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An Autonomous Surveillance Robot with IoT based Rescue System Enhancement

Hasan Mahmud[1], Jamal Uddin Ahamed[2] and Mohammed Nazrul Islam Khan[3]
[1]M.S. Engg., Department of Electrical and Electronic Engineering, University of Chittagong, Bangladesh.
[2]Professor, Department of Electrical and Electronic Engineering, University of Chittagong, Bangladesh.
[3]Principal Scientific Officer, Atomic Energy Centre, Dhaka, Bangladesh.

(Corresponding author: Hasan Mahmud)
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ABSTRACT: Nowadays, an Autonomous surveillance system is designed to take notice earmarked operation or places for the purpose of governing, controlling, or protecting. The users can monitor and identify if any unusual happens and after that, the essential steps can be taken by using an autonomous surveillance system. The aim of this system is to design and construct an autonomous surveillance robot with IoT Based rescue system enhancement which is capable of moving freely around an unknown place with updating the surrounding condition and the live video feed of that place. It can replace human high-risk investigation jobs and used as a rescue system enhancement robot under risky areas such as radioactive zone or destroyed structures due to unexpected tragedy. It can provide information on the surrounding condition of a place through IoT platform, clear video feed using a team viewer software, move in the dark area using torchlight app in a mobile phone which is attached to this autonomous bot so that the users can detect a living human body easily from the collapse building. The entire platform is monitored by the wireless system to eliminate wire entanglements. The proposed system consists of two main divisions; the first part is the autonomous bot, the robotic car is able to travel around and avoid barriers by the feedback from sensors. The second part communicates with the server (webserver) which represents different sensors value (bomb sensor, Gas/Smoke sensors, LDR, Temperature sensor, ultrasonic sensor) for monitoring various hazardous conditions in a dynamic way.

Keywords: Arduino; Autonomous; Rescue system; ESP8266 12e; IoT; Thinkspeak.

I. INTRODUCTION

Scientists and engineers have created many diverse robots to make human daily tasks easier, faster, and more accurate. These include robots that continue to make unparalleled contributions in manufacturing, transportation, exploration and treatment sectors [1]. The use of robots in various developmental fields is increasing day by day in the world.

With the rapid advancement of technology and the availability of smart devices to the public, artificial intelligence (AI) is becoming the most interesting and most researched field. Efficient methods and smart devices are rising in daily products, with a lot of functionalities [2].

Encounter-supplied robots perform uninterrupted tasks that are very risky for humans. It can help humans investigate and collect environmental information for places that are too risky or too difficult to identify [3]. Wireless air quality sensors are widely used to measure airborne particles in the environment, and have become increasingly important in various remote health monitoring applications [4].

The surveillance system is the monitoring of behavior, activities, or other changing information, usually of people which is used by governments or security agencies for intelligence gathering, prevention of crime, and the protection of a process. One of its best uses is in rescue work after an unexpected tragedy like BEIRUT tragedy in Lebanon.

This type of project proposes an autonomous surveillance system that would solve the human problems in performing inspection under risky or collapsed buildings [3]. These autonomous robots are able to do jobs by themselves unlike others where someone must always help to complete jobs [5]. Typically; Rescuer has to face many challenges during inspection work to enter the radioactive zones, narrow space and the damaged house where most of the structures have collapsed. There are many problems faced during inspection jobs such as narrow space which humans are not capable to enter, the damaged house in which most of the structures are collapsed, and radioactive areas. It became a hard and risky task for the investigator to enter without knowing background information of the area for inspection. So, an inspector faces a very dangerous situation while performing rescue work.

Mobility is a very important term in the modern mechanism of robotics. The surveillance robots are autonomous in nature without any human interference that can move it without having any collision with any object around its environment [6].

An autonomous surveillance robot is designed to replace humans in dangerous works. Besides, it is very useful in inspecting the collapsed structure whether is fully or partially damaged instead of entering by a rescuer. The affected building's structure might not be stable and might be damaged anytime. Performing and

testing inspection jobs under those hazardous areas is not safe for inspectors. Moreover, inspectors might face difficulties and insecure situations without knowing enough background information about the unknown area. Those problems might cause inaccurate or inappropriate data gathered by inspectors and also incorrectness of results [3].

Kelvin Ashton invented at first the concept; “Internet of Things” (IoT) back in 1999. The aim of this concept was to connect everything with everyone anytime everywhere. It is widely used in various sectors to connect the virtual and physical world [7]. The concept of IoT is used in Radio-Frequency Identification (RFID) tag, sensor, reader, and actuator. The number of connected devices grew quickly and the total number of devices overcame the world population in 2011. Statista (2018) enumerated that the total numbers of interconnected devices will grow continuously to 30 billion in 2020 and reach 75 billion in 2025 [7].

This autonomous Surveillance robot with IoT based rescue system enhancement has two different parts that carry out their own task simultaneously. The main goal of this system is to combine these two different systems into one advanced, user-friendly and more intelligent surveillance system that performs many times better than all existing systems. To meet the goal, an IoT-based monitoring system is combined with an autonomous surveillance robot that can be used, monitored wirelessly by users remotely via a computer.

Problem Statements: Some existing systems have been developed to facilitate surveillance activities statically or dynamically. Others can detect dangerous gas/smoke by sensors. Some systems provide wireless audio/video communication from remote places. However, the existing systems are not able sufficiently and completely to provide all features. There are a number of challenges to be developed such as

1 A surveillance tool in both high and low visibility condition with multiple sensors
2 Monitoring in various hazardous conditions
3 Providing video feedback via a web interface.

Aims and Objectives:

- To design and develop an autonomous robot that can replace humans in risky and hazardous jobs.
- To design a simple robot in small size, lightweight which can be easily controlled and monitored it’s surrounding by the users.
- To improve a user friendly interface.
- To design a rescue system enhancement which able to enter through unsmooth terrain and narrow spaces.
- To develop an Autonomous surveillance robot that can move around and avoid obstruction automatically without any human interfere, select a better pathway and send the various data values of the surrounding condition though IoT platform.

II. SYSTEM DESIGN

The system consists of two major sections - one is the autonomous section and the other is the communication section. An Arduino microcontroller At Mega328 is used to control the motors according to the given code in this robot.

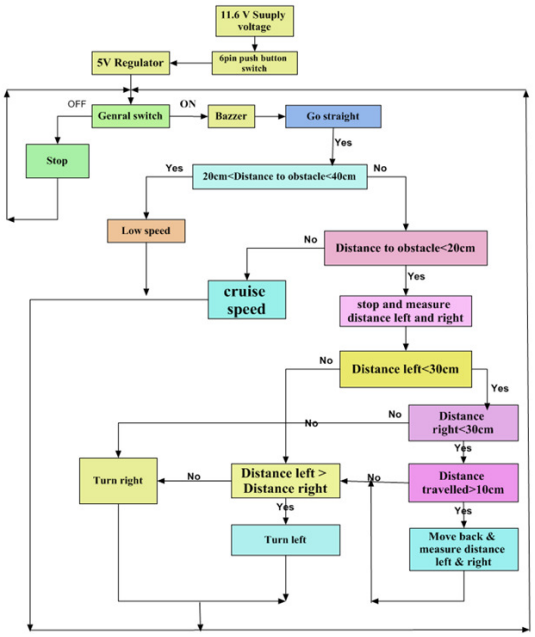

Fig. 1. Block diagram of an autonomous surveillance robot with IoT based rescue system enhancement [autonomous part].

In the autonomous section, there has an extra input circuit that needs many important ports of At Mega 328 for working its function properly. The activities of the AUTONOMOUS robot are started by connecting the wires of the main circuit with the connection of 11.6-volt LiPu battery. It is designed in such a way that at first, the input circuit gets power through a 6 pin push button switch from the battery. Normally, the Push button switch with LED 1 is NC connected which will be blazing as soon as the power comes on and the other connection part with the original circuit is in the NO mode which can be understood by LED2. In the autonomous part, three ultrasonic sensors is connected via 5 volts regulator. A buzzer and switch2 is always connected to the GND of the circuit and the Arduino mega 22 pin and 24 pin respectively. Pins 22 and 24 have been pulled up by programming. If switch2 pushes, mega gets power, and the robot starts its operation by autonomous mod. The output and echo pin on the trig pin in ultrasonic sensors is used as inputs. These pins help pulse in and set duration and distance respectively. It can define obstruction. Now come with the motor driver-Left Enabled, Right enabled, left motor 1, left motor 2, right motor 1, right motor 2 pin is used as an output pin. The rest of the pins are in the input.

Whenever the bazaar ton blows, it starts go straight. In this case, if there has an obstruction between 20 cm to 40cm front, it slows its speed and the obstruction is less than 20 cm, stops for 0.5 seconds, and measures the distance of the obstacle in the left and right side. If the distance of the left side is greater than the right side, then it turns left. The reverse incident happens when the obstacle distance of the left side is less than right. It carries out its activities by repeatedly following the conditions given in the Fig. 1.

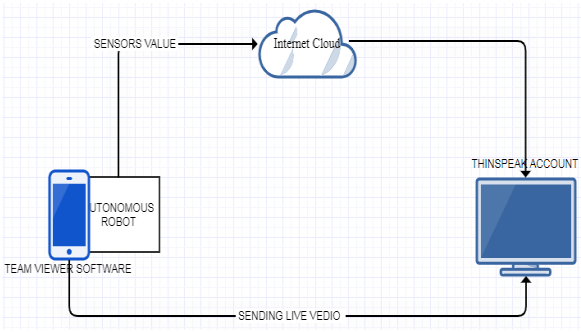

Fig. 2. Block diagram of an autonomous surveillance robot with IoT based rescue system enhancement [communication part].

In communication part, ESP-8266 01 plays as the main part. Another Arduino Uno is needed for sending data in the webserver because there is no available rest serial PWM port in Arduino mega. It receives power from the same input circuit. Communication circuit, Sensors, and Wi-Fi module ESP8266 is connected with this Arduino Uno so that the facility of Wi-Fi can be provided to the robot. The robot can send the sensor's information via the IoT platform according to the code. ESP8266-01 module sends the values of different sensors in the ThingSpeak account successfully during monitoring a place. After analyzing the sensor's values from the Thinkspeak channel and live video through Team viewer software, we confirmed about the surrounding condition of a place where a man's entry is very dangerous for enhancing rescue work.

III. CIRCUIT DIAGRAM

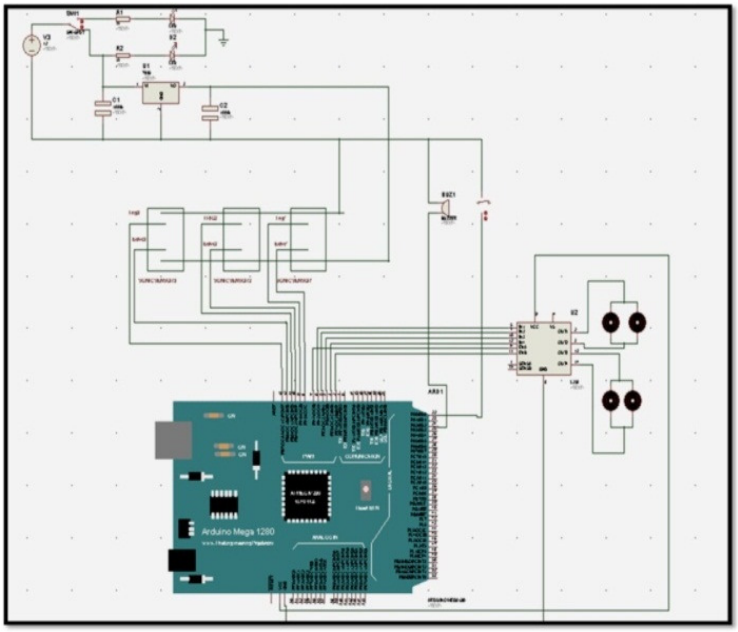

Fig. 3. Circuit diagram of an autonomous surveillance robot with IoT based rescue system enhancement [autonomous part].

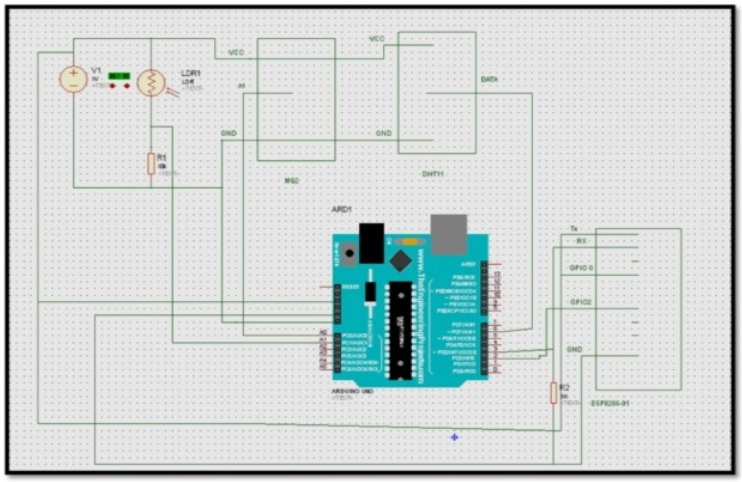

Fig. 4. Circuit diagram an autonomous surveillance robot with IoT based rescue system enhancement [communication part].

IV. HARDWARE USED

This autonomous surveillance robot needs a lot of essential hardware elements for correct functioning. The main elements employed in this project and their specifications and functions square measure as follows:

A. ARDUINOMICROCONTROLLER: Arduino microcontroller is employed to control the motors and additionally accustomed to send info on the encompassing condition to the user via the internet in step with the code.

B. DC MOTORS: DC Motors are known as rotary electrical machines which might convert electrical energy into mechanical energy.

C. LEAD ACID BATTERY: An 11.6-volt LiPu battery is used in this device as source voltage. The processor of this autonomous robot is connected to this battery through an associate input circuit.

D. L298N DUAL MOTOR CONTROLLER MODULE 2A: The L298N heavy-duty dual H-bridge controller, which is used to drive two DC motors at up to 2A [8].

E.LM7805 VOLTAGE REGULATOR: Positive polarity type LM7805 VOLTAGE REGULATOR is used in this robot. It can give a fixed 5V output voltage and also the property output current is 1.5A.150℃ is the Maximum Operating Temperature up to that it will operate and Minimum Operating Temperature is 0°C.

F. PIN PUSHBUTTON SWITCH: A 6 pin push button switch operates normally in 8A and 250 V applications. The initial maximum contact resistance for this device is 50mΩ.

G. ELECTRONIC BUZZER: Widely known for its reliability and potency, this is highly acclaimed and demanded. Also, their affordable evaluation structure and potency build these conductors the most popular market alternative.

H. ULTRASONIC SENSOR: Ultrasonic sensor is used in this device to measure the distance to an obstacle by using sound waves at a particular frequency [9]. This sensor can work in any lighting conditions.

I. INFRARED SENSOR: The character and aspects of the surroundings by emitting infrared radiation can be easily sensed through an infrared sensor [9]. It will notice edges present on its path.

J.DHT-11SENSOR: DHT11digital temperature and humidity sensor is a composite Sensor contains a calibrated digital signal output of the temperature and humidity[10].

K. GROVE-GAS SENSOR(MQ2): Fast response and High sensitivity Grove - Gas Sensor(MQ2) is used in this device which has a wide detecting scope and stable and longtime.

L.BOMB DETECTION SENSOR: Metal detector sensor is used for detecting bomb or any other explosive in this autonomous robot.

M.LDR (Light Dependent Resistor): The resistance of An LDR changes with the light intensity that falls upon it and allows them to be used in light sensing circuits[11].

N.WI-FI MODULE: The ESP8266 12e module is a self-contained chip consists of the TCP/IP protocol stack that's accustomed to offer network access to any microcontroller. It can be interfaced with the Arduino to provide the robot with the Wi-Fi facility [9].

V. SOFTWARE USED

A.ARDUINO SOFTWARE (IDE): The Arduino IDE open-source software that's accustomed to writing codes that contain a text editor for writing codes, a message area, a text console, a series of the programming codes are known as a sketch [9]. Typically, Arduino IDE is used to execute instructions on the robot through programming.

B. ThingSpeak: ThingSpeak is an open-source IoT application and API to store and retrieve data from things using the HTTP protocol over the Internet. It can enable the creation of sensor logging applications, location tracking, and a social network of things with status updates [12].

C. Team Viewer: Team Viewer is a computer software package for remote controlling, information sharing, and data transferring between two intellectual devices. In this autonomous bot, we used the Team Viewer for video transferring and monitoring [13]

D. Virtuino: Virtuino is an Android app for monitoring sensors or controls electrical devices via Bluetooth, local wifi, or the Internet. It can visualize the Arduino project.

VI. FLOW CHART

Fig. 5. Flow chart an autonomous surveillance robot with IoT based rescue system enhancement.

VII. RESULTS AND DISCUSSION

The wattage of the motor that is consumed is outlined by the subsequent formula[14]:

$$Pin = I * V \quad (1)$$

Here, Input power, Current, and Applied voltage are denoted by Pin (W), I (A), and V (V) respectively.

By using the subsequent formula, the output mechanical power of the motor could be calculated [14]:

$$Pout = \tau * \omega \quad (2)$$

Here, Output power, Torque, and Angular speed are denoted by Pout (W), τ (Nm), ω (rad/s) respectively.

Angular speed could be also calculated rotational speed of the motor in rpm[14]:

$$\omega = rpm * 2\pi / 60 \quad (3)$$

Here, Angular speed, and Rotational speed in revolutions per minute are denoted by ω (rad/s), rpm respectively. 60 mean the total amount of seconds in a minute.

The efficiency of the motor is calculated as mechanical output power divided by electrical input power [14]:

$$\eta = Pout / Pin \quad (4)$$

Therefore[14]

$$Pout = Pin * \eta \quad (5)$$

After substitution we get[14]

$$\tau * \omega = I * V * \eta \quad (6)$$

$$\tau * rpm * 2\pi / 60 = I * V * \eta \quad (7)$$

And the formula for calculating torque is going to be[14]

$$\tau = (I * V * \eta * 60) / (rpm * 2\pi) \quad (8)$$

Efficiency may be anywhere between zero and the maximum; for the sake of calculations below 100rpm may not be the optimal speed[14].

$$\tau = \frac{(0.22 * 5 * 0.7 * 60)}{(100 * 2 * 3.14)}$$

$$= 0.073567 \text{N} \bullet \text{m}$$

The load adds mechanical resistance. The motor starts to consume more current to beat this resistance and therefore the speed decreases [14]. The accuracy of the efficiency of the motor might not be correct rather than voltage, current, and speed was accurately measured because it depends on the sensor position, friction, alignment of the motor and generator axles, etc. [14].

Table 1: The input specifications of Driver motor.

Robot Mass	1.8 kg
Motors number	02
Radius of Wheels	65mm
Robot Velocity	0.2m/s
Supply Voltage	11.6V
Desired Acceleration	0.16m/s^2
Desired operating time	2 hours
Total Efficiency	70%

Table 2: These values were calculated based on the motor input specified values.

Angular Velocity	100 rpm
Torque	0.073567N.m
Total Power	2.3W
Maximum Current	0.22A
Battery Pack	1.60 AH

A. Driver motor output calculations

To calculate the desired torque, power, current and battery pack required by the robot, many factors were taken into thought, for example Force, Power, Current, and Voltage [15].

$$mgx = mg * \sin\theta \quad (9)$$

$$mgy = mg * \cos\theta \quad (10)$$

$$T = f * r \text{ (Torque required)} \quad (11)$$

$$\sum Fx = ma + fx \quad (12)$$

$$m * a + mg * Sin\theta = \frac{T}{r} \quad (13)$$

$$T = \left((a + g\,Sin\theta) * m * r\right) \quad (14)$$

$$T = \frac{\left(0.2 + 9.81Sin(20)\right) * 1.8 * 0.0325}{2} = 0.2678\text{N.m}$$

The total power per motor:

$$P = T * W \quad (15)$$

$$W = \frac{v}{r}(16) = 0.2/0.0325$$

$$= 6.1538 \text{rad/s}$$

Therefore,

$$P = 0.2678\text{N.m} * 6.1538 = \text{approx. } 1.648\text{W} \quad (16)$$

The maximum angular velocity was used so to be able to find the corresponding maximum power [15].

$$P = I * V \quad (17)$$

$$I = T * \frac{w}{V} \quad (18)$$

$$= 1.648/11.6 = \text{approx. } 0.142\text{Amps}$$

B. Solve for Vehicle Speed

$$Speed = (RPM\,(diameter * \pi) / 60) \quad (19)$$

Here,wheel diameter =65mm & Highest Motor Speed=100rpm

Table 3: Vehicle Speed.

Wheel Diameter (mm)	Motor Speed (rpm)	Vehicle Speed [in/sec]
65	10	34.034
65	20	68.068
65	30	102.102
65	40	136.136
65	50	170.17

C. The output value of Sensors

These are some part of the sensor's output value coming from the surrounding atmosphere of the robot. These data were collected from the Thinkspeak account immediately through the IoT platform when an autonomous robot went for monitoring a certain place.

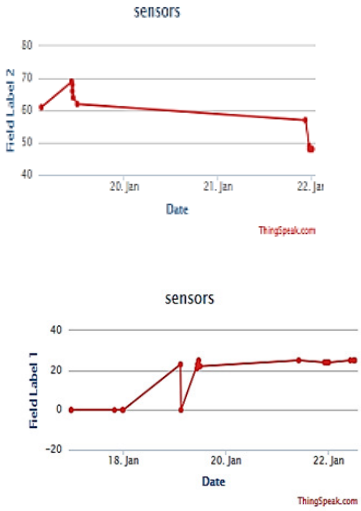

Fig. 6. Surrounding condition of a certain place sending from robot through Thinkspeak channel.

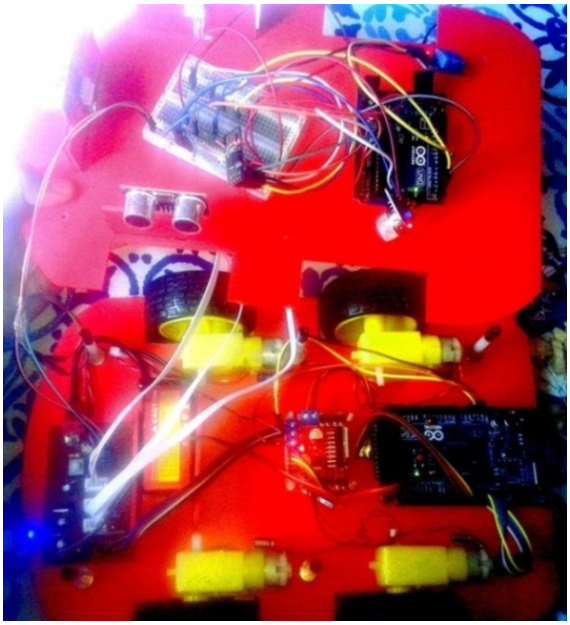

Fig. 7. Different parts of an autonomous surveillance robot with IoT based rescue system enhancement.

VIII. CONCLUSIONS AND FUTURE SCOPE

The proposed Autonomous robot has solved the problem to a large extent laid out in chapter one. This robot is capable of replacing humans in undertaking high-risk investigation works in risky places where it would be a very challenging task for humans to effort. After switching on, the robot is capable of maneuvering its surroundings competently while simultaneously updating the contiguous condition of that place through IoT platform and providing video feedback to the user through team viewer software. The robot will also rotate successfully to allow it to embark on its return journey. Besides that, in this robot, we can use full android system for controlling and monitoring. For connect and exchange sensor values, we used the Internet of things. Now–a–days Internet of things is a very popular network to connect and exchange sensor values. There are still a lot of scopes for robots to work in future. If we can use a high power IP camera instead of a mobile camera and add a robotic arm with various functionalities sensors, the performance of the robot will be increased by many times. There are many applications we can use this surveillance and rescue system enhancement robot such that displaying hidden Land mines, Surveillance home security, spying, nuclear research, and military applications**.**

Conflict of Interest. There is no conflict of Interest in this work.

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