Footprint Identification using Deep Learning

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Abstract— **Human footprint is the biometric system of the individual person. Everyone has specific footprints. It can be used instead of password-based authentication in the security system such as a user authentication for the financial transaction. The password-based system cannot verify that the person who entered the password is valid or not. Therefore the biometric system is more secure than the password-based system. For that reason, it's interesting to use footprint image in the creating of the footprint-based identification system. In this paper, the convolutional neural network training is used for deep learning classification. Convolutional neural networks are essential for deep learning and suited for image recognition.**

***Index Terms*—footprint, biometric, deep learning.**

I. INTRODUCTION

The biometric systems are the task to use individual identity based on differentiating physiological and behavioral features. These features are used for verifying the right and presence, such as fingerprint, palmprint, iris, and footprint. This technology is seen in films. Fingerprint scanning in investigation films based on actual use with Central Intelligence Agency (CIA) and Federal Bureau of Investigation (FBI), which has been operating under the name is called Automated Fingerprint Identification System (AFIS). In addition, the retina and footprint scanning has been used more widely for personal confirmation in the security system. So the biometric systems have more advantages than the traditional systems such as the password based confirmation.

Palmprint is defined as the measurement of the features to recognize the identity of the individual person. The features in palmprint include principal lines, wrinkles, and ridges. Palmprint does not change much across time. It is easy to capture using a digital camera. However, the line structure feature does not contain the thickness and width information so this method cannot identify the different palmprint with similar line structure. Iris scanning system can provide a high accuracy but the cost of devices is high. The footprint is a feature of the biometric systems. They have the distinctive properties of the individual person like the human hand. So the footprint is used to identify the individual person as well.

The footprints are occurred by foot pressure when standing or walking, so the foot pressure has the distinctive properties of the individual person like the others too. During the past decade, foot plantar pressure measurement technologies have become interested. A simple ink impression on a paper is a simple method that has been used for a long time. The sample result as shown in Fig. 1. However, it's still quite limited because of their pressure density cannot give the distinguishing pressure in each position and this method must require fresh materials in each test.

Fig. 1 Simple ink impression on a paper

Another method is Pedograph instrumentation, a matrix of small pressure sensors distributed over the sensitive areas. This method gives a clear pressure but low resolution and accuracy than the optical sensors as shown in Fig. 2. However, the pedograph instrumentation sold only as a complete package with hardware and software. They are very expensive and not suitable for local clinics and small hospitals.

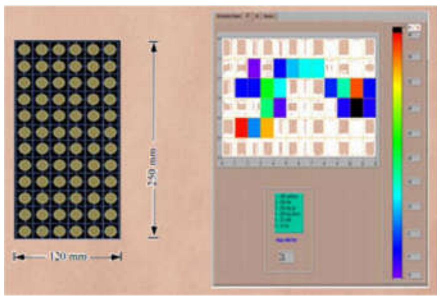

Fig. 2 Pedograph, which use a matrix of 72 pressure sensor.

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The optical sensor is the efficient method for foot pressure measurement, which gives a high accuracy and reliability, low cost, and suitable for local clinics and small hospitals. This system uses a reflected and scattered light by the glossy white paper on the sensitive area when the system has pressure on the platform. The color coding image of foot pressure result is shown in Fig. 3. The color coding image displays the foot pressure with jet colormap as shown in Fig. 4, each row in the array contains the red, green, and blue intensities for a specific color. The intensities are in the range [0,1], *i.e.* the red area correspond to the high pressure area and the blue area to the low pressure area.

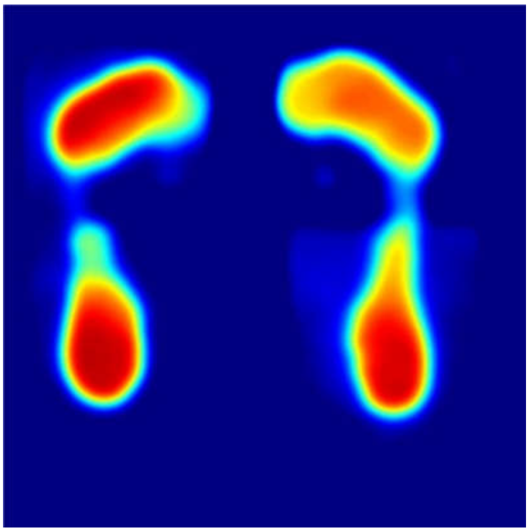

Fig. 3 The color coding image of foot pressure

Fig. 4 Jet colormap

II. METHODS

The methods are presented as follows.

A. The hardware system

To acquire a footprint image, the optical sensor system [1] is used in this paper. There are 6 main components of the hardware system: the platform, the base, the glossy white paper, the black acrylic box, the led strip, and the 4 digital cameras as shown in Fig. 5.

The platform was used for standing, it was made from transparent acrylic plate width 40 centimeters, height 40 centimeters, and thickness 1 centimeter. The led strip was attached to the sides of the platform and the base of the platform was made of steel. On the top of the platform, the glossy white paper was placed and covered with the black acrylic box for blocking the outside light and protecting the platform. The 4 digital cameras are placed underneath about 18 centimeters from the acrylic plate and each pair of digital cameras was used for each foot.

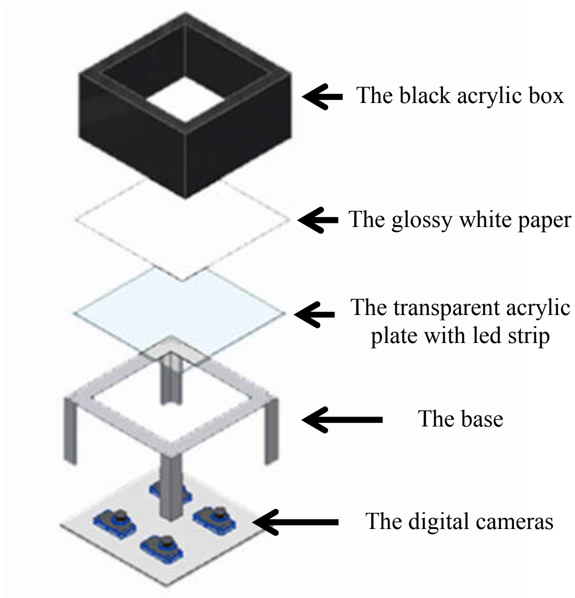

Fig. 5 The hardware system

On standby mode, the display will blue screen as a background in Fig. 3 until the digital cameras detect foot pressure. At the foot pressure point, the screen will show pressure in color coding mode as a consequence of air displacement between glossy white paper and transparent acrylic plate causing scattered and reflected light to the digital cameras as shown in Fig. 6. From below, these points were bright then the foot pressure was detected by the digital cameras. The brightness is increased with the amount of pressure.

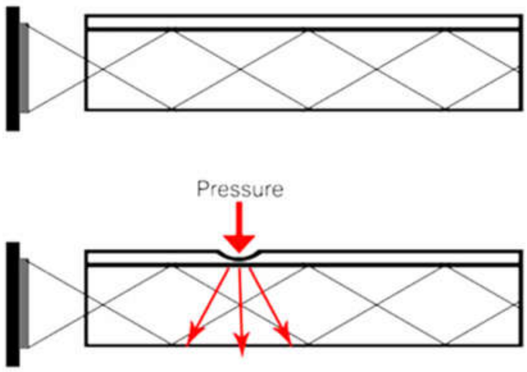

Fig. 6 The scatted and reflected light

B. The software system

The digital image processing software processes on Visual Studio 2017 using the OpenCV library and the convolutional neural network (CNN) training for footprint identification with Matlab. Fig. 7 represents the model of the footprint identification using foot pressure image from the optical sensor system [1].

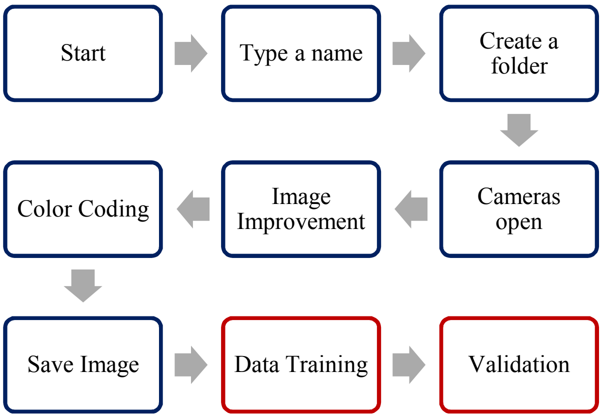

Fig. 7 Footprint Identification Process

Type a subject name or number, the folder with a subject name or number was created for saving the resulted images and then the digital cameras were enabled. The system converts the raw images into grayscale images. Next, the grayscale images were improved by using morphology, gaussian blur, median blur, and normalization. To provide better visualization, grayscale images with image improvement was converted to color coding images using jet colormap and save the resulted images into the folder.

Then the resulted images were used in deep learning which consists of data training and validation, these are described in the next section.

C. Deep Learning

Deep learning is part of machine learning methods based on learning data representations. Deep learning models are inspired by information processing and communication patterns in biological nervous systems. Deep learning uses a cascade of multiple layers of nonlinear processing units for feature extraction and transformation. Each successive layer uses the output from the previous layer as input.

This paper uses a simple convolutional neural network for deep learning classification. Convolutional neural networks are essential tools for deep learning and are especially suited for image recognition. The process of convolutional neural networks is described in Fig. 8.

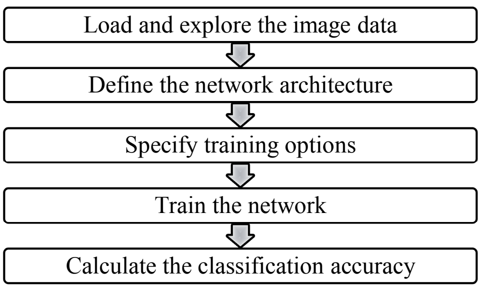

Fig. 8 The process of convolutional neural networks

First, Load the sample data as an image datastore. An image datastore enables to store large image data and efficiently read batches of images during training of a convolution neural network. The sample data is collected from 13 people using the dynamic footprint from the optical sensor system. Second, Define the network architecture such as image input layer, convolutional layer, classification layer, and others. Third, Specify training options such as initial learning rate, the maximum number of epochs, and others. An epoch is a full training cycle on the entire training data set. Fourth, Training the network using the network architecture, the training data, and the training options. Finally, Test the validation data using the trained network, and calculate the validation accuracy. Accuracy is the number that the network predicts correctly.

III. RESULTS

In the section of the image acquiring from the optical sensor system. The footprint images in color coding are saved in a folder with a subject name or number. The sample results of the footprint image as shown in Fig. 9 with color coding of foot pressure according to the amount of pressure measured. The color coding result image of foot pressure can be used to identify the individual person. They can also be used in the medical term such as finding the high-pressure spots to prevent the occurrence of injury in a diabetic patient and forming the special insole for an individual person.

The convolutional neural network is trained with the footprint images of 13 people and is tested the validation data using the trained network. This network produces 92.69% recognition of footprint. It means more than 92% of the predicted labels match the true labels of the validation set.

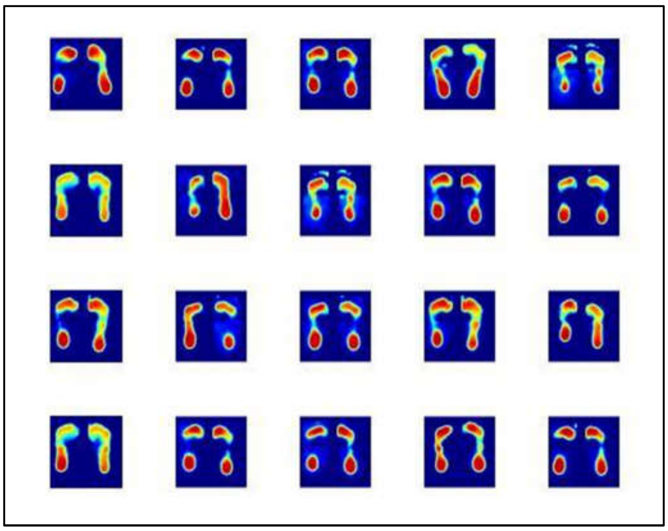

Fig. 9 The sample results of the foot print image

IV. DISCUSSION AND CONCLUSION

This paper presents the footprint recognition for personal identification using deep learning. It's an alternative method to using the footprint which is the biometric feature in individual identity based on differentiating physiological and behavioral features because they have the distinctive properties of the individual person. The footprints are occurred by foot pressure, so we use the optical sensor for footprint image acquiring. The optical sensor is the efficient method for foot pressure measurement, which gives a high accuracy and reliability, low cost and suitable for local clinics and small hospitals. In image acquiring, the convolutional neural networks are used for footprint classification. They are essential tools for deep learning and especially for image recognition. The color coding images of foot pressure are used in the convolutional neural network. The training and validation test was done among 13 people with footprint images from the optical system and 92.69% recognition rate was observed.

Future work includes personal confirmation algorithms into the footprint identification for the authentication system. In addition, footprint images from more people should be added to the convolutional neural network. They can increase the efficiency of the system.

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