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LRMSE: A Framework on Lunar Rover for Moon Surface Exploration

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Abstract:- An economical robot which utilises the Rocker-Bogie linkage, which is also used by NASA's Curiosity; to facilitate all terrain movement. The rover has 6 wheels with independent motors mounted to the linkage. The electronic components are mounted on a main chassis. The robot also consists of an ultrasonic sensor for obstacle detection and an android phone for live camera feed and accelerometer values transmitted via a Bluetooth module. While this is intended to model a space rover, it has terrestrial applications too. These include mapping and surveying unknown locations as well as locating survivors in wreckage and live feed.

Keywords – Lunar rover, Hardware Components, Object detection Module.

I. INTRODUCTION

A planetary rover is a space exploration vehicle designed to move across the surface of a celestial body. The advantage of a rover over an orbiting spacecraft is its ability to make microscopic observations and conduct physical experimentation. A rover is required to be reliable, compact and autonomous as far as navigation and data acquisition are concerned. NASA's current design uses a two wheeled rocker arm on a passive pivot attached to a main bogie on the opposite side (Bickler, 2004). Miller et al (2002) discussed the need for rovers with higher traversal speeds for future planetary missions.

They described a method of driving a rocker bogie linkage which can effectively step over most obstacles instead of impacting them, preventing high dynamic shocks. Barlas (2004) discussed the different types of suspension systems of wheeled locomotion which are required to be simple, lightweight, and have spring-less connections to maintain equal traction and be able to distribute load equally to each wheel and prevent slipping. Tarokh et al. (1999) have described a rigorous method for the kinematic modelling of the Rocky 7 Moon Rover in terms of measured wheel velocities and certain rocker joint angles. Stone (1996) described the design of NASA's Moon Pathfinder and its various subsystems. Patel et al. (2010) have provided the locomotion subsystem analysis of the Exomoon rover developed by ESA – a 3 bogie concept with flexible metallic wheels, body pose adjustment capability and 6-wheel steering. The paper focused on the suspension mechanism performance and wheel performance. Kim et al. (2011) presented an optimal design of a wheel type mobile robot with high stability and excellent adaptability while climbing stairs using the Taguchi model for optimization. Harrington et al. (2004) discussed the design of a lightweight, compact mechanism for the Moon Exploration Rover. It also highlighted the various latch and deployment mechanisms employed.

II. ROVER MODULE

Hardware Components

Arduino

Arduino is an open source platform used for building electronics projects based on easy to use hardware and software. Arduino boards are able to read the inputs such as light on sensor, a finger on a button, or a twitter message which turn it into an output such as activating a motor, turning on an LED and publishing something online. The UNO is one of the more popular board in Arduino family.

The Arduino platform as become a quite popular with people just starting out with electronics because the Arduino IDE uses a simplified version of c++, making it easier to the people who just started out with the electronics. Unlike most previous

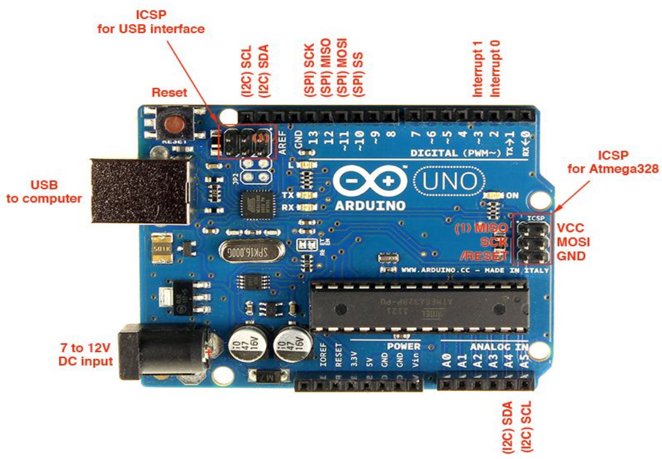

Fig-1: Arduino Board

programmable circuit boards, the Arduino does not need a separate piece of hardware (called a programmer) in order to load new code onto the board you can simply use the USB cable. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board.

L293D Motor Driver:

L293D is a typical Motor driver or Motor Driver IC which allows DC motor to drive on either direction. 12 volts DC Motor is a frequency of rotation 100 rpm (Revolution Per Minute) that is the number of rotations around a fixed axis in one minute. L293D is a 16-pin IC which can control a set of two DC Motors.

Motor1 consists of set of two wheels MA1 and MA2 to the right of the robot module. Motor2 consists of another set of wheels such as MB1 and MB2 to left of the robot module. If the rover wants to move to right then it stops the Motor1 and Motor2 start working and so on…and it is shown in table.

Ultrasonic Sensor:

The HC-SR04 Ultrasonic sensor module used to measure distance from 2cm to 400cm with an accuracy depends on the environmental temperature. The module includes ultrasonic transmitter, receiver and a control circuit. The transmitter at the

Direction	MOTOR A		MOTOR B	
	MA1(+)	MA2(-)	MB1(+)	MB2(-)
Forward	1	0	1	0
Backward	0	1	0	1
Left	0	0	1	0
Right	1	0	0	0
stop	0	0	0	0

module transmits an ultrasonic sound of 40KHZ.this sound will reflect back if the object is present in front of it. The reflected sound is received by the receiver present in the module. The distance can be calculated by measuring the time and speed of sound.

The module as 4-pins such as vcc, trigger, echo and ground

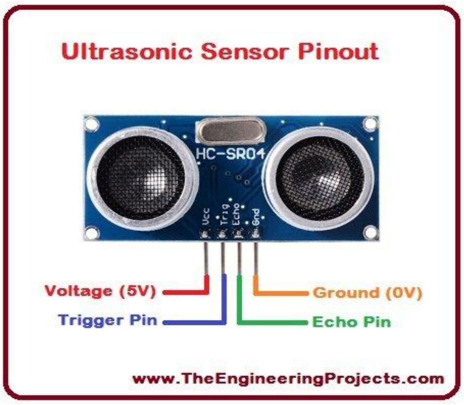

Fig-2: Ultrasonic Sensor

DHT11 Sensor [temperature and Humidity]

DHT11 sensor temperature range from 0-50ºc/± 2ºc.The operating voltage is between 3volts to 5volts. Maximum current required during measuring the temperature and humidity using DHT11 sensor it requires 2.5mA current. DHT11 sensor is integrated with a high-performance 8-bit microcontroller. Sampling rate is 1HZ that is one reading every second and the overall size of the body is 15.5mm x 12mm x 5.5mm.

Soil Moisture:

Soil moisture sensor measures the volumetric water content in soil. Since the direct gravimetric measurement of free-soil moisture requires removing, drying and weighting of a sample,

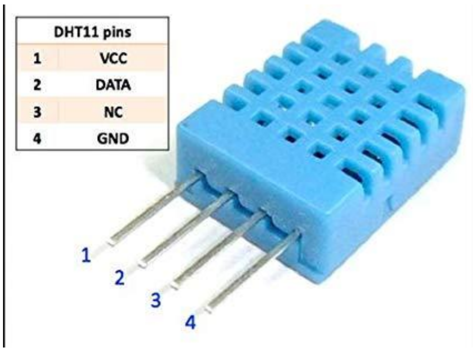

Fig-3: DHT11 Sensor

soil moisture sensors measure the volumetric water content indirectly by using some other property of soil such as electrical resistance, dielectric constant, or interaction with neutrons, as a proxy for the moisture content.

Technologies Commonly used to indirectly measure volumetric water content (include soil moisture) are: Frequency Domain Reflectometry (FDR), Time Domain Transmission (TDT) and Time Domain Reflectometry (TDR)

Fig-4: Soil Moisture Sensor

LCD:

LCD is an interface with the Arduino interface liquid crystal display (LCD) with an arduino to provide user interface. LCD is commonly used to display the data in devices such as reading of the temperature, humidity etc.…

WORKING:

Arduino is an open source platform that comes with its own IDE and is significantly simpler to code than many other microcontrollers, as it already has a vast set of libraries available. Hence an Arduino Uno board was preferred over an MSP 430 or other similar microcontrollers. The motors were

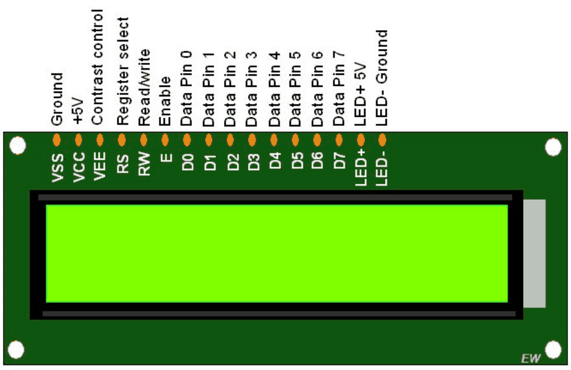

Fig-5: Liquid Crystal Display

controlled using motor driver ICs. The motor driver works on the principle of a dual H-bridge. If the inputs to the motor driver are LOW and HIGH, the shaft rotates in a direction such that the rover moves forward, and vice versa. If both the inputs are LOW (or HIGH) the motor stops, since there is no current flowing through the motor. To turn the rover to the right, the wheels on the right side are made to rotate in the reverse direction and the ones on the left are moved forward. In the opposite manner, the rover is turned left. So, the rover turns about its geometric centre. Due to limited availability of pins on an Arduino Uno board, the controls for the motors on each side were common. The motor controls were lumped so as to reduce the code size and adhere to the code limit of an Uno, which is 16KB. Autonomous control was the default control state of the rover and can be manually controlled by an override via the app. An Ultrasonic sensor HC-SR04 was used to detect obstacles. The sensor has four pins – trig, echo, Vcc and GND. Trig emits ultrasonic pulses for 10 microseconds when the pin is set to HIGH. The echo pin is set to HIGH when it receives a pulse. The duration between two successive instances of echo becoming HIGH is measured; and the distance of the obstacle calculated. The rover moves forward by default. When it detects an obstacle in front, it again triggers the left and right sensors, measures the distances of the obstacles to its left and right, and finally moves in the direction in which it has more space.[1][2]

III.OBJECT DETECTION MODULE

Raspberry Pi is B model and Linux-based microcontroller. It acts as minicomputer that connects all peripherals used by computer like keyboard, TV or monitor, mouse, SD card slot for loading operating, Ethernet port for LAN cable connection, 4 USB ports for connecting I/O devices, HDMI port for connecting monitor or HD TVs, memory, power source, memory, video/audio outputs and camera interface(CSI)

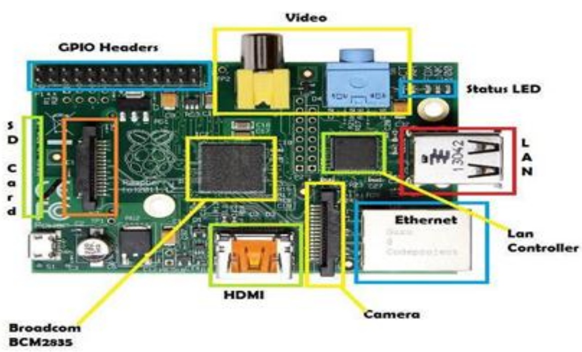

Fig-6: RaspberryPi

The RaspberryPi operating system can also be access by remote login through PC screen, with LAN cable. RaspberryPi 2 Model B boards has 40 I/O pins with 2.54mm which is marked as P1 and arranged in 2x20 strips includes UART, I2C, SPI, +3.3V, +5V and GND supply. It uses 900MHz quad-core Broadcom BCM2835 which is of ARM cortex A7 family. It has 1GB of built in RAM. Linux based operating system is loaded into SD card which includes several steps to load operating system into micro SD card and then plug into SD card slot. Ubuntu or any linux-based operating system can be used, Rasp bian-Jessie is the operating system used in this system which can be directly downloaded from the official RaspberryPi website.[5]

GPIO pin in RaspberryPi 2 advanced Model B board is shown in Fig.8. The first 26 pin are same as RaspberryPi 1 A/B boards. Additional 14 pins provide ground and GPIO pins.

GPIO pins provide different alternate functions like SPI, I2C, PWM and so. All GPIO p ins are reconfigurable. There are two I2C b uses on P1 and P5 respectively and one SPI bus.[6]

The raspberry pi-based obstacle avoiding robot consist of three main modules i.e. camera module, raspberry pi, motor drivers. The camera module gets the input image which are obtained are real time operation. The raspberry pi is a platform consisting of all necessary hardware module assembled on it. It receives the images from camera module. It carries out image processing and checks whether there are any obstacles in path of the robot and if any obstacle occurs then it will send the signal further to motor driver accordingly. The motor driver actually consists of two sub motors i.e. right and left motor. These motors receive the signal from raspberry pi in case of any appearance of the obstacle in its path the motors work accordingly to signal and moves in left or right direction with the help of left and right motor to avoid the obstacles.[4]

IV.STRUCTURE CHART

In the LRMSE, Arduino board is used along with the sensors such as DHT11, two L293D Motor Driver Module where one L293D motor driver is connected to the front wheels such as motor1 and motor2 than the another L293D motor driver module is connected to rear wheels such as motor3 and motor4.

The raspberry pi module is used for image processing where the camera captures the image and that image is given as the input where the processing of the image takes place through the raspberry pi module and shape and colour of the obstacle is given as the output. The Temperature, Humidity results where calibrated.

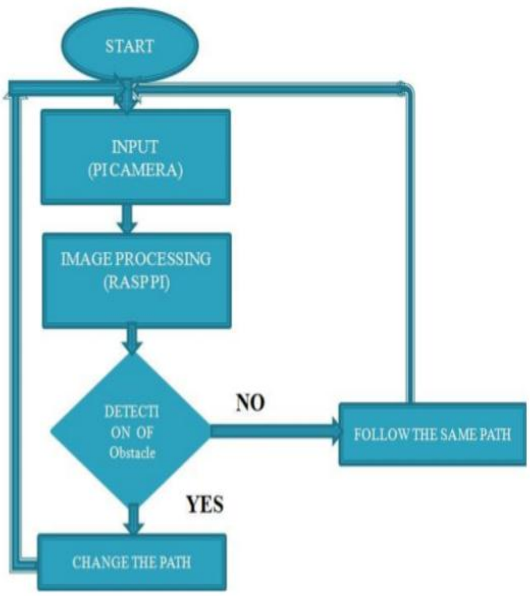

Fig-7: Flow Chart of Raspberry Pi obstacle avoiding robot

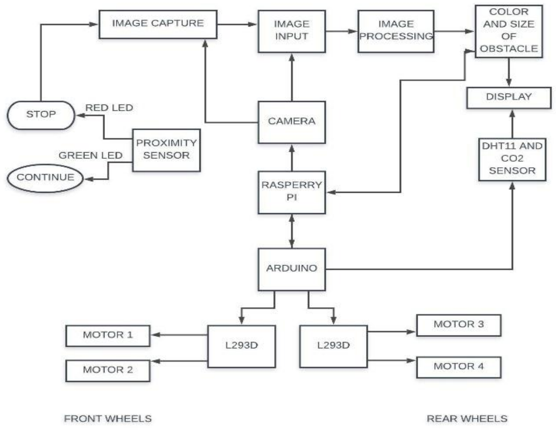

Fig-6: Structure Chart

V. FLOWCHART

In the LRMSE, Read the sensors attached to the Arduino board and raspberry pi module where it is given as the input along the captured image of the obstacle and displays the temperature, humidity and carbon dioxide. Then the ultrasonic sensors are used measure the distance by using ultrasonic waves. The sensor head emits an ultrasonic wave and receives the wave reflected back from the target. Ultrasonic sensor measures the distance to the target by measuring the time between the emission and reception.

If the obstacle found at left it rest over there and capture the image where the series of command is given to the raspberry pi to process the captured image in order to produce the shape and colour of the obstacle. Finally, it displays the colour and shape of the object and move towards the right

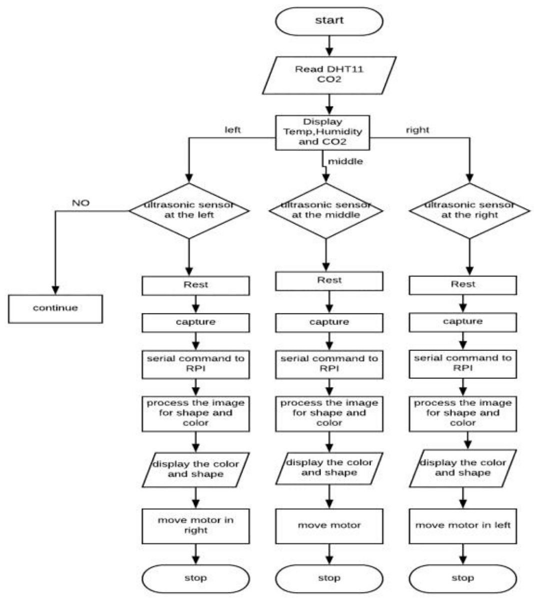

Fig-6: Flow Chart

If the obstacle found at middle it rests over there and capture the image where the series of command is given to the raspberry pi to process the captured image in order to produce the shape and colour of the obstacle. Finally, it displays the colour and shape of the object and move towards its original position.

If the obstacle found at right it rests over there and capture the image where the series of command is given to the raspberry pi to process the captured image in order to produce the shape and colour of the obstacle. Finally, it displays the colour and shape of the object and move towards the left.

CONCLUSION

The robot will be able to move as per the command given after detecting the obstacle through the camera module. When the video frame containing the obstacle is detected using the image processing algorithm the pi will command the motor as per the directions i.e. left or right and it will change its path accordingly.

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