ERBot – Emergency Rescue Bot

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***Abstract* — In many natural disasters like earthquakes, mining accidents, explosions etc. situations arise where humans are to be rescued. Search and rescue robots (SRR) are robots built for the sole purpose of rescuing trapped victims in disaster struck area. Mobile robots unlike human rescuers can enter collapsed premises looking for survivors. These robots can locate the victims and notify the human rescuers in pulling the victims to safety. Conditions in a disaster area are unpredictable. To overcome this, a variety of sensors are chosen to help locate victims easily. Thus a proposal of a search and rescue robot with robotic arms-a normal pick and place arm and a snake arm with well-chosen sensors are used to help find victims and also safeguard the robot from getting itself damaged too. The robotic arm is designed can be used to pass water, oxygen or give provide any immediate medical aid to the victim trapped. Thus the proposal helps in the search and rescue, medical aid operations during the disaster situations thereby helping the rescuers to prevent themselves from getting into dangerous situations while the rescue operation.**

Keywords— SRR, Sensors, Robotic Arm, Mobile Robots.

I. Introduction

The search and rescue robots are generally designed to automate the rescue process and help the rescue workers in the rescue operation. These robots generally benefit in many ways like reducing the manpower, increasing the human safety and helps access the inaccessible areas. The use of mobile search and rescue robots which can be both controlled and autonomous have been used since the aftermath of September 11 for Urban Search and Rescue [1]. A variety of mobile robots, for Search and Rescue, militia purposes etc. have been developed. Small robots were opted as they had the ability to go in places that were not accessible by bigger robots or humans. Small robots are mostly limited by their weight, size, geometry etc. Some of the robots that have been developed in the past are Talon, PackBot, Andros Mark V robots, Wheelbarrow MK8, AZIMUT, LMA, Matilda, Helios VI and VII robots, Variable configuration VCTV, and Ratler [10-16]. Most of these mobile robots have tracks for locomotion and a manipulator arm, for some pick and place purpose. The rescue robots that were used during the September 11 attacks had trouble in working and were constantly being broken or stuck. So scientists across the globe are designing various robots of different shape and size for the robot to successfully work in different and variant scenarios. In this paper we propose one such robot design which uses a wireless camera, various sensors that help in detecting parameters for the robot to properly work upon. The proposed system for the search and rescue robot has been designed in such a way that it is not very heavy, thus can be carried around easily, and also the cost effectiveness has been made. It is attached with sensors, so that victims can be easily found. The arm is used for providing medical aid to the trapped victims. The use of snake arm present in the robot, helps the arm to slither through places that are not even reached by the base robot.

II. RELATED WORKS

Many robots have been developed since 2001, with variety of designs, so as to either reduce cost, or make the design more stable, or add a variety of functionalities to the robot.

The Linear Mechanism Actuator tracking mobile robot, was one of a kind. And its operations are explained as follows.

"In the LMA two modes of operation: manual and preprogrammed were present. In the manual mode (remote control), the operator drives the LMA directly with the use of the remote controller. In the preprogrammed mode, a trajectory can be selected, parameters entered, and the LMA will follow the path automatically. During earlier operations and demonstrations of climbing and descending of stairs, only the manual mode was utilized. The operator navigates the LMA using the remote controller (joystick and buttons).The disadvantage of this mode is that the operator has to rely on his/her own judgment to set the robot in the right configuration in order to be able to successfully climb and descend stairs without overturning. In addition, effecting this operation from a remote location, based only on the view of video images, provides a serious challenge to the operator. First, the operation in manual mode is intuitive, and it would be almost impossible to ascertain stability on climbing and descent. Second, climbing and descending stairs in the manual mode requires operator's knowledge, experience, skills and training. This is not preferred since the operators may have to be replaced from time to time. It is therefore advantageous to provide a robot with autonomous climbing and descending, thereby enabling precise, faster, and safer operation while reducing the operator's load and possible damage to the equipment in cases the robot might roll off the stairs."[1] . The diagrammatic representation of the LMA is as shown below in Fig 1(a).

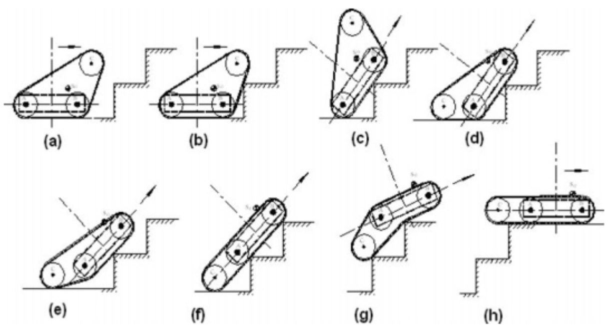


Fig 1(a): LMA robot movement

"USAR Sim simulators with high physical fidelity and small time steps of computation are qualitatively different from real-time simulators, which can handle multiple robots and large areas simultaneously. Real-time simulators are suitable for the training tools. There exist several 3D simulators for robots such as Open Dynamics Engine and Microsoft Robotic Studio. In order to impart effective training in the tele operation of the response robots it is necessary for the simulator to have real time abilities, high-quality images, easy handling of multiple robots, easily developable large environments, and extended connections to other software, if required. In addition, USAR Sim has also been utilized in the Rob Cup Rescue Virtual Robots Competition and it has been used in several studies on mobile robots. The biggest concern about USAR Sim is its computation ac-curacy. This is because it uses approximations of the physical computations to maintain real-time performance and because of its nondisclosure of proprietary parts of the physics engine. It is necessary to validate both the simulated robot models and the physical accuracy of the simulator in order to ensure its reliability as a training and research tool. Evaluated the images provided by the simulator by taking into account the distance of the robot from the target objects and the lighting conditions.

The main aim to develop a rescue-robot which is able to move on difficult terrain automatically, find victims, the mapping and the design of the power supply also for additional application. Various disaster scenarios will be simulated. The goal is, to develop a robot, which is able to move in difficult terrain and must fulfill various tasks e.g. find and rescue doll which symbolizes the victims. Depending on the difficulty you can reach your score. The difficulty depends on the color of the arena. There are six different arenas which are marked with six different colors (yellow, orange, red, blue, back-yellow and black).As mentioned above the results of this project phase will be the construction and manufacturing of the chassis and the driving concept. The benefit for us is to get a good knowledge in construction, manufacturing and programming a robot."[21]

The summary issues and proposed solutions for the mobile robots that have been found are shown as follows [1].

Table 1[1] :

Summary issues, research problems

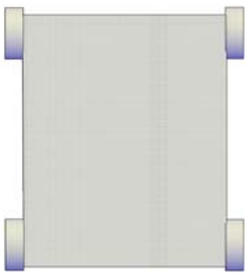
Issue	Research problem	Proposed solution
Manipulator arm and mobile platform are separate modules	Each module contributes to design complexity, weight and cost	Design the manipulator arm and mobile platform as one entity mechanism
Manipulator arm mounted or folded on top	Arm susceptible to breakage and damage when platform inverted	Integration of arm and platform as one entity in a geometrically symmetric design eliminates exposure
Flip-over occurrence: invertibility versus selfrighting	To provide selfrighting without special purpose or active means	Design a symmetric platform to allow flip-over without the need to return it, and as such greatly enhance mobility

III. ERBOT Mechanism design

In this section, we discuss about the mechanical design of the proposed Emergency Rescue Bot. The proposed system (a) integrates the robotic arm and the base with series of links, and motors. (b) Tracks and symmetry in the design to balance and be stable. (c) Ability of the robot to understand the surfaces so that it can avoid surfaces that are not stable.

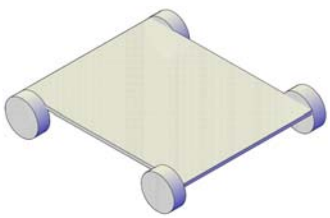
A. Base

The robotic base is also known as chassis. A chassis consists of an internal framework that supports a man-made object. It is analogous to an animal's skeleton. An example of a chassis is the under part of a motor vehicle, consisting of the frame (on which the body is mounted) with the wheels and machinery. The base includes two Johnson DC motors of 150rpm each. This is for the motion of the back wheels. The backward motion is transferred to the front wheels using a track. Thus right, left, front and backward motions are possible with the robot. Switches will be used in order to control the wired robot. The switches are called as DPDT (Double Pole Double Throw) switch thus help alternate movements of the robot i.e. front, backward, left and right motion. The robotic arm, and wireless camera are mounted on the base. The flipper arm is attached under the top plate of the chassis. The robot base approximately weighs 5.5kg including the DC motors, flipper arm, camera and robotic arm. The chassis has a dimension of 304 * 153mm. And, the height of the chassis from the ground is around 74mm approx. The chassis is attached with four clamps on its side. The chassis is made of steel, thus making it strong, not corrosive. Due to the constraint made in the size and weight, the bot is easier to use, and can be literally carried anywhere required, and can enter in areas not accessible by humans. The Johnson DC motor is a high performance motor with metal gear box used for high torque application and other automation purposes. The motor comes with 6mm off-centred shaft (side shaft) and M3 holes for mounting. A motor is a device which converts electrical energy into mechanical energy. The motor has two parts, the rotating part called armature and stationary part that includes coils of fire called field coils. The stationary part is also called stator. The armature is made up of coils of wire wrapped around the core and the core has extended shaft that rotates on bearings. Torque is generated by Lorentz force. A DPDT switch has six connections, but since polarity reversal is a very common usage of DPDT switches, some variations of the DPDT switch are internally wired specifically for polarity reversal. These crossover switches only have four terminals rather than six. Two of the terminals are inputs and two are outputs. When connected to a battery or other DC source, the 4-way switch selects from either normal or reversed polarity. Such switches can also be used as intermediate switches in a multiday switching system for control of lamps by more than two switches.



1(a)

1(b)



1(c)

Fig 1(a): top view, 1(b): side view, 1(c): isometric view

The CAD design of the flipper arm, is as shown below in fig 2(a)

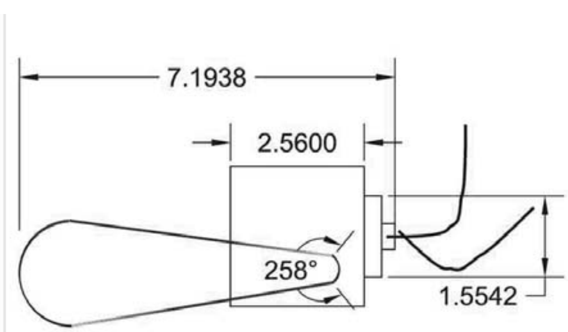


Fig 2(a): Flipper arm CAD design

The isometric view of the flipper arm is as shown in fig 2(b).

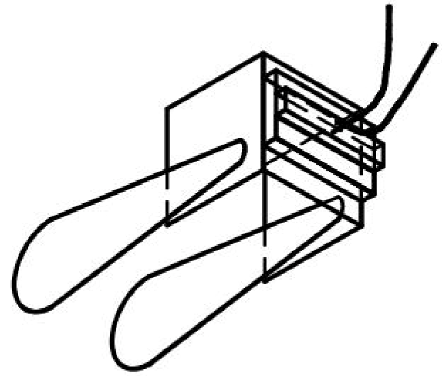


Fig 2(b): Flipper arm isometric view

B. Arm

The robotic arm is equipped with two 150rpm Dual Shaft Plastic Gear Motor requiring a power source of 1.5V. Acrylic sheet for the robotic arm's components. Designed using laser cutting. The arm controlled by the user is used for picking up objects, and also helpful enough to pass water, or giving some assistance to the victim. A basic robotic arm has 5 Degrees of Freedom. Each degree of freedom, is a joint on the arm, a place where it can bend or rotate or translate.The shoulder joint requires reinforcement by one or two servomotors in order to increase the torque driven through the joint, to counteract the weight of objects in the gripper. The other three motors each drive their own joint. There is a, a vertical shoulder joint , a vertical elbow joint, a vertical wrist joint, and a motor that drives the opening and closing of the two-fingered gripper. In total, it has a total of four degrees of freedom. Rotational base joint is driven by geared dc motor. The arm is a 5 axis robotic manipulator consisting of a rotating base, three links and a gripper. The five axes consist of the following: Shoulder, elbow, wrist (vertical movement), an axis at the base (horizontal movement), and Finger (gripping movement). The base of the robotic arm is attached to a DC motor, in order to give a full 360^o rotation. The main thing that should be kept on mind, is the weight which has to be balanced. The design of the shoulder of the arm uses metal plates that are connected to the left and right side of the arm, the arm has a linear movement of about 180^o. The elbow is supported by a single DC motor, so that weight to be lifted can be done easily. It only needs to support the wrist and gripper.
The wrist is made up of standard DC motors, that are attached side by side to move by 90^o and also a DC motor attached at the top to control the gripper.

Fig. 3: Robotic Arm

C. Communication Module

The base is attached with a wireless camera of 0.5 pixels resolution. The tuner is in the receiver side, thus making it possible for the wireless camera to receive both audio and video and sending to the receiver's screen. Using Image processing in MATLAB we filter out the noise.

IV. DESIGN AND SIMULATIONS

The design of the Emergency Rescue Bot is done in such a way that, it allows easy movement, and handles the weight at the same time. A flipper arm is attached in the front of the chassis that helps the bot climb stairs using the link. In order to prevent danger from obstacles, the wireless camera on the base helps us see the surroundings, thus allowing to maneuver the bot easily.

A. Modelling and Simulation Of Robot

The table consists of the details of the robot and how it is modeled.

Table 2: Robot Design Specifications

Total mass	20(kg) approx.
Length (arm deployed)	284 (mm)
Height (arm stowed)	257 (mm)
Speed of platform	up to 1 (m/s)

AutoCAD is used to model the bot and for simulation Inventor is used to find out the working of the bot.

B. Stair Climbing

The proposed bot is designed to move up different terrains like stairs, slopes etc. This have been done with reference to

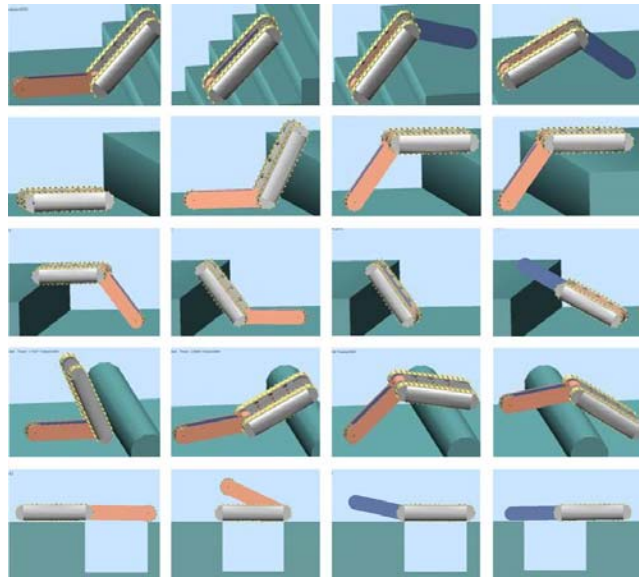


Fig. 3: Movement of the robot in various surfaces [1]

Previous bots that have been made for Urban Search and Rescue. The movement of the proposed robot on stairs, circular obstacles, ditches etc. are somewhat similar to the one shown above in Fig 2. [1] The stair climbing mechanism is as shown in the picture. The flipper arm is used as a support and with the help of the base we move the bot forward, thus forming a tripod like shape. This enables the bot to be pushed forward and moved in the front.

Ditch crossing is also done in similar way. With the help of flipper arm, we have the ability to move forward, using it as a support or an additional wheel whenever needed.

V. CONCLUSION

The proposed paper presents the full development and results of a better mobile robot system that can be used for a variety of purposes, such as: search and rescue missions, surveillance, etc. The new mobile robot design integrated both the base and the arm with a pressure sensor in order to find out surfaces that are fragile, thereby allowing the bot to be safe. A wireless electrical system is used in order to control the robot. The robotic arm is controlled wirelessly with the help of a joystick. The movement, manipulation and locomotion have been used to traverse and climb and descend stairs (variety of slops, materials, and sizes); climb and descend tall obstacles (up to 0.7 m); cross ditches; lifting payloads of up to 2 kg. The additional tracks allows the bot to climb even better and not get stuck. By usage of tracks, the number of motors has reduced, thus making the weight of the bot considerably less.

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