RoboCup2005
Rescue Robot League Competition
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RoboCupRescue - Robot League Team MRL (IRAN)

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http://robocup.mechatronics.ws/rescue_robot.htm

Abstract. In this paper the MRL rescue robot team and its robots are explained. We have designed and build four different robots for different situations. Our main goal of this activity is to achieve a practical rescue robot for real situation such as earthquake which is quite common in our country. We have organized all Robocup teams research works at the Mechatronics Research Laboratory.

Introduction

Rescue operation in a disaster situation is quite important and should be fast enough to save victims life. So implementing high technologies such as robotics could be quite helpful for search and rescue operations. There are so many earthquakes every year in many countries such as Japan, USA, Turkey and Iran. Robocup real rescue competition has provided quite stimulating situation for University educator to involve in such a humanitarian activity.

Our students in Qazvin Azad University are planning not only to take part in the competition but also to get enough knowledge to achieve a practical robot to help search and rescue operations in a disaster situation.

A major earthquake measuring 6.3-6.7 on the Richter Scale hit Iran on the morning of 26 December 2003 at 05:28 (local time), centered on the city of Bam, Kerman Province in the southeast of the country (Figure 1). Some 97,000 inhabitants of the old historical city used to live in low houses and buildings (one to two stories in height) made of bricks and mud (UNDAC figures indicate there is a total estimated population of 240,000 in Bam and the surrounding area).

Figure 1: Bam Earthquake

Within 30 seconds, more than 85 percent of these buildings turned into rubble. Surrounding villages also suffered limited damage.

Population	2 97,000
Deaths (preliminary)	28,000
Injured/evacuated	13,000
Injured/treated locally	17,000
Homeless	80,000

In this paper the MRL rescue robot team and its robots are explained. We have designed and build four different robots for different situations. Our main goal of this activity is to achieve a practical rescue robot for real situation such as earthquake which is quite common in our country. We have organized all Robocup teams research works at the Mechatronics Research Laboratory.

Obviously, based on the environmental situation a special robot with proper abilities is required. In other words, there could be no unique robotics solution for searching and rescuing program in a disaster situation. As a result we have designed different robots with different maneuverability. For example NAJI-II with a high power and flexible mechanism which overcomes hard obstacle is also capable of supporting a powerful manipulator for handling objects.

There are so many rough and hard terrains in a disaster situation which the rescue robot should be fast enough and low weigh to pass and explore environment quickly while it is stable. NAJI-I and NAJI-III are good examples of such a robot while NAJI-III with a novel mechanical design is quite faster, flexible and more stable. NAJI-IV which is facilitated with most required sensors, is a good experimental mobile robot to carry out different research programs which is also suitable for the yellow arena.

Rather than NAJI-I which is powered by a Laptop and Windows XP, the other three robots are powered by Embedded PC based on optimized RT/Linux which are able to process data and control the robot in Real-time.

1. Team Members and Their Contributions

- Team Leader: Ali M. Shahri
- Operator: Ali Paikan, Saeed Mokaram
- Mechanical design: Saeed Khalilzadeh, Pouya Heirati, M. Chitsazan
- Controller development: Mohammad Norouzi
- Software development: Ali Paikan, Saeed Mokaram
- Hardware development: Seied Mohammad Maavaei, Hossein Seifmanesh
- Electronics design: Jafar Chegini, Sara Pourazizi
- Instrumentation: Abozar Aghajani, Maryam Razzaghi
- Sponsor: Qazvin Azad University

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

As it is compulsory to set-up and break down in less than 10 minutes, we are going to consider several things for fast handling and operation. We are going to use notebooks rather desktop computer.

We are going to design a good mobile tool boxes to put everything on it for fast handling. Our operator is practicing more and more in a real situation to do everything as fast as possible. A good joystick with several control keys and handles is selected for easier and faster operation. It should be noted that we are educating two operators to replace any of them in case of happening any problem.

Our operators are equipped with a communication headset to contact their team members in case of requiring anything or organizing the set-up and break down process just on time. (This headset is just for the set-up and break-down tasks).

3. Communications

We are planning to make our robots ready for both tether and radio control techniques. This will help us to make a better decision depends on the situation. In case of radio control as it is suggested, we are going to use W-LAN 802.11A (5GHz). We are also going to use radio modem with the 433 MHz frequency.

Our communication system is designed somehow to be able to switch between W-LAN and radio modem. In case of missing the network connectivity or PC failure it is possible to command the robot through radio modem which is interfaced to the embedded microcontroller system.

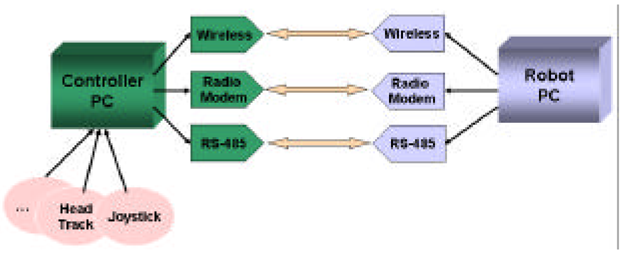

Fig 2: Communication

Rescue Robot League		
MRL (IRAN)		
MODIFY TABLE TO NOTE ALL FREQENCIES THAT APPLY TO YOUR TEAM		
Frequency	**Channel/Band**	**Power (mW)**
5.0 GHz - 802.11a	52 / 54 Mbps	N/A
2.4 GHz - 802.11b/g	11 / 54 Mbps	N/A
27 MHz	N/A	N/A
433 MHz	N/A	N/A

4. Control Method and Human-Robot Interface

The control scheme is partial autonomous. It means that the camera images are sent to the computer are processed by operator to navigate the robot. All other sensors information are also sent to the operator to investigate the arena and detect all possible victims. To avoid colliding the robot with the obstacles or victims an ultrasonic obstacle avoidance algorithm has more priority than the command of the operator.

Although the map generation is autonomous, when a victim is located, operator has to define the victim conditions based on the sensors data. In order to save time, a proper GUI is designed with several push bottom keys to define the victim's condition just by clicking the mouse button.

In case of loosing the control of the robot by the operator, a program is designed to return the robot back to the starting point autonomously using the map stored in the robot. All the sensors data are collected in a data bank to be used even off-line after the operation.

It should be mentioned that the applied servomechanism is digitally controlled by a PID control algorithm implemented on an AVR microcontroller system. An optical shaft-encoder is used to feedback the position and speed of the robot. All embedded-microcontroller system designs for servomechanisms, instrumentations and drivers are modular for easy repair and maintenance.

5. Map generation/printing

Map generation method is based on the operator assessment in conjunction with the collected data and a GUI program, which enables operator to locate and register different object such as victims, obstacles, walls and doors. As the robot proceeds to search and identify the field, the map of the environment will be developed which might be printed at the end of the robot mission. In our program, two maps will be generated. First, a 3D-map of the robot path with the location of all the victims will be generated autonomously. In this method, environmental conditions will be recorded while the robot is navigating the arena autonomously and the victims' condition will be recorded by the operator decision in the victims' data bank. At the end of the operation the victims' conditions will be printed by selecting each victim individually as the second map. Fig 3 illustrates a sample page of the NAJI Rescue Robot GUI.

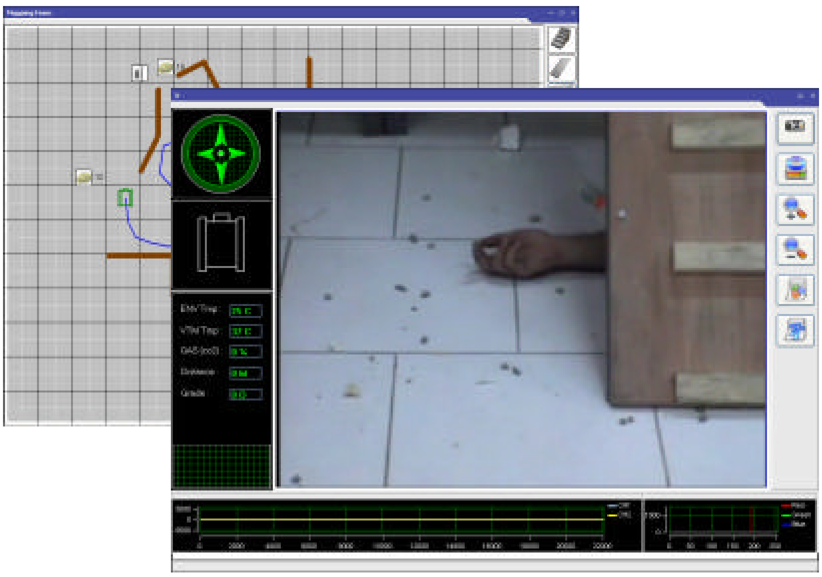

Fig 3: A sample page of NAJI Rescue Robot GUI

6. Sensors for Navigation and Localization

In order to navigate the robot in an unknown environment, a set of two cameras are used to help the operator to command/guide the robot and also a set of ultrasonic sensors to detect unknown obstacles which can be used in an automatic collision avoidance algorithm. As we have used digital compass and optical encoder for localization, these sensors can also be used for navigation as well. We have also used tilt senor for the robot for the arenas with slops on them to define the roll and pitch of the robot to correct the digital compass data and also correct the shaft encoder data to be able to generate a 3D-map. The localization is carried out by different methods to increase the precision and certainty. Conventional Dead Reckoning in conjunction with a digital compass decrease the error associated with this method.

7. Sensors for Victim Identification

We are planning to detect victims using a sensor fusion technique with logical combinations of camera images, chemical, audio, and IR-temperature sensors. The camera and other sensors data collected and managed by the operator are also processed using sensor fusion technique. Based on our experience in Padova, we are going to use an automatic adjustable camera to read the tag of the victims from a far distance. We have also used an IR range finder to locate the exact position of the victim compare to the robot position.

8. Robot Locomotion

We have designed four different robots for different arena (situation). But as a general rule all four robots are based on differential servomechanism which is explained briefly. We have used two identical dc servomotors to drive each robot. The robot may travel forward or backward by driving two motors in CW or ACW direction and it may rotate around its center of gravity by driving motors in reverse directions.

It should be mentioned that all the mechanical design process are carried out by our team members using AutoCAD2002 and 3DWORKINGMODEL. All the robot parts are built by CNC machines. The name of our robots are chosen as NAJI-I, NAJI-II, NAJI-III and NAJI-IV since NAJI means rescuer in Persian language.

The servomechanism control system is based on an embedded microcontroller and H-bridge driver using PWM method. The velocity and position of the servomechanism are controlled using optical encoder.

NAJI-I:

This robot is designed for outdoor and harsh environment. This robot was tested in Bam earthquake.

Fig 4: Photos of NAJI-I in a real earthquake situation in Bam and in the MRL test arena.

Table 1: NAJI-I Specifications

Weight	35	Kg
Cartridge Load	70	Kg
Max Velocity	15	Cm/Sec
Length	693	mm
Width	400	mm
Height	344	mm
Locomotion	2 DC servomotor	150 W

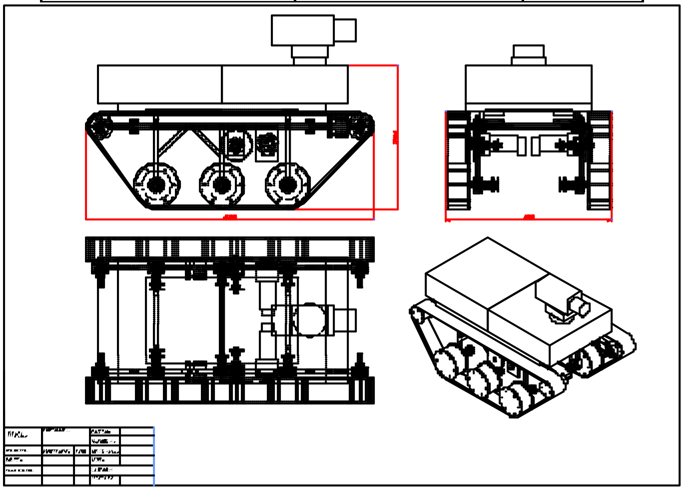

Fig 5: NAJI-I AutoCAD Design Map

NAJI-II

This robot is also designed for real outdoor situation which is able to navigate in a harsh environment and stairway. The robot has two arms with 360 degree rotation which enable it to move in bumpy area and stairway.

Fig 6: Photos of NAJI-II in a stairway

Table 2: NAJI-II Specifications

Weight	45	Kg
Carriadge Load	100	Kg
Max Velocity	1	m/Sec
Length	897	mm
Width	486	mm
Height	197	mm
Locomotion	3 DC servomotor	200 W

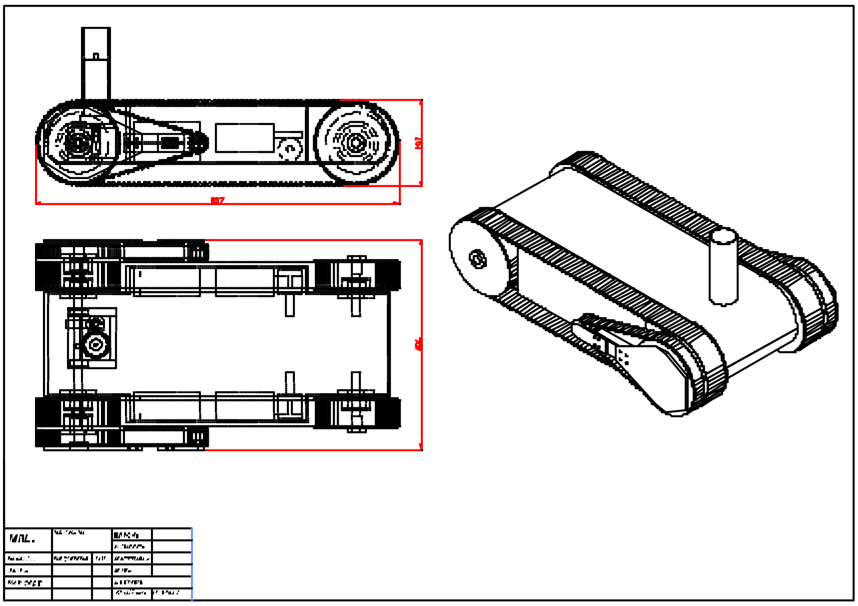

Fig 7: NAJI-II AutoCAD Design Map

NAJI-III:

This robot is also designed for a bumpy situation. It is equipped with a special mechanism to move in a bumpy arena while is quite stable. It is possible to change the height of the robot bottom. As weight of the robot is fairly low and needs less energy, it might operate longer compare to previous robots.

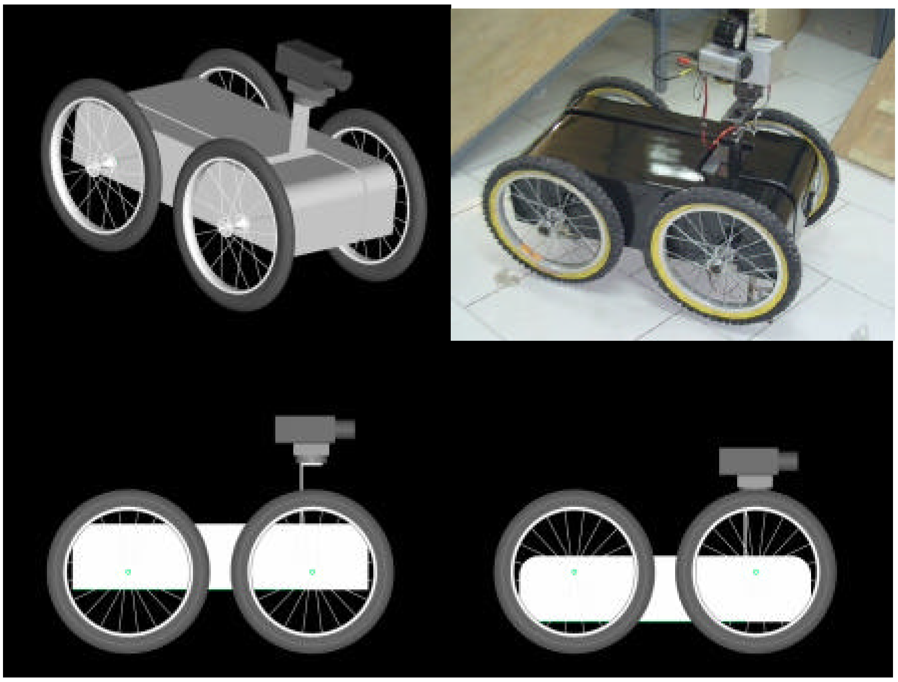

Fig 8: Photos of Real and Simulation of the NAJI-III

Table 3: NAJI-III Specifications

Weight	15	Kg
Carriadge Load	60	Kg
Max Velocity	10	m/Sec
Length	870	mm
Width	488	mm
Height	407	mm
Locomotion	2 DC servomotor	120 W

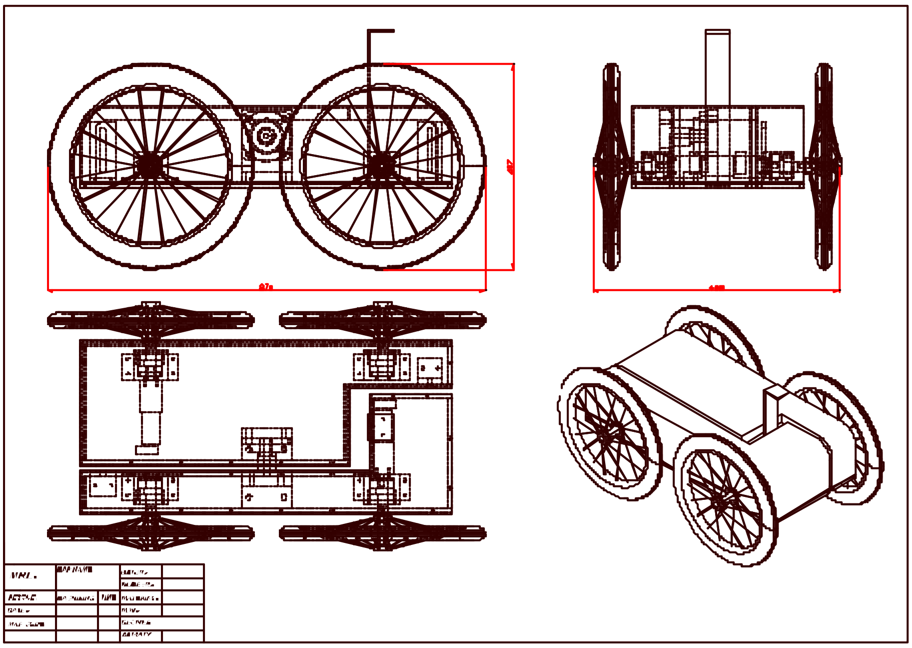

Fig 9: NAJI-III AutoCAD Design Map

NAJI-IV:

This simple robot is just designed for indoor and flat surface. The control and navigating of the robot is quite easy. Dead-reckoning technique with digital compass provide a very good and accurate localization method. The systematic mechanical errors compare to other NAJI robots is quite less.

Fig 10: Photo of the NAJI-IV

Table 4: NAJI-IV Specifications

Weight	5	Kg
Carriadge Load	7	Kg
Max Velocity	0.5	m/Sec
Length	378	mm
Width	378	mm
Height	180	mm
Locomotion	2 DC servomotor	120 W

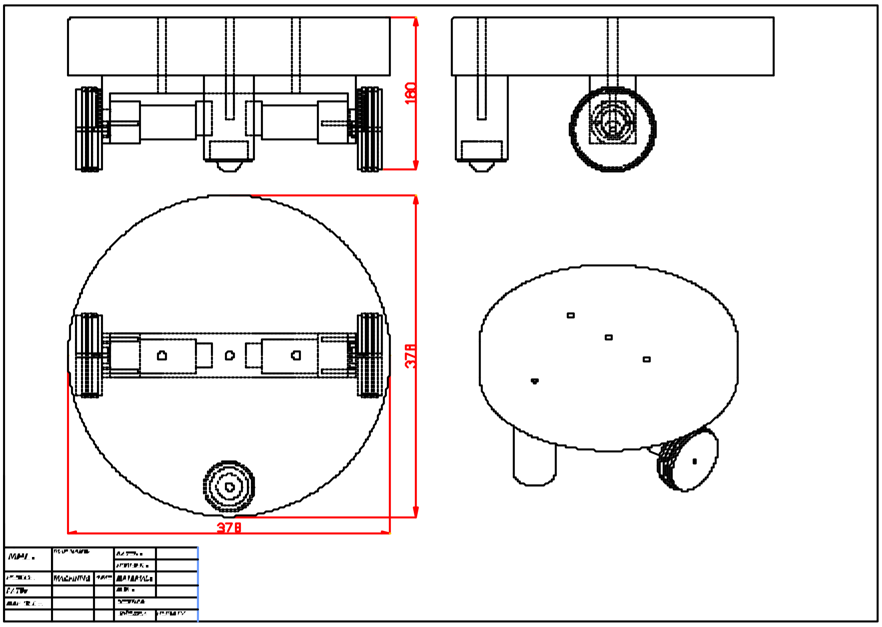

Fig 11: NAJI-IV AutoCAD Design Map

9. Other Mechanisms

N/A

10. Team Training for Operation (Human Factors)

As mentioned before we have managed to train two operators. We have also prepared a combination of the Yellow and Red arena next to the Mechatronics Research Laboratory to test our robots. So operators can improve their skill to command the rescue robot professionally.

11. Possibility for Practical Application to Real Disaster Site

As we experience so many earthquakes in our country, our main goal is not only to take part for Robocup competition but we are aiming to design and build real rescue robot for real situation. For example our first robot NAJI-I which was in Padova was tested in Bam earthquake to realize real problems and finding proper solutions.

12. System Cost

Most of the mechanical parts of the robots are designed and built by our team members. Depends on the type of the motor we have bought our DC servomotors from Maxon and Faulhuber. Ultrasonic sensors and digital compass are bought from a company named Robot-Electronics. Other sensors, Wirelss-LAN card, Radio modem and electronics parts are bought from local shop. The cost for each robot differs depending on the size and complexity of the robot but approximately each robot cost us about 3000-7000 $US.

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TOTAL SYSTEM COST (per robot): N/A