RoboCupRescue 2010 - Robot League Team <SAVIOUR II (Pakistan)>

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Abstract.. In this paper, we have introduced our second competitive rescue robot. It is track based, with two sets of independent flippers. It is semi-autonomous, requiring one human operator, and is designed to aid the operator during decision making. This is not a commercial product, but meant to demonstrate how much capability can be achieved for extremely low costs.

Introduction

SAVIOUR (Semi Autonomous Vehicle for Inspection, Observation and Ultimate Rescue) is a robot capable of traversing and mapping a complex and unknown terrain. The impetus was the October earthquake in the northern areas of Pakistan, and how many lives could have been saved had such a robot been easily available to the rescue teams then.

It has a low CG design for maximum stability. It has leveraging capabilities using two sets of independent flippers to climb over obstacles.

It requires one operator; however, the operator is aided in the driving decisions by the robot. All the other functionality is fully automatic i.e. all the sensing. The operator will make the final call wherever needed, e.g. in the detection of victims, or when overriding a safety braking mechanism etc.

SAVIOUR II is primarily a mechanical upgrade from the previous version.

1. Team Members and Their Contributions

- Dr. M. Junaid Mughal (Faculty of Electronics Engineering) Advisor
- Dr. S. A. Bazaz (Faculty of Electronics Engineering) Advisor
- Dr. Sultan (Faculty of Mechanical Engineering) Advisor
- Azzam Ahmed Qureshi Control and Communications
- Farrukh Sohail Mechanical Design
- Salman Khan Mechanical Design
- Muhammad Waqar Chughtai Electronic Fabrication
- Amaid Zia Electronic Design
- Ehtisham Sikander Electronic Design

1. Operator Station Set-up and Break-Down (10 minutes)

One person from the team will be in charge of the station set-up and breakdown. Station set-up includes.

1. Laptop set-up
2. Wireless communication set-up
3. Testing of components

2. Communications

Most of the processing of all kinds will be done at the base station. All communication to the robot is entirely wireless.

a. Data to be transmitted:

Motor(s) control

Camera control

b. Data to be received:

Sensor data

Video Streams

Other observatory data (if infra-red, etc.)

The robot communicates with the base station, and vice versa, as a specialized Wireless LAN network. At the receiving end are microcontrollers that need to be provided logic levels to function. They are sent over a standard wireless connection.

We are using a TP-Link TL-WA601G Wireless Access point and are also using a router to multiply the number of available Ethernet side interfaces. The switch used is a Baynet BN-1708K 8 Port Nway Switch. This is a standard 8 port switch.

Our system uses a communication frequency of 2.4GHz, and adheres to 802.11g standards.

Rescue Robot League		
SAVIOUR (Pakistan)		
Frequency	**Channel/Band**	**Power (mW)**
2.4 GHz - 802.11b/g	Any	-
1.2 GHz - Video Transmitter	-	-
900 MHz - Video Transmitter	-	-

There is no wireless internal communication of the components. Each module is a self dependent system serviced via the external wireless service.

4. Control Method and Human-Robot Interface

SAVIOUR is being navigated remotely by the operating station via keyboard and joystick. The control of the robot is being achieved by two AT89C51 microcontrollers. The first is responsible for controlling the locomotion of the robot by generating appropriate PWM while the second is interfaced with different sensors (ultra-sonic, IR etc) for victim detection and obstacle avoidance.

4.1 Command Center:

- Laptop and joystick
- Human Computer Interface

4.2 GUI

Graphical user interface is designed to aid in the navigation of the robot and victim detection. It is underdevelopment.

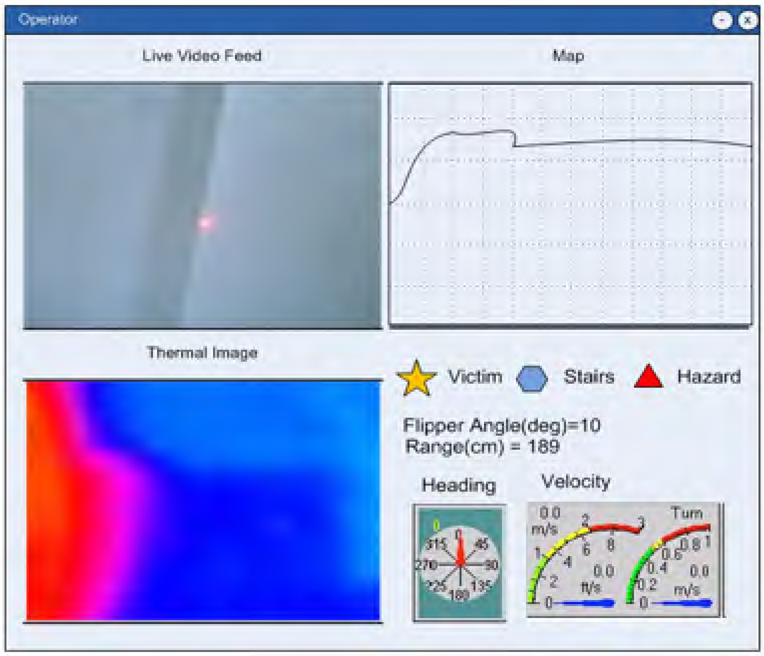


Fig. 4.1 Sample SAVIOUR GUI

The GUI is logically divided into four parts

Live Video Feed

The video will be from the wireless camera. The operator will be monitoring the live feed and adding details to the map e.g. Victim detected

Map being generated

Map will be generated on basis of simple rangefinder program.

Thermal Image

Thermal image obtained from the thermal sensors in conjunction with the camera image.

Information from other sensors

Other sensor information will also be displayed. E.g. Digital compass, tilt sensor etc.

5. Map generation/printing

(a) 6-axis Inertial Measurement Unit (IMU)

(b) Magnetometer

(c) Ultrasonic sonar

Magnetometer defines the initial position of the robot. Displacement data of the robot will be obtained from the IMU and orientation with respect to the magnetic poles from the magnetometer. Using this data, x-y-z coordinates will be generated and displayed on a simple GUI. Obstructions will be detected using the sonar and their positions on the map will also be displayed on the GUI.

Figure 5.1 IMU

6. Sensors for Navigation and Localization

6.1 Ultrasonic Sensors

40 kHz ultrasonic sensors are being used for obstacle avoidance. Any obstacle within 0.3m of the robot triggers the sensors to give a high pulse which overrides the operator control momentarily. Four of these have been placed on the sides of the robot. This range can manually be changed by adjusting the variable resistors.

Fig 6.1 Ultrasonic sensor

The code for the microcontroller has been written to avoid the obstacle detected by the sensor.

6.2 IR distance sensor

IR range finder is used along with laser data to generate the map. The Sharp GP2Y0A02YK infrared ranger is able to continuously measure the distance to an object. The usable range is 20 cm to 150 cm. The device generates an analog voltage that is a function of range, and the output voltage can be measured by an analog-to-digital (ADC) input line.

Fig 6.2 IR range finder

6.3 Cameras

Two cameras are being used

1. Front Night vision camera

This is the primary camera being used for map generation and victim detection.

2. Rear Camera

This camera has been place at the rear of the robot to have a greater view of the surroundings

Fig 6.3 Night Vision Camera

Fig 6.4 Rear Camera

6.4 Tilt sensing

An accelerometer is being used to sense the tilt of the robot. This data is fused with data of the camera for accurate map generation.

6.5 Position and Orientation

An optical mouse sensor will be used for position and localization. This sensor communicates via synchronous serial and will give the x and y positions.

The optical and compass sensors will be used to continuously update the robot's position and orientation for mapping and navigation purposes

6.6 Tachometer

The speed of the two primary motors is being measured. The data is being compared so that they are revolving at the same speed. This data also helps in the map generation.

7. Sensors for Victim Identification

7.1 Microphone

An electric microphone is being used for victim detection. Sound processing is done on the base station which prompts the user if a victim is detected. The audio data will be transmitted back to the user via the same wireless transmitter that is used to transmit the video feed.

7.2 Thermal sensors

Thermal sensors are being used to detect victims autonomously by their body heat. Servos move the sensors to create a 2D image. Thermal image is created with colors depending on the temperature values. The sensors data is sent to the base station where this image is created.

Fig 7.1 TPA-81 Thernal Sensor

7.3 Motion detection

The front low light camera is being used to capture the video. Video processing is done on the base station to detect any motion.

8. Mechanical Design and Locomotion

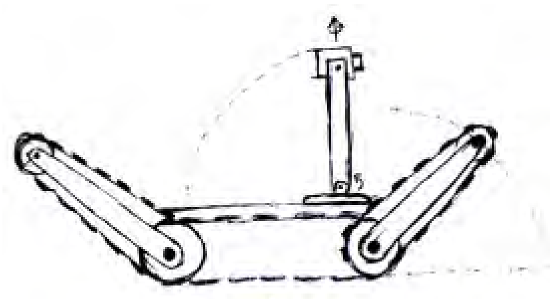


Fig **8.1** Mechanical Design

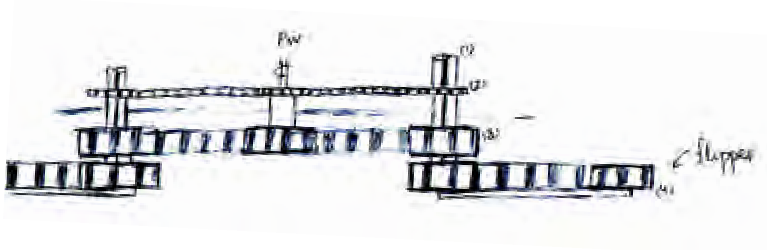
8.1 General Description

The robot runs on rubber tracks, a total of six that will be controlled by 2 motors; one motor for each side. Robot uses a total of four flippers, two at front and two at rear. Front and rear flippers have separate lowering and raising mechanisms. So a total of 4 motors are required for the locomotion of the robot, one each for the front and rear flipper's lowering and raising mechanism and one each for the rubber tracks on the left and right side of the robot.

In addition to this, couple of servos will do for the camera mount providing 360^{o} view as well as tilting mechanism. The camera can be lowered to accommodate in the base while entering spaces with little vertical clearance or chances of rollover. Camera mount will be discussed in detail later. Detailed designs and pictures can be found in the appendix.

8.2 Tracks

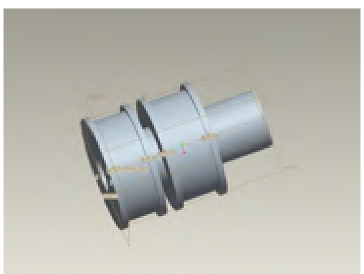
Several track designs were formalized and tested. The issues that we faced were torque transmission and derailing. We faced two problems; firstly, flanges had to bbe used and secondly, they were also having some power losses. The tracks being used for the robot are an assembly of rubber strips and attachment chains. The motors drive the hollow cylinders which are assembled with sprockets connected in parallel. Two parallel chains run on these sprockets. The corresponding links are connected with an assortment of rubber strips. The rubber tracks that we are using are such that they have an interface with the ground ensuring maximum grip which is needed for climbing the ramps, stairs and other obstacles. In addition the track also possesses the ability to lock on to an obstacle. This is how it can endure obstacles of any size and



shape.

Fig 8.2.1 Flipper Design

The Motor on the middle shaft (Pittman DC motor) rotates the chain wheels using chains; this motion drives the tracks of the main base and both the flippers of one side of the robot. Shafts, excluding the middle one, are hollow shafts. These shafts have ball bearings inserted at both their ends. Another shaft passes through these bearing and the hollow shaft that is used to raise or lower the flippers. The tracks are mounted on sprockets that turn with the hollow shafts.



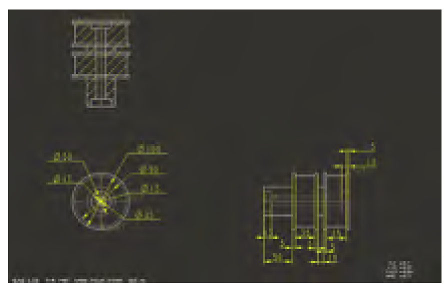


Fig 8.2.2 3D Design and Modelling

For the lowering and raising of the front and rear flippers; two separate power window motors are being used. Each motor drives two flippers using the chain sprocket mechanism.

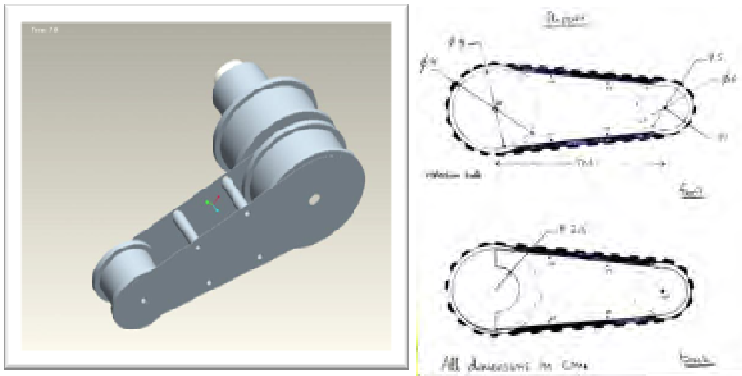


Fig 8.2.3 Flipper Design

Track Tensioning:

We have used a different sprocket attached at the side of the body to keep the chain in the tensioning. These attached to the body with the help of an MS bracket using bolted fasteners. For further tensioning of the second chain we will be incorporating aluminum rollers attached to a 12.4 mm shaft with bearings on upward and downward sides of the track. The shaft was analysed and tested for maximum possible impact force. According to the calculations and readings the shaft was bearing the loads.

8.4 Conceptual Design Changes

In the new savior model, we have made some conceptual design changes. These include a unique shape of the body. The front and rear of the robot has a slanted edge at the vertex which will be lubricated. This feature was added so that in case of a clash with a an obstacle the normal component of the force will push the robot upwards. There will be a small component of friction (due to the lubrication). Another change was the increase in the surface area of the tracks to provide different locking advantages. The angle was decided so that the vertical component is maximum.

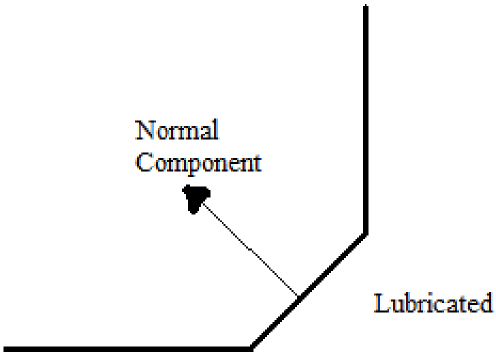


Figure 8.3 Front and Rear Shape

8.5 Camera Mount

To mount the camera, laser and other sensory devices, a camera mount has been provided, that requires two motors. This mechanism allows for 360° rotation along the z-axis (axis perpendicular to the ground) and 180° rotation on the axis parallel to the ground. The motor that will be used for the full 360° rotation is a stepper motor. The 180° rotation is provided by a servo motor by rotating form -90° – 0° – 90°. The advantage of this mechanism is that it provides us with same maneuverability as in any other mechanism, but with less no. of motors. We can lower the camera using this mechanism to allow the robot to travel through places with low vertical clearance.

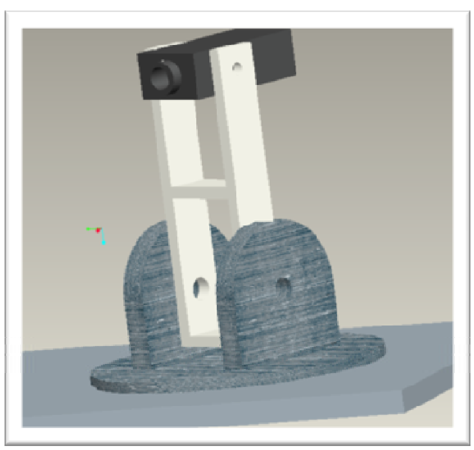


Fig 8.4 Camera Mount

8.6 Center of Gravity

The robot will have to have low center of gravity to ensure that it does not encounter any situation that will cause the robot to roll over. The highest risk of roll over lies in climbing the stairs. We calculated the position of Center of gravity of the robot that will prevent the rollover state.

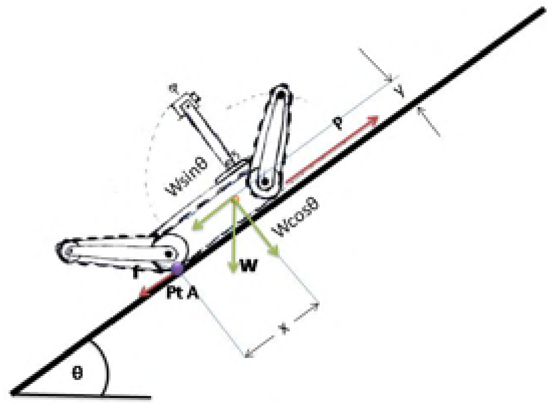


Fig 8.4 Center of Gravity of SAVIOUR

8.7 Motors

Main tracks are being driven by Pittman DC motors. Servo mechanism is being employed for the thermal imaging. Stepper motors with high resolution are being used for the rotation of laser and camera.

8.7.1 Pittman DC motors (geared)

High torque is needed to pull SAVIOUR through the extreme terrain that it is intended to travel. The rotational speed is low. It has instant braking ability. It has a gear reduction of 1:144; therefore a small ratio is needed. Also they are affordable.

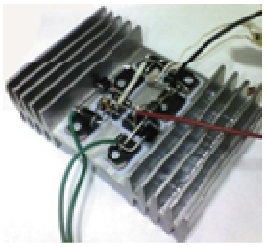


Fig 8.7.1 Pittman Motors

Fig 8.7.2 Motor Drivers

The motor drivers have been designed for high current.

8.7.2 Stepper motors

Laser and the camera are mounted on the stepper motor with step angle of 1.8 Deg ± 0.5°.

Fig 8.7.3 Stepper Motor

9. System Cost

•Total Electronics Cost	Rs. 84,100
•Total Mechanical Cost	Rs. 20,000
•Total Machining and Processing Cost	Rs. 11,000
•Total Processing Costs	Rs. 27,000
•Additional Miscellaneous Costs	Rs. 50,000

Total Costs Rs. 1, 92, 100

10. References

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