AN IoT-BASED SMART WALKER FOR PAKINSON'S DISEASE PATIENTS

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ABSTRACT

This work is focused on implementing a smart walker for Parkinson's disease (PD) patients. There are many walkers for the PD patients such as a stuff with pipes and a stuff with laser straight light. However, these walkers are not comfortable or supportive of all levels of the PD patients. Specifically, the patients in level 3 and 4 cannot balance their bodies without anything to support them. Therefore, we build a smart walker that can support balance and facilitate walks of the PD patients. This walker is easily used because it can adapt its speed according to the speed of the user. In addition, it can turn left and turn right by just pressing the handle. We also provide an LCD display to inform the user about the number of steps, distance, and speed. These data are also sent to and stored in a web server where the user can utilize them again.

Index Terms – *Parkinson's disease walker, Walker, Parkinson's disease, Arduino, Internet of Things*

1. INTRODUCTION

Parkinson's disease (PD) is a chronic and progressive movement disorder, meaning that symptoms continue and worsen over time. Statistically, the number of patients with Parkinson's disease worldwide is about 1 percent of people over the age of 65 year. In Thailand, Thai Red Cross found that the incidence of Parkinson's disease was 425 per 100,000 population, which is found in the central part of Thailand .Thai ancient people have known PD as 'League of the chicks'. They do not know the cause of this disease but there are many ways to treat this disease such as medication and surgery to manage its symptoms.

PD is cause by the cell in the midbrain death. Called substantia nigra. This reduce the neurotransmitters that called Dopamine which are control movement of human body. The death of cells in midbrain started 4-10 years before the patients saw his body is not working normally. A general symptom of a PD patient is a change in walking (gait). This commonly includes the inability of a person to swing his/her arms naturally while walking, taking short shuffling steps, "freezing spells" (difficult to start walking and difficult to stop walking), and difficulty in maneuvering turns and corners.

We make a smart walker to help PD patients. Our smart walker is equipped with motors to make the PD patients walk easier than using a regular walker. In addition, we have sensors on the smart walker to collect the PD patients' vibration, walking distance, and number of steps when the walker is used. These data are sent to a web server and stored in a database. We have implemented a webpage such that the PD patients and their doctor can monitor and analyze these data.

This paper is organized as follows. Related work is reviewed in Section 2. The proposed IoT-based smart walker is explained in Section 3. The details of the smart walker, its web application, and experiments are described in Section 4. We show the conclusion of this paper in Section 5.

2. RELATED WORK

2.1 Smart Walker Solutions for Physical Rehabilitation. [1]

The authors design this walker for helping patients about gait changes and patients who got a balance disorders due to various factors. Smart walkers are an active area in the rehabilitation research field. As the age of the Internet of Things (IoT), a smart walker can be equipped with sensors whose values can be monitor over the Internet or a mobile application.

2.2 Low-cost Laser Parkinson's Walker. [2]

The authors have created a walker that uses a laser to improve the gait by pointed the laser line on the ground. Then, the patient step over this line. When the patients cross the line the line will disappear automatically then when they move the walker forward the laser will appear on the ground again. This walker help the patients by the patients saw the light. They want to cross that line so this help patients to improve the walking step. Their walker are easily to use and easy to carry it to others place.

2.3 Legs Tracking for Walker-Rehabilitation Purposes. [3]

This project focuses on the leg detection. This project working by measure the distance between the walking step and the walker. They set up the laser at the middle of the walker. This laser detect the gait left and right by capture and calculate the distance between the legs and the walker. Then they bring this value to analyst how the patients walk such as the patients walk by right leg more than left legs.

2.4 Sensory Cues Guided Rehabilitation Robotic Walker Realized by Depth Image-Based Gait Analysis. [4]

This project focuses on improving the PD patients' gaits by using sensory cues which are known to have remarkable effects in many studies. The sensory cues include a visual cue and a rhythmic auditory cue cooperating with a robotic walker, which aimed to stimulate and provide walking assistance in their ambulation. For the sensory cues, an adaptive gait mechanism is proposed to improve patients' gait based on their personal gait pattern as well as to reduce uncomfortableness of them by doing the rehabilitation.

2.5 Design and Implementation of an Active Robotic Walker for Parkinson's Patients (CAIROW). [5]

CAIROW is the robotic walker. There are many technology to help the patients to relax and it also can analyze how the patients walk and represent it by graph. This walker show the walking step, distance and times. The authors tested this walker by measure the distance. They use CAIROW with the patients for 6 days. The first day the patients can walk less than the sixth day when measure by the distance. They said this walker can help the patients to rehabilitation themselves.

3. PROPOSED IoT-BASED SMART WALKER

The proposed smart walker can help the PD patients to walk easily. It is equipped with sensors whose values are sent to a web server. In addition, a web application is created to show these sensor data. The doctor and patients, then, can monitor/analyze these data again.

The functionalities of the IoT-based smart walker for the PD patients are listed below.

- Infrared sensors are equipped to the smart walker to count the number of steps, which controls the walker's speed.
- A hall effect sensor is equipped to the smart walker to measure the walking distance.
- Force sensors are equipped to the smart walker such that the PD patients can control the smart walker's directions easily (turn left/right).
- Vibration sensors are equipped to the smart walker to measure vibration of the PD patients.
- An LCD display is equipped to the smart walker to show the following *measured values*: the walking distance, the number of walking steps, the walking speed, and the vibration value.
- The walking distance, the number of walking steps, and the vibration value are sent wirelessly and stored into a web server.
- The doctor and PD patients can monitor the walking distance, the number of walking steps, and the vibration values via a webpage.

The block diagram of the IoT-based smart walker is shown in Figs. 1 and 2. The proposed smart walker exploits two microcontrollers.

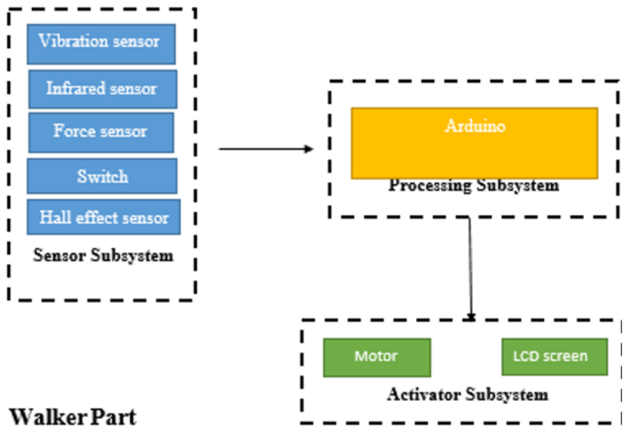

Fig. 1 A block diagram shows the circuit connection among the Arduino microcontroller, sensors, and actuator.

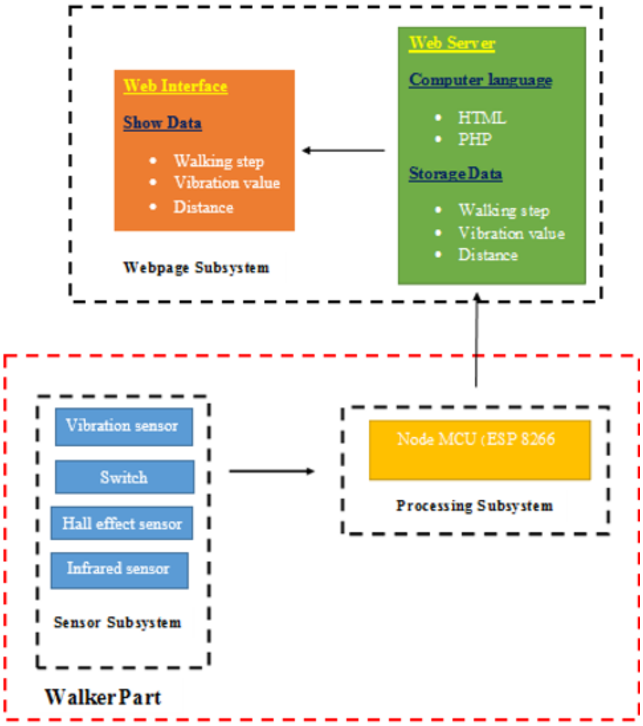

Fig. 2 A block diagram shows the circuit connection among the NodeMCU microcontroller, sensors, and a web server.

Fig. 3 Smart walker's hardware design.

First, we use an Arduino microcontroller to control the movement of the walker and display the measured values. The Arduino microcontroller is connected to a vibration sensor, infrared sensors, force sensors, a switch, a hall effect, sensor, DC motors, and an LCD display. The block diagram displaying this connection is shown in Fig. 1.

Second, we use the NodeMCU microcontroller to send the measured values to a web server. The NodeMCU microcontroller is connected to the following sensors: a vibration sensor, infrared sensors, and a hall effect sensor. The block diagram displaying this connection is shown in Fig. 2.

4. RESULTS

In this project, we have implemented an IoT-based smart walker for the PD patients. The smart walker is equipped with many sensors whose values are sent to and stored in a web server. These values are the number of walking steps (from the infrared sensors), the walking distance (from the hall effect sensors), and the vibration value (from the vibration sensor). Both doctors and patients (users) can monitor and analyze these values by logging into the system via a web browser. The details of the walker design, the web application, the database design, and experiments are shown and explained below.

4.1 Smart Walker Design

Our walker is designed to be easily used .The sensors are placed at various points as specified in Fig. 3.

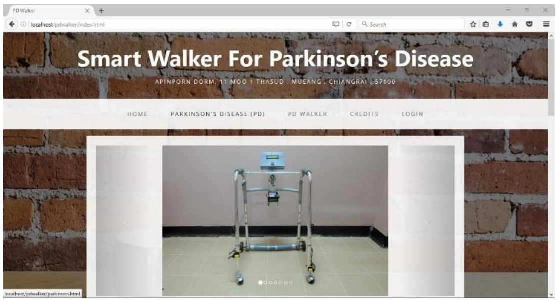

Fig. 4 Main web page.

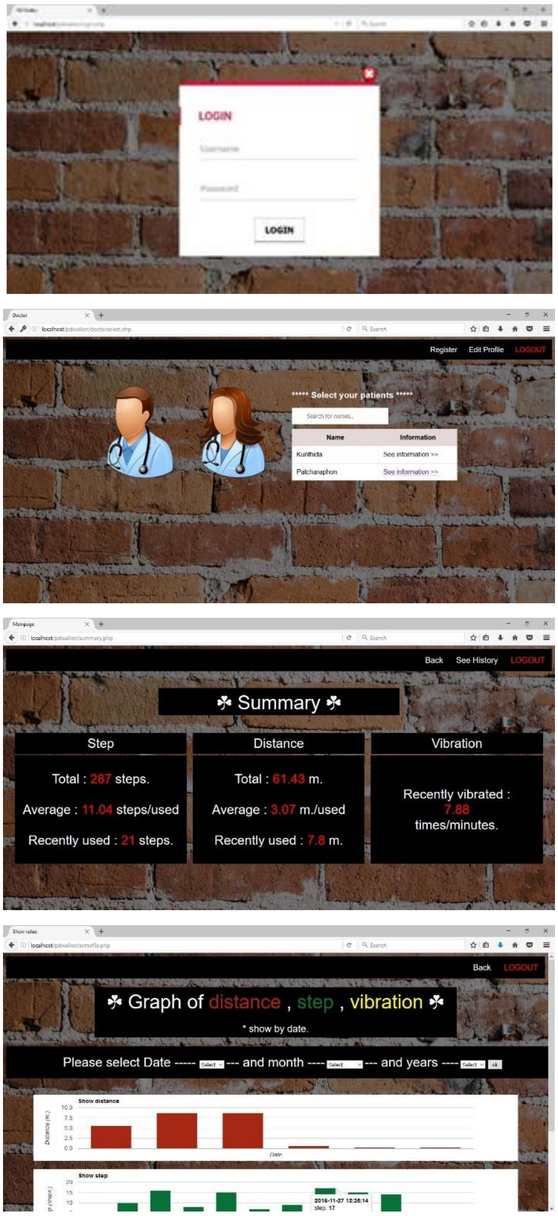

Fig. 5 System web interface.

4.2 Web Application

Our web application consists of the following web pages and system web interfaces.

Table 1 Distance comparison.

No.	Distance (meter)	Measured Distance by Arduino (meter)	Measured Distance by NodeMCU (meter)
1	10	9.92	9.92
2	10	9.92	9.92
3	10	9.92	9.92
4	10	9.92	9.92
5	10	9.92	9.92
6	10	9.92	9.92
7	10	9.92	9.92
8	10	9.92	9.92
9	10	9.92	9.92
10	10	9.92	9.92
11	10	9.92	9.92
12	10	9.92	9.92
13	10	9.92	9.92
14	10	9.92	9.92
15	10	9.92	9.92
16	10	9.92	9.92
17	10	9.92	9.92
18	10	9.92	9.92
19	10	9.92	9.92
20	10	9.92	9.92

a) We provide the following web pages to introduce our work (as shown in Fig. 4).

- Main web page shows the project name, background and problem definition, objective, and scope.
- PD Walker web page compares features of our project and related work.
- Credits web page lists the sources where we get information from.
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b) In our web application, the doctors and patients can log into the system to see the sensor data sent from the smart walker. We create the following web pages (as shown in Fig. 5).

- Log-in web page is required to logging into the system. If a doctor logs into the system, a list of his patients will be shown. The doctor can see the information of patients, register new patients, edit their passwords, and the sensor data from the patient's smart walker. If a patient logs into the system, he/she can see only his/her sensor data.
- Sensor data web page shows the sensor data. The doctors and patients can choose to view these data as Summary and a line chart.

4.3 Experiments

The objective of the experiments that we conducted in this section is to show how much the accuracy of the sensors data from the smart walker are.

- We compare the distance values obtained from the hall effect sensor and the actual distances in Table 1. We see that there are some minor errors from the distances read by the hall effect sensor. The average error from this experiment is about 0.08 meter.
- We compare the numbers of steps obtained from the infrared sensors and the actual numbers of steps in Table 2. We see that there are some minor errors from the numbers of steps counted by the infrared sensors. The average error from this experiment is about 0.125 meter.
- We compare the vibration values read by the vibration sensor and the actual values in Table 3. We see that there are some minor errors from the

Table 2 Number of steps comparison.

No.	Step (steps)	Measured Step by Arduino (steps)	Measured Step by NodeMCU (steps)
1	20	21	21
2	20	19	21
3	20	20	20
4	20	21	21
5	20	20	19
6	20	19	17
7	20	17	19
8	20	21	20
9	20	20	19
10	20	20	18
11	20	21	20
12	20	19	19
13	20	20	20
14	20	19	21
15	20	21	20
16	20	19	20
17	20	20	21
18	20	20	20
19	20	21	22
20	20	20	19

Table 3 Vibration comparison.

No.	Vibration (times)	Measured Vibration by NodeMCU (times)
1	20	23
2	20	21
3	20	20
4	20	20
5	20	21
6	20	22
7	20	22
8	20	21
9	20	20
10	20	23
11	20	22
12	20	20
13	20	21
14	20	21
15	20	20
16	20	21
17	20	21
18	20	23
19	20	22
20	20	20

vibration values read by the vibration sensor. The average error from this experiment is about 1.2 times.

5. CONCLUSION AND FUTURE WORK

A smart walker for the PD patients is implemented. The walker is equipped with the infrared sensors, the hall effect sensor, the vibration sensors to measure the number of walking steps, the walking distance, and the vibration value, respectively. An LCD display is used to shown these values on the walker. In addition, the walker is equipped with the force sensors and the DC motors to facilitate the users walking. The number of walking steps, the walking distance, and the vibration value are sent to a web server by using NodeMCU. The doctors and patients can monitor these data anywhere and anytime by logging into the system. The doctors and patients can choose to see the recent updated data and a line graph of the data recorded in the past. Experiments have been conducted. The results show that there are some acceptable errors measured by the sensors. The smart walker implemented in this pare can be improved further in many ways as follows. It might be added more sensors to collect more data. It might be modified such that the walker can adapt the speed better than the current version. Last, but not least, we might focus on analyzing and interpreting the collected data.

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