Study and development of searching casualty and detecting fire by rescue robot

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Abstract. The project titled study and development of searching casualty and detection of fire by rescue robot is associated with new equipment to complete the task and to respond in hazards situation. Search and rescue robots are developed for a certain purpose that humans can’t perform. Our objective is to design, construct, and develop a robot to use in emergencies that will be able to perform the seek and salvage operation. Fallen structures are the shakiest spot to perform search and salvage mission by human where the weight and size restricts the rescuer developments. The robot is designed to find injured victims and trash life, create a map of the disaster area, and collect the necessary information by digging and supporting robots to the data centre.

Keywords: Rescue, robot, victims, emergencies, rescuer.

1. Introduction
The Human rescuers have restricted time (around 48 hours) when it seeks looking and protecting caught casualties in fallen structure. The possibility for saving casualties that are as yet alive is low. This is a result of risky circumstance that should have been decidedly ready before rescuers can enter the structure [1].

Collapsed structure, mines, fire and hostage situations all have one common thing, and they are dangerous and full of risk for rescuers. Key functions in rescue operations are to identify the emergency, to assess the situation, to find the contact of the victims, and to find a way to contact them. All these tasks are very difficult and very dangerous for human rescuers. Inside a collapsed building, holes and paths can be reduced to a handful of debris litters, search can be difficult in debris, fire and smoke can affects the visibility.

Because of the dangerous conditions in which rescuers go to do their work, they may continue to be injured from the second disaster. Therefore, rescue robots that save lives and perform many other tasks in a dangerous environment should be developed and used in areas such as fire stations, police stations, train stations and city offices, public and private sectors, especially at higher elevations.

Unmanned ground vehicles (UAVs), furnished with an assortment of sensors, and are being utilized to give noteworthy data to expand specialists on call situational mindfulness in debacle regions for industrial SAR tasks [2].

2. Literature Review

2.1 Design of rescue robot gripper. By Sadashiv, et al. (2020)
Since most recent couple of decades India has seen a few young children being caught into bore wells making danger their lives. Numerous instances of little youngsters being caught into the boreholes are accounted for particularly in Rural India. The ordinary Parallel Pit Method ends up being time, work and cash expending. It additionally relies upon Geographical Factors of the region. The restricted size of the drag well, helpless lighting inside and shortage of oxygen makes the assignment exceptionally trying for the grown-up rescue work force [3].

2.2 Designing, building, and testing an autonomous search and rescue robot by Hazelwood (2014)

The goal of this paper is to build up an economical, simple to work, self-governing robot that is fit for exploring itself in risky circumstances. This would be a noteworthy venture, since it would exhibit that utilizing robots isn't excessively far off, in any event, for nearby crisis teams and law enforcements. This project investigates artificial intelligence as it related to independently directed robots, microcontroller programming and code improvement, remote video real time, and controller utilizing a smartphones or tablet accelerometer. Upon the project fulfilment, the arrangement is to build up an exceptionally easy to utilize robot fit for driving itself through a structure while sending a video feed from a client controllable camera back to the smartphone [4].

2.3 Search and rescue robotics by Murphy, et al. (2008)

Rescue robots fill in as expansions of responders into a disaster, giving on going video and other tangible information about the circumstance. Starting at 2006, they have been utilized in just four disasters in the United States (World Trade Centre, and tropical storms Katrina, Rita, and Wilma), where they were still seen as an oddity. Nonetheless, rescue robots are seeing some utilization in neighbourhood occurrences. For instance, a few fire rescue divisions in Japan and the United States regularly utilize little submerged robots for water-based hunt and recuperation, a ground robot has been utilized for a mine blast in the United States, and enthusiasm for the utilization of elevated vehicles for wild inquiry and rescue is developing. Robot is planned with the longitudinal body plan. Safeguard framework gives the damper impact against falls just as including progressed balance properties while going through a harsh land. The robot has adequate ground clearance to overcome obstacles during operation [5].

3. Research Analysis

We have found out many research papers and have gone through them. While reading them, we got to know that some objectives were being fulfilled for the robot but also many drawbacks were there. Robot was not performing well in the condition of fire like communication problem, not resisting fire for the long period of time. As there was no camera, it could not perform the search operation except the rescue one. Some robot was unable to detect the behavior of fire at the hazardous site, due to the heavy design of the robot they could not enter the small holes, narrow places and also having weight problem. Lack of the sensors used in robot is lagging the objectives behind as not giving accurate readings.

We have identified all these problems and will overcome and make the advancement in these drawbacks for the fulfillment of the objectives.

- To find out the casualty in fire or any hazardous situations.
- To easily communicate with the firefighting team and casualty in the absence or damage of other communication system.
- To detect the behavior of fire, temperature and mapping the safe egress way.
4. Equipment

4.1 Camera
The camera is mounted in a rescue robot to search the environment and view fire, internal damage and casualty by the operator standing outside. High temperature resistance glass is installed in front of the camera to protect against heat. This camera makes robot control easier by sending the data from camera and the user can know the behavior of fire and number of injuries can be determined. This detail also helps firefighters to find where and how to stop a fire and how they should continue their work.

![Camera](image1.jpg)

Figure 1. Eachine 700TVL 1/3CmosFPV Transmitting System having 148° Camera Module with 40CH

Specification -
- Product Dimensions - 3.2 x 2.35x 3.2 cm; 50 Grams
- Compatible with Immersion RC Boscam, Foxtech and other generic Recipients of FPV type within the same frequency range.
- Low power consumption and light in weight makes it favorable for smaller aircraft. It has 200mW 32ch FPV small video transmitters.
- Photo settings viewed by FPV during flight test hours to ensure good performance in challenging lighting conditions.

4.2 Heat Detector
A fire alarm device intended to respond when fire increases the temperature of an object that is sensitive to heat is called heat detector. The thermal mass and conduction of the object controls the flow of temperature to the object. All heat detectors have this thermal lag.

![Heat Detector](image2.jpg)

Figure 2. Melexis MLX90614

Specification: -
- Small size and low cost.
- Easy to integrate
- Industrial temperature range: -40 to 125 °C temperature sensor and -70 to 380 °C object temperature
- Precision of 0.5 °C for wide temperature range (0. +50 °C for both Ta and to)
- Single and double types of sinners
- Availability in 3V and 5V versions
- Adapt easy synchronization for 8 to 16V applications
- Energy saving mode
- Offers different package options for applications and usability scales.

4.3 Raspberry Pi

Raspberry Pi is a progression of little single-board PCs created in the United Kingdom by the Raspberry Pi Foundation to put PC power and advanced in the possession of individuals around the globe. The Raspberry Pi is inexpensive, small card-sized device that connects to a computer monitor or TV and uses a standard mouse & keyboard. A small, powerful tool that allows people of all ages to navigate a computer and learn programming in languages like Scratch and Python. It can do everything you would expect a desktop computer to do, from browsing the Internet and playing HD video, creating spreadsheets, processing word files, and playing games [6].

![Figure 3. Raspberry pi 4](image)

**Table 1.** Raspberry Pi 4 configuration.

| Processor     | Broadcom BCM2711, 4- core Cortex-A72 (ARM v8) |
|---------------|-----------------------------------------------|
| Memory        | 1, 2, or 4 Gigabyte LPDDR4 (model dependent)   |
| Connectivity  | • 2.4 GHz and 5.0 GHzIEEE                      |
|               | • Wireless LAN,                                |
|               | • Bluetooth 5.0                                |
|               | • GigabitEthernet                              |
|               | • USB ports (2.0 & 3.0)                        |
5. Thermal Control
A robot will be used to enter a fire station and send images from the scene using a hot-duty camera to learn more about fire behaviour.

To prevent the robot from the damages that can be incurred by the heat or very high temperature condition, it should be covered with the material with the low thermal conductivity like ceramic fibre paper to protect electronic circuits.

The electronic units and connection fixed in robot must be kept at the room temperature for stability of their working; they are normally be controllable at room temperature only.

So, here for robot we are using Aramid Fiber for Fire protection or we can say body panel protection.

Aramid fibres ‘Figure 4’ are same as of synthetic fibres that are very strong and heat resistant as well. The name is portmanteau for "fragrant polyamide". The molecules of the chains in the cables are directed along the fibre axis. As a result, the higher part of the chemical bond contributes more to the strength of the fibre than too many other synthetic fibres. Aramids have a very high melting point (>500 °C) [7].

Characteristics:

- Good resistance to abrasion
- Good resistance to organic solvents
- Non-conductive
- High melting point (>500°C)
- Very low flammability
- Fabric integrity to be good at elevated temperatures
- Sensitive to acids and salts
- Sensitive to ultraviolet radiation
- It tends to build electricity tariffs without being completed

![Aramid Fiber](image)

Figure 4. Aramid Fiber

6. PARAMETERS OF SEARCHING CAUSALTY AND DETECTION OF HEAT BY RESCUE ROBOT

- The robot weight should be light so debris could not damage its body part.
- The robot should be able to get into small holes, so it’s size should be very small as possible.
- The ground clearance of the robot should be adequate so that there are no obstacles.
- The robot must be able to withstand fire and heat.
- The assembling of the robot ought to be straightforward in light of the fact that the less activity time and the least expensive method of assembling are liked.
- The less part simplifies the robot and make the maintenance simple in the event.
- The design of the robot ought to be just about as essential as conceivable to make it more obvious and change.

Search and rescue robots are designed to have adjustable levels of autonomy. This requires not only the development of control algorithms to increase autonomy but also a system to enable an external agent to exert varying degrees of control over the robot [8].
Figure 5. Bottom plate Design for robot

Figure 6. Top cover design for robot

- Base plate diameter - 210X210 mm
- Wheel width – 50mm
- Wheel diameter – 80mm

Figure 7. Complete design of robot
7. Calculation

7.1 POWER REQUIREMENTS FOR ROBOT

We are assuming that the amount of weight and power required for robot for movement. To choose an
enough force engine straight forward force estimation had been finished by the heaviness of the robot.
From the start the weight of the robot is believed to have been about 31 kg. It must not be overlooked
that this worth was a hypothetical worth not the genuine one and even 1 kg of weight builds make the
force utilization expanded drastically. To transfer the load down on surface, the engines must use more
power than the power taken from frictional source. Lots of dry stuff covered have friction coefficient
values somewhere in the range of 0.3 and 0.6. For calculating the frictional powers, 0.3 (approx.)
would be the coefficient of friction and the whole burden is influenced on the robot by this friction.
The condition utilized for choosing rating of the engine:

Assumption as:

We now know that power is a measure of the amount of time a work is done. Therefore, at any given
time, power can be defined as

\[ P = \frac{dW}{dt} \]

DW is a function performed during dt. Since, we know that
\[ W = F \cdot dx \]
we can rewrite the above equation as

\[ P = F \cdot \frac{dx}{dt} \]

Here, F is the force, dx is the change in position of an object and dt is the time of that movement.
Since, knowing that \( v = \frac{dx}{t} \), we can rewrite the above equation as eq. no.1:
Force is denoted as ‘F’ and ‘V’ is the instantaneous velocity.

Now from Equation no. 3.1,

\[ P_m = F_{\text{app}} \times V \]  \hspace{1cm} (2)

Where,

\( P_m \) = power required \( F_{\text{app}} \) = force applied \( V \) = Velocity at which Robot is moving.

Robot’s velocity can be calculated by multiplying the wheel circle perimeter with the expected number of sprocket revolution. Robot’s velocity would be:

\[ V = 2\pi r \]
\[ V = \pi \times 80 \times 8.33 \text{rev/s} \]
\[ V = 2.09 \text{ m/s} \]

So,

\( W \) = weight, \( N \) = Normal Force

\( W = mg \), applicable all time whether object is accelerating or not.

\[ W = N = m \times g \]  \hspace{1cm} (3)

When an object falls freely there is no other force acting, but gravity.

Coefficient of friction, frictional force ratio against the movement of two surfaces in contact to the typical power that presses the two territories together. It is normally addressed by the Greek letter in \( \mu \) (\( \mu \)). Mathematically,

\[ \mu = \frac{F}{N}, \]  \hspace{1cm} (4)

Where, \( F \) = frictional force and \( N \) = normal force. Now from eq. 3 and eq. 4 the eq. 2 can be written as,

\[ P_m = 31 \times 9.81 \times 0.3 \times 2.09 \text{ W} \]

For determining operating torque, divide power by rotational speed, can be written as:

\[ \tau = \frac{P_m}{\omega} \]  \hspace{1cm} (5)

where,

\( \omega \) = rotational speed,
\( \omega = \frac{v}{r} = 2.09/0.04 \omega = 52.3 \text{s}^{-1} \)

Putting the value of \( P_m \) and \( \omega \) in eq. 5, \( \tau = 190.5/52.3 \)
\( \tau = 3.7 \text{ Nm} = \text{Approx. 5 Nm} \)
Therefore, motor having torque more than 5 Nm should be selected.

8. Result

The Robot is made to perform the task of first responder, making all the possibility for the fire-fighter to save casualties using the devices fitted in the robot-like camera, heat detector, raspberry pi. The insulation materials and body framework are calculated on the heating source coming from outside (max. up to 850°C). Keeping all the objectives in mind, the robot is going to perform tasks.

9. Discussion

Overall, the study and development of searching casualty and detection of fire by rescue robot has been successfully done. All actions which have to be performed like searching casualty in hazardous situation, detection of temperature in various areas and to find out the stage of fire is working properly. Search and rescue robot with more modifications will be a new success in terms of safety as well as fire fighting and rescue operations.

The problem for which the solution in the form of this project is given was to develop a small, portable and light robot which provides aid in rescue services in small duration of time, reduce and eliminate hazards that occur due to fire in places which are in confined areas and are also not accessible by larger and bulkier full-sized fire fighter. We by working on this project are trying to improve and develop solutions for such situations and emergencies.

It is will also set a future mark for the safety robot manufacturer as it will be capable to extinguish fire in running condition. As, a conclusion the project entitled ‘study and development of searching casualty and detection of fire by rescue robot’ has achieved its aim and objectives successfully.

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