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# A Finger Vein Image Based Personal Identification System Using Gabor Filter And Infrared Imaging

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*Abstract :* Security system is most power full technique to protect useful information from fraud people. Among all biometric system vein based pattern is a latest biometric technology for person identification. System itself has natural encryption for information. This paper work, demonstrate to design technique for identification of person based upon near infrared (NIR) finger-vein pattern. Proposed system consist of Raspberry pi, NIR filtered Pi camera, NIR LED array with LED Driver. infrared light is emitted by NIR LED array, which transmit via finger body, as the hemoglobin take up more near infrared light than the enclosing tissue, therefore area which more NIR light are observed (i.e. vein) appeared as dark region because vein observed less NIR light. Captured image which display using NIR filtered camera which located below the finger. The captured image is analyzed using mean square error (MSE) and peak signal to noise ratio (PSNR) to obtain preferable set point of potentiometer and both parameter indicate image which has less affected by noise. After capturing an appropriate near infrared finger imaging, utilize Gabor filter to extract vein pattern of finger for different orientations and width. Gabor filter are used to minimize noise and extract pattern of vein. Final objective to implement sparse representation algorithm in terms of global thresholding and Otsu's technique to detect the object (i.e. vain). The main purpose of this work to match or not- match finger images based on pixel to pixel matching.

***IndexTerms*** **- Near infrared finger image, Raspberry Pi, NIR filter camera, Mean square error, Peak signal to noise ratio, Gabor filter, Sparse algorithm.**

## I. INTRODUCTION

Aim of this research, to implement Image acquisition section, to capture image of finger body using NIR light which illuminated appropriately from near infrared LED array. Constant illuminated of LED array located above the finger and camera is located below the finger to capture the images of finger. The captured image get overexposure (more brightness in image) and underexposure (more darkness in image) problem to cause information loss in image, vein pattern get distractive in nature, which is impossible to recovered vein pattern through image enhancement process. Therefore at particular set point of potentiometer to adjust illuminance of infrared LED array to minimize overexposure and underexposure problem. To solve these problems, to implement image acquisition module to acquire the image by manually adjusting illuminance of NIR LED array. After capturing appropriate image, apply Gabor Filter to represent vein pattern in the form of texture images. Using mathematical equation to understand Gabor filter. Proper analysis for Gabor filter must be important for getting vein pattern. Final objective to determine matching performance using sparse algorithm. Sparse algorithm represent object and shows original nature of object. It shows where object located inside the finger body.

## II. FRAME WORK

The framework shows any biometric system has two phases. Phase one for image enrollment and phase two for image verification. At the time of image enrollment, we have to enroll our name and biological characteristics (in terms of feature) as a database. After that we can proceed for image verification. Image verification contain three phase (e.g. Fig. 1). Phase one for near finger vein image acquisition. near finger image acquisition module is designed to capture appropriate infrared finger images and get the information of optical model of finger body. Second stage in framework preprocessing, module contain preprocessed over acquired image in terms of removing noise, extracting feature. in third stage to detect object and matching the verified image with enroll image and predict the class of object.

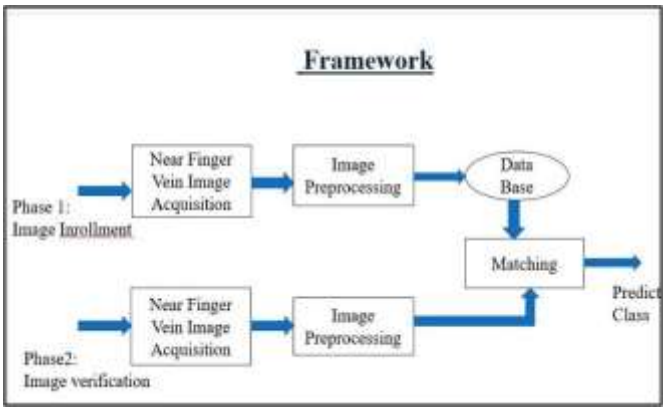



**Fig. 1 Framework for finger vein system**

### 2.1 Proposed system

Proposed system contain image acquisition module. Image acquisition module capture appropriate finger image for particular level of potentiometer. The basic principle for proposed system, when finger is located on camera module, raspberry pi unit initialize camera to capture finger images (e.g. Fig. 2). After capturing finger images it display on monitor. An image suffers poor quality and it does not give proper information. Because of overexposure (means more brightness in image) and underexposure (more darkness in image) problem, camera does not record any details in an image. Because of overexposure and under exposure problem vein pattern get destructive in nature. To avoid over darkness and over brightness in image, we have to adjust illuminance of near infrared (NIR) LED. In the proposed system to adjust illuminance of NIR LED using LM 317 regulator IC with potentiometer. under adjusting lighting condition we capture finger images.

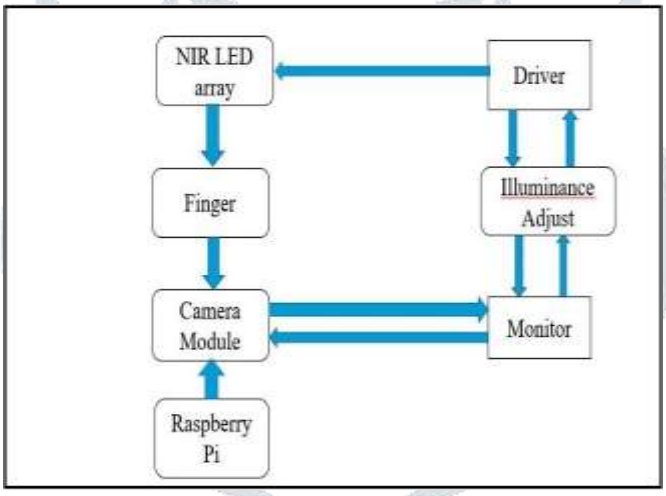
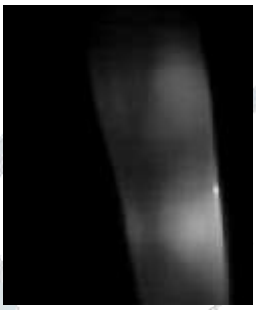
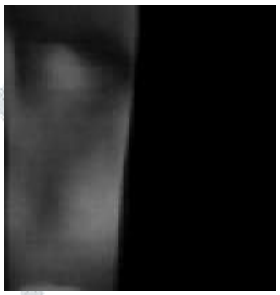



**Fig. 2 Image acquisition module.**

After capturing finger images, for particular pot of potentiometer have set, to avoid overexposure and underexposure problem for that, we have used eight level of potentiometer and it is corresponding adjusting illuminance images. We can see first level which has low illuminance, it causes underexposure problem. And eight level of potentiometer and it is corresponding adjusting illuminance, it has more brightness, it causes over exposure. Which level of potentiometer select for preprocessing, for that estimate mean value of each level of potentiometer. Mean value describe how bright the pixel is. Mean value contain intensity present in image. more the lightness of image, higher the mean value for images. Images shows, eight level of potentiometer which has a different mean value. Whichever highest mean value have selected that image is reference image (e.g. Table 1). After selected reference image we proceed mean square error (MSE).

Table 2.1 Approximation value of mean for different level of potentiometer

| | | | |
|---|---|---|---|
| Mean = 6.0626  | Mean=10.1028  | Mean =13.9954  | Mean = 19.90556  |
| Mean =22.24232  | Mean =24.04902  | Mean = 28.15862  | Mean = 35.6658  |

**2.2 Mean square error (MSE)**

Mean square error defined what is difference value of sampled image from reference image. we can see following images, capturing after adjusting illuminance. The approximation level eight is reference image because it's mean value is higher and other approximation level of potentiometer which is sampled images show in table 1.

**2.3 Peak signal to Noise ratio (PSNR)**

PSNR ratio is used a measure the noise present between reference image and sampled images. Higher value of PSNR gives good quality of that particular image. Value of MSE and PSNR, selected approximate level 5 which has low MSE and PSNR value for capturing image for preprocessing of images shown in table 2.2.

Table 2.2. Calibrating mse and psnr value for individual image

| Level of potentiometer | MSE Value | PSNR Value |
|---|---|---|
| 1 | 5.2186e+03 | 10.9553 |
| 2 | 2.5621e+03 | 16.0573 |
| 3 | 2.0051e+03 | 14.0449 |
| 4 | 1.6119e+03 | 15.1095 |
| 5 | 754.2639 | 19.3556 |
| 6 | 1.6108e+03 | 16.0604 |
| 7 | 1.3312e+03 | 16.8885 |

value of MSE and PSNR is estimate using MATLAB. Function name to calibrating MSE and PSNR in MATLAB is immse(Img1, img2) and psnr(img1,img2). And to estimate mean value the function name in MATLAB is mean(cell2mat(file name)) (Table 2).

## III. GABOR FILTER

The Gabor filter is linear spatial domain filter. Corresponding to frame work, it is preprocessed over captured region of interest of image, to filter the image to removing noise. Why Gabor kernel for preprocessing of image? Gabor Kernel capture textural pattern based information related to spatial domain and direction selectivity. Gabor filer are generally helps to object representation in texture analysis. It also detect edges of object, extraction of feature from the object. Gabor kernel is a Gaussian function have been found specifically texture. Representation and discrimination data form in 2D images. Gabor is a convolution filter, representing a combination of Gaussian and sinusoidal term. The Gaussian component provides weight or magnitude and sine component provide directionality. Gabor used to generate feature that represent texture and edges. In fact Gabor filter actually recognize texture with our eyes. We can understand the concept of Gabor kernel in terms of mathematical equation.

$$g(x,y) = \left(\frac{\gamma}{2\pi\sigma^2}\right) \times e^{\wedge} \frac{x'^2+\gamma y'^2}{2\sigma^2} \times \left(\cos\left(2\pi\frac{x'}{\lambda}+\Psi\right)\right)$$

**Fig. 3 Mathematical equation of Gabor filter**

### 3.1 Significance of parameter

1. g (x, y) is Gabor filter bank in direction for 2D co-ordinate x and y.
2. Sigma (σ) it is a standard deviation of Gaussian function, significance of sigma it shows how much spreading of vein pattern
3. Lambda (λ) is the wavelength of sinusoidal factor
4. Theta (θ) is Gabor kernel direction in the direction of rotational co-ordinate (X', Y')
5. (X', Y') are rotational version in the co-ordinate x and y.
6. Gamma (γ) it is aspect ratio of elliptical Gaussian envelope. If Gamma (γ) = 1, vein pattern in elliptical form and if gamma near to zero, it shows vein pattern in circular in form.
7. (Ψ) phase angle offset, to control the orientation in rotational co-ordinate.

### 3.2 Parameter analysis

Table 3 range and value of Gabor kernel

| **Parameter** | **Range** | **Selected value** |
|---|---|---|
| g(x, y) | – | – |
| σ | (7,15) | 14 |
| λ | Greater than or equal to 2 | 15 |
| θ | (π/2 and π) | π |
| γ | (0 to 1) | 0.5 |
| Ψ | (-π to π) | 0 |
| Ksize | (32,32) | (30,30) |

comparison finger vein Pattern for two users: After extracting feature, common question is finger vein is unique in nature? The answer for yes, in human every finger has different vein pattern, position of vein and it's size in finger has changed. Because of position of vein is change the property of pixel is also change. Now we can see table vein pattern for different user.

Table 4 comparing vein pattern for two user

| | |
|---|---|
|  Image (a) Finger image and ROI for user 1 |   Image (b) Feature extracted for user 1 |
|  Image (c) Finger image and ROI for user 2 |   Image (d) Feature extracted for user 2 |

## IV. SPARSE REPRESENTATION

To represent the class from the test sample. A sparse representation algorithm include both object detection and matching technique to compute the recognition rate. Sparse representation used to find repeated line tracking and pixel to pixel matching. less than or equal to thresholding value, the output pixel is marked as black colour (Background).In experiment, otsu's technique used. It also called as auto thresholding to automatically set thresholding value to get object from background pixel.

***How to detect object and separate out object pixel from background pixel?:***

Sparse representation, Global thresholding used to separate out foreground pixel from background pixel. If the intensity of pixel in the input image is greater than thresholding, the corresponding output pixel is marked as red colour (foreground), and if the input pixel intensity is less than or equal to thresholding value, the output pixel is marked as black colour (Background).In experiment, otsu's technique used. It also called as auto thresholding to automatically set thresholding value to get object from background pixel.

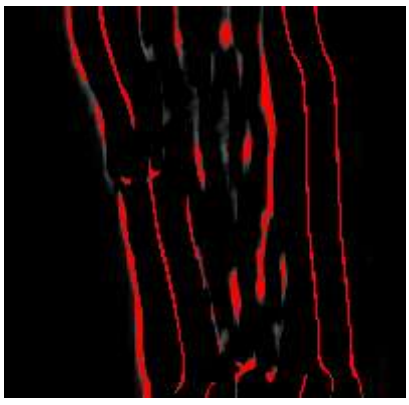


**Fig 4. Detection of vein pattern.**

***How to match, un-match one pixel from other pixel?:***

Basically in Python open-CV. Data is representation in terms of multidimensional array, in experiment 2D array is used. Array contain information of pixel in terms of x and y co-ordinate. According to Sparse, in experiment read two images, and have taken difference between two images. Apply masking technique on difference image, to get common pixel quantity for two images. In Array y-axis represent vertical pixel information. set of pixel quantity on y axis. Compare y axis array for two images, if vein pattern for two mask images is present same position on y-axis then result is matching the data. If vein pattern is not present for one image compare to other image on y-axis then pixel to pixel matching is fail.

## IV. RESULTS AND DISCUSSION

### 4.1 NIR LED driver and processing unit.

Shows the basic requirement for implementation of system is adjust the illuminance of NIR LED. Under adjusting condition to capture finger images. LM 317 regulator IC and potentiometer has importance role to adjust the illuminance of NIR LED. hardware section used to implement Image acquisition module to capture finger images.

**Fig 5. NIR LED driver**

System having raspberry pi and NIR filter camera has big role to capturing, analysing, and to extracting the information from the captured image. Camera is the basic requirement for our experiment.

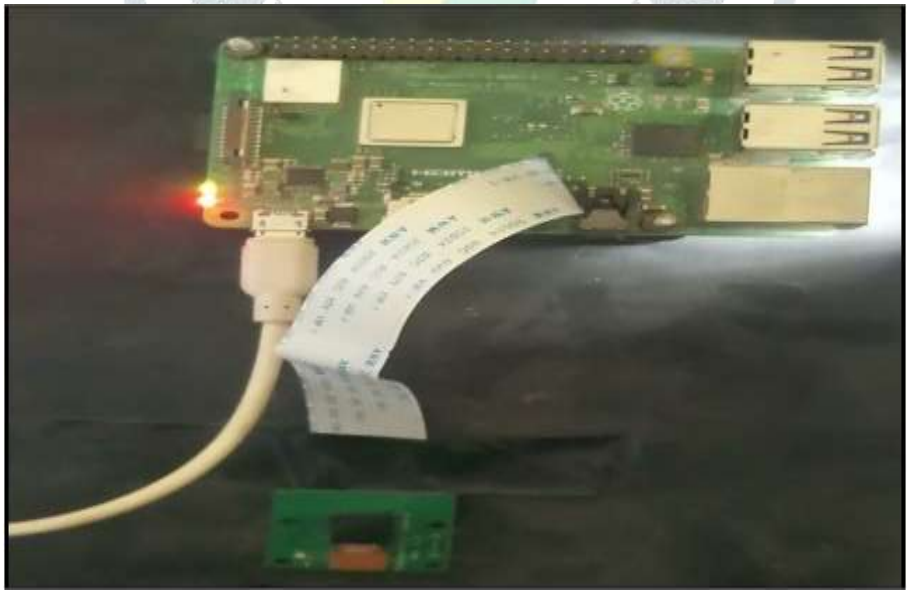
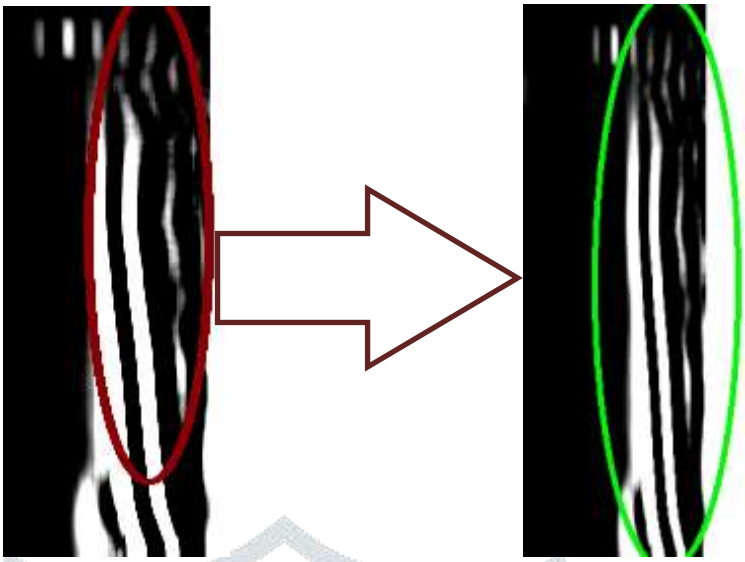


**Fig 6. Processing unit**

**4.2 Matching Result**



Images shows vein pattern of left hand index finger. If comparison of same vein pattern we get matching result.

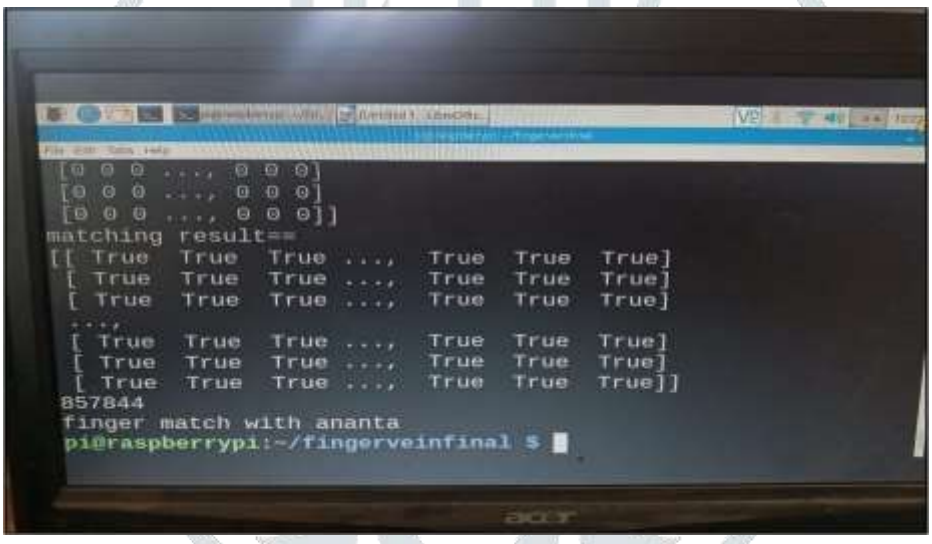
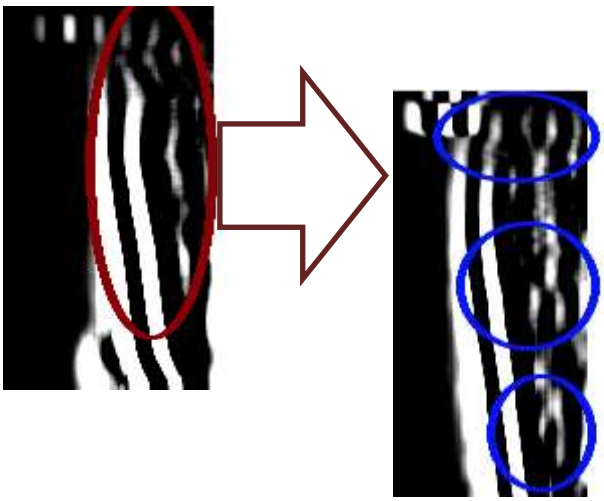



**Fig 8. Matching Result**

Matching result shows sparse matrix contain residual result for matching pixel. The score value shows how many pixel are interact with each from other with certain cut-off between two different images.

**4.3 Not-matching result**



Images shows vein pattern of left hand index finger. If comparison of vein pattern of left hand middle finger we get not-matching result.

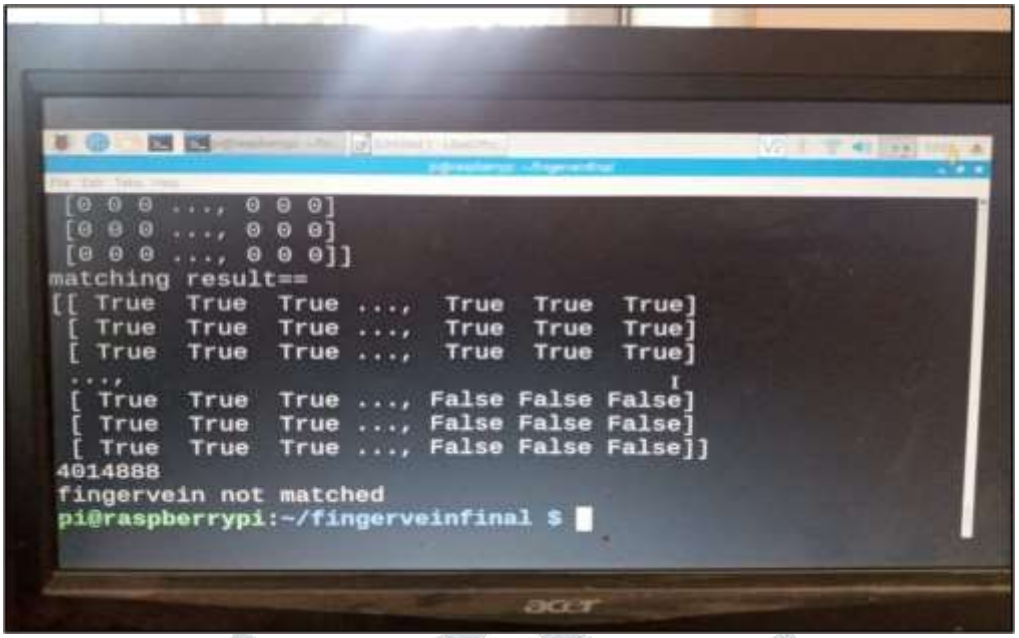



**Fig 9. Not matching Result**

Not-Matching result shows sparse matrix contain true and false value.

## V. CONCLUSIONS

The finger vein image based personal identification system depends on frame work and it's module. System has three module and each module depends on each other. First module in frame work to capture appropriate finger image using NIR LED array. If we unable to get appropriate image then brightness of each and every pixel is different. It is difficult to get object, so proper and constant illuminance is good for capturing image finger.

The second module in frame work, preprocessing of captured image, for that we implement Gabor filter. Gabor is the best solution to extract texture pattern of the vein. Using Gabor filter proper acquisition is maintain. It remove the noise in the form vascular body pattern of finger image. We have been seen mathematical equation and proper parameter value, selection and analysis proper value is the main role to extract vein pattern.

In frame work matching is the last module. Sparse algorithm has main role in matching module. using Sparse representation to represent object. we have seen Sparse is the best technique to detect object. After detecting object, using convolution to get common area between object and get match and not match result using x and y array.

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