UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF AN AUTONOMOUS ROBOT FOR INSPECTION SYSTEM USING ARDUINO

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Electronics Engineering Technology (Industrial Electronics) with Honours

by

AHMAD RIDHWAN BIN MOHD KAMIL

B071410740

921220-10-5637

FACULTY OF ENGINEERING TECHNOLOGY

2017

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Development Of An Autonomous Robot For Inspection System Using Arduino**

SESI PENGAJIAN: **2017/18 Semester 1**

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours. The member of the supervisory is as follow:

Signature : …………………………………………………

Supervisor's Name: SHAHRIZAL BIN SAAT

Date :

ABSTRAK

Lebuhraya Malaysia adalah salah satu yang utama digunakan untuk perjalanan antara negeri-negeri. Beberapa lokasi mempunyai permukaan jalan yang tidak rata yang menyebabkan lopak air semasa hujan. Lopak-lopak ini menjadi berbahaya kepada pemandu terutamanya apabila hujan. Ini akan menjejaskan kecekapan geseran tayar kenderaan ke atas jalan raya. Dari kehilangan kecekapan, kebarangkalian kenderaan untuk kehilangan kawalan tinggi dan akan menjejaskan keselamatan pemandu dan penumpang. Projek ini memberi tumpuan kepada reka bentuk, menganalisis dan membuat robot autonomi yang dapat mengesan ketidaksamaan permukaan dengan bergerak secara autonomi di permukaan. Sistem projek akan menggunakan Arduino sebagai mikrokontroler untuk menyambung dengan sensor lain. Sistem ini akan melengkapkan sensor IMU yang akan mengukur orientasi dan arah robot. Sistem ini juga akan dilengkapi dengan enkoder yang akan mengukur jarak perjalanan oleh robot. Input utama sistem adalah orientasi dan juga jarak. Output data akan dihantar melalui komunikasi bluetooth. Antara muka pengguna grafik (GUI) akan dibangunkan untuk menggambarkan jarak kecerunan dan jarak.

ABSTRACT

Malaysian highway is one of the main used for travelling between states. Some of the location had improper road that causes puddles during raining. These puddles become dangerous to the driver especially when raining. These will be affecting the efficiency of the vehicle tyre friction towards the road. From the loss of efficiency, the probability of vehicle to losing control is high and will compromising the driver and passenger safety. This project focused on the design, analyse and fabricate an autonomous robot that can detect the flatness of the surface by moving autonomously on the surface. The project system will be using Arduino as the microcontroller to interface with other sensors. The system will equip with IMU sensor that will measure the orientation and heading of the robot. This system also will equip with rotary encoder that will measure the distance travel by the robot. The main input of the system is orientation and also distance travel. Output of the data will be transmitting through serial communication. Graphical user interface (GUI) will be develop to visualize the gradient and travelling distance of the robot

DEDICATION

To my beloved parents

Mohd Kamil Bin Mohd Ali and Norhasimah Binti Abu Hasan Ashari

To supervisor

Encik Shahrizal Bin Saat

To all friends that help me a lot towards completing this project.

ACKNOWLEDGEMENT

In the name of Allah, the Most Beneficent and Most Merciful.

Firstly, all praises to Allah, the Almighty God that has given me the strength and spirit to complete this project.

I would like to thank to my parents and friends for supporting me from when I started until finished this Final Year Project.

Special thank also to my supervisor Encik Shahrizal Bin Saat for guiding, support and put the trust on me while conducting this project. Lastly, not to forget to thanks all of my friends that help me a lot in completing this project.

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CHAPTER 1
INTRODUCTION

This chapter provides an overview of the road flatness measurement issues. The problem background and problem statement describe the details of this project later in this chapter. This is followed by research objectives and scopes of study which involves the design and development of an autonomous robot for flatness inspection system

1.1 Background

Malaysian highway is one of the main used for travelling between states. Some of the location had improper road that causes puddles during raining. These puddles become dangerous to the driver especially when raining. These will affect the efficiency of the vehicle tire friction towards the road. From the loss of efficiency, the probability of vehicle to losing control is high and will compromising the driver and passenger safety. This project focused on the design, analyse and fabricate an autonomous robot that can detect the flatness of the surface by moving autonomously on the surface. The designed system is able to find out the location and the flatness of the road which will later be proposed after this. Figure 1.1 below show example of puddles on the road.

Figure: 1.1 Accumulation of puddles on highway road during rain time.

1.2 Problem Statement

Sometimes, improper flatness of the road causes some serious problem like accumulation of puddles during raining time. Puddles is a small of accumulation of liquid usually water that forms on the road during raining. Puddles can cause the vehicle to loss the grip towards the road thus will affecting the driver and also passenger safety. This project investigates the flatness by measuring the slope angle of the road surface along the road. Besides that, by using manual inspection method additional workers and time is required. The problem can be improved by introducing an intelligent mobile robot for flatness inspection to measure which location flatness is under standard. Furthermore, manual inspection method required a professional person to visualize the flatness manually.

1.3 Objective of The Study

The purpose of this project is to improve the flatness inspection system by using technology. Thus, the objective of this project are as stated below:

I. To study IMU sensor for flatness inspection system
II. To develop autonomous robot for inspection system.
III. To evaluate and visualize the result on graphical user interface.

1.4 Scope of The Study

An Inertial Measurement Unit(IMU) is an electronic device that measures and reports a body specific force, angular velocity and sometimes the magnetic field surrounding the body by using a combination of accelerometers and gyroscopes sometimes also a magnetometer. MPU 6050 is a 6 degree of freedom sensor which is mean it has 3 axis accelerometer and also 3 axis gyroscope. Both sensor will generate 3 analogue output describing the accelerations and angular rate along of each axes. MPU6050 has an internal 16-bit ADC. The information from the sensor can be interfacing using I2C.

A Rotary Encoder is used to translate linear motion in to digital signal. It is used to determine the speed, distance and position of the robot while carry out measurement. The information will then be send though the computer through the serial communication.

Visual C# language is used to develop the software to display information of flatness and distance to user. It provided a way for interaction between user and the robot.

1.5 Summary

In this project, there are five chapter in this project to describe and clarify the flow for this project. In first chapter, it includes the background information and objective of this project, relevant solution and method to solve the problem. In chapter two, literature review included the fundamental theory of the material and element used in this project. It also includes the review on the previous work from journal article, book and other sources. Comparison between previous work and current project will give better overview on knowing the method used in previous work and advantages of this method. In chapter 3, methodology describe the flow of the project and method used to accomplish the target output. In chapter 4 cover the actual results get from this project and discussion on finding. Lastly, chapter five will conclude overall result from this project.

CHAPTER 2
LITERATURE REVIEW

This chapter summaries prior works related to design an autonomous robot for flatness inspection system. It will cover the background and details of flatness inspection system. It also summarizes the usability of hardware and software that will going to be utilize to this project. Beside that this chapter will summarizes and discuss the past related research of flatness inspection system.

2.1 Introduction

Not all the road has the perfect flatness, flatness sometimes can be affected during defect during construction, after long time of period and also nature disaster. This can cause accumulation of puddles to build up during the rain. This puddles endanger the car driver and also pedestrian walking beside the road. For the car user this will decreases the friction efficiency between the road and the vehicle tires. This will sometimes cause the driver to lose control their car by skidding on the wet surface.

As technologies evolved and instrument such as flatness measurement sensor, positioning devices etc. become affordable and well-known, an autonomous robot for flatness measurement inspection system is not no more a complicated project.

To solve the existing problem, an accurate flatness measurement inspection system is needed. With the autonomous robot that can carry out measurement inspection system on the road, this can ease the workload of the road management team. Hence more human resource and time can be reduced.

2.2 Reviewing on Previous Work

2.2.1 Review on Bluetooth Low energy profile for MPU9150 IMU data transfers

IMU sensor used to with small form factor and low cost to present a three-dimensional space object orientation. A Bluetooth low energy is used to transfer data in wireless mode. These sensors inherent the inaccuracy but by using sensor fusion that can increase the reliability(Maro *et al.*, 2015).

2.2.2 Review on Design of instrumentation for flatness measurement of railroads

Develops and designs a flatness measurement system consisting of multiple sensors to determine whether railroads are flat. The method used in this study is to deploy sensors for measuring flatness on railway carriages from one railway station to another. The measurements provide field data about translational and rotational shifts of position and angle in particular locations. The magnitudes of the shifts are obtained from the Inertial Measurement Unit (IMU) integrated sensor that contains Accelerometer Sensor, Compass Magnetometer, Gyroscope, Air Pressure Sensor and GPS. LabVIEW 2013 is here used in cooperation with GUI systems equipped with a data logger for automatic data saving(Nugraha *et al.*, 2016).

2.2.3 Review on Design and development of a tablet based real time wireless data logger

Wireless data logger is developed using microcontroller with analog-to-digital converter (ADC). The design of the portable wireless data logger is compact and light to increase the mobility and usability. Sampled data with time stamp from real time clock (RTC) module will be stored into SD memory card which is attached to controller board. Wireless data logger can directly transmit the data to end user if the device is in the communication coverage or stored the data into memory card if it is out of range. Graphic user interface (GUI) developed using Visual Basic and Android application. These applications can communicate with wireless data logger through wireless XBee module and Bluetooth module. End user can change the data logger settings such as, data sampling frequency, date and time remotely(Siew *et al.*, 2012).

2.2.4 Review on Easy speed measurement for incremental rotary encoder using multi stage moving average method

Speed measurement for incremental rotary encoder using multi stage moving average method. Classical theoretical algorithms which include frequency counting and period counting algorithm can reduce measurement error and increase the measurement accuracy for rotary incremental encoder is very useful for application in speed and displacement measurement(Ilmiawan *et al.*, 2014).

2.3 Introduction of Inertial Measurement Unit (IMU) Sensor

Inertial Measurement Unit(IMU) is one of the unit in the electronic module that will collects both acceleration data and angular velocity which will then sent to the main processor. Inside the electronic module of IMU, it actually contains of two sensors which are accelerometer and gyroscopes.

An accelerometer is very useful for sensing the vibration or orientation of an object. The acceleration measurement can be divided into two type which is static and dynamic acceleration. A static forces of acceleration is due to the gravitational pull of freefall object which measure in meters per second squared (m/s^2) or in G-forces (g). At any surface on the earth, an accelerometer at rest will indicate approximately 1 g upwards, because acceleration acting in upwards direction is relative to the local inertial frame. In outer space, an accelerometer will read only zero during any type of free fall. An analogue accelerometer will produce a continuous voltage proportional to acceleration. While dynamic forces of acceleration are measured based on movement and vibration of the object itself. Accelerometer generates three analogue signals along three axes x, y, z among it six's surface. The force can act in direction x+ or x- which means forward and backwards, with the same conditions goes for axes y and axes z. Hence it will be able to measure acceleration among all six surface.

A gyroscope is very useful to measure or maintain orientation. Unlike the accelerometer, a gyroscope will not be affected by gravitational force.

Due to not affected by any linear acceleration based on vibration, a gyroscope is able to maintain its level of effectiveness and measure the rate of rotation around a particular axis. Gyroscope is used to sense rotation and measure angular velocity of the object itself. The measurement unit of angular velocity are degrees per second (°/s) or revolutions per second (RPS). Typically, a triple axis gyroscope can measure rotation around three axes which are x, y, z. But limitations of gyroscope are it often used on objects that are not spinning at a very high speed. Figure 1 shows IMU sensor measure angular velocity with three orthogonal gyroscopes and measure forces with three orthogonal accelerometers. Figure 2.1 on the next page will illustration of 6 degree of freedom.

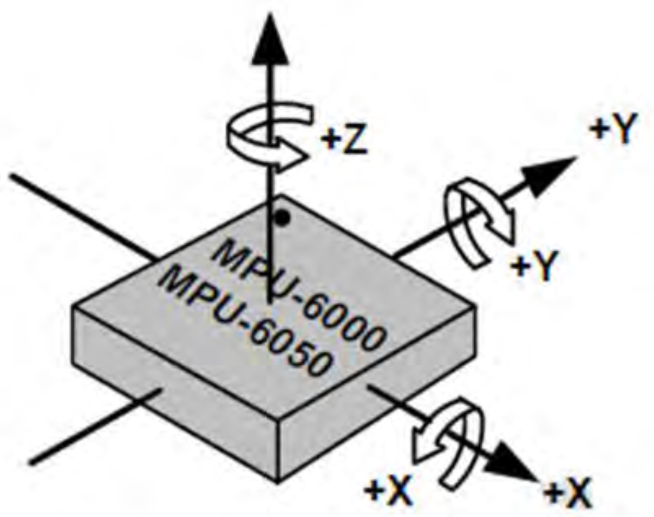

Figure: 2.1 MPU6050 6 degree of freedom illustration

2.4 Rotary Encoder

Rotary encoder is a name for specialized switch. It converts the mechanical motion into some contract operations which can sense the electronically operation. A rotary encoder converts the motion (shaft rotation) into contract operation. The linear encoders also exist will exist where a straight-line motion and it is able to convert from linear motion to contract operation.

Rotary encoders, also known as “shaft encoder” or “position encoder”, the position of a machine tool spindle may be placed through a rotary encoder. A simple rotary encoder on its shaft can measure the RPM speed of a motor. Furthermore, it can also measure the angle of the robotic arm joint, or the azimuth of a rotating radar antenna. The rotary encoder application allows the users to scroll via an LCT menu and select options. By using the low-end application of rotary encoder, we can learn to carry over the usage of encoder. Doing a mistake or miss one of the relative reports, all position information will be wrong. During power-up and initialization, we must record the relative shaft rotation to known reference. The absolute encoder will act like a non-volatile memory as it will report the shaft’s position at start-up as it did when last running(Babalola *et al.*, 2014).

There are two types of rotary encoder:

1. Absolute encoder

   It provides an output that can identify the shaft angle. An absolute encoder can be specified as a multi-position rotary switch; as you rotate the switch to break the contract and then a new set of contract make. Hence, the angle and the contracts have direct relationship. If we can know which the contract is closed, we know the shaft position. The prior position of the shaft is determined; to uniquely determine the shaft angle all we have to know is which contract is closed(Ilmiawan *et al.*, 2014).

2. Incremental encoder

   It provides information on the direction for the shaft rotation. For example, we can know shaft rotate clockwise or anticlockwise and how many degrees did the shaft rotate(Ilmiawan *et al.*, 2014).

2.5 Arduino Microcontroller

The Arduino is an open-source to use for programing of electronic. The Arduino can send and receive the information to many electronic devices; it can command the specific electronic device via internet. Arduino Uno is hardware of Arduino and it use Simplified C++ as the software programming language. Arduino currently used in a lot of microcontroller programming among other things due to its user friendly and it is easy to understand by user. The Arduino can help the user read the coding from input devices, for example: Sensor, Potentiometer and so on. Furthermore, Arduino can send signal information to output device like LED, LCD screen, and motor and so on.

For hardware, the Arduino consists of a lot of component that combine to make it function. The USB plug is the first part of the Arduino, it is used to transfer the data coding from the computer to microcontroller board and it has a regulated 5 volts which is also the power supply for Arduino board. It also provides external power supply but it is limit to 9 to 12 volts only. There is a reset button which reset your program inside the microcontroller board for upload another programming command. As a programming hardware, it must have a microcontroller to receive and send the data information or command that had compiled in the PC to the circuit. The Arduino has 5 analog input pins and 14 output pins. The board also provide the ground pin and power pins that is 3.3 and 5 voltages power pins.

For software part, there is a set of instruction to inform the hardware what to perform and how to do it. The Arduino IDE (Integrated Development Environment) has three main parts: 1) Command Area, 2) Text Area and 3) Message Window Area. For the Command Area, it is the area where the menu items can be used. The menu items such as File, Edit, Sketch, Tools, Help and Icons (Verify Icon and Upload Icon), New, Open, Save and Serial Monitor can be found inside the Command Area. The Serial Monitor is used for receiving and sending the information between the Arduino and the IDE. For Text Area, it is the place where the programming code to write and usually the coding is using the Simplified version of C++ programing language to write. It is because the simplified version of C++ programming language make user easy to write and understand. There are two important parts: the step function and the loop routine. In the step function, user has to initialize the variables and assign the variable if there is needed. The command of setup function should be written like this void setup () {//put your coding here, to run once}. The loop routine will run and execute the main code over and over again. This is the example, void loop () {// put your main code here, to run repeatedly}. For Message Window Area, it shows the message from the Arduino IDE in the black area after it verified the coding that user had put in(Badamasi, 2014). Figure 2.2 below show the pinout of Arduino UNO.

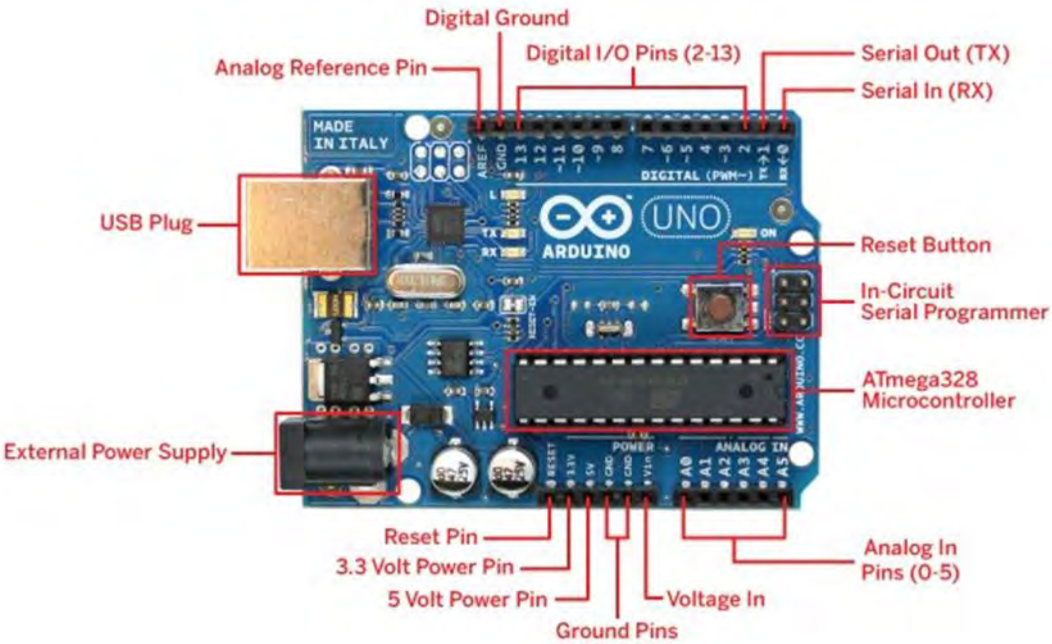

Figure: 2.2 Arduino UNO pinout

2.6 JAVA Programming Language

Java is a programming language that is developed by Sun Microsystem. It is originally developed for digital mobile devices. Java is object oriented language. The Java language is similar to C++ but C++ is complex in its syntax and inadequate. Java built on and improving the ideas of C++ to provide better programming language. The java language is cross platform thus it will reduce time to developed for a numerous type of device.