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Design and Implementation of Vascular Pattern Recognition System

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Abstract:* This paper proposes a novel technique to analyze the vein patterns in the back of the hand for biometric authentication system and medical purposes. It deals with the design development of non-invasive subcutaneous vein detection system and is implemented based on near infrared imaging and interfaced to a PC to make it portable. A web camera is used for capturing the images and Computer Software modules (MATLAB & SIMULINK) is used for the processing. The first task is to extract the hand and then the vein patterns. To identify the patterns in hand, near-infrared rays generated from a bank of light emitting diodes (IR LEDs) penetrate the skin of the Palma dorsa. An image of hand veins acquired by near-infrared (NIR) imaging device, usually suffers from low contrast and noise due to non-illuminated and thickness of the hand skin. This makes subsequent processing such as segmentation difficult. To enhance the quality of hand vein image we used the threshold segmentation method. Extensive experiments were carried out on dorsal veins to achieve the promising accuracy and thereby provide new insights on this new biometric approach.

***Keywords:* Vein Recognition; Image Processing; Dorsal veins**

I. INTRODUCTION

Biometric based security systems such as a retinal scan, fingerprint sensing, iris recognition and face recognition have been gaining limelight in the recent years. These systems are extremely accurate, but are more prone to data theft and fraud. One of the relatively new techniques used for biometric detection is the extraction of Vein patterns underneath a person's skin. Researchers have determined that the vascular pattern of the human body is unique to a specific individual and does not change as people age. Moreover, as the complex vein structure is hidden under the skin it is not possible to steal, forge or replicate the vein pattern because it cannot be left behind unintentionally. Because of these advantages, this technology is carving its spot in the market of biometric recognition. Additionally, the problem faced by the doctors today, is difficulty in accessing veins for intravenous drug delivery, cathedral insertions, blood draws and other medical situations. Many a times, even trained nurses and doctors find it difficult to exactly locate the blood veins on the first attempt. Venipuncture is an everyday procedure in healthcare settings. Thus, this system can also be used for detecting the veins for medical applications.

Fig 1. Vein pattern in the dorsum

Fig 2. Vein puncture for medical tests

Hemoglobin is the main component of the red blood cells found in the blood stream that carries oxygen from the lungs through arteries and helps in the transport of carbon dioxide from tissues through veins back to the lungs. Vein pattern recognition system uses deoxidized hemoglobin. The reason is that the deoxidized hemoglobin absorbs infrared light, making the vein pattern visible when we use a camera to illuminate it and the oxidized hemoglobin become almost transparent.

In this paper, we specifically focus on the vein pattern from the Palma Dorsa. The aim of the project would be to focus on vein recognition algorithm which could extract the veins from the user's hand. A new absorption-based technique has been proposed to collect good quality images with the help of a camera and light source (IR LED). This project involves two stages: extraction and verification. In the extraction stage, vein image of the user is captured. After that, image processing methods are employed for enhancing the quality of vein image. Based on the enhanced images, features are extracted and stored as the templates. In the verification stage, a vein image of testing user, is captured and then image pre-processing and feature extraction are performed on the captured image. At last, the verification result is obtained by comparing the similarity between testing feature and stored templates.

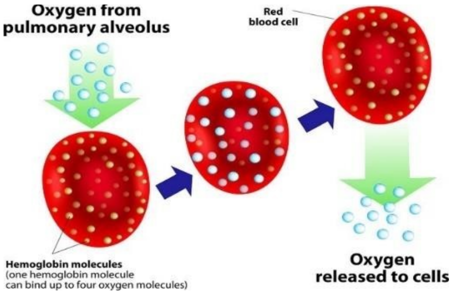

Fig 3. Hemoglobin Molecules

II. LITERATURE SURVEY

A. The paper titled "Vein detection system using infrared light" by Mayur Wadhwani, Abhinandan Deepak Sharma, Aditi Pillai, Nikita Pisal, Dr. Mita Bhowmick says,

That the design of non-invasive subcutaneous vein detection system and is implemented based on near-infrared imaging and interfaced to a laptop to make it portable. The main aim was to make a portable and cost-effective device. A customized Charge Couple Device camera was used for capturing the vein images and Computer Software modules such as MATLAB & LabVIEW were used for the processing.

The image of the arm was captured using an ordinary webcam by replacing the visible inbuilt LEDs with 8 infrared LEDs. This was done to improve the image quality so that the vein patterns can be more easily detected during the segmentation. Then the region of interest was cropped and isolated using filters to reduce noise and enhance the contrast.

Since the images were captured using a modified webcam, a considerable noise was present in the images. Gaussian and median filters were used to remedy the effect of this noise. The second was contrast enhancement, which was necessary as the vein pattern was faint. This was done by using Global threshold method. This method uses the bimodal histogram and calculates the inter-variance between them. Adaptive histogram splits the image into different tiles of 8x8 pixels and finds the histogram in each tile to give a better contrast.

This paper investigates near-infrared techniques for vein imaging. Thus, portable NIR vein detection system was able to visualize and detect vessels from the anterior forearm.

B. The paper titled "Low cost, high quality vein pattern recognition device with liveliness, workflow, implementations" by Septimiu Crisan, Bogdan Tebrean.

This paper aims to propose and implement a robust, modular hardware device that retains the low-cost entry barrier for academic experiments while providing high-quality scans of the blood vessels with significant improvements over traditional scanning systems. The inclusion of a powerful liveness detector using additional raw image calculations and external parameter monitoring (image contrast, temperature or skin reflexivity) completes a possible roadmap for an open-source vein pattern device.

The research leading to this paper has mainly focused on integrating a commonly available device, the PI NoIR camera into a vein pattern processing chain. The PI NoIR is used together with a Raspberry PI device for all the required image preparations.

The algorithm used in this paper - A central 50x50 pixel region of interest was selected from the raw image of the vein pattern after determining the contour of the hand. For a 320x240 pixel image size, this offers sufficient data for analyzing the pixel values transitions. The ROI dimensions are strictly related to the optical acquisition module and the active area was constrained inside the hand. For each pixel, the absolute difference between the values of the adjacent pixels -raw and column- and the target pixel are calculated. The differences are added and stored for averaging. After completing the entire image area, the maximum and minimum difference between two successive pixels is calculated. The resulting interval represents an expression of the local contrast in the image and was used together with the average pixel difference value. In order to increase the protection of the system against false samples, additional low-cost external devices are used. The hand is illuminated by a set of red LEDs with a central wavelength of 650 nm. The reflected light from the surface of the hand is captured by two photodiodes placed on opposite sides of the camera. The particular optical properties of the human hand offer a distinct set of reflection values that are difficult to spoof. A secondary sensor used for non-contact temperature measurement is attached to the system. This paper has tackled the need for a modular hardware device that can act as a potential standard in vein pattern recognition.

III. PROPOSED TECHNIQUE

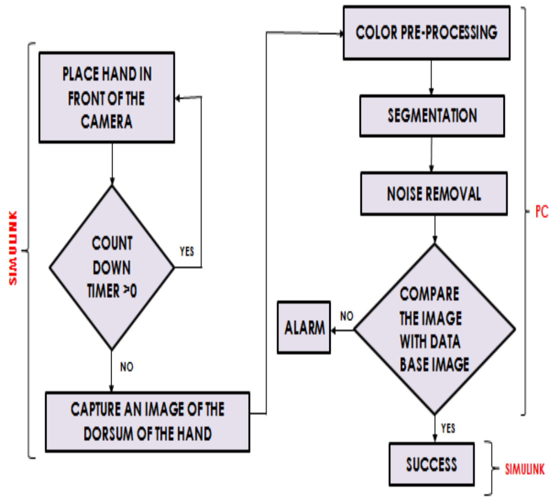

Fig 4. Flowchart of vein pattern recognition system

The hand fist is placed inside the black box. The hand is placed in the fist mould in front of the camera at a certain distance. There is a count up timer set to 2 Simulink seconds. When the timer reaches the set time and a picture of the dorsum is not captured, then the hand should be placed properly again in front of the camera for capturing the image of the Palma dorsum.

Once the image is captured, color pre – processing of the image is performed. Firstly, the hand has to be extracted from the background. For that process, a suitable color model has to be chosen such that any skin tone can be easily identified and distinguishable from the background so that the background can be easily nullified.

Next, a process called 'Segmentation' is carried out. In this process, based on the threshold method of the hand, the entire background is made as black and the hand as white. There are a lot of noise pixels generated after the above process. These noise pixels are nullified using suitable noise removal techniques. After the noise removal, the same process is repeated for the extracting the veins. This is can be used as an application in the medical industry. For the biometric security system application, the extracted vein pattern image is compared with the pre – loaded image that forms the database of the system. When the live detected image is matched with the database image, then the access is granted. If not, there is a ringing of a false alarm indicating that there is trespassing.

IV. PICTORIAL REPRESENTATION

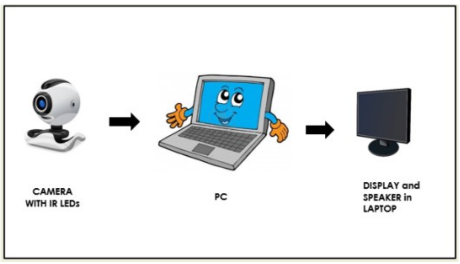

Fig 5. Pictorial representation of the vein pattern recognition system

The figure 5 represents the pictorial representation which consists of a camera mounted with an IR LED ring inside a black box. The black box is connected to the PC where the image processing and comparison of the vein pattern is carried out in a PC.

A black box is designed and a mould is used to make sure that there is no difference in the position of the hand fist inside the box. The hand is placed in the fist mould at a certain distance from the camera. After the image is captured, processing of the image is carried out using MATLAB and Simulink. Live data processing and comparison with the data base is executed in the PC using Simulink.

V. RESULTS

The following images show the final extracted hand and veins. The extracted veins can be used for various purposes in the medical industry. Further, for developing a biometric recognition system, the final extracted vein pattern is fed into the database. The real time images are processed and compared with the database images for authentication.

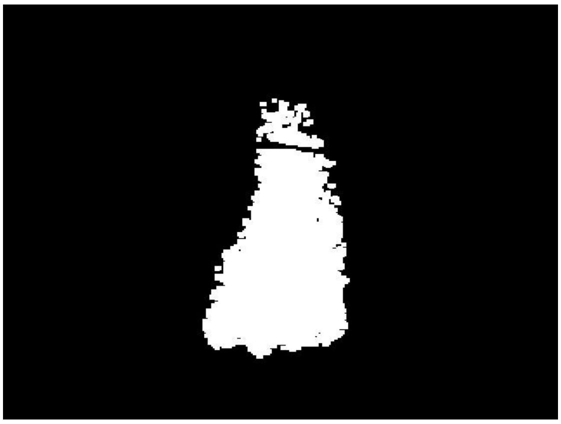

Fig 6. Final Hand extraction

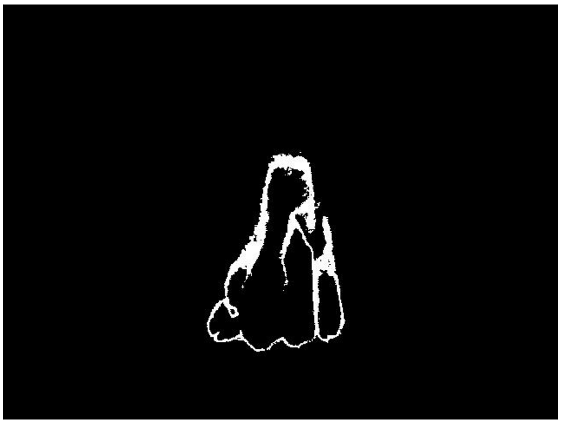

Fig 7. Final Vein extraction

VI. CONCLUSION

The stand-alone, portable NIR vein detection system was able to visualize and detect vessels from the dorsum. Various image algorithms were tried on still images and threshold segmentation worked best on MATLAB. Real time processing was implemented using SIMULINK and samples were obtained. Taking sample images from people of different skin complexities and muscle built, the desired image output were successfully obtained. Since we have made portable IR imaging due to that we have encountered motion artifacts issues. Therefore, our goal of obtaining a portable cost-efficient vein imaging system is accomplished.

Though the current database is relatively small and it is not adequate to draw any firm conclusion on the discriminating power of vein patterns for a large population (in terms of millions of users) group, the experiments do show the potential of the minutiae of the vein patterns as a biometric feature for personal verification applications in a reasonable sized (in terms of hundreds) user group. Continuous efforts are being made to expand the database, however, vein pattern data collection is a time-consuming process. The results presented here indicate the potential of the use of hand-vein pattern minutiae as a discriminating feature in the hand-vein images.

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