DESIGN AND FABRICATION OF POTHOLE DETECTION AND LEVELLING ROBOT

MINI PROJECT REPORT

Submitted by

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ABSTRACT

The main objective of the project is to design and fabricate an Semi-Automated Robot, which will detect the Pothole on the road and will discharge the required amount on concrete quantity, which is needed for the detected pothole and to do the levelling process on the discharged concrete and hence the pothole on the road filled completely.

The power source for the robot is switched ON and allows the robot to move on the road. The Ultrasonic sensor on the front of the robot is allowed to sense the surface of the road, if the pothole will be detected the sensor send the signals to the Arduino Controller, and the controller suddenly stops the movement of robot near the pothole, and allows to discharge the required concrete needed for the detected pothole. Then after filling the pothole the slider crank mechanism is used for levelling process.

KEYWORDS: Ultrasonic sensor, Slider crank mechanism, Levelling, Semi automated robot.
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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Roads make a crucial contribution to economic development and bring important social benefits. They are of vital importance in order to make a nation grow and develop. Roads open up more areas and stimulate economic and social development. For those reasons, road infrastructure is the most important of all public assets. But due to repeated loading and weathering on roads, a pothole may be caused which may affect the human life very badly.

A pothole is a structural failure in a road surface, caused by failure primarily in asphalt pavement due to the presence of water in the underlying soil structure and the presence of traffic passing over the affected area.

So our project is to make a robot which helps the society in promoting the road safety and to reduce the difficulties in detecting the pothole and also reduce the usage of human power, and hence saves the time.

We designed a Semi Automatic Robot which will detect the pothole on the road, and will discharge the required amount of concrete to fill the pothole and to do a levelling process on the discharged concrete using the slider. Therefore the pothole on the road (Fig. 1.1. Pothole) may be filled completely and hence the accidents occur due to the pothole may be reduced.

Fig. 1.1 Pothole
1.2 OBJECTIVE OF PROJECT WORK

The main objective of the project is to design and fabricate an Semi-Automated Robot, which will detect the Pothole on the road and will discharge the required amount on concrete quantity, which is needed for the detected pothole and to do the levelling process on the discharged concrete and hence the pothole on the road filled completely.

The power source for the robot is switched ON and allows the robot to move on the road. The Ultrasonic sensor on the front of the robot is allowed to sense the surface of the road, if the pothole will be detected the sensor send the signals to the Arduino Controller, and the controller suddenly stops the movement of robot near the pothole, and allows to discharge the required concrete needed for the detected pothole. Then the pothole is levelled by slider crank mechanism.
1.3 ORGANISATION OF CHAPTERS

- Introduction
- Literature Review
- System Design
- Design Calculations
- Assembly Drawing
- Process Chart
- Programming Concept
- Cost Estimation
- Experimentation and Performance Analysis
- Conclusion
1.4 CONCLUSION

The objective of this project work has been framed into chapters for the development of pothole detection and levelling robot. The basic C programming and design calculations along with photos have been included in the following chapters.
CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Before starting this project, it is important to research existing machines and the technologies used in them. This will help us understand any existing problems and try to find solutions for these problems in such a way that it can be implemented in our project. Going through the literature also helps us understand the practical outcomes of the project and how to attain the required outcomes.

2.2 Pothole-Definition

SHRP established a basic requirement for the scope of potholes to be repaired. An expanded definition included other variations that would be encountered in practice.

Pavement Type:

The pothole would be in pancake pavement, flexible base, or rigid composite base. Pavement areas adjacent to the pothole might be asphalt.

Pothole Size Limits:

1 to 6 inches (2.5 to 15 cm) in depth, 1 to 10 square feet (.09 to .93 sq m) in surface area.

Pothole Frequency and Location:

Closely spaced or infrequent. Anywhere in 10 to 12 foot (3 to 3.66 m) lane width but usually in wheel paths assumed to be 7 feet.

Repair Conditions:

It should be the objective to make repairs in virtually any weather condition, day or night time operation whenever potholes develop.
2.3 Automated Patching

An operational requirement was that the system be productive and place as much material per day as possible, with less labour, and at lower cost. The overall design of the system and many of the engineering decisions depend on calculated operational and maintenance costs. There are many sources of information for determining the cost of various patching operations.

The primary economic drivers include: the cost of materials, labor rates, productivity of patching operations, costs of delays, and patch lifetimes. No single source was found that could bring all of these costs into a single comparison. For this reason, we developed a productivity model to analyze how pothole patching costs are related and used it as a tool to evaluate the impact of some engineering decisions on final patch cost.

Various scenarios are analyzed in Appendix B. One can look at pothole repair costs on a daily, seasonal, or yearly basis, but that only tells part of the story. To perform a fair cost comparison of different approaches, it is perhaps best to look at the cost of making a single repair, and assume equivalent patch lifetimes. When field data are available on actual lifetimes and other cost variables, the basic comparison can be adjusted.

2.4 Vision Evaluations

The vision system had to determine a pothole's measurements, depth, and volume so that it can be repaired automatically by a robot. For which ultra sonic sensors are used.

2.4.1 Remote Manipulator Evaluations

Manipulation of the repair nozzles and tools, whether it be cutters, lances, or filling nozzles, requires a support system and a mechanical structure sufficiently strong to handle significant weight and impact forces. Since the road surface is basically planar, only two degrees of freedom (X and Y direction) are required for the remote manipulator. A third vertical axis of motion (Z direction) is needed if the tool must descend into the cavity in controlled fashion. It
was our objective to find a commercial manipulator (robot) that had speed, strength, high payload capacity, tolerance to extreme shocks, and yet only require low maintenance in a dirty environment. None of these features is typically available in commercial robots, however, We considered XY 'plotter type' tables during the cutter evaluations and find them subject to problems from dirt, spray, weather conditions, and small accidental impacts to the chassis. As noted previously, the XY table also must be well supported at all comers, forcing it to be located under or inside the truck.

Fig. 2.1 Relevant Core Technologies of Automation in Highway Works

The following areas of technology constitute the basis for development of automated road construction and maintenance machines (Hendrickson 1989).

**Manipulators:**

Stationary, articulated manipulator arms are essential components of industrial robotics. The role of a manipulator arm is to move an effector tool into a proper location and orientation relative to a work object.
End Effectors:

A variety of end effectors can be employed on robot arms. Typical end effector tools and devices on automated road construction and maintenance equipment include discharge nozzles, sprayers, scrapers, and sensors.

Motion Systems:

Mobility and locomotion are essential features for road construction and maintenance equipment. A variety of mobile platforms can support stationary manipulator arms for performance of required tasks.

Electronic Controls:

Controllers are hardware units designated to control and coordinate the position and motion of manipulator arms and effectors. A controller is always equipped with manipulator control software enabling an operator to record a sequence of manipulator motions and subsequently to play back these motions a desired number of times.

Sensors:

Sensors convert environmental conditions into electrical signals. An environmental condition might be a mechanical, optical, electrical, acoustic, magnetic, or other physical effect.

2.5 Filling

The prototype filling system has been designed to be automatically controlled on a vehicle. Some of the commercial systems we evaluated showed promise but none offered the required features for this task. The testing program clearly demonstrates that this design achieves very high rates of productivity, with a very simple approach having controls ideally suited to our automation needs. They can simultaneously control the aggregate feed rate, emulsion flow rate,
temperature, aggregate coverage, and fill. This is the surest way of achieving the most consistent patch performance.

### 2.6 Benefits

The technology developed and applied through this SHRP study will have lasting benefit to all roadway maintenance authorities and workers by making pothole repair safer for all, with greater performance and productivity than traditional methods. Given a successful commercialization program and field testing, production models could start to become available for the benefit of the pavement maintenance community in 1994. We think that different configurations would be manufactured to maximize the benefit to state highways, districts, cities, and private contractors. Every group has special requirements as to size, maneuverability, level of automation, and material capability. Since the APRV was designed as a modular system, each of the components could be modified to suit the needs of the end user.

### 2.7 CONCLUSION

Thus, research was done regarding this project on various sources of literature. The many methodologies were studied and this information has helped to complete the project successfully.
CHAPTER 3

SYSTEM DESIGN

3.1 INTRODUCTION

This Robot is designed, which helps the society in promoting the road safety and to reduce the difficulties in detecting the pothole and also reduce the usage of human power, and hence saves the time.

This is done in ensuring perfection in all the aspects such as speed, accuracy, flexibility, safety, reliability and cost effective during the maintainence and service of the robot. The overall concept of the system will be explained in this chapter.

3.2 ULTRASONIC SENSOR

An Ultrasonic sensor is a device that can measure the distance to an object by using sound waves. It measures distance by sending out a sound wave at a specific frequency and listening for that sound wave to bounce back. By recording the elapsed time between the sound wave being generated and the sound wave bouncing back, it is possible to calculate the distance between the sonar sensor and the object.

3.3 DC MOTOR

A DC Motor like we all know is a device that deals in the conversion of Electrical energy to mechanical energy and this is essentially brought about by two major parts required for the construction of dc motor, namely.

1) Stator – The static part that houses the field windings and receives the supply and
2) Rotor – The rotating part that brings about the mechanical rotations.
Other than that there are several subsidiary parts namely

3) Yoke or casting of dc motor.
4) Magnetic poles of dc motor.
5) Field winding of dc motor.
6) Armature winding of dc motor.
7) Commutator of dc motor.
8) Brushes of dc motor.

All these parts put together configures the total construction of a dc motor, that has been pictorially represented in the diagram below. Fig.3.1.Construction of DC motor.

3.4 ARDUINO ATMEGA-328:

The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328 (Arduino Nano 3.0) or ATmega168 (Arduino Nano 2.x). It has more or less the same functionality of the Arduino, but in a different package. It lacks only a DC power jack, and
works with a Mini-B USB cable instead of a standard one. Fig. 3.2 Architecture of Arduino Atmega-328.

![Fig. 3.2 Architecture of Arduino Atmega-328](image)

**I.) Power:**

The Arduino Nano can be powered via the Mini-B USB connection, 6-20V unregulated external power supply (pin 30), or 5V regulated external power supply (pin 27).

**II.) Memory:**

The ATmega-168 has 16 KB of flash memory for storing code (of which 2 KB is used for
bootloader); the ATmega328 has 32 KB, (also with 2 KB used for the bootloader). The ATmega-
168 has 1 KB of SRAM and 512 bytes of EEPROM (which can be read and written with the
EEPROM library); the ATmega328 has 2 KB of SRAM and 1 KB of EEPROM.

III.) Input and Output:

Each of the 14 digital pins on the Nano can be used as an input or output, using pinMode(),
digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive
a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50
kOhms. In addition, some pins have specialized functions:

Serial:
0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins
are connected to the corresponding pins of the FTDI USB-to-TTL Serial chip.

External Interrupts:
2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or
falling edge, or a change in value. See the attachInterrupt() function for details.

PWM:
3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analogWrite() function.

SPI:
10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication, which,
although provided by the underlying hardware, is not currently included in the Arduino language.

LED:
13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the
LED is on, when the pin is LOW, it's off. The Nano has 8 analog inputs, each of which provide 10
bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts,
though is it possible to change the upper end of their range using the analogReference() function.
3.5 HUMAN SAFETY

In any automated process human safety holds the first priority. In this process the robot is monitored by a well equipped skilled person. This prevents the damage to the other humans on the road. Since the Ultrasonic sensor is fixed on the front of the robot, if any obstacles is detected it immediately stops the movement of the robot.

3.6 CONCLUSION

The various functionalities and principles used in the Robot have been explained. The entire working of the Robot has been described. Further details will be seen in the following chapters.
4.1 INTRODUCTION

This chapter will include the mechanical design calculations required for the Selection of Motor used in the project.

4.2 MECHANICAL DESIGN:

The following shows the 3D modeling of the robot. The mechanical Design of the robot is designed and calculations are made as follows. Fig.4.1. 3D Model of the robot.
The weight acting on the shaft will be considered as uniformly distributed load.

**Motor Selection:**

Total mass of robot = 10Kg
Weight of the robot = 10 * 9.81= 98.1N
Weight acting per shaft = 98.1/4 = 24.5 N
Length of wheel shaft =60 mm

\[ T = \left( \frac{\pi}{16} \right) \tau d^3 \]

\[ T = F \cdot R \]

\[ F = \mu \cdot R \cdot N \]

= 0.7*24.5 = 17.15N
So, \( T = 17.15 \times 0.5 = 8.575 \) Nm

Take velocity = 0.1 m/s

Angular velocity = \( \frac{v}{r} = 0.1/0.05 = 2 \) rad/s

\[ P = T \cdot W = 8.515 \times 2 = 17.15W \]

\[ W = \frac{2\pi N}{60} \]

\[ N = \frac{(2 \times 60)}{2\pi} = 19.098 \text{ rpm} \]

**Finding diameter of shaft:**

\[ T_e = \sqrt{T^2 + M^2} \]

= 6.1 Nm

\[ 6.1 = \frac{\pi}{16} \times (250 \times 10^6) \times D^3 \]

D = 4.99 * 10^{-3} m

D using Normal torque = 4.968 * 10^{-3} m
D using equivalent torque = 4.99 * 10^{-3} m
4.3 CONCLUSION

Thus, the design calculations for the selection of motor were done. These calculations were done keeping in mind the dimensional restrictions for this project, along with economic views. The values are well within the limit and the design is safe and accurate.
CHAPTER 5

2D AND 3D DIAGRAM OF ROBOT

5.1 INTRODUCTION

This chapter consists of the complete 2D and 3D diagram of our project.

5.2 2D AND 3D SETUP

The full view and the 3D design of this project is shown below. Fig.5.1.full view of our robot
The following shows the Part Diagram of the outer mechanical box in the robot Fig.5.2. Part diagram

Fig.5.2. Part diagram

The following shows the sectional view of the pipe that is used to discharge the concrete. Fig.5.3. Sectional view of the concrete discharge pipe.

Fig.5.3. Sectional view of the concrete discharge pipe
The 2D CAM model of the part is shown as follows in the Fig.5.3. 2D CAM model

Fig.5.3. 2D CAM model
5.3 CONCLUSION

Thus, the part drawing was done using Solid Works modeling software. Based on this design, the design calculations were done and the machine is kept within these dimensions. The complete layout of the system is also shown.
CHAPTER 6
PROCESS SHEET

6.1 INTRODUCTION

The prime motive of the ‘PROCESS SHEET’ chapter is to provide the fine details about the components being used, their material and quantity of each component involved in the project. It also illustrates the processing steps to complete the project.

6.2 COMPONENT SPECIFICATIONS

6.2.1 ARDUINO ATMEGA-328

The following Table 6.1 General Specifications Arduino Atmega-328 shows the component specifications were done in this project.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Operating voltage</td>
<td>5 V</td>
</tr>
<tr>
<td>Input voltage</td>
<td>7-12 V</td>
</tr>
<tr>
<td>Digital I/O Pins</td>
<td>14(of which 6 provide PWM output)</td>
</tr>
<tr>
<td>Analog input pins</td>
<td>8</td>
</tr>
<tr>
<td>Memory</td>
<td>Flash memory(16KB OR 32KB)</td>
</tr>
<tr>
<td>Clock speed</td>
<td>16 MHz</td>
</tr>
<tr>
<td>Dimensions</td>
<td>0.73 X 1.70</td>
</tr>
</tbody>
</table>

Table 6.1 General Specifications Arduino Atmega-328
6.2.2. DC MOTOR SPECIFICATIONS

The motor Specifications are shown in the Table 6.2 Specifications of DC Motor.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>VALUE</th>
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<tbody>
<tr>
<td>Voltage</td>
<td>12V</td>
</tr>
<tr>
<td>Speed</td>
<td>30rpm</td>
</tr>
<tr>
<td>Current</td>
<td>1 amps</td>
</tr>
<tr>
<td>Weight</td>
<td>Able to lift 5kg</td>
</tr>
<tr>
<td>No of motor</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 6.2 Specifications of DC Motor

6.3 CONCLUSION

Thus the process sheet has been illustrated by tabulating all the process took place during the design and fabrication of Pothole detection and levelling robot. The tables also contain the details about the controller used along with their dimensions.
CHAPTER 7
PROGRAMMING CONCEPTS

7.1 INTRODUCTION

For the detection of the pothole and to stop the robot automatically when the pothole is detected, programming is done using C language in Arduino portal.

7.2 ARDUINO PROGRAMMING

//ultrasonic sensor
int tr=2;
int ec=3;
//motor
int a=4;//left motor
int a2=5;
int b1=6;//right motor
int b2=7;
int c1=8;//sweeper
int c2=9;
float d;
void setup() {
pinMode (2,OUTPUT);
pinMode (4,OUTPUT);
pinMode (5,OUTPUT);
pinMode (6,OUTPUT);
pinMode (7,OUTPUT);
pinMode (8,OUTPUT);
pinMode (9,OUTPUT);
Serial.begin(9600);
7.3 CONCLUSION

Thus the control of the Robot and the levelling operations programming is done in Arduino portal using basic C language.
CHAPTER 8

COST OF THE PROJECT

8.1 INTRODUCTION:

This chapter lists the approximate cost of various components used in the project.

8.2 ESTIMATION TABLE:

The following table shows the Cost estimation of this project TABLE 8.1 Cost Estimation

<table>
<thead>
<tr>
<th>S.NO</th>
<th>COMPONENTS</th>
<th>QUANTITY</th>
<th>COST</th>
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<td>1</td>
<td>Arduino Atmega-328</td>
<td>1</td>
<td>220</td>
</tr>
<tr>
<td>2</td>
<td>DC Motor</td>
<td>2</td>
<td>900</td>
</tr>
<tr>
<td>3</td>
<td>Ultrasonic sensor</td>
<td>1</td>
<td>150</td>
</tr>
<tr>
<td>4</td>
<td>Wheel</td>
<td>4</td>
<td>280</td>
</tr>
<tr>
<td>6</td>
<td>Metal body</td>
<td>Fully</td>
<td>1000</td>
</tr>
<tr>
<td>7</td>
<td>Additional cost</td>
<td>-</td>
<td>500</td>
</tr>
</tbody>
</table>

**TOTAL** | **3050**

TABLE 8.1 Cost Estimation
8.3 CONCLUSION:

The components were chosen with cost as a parameter to optimize the development of the system.
CHAPTER 9

CONCLUSION

9.1 INTRODUCTION

Therefore our Semi Automated Robot, helps the society in promoting the road safety and to reduce the difficulties in detecting the pothole and also reduce the usage of human power, and hence saves the time. Therefore by filling the pothole accidents which occur on the road may be reduced.

9.2 CONCLUSION

The project is successfully completed and tested. All the specified requirements were fulfilled upon completion the project.
REFERENCES


