# Embedded Foot Plantar Classification System Using Raspberry Pi

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***Abstract*—Foot plantar classification is crucial to prevent dangers to patient's health that originated from an abnormal type of foot. When patients comprehend their type of foot, they will be able to form personal insole to prevent a hazard. On the contrary, some patients who ignore their risk will possibly have the problem. We design the system to classify type of foot by measuring foot pressure and foot curvature. For the software, we use webcams to capture the foot images that will be further processed by Raspberry Pi with OpenCV and color coding which correspond to foot pressure. For the hardware system, we use the component which is inexpensive and easily available. The hardware structure is composed of steel as a base where the transparent acrylic plate and glossy white paper is placed on. The black polypropylene sheet covering on the uppermost is used to block light from outside. Aligned on the side of the transparent acrylic plate LED strip is used for light source for the system. Underneath the steel base there are four webcams which is used to record feet images (two webcams for each foot). The images are sent to Raspberry Pi for image processing and displaying. The system is able to classify three types of the foot for patients including normal foot, high arch foot, and flat foot.**

*Keyword—Foot Pressure, Image Processing, Color Coding.*

## I. INTRODUCTION

Feet are important organs in human's life. They have many necessary functions for a body. Generally, the foot has paws for supporting body's movement and loading the body weight. It reduces an effect of pressure and protects joints. But abnormal types of foot, both abnormal curve, and abnormal pressure, always make problem with the body. Each individual person has the different type of foot and different foot pressure. This system studies 3 main types of foot. The first is a normal foot. This is the most efficient type of people for supporting. The next is a high arch foot which is a type with curvature more than usual and causes the foot to tilt outward (Supination) when walking and running. This is the problem causes sprained ankle because the feet have low flexibility. The last is the flat foot which is a type of foot with curvature less than usual. This abnormality makes joints receive impact more than they should be and destroys joints especially knee and ankle. It also causes bodily injury, including hamstring inflammation and metatarsal pain, from foot tilts inward (Overpination). Moreover, some patient cannot feel when their feet were pressed. Especially in diabetic patients, when they have an ulcer at a high-pressure point leading to gangrene and amputation. Embedded foot plantar identification using Raspberry Pi help patient to realize their type of foot. Afterwards, they are able to form individual insole for preventing dangers from the abnormal foot.

Previously, there are many methods to measure foot pressure such as laser scanner and force sensor. Nevertheless, they have disadvantages. In the laser scanner method, it is disturbed by light from outside while patient measured. In addition, it was not able to measure in real-time. Another one, the force sensor method used many sensors from each expensive price sensor as shown in Fig. 1. It does not provide the high-resolution image. So, we select optical sensor because it solves many problem of poor resolution and inexpensive. Our system can also further applied to measure in real-time.

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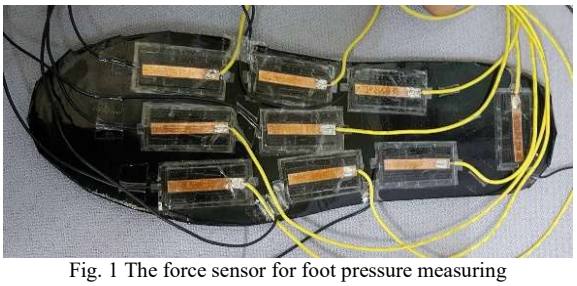

Fig. 1 The force sensor for foot pressure measuring

## II. METHODS & RESULTS

The methods and results are presented as follows.

### *A. Hardware System*

There are 6 main components of the hardware system: the transparent acrylic plate, the base, the glossy white paper, the polypropylene sheet, the LED strip and the four digital cameras. The hardware system is shown in Fig. 3. The transparent acrylic plate dimension is 40 cm. (width) x 40 cm. (height) x 1 cm. (thickness). The platform was used for patient to stand on. It has a high transparency and flexibility. The upper of the platform was placed by the glossy white paper. The topmost of the system has the polypropylene sheet that used to cover the system in order to block the light from outside and protect the platform from scratch. The sides of the platform was attached the LED strip. The facing upwards of four digital cameras are installed underneath the platform. The reason that we use four cameras is reducing the height between the platform and floor. In addition, four cameras provide higher resolution images more than two cameras. Each pair of cameras was used for one foot to take pictures.

The cameras provide dark background when the system has no pressure on the platform because there is no light to reflex with the platform. As soon as foot presses, the air between the glossy white paper and the platform is displaced. The light is reflected and scattered by the glossy white paper. The spots pressed by foot were bright then the digital cameras take images. The spots and brightness increase with the amount of pressure.

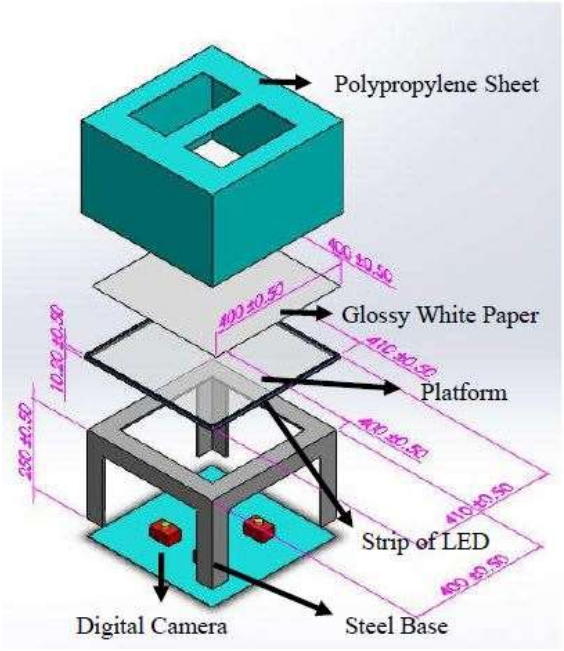


Fig. 2 The hardware system

Fig. 3 four digital cameras underneath the platform

### *B. Software System*

The Raspberry Pi is the main processor for the digital image processing. The software on the Raspberry Pi use OpenCV as the key library. Starting by adding a patient name on the command window, it creates folder preparing for collecting images from four digital cameras. Next, cameras initialize and capture the four images. The size of an image is 640x480. The whole left and right foot pressure images made from four captured images stitching. The images are then converted to grayscale images and use the morphological process to eliminate the speckle noise. The color-coding is performed to map the pressure to color for analysis.

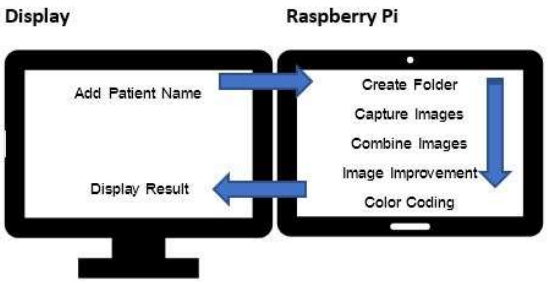


Fig. 4 The software system

*C. Linearity*

In order to test the linearity of the optical sensor, we place a determined weight on the platform and measure the pixel value. A circular rubber with 1.25 cm. in diameter is used to mimic the pressure point. On the top of the rubber, a square sheet of wood is placed. A metal disc with the weight varied between 1.25 kg. to 10 kg. is placed on the wood. The pressure can then be computed by weight/area. The area is derived from the area of the circular rubber. The pixel value is then measured from some determined area and averaged. The averaged pixel value is then plotted against the computed pressure. The response graph is shown in Fig. 5.

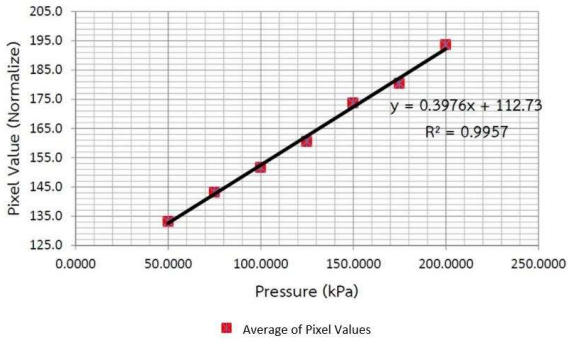


Fig. 5 Related graph between pressure and average of pixel value

From the graph, the $R^2$ is 0.9957 which demonstrates the linear response of the optical detector

*D. Result*

The operation of the embedded system starts at user enters a patient name. The Raspberry Pi creates the folder and captures images. The processing is shown on command window of the Raspberry Pi as shown in Fig. 6. The color coding is the code that shows the pressure measured. There are 7 colors corresponding to the level of pressure. The color code, in ascending order of pressure, is gray, light blue, deep blue, yellow, green, orange and red i.e. red area corresponds to the highest-pressure area. The resulted color coding image of foot pressure is shown in Fig. 7.

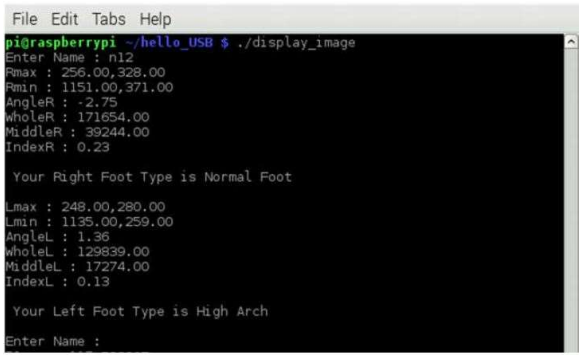


Fig. 6 Command window of the Raspberry Pi

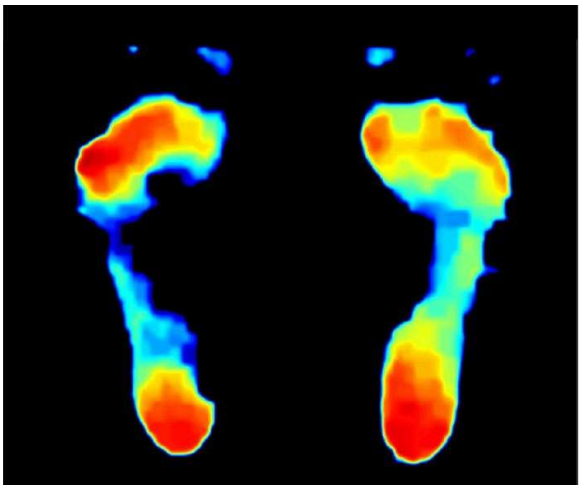

Fig. 7 The result on the display

The patient is able to find methods to prevent the disorders when they comprehend the image result from the color-coding classifying type of foot by form the special insole for an individual person. The foot can be classified into 3 types including normal foot, high arch, and flat foot. Because the middle footprint area in each foot has a difference, we measure arch index that is the ratio between the middle footprint area and the whole footprint area. The calculation divides the footprint area following Fig. 8.

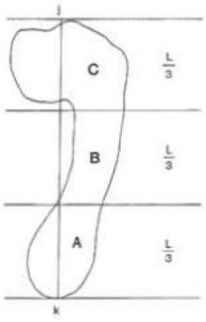


Fig.8 The area of dividing

The arch index is calculated as follow:

$$\text{Arch Index (I)} = B/(A+B+C)$$

The arch index and the foot pressure image are computed from our system is shown in Fig.9. The normal foot type has an arch index between 0.20 and 0.26. The high arch type has an arch index below 0.20 and flat foot type have an arch index over 0.26.

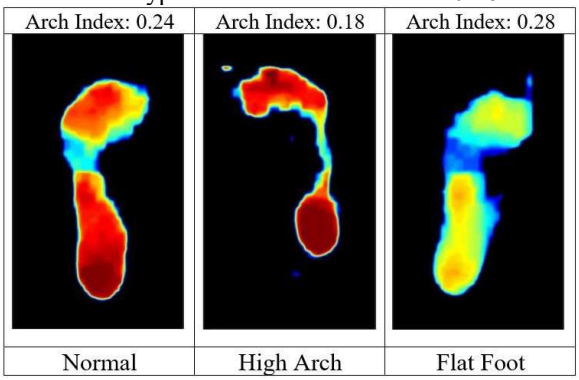


Fig.9 The image results that are calculated from arch index

## III. DISCUSSION AND CONCLUSION

This system presents the method for classifying the type of foot for patients comprehend the danger that should happen. The optical sensor reduces disadvantages from the previous. Moreover, the materials are able to find on their local easily. So, the system is the proper method for a third world clinics and hospitals. The composition of the system is the transparent platform for a patient to stand on. On the top is placed by the glossy white paper (120 grams) that used for different light scattering when patient pressing. And then, they are covered by polypropylene sheet that uses for block light from outside. Underneath the platform install four cameras for capture the foot image. The main of processing use the Raspberry Pi in order to perform digital image processing which is image enhancement, image stitching, color coding and arch index computation.

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