Intelligent Pothole Repair Vehicle

[1]Adarsh O.B [2]Alen Varghese [3]Gokul Krishna S [4]Louis Philip
[1,2,3,4]Department of Electrical and Electronics Engineering
[1,2,3,4]Muthoot Institute of Technology and Science, Varikoli

Abstract

Identifying and repairing potholes on the roads is labour intensive and expensive. It typically requires three or four people to do the monotonous job in difficult environments. So this is a great opportunity for a type of robotic technology to be introduced for the same. This robotic project aims to develop a remote controlled vehicle which can be used to help fill the potholes and sunken trenches on the roads. The robotic vehicle will consist of scanners mounted on it to identify the road surface features and determine whether an object is a hole, bump, manhole cover or crack and send necessary feedback signals to the controller on the vehicle. Any anomalies will be cleaned with high pressure air or vacuum. After identifying the cracks on the surface a set of pipes will carry the necessary filling material to repair and patch the cracks. Again the quality of repair will be scanned. The vehicle will be designed to be an all-terrain vehicle which can move through difficult surfaces and protective coverings will be provided to keep the controller and other important circuit connections safe. Safe execution of road construction using this robotic vehicle technology will contribute to the improvement of productivity and quality of work by removing workers from cumbersome, repetitive, and often hazardous environments.

Keyword- Remote Control, Pothole, Controller, Robotic Vehicle

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I. INTRODUCTION

A well maintained road network is a must for the economic development and the wellbeing of people in any country. Every year, especially after colder periods of time, authorities have to deal with lots of complains regarding the poor condition of the roadways. Many drivers regard potholes as driving hazards and blame them not only for damaging their cars, but even for causing accidents. Bad roads also count for slower, more energy consuming and polluting traffic. One of the major reasons for road accidents is potholes. Vehicles tend to lose balance when they come across a larger pothole. Whenever a driver slows down the vehicle to avoid the effect due to pothole, there are chances of collisions with the vehicle following it, whose driver has no idea about the potholes. Another problem is, during night times, potholes are not easily detectable by human eye. In 2015 over 10,876 road accidents are caused due to potholes. Potholes, formed due to heavy rains and movement of heavy vehicles, also become a major reason for traumatic accidents and loss of human lives. According to the survey report "Road Accidents in India", 2011, by the ministry of road transport and highways, a total of 1,42,485 people had lost their lives due to fatal road accidents. Of these, nearly 1.5 per cent or nearly 2,200 fatalities were due to poor condition of roads. Over the last two decades, there has been a tremendous increase in the vehicle population. This proliferation of vehicles has led to problems such as traffic congestion and increase in the number of road accidents. Pathetic condition of roads is a boosting factor for traffic congestion and accidents. To address the above mentioned problems, a cost effective solution is needed that collects the information about the severity of potholes and helps drivers to drive safely. Solution to all these problems can be decreased up to some extent using our project Intelligent pothole repair vehicle (IPRV).A well maintained road network is a must for the economic development and the wellbeing of people in any country. Every year, especially after colder periods of time, authorities have to deal with lots of complains regarding the poor condition of the roadways. Many drivers regard potholes as driving hazards and blame them not only for damaging their cars, but even for causing accidents. Bad roads also count for slower, more energy consuming and polluting traffic. One of the major reasons for road accidents is potholes. Vehicles tend to lose balance when they come across a larger pothole. Whenever a driver slows down the vehicle to avoid the effect due to pothole, there are chances of collisions with the vehicle following it, whose driver has no idea about the potholes. Another problem is, during night times, potholes are not easily detectable by human eye. In 2015 over 10,876 road accidents are caused due to potholes. Potholes, formed due to heavy rains and movement of heavy vehicles, also become a major reason for traumatic accidents and loss of human lives. According to the survey report "Road Accidents in India", 2011, by the ministry of road transport and highways, a total of 1, 42,485 people had lost their lives due to fatal road accidents. Of these, nearly 1.5 per cent or nearly 2,200 fatalities were due to poor condition of roads. Over the last two decades, there has been a tremendous increase in the vehicle population. This proliferation of vehicles has led to problems such as traffic congestion and increase in the number of road accidents. Pathetic condition of roads is a boosting factor for traffic congestion and accidents. To address the above mentioned problems, a cost effective solution is needed that collects the information about the severity of potholes and helps drivers to drive safely. Solution to all these problems can be decreased up to some extent using our project intelligent pothole repair vehicle (IPRV).

II. LITERATURE REVIEW

Roads are the dominant means of transportation. One of the major problems in developing countries is maintenance of roads. Well maintained roads contribute a major portion to the country's economy. Identification of pavement distress such as potholes and humps not only helps drivers to avoid accidents or vehicle damages but also helps authorities to maintain roads. In recent years several methods and techniques have been proposed for detection and warning of the road conditions such as Laser based detection, Lidar and camera based detection, Mobile node and access point based warning system etc.

Rajeshwari Madli, Santosh Hebbar, Praveenraj Pattarand and G.V.Prasad proposed Automatic Detection and Notification of Potholes and Humps on Road to Aid Drivers [1]. It deals with combined using sensor and global positioning system to detect the tracking of potholes and humps on the road. Here ultrasonic sensor is mainly used. It consists of a transmitter and receiver. It is used to detect the potholes and humps on the road. It is used to measure the depth and height. The ultrasonic sensor transmit high frequency sound wave and wait for reflected wave to hit the receiver. The depth and height is calculated based on time taken by the ultrasonic pulse to travel a particular distance. The global positioning system is used to find the location of potholes. The sensed data will be stored in a database and act as a valuable source of information to the drivers. The android application is used to alert the drivers when there are any potholes or humps that are approaching to the vehicle. The microcontroller module is used to gather information about potholes and their location. The information from microcontroller is passed to server module where processing and stored in database. The mobile application module uses these data and provide timely alert to the driver.

Sudarshan S. Rode, Shonil Vijay, Prakhar Goyal, Purushottam Kulkarni, Kavi Arya, proposed Pothole Detection and Warning System[2]. The pothole detection system is a system that aims at warning the driver about the potholes present on the road.

The design of pothole detection system, which helps the driver in avoiding the potholes on the road, by providing warnings or alarm. The system consists of two components. One is Access point and other is Mobile node. The Access point responsible for storing information about potholes, updating information and broadcasting information to other vehicle. The Mobile node detects the potholes and warns the driver. It also sends information to access point about newly sensed potholes.
Here, firstly we feed some information about potholes to the Access point. The access point keeps broadcasting the data. The mobile node is placed on vehicle receives the data containing the information about location of potholes. The device is responsible for warning the driver about the occurrence of potholes.

Due to the environmental condition, new potholes can also be formed on the road. So their information will not be present on the access point. So mobile node cannot send warning to the driver about new potholes that are present. When the vehicles passes through these newly developed potholes then the Mobile node acts as a sensor and detects the new potholes formed on the road. If any new potholes are found out, then Mobile node sends data of new potholes to the Access point. The communication system is act as link between Access point and Mobile node. Communication system collects data from different vehicles. Then it will be coordinated and broadcasted into other vehicles. Communication system uses Wi-Fi infrastructure for communication between Access point and Mobile node.

In recent years, several techniques of detecting potholes have been proposed. In 2005, Kiran Kumar Vupparaboina et al. proposed Laser-based Detection and Depth Es-timation of Dry and Water-Filled Potholes [3]. In this paper, they developed a physics-based geometric framework, where such detection and depth-estimation can be accomplished using suitable laser. They relate dry pothole depth to measured optical deviation using simple ray optics and uses Snell's law of refraction to obtain a quartic equation, and its appropriate real root to relate water-filled pothole depth to the corresponding op-tical deviation here a camera-laser arrangement mounted on the vehicle to sense the presence of pothole.

Camera is placed on top of the laser such that it captures the light projected by the laser. the chosen laser source is a line laser so that when illuminated, camera sees a straight line on the normal road surface. However, in the presence of pothole, laser line undergoes deformation which is captured by the camera. Detection and measurement of this deviation is automated using basic image processing based on template match-ing. Maximum deviation measured indicates the deepest point in the pothole, which is further used to estimate the depth of pothole. Note that laser deviation will be less in water-filled pothole as compared to dry pothole, due to refraction of light, making depth calculation challenging.

In 2017, Byeong-ho Kanget al. proposed Pothole Detection System using 2D Li-DAR and Camera [4]. By using 2D LiDAR, the distance and angle information of road are obtained. 2D LiDAR and Camera based pothole detection system has the advantage that is not affected by the electromagnetic wave and the road surface state.

Here two 2D LiDARs are installed 1 m above the road and two LiDARs are 1 m apart, and scan axis of 2D LiDAR is orthogonal to the road surface. One camera is also installed 1 m above the road and is located at the center between two LiDARs. 2D LiDAR system collects pavement surface distance data across a 4 m wide pavement. The Camera is used to collect and store pothole video data. Two 2D LiDAR, called as RPLIDAR, and a camera are connected to the Raspberry Pi 3 small single-board computer.

The RPLIDAR is the low cost 360 degree 2D laser scanner. Each LiDAR sends information such as the distance to the object, angle, and accuracy using serial communications to the single- board computer. After obtaining LiDAR information, proposed pothole detection algorithm is performed using MATLAB. Here Pothole detection using video data is combined with that of 2D LiDAR, and combined data gives more accurate pothole detection performance.

A method for detecting defects on the road surface using accelerometers was pro-posed by Mircea Strutu [5]. Here a cost driven solution which needs only accelerometers and GPS in order to locate and categorize the road defects. It makes use of GPS system to identify the exact location of the defects. Pothole detection algorithm runs on a mobile platform (moving vehicles), which is installed with accelerometer, GPS, local computer and a wireless router. The sensed data is communicated to the central database using primary access points and secondary access points which can be used for future processing. However, installing wireless router and local computer on all mobile platforms and setting up access points turns out to be quite expensive. As an extension, video recordings of the pavement can be used either for validation or in order to better assess the pothole magnitude.

With a growing level of accelerometer usage for more diverse devices and tech-nologies, their price dropped and their performance increased during the last decade. This makes them one of the most appealing technologies to be used in system architectures that demand large quantities of devices that collaboratively lead to solving com-plex problems. The proposed solution is based on using 3D accelerometer data in order to assess the magnitude of the asphalt degradation. The mobile platform consists of a local computer, GPS antenna, accelerometer and video capturing equipment.

In order to keep sensor data only for a limited period of time and therefore resulting in a smaller database size, an onsite pseudo real time pothole detection algorithm has been developed. Therefore, the GPS, accelerometer and video data are only stored on the local computer for a limited period of time, enough to run the algorithm and extract the useful data. The processed information is stored in the local database until the data is sent to the central server. As the entire wireless network consists of many mobile platforms, these need to be connected to the central server by several access points. The pothole identification algorithm is based on the accelerometer readings. It has the ability to differentiate between a series of events as they are recorded by the on-board accelerometer.

A novel pothole detection system, which assists the driver to avoid potholes on the roads by giving prior warnings, was proposed by Shambu Hedge [6]. The idea is to build a robot vehicle that is capable of detecting the potholes and transferring this information to the nearby vehicles in the vicinity. By sharing the information about potholes with the nearby vehicles, the probability of accidents or collision can be reduced. Here, they propose a pothole detection model, which can detect the potholes with a minimum depth of 1 inch and share the information within 100 m range.

Proposed by	*Technique used*	*Affecting Factors*	*Implementation difficulty*	*Practicability*
Kiran Kumar vupparaboina et al…..[3]	*Laser based*	*Ability of camera to pick reflected laser light*	*Medium*	*Medium*
Byeong-ho Kang al…..[4]	*2D Lidar and Camera based*	*Image taken by camera depends on lighting conditions*	*High*	*Low*
Rajeshwari Madlietal[1]	*Ultra sonic sensor based*	*Obstacles on the road surface which affect the ultrasonic waves*	*Easy*	*High*
Sudarshan S. Rode et al…[2]	*Mobile node and access point based*	*Range of wireless communication*	*High*	*Medium*
Mircea Strutu et al…[5]	*Accelerometer and GPS based*	*Network signals from different access points*	*High*	*Medium*

Here we consider two vehicles namely transmitting vehicle and receiving vehicle. We establish a one way communication between these two vehicles and show how this idea can be extended to achieve multivehicle communication. The transmission system consists of a vehicle with sensor attached to it. Microcontroller receives the sensor output and controls the motors through motor drivers. It also transmits the information to the receiving vehicle. Based on this information, the microcontroller takes decision about the speed of the motors. Each pothole will have varying width and depth. The effect of potholes on the vehicle depends on the ground clearance of the vehicle and vehicle suspension. Ultrasonic sensors are used to detect the depth of potholes. Ultra-sonic sensors work on a principle similar to radar or sonar, which evaluates attributes of a target by interpreting the echoes from radio or sound waves respectively. Zigbee modules which has a range of 100 meters are used for communication. With effective use of Zigbee protocol, communication between multiple vehicles can be achieved.

III. PROBLEM IDENTIFICATION

Usually potholes are a major concern for people while travelling through the roads, if the maintenance is not done periodically then it leads to severe problem. Potholes on the road can be easily located and can be easily repaired. Nowadays detection and repairing of potholes are done manually, and the many labours are required for these process. So the cost for repairing work will be high. During the repairs of potholes, chances of accidents will also present. We cannot ensure full safety during the repairing of potholes. By using these existing methods of pothole detection and repairing, the time consumption will also be high and we require more time to complete the work. The practise of conventional method does not ensure the better quality of roads. The potholes may be formed after two or three weeks due to the improper working of labours during pothole repairing work. The main defect while using of existing methods of pothole repair is that, pothole repair cannot be done during rainy season. These methods are applicable only with good weather. In this Scenario our project is a helping hand to avoid these entire problems.

Millions of dollars are spent in maintaining and repairing potholes by municipali-ties around the world. A pothole refers to a shallow pit on a road's surface, caused by activities like erosion, weather, traffic and some other factors. These anomalies when accumulated in the transportation system, constitutes to major problems. These problems, even though they appear to be less significant at an individual level, constitute to major problems when taken in cumulative, collective and large scale manner.

The problems constituted by these potholes result in low fuel economy, accidents, traffic coagulations etc. which have an adverse impact on the economy of a country and day to day life of citizens. The number of reported accidents is exponentially increasing due to poor road conditions. The roads are deteriorating with more usage and lesser maintenance. It is hazardous to travel by road without any warning sign, especially during night. In order to avoid these accidents, a maintenance system is required which will detect the potholes, manholes, bumps etc. on road surface before it is encountered with so that the driver gets enough response time.

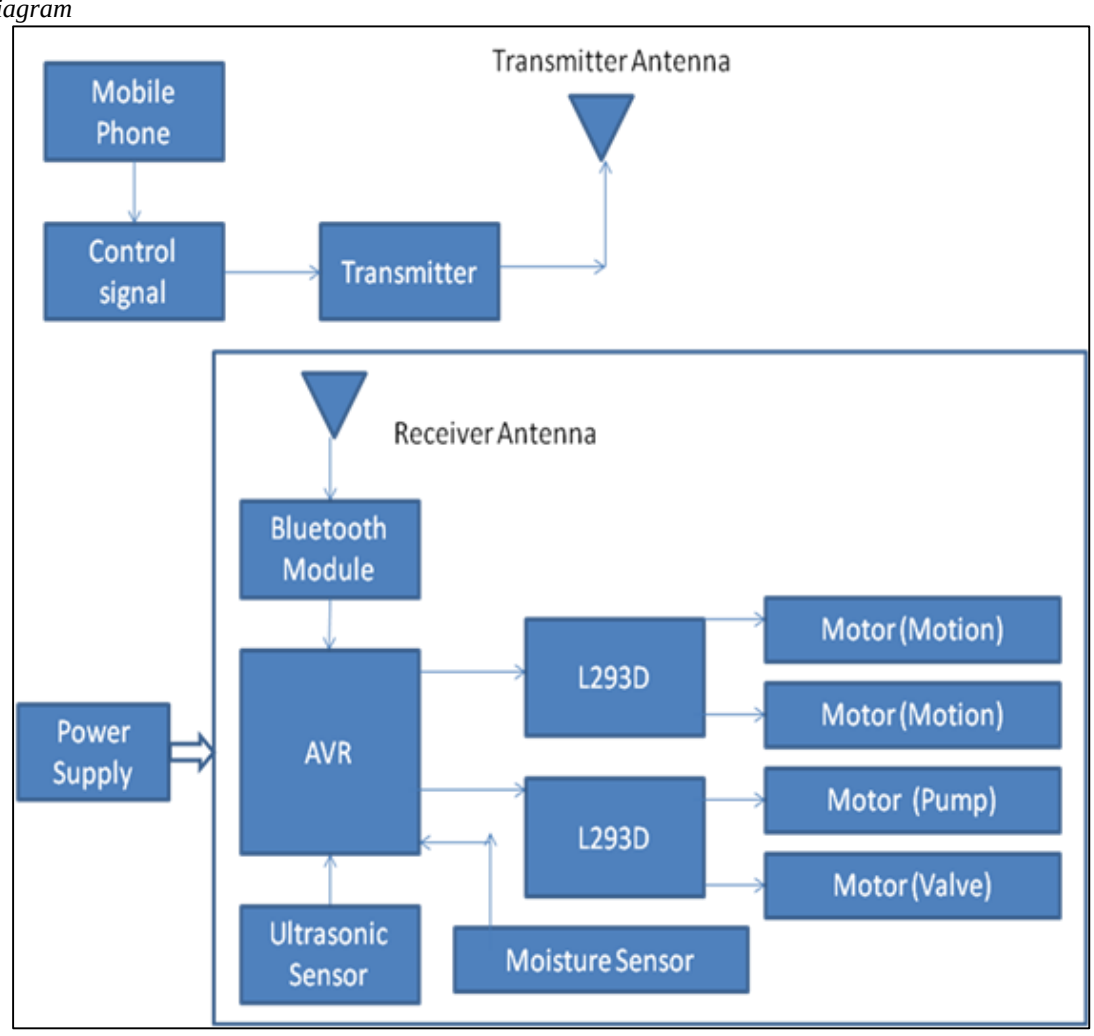
For this a system should be developed which will detect the defects on the road. The prime motivation behind making a pothole detection method is to aid drivers in various aspects and thus assist them in avoiding a possible accident. All these reasons urge the need to get information of such bad road conditions and its remedy. The system detects such potholes and automatically fills them in order to maintain the road condition. Potholes are depressions rather than protrusions. Other obstacles like people, speed breakers will not be taken into account.

IV. PROPOSED PLAN

The proposed plan is to design and construct a prototype of a semi-automated road repair vehicle called the Intelligent Pothole Repair Vehicle. This vehicle is capable of automatically detecting and filling potholes on road surfaces with operator assistance. The vehicle makes use of different sensors for the easy detection of potholes and depth measurement. The overall control is done by a microcontroller to which the sensors and different motors are interfaced. Different mechanisms for clearing and patching the potholes are included on the vehicle. The motion control of vehicle made easier using a Bluetooth module and an android application.

In the proposed model of the vehicle we have decided to use ultrasonic sensors. Ultrasonic sensors can be easily interfaced with microcontroller. These sensors have greater accuracy than other methods for measuring the thickness and depth of parallel surface. The motors used for the motion control of the vehicle will be interfaced to the microcontroller through motor driver circuits. A relay circuit is also present for switching operation of the motor used for pumping out water found in the potholes.

A. Block Diagram



V. COMPONENTS

A. AVR

The Atmel AVR core combines a rich instruction set with 32 general purpose work-ing registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle.

The On-chip ISP Flash allows the program memory to be reprogrammed in-system through an SPI serial interface, by a conventional nonvolatile memory programmer. Atmel ATmega32 is a powerful microcontroller that provides a highly-flexible and cost-effective solution to many embedded control applications.

B. Motor

In the hardware design of the vehicle we use permanent magnet DC motors of 60rpm.
The motor is driven by a motor driver L293D.There are 4 motors in the vehicle. Two 60 rpm motors for the backward, forward, left and right movement of the vehicle and another 60 rpm motor is used for opening and closing of tar tank valve.

C. Motor Driver IC

The L293D is a quadruple high-current half-H drivers. These devices are designed to drive a wide array of inductive loads such as relays, solenoids, DC and bipolar step-ping motors, as well as other high-current and high-voltage loads. All inputs are TTL compatible and tolerant up to 7 V.

Drivers are enabled in pairs, with drivers 1 and 2 enabled by 1,2EN and drivers 3 and 4 enabled by 3,4EN. When an enable input is high, the associated drivers are enabled, and their outputs are active and in phase with their inputs.

D. Relay

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and most have double throw (changeover) switch contacts as shown in the diagram.

E. Motor Pump

A 12V mini submersible water pump is used for pumping out the water from pot-holes and to make pothole dry for effective tarring.

F. Ultrasonic Sensor

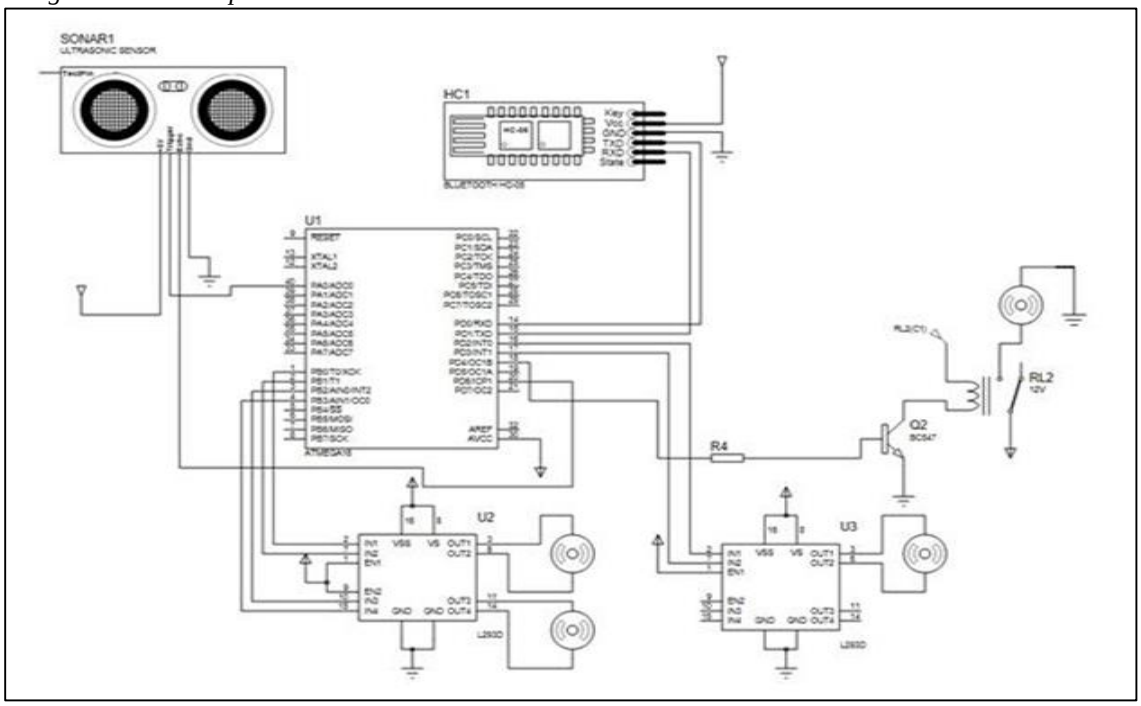
The main part in the system is the microcontroller that controls the other components of the system. When the ultrasonic sensors detect any difference between the threshold value and measured value (above threshold value), it will activate the motor, which controls the opening and closing of tar tank automatically. If sensors detect any potholes within a range of 10cm or above at this point of time tar tank motor will be activated.

G. Bluetooth Module

HC05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, de-signed for transparent wireless serial connection setup. The HC-05 Bluetooth Module can be used in a Master or Slave configuration, making it a great solution for wire-less communication. Here it is used to control the motion of the robotic vehicle.

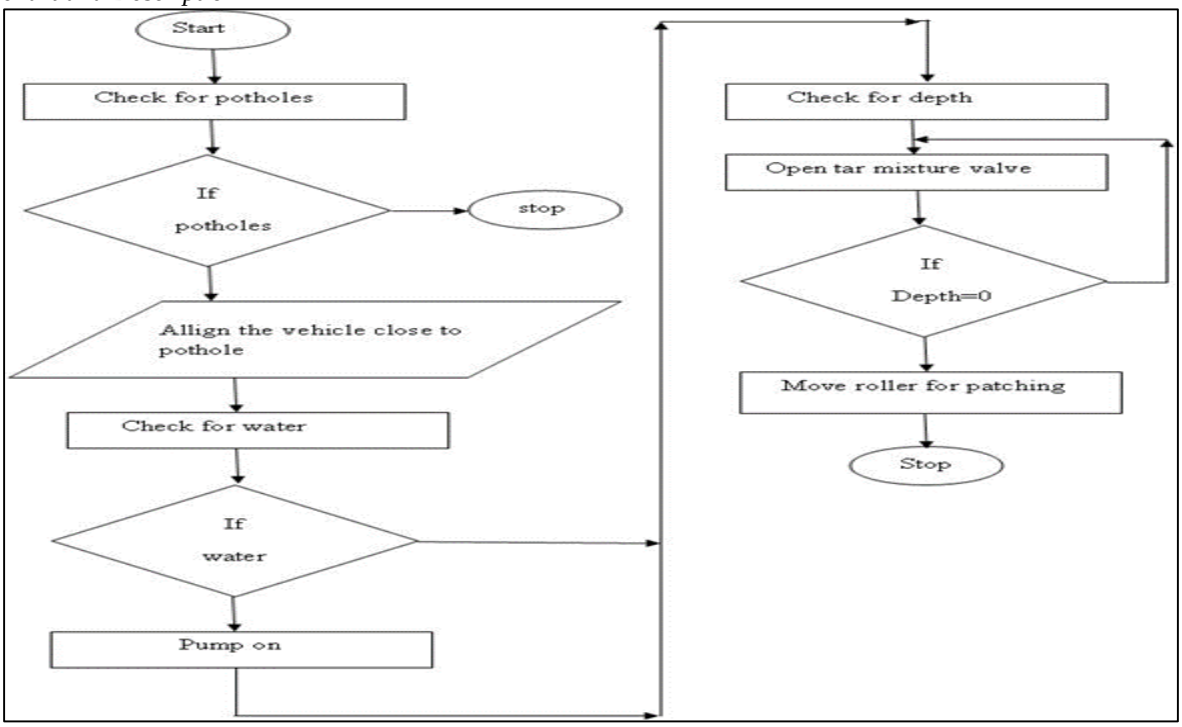
VI. METHODOLOGY

A. Circuit Diagram and Description



DC power supply is given to the circuit of the robotic vehicle. The AVR microcontroller is used to control the motors used for the wheel of the vehicle. The motor driver IC L293D is used. The signals for the movement of the vehicle is sent using an Android device via a Bluetooth module connected to the microcontroller. Ultrasonic sensors are used for the detection of potholes and their depth measurement. In case the potholes contain water, then a water sensing circuit is used to sense water and send signal to the microcontroller. There will be a relay connected to the controller which controls the on/off switching of the motor which is used to pump out the water. Then there is a motor to control the opening and closing of a valve through which the filler material for the pothole is released. Servo motor which can be connected to the microcontroller is used for the valve control.

B. Flowchart and Description



The controlling of vehicle is shown in the flowchart, the input values we obtain from keypad and sensors decide the flow of the process. The keypad values can drive the vehicle to forward, backward, left and right.

Then the ultrasonic sensors will check for potholes in the roads. If any pothole is detected then the robotic vehicle will align close to the pothole .then a water sensing circuit is used to detect the presence of water in the potholes. If there is water present in the pothole then the pump connected to the vehicle will be activated and will suck out the water. The ultrasonic sensor will measure the depth of pothole accurately and the tar mixture valve will be operated. The tar mixture will fill the pothole. The ultrasonic sensor will again check for depth to check whether the pothole is filled with tar mixture. If it is not filled completely then the tar mixture valve will again be operated and this cycle repeats. If the pothole is completely filled. Then the roller will be activated and it will patch the pothole and make it smooth.

VII. CONCLUSION AND FUTURE SCOPE

The proposed project deals with a road tarring robot which is a small vehicle by which we can solve the issue of potholes in roads. This vehicle can move through roads and fix the potholes on roads by filling it with tar mixture and also patch the road.

The Project will definitely prove to be really useful for illiterate workers who does the road tarring operations without taking any precautions to avoid diseases which may cause serious health issues. This work has many advantages which are as follows:

- This robot is can monitor the condition of roads and work accordingly.
- It reduces the number of labourers and also reduces the work load.
- The chance of accidents happened due to potholes will be reduced substantially.

In the long run the maintenance cost and running cost is very less when compared to the present systems.

The future scope of the proposed system is that it will be better if the vehicle moves automatically through the roads and detect the potholes and clear the potholes. Implementation of collision avoidance, artificial intelligence algorithm for fully automated system design. Since the robot is constantly moving through roads for detecting potholes solar panels can be placed on the roof for electricity generation Technologies like GSM can be combined with GPS module in vehicle can used for location identification of pothole. If a GSM module is included in the robotic vehicle then any external party can message the vehicle that there is a pothole at the desired location. If the GPS location of the pothole is known the robotic vehicle can move to the location and clear the fault. This robotic vehicle can be used by public road development authorities and manage the potholes by giving the robotic vehicle a unique zone for its working. By implementing this roads free of potholes can be made and the number of accidents can be reduced substantially.

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