# DESIGN OF PALMPRINT - PALM VEIN TOUCHLESS MULTIMODAL BIOMETRIC SYSTEM SETUP USING IP CAMERAS AND INFRARED LIGHT SOURCE

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***Abstract:*** A biometric system using palmprints and palm veins has been designed for use as a verification system in access control application. It uses two cameras - D-Link wireless web camera and Raspberry Pi No IR camera, which are both Internet Protocol (IP) cameras. The system setup is designed for touchless mode of acquisition. The robustness of the system to rotational, scaling and translational variations in the placement of hand has been studied. The setup is equipped with facility of varying the illumination using halogen lamp and an array of 33 Infrared (IR) LEDs of 850nm. This paper presents details of the setup and various experiments carried out. The paper ends with a discussion on the results obtained.

***Index Terms* – Palmprint Biometric, Palm vein biometric, Internet protocol, Raspberry Pi, Infrared.**

## I. INTRODUCTION

Palmprint and palm vein can be used as biometric identifiers because they posses important characteristics of stability and uniqueness. This paper details the design and development of a multimodal palmprint, palm vein system. The biometric system has been designed for use as a verification system in access control application. It requires two cameras - one for palmprint acquisition and other for palm vein acquisition. The cameras are positioned very close to each other so that both images can be captured simultaneously. The setup enables touchless mode of acquisition. Efforts have been taken to provide easy accessibility. So there is no enclosed structure and acquisition can be made in an open environment. It is a peg free system with minimal restrictions or constraints to the user for placement of hand. A touchless system has rotational, scaling and translational variations in the placement of hand. An open environment has variations in illumination.

The setup is designed to provide variations in illumination and distance from cameras. Different parameters such illumination intensity, distance from camera, palm images of different persons, orientations of hand placement have been varied and images acquired. The performance of the biometric system has been evaluated in the presence all these variations and analyzed in this paper.

## II. CONFIGURATION OF THE SYSTEM

Nowadays, with advanced technology, IP web cameras accessible via internet are available. Use of such cameras provides some flexibility in integrating the different components of the biometric system. It also provides an advantage that the acquisition setup can be compact and installed at one place and the administrator computer system can be installed at another place. Considering these benefits, both the cameras chosen for system development are IP cameras. A D-Link wireless web camera is used for acquiring palmprint images and a Raspberry Pi No IR camera is used to acquire vein images. The block diagram of the system is given in figure 1.

The cameras are positioned at the top of the system facing in the downwards direction. The user is required to place the palm on the flat surface provided at the bottom of the system with the palm ventral side facing the cameras. The structure on which the cameras are fixed is movable in the vertical direction. This facility enables variations in the distance of cameras and palm. Facility of varying illumination is also provided. It is known that illumination with yellow light gives higher accuracy in biometric systems [1]. Hence halogen lamps irradiating yellow light are used in the system. An electronic regulator is connected in the halogen lamp intensity control driver circuit. To facilitate palm vein acquisition, an array of 33 IR LEDs of 850nm is mounted around the cameras. IR LED driver circuit built with transformer, rectifier and voltage regulator is used to control the illumination of this IR source. Butter paper is attached below the IR LEDs to function as a diffuser.

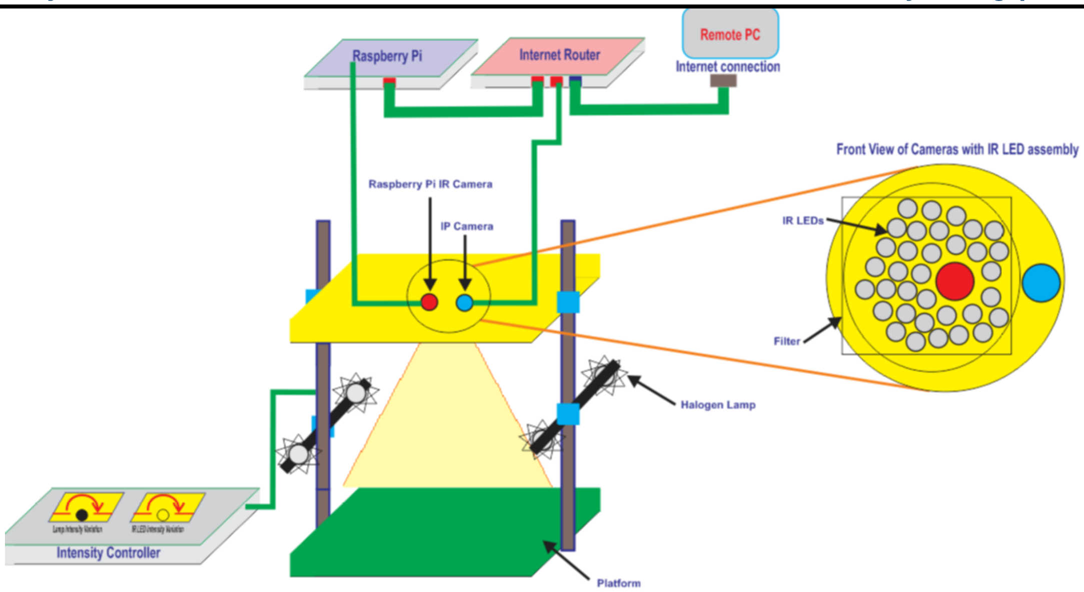



Figure 1: Block diagram of the system

## III. Palmprint Acquisition

To develop the system, D-link wireless IP camera model DCS-933L shown in figure 2 (i) is used for acquiring palmprints. This camera has a VGA 1/5 inch CMOS sensor and provides resolutions up to 640x480. It has built in CPU and web server that transmits high quality images [2]. The Raspberry Pi NoIR camera shown in figure 2 (ii) is used for palm vein imaging. The camera board v.1 has a 5 MPixel Omni Vision Color CMOS sensor with the IR filter removed and is sensitive to IR wavelengths 700nm to 1000nm. It has a fixed focus, but parameters such as resolution, image quality, automatic white balance, exposure modes can be set with available options [3].


Figure 2: (i) Front view of D Link camera (ii) View of Raspberry Pi NoIR camera

The system was optimized for palmprint images. Generally black background is suitable for capturing colour images because it gives high contrast images. However while acquiring images with D- Link camera with black background; it was observed that the images had no contrast as camera switched to night mode as shown in figure 3(i)

Figure 3: (i) Images with D Link camera in night mode (ii) Images with D Link camera in day mode

To address this issue, use of colour background became essential. The images improved in clarity as shown in figure 7 (ii). Palm images with coloured backgrounds are properly segmented and ROIs also extracted. The method of palm image alignment and ROI extraction explained in [4] is used. After proper optimization of algorithm parameters, the images have been correctly aligned in the desired manner and their corresponding ROIs have been successfully obtained.

## IV. Palm Vein Acquisition

Veins lie under the skin and Near Infrared light from 700nm to 900nm enters upto 3mm below the surface of the palm. Haemoglobin in the veins at this depth absorbs IR light. Literature review indicates use of IR LEDs of 850nm for illuminating the palm results in relatively good contrast images. The contrast between veins and tissues is higher at 850nm.Further, Contrast Limited Adaptive Histogram Equalisation (CLAHE) is used to enhance the images [5,6]. Also, the quality of hand vein images is improved by increasing illumination intensity [7]. At least1W power is required from the IR source to detect the veins [8].

In the system developed, the IR source is designed with 33 IR LEDs of 200mW and 850nm. The total power delivered by the IR source is 4.8W. The LEDs are arranged in a manner that there are more LEDs surrounding the Raspi No IR camera. The arrangement of IR LEDs is shown in figure 4.


Figure 4: Arrangement of IR LEDs

The settings of the camera were altered and through series of investigations, the automatic white balance was turned off, frame rate was decreased to 10 fps, image quality was increased to 100 and saturation was decreased to -100. Also when light from IR LEDS was directly incident on the palm, the images were difficult to segment. A diffuser is connected below the IR LEDs to minimise this problem. With these settings, the vein images are obtained as shown in figure 5.

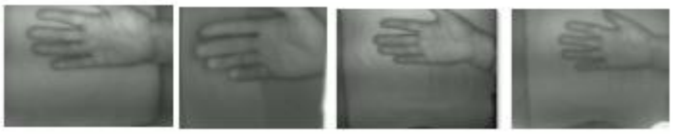


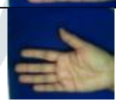
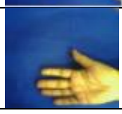
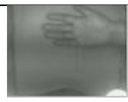
Figure 5: Images with Raspberry Pi NOIR camera

In this way, image acquisition with individual cameras was tested. The acquisition setup was optimized for D-Link and Raspi cameras to build a final setup.

## V. Final System Setup

A multimodal system with has been developed. Raspberry Pi and D-Link cameras are placed at closest possible distance with each other on the top. Space for placing the palm is provided at the bottom. The user needs to place the palm such that the palm side is facing the cameras. Table 1 shows the images acquired simultaneously.

Table 1: Images acquired with system

| Distance from cameras | Illumination intensity | | | | | |
|---|---|---|---|---|---|---|
| | 100 lux | | 400 lux | | 700 lux | |
| 25 cm |  |  |  |  |  |  |
| 30 cm |  |  |  |  |  |  |
| 35 cm |  |  |  |  |  |  |
| 40 cm |  |  |  |  |  |  |

It is observed that retaining palm within the field of view of both cameras is not easy. At distance of 25 cm, the palm is not fully captured with IR camera. At 30 cm, the thumb is not captured, but the palm region can be segmented. At distances greater than 30 cm, full palms are captured by both the cameras. When distance from the camera is increased, then the area occupied by the image decreases. So the distance is should be within 30 to 35 cm.

## VI. Study of Performance of the System with Palmprint Images

Palmprint images have been acquired with illumination, rotation, scale and translation variations. ROI are extracted for each case. The illumination of light source has been varied from 100 lux to 700 lux. Palm images have been acquired at different illuminations and ROIs extracted as shown in figure 6

Illumination intensity 100 lux 400 lux 700 lux

Palm images

ROIs extracted

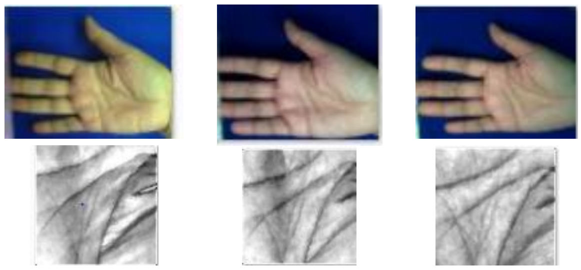


Figure 6: ROI extraction with illumination variation

At 100 lux, the illumination of halogen lamps is minimum. The ambient light of tube lights in the room falls on the palm surface. The surface of the palm appears to shine at this intensity. As the intensity of halogen lamps increases from 200 lux to 700 lux, the dominance of halogen light is more than ambient light and good quality palm images are acquired.

The palm acquisition has been examined for rotational, scale and translational invariance. Figure 7 shows images and their corresponding ROIs with rotational variation.

Palm images

ROI extracted

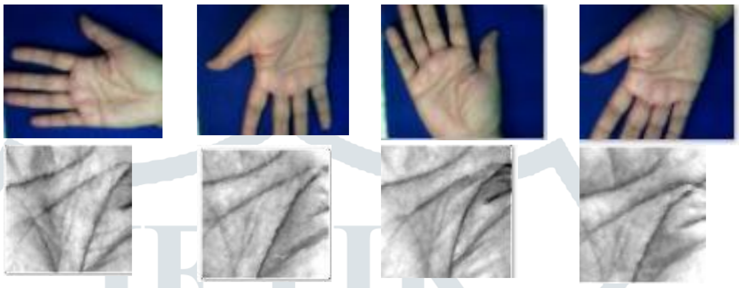


Figure 7: ROI extracted with rotational variation

Figure 8 shows palm images and corresponding ROIs with scale variations.

Distance from camera 25 cm 30 cm 35 cm 40 cm

Palm images

ROI extracted

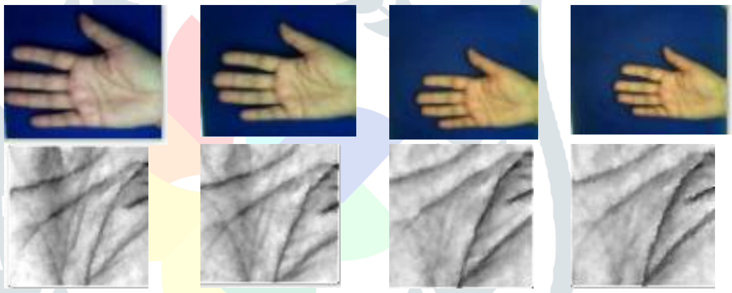


Figure 8: ROI extracted with scale variations

Figure 9 shows palm images and corresponding ROIs with translational variations.

Palm images

ROI extracted

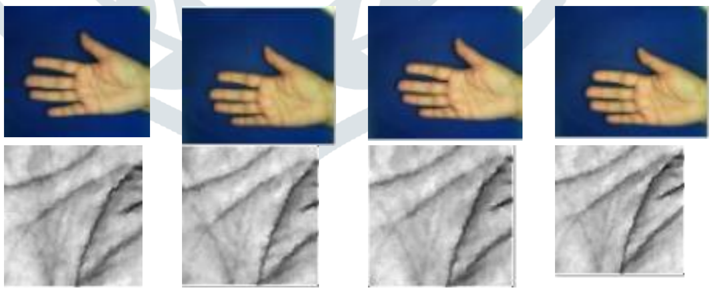


Figure 9. ROI extracted with translational variations

The ROIs are properly extracted with all these variations. After normalization, they all appear to be similar. Thus the alignment and ROI extraction method proposed in this work is working effectively on all these images. It proves that the method is immune to variations in rotation, scale, translation and illumination.

## VII. Results And Discussion

The palmprint images acquired were noticeably good as compared to palm vein images. Hence initially performance is analyzed only for palmprint images. First identification tests are carried out with 5 images each of 10 persons. The results of the biometric parameters are found for identification is given in table 2.

Table 2: Performance with change in distance and illumination

| Performance | 25 cm | | | 30 cm | | | 35 cm | | | 40 cm | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100 lux | 400 lux | 700 lux | 100 lux | 400 lux | 700 lux | 100 lux | 400 lux | 700 lux | 100 lux | 400 lux | 700 lux |
| GA | 46 | 49 | 47 | 49 | 49 | 48 | 49 | 48 | 47 | 49 | 48 | 47 |
| FA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| FR | 4 | 1 | 3 | 1 | 1 | 2 | 1 | 2 | 3 | 0 | 2 | 3 |

The number of Genuine Accepts is large. Number of false accepts is almost zero. There are few false rejects. But overall the system gives good identification with palmprint images. The performance with palm vein images is evaluated for fixed system parameters. The distance is kept fixed at 30 cm and illumination intensity is optimized at 400 lux. The images of these settings are used to evaluate the performance. The results obtained are FA as 0, FR as 10 and GR as 40. These are low results as compared with palmprint results. The IR images acquired do not have high contrast. Hence the palms are not properly segmented with the method used with palmprint images. The ROI extraction has been basically applied to palmprint images. The coordinates of the corner points of palmprint ROI are used to define the corner points of vein ROI images. Hence ROIs are not similar leading to less GA. The palmprint and palm vein images of the same settings are used to evaluate performance of multimodal system. The results are FA is 0, FR is 4 and GA is 46. The results of palm vein have affected the results of multimodal system.

## VIII. Conclusion

Development of a working biometric system with number of facilities and flexibilities is a challenging and difficult task. Yet a working system has been developed. The system integrates two IP cameras for image acquisitions. This facilitates independent positioning of the acquisition setup. To optimize the parameters of the system, there are arrangements to vary intensity of the light sources. The inclination of halogen lamps can be changed. The support on which the cameras are mounted can be moved in the vertical direction. This facilitates varying the distance between cameras and hand. The setup is working appropriately. The palmprint and palm vein images are acquired simultaneously. RST features are implemented in the algorithms used for ROI extraction. But when two images are to be acquired simultaneously, the palm should lie in the field of view of both. This imposes some limitations on the positioning on the hand. The performance of the biometric system is excellent for palmprints even with rotation, scale, translation and illumination variations. The performance for palm vein images needs to be improved. Overall the system is working properly and the performance parameters have been evaluated in this paper.

## References

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