International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 05 May 2024
Page No: 1265 - 1270
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2024.0174

Enhancing Security Within Restricted Hospital Zones by Integrating Finger Vein Authentication

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Abstract
The integration of finger vein authentication technology to enhance security measures within restricted zones in hospital environments, is the aim of this project. An advanced biometric technique called finger vein authentication uses each person's individual vein patterns to confirm their identification. It is especially desirable for applications where security is critical, such financial transactions, healthcare, and access control, because it provides a very safe and non-intrusive means of authentication. Although there has been considerable success with traditional finger vein authentication methods, deep learning techniques have completely changed this field. A branch of artificial intelligence called deep learning has shown impressive results in pattern recognition and picture analysis, which makes it a prime contender for improving the precision and dependability of finger vein authentication systems. Finger vein authentication utilizes biometric characteristics unique to everyone, providing a highly secure method of identity verification. By implementing this technology, hospitals can bolster access control, prevent unauthorized entry into sensitive areas, and safeguard patient information and critical resources. The project aims to implement finger vein authentication systems to regulate access to restricted areas such as operating rooms, medication storage areas, and patient information sections. Authorized personnel will undergo authentication via finger vein scans for entry, ensuring that only authorized individuals can access these zones.

Keywords: *Authentication, Biometrics, Finger vein, Sensitive areas.*

1. Introduction

Compared to signatures and fingerprint authentication, the finger vein authentication system (FVAS) is more secure. This is a result of veins being prevalent behind the skin of humans, making them nearly cannot be duplicated. Moreover, the vein pattern is still present persistent over the course of a person's life, thereby removing the risk changes as opposed to iris and fingerprint biometrics. In fingerprints, the ridges start to wear away and space out when a person gets older. When employing iris authentication, the iris pattern can be changed by cataract surgery, which poses a serious challenge for security systems. The plan is to create a finger vein authentication system as a distinctive biometrics pattern. The target finger's image is a Near-Infrared (NIR) camera was used to record the transmission of infrared (IR) light. The output of this NIR camera vein patterns can be seen in photographs of the finger. The picture also includes different hues created by the thickness of finger bones, tissues, and muscles around the vein. The veins in the fingers branch off from one another and connect to generate these patterns. These patterns can be used for biometric identification since they are complex in nature. Finger veins are found in the subcutaneous tissue, which is the layer just beneath the skin's surface. Individual differences exist in the position and depth of finger veins, which may be influenced by age, heredity, and general health. Though they differ, the veins' overall distribution throughout the fingers is largely constant. The control of blood flow to and from the extremities is largely dependent on the veins in the fingers. Variations in the dynamics of blood flow, such as vasoconstriction or vasodilation, can impact how finger veins look and are visible. Variations in temperature, level of physical activity, and health status can all affect the dynamics of blood flow in the fingers. The creation of a method to recognize finger veins is the main topic of this study and the steps taken to secure transactions.

2. Literature Review

The literature surveyed some different papers to get information about the existing work which have been done. Shiyong Tao et al [1], in this paper has proposed a Deep Generalized Label Finger-Vein (DGLFV) model to extract feature maps and achieve excellent recognition accuracy. Using picture semantic segmentation, advanced bidirectional traversal, and center diffusion approach for the known categories, the largest rectangular finger-vein region is retrieved. Raunak Bhupal et al [2], in this paper has suggested a method that uses filtering techniques like segmentation, masking, skeletonization, and gabor filtering to extract ROI from the image with an accuracy of over 90%. This ROI will be used for comparison and help reduce the number of forgery instances that result from other biometrics. Jong Min Song et al [3], have looked into convolutional neural network (CNN)- based recognition techniques as a potential solution to the shortcomings of manually constructed feature-based techniques. Furthermore, the technique for determining the distance between feature vectors is less accurate than the method using different images and is unable to use all layers of the trained network. In order to solve these problems, a deep, densely-connected convolutional network (DenseNet) was fed a composite image of two finger-vein images as the input. This approach is less sensitive to noise and makes use of the entire network. Cihui Xie et al [4], has demonstrated that the Convolutional Neural Network (CNN) is remarkably capable of learning biometric features that provide reliable and accurate matching. This paper presents a novel method for authenticating finger veins using CNN and supervised discrete hashing. The suggested method not only outperforms other CNN architectures that have been studied in the literature, but it also offers a much smaller template size than other finger vein image matching techniques that have been studied in the literature. Haiying Liu et al [5], employ manually created descriptors like local binary pattern (LBP), local line binary pattern (LLBP), and Gabor features. In order to accomplish this, we first compute the difference between each pixel and its straight-line neighboring pixels in order to extract multidirectional pixel difference vectors (MDPDVs) for each pixel in a training finger vein image. Manisha Sapkale et al [6], have proposed a novel finger vein recognition algorithm will be used to implement the system. Lacunae, fractal dimension, and gabor filter are the algorithms used to extract features, and a distance classifier is used to match the extracted features.

3. Proposed System

The system enrolls the user's finger vein pattern, usually by taking a close-up picture of the veins under the skin, to accomplish this; a near-infrared light is used. The system gathers and saves unique characteristics of the finger vein pattern during enrollment. The system takes a real-time picture of a user's finger veins and compares it to the reference template that has been stored in order to verify their identity, to ascertain whether the live image corresponds with the enrolled pattern within a predetermined tolerance, the system utilizes sophisticated pattern recognition algorithms.
The user receives access if there is a match; if not, access is refused show in Figure 1.

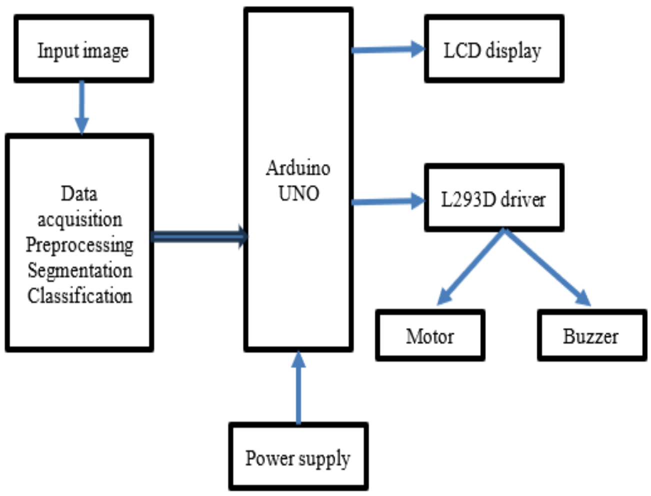

Figure 1 Block Diagram

3.1. Block Diagram Explanation

The system makes use of an image preprocessing unit that enhances and cleans the captured finger

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vein images removing noise and improving overall quality. The feature extraction module identifies unique features within the finger vein patterns, creating a distinctive representation for each user and the template storage within the database stores the extracted vein feature templates associated with registered users. Then the user authentication is done by using an authentication algorithm that compares the extracted features from the scanned finger vein image with the stored templates to verify the user's identity. The output results are displayed in the LCD. This is done by integrating Arduino UNO to the system and connect it to the LCD Display, if the personnel is authorized or unauthorized. The buzzer module will indicate the unauthorized personnel and the motor indicates authorized personnel.

3.2. Methodology

A proposed system for using finger vein authentication to enhance security in hospital restricted zones could consist of several components. This includes specialized biometric scanners equipped with near-infrared (NIR) imaging technology capable of capturing and analyzing the unique vein patterns in individuals' fingers. A centralized database is required to store the biometric templates generated from individuals' finger vein patterns during enrollment. This database should be securely encrypted and accessible only to authorized personnel responsible for managing the authentication system. During enrollment, individuals' identities are verified and linked to their biometric templates. The system requires specialized access control software responsible for coordinating the authentication process. The proposed system should integrate seamlessly with the hospital's existing security infrastructure, including surveillance cameras, alarm systems, and personnel identification badges. A user-friendly interface is essential for hospital staff to interact with the authentication system efficiently. The system should maintain detailed logs of access attempts, including successful and unsuccessful authentication events. This audit trail provides administrators with valuable information for monitoring system activity, identifying security incidents, etc. Comprehensive training and ongoing technical support are essential for hospital staff members responsible for operating and maintaining the finger vein authentication system. Training ensures that personnel understand how to enroll users, troubleshoot issues, and respond to security incidents effectively. Given the sensitive nature of healthcare data, the proposed system must adhere to strict privacy regulations such as HIPAA. This includes implementing robust data encryption, access controls, and audit mechanisms to safeguard patient information and maintain compliance with regulatory requirements. The system should be designed with scalability in mind to accommodate future growth and expansion of the hospital's facilities. This includes support for adding additional biometric scanners, enrolling new users, and integrating with emerging technologies as needed.

3.3. Software Requirements & Implementation

MatLab GUI application which allows users to control your software applications with point-and-click capabilities to learn a language or type commands in order to use the program.

Image acquisition: It is necessary to take multiple images at various illumination levels and fuse the images together using pixel-by-pixel averaging in order to get a good image for data acquisition at the first block. Since the most common issue is achieving some level of vein visibility into the area surrounding the illuminators, it is necessary to select a non-balanced average that attempts to reduce the score of highly illuminated areas in order to achieve the desired results in Figure 2.

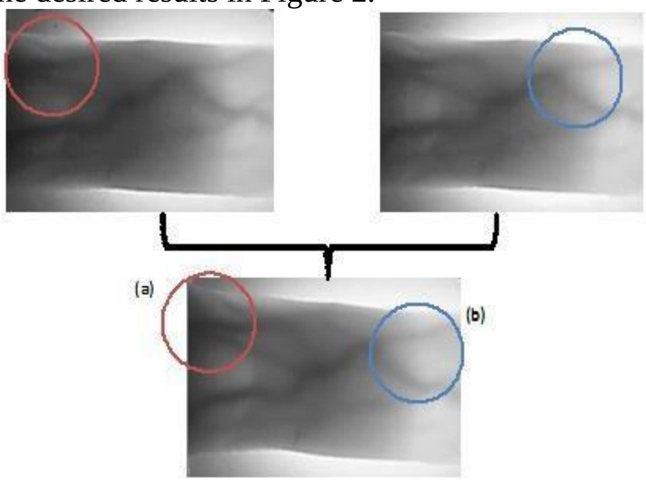

Figure 2 Image Acquisition

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Finger vein segmentation: Typically, only a small portion of the finger's interior is used to acquire the vein pattern. Nevertheless, testing conducted for this project revealed that adding the finger shape as an additional finger vein and merging it with the vein nearer the finger's edge enhanced the end user experience and raised the likelihood of identifying a real user. By using a fuzzy segmentation technique, the finger vein contour is not identified in order to separate it from the finger vein pattern during the extraction process in Figure 3.

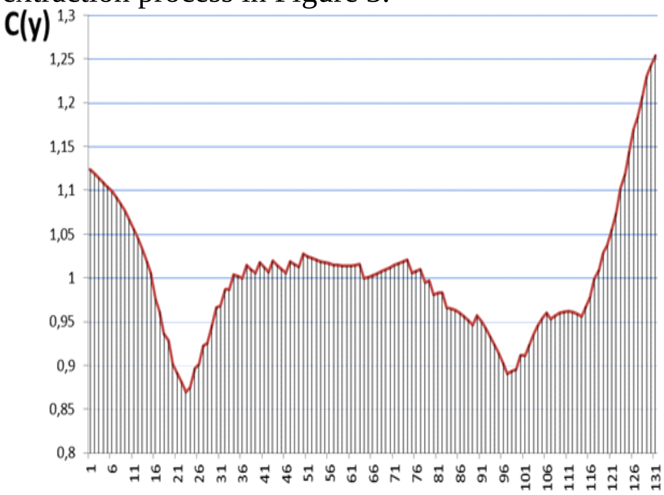

Figure 3 Cross-Sectional Profile Of Finger-Vein Image

Features extraction and matching algorithms: The next stage in an identification system is to select, design, and implement the pattern recognition algorithm and features that will be used for identification once the finger vein pattern has been obtained. It is possible to combine several data types and pattern recognition techniques into a single final score.

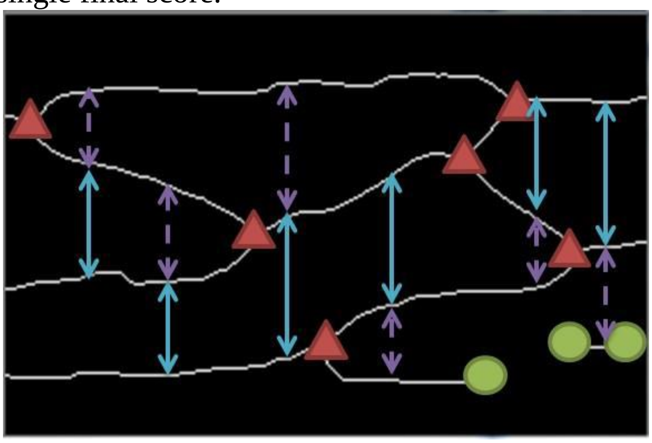

Figure 4 Feature Points Extraction

Since these systems employ various features to accomplish a single identification, they are commonly referred to as multimodal systems. Three distinct types of data from the finger vein pattern were chosen for this project as feature points, and the fusion of these features produced the desired outcome. As is show in Figure 4.

3.4. Hardware Requirements & Implementation

- ESP32 camera module
- IR LED Array
- Arduino UNO
- Liquid Crystal Display (LCD)
- L293D driver
- Buzzer
- Motor

Set up the development environment for programming the ESP32-CAM module. The Arduino IDE with the ESP32 board support package can be installed. Develop code to trigger image capture on the ESP32-CAM module. Capture multiple images under different lighting conditions illuminating IR LED Array and finger orientations to ensure robustness of the vein pattern recognition algorithm. Transfer the captured finger vein images from the ESP32-CAM module to a computer or network server for further processing and analysis. After the processing, integrate the software results into the hardware components with the use of Arduino UNO. The Arduino can be powered through its DC barrel jack or the VIN pin, which accepts voltages from 7V to 12V. Connect the positive (+) and negative (-) terminals of the LCD to the corresponding pins on the Arduino or an external power supply, depending on the LCD's voltage requirements. Ensure that the power supply can deliver the required current for the LCD. Connect the positive (+) and negative (-) terminals of the buzzer to digital pins on the Arduino, and ensure that the power supply can deliver enough current for the buzzer to operate. Supply power to the L293D motor driver separately from the Arduino. This power supply should provide the voltage required by the motor and be capable of delivering the current required by the motor under load. Once everything is connected, test the system to ensure that each component receives power and functions

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as expected. The function of the LCD is to display whether the user is authorized personnel or an unauthorized one. The function of the motor is to run when the authorized person's finger vein image is given. The function of the buzzer is to beep if an unauthorized person's finger vein image is given in Figure 5.

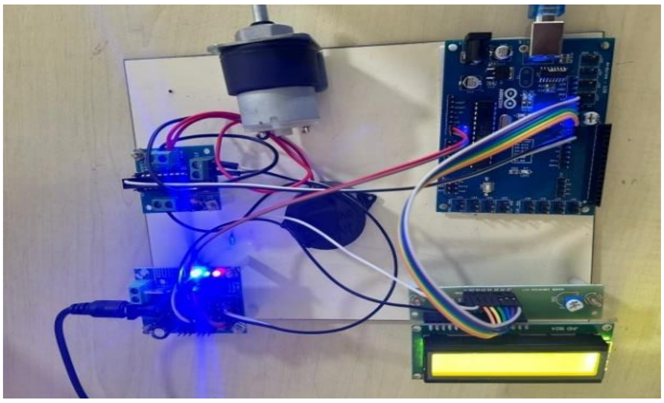

Figure 5 Hardware Implementation

4. Results And Discussion

4.1. Results

The method for obtaining the finger vein pattern from an input near-infrared camera and the necessary actions to turn it into a dependable system for identifying finger veins have been described. This study has demonstrated how the issues associated with the finger's non-uniform lighting from a variety of illuminators can be resolved. It would be advised, therefore, that similar design flaws be avoided in subsequent device designs. It was feasible to determine the impacts of rotations and various finger curvature levels during the experimentation with the segmentation, extraction, and matching processes of the finger vein. As a whole, establishing finger vein authentication into place in hospital restricted zones provides a complete way to improve efficiency, security, and compliance while preserving patient privacy. Hospitals may build a safe environment that keeps resources and sensitive places safe from unwanted access by utilizing biometric technology.

4.2. Discussion

This study offers a networked implementation of a finger vein identification system after observing the viability and effectiveness of various setup and methodologies. The method for obtaining the finger vein pattern from an input near-infrared camera and the necessary actions to turn it into a dependable system for identifying finger veins have been described. This thesis has demonstrated how the issues associated with the finger's non-uniform illumination from a variety of illuminators can be resolved. It would be advised, nevertheless, that such design flaws be avoided in subsequent device designs. It was feasible to determine the effects of rotations and various finger curvature levels during the experimentation with the segmentation, extraction, and matching processes of the finger vein. To determine the final parameters of our suggested solution, it has researched and defined the characteristics of various approaches and scoring configurations. Additionally, it is demonstrated that low-accuracy methods can be used to define a multimodal system with higher accuracy. However, it has also been demonstrated that the system's minimum required FAR can suffer greatly if one of the combined systems fails, and that combining multiple samples per user can significantly improve system performance in Figure 6.

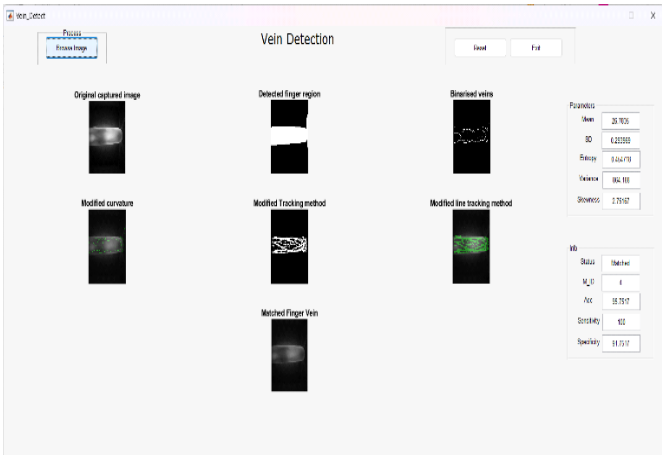

Figure 6 Output of The System

Conclusion

In this stage of the finger vein authentication system's development, the focus is primarily on image processing, feature extraction, and segmentation, which integrates various matching algorithms. We take care of all the project's implementation and software requirements in this.

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https://doi.org/10.47392/IRJAEH.2024.0174

A more precise and accurate hardware-supporting system will be created in the following stage. The finger vein authentication system may be widely used in the future in several industries that need secure transactions and biometric authentication. The current biometric authentication systems will undergo a significant transformation as a result. The real time monitoring of finger vein will be established along with the idea of developing a finger vein scanner that is cheaper and easily available in the market.

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