

Autonomous Robot for Environmental Monitoring & Surveillance

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Abstract- *Monitoring, collecting data and analyzing dynamic environmental changes plays a key role in a manufacturing or any industry. The main objective of this paper is to design fabricate and implement an autonomous robot, which would travel autonomously in a pre-planned environment, measure and analyze parameters like temperature, humidity, carbon-di-oxide, nitrogen, dust, noise and radio frequency levels. The measured values are then uploaded to a cloud, perhaps if the measured values are more than a threshold, it will show an alert (or send a notification to the admin). The robot's movement is controlled using gyroscope and distance sensors. The robot also has a manual control mode which is enabled with high technology cameras for surveillance. The robot is controlled through a Raspberry Pi and the inbuilt Wi-Fi module helps to upload the measured data to the cloud. The Raspberry Pi controls the motor driver circuit, which in-turn drives the motor. Raspberry Pi is enabled with image processing which helps the robot to identify its home. The entire setup is run with the help of 12v 2200 mAH lithium polymer battery.*

Keywords: *Raspberry Pi, Arduino Uno, MPU6050, LM393 Speed Sensor, L293D Motor Driver, Noise, Dust, Carbon, Nitrogen, Autonomous.*

need for manual monitoring and will also reduce the risk of manual errors. Sensing and analyzing the precise data from the sensors can also save industries from destructive circumstances. Robots can do repetitive tasks without fatigue that is usually associated with humans and can lead to improved efficiency (rate of production) and effectiveness (quality of output) in operations resulting in higher productivity for industries.

Gyroscope and speed sensor helps the self-driving robots to travel around a pre-planned environment where the path is preprogrammed. The MPU6050, 3-axis accelerometer-gyroscope module, guides the yaw values that determine the angle of rotation of the robot, while the speed sensor which is an optical rotary encoder calculates instantaneous velocity from which the distance travelled can be estimated. The information about the path is processed by the Raspberry Pi 3-B, the CPU of the robot, which runs on a Linux based operating system called Raspbian Jessie. It hosts a flask web server which broadcasts a live feed from the camera and will also help the user to drive the robot manually. The Raspberry Pi is also enabled with advanced image processing program which is used to identify the robot's home and the robot will automatically start charging once it has reached its home.

The objective of this paper is to measure, analyze and upload the industrial parameters to the cloud^[1]. A detailed analysis is done and if the values exceed the threshold, a warning is sent to the Administrator for immediate recovery. In essence, this robot can save industries from employing huge manpower and prevent human errors caused by manual monitoring, the collected information is a value-added asset to the industry, the global trend towards IoT and analysis is the first success step for this paper.

I. INTRODUCTION

An autonomous robot has the potential of executing tasks with high level of precision which is exceedingly desired by industries to monitor vital data of their operating environment without any human intervention. Typically, industries require human resources to monitor their industrial parameters. An autonomous robot can eliminate the

II. EXISTING SYSTEM

The major existing systems present around are mapping robot and manual control robot using Zigbee. The mapping robot initially maps the environment it has to travel and then the user specifies the path, it has to move. The major disadvantage in this system is that the dynamic obstacles also get mapped, leading to a differential confusion in the path. This ambiguity in path could be resolved through our proposed system which is capable of travelling without any pre-mapped location. The manually controlled Zigbee robot defies the entire concept human less intervention thus proving to be pointless from our point of view.

III. PROPOSED SYSTEM

In our proposed robot's running is guided by speed sensor and gyroscope. The developer initially codes the robot based on the distance and the turning angles with reference to the well known environment. The robot is programmed in such a way that it would start its travel at corresponding time intervals; say once in every two hours^[2]. The robot will then start its sensing journey around the factory and return back to its home for automatic recharging. This robot uses Raspberry Pi 3-B as the major processor and the sensors are controlled using Arduino boards, which communicates serially to the Raspberry Pi. The entire code for the robot is done using python programming language. A Raspberry Pi camera module is enabled to the pi for image processing; furthermore an advanced technology USB web camera is enabled for surveillance and live streaming.



Figure 1: Proposed System

IV. BLOCK DIAGRAM

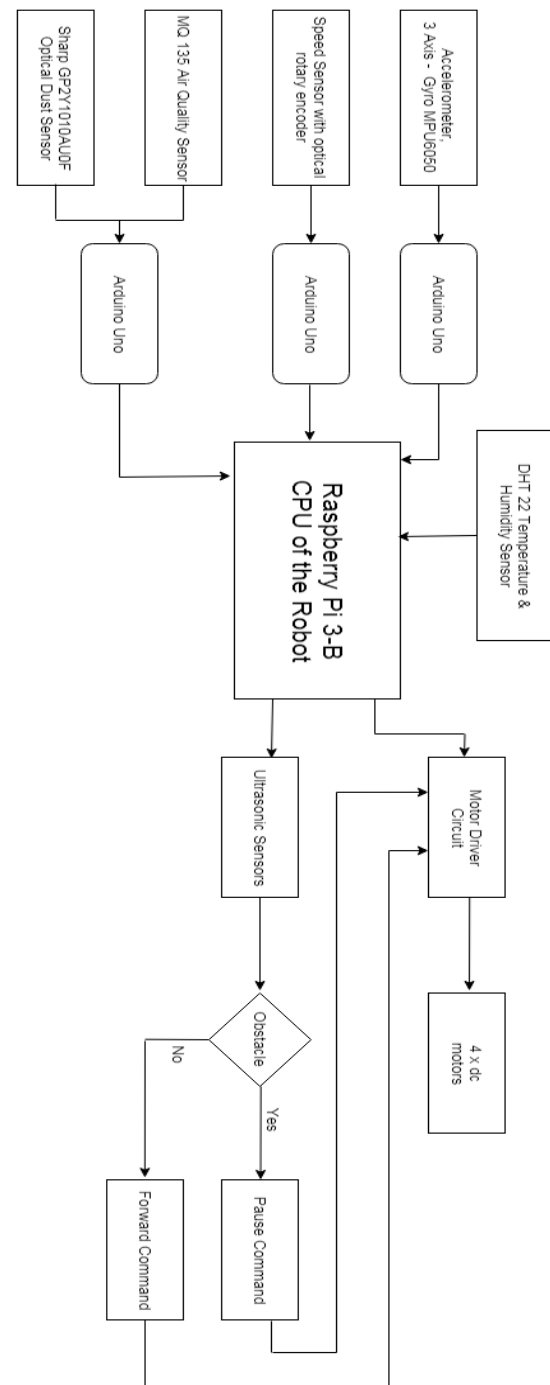


Figure 2: Block Diagram

V. HARDWARE COMPONENTS AND IMPLEMENTATION

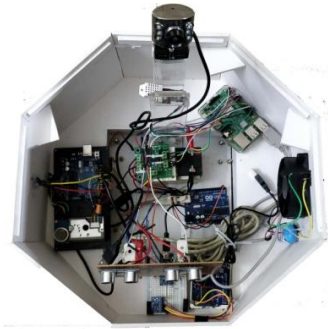


Figure 3: Entire Hardware Components

A. Raspberry Pi 3-B as CPU of the Robot

Raspberry Pi 3-B is used as the CPU of the robot. Raspberry Pi is a mini on-board computer that uses Broadcom BCM2835 system on chip (SoC), it is enhanced with a quad-core ARM Cortex-A53 processor and 1 Giga Byte of RAM.^[1] Raspberry Pi is capable processing high level programming language like python and JSON parsing. Raspberry Pi 3-B has 40 input-output pins where the digital pins are connected to the motor driver circuit. The motors used are 12V, 100 RPM, DC motors. The positive and negative pins of the motor are connected to the L293D motor driver, and the driver circuit is powered through a 12V battery, hence the forward and reverse commands of the motor are governed through the high and low commands from Raspberry Pi. The forward command is governed by the ultrasonic sensor for obstacle detection; this ensures that the robot would run safely without any collisions^[3].



Figure 4: Raspberry Pi 3-B

B. Gyroscope

MPU 6050- 3 axis accelerometer and gyro is used in the robot for precise turning angles. The gyroscope is connected to the Arduino Uno board in such a way that the SCL, clock pin of the gyro is connected to the SCL, clock pin of the Arduino and the SDA, digital pin of the gyro to the digital pin of the Arduino^[4]. MPU 6050 3-axis gyroscope is powered to 5V through the 5V regulator of the Arduino. The Arduino is programmed to read the yaw values and sends it to Raspberry Pi serially. The Raspberry Pi then reads the yaw values and directs the left and right motors accordingly to make a precise turn^[5].

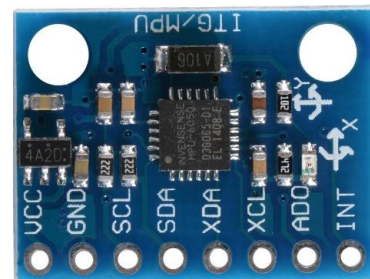


Figure 5: Gyroscope

C. Speed Sensor

The speed sensor is attached to another Arduino, where the 5V pin connected to the regulated 5V supply of Arduino, sensor's ground pin to Arduino's ground and the digital pin of the sensor to the digital pin 2 of Ardionouno. The speed sensor used in the robot is an optical encoder with 20 notches. Every time a notch is detected a high pulse is sensed. If 20 high pulses are detected then the distance travelled by the wheel is equal to the circumference of the wheel ($2 \times \pi \times \text{radius}$). The wheel used in the robot has a diameter of 7cm, thus the circumference of the wheel is 22cm and hence for one full rotation of the wheel, the distance covered by the robot is 22cm^[6]. Thus, the robot could be programmed to the distance it has to travel and this distance is accurate with at most 1cm precision.

$$\text{Circumference of a circle (C)} = 2\pi r = 22 \text{ cm}$$

$$1 \text{ rotation} = 20 \text{ pulses} = 22 \text{ cm}$$

$\therefore 1 \text{ pulse} = 0.909 \text{ cm}$ Hence, the accuracy is **1cm**

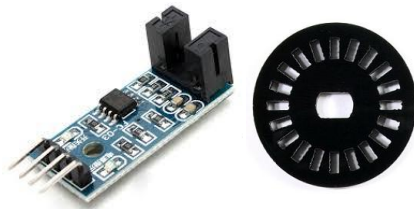


Figure 6: Speed Sensor

D. Raspberry Pi Camera Module

The camera module used in this paper is Raspberry Pi Camera Module V2 with 8 Megapixel as still resolution and Sony IMX219 sensor.^[7] The camera module is attached to the Raspberry Pi's CSI port with the help of CSI connector. The image taken by the camera module is sent to the Raspberry Pi where the image processing is done with the help of software named "OPEN CV". This software is programmed using Python programming language and it detects green signals, which indicate proceed signal and red signal, which indicates stop signal. This method is useful for the robot to find its way back home and charge itself automatically. This camera module could also be used Machine learning algorithms, which is considered as the future work for this paper.

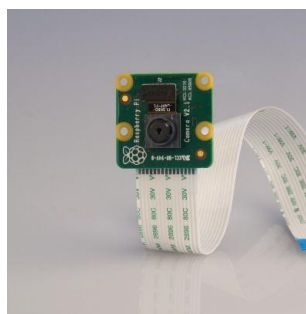


Figure 7: Raspberry Pi camera module

E. USB Webcam for Surveillance

An USB web-camera is attached to the robot in the USB hub of the Raspberry Pi. The Raspberry Pi acts as the host for the Flask webserver, this webserver can also access the motors attached to the Raspberry Pi through the motor driver circuit, thus the robot can be entirely controlled

through this webserver^[8]. The Flask Web-server is in the local IP of the Raspberry Pi, hence the robot could be accessible to the devices connected to the same network. At emergency situations this robot could also be driven to unplanned environments for monitoring the adverse conditions.

F. Sensing Parameters

The various dynamic attributes the robot will sense are^[9].

i. Temperature and Humidity

DHT 22 is used as the temperature and humidity sensor. The 3.3V pin of the sensor is connected to the 3.3V of the Raspberry Pi, the digital pin of the sensor to the digital input pin of the pi and the ground pins are shared together.^[10] This DHT-22 sensor constantly measures the temperature in degree Celsius and the percent humidity. This value of temperature and humidity is then uploaded to the cloud to be displayed in the user interface (UI) and be used for analytical purposes^[11].



Figure 8: DHT 22 Sensor

ii. MQ135 Air Quality Sensor

The intoxication of carbon-di-oxide and nitrogen levels in the air could be sensed with the help of MQ135 air quality sensor^[12]. The sensor is hooked up with an Arduino Uno board and the sensor values measured are sent to the Raspberry Pi serially via an USB cable. The Raspberry Pi reads the values and uploads it to the cloud for the user-interface and data analytics.



Figure 9: MQ135 Air Quality Sensor

iii. Sharp GP2Y1010AU0F Optical Dust Sensor

This dust sensor is also connected to the same Arduino Uno board where MQ135 gas sensor is connected to. The dust sensor consists of an infrared emitting diode which is diagonally arranged to a phototransistor. This setup of IR LED and photo-transistor detects the light, reflected by the dust particles. The V-LED of the sensor is connected to the 5V pin of the Arduino Uno with a 150ohm resistor in between, the LED pin is connected to the digital pin 12 of Arduino Uno, V0 to analog pin 5, Vcc to 5V pin and the ground pins were grounded commonly^[13]. The Arduino was coded efficiently to obtain the precise values and a 16V 220uF capacitor was attached to the input pin of the Arduino Uno to ensure accurate values despite voltage spikes.

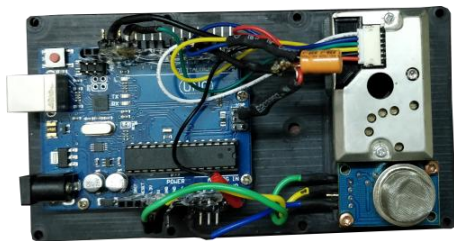


Figure 10: Optical Dust Sensor

VI.

EXECUTION AND RESULT

All the programs were combined, and the resultant program was scripted to the boot of the Raspberry Pi. Now this program starts its execution every time the Raspberry Pi boots up. More care was taken for the robot to follow a straight path and the robot will realign itself in case of any deviation. The chassis of the robot was designed carefully and made sure that the wheels were aligned properly. The entire setup was covered with a case made of foam board and cooling fan was attached to ventilate the Raspberry Pi. The sensors and camera were projected to the upper part of the casing to measure realistic environmental parameters. The robot underwent a series of durability tests and it was provided with a voice. This is produced from the speaker connected to the AUX port of the Raspberry Pi, this would ensure the

movement of the robot is noticeable to the humans, so that they don't step over it.



Figure 11: Execution part

Figure 12. Manual control Mode and Surveillance

The sensor data was uploaded to a Cloud Software named "THINGSPEAK" and the sensor values were plotted in a map and displayed in a gauge for easier analysis^[14]. This was also accompanied by a CSV file from the cloud, which could be further utilized for Machine Learning and analytical purpose.^[15]

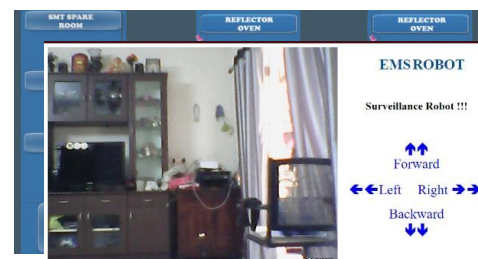


Figure 13: UI Design

Google gauge and graph were deployed to display the measure sensor values. Gauge shows the instantaneous value, while the graph shows the history of measured values^[16].

acknowledged to be useful for the manufacturing industry

VII. CONCLUSION

This paper has its best application in production and non-production factories, the fully automated algorithms help the robot to travel without any human intervention. The robot could be deployed even under severe conditions where human monitoring is not possible. This robot is more advantageous than static models available in the market, this is mainly due to the lack of internet facilities in large factory environment. This robot with a built-in memory of 32GB can store the sensed information and upload it to the cloud when an internet of decent connectivity strength is discovered. The robot is automated with a voice command and can also guide the visitors to the factory in a sophisticated way. Thus, the advancements in Internet Of Things, Analytics and Artificial intelligence enhances the user experience and encourages more factories towards the goal of complete automation. Robots like ours could be considered as a best example for automated environmental sensing and analyzed information from the sensed data could be a great asset to the factory for further development.



Figure 14. Value Update and Analysis

The robot was rigorously tested in a private factory and the measure value were updated to the admin. These values were appreciated and was

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