diagram of proposed system

A. *Data Acquisition*
   Utilizing a high-resolution imaging system, hand geometry data is captured, focusing on key features such as finger length, palm width, and finger spacing. This data serves as the foundation for training and testing the machine learning model.
B. *Preprocessing*
   Raw hand geometry data undergoes preprocessing steps, including normalization and feature extraction. This ensures consistency and relevance in the features used for authentication. The gray image has noise due to the presence of some noise in the captured colored image caused by the dust and surroundings conditions. This leads to the variation in database features and measured features and as a result affect the accuracy of the system. Therefore it's important to eliminate the noise from the image because it could decrease the difference between the real hand and the taken image.

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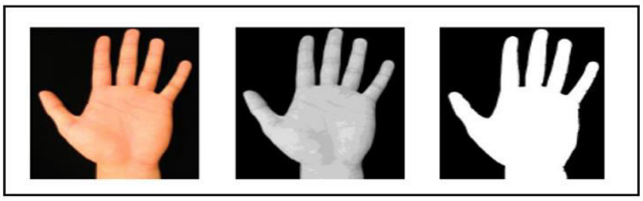

Fig 2: Converting colored, gray scale and binary image

C. Machine Learning Model

A machine learning model, such as a convolutional neural network (CNN) or a support vector machine (SVM), is employed to learn and recognize patterns within the hand geometry data. The model is trained using a labeled dataset, consisting of authenticated hand geometry samples.

D. Training, testing and evaluation

The machine learning model is trained using the labeled dataset, optimizing parameters to achieve high accuracy in recognizing legitimate hand geometries. The proposed system is rigorously tested using both genuine and imposter hand geometry samples. Performance metrics such as accuracy, precision, recall, and F1 score are calculated to evaluate the effectiveness of the authentication system.

IV. CONCLUSION

In the pursuit of secure and user-friendly authentication systems, the integration of hand geometry with a Machine Learning (ML) approach stands as a testament to the evolving landscape of biometric security. This research has delved into the intricate interplay between the unique physical attributes of an individual's hand and the adaptive capabilities of ML models, demonstrating the potential to redefine the benchmarks of secure access. The utilization of hand geometry as a biometric modality presents a compelling solution, offering inherent advantages such as user convenience and physiological stability. The dynamic nature of human hands, however, necessitates an intelligent and adaptive system to harness the full potential of this biometric method. The ML approach, particularly through the application of neural networks, has proven instrumental in extracting meaningful features, discerning complex patterns, and adapting to the inherent variability in hand geometry.

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