Smart Stepper Motor Control using MIT App Inventor for Microwave Head Imaging Platform

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***Abstract*: This paper proposes a Microwave Head Imaging Platform (MHIP) based on MIT App Inventor application. One of crucial element in the Microwave Imaging (MWI) is the imaging platform which used to hold and control the movement of antenna in certain angle. In the MHI platform, the key challenge is to improve the efficiency of angle control for brain stroke detection in the head phantom. Thus, the principal contribution of this work is the smart stepper motor control using MIT APP Inventor application for MHI platform which integrated with Arduino UNO module and Bluetooth module. The movement of platform based on two directions (clockwise and anticlockwise) with 10º step of angle or 36 unique positions. Overall, the proposed system offers the smart data collection using smartphone which MIH as an alternative technique for brain stroke diagnostic.**

***Keywords*: Microwave Head Imaging Platform; MIT App Inventor; Stepper Motor**

I. INTRODUCTION

Many researchers have put a lot of work into developing microwave systems for medical applications like breast cancer screening and heart failure detection [1]–[5]. However, just a few attempts have been made to create a full microwave system for head imaging [6]–[10]. The system comprises imaging platform, antenna and imaging algorithm. Head imaging is used to determine the existence and location of damaged brain tissues caused by a variety of injuries. Because of the notable contrast in the electric characteristics of healthy and stroke-affected brain tissues, microwave signals have the potential to be used for head imaging. The system can be a useful tool for a first response ambulance crew whose actions are critical to the patient's recovery because it is low-cost, portable, and uses non- ionizing radiation [11]–[13]. The existing diagnostic technique, like Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) scan offers the reliable and efficient detection. However, both systems are expensive, bulky, static and ionization radiation effect [14], [15].

A rotating platform is a key component of the head imaging system, as it is used to fix the model of a human head or antenna and establish the overall data gathering method. Recently, the head platform based on PVC material [16] and wood [17] – [18] have been developed for monostatic and multistatic configurations. The configuration refers to the number of antenna used in the system. Some of the designed required the platform moving along the head phantom or the head phantom is fixed [19]. Another issue of designing the imaging platform is the type of microcontroller used to rotate the platform. The Arduino module [1],[6],[15] and Raspberry Pie module [17] – [18] have been used to control the angle of platform. The method used to collect data for the angle of rotation will affect the imaging quality. The gained data will be fed into an imaging algorithm that will generate brain image. As a result, in a microwave imaging system, the angle of rotation is crucial. From the existing head imaging platform design, the angle of rotation was set at various angles, such as 11.25° [20] and 7.2° [17]. However, most of the designs are working in manual setting, one direction only and fixed angle of rotating.

In this work, the angle of rotating head platform is controlled automatically using MIT app inventor application. The main component of systems including stepper motor, micro step driver, Arduino module, Bluetooth module and MIT app inventor. The app able to control the platform with flexible direction and angle of rotating.

II. LITERATURE REVIEW

The head imaging platform in [6] is made of a plastic container with adjustable platform height and twelve patch antennas arranged in an array structure. In the centre of the circular platform is a head phantom with a realistic malignancy. The angle of the stepper motor is manually regulated using an Arduino module. The system includes an RF switching module and a Vector Network Analyzer (VNA) for the multi-static measurements. The tumour detection technology is based on radar principle.

A compact prototype microwave imaging system in [21] capable of imaging, detecting, and classifying human brain strokes utilising microwave technology. It includes a slot bowtie antenna array holder, human head phantom with stroke, and related measuring technology and software. S-parameters for a hemorrhagic phantom were measured sequentially in 23 independent positions, and dielectric parameter distributions were reconstructed using the Gauss-Newton iterative reconstruction algorithm. The antenna element holder receives the head phantom vessel. The measurement is based on the principles of tomography.

For brain stroke detection, a compact rotating platform with an array of nine antipodal Vivaldi antenna in a circular layout and a Raspberry Pi Module (RPM) as a microcontroller was designed [17]. The constructed head phantom is positioned in the middle of the platform and the head phantom comprise is white matter only, and was made with low-cost materials. Platform rotation is made up of a wood-based platform and Perspex material. The raw data in S-Parameters was then uploaded to the MATLAB software for analysis via a Python script and VNA interface. The technology is cost-effective, compact, and capable of effectively collecting data around a head phantom with a target clot and without a target clot at 50 various positions.

The system in [22] describes a portable microwave head imaging system with a monostatic setup. Imaging platform with adjustable antenna holder, tiny UWB antenna, Agilent N801A microwave transceiver, and 3D human head phantom are all part of the system. Through one antenna, the transceiver managed the quick data acquisition of a system with an 80 dB dynamic range.

The rapid diagnosis of brain damage through wideband microwave head imaging system has developed in [23]. Flexible antenna holder, compact unidirectional antenna array, SB-8SPDT-A18 switching network, Agilent N7081A microwave transceiver, and low loss and lightweight cables are all part of the system. Each antenna is secured with two nylon screws to a 3D printed bracket. As an antenna divider from the head, a foam block that is transparent to microwave waves is employed.

III. METHODOLOGY

The development process of MIHP comprises hardware and software part. Fig. 1 shows the flowchart of MIHP development. In the hardware part, the major components including HS-4401 stepper motor, Arduino UNO Rev 3, HC-06 Bluetooth module, TB 6600 micro-step driver, round water container and head phantom.

In this work, the HS-4401 stepper motor or NEW 17 stepper motor is used to control the angle. It is a hybrid stepping motor with a 1.8º step angle (minimum value) or 200 steps per revolution. The desire step angle of this work is 10º or 36 different position. It means for every 10º, the antenna will collect the data (S-Parameter) from the head phantom, which the reflected microwave signal from head phantom. This stepper motor working in the lower voltage, 12 V, current, 1.7 A, torque (40 N.cm) and has six lead wires. Since the plastic water container used as a platform (Fig. 2), it easy-to-use stepper motor to move the holding an object in forward and reverse direction for every desired angle. The variety colour arrow used for pointing and as a replacement for the actual

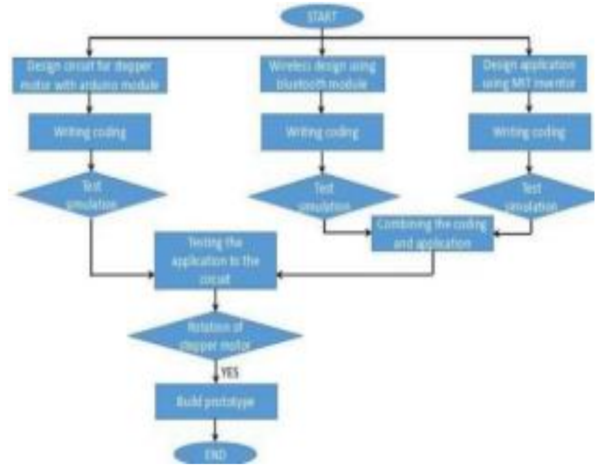

Fig. 1 Flowchart of MHIP development

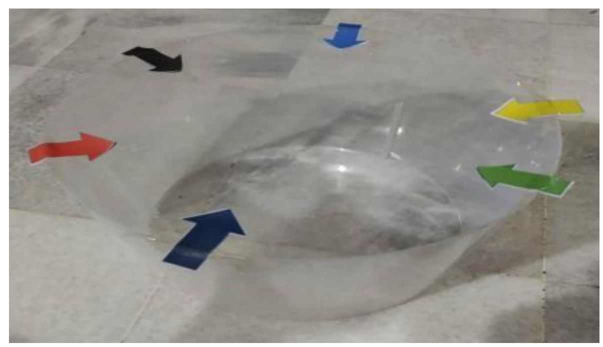

Fig. 2 Plastic Container Platform

Antenna as microwave sensor. The reflection microwave signal from head phantom will be transfer to VNA for brain stroke analysis. However, this focuses on the imaging platform development only. The head phantom based on Styrofoam material.

The function of Arduino UNO module is to set up the stepper motor circuit at desired step angle, which works as microcontroller. It provided open source hardware, a set of digital and analog input/output pin that can interface to various expansion boards and other circuit. The Arduino programming, an Integrated Development Environment (IDE) based on Processing programming language.

In this work, the micro-step driver used as a bridge between Arduino module and stepper motor. To produce torque, it transfers power to proper step motor windings through splitting the current across the motor phases and allowing the step motor to move in smaller amounts between full steps. It helps to reduce motor noise, reduce low speed resonance and generate smooth rotation across a broad speed range at 50 rpm. The communication between main circuit and MIT App Inventor is through the HC-06 Bluetooth module, which allows the user to control the circuit. This module based on Bluetooth 2.0 protocol and intended for short-range wireless data transfer at speed up to 2.1Mb/s between two microcontrollers. The operating frequency of module at high frequency ranging from 2.402 GHz to 2.48 GHz.

MIT App Inventor controlled the direction of the platform at a certain angle. The primary advantages of MIT app inventor are free application and open source programming language through visual and block-based programming for creating Android applications. The parts required in developing the app including registration, designer panel, block editor. At first stage, the user can create the application in the project menu and start a new project after email registration on the web as shown in Fig. 3.

Fig. 3 Create new App Inventor project

In the designer panel, the list picker button displays a list of available Bluetooth devices and Bluetooth connection established through Bluetooth client component as shown in Fig. 4. For stepper motor controlling, the app provided left and right button.

Fig. 4 Bluetooth connection of App

Then, to receive data from the linked device, add a text box. A timer is used to implement data reception. The client checks every second to see if the data is available. Fig. 5 shows the clock sensor component as a hidden component of app.

Fig. 5 Clock sensor component

The app behavior is programmed in the block editor. The blocks offered math, logic and text operations. Fig. 6 shows the initial setup of app (before add right and left button). After added left and right button, the accelerometer sensor is used to control the stepper motor once is connected as shown in Fig. 7.

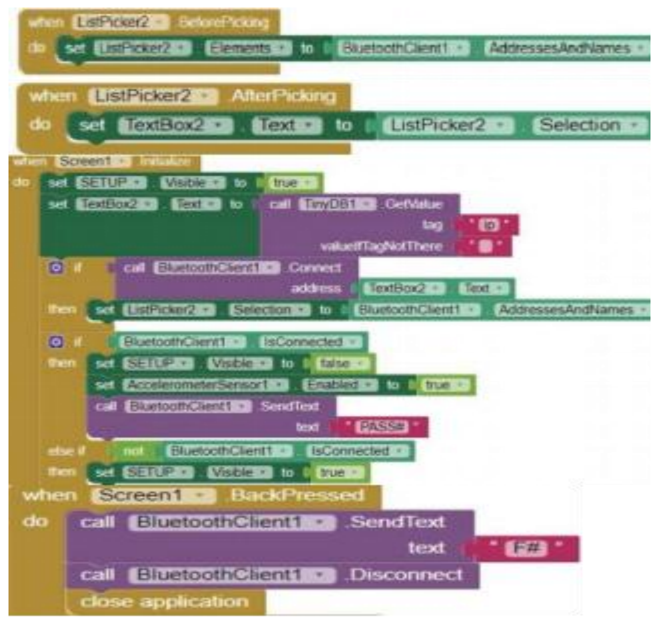

Fig. 6 Initial setup of app

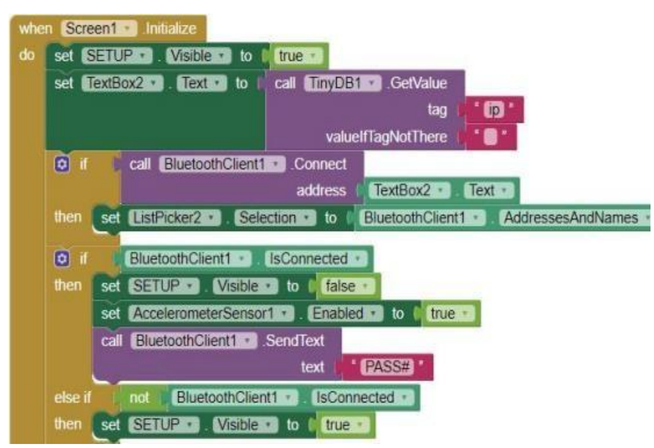

Fig. Final setup of app

IV. RESULTS AND DISCUSSION

Fig. 8 shows the software and hardware integration of the stepper motor (Arduino module linked to Bluetooth module). It has established the connection through the blinking condition of both modules. Before using the Bluetooth module, the component required to flash using HC-06 flasher with HC_BAUD 9600 in the apps. During the flasher stage, Bluetooth module and Arduino module have connected with

3.3 V voltage regulator and capacitor which to control the value of voltage from Arduino module and through Bluetooth module.

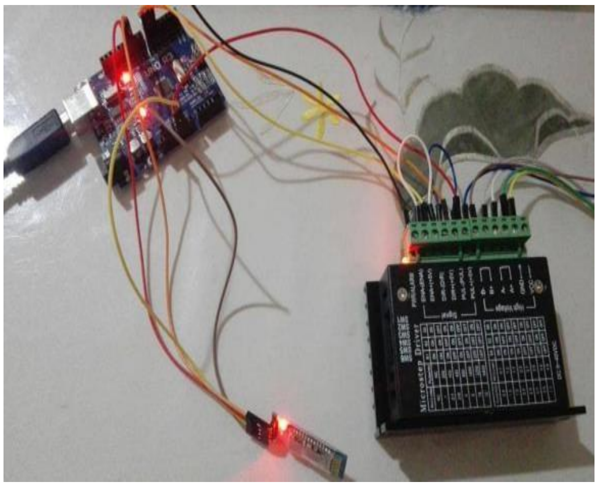

Fig. 8 Arduino Module and Bluetooth connection

From the display of COM3 in Fig. 9, shows that the data signal is ready to transmit which for controlling stepper motor through app. All the data input from the app will displayed in the COM3 as shown in Fig. 10. The launched app is ready to control the stepper motor after the Bluetooth connection in the smartphone has been established. Fig. 11 shows the display of MIT app inventor when connected to Bluetooth module.

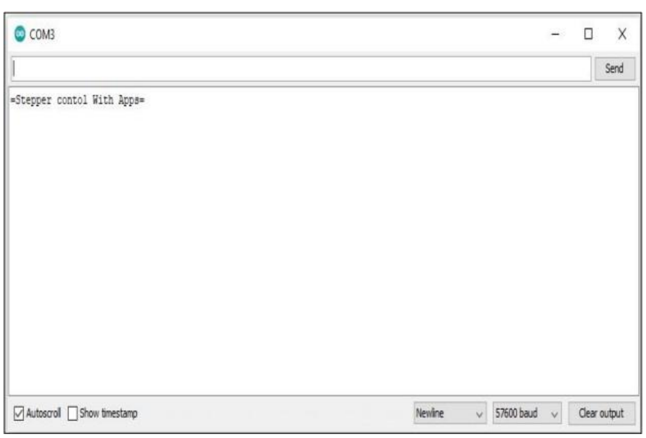

Fig. 9 Data signal ready to transmit through app

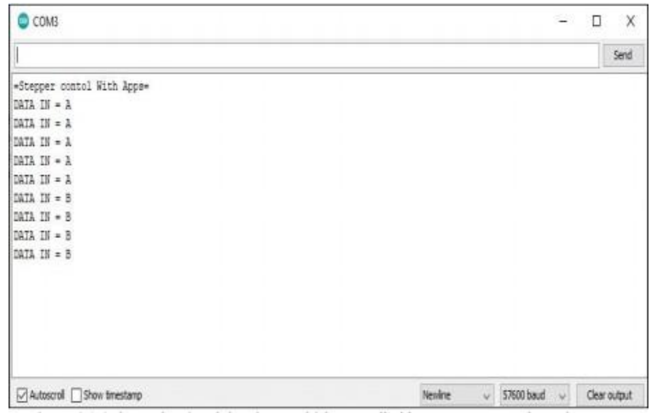

Fig. 10 Data input of app

Fig. 11 Display of MIT app inventor

Fig. 12 shows the completed of MHIP which not including the real antenna. The app able to control the container platform at the desired angle. From the theoretical, the angle of each position will reflect to resolution of brain stroke image. The accuracy of image proportional to the number of position. However, the overall system required to consider to processing time of image which more data collection will increase the complexity of system. This application also useful for during the measurement of head imaging system in anechoic chamber which offers echoless and absorbs sound and electromagnetics wave.

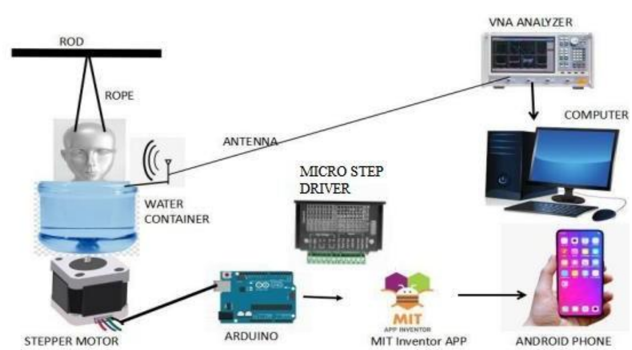

Fig. 12 Microwave Head Imaging Platform

V. Conclusions

The microwave head imaging platform based on MIT app inventor for stepper motor control has been successfully developed. The system working in Bluetooth connectivity and direction of platform can be controlled by the user using a smartphone at certain angle. For the brain stroke image analysis, the complete system which imaging platform, antenna and imaging algorithm are needed.

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