Android Application to Prevent Foot Ulcers and Monitor Weight of Diabetic Patients

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***Abstract* – This device combines a scale, camera and an Android application to monitor weight as well as the soles of feet to prevent foot ulcers in diabetic patients. Once stepped on, the scale will send the person's weight to a Android app and the app will record this number in order to keep track of progress over time. Then, the patient will take a picture of their right and left foot, respectively, by positioning their feet over a microcontroller with a camera attachment. The photos will then be sent to and stored on the app so the patient can monitor the soles of their feet.**

I. Introduction

The purpose of the device proposed in this paer is to monitor weight and prevent foot ulcers for diabetic patients that suffer from peripheral neuropathy. Diabetic peripheral neuropathy is the most common complication associated with diabetes [1]. Peripheral neuropathy is associated with nerve damage in the hands, arms, legs and/or feet. One of the most dangerous side effects of peripheral neuropathy in the feet is numbness, which can induce the development of ulcers on the soles of patient's feet. These ulcers progress due to the fact that the patient is unaware that there is an open sore [2]. An untreated ulcer can result in infections in the skin or bone, which may lead to amputation of the foot or leg. Furthermore, almost 90% of people living with type 2 diabetes are overweight or are obese [3]. Obesity can promote the development of ulcers due to the amount of pressure on the patient's feet. If a patient develops these ulcers, weight loss may aid in accelerating the healing time and if caught early enough, infection can be avoided. By monitoring weight and the soles of the feet at the same time, a patient can avoid these ulcers as well as benefit from losing weight.

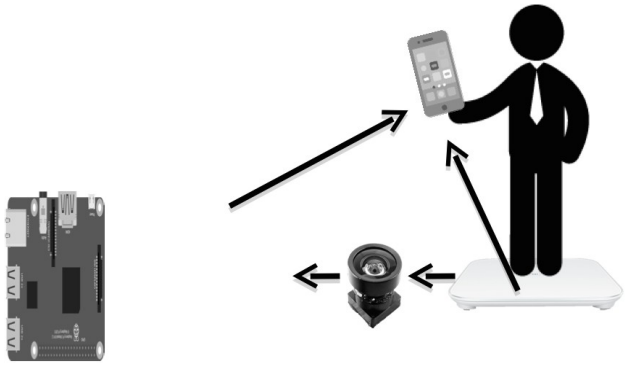

Figure 1. Visual representation of the system. Patient steps on scale then takes pictures of their feet. Once this is done, the images are processed through the Raspberry Pi 3 and then saved on the Android application.

This project is the first multifunctional medical device to preemptively monitor diabetic patient's feet for ulcers. Figure 1 describes the overall block diagram of the device. The combination of a scale, camera, mobile application and microcontroller allows for a patient to have a "one stop shop" product that they can integrate into their daily routines. The goal of this project is to aid diabetic patients who are suffering from peripheral neuropathy in the prevention of a foot ulcer and promote weight loss to benefit their overall health.

II. Methods

A. *Hardware*

This project incorporates three main hardware components: a camera, a Bluetooth scale and a Raspberry Pi 3 miniature single-board computer. The camera is a wide-angle fish eye lens that attaches directly to the Raspberry Pi 3 Camera Interface port. This allows for the device to take clear photos of the patient's foot that will be used to monitor the soles of the feet. The Bluetooth scale is a Xiaomi Smart Scale XMTZC01HM that meastures a user's weight in pounds and communicates via the Android application. This weight is then stored for later use to track weight loss or gain. The Raspberry Pi 3 with the camera was used to take photos and send images to the Android app. The Raspberry Pi 3 uses a Broadcom BCM2837 chip, powerful enough to process all the necessary information. Together, these components create an all-in-one device to prevent foot ulcers and to monitor weight.

A separate START push button is added to trigger the consecutive execution of these three scripts. Figure 3 shows the connection of this button to the general-purpose input/output (GPIO) connector of the Raspberry Pi 3.

B. *Raspberry Pi 3 Software(A, B can be combined)*

Two pieces of software were developed, one running on Raspberry Pi 3 and one on Android. The Raspberry Pi 3

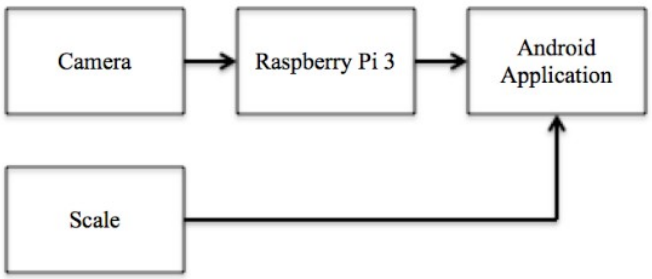

Figure 2: Block diagram of the overall flow of device created.

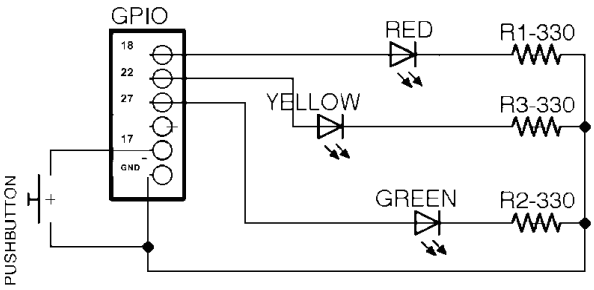

Figure 3: Schematic of circuit used to automate the Raspberry Pi 3.

software was coded using Python, and includes three scripts. The camera.py script takes pictures of the foot. The imagecompression.py script compresses the image that was taken. Finally, an additional script server_sendfile.py creates a network Transmission Control Protocol (TCP) socket to send images to the Android Application.

Once a user presses the START button, the Python program residing in the Raspberry Pi 3 runs, takes a picture of the foot and sends the picture to the Android application. The three different color LEDs light up one after another to indicated the Raspberry Pi 3's current status. The red LED signifies an idle state, the yellow LED denotes the Raspberry Pi 3 is taking a picture and then compressing the image, and the green LED signifies a successful image transfer to the Android application.

C. Android Software

The Android application was developed using Android Studio (version 2.2.2). This user-friendly application allows the patient to store information such as photos and weights in one place. The Android software obtains the weight information ofthe user via Bluetooth. A TCP network protocol is used for the image transfer from Raspberry Pi 3 to the Android application through a local Wi-Fi access point.

III. RESULTS

Figure 4 shows the Android application displaying the weight of the patient when stepping on the Xiaomi scale. This weight unit can be chosen between pounds or kilograms, depending on what the patient prefers.

Figure 4 also shows where foot image is displayed. The photo taken by the user will replace the image of the two animated feet (it is better to have foot image). This image is then stored for review later. By clicking the "photos" button, the user will be taken to a database where he or she can view images and weights from previous days.

In the future, patients will integrate this device into his or her daily routines so that these saved images can be compared. Once the images are compared, the patient will be able to see subtle changes to the soles of their feet. This will allow the start of a sore to be oticed before a foot ulcer develops. Patients can then decide if further actions need to be taken in order to prevent the development of a foot ulcer.

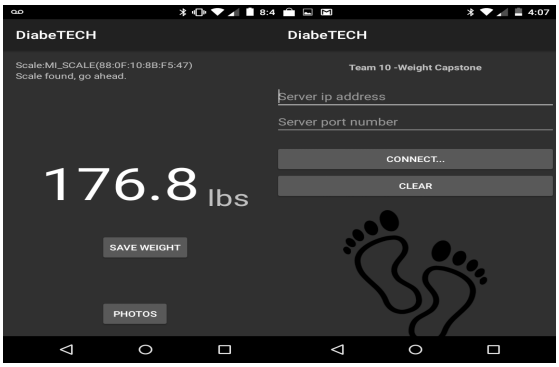

Figure 4: Screenshots of the Android application.

IV. DISCUSSION

This project focuses on a major health issue in today's society. Diabetic foot ulcers are the number one non-traumatic cause for lower limb amputation in the US [4]. This not only lessens a patient's quality of life but also creates a burden on the healthcare industry due to the fact that it costs up to $45,000 dollars each time a patient is hospitalized for diabetic foot ulcers [4].

There are no other preventative foot ulcer measures similar to this device currently on the market. Patients are able to easily compare the soles of their feet over time. A further improvement will be an algorithm that is able to highlight any changes in the surface of the foot and notify the user. If the patient notices any differences in the pictures, they are able to preemptively seek medical attention before an ulcer develops, thus avoiding infection and hospitalization. Many foot ulcers start to develop due to irritation and go unnoticed because of nerve damage. The solution is usually simple, as easy as purchasing new shoes.

Diabetes is a growing problem in today's society and this project is working to use modern technology to help these patients avoid hospitalization and ultimately retain their quality of life.

ACKNOWLEDGMENT

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