MECHANICAL MOVEMENT 2D FOR GROUND PENETRATING RADAR

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Abstract

In various fields, such as mining, agriculture, and the environment consider the information about the important of soil content. Many methods can be done to determine soil content under the surface. One of the method is Ground Penetrating Radar (GPR). GPR is a radar system that use to detect an object on the ground without having to dig it out. The GPR antenna sends an electromagnetic signal to the ground and then touches the object or target and then generates a wave of reflection that is then sent back by the receiver antenna.

At this time to move the GPR worked manually by moving itself, based on my colleague's experience is very ineffective most of them get a result that is not maximized and should be re-detection, because the movements inaccurate and unprecise. To solve this problem, an automatic control system is required to make the Mechanical Movement 2D for Ground penetrating Radar. Stepper Motor as the actuator for the GPR antenna movement and Arduino as the brain from the command maker of the tool, it can be made the GPR antenna that moves automatically.

In this thesis the mechanical movement system produces an accuracy value of 90.24 % when the tool moves forward, and 88 % when the tool moves backward. The precision movement value is 97% when the tool moves forward, and 91 % when the tool moves backward. The recall value of tool performance is 92 % when the tool moves forward, and 94 % when the tool moves backward.

The proposed mechanical movement is expected to provide a contribution in facilitating the detection of GPR and getting more accurate data.

Keywords : GPR, Radar System, Stepper Motor, Arduino

1. Introduction

Automatic movement has been widely use in daily life but the difference is the object that is moved and the type of mover, for example from the previous research [1] [2] , that is clothesline drive and automatic movement for machine vision. For the research [1] the mover use motor DC but the rotational angle of the rotor is not proportional to the pulse input, making it more difficult to adjust how far to move. For the research [2] the mover using hybrid stepper motor there is no cumulative position error, the rotor is stable, and Position and repetitive movements can be determined precisely. Detecting soil content is one of the activities that are often worked in the field of mining, but at the moment not only the mining field that work. The field of agriculture, environmental field, the field of architecture, and military field at this time consider soil content information is very important, many methods can use to determine the soil content one of the method is using GPR (Ground Penetrating Radar) according to research that has been done [3]. It is recommended to detect in a wider box and precise movement, so that there are not many undetected signals and based on previous research [4] the GPR image result is highly dependent on the propagation characteristics of the ground as well as the antenna characteristics. The GPR (Ground Penetrating Radar) is a radar system that use to detect an object on the ground without having to dig it out [5]. uses radio waves to probe "the ground" which means any low loss dielectric material [6].

From the previous research [7], in telecommunications, the stepper motor is used to actuate antennas and combinersPosition control or automatic tracking systems have previously been implemented in the research [8], which aims to get precise position control, and an efficient tracking process.

This undergraduate thesis focuses on reducing the factors that cause undetected signals, which are caused by inaccurate movement and facilitating detection with mechanical movements.

1.2 Problem Formulation

Experiments or the use of GPR at this time do not automatically move to determine the object, at this determine the object, at this time determine the object still by manually moving the tool. Therefore, a mechanical movement for GPR is needed besides being able to make the time more effective and the accurate of data increases.

2. Basic Theory

2.1 Mechanical Movement 2D for GPR System

Mechanical Movement 2D for GPR system is a combination of several components that work together in a reciprocal and form a system configuration that will give you the desired result. This result is often called a system response. The control system can also be interpreted as the process of setting or controlling against one or several magnitudes (variables, parameters) so that they are at a certain price (range). Control is closely related to the strategy that allows a controller that acts as the brain in the control system to direct the movements of a controlled device with an actuator intermediary. Controllers here are Arduino Uno and Stepper Motors as actuator.

2.2 Arduino Uno

The mechanical movement control process requires microcontroller, here the microcontroller used is Arduino UNO. Arduino is an open-source physical computing platform based on a simple input/output (I/O) board and a development environment that implements the Processing language [9].

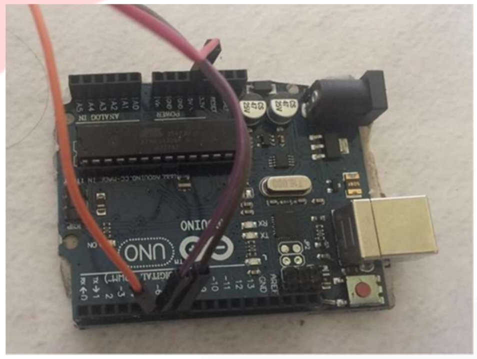

Figure 2.1 The Arduino Uno that used in the thesis

Arduino/Genuino Uno is a microcontroller board based on the ATmega328P It has 14 digital input / output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button [10]. Arduino UNO contains everything needed to support the microcontroller, easily connect it to a computer with a USB cable or supply it with an AC adapter to DC or use the battery to start it [11]. The figure of Arduino Uno shown on the figure 2.1.

2.3 Stepper Motor

This system used Stepper Motor as an actuator to move the GPR. Stepper Motor is an easy motor to be applied because of its ease, at this time Stepper Motor is often used for various kinds of needs, such as industrial equipment and household. Stepper Motor is a machine that converts the electric energy in direct current into mechanical energy [11]. It is designed to accomplish a discrete movement (notion of step) and reach a precise position. Stepper motor requires sequencers and driver to operate. Sequencer generates sequence for switching which determines the direction of rotation and mode of operation. Driver is required to change the flux direction in the phase windings. In this undergraduate thesis the stepper motor type is hybrid stepper motor, the stepper motor that used in this thesis shown in the figure 2.2.

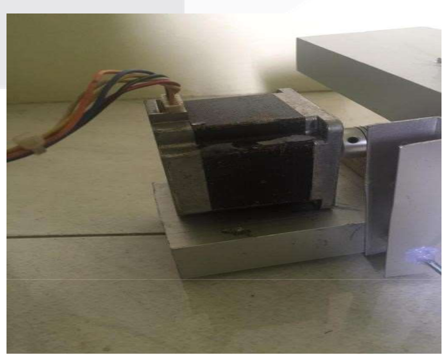

Figure 2.2 The stepper motor that used in this thesis

2.4 Driver Motor

Driver Motor used are Microstep driver motor TB6600, TB6600 single axis drive is a low cost microstepping drive. It is suitable for driving 2-phase and 4-phase motors. the driver motor shown in the figure 2.3 and the electrical spesifications of stepper motor shown in the table 2.1

Table 2. 1 The table contains the specification of Driver Motor TB6600 type [12]

Parameters	Min	Typ	Max	Unit
Output Current	0.7	-	4.0 (3.5 RMS)	A
Supply Voltage	+9	+36	+40	VDC
Logic Signal Current	8	10	15	mA
Puls input frequency	0	-	20 when duty cycle is 25 high / 75 low 13 when duty cycle is 50/50	kHz
Insultation Resultation	500	-	-	M W
Microstep / 1.8	200	-	6400	-

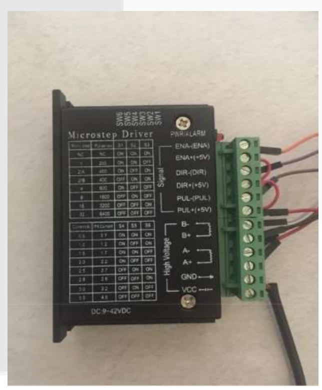

Figure 2. 3 The figure shown the driver motor TB6600

3. Work System

In the design of Mechanical Movement 2D for GPR system, Arduino UNO microcontrollers are used as the main components governing and controlling the movement of the Stepper Motors. The tool on this undergraduate thesis designed Ground Penetrating Radar that moves automatically. Before creating the appliance, first done the design by creating a diagram block, diagram block system shown in the figure 3.1. With this diagram block, of course, it has been visible what includes the inputs, controls, and outputs.

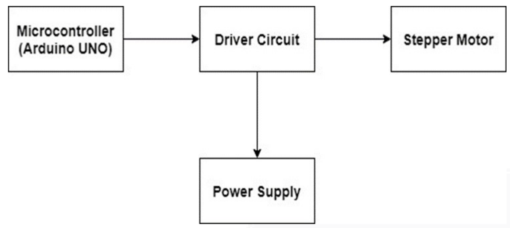

Figure 3.1 The block diagram of mechanical movement system

3.1 Hardware Configuration

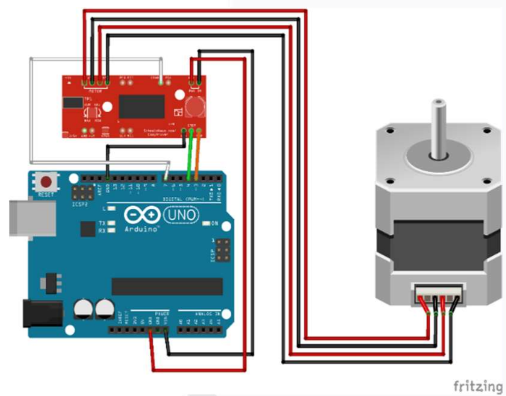

Figure 3.2 The figure shown the circuit of system

The system uses a hardware configuration that is, Stepper Motor Nema23 that serves to move the board used as a GPR antenna holder. The circuit of system shown in the figure 3.2 Stepper motor moves over control of Arduino UNO, while the direction and speed of the stepper motor is controlled by the motor driver, that is connected to Arduino UNO and power supply.

3.2 Software Configuration

Software on a mechanical movement system is software used to control ground-penetrating radar movements during the detection process. Software used in this tool is C language, then the software is installed on a computer de-vice as an interface. The interface is software that functions to communicate all commands that can be read properly by all hardware. With the mechanical movement 2D for GPR interface, it moves according to the previously designed program.

3.3 Result of Mechanical Movement Performance

From several experiments the number of steps used to move a cross section a distance of 1 cm and close to perfect precision is 3500 steps, the graph of tool performance when inputted 3500 steps shown in the figure 3.3 and 3.4.

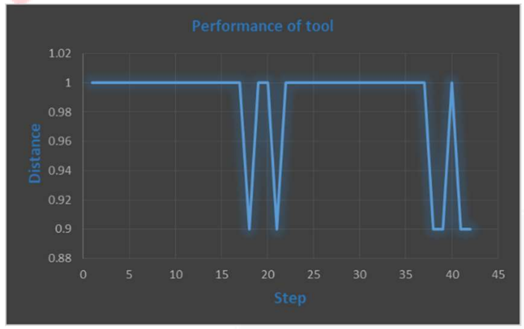

Figure 3.3 The figure shown performance of tool when the tool move forward

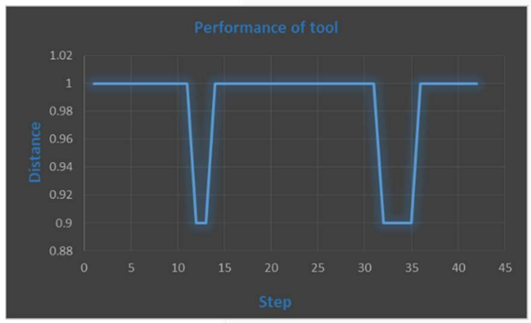

Figure 3.4 The figure shown performance of tool when the tool move backward

3.4 Analysis of Mechanical Movement Performance

In testing the mechanical movement tool is carried out several times the test to get the right step used to achieve a movement in accordance with expectations. The next stage evaluates the performance of the system which uses a confession matrix by testing precision, recall, and accuracy. Using the formula below:

$$Precision = \frac{TP}{TP+FP} \times 100\% \quad (4.3)$$

$$Recall = \frac{TP}{TP+FN} \times 100\% \quad (4.4)$$

$$Accuracy = \frac{TP+}{TP+TN+FP+FN} \times 100\% \quad (4.5)$$

Where,

TP: True Positive, actually move 1 cm, and prediction equal to actual.

TN: True Negative, actually move not within 1 cm, prediction equal to actual.

FP: False Positive, actually move within 1 cm, prediction move not 1 cm.

FN: False Negative, actually move not within 1 cm, prediction move 1 cm

From the experiments conducted get the results shown in the figure 3.5 and 3.6.

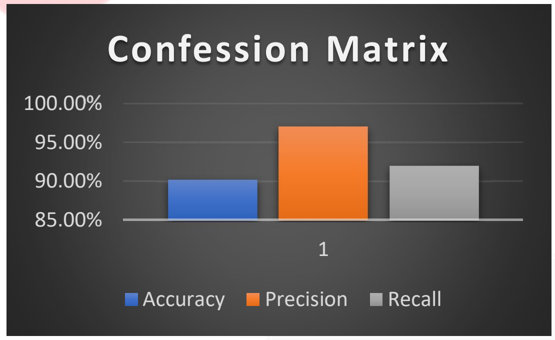

Figure 3.5 The figure shown the result calculation of tools performance when the tool move forward

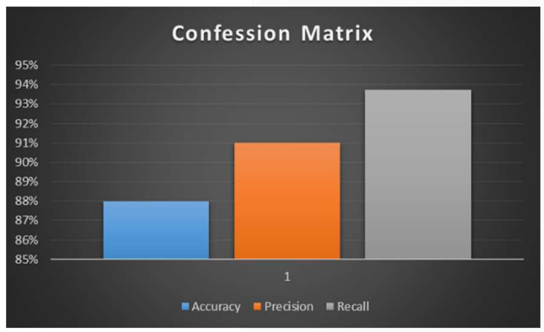

Figure 3.6 The result calculation of tools performance when the tool move backward

which affects the system to work less optimally, that is a mechanical body that is less precise, causing not optimal movement and cross-section placement that does not fit with the home of step.

4. Conclusion

This research aims to design a tool that can move GPR automatically and precisely. Nowadays, to move the GPR detecting manually. Based on research and testing that has been done, it can be concluded that the tool designed can work well. The test results are presented in the discussion of results and analysis, the success rate of mechanical movement 2D for GPR for precision is 91% - 97%, recall of 92% - 94%, and accuracy of 88% - 90.24%.

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