# Low Cost Hand Vein Authentication System on Embedded Linux Platform

**Gayathri S, K Gerard Joe Nigel,S Prabakar**

***Abstract— Biometrics is one of the highly accurate technologies in the field of user identification. This paper presents a low costcontactless biometric identification system on Embedded Linux platform which is used to authenticate a person using the vein pattern in hand. As the system uses the vein pattern which is unique to each individual and is contained within human body, it is highly secure and accurate. Moreover, its contact less feature gives it a hygienic advantage over other personal authentication technologies. The system works by capturing a person's vein pattern image by radiating it with near -infrared rays. The deoxygenated blood in the vein absorbs the near infrared radiation and thus the vein pattern appearsas black areas in the image. This captured pattern is stored as a template for the user verification. The experimental results of the proposed system shows that the dorsal hand vein pattern is highly unique and is a better alternative for other personal authentication systems. Also, the use of low cost ccd camera and open source Embedded Linux made the system cheaper than the conventional systems without risking accuracy.***

***Index terms — Embedded Linux, Hand vein authentication, pattern extraction, pattern matching, verification.***

## I. INTRODUCTION

Biometric recognition which is based on the inborn physical and behavioral characteristics of a person, has become an important techniquefor security systems. Fingerprint, face, voice, iris, retina and hand geometry are some of the biometrics which are in use since long for personal identification.One of the most secure and accurate biometric is the vascular technologies. A vein authentication system uses blood vessel patterns as a personal identification factor.Uniqueness is one of the main advantages of this system as the vein pattern of each individual differs. Also right and left hand vein pattern of the same person is entirely different. It provides a high level of accuracyas the vein information which are internal to the human bodyis hard to forge. As the system uses the near infrared imaging techniques, there is no need to inject any chemicals into the body. The main aspect of such systems is to capture and extract the vein pattern correctly with a reduced cost and processing complexities.The opportunities to implement hand vein authentication system span a wide range applications including security systems,banking, commercial enterprises and educational facilities.

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SYSTEM DESCRIPTION

The entire system can be divided into four steps: data collection, preprocessing, feature extraction and feature matching.

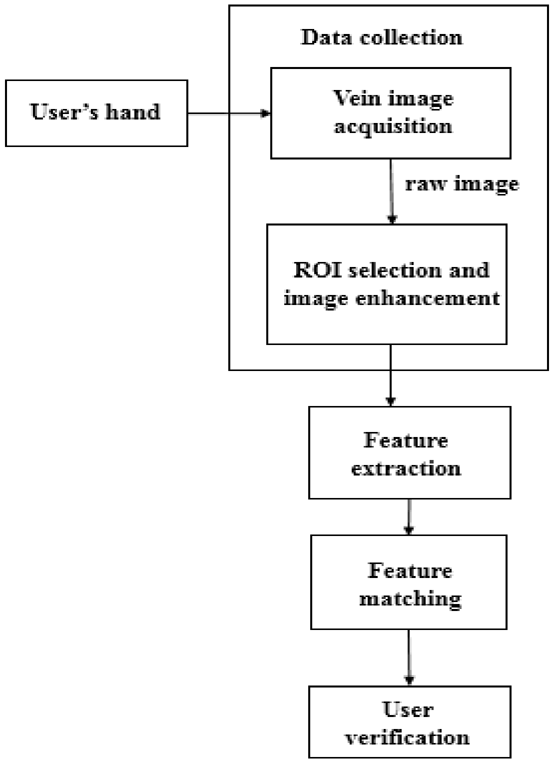


**Fig 1: Block diagram of the proposed authentication system**

An IR sensitive ccd camera which is provided with an array of 24 IR LEDS is used to capture the vein image. A rectangular region in the hand images is defined as the region of interest (ROI). The clarity of the vein pattern in the extracted ROI varies from image to image, therefore the quality of these images need to be enhanced before further processing. So the contrast of the vein image is enhanced using histogram equalization. Histogram equalization redistributes the pixel intensity values thereby changing the contrast of image. As the size of vein grows, only the shape of the vein pattern is used as the sole feature to recognize each individual. A good representation of the vein pattern represented as dark lines is done via extracting its skeleton. The extracted feature is then matched with the stored template using correlation to authenticate the user.

## III. IMAGE ACQUISITION

In electromagnetic spectrum, the wavelengths from 740 to 1100 nm is called the medical spectral window. Infrared (IR) is long wavelength electromagnetic radiation whose wavelengths lies between about 750nm and 1mm. It is commonly divided into 3 spectral regions: near, mid and far-infrared light. Infrared imaging is a non-invasive technique and is capable of capturing subcutaneous veins, i.e. veins on the surface of skin. Therefore by exposing the subjects' vein to infrared illumination of a specific wavelength, vein images can be captured and analyzed. It provides a contactless, non-invasive method and requires no injection of any agents into the blood vessels and hence it is the best method to capture vein images.

The infra-red imaging techniques can be divided in to two types, Far-Infrared (FIR) and Near- Infrared (NIR).FIRmethod uses the property that the superficial human veins have higher temperature than the surrounding tissues.So this method can be used only in subcutaneous vein imaging. The NIR method gives better results for vein detection because of its certain attributes as compared to FIR. This method is not a temperature based technique since normal body temperature or surrounding temperature cannot interfere with this method. Also in NIR region the absorption of light is minimum and hence light penetrates through the tissues deeply, making the technique non-invasive. Thedeoxygenated blood in the vein absorbs the NIR light almost completely and thus the vein appears as darker areas in an image taken by an IR sensitive CCD cameraSo NIR method can be used in all veins imaging with high accuracy. A maximum penetration distance is 3mm and the captured images will be always grayscale thus benefitting the processing.

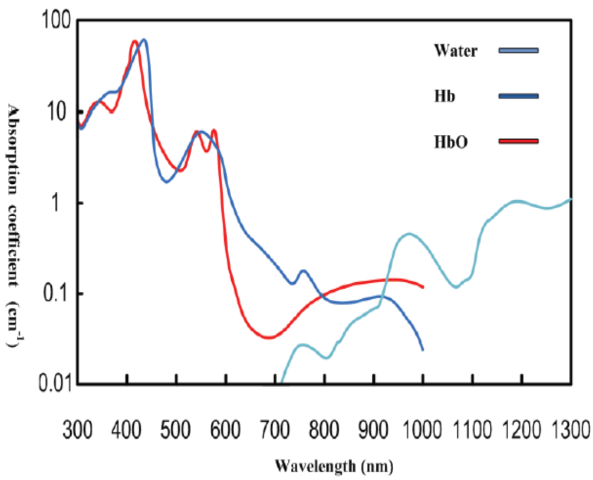


**Fig.2.Venous plexus of the hand**

In order to develop a low cost system which has the ability to capture the vein patterns a Capture CCD IR bullet camera is used. The camera has an array of 24 IR LEDs.It requires 12V DC supply and its video format is PAL. To capture the vein image with high quality the camera is kept in night mode. The camera is connected to the Embedded Linux platform via a USB 2.0 connection.The size of the acquired image is 320 x 240 pixels.

**Fig. 3 IR sensitive CCD camera**

A database of dorsal hand vein images of different individuals are collected in order to verify the uniqueness of the vein pattern. It is found out that the hand vein pattern are different for each individual and even right and left hand vein patterns of same individual are different.

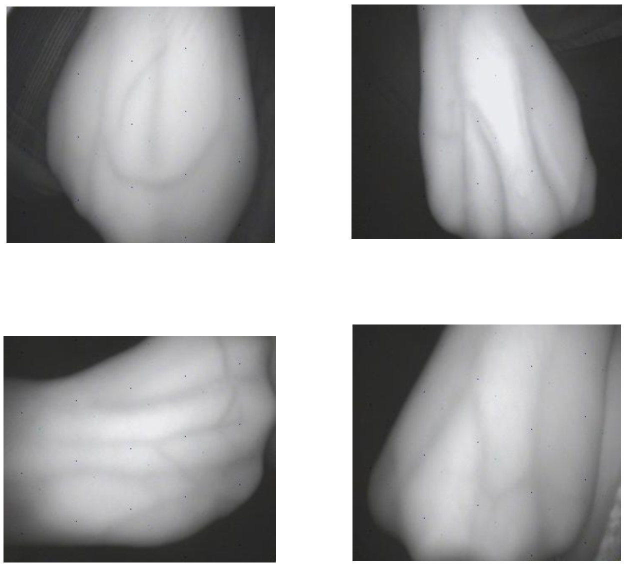

**Fig.4 Samples of the captured hand dorsal vein images**

## IV. HAND VEIN IMAGE PROCESSING

Infrared radiation does not penetrate all kinds of tissue in the same manner and therefore images taken from various subjects may vary significantly in terms of clarity of the vein model and in some severe cases the resulting image may have connectivity problems, several regions could be blurred or even impossible to detect. So various image processing algorithms are needed to extract the correct information from the captured images. All the processing is done using Python with OpenCV bindings.

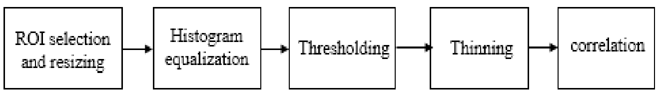


**Fig.5 Hand vein image processing**

### *A. Region of Interest Selection*

The entire region is not needed for processing. So a region of interest has to be selected. Here a rectangular region of interest is defined and is resized for the future processing.



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### *B. Histogram Equalization*

The histogram is a graphical representation of the information contained in the image. It shows how the intensity values of an image are distributed and the range of brightness from dark to bright. For an 8-bit grayscale image, the histogram information is 256 binary size. Histogram is a useful tool to analyze the brightness and contrast of an image. By adjusting the intensity value of the pixels, an image can be contrast enhanced thus making histogram equalization a well-known technique for contrast enhancement. The contrast of the image is enhanced by increasing the dynamicrange of intensity given to pixels with the most probable intensity values without chan. One transformation function that accomplishes this is a cumulative distribution function. This method redistributes the pixel intensityvalues evenly by using cumulative (sum) histogram as a transfer function. The input pixel intensity represented by *x* is transformed to a new intensity *x'* by the transform function T without changing the number of pixels in *x*. The transform function, T is cumulative distributive function of *x* multiplied with a scale factor. The scale factor scales the new intensity value withinthe range of the intensity values, normally 0 ~255.

$$x' = T(x) = \sum_{i=0}^{n} n_i \bullet \left(\frac{max.intensity}{N}\right)$$

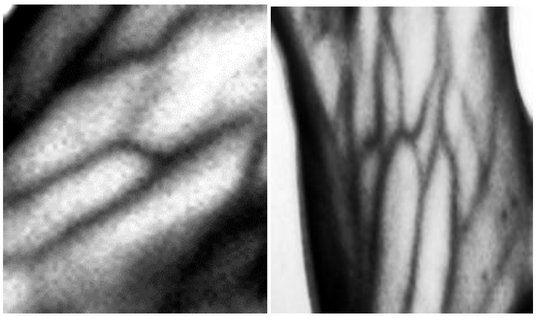

**Fig. 6Histogram equalized vein images**

### *C. Thresholding*

Image segmentation is a method which groups certain regions with respect to some common properties or the difference between the regions. It divides the image into a continuous set of pixels according to the assigned properties and hence used to separate the region of interest. One of the most important method for image segmentation is thresholding. In Thresholding pixels that are alike are grouped together and thus light and dark regions are seperated. Thresholding can be defined as:

$$g(x,y) = \begin{cases} 1 \ if \ f(x,y) > T \\ 0 \ if \ f(x,y) \leq T \end{cases}$$

A threshold T is chosen to separate object from background and thus creates binary images by changing all pixels above T to 1 and below to 0.

Fig. 7 Thresholded vein images

### *D. Thinning Algorithm*

Thinning is a morphological operation that can be used in a number of applications especially in pattern recognition and skeletonization. It is normally applied to binary images which remove selected foreground pixels from the givenimages and produces another binary image as output. Thinning operation normally tidy up edges by reducing all lines to single pixel thickness thereby creating the skeleton of the image. The behavior of the thinning operation depends on a structuring element with either one or zero at the origin. The thinning of an image *X* by a structuring element *Y* is defined as:

***Thin (X,Y) = X – hit and miss(X, Y)***

where the subtraction represents a*logical subtraction* which is given by:

***A - B = A ∩ NOT B***

The origin of the structuring element *Y* is translated from pixels to pixels in the given binary image*X* and at each such position it is compared with the underlying image pixels. Then the image pixel under the structuring element origin is set to zero if the foreground and background of structuring element and image exactly match with each other or else remain unchanged. As the thinning operation try to extract the skeleton of an image, it is a useful method in the vein pattern extraction. The skeleton is a binary representation of the pattern which is only one pixel wide.

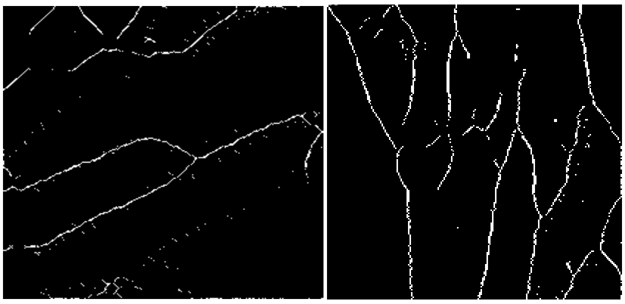

**Fig. 8. Thinned vein images**

### *E. Correlation*

The cross-correlation algorithm is the most conventional method to match two images. The correlation operation is shift invariant and linear. It is a windowed operation and search for each and every possible points in the image to find a match with the template.


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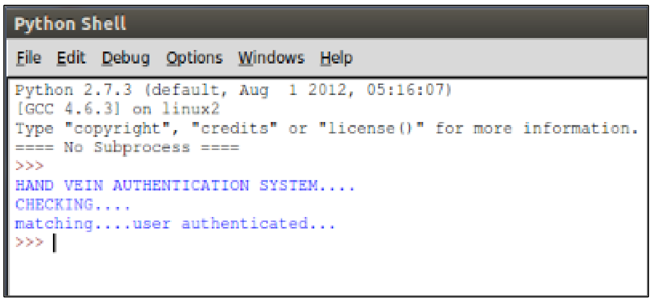
The similarity between the image and the template is calculated by measuring the sum of the squares of the differences between values in the images and template. As the difference between the image and template increases the measured value also increases. The two-dimensional cross-correlation operation of images is given as:

$$\boldsymbol{A} \bullet \boldsymbol{B} = \sum_{j=-N}^{N} \sum_{i=-N}^{N} A(i,j)B(x+i,y+j)$$




Where A and B represents the images for matching.

**Fig.9 result for matching**

## V. RESULTS

The proposed hand vein authentication system uses the near infrared imaging techniques. It captures the vein images using low cost IR sensitive camera kept in night mode. Captured images will be processed before matching for noise suppression and data reduction. As the first phase, a study of various methods for vein image capturing is done and a low cost imaging method is selected. The real time software implementation is done using python OpenCV in Embedded Linux which is a free prototyping software.

## VI. CONCLUSION AND FUTURE WORK

In order to make a complete system the proposed systemhas to be implementedon ARM 9 development board which support Embedded Linux platform as the future work. This system can be used in wide range of applications like ATMs, door security systems, PC login authentication, vehicle security systems etc.

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