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RoboCupRescue - Robot League Team Shahed (Iran)

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Abstract. We are **Shahed** robotics group. Our team has four members. We arranged a 2-robot team and a base station. Each robot has an I/O Processor (a microcontroller) for collecting sensor data and applying command to motors, and actuators, and doing critical decision such as collision avoidance. I/O Processor sends all collected data to a host computer which is already a laptop but can be a biscuit board (Industrial PC) via USB. Our robot has truck locomotion system. Each belt is droved by a gear boxed motor through a timing gear. Our design has provisions for redundancy. Our robots have three Ultrasonic Range Finders, three IR Range Finders, one Compass, one Gyro, one IR Detector with Lenz to detect heat wave radiated from human or animal body, one Zoom Microphone, two Motor and one Camera with night vision compatibility. They operate via Wireless LAN Connection and receive/send voice/video/data via it, and also have one RC Control System. Two robots can also exchange data with each other.

Introduction

Shahed Robotic Team started from September 2003. It has four members; Mohsen Rahnavard, Mahdi Asadpour, Hamed Esteki and Nasrollah Gheisari. Each of us has responsibilities related to his field of study and also Mohsen and Nasrollah both studied electronics, none of us works on the same task. Electronic and Sensory design and

Microcontroller code development is done by Mohsen. Computer software on robot and host laptops are developed by Mahdi and Mechanical design and construction is done by Hamed. Our work has a temporary stop for M.S entrance exam, and we are working hard to complete our robots construction by the end of March. Our design is completed now. We worked on a robot that can be so reliable that can be used really in destroyed area.

1. Team Members and Their Contributions

Team participators:

- Mohsen Rahnavard — Electronics, Sensors, microcontroller code developer and designer
- Mahdi Asadpour — Computer software developer
- Hamed Esteki — Mechanical design and construction
- Nasrollah Gheisari — Electronics fabrication and system assembling

Team advisor:

- Mohsen Rahnavard

Team sponsor:

- Shahed Scholars Center

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

We need a desk with a 4-way 220-240 volts power plug.

We use these equipments on this desk:

- A laptop,
- A joystick connected to laptop,
- A monitor connected to cameras on robots and
- A battery charger.

We will use pre charged batteries according to our design, robots can run with full power for 2 hours and we will use one set of spare charged batteries.

Using your WLAN Infrastructures we can setup **wireless network connection** between robots and host PC in 2 minutes. We will assemble our robots at our workshop so there no need to time for assembling.

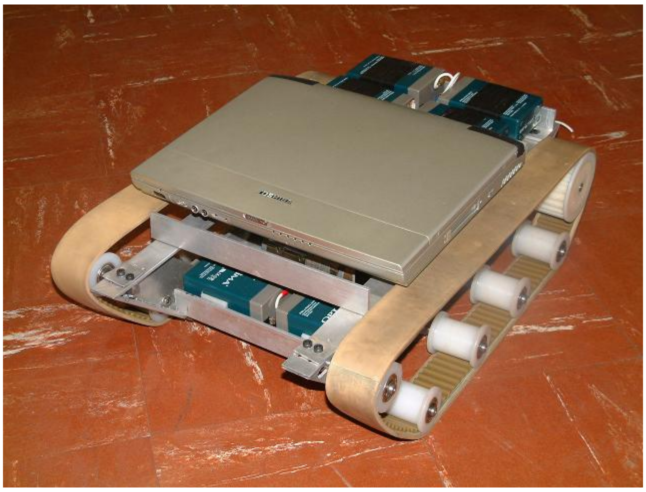

Fig. 1. Top view of our robot_1.

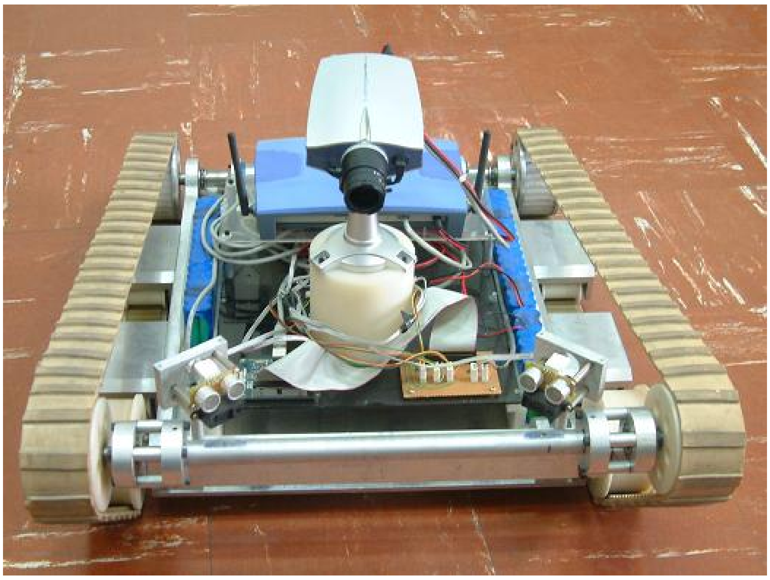

Fig. 2. Top view of our robot_2.

3. Communications

We will use **802.11a** standard to network our Robots.

We will use wireless network connection for this purposes:

1. Transiting control commands to robots.

2. Receiving status of robot parts e.g. motor temperatures.
3. Receiving sensor values on robots.
4. Receiving video stream and voice stream from camera and microphone located on robots.
5. Sending a video and voice to robot to help victim from remote station.

We need only one Mbit/sec. for all of those applications for each robot, so we only need a bandwidth of two Mbit/sec from wireless network.

We will use Radio Control instrument and probably a video link in 27 MHz. This is mainly because of reliability. Some fatal commands (e.g. Stop, Start, System Restarting and …) can be transmitted by this mean.

4. Control Method and Human-Robot Interface

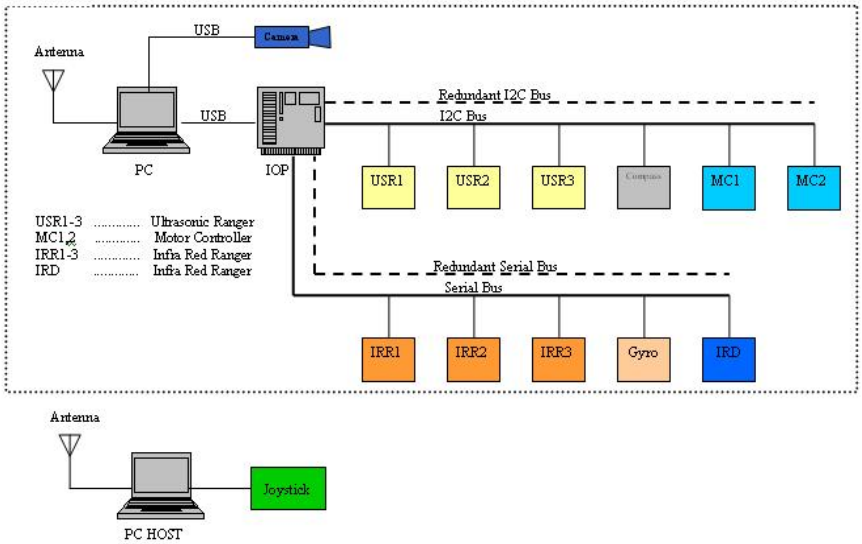

Fig. 3. Block diagram of system.

We will use partial autonomy strategy. This means that our robot can handle some of its needs.
Our robot will do these tasks automatically:

- Obstacles detection, impact avoidance
- Gyro stabilized movement
- Closed loop speed control
- Accepting joystick / arrow keys on laptop is used for guidance and control
- Semi automatic path finding: less probability of impact to barrier

What operators do is:

- Setting the Speed,
- Setting the Direction and
- Adjusting the camera pan or tilt or zoom.

5. Map generation/printing

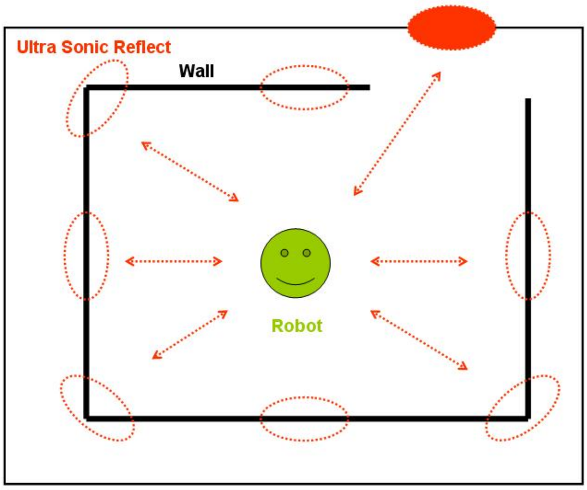

Fig. 4. Path finding using ultrasonic and IR range data.

We are using:

1- Speed control with better than 1% accuracy.
2- Gyro stabilized movement with approximately 5% accuracy.

So, our speed and direction of movement is supposed to be accurate.

We will use them for position measurement. Data from GPS and Compass is used to improve the accuracy of position measurement.

Victim sensing: IR radiation from victim’s body is used to detect the victim. We can improve this detection with color recognition.

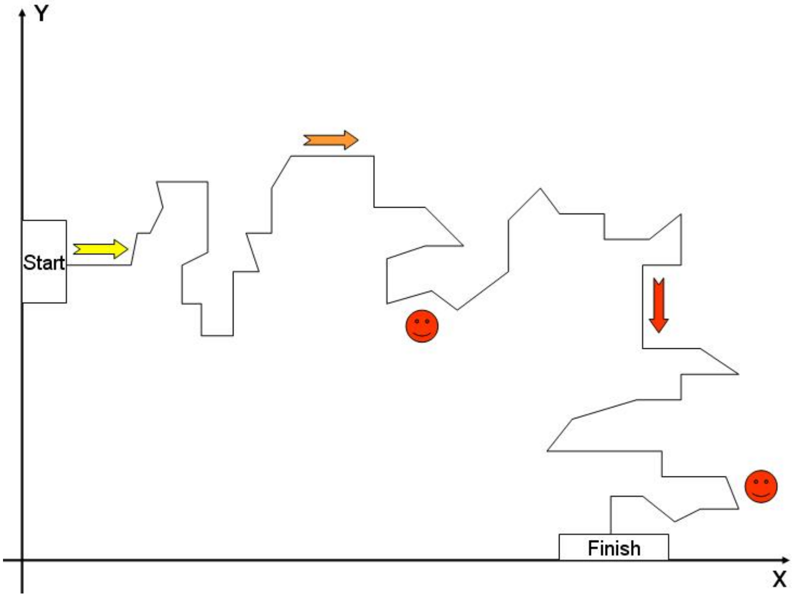

Fig. 5. Robot trajectory and victim identification output from our program.

We will report these data in a picture file with legend and scale. One example is seen in Figure 5. We can merge this trajectory with a given bitmap picture file to produce a complete map and robot trajectory and victim locations in one picture.

6. Sensors for Navigation and Localization

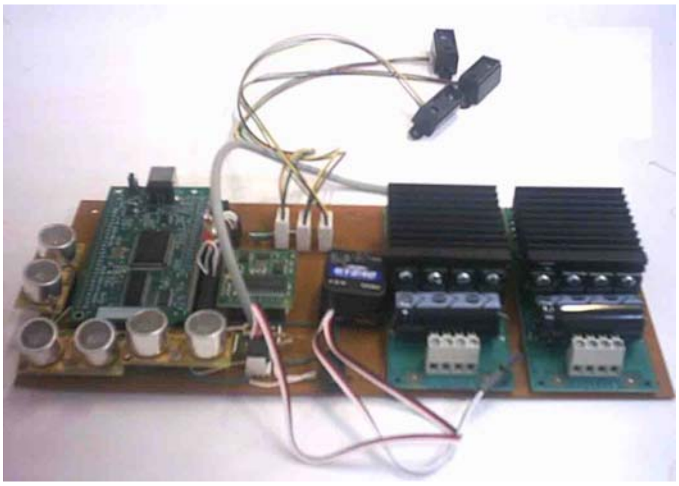

Fig. 6. Electronic board.

- **Ultrasonic Range Finder** with up to 17 reflections from environment. Ranges data are in centimeters for up to 8 meters
- **IR Range Finder** for sharper and more accurate range finding in the range of up to 80 cm from robot.
- **IR Heat** sensor from body of living objects (Victims, Animals …)
- **Tachometer Speed Meter**
- **Light** sensor (environment)
- **Compass** with 0.1 degree resolution
- A **gyroscope**
- Visible and **IR** (night vision) camera
- **Zoom microphone**
- **GPS**

7. Sensors for Victim Identification

We are using three sensors:

- Human body IR sensor (1-14km)
- Color detection in visible band pictures
- Zoom microphone to search for human weak voice

We considered human voice detection but due to large acoustic noise in the championship room we canceled it. We only transmit sounds around the robot to operate stations so operate can locate the victims. After locating a victim, operator can establish a voice/video connection to robot, so operator can see and hear victim and also victim can see and hear the operator and receive instructions to help him/her self.

8. Robot Locomotion

According to a destroyed area situation and time importance in a rescue service, there are assumed some parameters according below:

1. **Ability of destroyed area crossing**
   Truck systems, according to tank motion mechanism, because of large surface contact and ability of crossing parallel stops, is a suitable system. Using free wheels with short distance to each other, in addition to reduce friction, reduce belt deflection and cause moving freely.

2. **Ability of turning on certain point**
   According to applying velocity on a point at the center of each truck, robot can turn around its center. So robot occupies less area while turning.

3. **Large Revolve Speed/Torque ratio**
In truck system, because of using driving wheel with small diameter, we can supply needed force to move with less torque. According to inverse ration of speed and torque and limitation of torque based on weight in DC motors, there is assumed an optimized point for speed and torque. Linear speed motion of robot_1 is 0.7 m/s and applied torque is 5 N.m. At the robot_2, we can apply 10 N.m , with the same velocity.

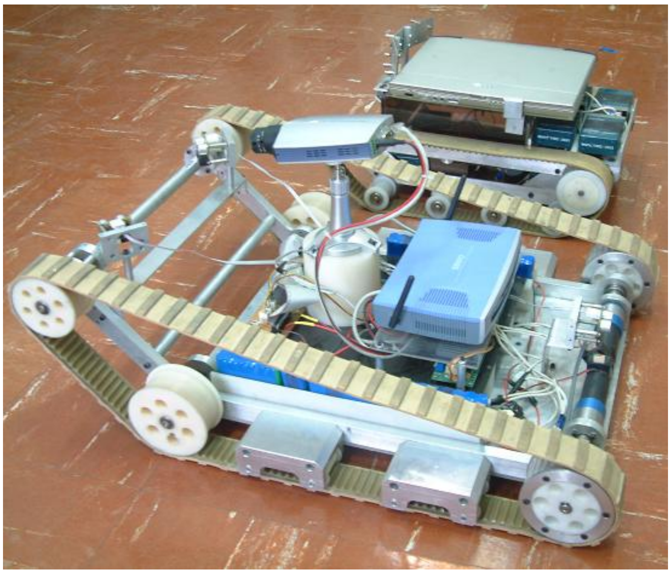

Fig. 7. Side view of robot_1&2 locomotion devices.

Truck System:

1- Two DC servo motor
   - With parallel situation in robot_1

   This model has three benefits:
   a. We can change our motor speed, because of motor limitations.
   b. We can reduce our robot width, so we reduce the motor torque needed and reduce the robot weight.
   c. Canceling weight concentration in one point.

- In one raw in robot_2.

2- Set of timing Gear and Belt to transport power to driving shaft in robot_1.

Fig. 8. Power transition of robot_1.

3- Timing Gear on driving shaft in the back side.
4- Timing Belt with antifriction belt at the external surface. Anti friction belt has two benefits:
   a. Wheels have steps to avoid cross moving of timing belt. This belt avoids contacting of wheel and ground.
   b. Having high friction coefficient cause climbing robot from high bodies.
5- Set of free wheels.

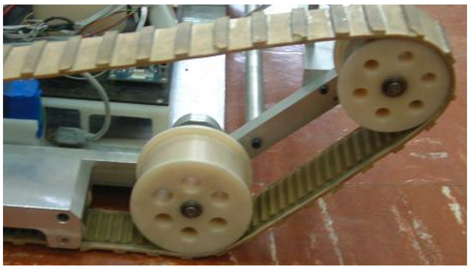

Fig. 9. Truck of robot_2.

Using two robots with different shape and scale help us to approach these goals.

- Robot_1 can move in tight paths
- Robot_2 ,because of its dimensions can cross high steps

So we can search all the surrounding.

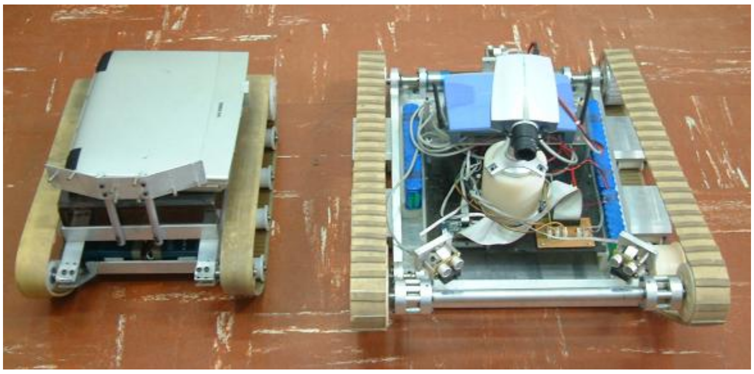

Fig. 10. Front view of robot_1 and robot_2.

9. Other Mechanisms

We use a microcontroller from Cypress that has an 8051 CPU core and a USB client interface. Microcontroller collects data from sensors and applies commands to motors and actuators. It sends all connected data to host computer on robot for further processing, those tasks may require more processing power that one available on this processor. It also isolated I/O devices and noisy and high current motors from expensive laptop. Another idea that we used is that all sensors and actuators are on serial buses. This enables us to prepare a redundant bus or also redundant CPUs. This idea hot implemented in our robots and only we foreseen a structure that potentially can accepts this idea. Another redundancy in our system is the control from separate R/C Controller. So on failure of WLAN we can manage our robot to a safe location or bring it out from a blind spot of WLAN coverage.

10. Team Training for Operation (Human Factors)

We will operate our robots. Each of us by him/her self can operate robots.

We think a person familiar with electronic/computer instruments and knowledge of driving can operate our robots, in case of need for training 4-10 hours seems to be adequate.

Fig. 11. User program interface for controlling robots.

11. Possibility for Practical Application to Real Disaster Site

Our robots are well made and as see you can see in attached movie clip it can pass large barriers with its full speed. Our electronic does not produce much heat so we can seal it.

We conclude that our robot can be used in real places. Maybe some modification and strengthening are needed.

12. System Cost

We bought parts of our robots from the following vendors. Mentioned sites have prices. Total cost of each robot is approximately 600USD plus 3000USD for laptop which can be used for daily usage after championship.

TOTAL SYSTEM COST (per robot): 600USD + 3000USD (laptop)

KEY PART NAME: **Laptop**
MANUFACTURER: TOSHIBA
COST: 3000USD
WEBSITE: http://www.toshiba.com/

KEY PART NAME: **Motors, Gearbox, Tachometer**
WEBSITE: http://www.faulhaber.com/

KEY PART NAME: **Motors, Gearbox, Tachometer**
WEBSITE: http://www.robot-electronics.co.uk/

KEY PART NAME: **Motor Controller, Compass**
WEBSITE: http://www.robot-electronics.co.uk/

KEY PART NAME: **Ultrasonic Ranger (SRF 08)**
WEBSITE: http://www.robot-electronics.co.uk/

KEY PART NAME: **Gyroscope, IR Ranger, IR Detector**
WEBSITE: http://www.acroname.com/robotics/parts/c_Sensors.html/

KEY PART NAME: **Chips**
MANUFACTURER: Our local electronic markets

References

We study these books during our robotic works:

1. John Hyde: USB Design by Example A Practical Guide to Building I/O Devices (Second Edition), INTEL-PRESS, 2001
2. Myke Predko: Programming Robot Controllers, McGraw-Hill, 2003
3. MINDSHARE, INC., Don Anderson, Dave Dzatko: Universal Serial Bus System Architecture (Second Edition), ADDISION-WESLEY, 2001
4. Penelope Probert Smith: Active Sensors for Local Planning in Mobile Robotics, World-Scientific, 2001
5. W Khalil & E Dombre: Modeling, Identification & Control of Robots, Hermes Penton Ltd (HPS), 2002