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RoboCupRescue - Robot League Team Persian Gulf (Iran)

Meysam Radmanesh[1]

Asadollah Norouzi, S.M.Mohammadzadeh[2]

Zahir Barahmand, S. Behzad Ejlali[3]

[1] Electric and electronic Department
[1]Computer Department
[3]Mechanical Department
I.Azad University Tehran Central Branch
Vali-Asr complex, Damavand Ave.
Robocup2005@prpco.com

Abstract. Nowadays one of the important robotic industry usages is to utilize robots as a help in unexpected evens such as earth quacks, floods, fires, explosions, and etc. the bam rescue robot is designed and built in order to increase the exploration and searches speed and also the rescue operations. This robot has a really well shaped and convenient mechanical design .the robot control system preparation and according to its multi_ layer architecture working in any conditions and any occurrences are possible. The low transferred information is one of this robots ability. This robot's soft ware is been designed intelligent and semiautomatic. all the below specifications are including the researches activities and the used tools in the second robot's generation. Most of the second generation plans and designs are finished and we are doing our best to complete other parts as soon as possible. we are also doing our investigations about this robot's third generation. the third generations design goal is to build an autonomous and automatic rescue robot. In this paper We have often pointed to some parts of its plans. The major additional technique compared to last year is our new map generator and navigation systems.

Introduction

The robot's design and construction's aim is to have a practicable usage in the disaster sites for the exploration and the injuries saving. This robot is being prepared for the world competition participation with all the masters and experts' guidance and consults. And is Prosperous many unique abilities. The design and the multi layer control system construction implement, predicting most of the unexpected events, the convenient and powerful mechanics, reliable software and the intelligent insurance are the bam robot's advantages. As being mentioned upper one of this robots unique merits is the multi layer system control so that due to any control, connection, and software tools laid up, the whole system can give user the robot control by a manner. The computer equipment using or not using ability in robot guide is one of these points.

One of the other robot's special points is the comprehensive and complete mechanical instruments design by using various software systems. Removing the problems and the planes amendments by using the various soft wares the mechanical specifications has been examined and tested and the brilliant sequences caused to take steps for building the robot.

1. Team Members and Their Contributions

We have made some changes to our last year's team (BAM) including inviting new people for better performance. The team members and their contributions are as follows:

- Team Leader: Meysam Radmanesh
- Operator: AmirMehdi KhademAstaneh
- Mechanical design: S. Behzad Ejlali
- Mechanical design: Zahir Barahmand
- AI[1] Developer: S. Mohammad Mohammadzadeh Ziabary
- AI Developer: Asadollah Norouzi
- Controller development: Hani Moghaddam
- Software Developer: Hadi Firouzi
- Navigation system: Mehdi Emami
- Navigation system: Ehsan Abbasi
- Navigation system: Pedram Johari

[1] Artificial Intelligence

- Electronic And Control: Amir Mohamadi Tashakori
- Electronic And Control: S.Fatemeh Taheri
- Advisor: Prof. Abdullah Jasbi
- Advisor: Prof. Karim Zare
- Advisor: Dr. Rashidi
- Advisor: Dr. Teshnelab

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

2.1 Packing

Attending to the held competition place (Portugal country) the travel difficulties, traveling costs, tools, pieces and fragments sensitiveness and avoiding the probable robot damages from the first the robots design has been started with a fit image and the final goal has been decided to be able to completely disjoining robot to the detailed pieces. According to this decision the complete robot is sep repeatable after build and is an able to settled in a small movable suitcase, which can be packed in the least possible time.

Considering the rescue robot s in 11 September films, the bam tragic disaster in Iran, and this year's competition rules and just to use robots in the actual disaster sites we have prepared two packing systems for robot the advantages and the usages are explained below.

2.1.1 Travel Packing System

The robot tools have been designed and completely mapped by attending to the instances such as

- The easy and confident robot transferring in the between cities traveling
- Sending the robot by post
- Decreasing the robots bulk

According to that the robot mechanical system is able to separate and in separate the robot parts completely it means that all the robot parts from electronical tools to wheels and the robot body are part with each other and must be put in a suitcase so then by need it its easy to pack.

The complete robot montaj time for at least 2 persons are 15 to 20 minutes nearly equivalent of this time is needed to separate to the small parts to settle in the suit case. The special suitcase for these is a metallic suitcase that is partitioned with sponge and yonolites.

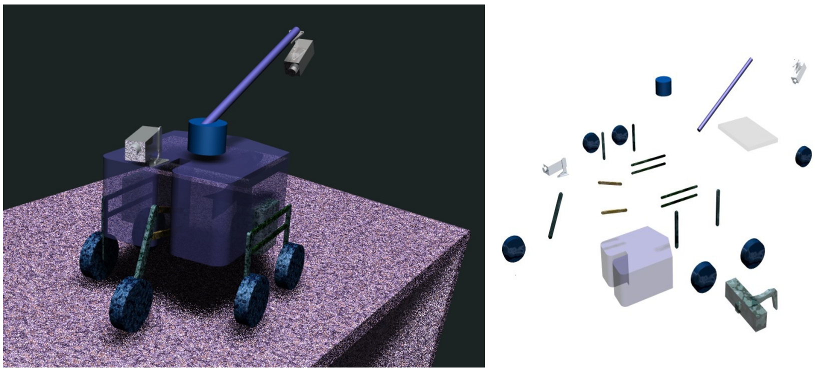


Fig. 2.1.1.1

2.1.2 Portable Packing System

Referring to that the rescue activities in the real disaster sites is needed to a transportation from a place to another, we need an easy system to move the packed robot accompanied by the control instruments. So for this reason we have designed another system. Packing for moving the robot in a point to another in the disaster, which is including fit specifications. Contradicting to the travel packaging system, this system is dividing the robot in to two or three main parts .the robot tool collection which contains control system (portable computer), the robot body, the forth camera, and the hand controller must be settled in a military backpack. To avoid any human rescue back damages there will be two yon olit colors that cover the round robot before putting the robot in the backpack.

The portable packaging system processing speed time is so proper and is about 3 minutes and the equivalent of this time is needed for packing and putting the robot in the backpack that just need a single person.

- We can compute some of the systems Particulars below
- Carrying the control tools by robot
- The lightness system (using backpack instead of the steel suitcase)
- The equilibrium preservation during the running and going up the stairs with robot.

The packaging high speed (in separating and in separating) the minimum number of the system operators (one person)

2.2 The Automatic Test

One of the other system arranged specifications is to test and examine each part of the system before using the robot .the system automatic test will be active automatically after the packing and turning the robot on.

This soft ware with the step by step test, is examining the tools accuracy and the exact command executing by robot tools and at the end of each test it will announce the succeed or defeat sequences by an acoustic system and a software program.

- Testing and recording all connection system nominal and operating capacities
- Considering the motors receipt feed back by giving the short commands to the wheels (motors)
- Sensor connection or disconnection with considering their received quantities
- Testing The robot sight by examining the camera signal receives, the connections between soft ware and cameras test, the camera primary calibration and the forth camera 's test (the mobile camera)
- The system localization test and its quality

At least by testing the different robot parts (such as the sonar soft ware calibration and etc.). The primary robot testing and setting up will be finished. The testing robot soft ware will automatically execute this step and the program maximum duration is about 2 to 3 minuets.

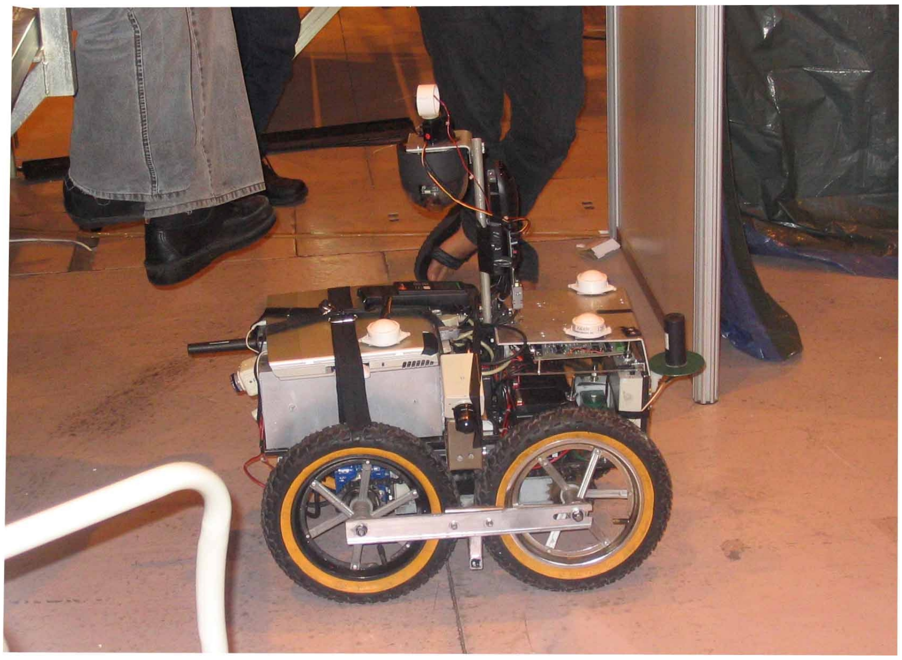


Fig. 2.2.1 BAM robot competing in RoboCup2004

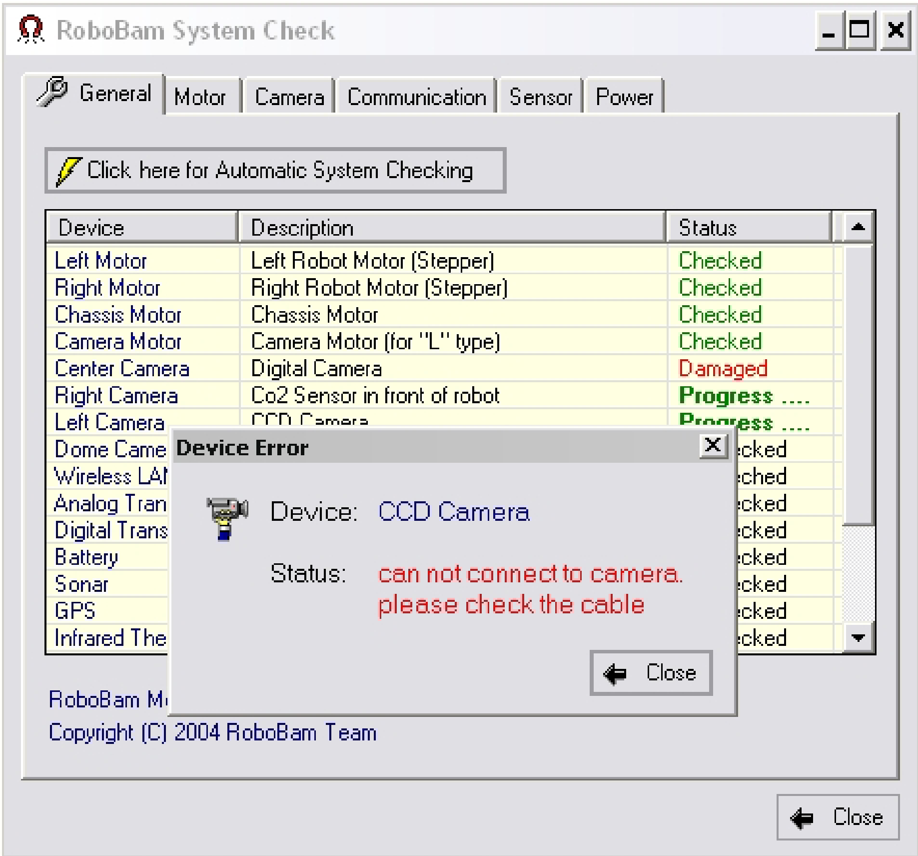


Fig. 2.2.2

The worth mention point is that all the automatic steps which has done by the software can be accomplished hand operated and step by step that is obvious to find in the picture below:

Attending to all the above points the system primary set up (accounting the tools software testing system) is maximum 6 minutes and approximately needs 3 minutes time to recollect the robot in to the special backpack which is totally so proper time for set up and system using.

3. Communications

In order to have more confidence in sending and receiving data there are 2 different (separate) ways to communicate between operator and robot. First one uses a wireless LAN card and has a digital connection because there environments such as the competition or natural environments are so noisy, digital system are encountering problems as: bound width, data interference, lack of enough channel for sending

/ receiving data and etc. that's why we use 2 send /receive systems on another frequency.

On system is receiving control information from the operator which digital transmitter sends. And will be encode in a high bound width. Bound width is very low but reliable, so it is just used to control the robot directly. There is another system for unexpected images and robot – computer to control room by a military video transmitter with a special encoding through frequency fields. It works parallel and synchronous with mobile computer to send the main camera's information.

3.1 Wireless LAN Card

In order to choose the LAN card for communicating robot computer and controller We have made comparison Between 2 models:

- LAN card 802.11 a – 5ghz – 54mhz
- LAN card 802.11 b – 2.4ghz – 11mhz

RF Range	802.11a: 5.15 ~ 5.85 GHz 802.11b: 2.4 ~ 2.4835 GHz
Data Rate	802.11b 11 / 5.5 / 2 / 1 Mbps 802.11a: 54 / 48 / 36 / 24 / 18 / 12 / 9 / 6 Mbps
Modulation	802.11a: BPSK, QPSK, 16 QAM, 64 QAM 802.11b: DBPSK, DQPSK, CCK
Number Of Channels	802.11a: 5.15 ~ 5.25 GHz Four 20 MHz channels, 5.25 ~ 5.35 GHz Four 20 MHz channels, 5.7255 ~ 5.825 GHz Four 20 MHz channels 802.11b: Europe - 13, US - 11, France - 4, Japan – 14

Fig. 3.1.1 802.11a and 802.11b

PCMCIA LAN card made by d-link with 802.11 a standard was selected and used on robot telecommunication system because of some reasons such as:

Increasing number of ports, reliable modulation and special high data rate.

Which will be installed on both robot – computer and controller computer.

The Selected model is dwl-a650, which can increase data rate to 72 mbps and pear to pear without access point by using "Wi Fi5" technology. Properties:

Adapter Type	Type II CardBus
Range	54 Mbps @ 40 feet
Range	6 Mbps @ 300 feet
Available Channels	Eight (8) non-overlapping channels for North America
Weight	0.25 lbs
Network Architecture	Ad-Hoc Mode (Peer-to-Peer without Access Point)
Network Architecture	Infrastructure Mode (Communications with Access Points)
Operating Temperature	0°C to 60°C
Operating Voltage	3.3V± -10%
Physical Dimensions	117.86 x 54 x 5 (mm)

Fig. 3.1.2

Fig. 3.1.3 D-Link DWL-A650 Wireless PC Card Adapter

3.2 Analog Telecommunication

Opposed to the wireless LAN Analog telecommunication (send/receive image) system which can send /receive in both sides simultaneously this system can just send from one side and receive from the other side.

This is a military system aimed to send the camera images or monitor analog out puts, and can take images from a noise range because of FMWB modulation.

We use this system only for sending video data from robot and receiving with controller. 1.5-watt transmitter on robot side receives analog image from control board after receiving analog information and using a video AtoD transformer, receiver on controller side gives information by a sub port.

Transmitter properties:

- The Frequency: L band 1.2 GHz to 1.43 GHz by 25 MHz distance
- Modulation: FMWB with 27 MHz deviations
- Output power: 1.5 watt
- Spurious: <-85 dBm
- Power supply: 12 volt

• RF connector: n type, 50ohm

Fig. 3.2.1 Video Analog Sender 1.5 Watt

The Receive is applicable to the transmitter. Sensitiveness of transmitter for image in signal/noise 450 dBm is minimum -15db.

• Power is 15v and descent frequency is 80db.
• Image output connector is BNC and RF connector is N.

3.3 Digital Telecommunication

This system will be used in order to control robot simply with control board (on robot), when necessary. It can change 318 MHz, 433.92 MHz and 868 MHz frequencies. And uses ask, FSK modulations. Both of transmitter and receiver is designed and produced by designer team. Most of bound with is used for data coding. And so received data is reliable, because this system is used to have direct communication with robot hardware, noise or unreliable information may cause collision.

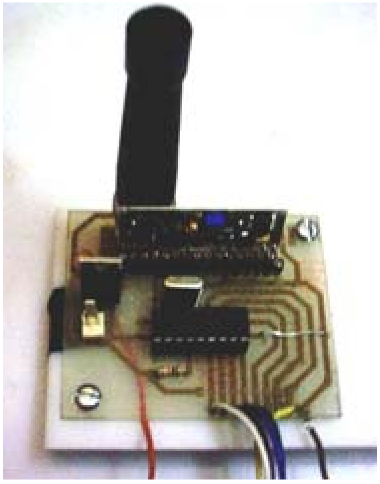


Fig. 3.3.1

Telecommunications send/receive board can be changed easily, if noise or collision Interferes .it has a soft ware (automatics/manual), in order to examine the efficiency or qualification.

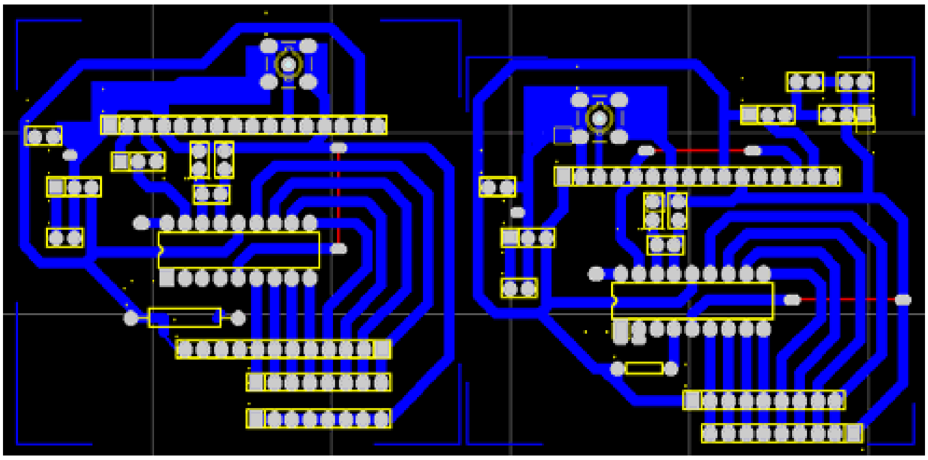


Fig. 3.3.2

4. Control Method and Human-Robot Interface

The mechanisms for controlling a robot have even greater importance than the other tools for designing it. In the other word, more over a robot successful and efficient in performance process (stage) depends on a sufficient and precise design of the control. One the most complicated process in design and develop of a robot is the communication of computer, mechanical and electronically mobile devices beside each other. The usual problem in this part is the lack less of the complete use of the experience of other robots. Because the way of controlling a robot has a direct relation to the computerized, mechanical and electronic parts in this way if one of the devices of the system changes a Bit, the way of controlling the robot will be completely changed.

According to the past experiences and having different sessions with the internal and external companies and also their agents in Iran and of course the team consulting sessions and by using the experts, our rescue robot comprehensive controlling system has been designed in two main layers, which is shown below:

The first layer of the controlling system involves mobile controlling devices that responsible for the many of the primary processes, automatic and semi automatic control. The second layer of the system includes the devices in control room that is used by robot operators. The connection between the mentioned layers of control is done by the various communication systems. As the accidental environment are full of noise and danger and also are unsecured and the control of the robot is done by remote control, one of the primary basic of designing of controlling systems of these robots are predictable of unexceptional events.

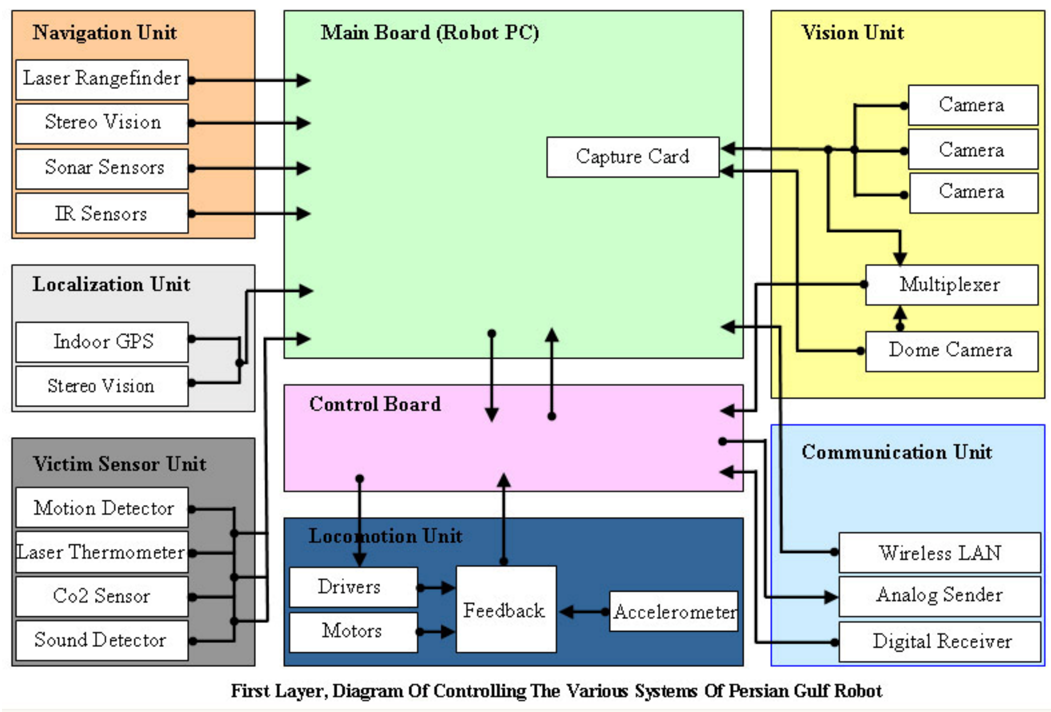


Fig. 4.1 First layer, diagram of controlling the various systems of Persian Gulf rescue robot

4.1 Automatic Control System

As you observe the figure, all tools are under control of central computer system (one of the unique and useful specifications of the robot is the direct control of the computerized system of the instruments).

Most of the controlling systems include the hardware or software system gather receive information from robot and send them to the controlling computer of the robot. Sending the information of sensors, images of cameras and gathered information from environment feedback and etc make the huge set of data and sent to operator computer without any process and then controlling computer returns the necessary instructions by processing information and receive operator's orders to conduction and guidance of robot which the information has a long capacity according to different devices.

The designed system, which is used in our rescue robot, is based on the omission of into mediator in process of information. It means that the information of sensors, the images of the camera and the other gathered information of robot on the computerized system of robot gather and process and the conclusions display inside the controlling software on the robot and then the information send from the same software to the different devices for conducting and controlling the robot on the other hand the operator that controls the robot can observe the desktop of the computer in the robot wireless and from remote with the use of the specifications of operating system (OS) and also the use of LAN communication and transfers the information from mouse and keyboard to the computer of robot with active little data. In simple word, it transfers instead of transferring the information of computer of robot to the controlling computer. The comparison between the capacities of data (the information of sensors, the images of different cameras, etc) instead of the desktop image of the robot computer and sending the information of mouse and keyboard instead of transferring the controlling and conducting instructions seen to be ideal. Therefore it makes less difficulty for controlling the robot in the case of reducing of bit rate of network and even we can decrease desktop image quality in the difficult situation.

Advantage of this method instead of transferring data:

- Decreasing the capacity of exchanged information
- Increasing the efficiently and the control speed
- Selectively of the operation system of controlling computer (today there are remote desktop connection programs on the any kind of Windows, Linux, and etc).
- Software integrity (using of the software in order to observe and control the system)
- Omitting the heavy pooling connection TCP/IP network in order to exchanging data)
- Not to lose the information packets

4.1.1 The semiautomatic controlling system without connection to LAN (Emergency 1)

Automatic controlling system need a simple wireless network (or every other network) in order to connect two systems to each other, the duty of communication is on. The wireless LAN card, model 820.11A in the our rescue robot, as the situation of the accidental environment involve the unexceptional events, we add a controlling system layer to the system in order to avoid the wireless digital network get out of order and to hold the communication between robot and us and to continue the rescue activities in the emergency situations.

An analog video sender system puts on the robot that can transfer the images of the computer monitor of robot to controlling computer in case of cutting the wireless LAN communication. On the other hand a digital information receiver with the low data rate that puts on the controlling board is responsible for receiving the information control of camera and engine. The software automatically does the display of cameras and gives the different information from the sensors and the status of environment that the transfer of desktop image of robot computer on the monitor of control computer observes the information. A small box instead of the software directly controls the robot, which is in operator's hand.

Of course, for the 3rd generation of the rescue robot, have done the completely design in order to control of more than 80% software through some keys which put on the controlling box. Therefore, operator can continue the process of rescue and conducts the robot by holding the controlling box in his hands in the case of emergency situation and loss of robot communication.

4.1.2 Semiautomatic controlling system without the use of robot computer (Emergency 2)

The robot computer may be disable in rare case because of shock or even without any reason and doesn't restart by using of controlling box (ref the part of controlling box) and the main board burns or disables, in this case we can use the controlling box and receive the images from the previous analog receive in order to control the robot like the emergency situation 1. The only difference is instead of receiving the robot computer monitor, the analog sender takes the images of 4 cameras all together by video switcher and the operator observe the images of 4 camera be inside each other. There is certainly no access to the information of sensors because the computerized system of robot gets out of order and the existence system will continue to the rescue activity just by vision.

4.2 The 2nd layer of control

The 2nd layer of control that includes the controlling devices and tools of the robot in control room that is being used by the operator .we have tried to utilize the most simple and efficient devices.

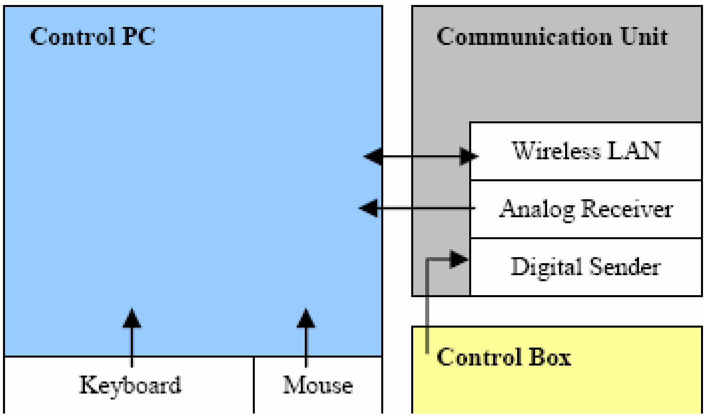


Fig. 4.2.1

4.2.1 Control PC:

We can use o simple Laptop at last

4.2.2 Communication Unit:

Communication Unit: we discuss in this regard before (ref communication part)

4.2.3 Control box

this mall box is able to remote control the robot directly. The small box can control the robot engines, camera engines and also to restart the robot computer (watchdog system) and changes the status of sender analog image between the images of 4 cameras (in the way of 4 images beside each other) and the image of monitors of robot computer.

Watchdog system is one of the unique controlling system activities. It means that we can restart the computerized system of robot through the control box and digital communication on the control box. This action has a great importance in order to restart computerized system in necessary cases.

4.3 Explaining different units

In this part the way of connections and explanations about skeleton in summery presented.

4.3.1 Navigation, Localization and Victim Sensor Unit

The robot computer takes the information of the unmediated sensors.

4.3.2 Motor Unit

To acquire light weight and consequently high speed we use six RE35 maxon motors of 90 watts equipped with 103:21 GP32C gear heads. According to formulas (1), (2) and (3) and the following parameters: $\varpi =$ 7070rpm, $N =$ 103, T=110mNm, $ef =$ 70% and D=100mm our robots maximum velocity is 35.99cm/s

$$\varpi' = \frac{\varpi}{N} \tag{1}$$

ϖ' : Gear head and wheels velocity
ϖ : Motor's angular velocity
N : Reduction coefficient

$$T' = T \times N \times ef \tag{2}$$

T' : Gear head torque
T : Motor's torque
N : Reduction coefficient

ef : gear head efficiency

$$d = D \times \pi \times \frac{\omega'}{60} \quad \textbf{(3)}$$

d : Distance traveled per sec

D : Wheel diameter

ϖ' : Gear head and wheels velocity

4.3.3 Vision Unit

Having sufficient video images with a good quality is one of the most important rescue robots succeed factors seeking an injured person. For this reason we have used 3 cameras with a good view angle till the ability of cameras can help the conductor of robot.

Because the robot height is less than the sight level of standing a human, controlling of the robot from the cameras is very difficult and sensitive that more over it needs experience and practice in control, it also needs the vast sight for this reason and in order to provide a better sight for operator, we add the 4th camera to the vision system of the robot. The 4th camera Dome can provide a good sight from the all surrounded angle of the robot by using a long and movable leg in the form of L and the ability of moving in all directions.

This camera (4th camera) is a CCD Panasonic 1.4" that is turned by Servo Motor of Hitec company in ±90° vertical and ±180° horizontal. One of the other ability of this camera is to zoom very good.

Camera	CCD	CCD 1.3" (380 Line TV)
	Resolution	500H x 5827 (0.5 Lux - f2.0)
		>46 dB (1/100000 sec – 127 cc – 120 mA)
	Wieght	200 gr
	Dimension	Ø87 x 72 mm
Motor	Motor	Servo HS700BD (Hitec)
	Power	Couple 80 N.cm (0.19 s/60°)
	Volt	6V
	Dimension	58.5 x 51 x 28 mm
	Wieght	102 gr
	Price	63.60 €

Fig. 4.3.3.1

The 4th camera movement is being done by the sent main board's instruction. Of course, these instructions can be received from the communication part of a digital receiver from control box. (Ref 2nd layer of control box)

Each camera's outputs are connected to a capture card of video images, also are connected to a video switcher system. The inputs of video capture are the bases of the camera images entries to the software system. The video capture card, which is connected to the robot computer, is a PCI card with the ability of capturing the images and regulating it in the different resolutions.

Fig. 4.3.3.2

Display and record each camera or any video signal simultaneously.

- Adjustable video source (brightness, contrast and etc.), quality, alarm, motion detection area.
- Motion Detection (watch for movement detected and record the video clips)
- Preview size adjustable.
- Image quality and Compression ratio adjustable.
- Allow the users to define the environment that they do not wish to observe, by adjusting
- Mask area and sensitivity.
- Video file database management, delete, backup or review.
- Storage Recycle: When running out of disk space, you can delete the data of earliest date.
- Remote view through TCP/IP or IPX protocol (Internet/Intranet), fixed IP is recommended.
- Remote view through modem communication protocol (Only for 4 port).
- Supports following network architecture: T1, T3, ADSL, ISDN, PSTN, Cable modem, Hi building etc.
- Compression ratio (without motion detection)
- High Image Quality: 4:1
- Low Image Quality: 30:1
- Every camera frame rates: 4 port: 3.0 to 5.0 fps

The output of the video switcher will be used just in the emergency cases. In fact, the main duty of video switcher is to put the image of 4th camera as one image. Both analog video switcher output and monitor analog output (that returns the current image of the monitor) are connected to a simple switch on the controlling board. The switch output is directly connected to an analog sender, too. Which transfers the image to the controlling computer. The controlling board switches the transferred image from the monitor image to the camera image and vice versa by receiving simple commands through the software or a control box.

4.3.4 Control Board Unit

In the heart of a controlling board we have used a PIC microcontroller with the number 16F877. The microcontroller has a flash 8K*16 word and also uses the watchdog and A/D systems. The main duty of a control board is to provide the motor frequencies and has the ability of turning rounding and moving in any pleasured directions and under every angle that has been put in the main program before.

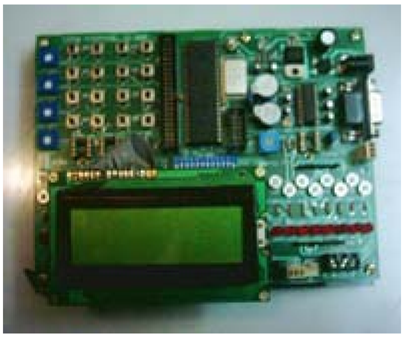


Fig. 4.3.4.1

The main port, converts the given instruction from the robot computer into the movements in motors by sampling from the LPT1 port. The other duties of this board are to control the amount of the cameras rotation and the amount of the angle of wheels and to show the batteries quantities and to control the conducted driver inputs.

Fig. 4.3.4.2

The sending information consideration from the controlling board to the main board is being confirmed in the research phase of the 3rd generation of the rescue robots. It means that the controlling board can receive information from the LPT1 port and digital communication system also can put information on the LPT1 in parallel in order to be transferred into robot. Referring to this ability we can use the software without using the remote desktop connection

4.3.5 Main Board Unit

As the requested needing for the computerized system of a rescue robot has a compulsory specifications and is not unified such as:

- The system in puts polarity
- Having number of analog inputs
- The digital outputs needs
- The industrial port needs

And many other cases to uses of a normal computer system. To days the usage of the industrial hardware systems is in the producing and completing automatic and semi automatic industrial devices that each of then has the unique and reasonable specifications in order to use the computer and hardware of it in industry more. We can point to the industrial Main Boards, these boards have good and unique abilities such as:

- Analog and digital inputs channels
- Analog and digital output channels
- The more number of input serial ports

• The ability of using RAM, CPU, and the other PC card
• The occupation capacity smallness
• Having the industrial ports

And etc … in the below figure for can observe a sample of an industrial Main Board which is used in our rescue robot.

Fig. 4.3.5.1 A simple of an industrial Main Board

As you can observe there are not much appearance differences between this sample of Main Board and the current PC Main Board systems other except their small size. More over .in addition to that we can add various selective cards (in order to supply some of the robot needs)by using different ports such as PCIs.

I/O card is used in order to receive information from sensors and devices that gathers the existence environmental information on the robot and transfer the information to the system. This card enters the analog information by connecting on the frame of Main Board of the robot's computer. Other technical specifications of this card are the 8 analog data input channels, The 12 bit analog to digital transformer and 2 channels of 8 digital output and input bits.

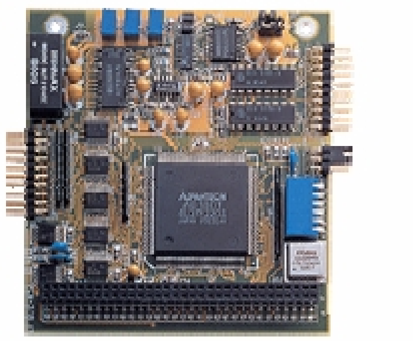


Fig. 4.3.5.2 I/O Card PCM-3718H

Another card used in order to (supply) the hardware device power (in fact it is a power supply). This small card has efficient and important specifications such as:

Fig. 4.3.5.3

- Clean and filtered power for the PC/104 bus
- PCM-P50: 5 V & 12 V
- PCM-P50N: ±5 V & ±12 V
- "Load Dump" transient protection
- 6 to 40 VDC input range
- 50-Watts output
- Stacks on the PC/104 bus
- Highly compact, PC/104 compliant
- AC bus termination optional
- -40 to 85° C operation

The computerized system of the robot is made by the mentioned set cards with the image cards, video capture cards (grabber card) and etc. in fact this system decides about all input and output processes.

4.3.6 Communication Unit

The communication system unit is using different devices in order to make communication between robot and operator that complete explanation of these devices is mentioned in the previous sections.

5. Map generation/printing

We have used a number of combined different methods that are gathered and managed having well developed software with optimized algorithms for map generation. The design of our map generator has been to minimize operator's interference with this important and complex task. The outcome of the ongoing study and research over this problem that started about a year ago was the development of an optimized and intelligent algorithm for map generation using the hereunder techniques:

- Laser Range Finder

- Stereo Vision

5.1 Laser Range Finder (LRF)

LRF is fast, accurate, and efficient compared to similar available range finders. We have equipped our LRF with laser line scanner and HSIF to have a laser scanner system (see Fig. 5.1.1-5.1.1.5) with the following specifications:

- Up to 50000 sampling per second
- Scanning 43 lines per second
- Provided with 64K buffer
- Connection via PCI port
- Equipped with two PWM together with shaft encoder reader

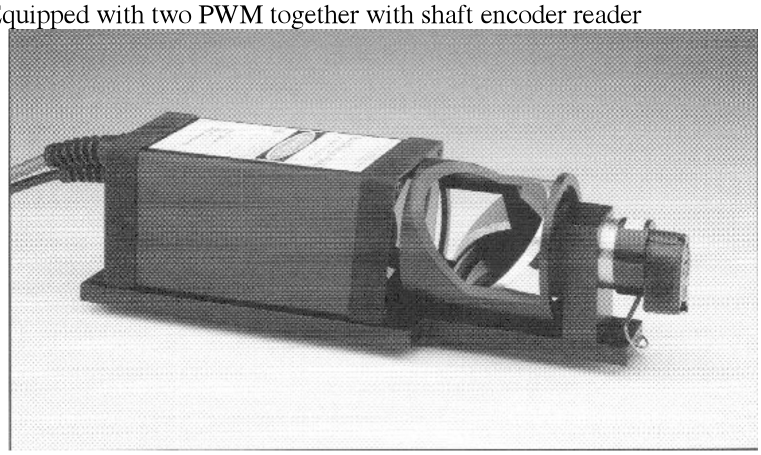


Fig. 5.1.1

Fig. 5.1.2

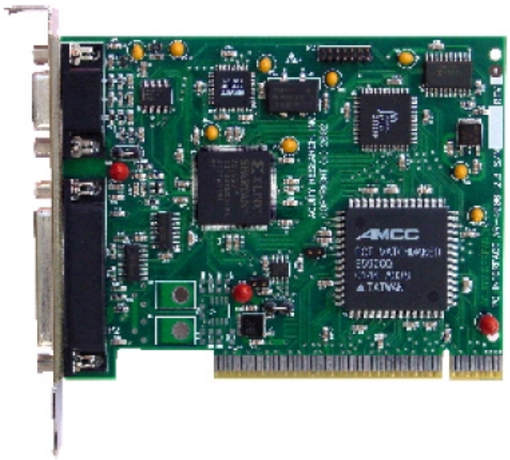


Fig. 5.1.3

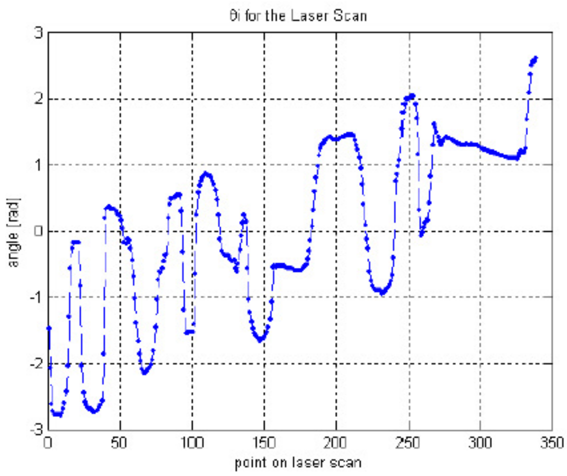


Fig. 5.1.4

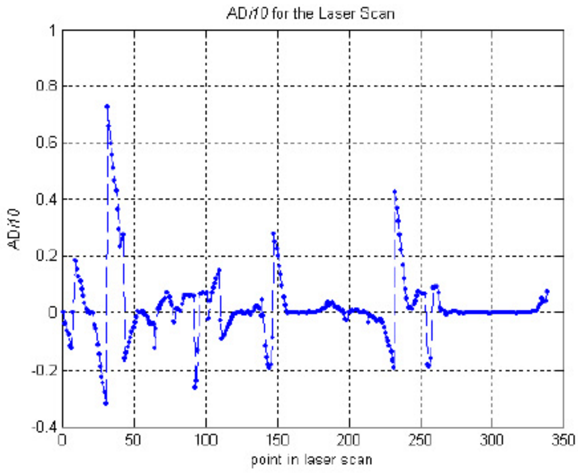


Fig. 5.1.5

Our laser scanner scans some parallel planes to the ground that are of defined altitudes from the ground using a mechanical ladder that moves the laser scanner vertically up and down.

To draw a 2-D map we have combined a number of algorithms and optimized them to gain our desired goal. The real time output of the scanner is analyzed by a special processor where the results are stored in a matrix. In fact, we consider the field as a big grid with high resolution. The mentioned matrix is proportional to this grid where each element of it represents a square of the grid. We have divided the matrix elements into four groups that define four regions on the 2-D map. The regions are:

- Rigid obstacles (e.g. wall)
- Passable obstacles (e.g. stone, small stuff on the surface)
- Free space to move
- Anonymous sections

At the beginning all elements are of the fourth region and gradually the field is recognized and matrix is filled with real values. However, other details like victims locations are determined and annotated on the map at the end when preparing the final map.

Due to the structure of our map generator, scanning an area several times and at various altitudes is inevitable. However, using a mean value calculated by a special algorithm we would be able to determine that the area belongs to which region with a probability of 95%.

Imagine a robot to be functioning in the area of Fig. 5.1.6 and the laser scanner is scanning the area. Consider $G[x][y]$ as the grid matrix and (X,Y) as robot's current position.

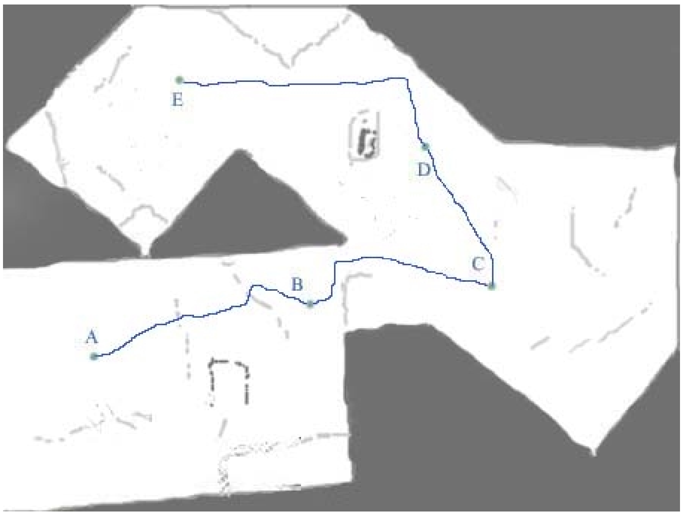


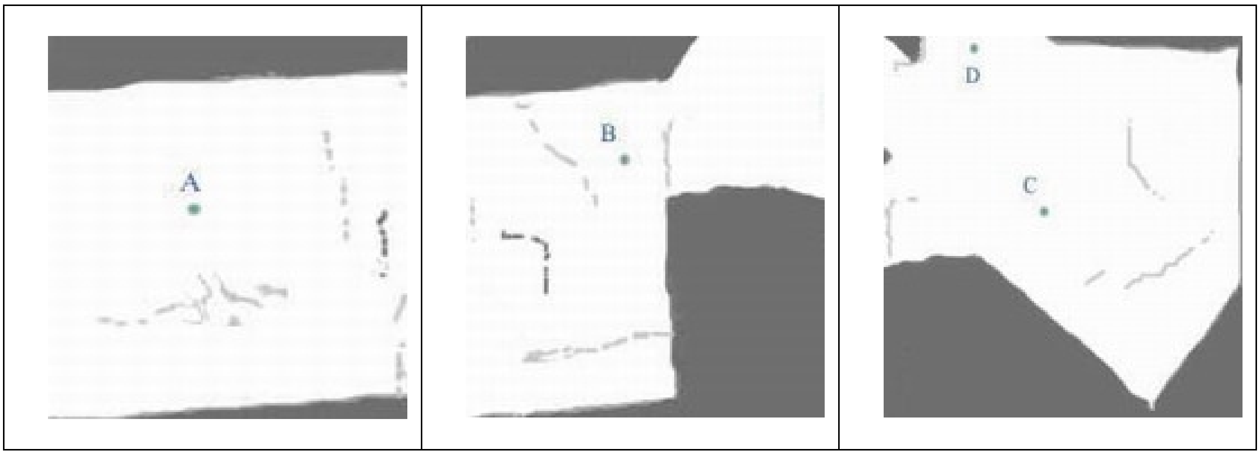
Fig. 5.1.6

To determine obstacle using the hereunder formulas we have:

$$x = [X + L\cos\varphi] \quad \textbf{(4)}$$

$$y = [Y + \tan\varphi(x - X)] \quad \textbf{(5)}$$

From (1) and (2) we deduce that $G[x][y]$ is an obstacle. The matrix is fulfilled by scanning the determined regions (see Fig. 5.1.7) and then the final map will be generated by the map generator software.



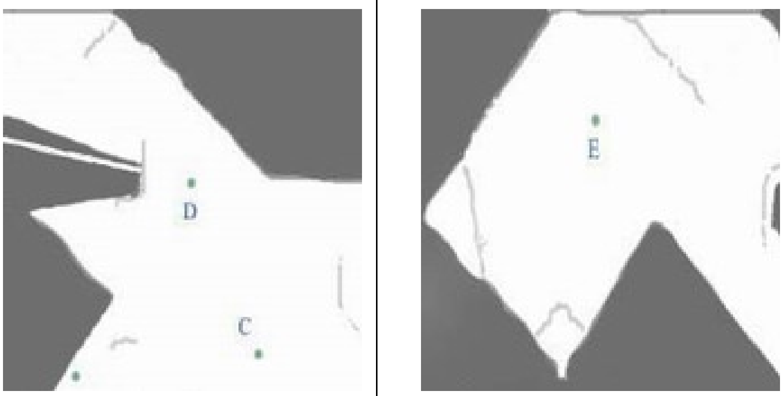


Fig. 5.1.7

We this 2-D map generator for simple surfaces, however, for complex surfaces like stairs we use these two methods:

- 3-D Laser Scanner
- Stereo Vision

5.1.1 3-D Laser Scanner

We have equipped our 2-D laser scanner with pan/tilt mechanism to acquire a 3-D laser scanner. Our map generator software, then, is switched to 3-D mode. Thus, here we have a three dimensional array of $G[x][y][z]$. We divide the three dimensional array elements into three groups:

- Solids (positive elements)
- Free space (negative elements)
- Anonymous sections (nil elements)

Our 3-D laser scanner scans a stationary region by less than five seconds.

5.2 Stereo Vision

Stereo Vision is used on specific situations instead of 3-D laser scanner. Stereo Vision is, in fact, responsible for correcting and optimizing the localization and map generator systems. Our Stereo Vision system is equipped with two parallel cameras.

Some optimal image processing algorithms together with complex mathematical formulas are used to retrieve image depth information and determine the target point position.

The major problem of using stereo images is that processing and analyzing these images take a lot of time. We have used some special techniques to overcome this problem. One factor that makes stereo image processing complex is finding a common point in between images of the two cameras. To simplify this task we consider a point where its rough position is determined by the laser scanner. Then, having its rough position, we will process specific regions of images and neglect other regions. As a result of this technique, less time is consumed to find the common point.

Stereo Vision also works as an assistant of the operator giving a better view. Note that this section is still under implementation, but we estimate that it will be finished by the end of April.

6. Sensors for Navigation and Localization

We have designed a system similar to Indoor GPS. One privilege of using GPS is that we would be able to have our position at any moment even in anonymous environments where the error rate is constant.

Here we compare the wave from a reference point to the target point with a reference wave and will calculate their phase difference ($\Delta\varphi$) using AD8302 Phase Detector. Then, using the calculated $\Delta\varphi$ we get the direct distance between the target point and the reference point. The AD8302 Phase Detector has useful capabilities like calculating the phase difference and gain rate of two input waves to 2.7GHZ, and it can also calculate the phase difference between 0 and 180 degrees with an accuracy of one degree.

The distance between the target point and the reference point is calculated using the hereunder relation:

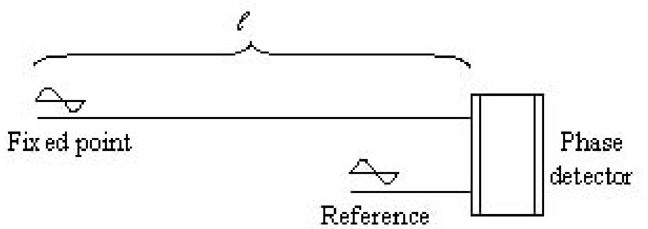


Fig. 6.1

$$L + L' = \frac{\lambda \Delta\varphi}{2\pi} + n\lambda \qquad \textbf{(6)}$$

Where L' is the system error, λ is the wavelength.

In formula (3) L' is a constant value and its value is determined within the device calibration. The calibration is done through placing the target in the reference point and reading the $\Delta\varphi'$ output. In this case we have:

$$L' = \frac{\lambda \Delta \varphi}{2\pi} \tag{7}$$

Another problem in (3) is the value of n. Since the wave is distributed in various environments the gain cannot be used to determine the number of n. To solve this problem we use some different frequencies to determine the distance. Different frequencies have different wavelengths where by using an optimum algorithm we managed to calculate the distance between source and destination with an accuracy of less than 2mm.

Now if we have three stationary reference points as in Fig. 6.2 we would be able to determine the exact position of the target using the hereunder relations:

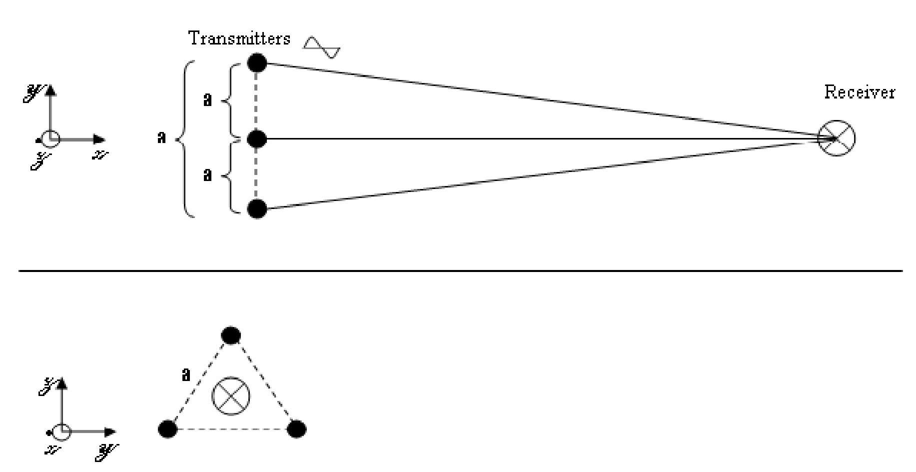


Fig. 6.2

L_1, L_2 and L_3 are determined by the phase difference system:

$$y = \frac{a^2 + L_1^{\,2} - L_2^{\,2}}{2a} \tag{8}$$

$$z = \frac{a^2 + L_3^{\,2} - L_2^{\,2}}{2a} \tag{9}$$

$$x = \sqrt{L_2^{\,2} - y^2 - z^2} \tag{10}$$

This system's absolute error would be calculated as follows:

$$dy = \frac{2dL_1 \cdot L_1}{2a} - \frac{2dL_2 \cdot L_2}{2a} \Rightarrow \Delta y = \Delta z = \frac{2\Delta L \cdot L}{a} \tag{11}$$

In (8) ΔL is the phase difference system error which is less than 2mm. The y and z errors are less than 5cm.

The implementation of the above system faces two major problems that occur because of the comparing waves. The first problem is that the phase difference is not constant since frequencies are not accurate. The second problem is the synchronization of the two waves at $t = 0$. To solve these problems we will use fast and accurate DDS that is capable of having up to 1GHZ output. Its frequency accuracy is 0.01Hz and we can set its start time and primary phase. We are using two DDS one of which is installed on the robot to generate the reference wave and the other is where the operator is working. To synchronize the two DDS we first initialize their phases and set their frequencies to a specific value. At $t = 0$ when the two DDS are ready to function, we will connect their starts and then connect them to the central controller. To begin the calibration we place the robot on the point $(0,0,0)$. The central controller sends the start signal and starts its timer and at $t = 0$ recalls the $\Delta\varphi'$ for calibration. Note that $\Delta\varphi'$ here includes both the system and primary phase difference errors, therefore, reducing this value later will eliminate all the errors.

To control the problem of frequencies mismatch that is due to DDS frequency error, we hold the robot stationary and will read the phase difference of one of the reference points at t_1 and t_2. Consider $\Delta\varphi_1$ as the read phase difference at t_1 and $\Delta\varphi_2$ as the read phase difference at t_2:

$$\begin{aligned} \Delta\varphi_1 &= \Delta\omega t_1 + \Delta\varphi' \\ \Delta\varphi_2 &= \Delta\omega t_2 + \Delta\varphi' \end{aligned} \quad \Rightarrow \quad \begin{aligned} \Delta\varphi_2 - \Delta\varphi_1 &= \Delta\omega(t_2 - t_1) \\ \Delta\omega &= \frac{\Delta\varphi_2 - \Delta\varphi_1}{t_2 - t_1} \end{aligned} \tag{12}$$

From (9) we can calculate the phase difference by subtracting the frequency error as follows:

$$\Delta\varphi = \Delta\omega t + \Delta\varphi' \tag{13}$$

$$\Delta\varphi' = \Delta\varphi - \Delta\omega t \tag{14}$$

Where t is the time of reading $\Delta\varphi$.

We use our Stereo Vision mechanism as well to correct positioning errors as follows:

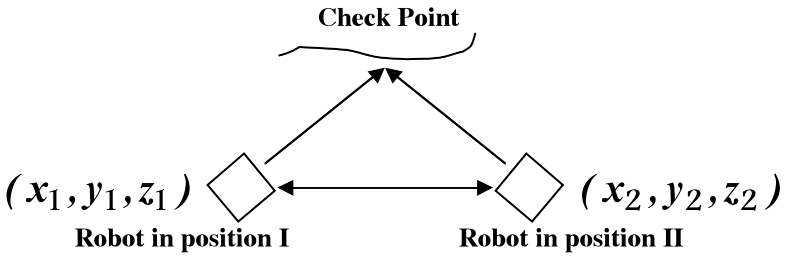


Fig. 6.3

As can be seen in Fig. 6.3 we consider a stationary point in a specific position as the Check Point. This is done using the stereo images and P_1 vector. Then to correct the positioning errors we look at the Check Point area using the stereo cameras and image processing algorithms will find the Check Point and calculate the P_2 vector. Thus we have:

$$\vec{P} = \vec{P}_2 - \vec{P}_1 \quad \textbf{(15)}$$

Where $\vec{P}$ is the displacement vector.

Even though this system, too, has errors but the overall mechanism of our positioning is to a wide extent accurate and intelligent.

7. Sensors for Victim Identification

It is important collections of the feedbacks which are culminate in to the victim findings, receiving proper information from the victim recognizer sensors on the robot. Attending to the real disaster site conditions and the simulated environment in the competition so it seems to be necessary to put minimum 3 kinds of this sensors on the robot. The rescue robot team has considered all kinds of the victim finder sensors in order to receive the information from the environments feedbacks and have used the below tools and instruments, which are the most important criterion according to the particulars such as the accuracy, speed, connecting to the computer system abilities.

The robot soft ware system is receiving the exact information by using the light bulk processes with the highest speed and representing the information in statistic and schematic form on the page.

7.1 color vision

Having used 3 fixed cameras in front and in two besides and utilizing a dome camera as the forth movable camera on the head of the robot is guaranteeing the full colored screen sight all over the environment.

So that the victim dresses acquaintance and locator strobe will be done more easily. Implementing an intelligent system to recognizing the victims in the third generation rescue robot, programming a soft ware to distinguish the victims shape, color,. …automatically are the future ideas.

7.2 Infra-Red Gas Analyzer

7.2.1 Non-Depressive Infrared Detection

Sensors based on the principal of Non-Depressive Infrared Detection (NDIR) look for the net increase or decrease of light that occurs at the wavelength where CO2 absorption takes place. The light intensity is then correlated to CO2 concentrations. Figure 2 provides an example of a typical NDIR sensor where ambient air is allowed to diffuse into a sample chamber that contains a light source at one end and a light detector at the other. A selective optical filter is placed over the light detector to only admit light at the specific wavelength where CO2 is known to absorb light. Though not common in all IR sensors this illustration also shows a second detector in the assembly that is covered by an optical filter that is tuned to a wavelength where there is no gas absorption. This second detector and filter is used as a reference to correct for changes in the optics of the sensor over time that may result in sensor drift. Important considerations in the design of this type of sensor are to minimize or eliminate sensor drift that may occur because of particle build-up in the sensor and/or aging of the light source. One method of minimizing particle buildup is to use a gas permeable membrane that will facilitate diffusion movement of gas molecules but will block out larger particulates that may change the sensor optics.

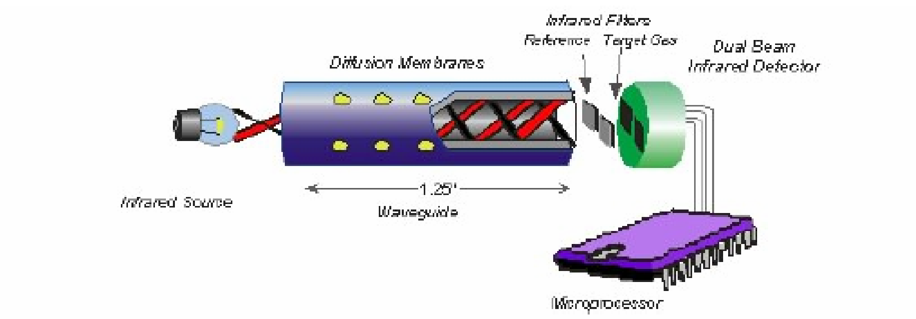


Fig. 7.2.1.1 NDIR CO2 Sensor

Aging of the infrared source, one of the most significant factors in sensor drift can be compensated for by manufacturer selection of sources with stable characteristics and through corrective algorithms that adjust for light source aging over the long term. The dual beam approach shown in figure 2 is one method of compensating for drift. Another approach involves having the sensor calibrate itself on a nightly basis when the space is unoccupied and inside levels drop to baseline outside levels. Figure 3 shows the results of over almost three years of operation of three sensors utilizing a nightly automatic baseline calibration where the sensor accuracy was checked on a regular basis with a calibrated gas of 980 ppm CO2. Sensor accuracy remained well within a +/- 50 ppm over the duration of the test period showing that good long-term stability is achievable with these type of sensors.

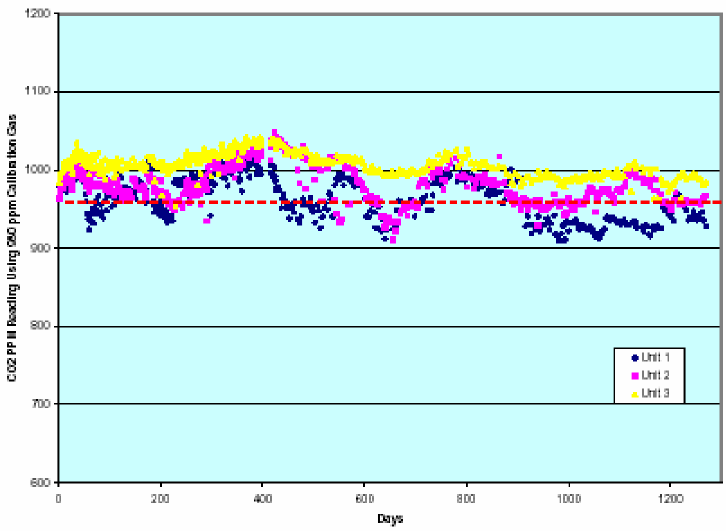


Fig. 7.2.1.2 Long Term Stability of CO2 Sensors Utilizing a Nightly Automatic Background Calibration Algorithm

7.2.2 Specification of CO2 detectors in the Rescue Robot

We use infrared CO2 gas analyzer for measuring CO2. The infrared CO2 gas analyzer (IRGA) is a standard tool for the measurement of respiration and photosynthesis. Unlike the bulky, power-hungry and expensive IR Gas of the past, for photosynthesis, or respiration in insects and small animals, use IRGA with its range of 0 - 2000 ppm and resolution better than 1 ppm CO2. These analyzers have a digital display and a 0 - 5V analog output for data acquisition.

7.3 Infra-Red Thermometer

The perimeter temperature (heating blankets) and the victim body heat can be measured with different thermometers .the infrareds will send the digital results back to the computer system in addition to the accuracy and being able to measure one special point heat which is far from the robot.

In order to that we have used a MX thermometer manufactured by the raytek company that is able to measure the heat with the infrared ray. This non contact temperature measurement has the capacity of recording the heat in the range of the -30° to 900° C (-25° to 1600° F .we can mention the other specifications below:

- 16 point circular laser sighting.
- 60:1 distance to spot
- RS232 Data output
- Adjust level emissive

Fig. 7.3.1

7.4 Microphone

In the rescuing conditions the voice emits can occur, that can be received by the sensitive microphones. In addition to use the suitable tools for receiving the voice ,the automatic recognizing victim's voice system , is one of the team's activities in order to implementing the automatic specifying voice .

To detect the victims voice in the disaster sites, first of all we will consider the different methods of specifying the voice activities and then by selecting the best and useful methods we have started designing a proper system [1] in fact distinguishing the voice activity is the same as specifying the human voices of silence which is frequently in the connection industries, the speech specifying and coding the speech and etc. is being used.

But unfortunately in spite of the various methods in this field most of the voice activities specifying styles in the noise environments where the ratio of voice to noise amount is low. Is including many problems.

Because of this using those methods in robot is based on their. Improvement and optimization. With this aim and in order to simulate the rescue competition acoustic environment among three human voice samples, the voice which is contaminated with noise and a noise sample have been used by order from these data bases: TIMIT, Spear, NOISEX. Generally, the human voice recognizing methods are dividing to three groups:

7.4.1 Energy Threshold Method

In this way supposing that when the voice is in the milieu the input signal energy is much more than the cases, which the background noise is in the milieu. Knowing this specification when the input signal energy is coming over the threshold boundary means that the voice is in the surrounding.

The threshold boundary amount can be unchangeable and fixed during the algorithm or it can be dynamic and computed according to the background noise energy alterations when there is no voices found in the environment

7.4.2 Zero Crossing Rate Method

In this method the crossing zero input signal rate is being measured and will be compared to the threshold boundary. in this method we suppose that the crossing zero noise rate is worthy of attention considerable much higher than the crossing zero sound rate .this suppose is true for the environments which the ratio of signal to the noise is upper .because of this reason in such a places we can find out the existing or not existing voice in the environment by measuring the crossing zero rate.

7.4.3 Periodicity Estimator Method

In this method by using the human voice consecution identify which is called the pitch frequency, we can find out the existing or no-existing human voices in the environment. It means that whenever the frequency pitch system has recognized a person's voice it is explained as the voice existing. Generally we will be able to specifying the Pitch Frequency with using the cepstral and also using the input signal Autocorrelation. an important point here In the estimating the sound frequency .is to avoid the non acoustic frequencies signals. which reasons the mistake occurring or the system less accuracy. So that the primary process on the input signals are seems to be certain to avoid or decrease it.

In the energy threshold boundary and the crossing zero rate just the environments can be use full where their ratio of signal to their noise is high. Because generally the ratio signal to noise is low or even negative in the rescue situations these two methods are not proper to use.

:by attending to the negative ratio of signal to noise and the low energy alternates in the disaster environment and the rescue conditions the first and second methods hasn't any usage. According to that the existing noises in the rescue environment must be supposed stationary so that the background noise signal separation is impossible. So that this point is many problems cause and has conflict to these two methods which their implementations are so easy, the estimating frequent method that is not based on the voice and background noise signal energy differences and the voice separation from the noise seems to be more convenient. In addition to the estimating frequently method have much less error percent comparing to the crossing zero-rate method. The below table is comparing those two methods:

Method Name	Accuracy Percent
Crossing zero rate method	34.2
Periodicity method	71.4

Fig. 7.4.3.1 Comparing the crossing zero rate method and periodicity estimator methods accuracy

7.5 Motion Detector and Sonar

The victims have a moving appendage, which can simulate the movements and producing trembling. According to that and to detect the mobile objects in an infra-red motion environment we have used the MK677 Seri infrared motion detecting, which belongs to the elegance company.

Although using a motion detector on a movable object will decrease the accuracy percent. But using this tool output data s during the time that robot is fixed in the environment it would help us to find the victims who are out of the sight.

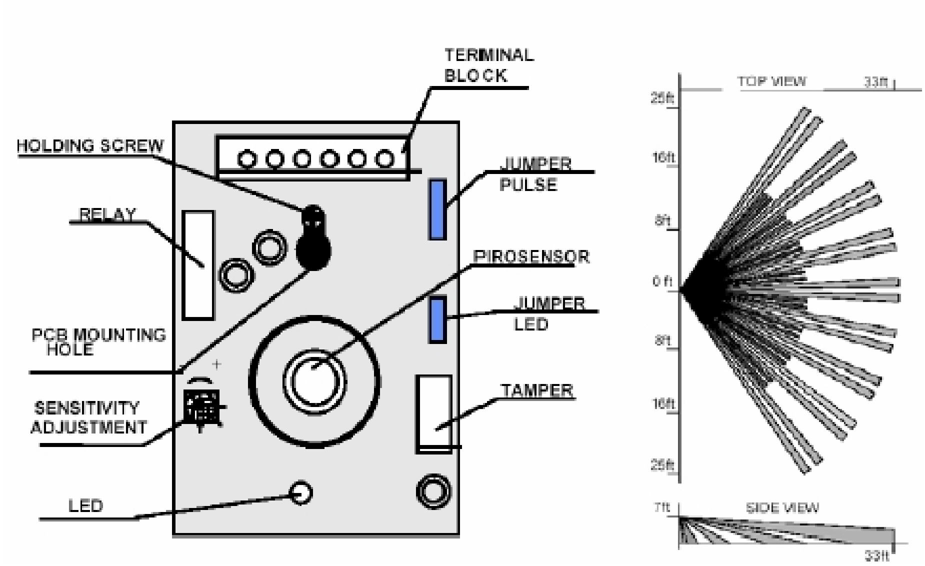


Fig. 7.5.1 PCB Layout and Wide-angle lens

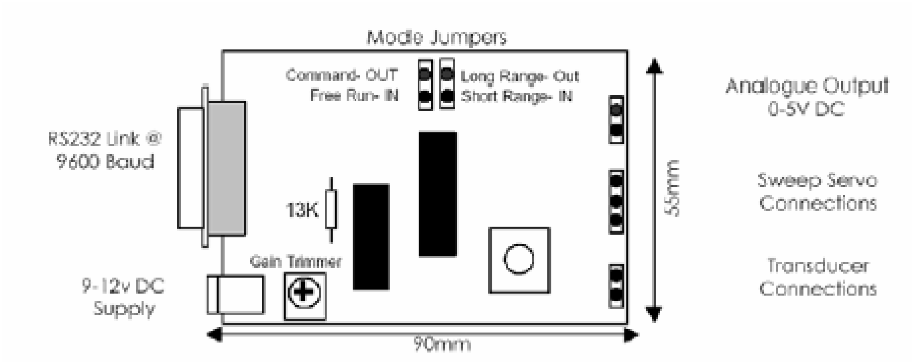
7.6 Sonar

Provide for the robot mobility environment. Contain receipt has just used a Polaroid ultrasonic system with these below specifications. This system is a rotate ultrasonic which has the obstacle discernment ability in a range between 10 to 15 centimeters. The fit and arranging accuracy, 2 kind analog and digital outputs the

The used ultrasound picture with its controller

Fig. 7.6.1

180degree coverage are this facility's preferences. And the easiest way to receive the digital information is using the''rs232'' port. The information comes to the computer system in polar and Series and the distance between each angle is transferring to the system by a byte that actually the digital quantity is between 0 to 5 volts system analog output.



The ultra sound system controller details

Fig. 7.6.2

By arranging the sonar control board jumpers can reach 2 accuracy levels. Arranging the first jumper: system is being put in the specifying situations in short distances and is able to measure the object intervals in 0.15 span (range) to 26 meters .in this state the system accuracy is 10 millimeters so is a suitable accuracy for moving a robot such as the rescue robots dimensions.

By arranging the second jumper system has been put in the specifying far distances and is able to measure the object intervals up to more than 10 meters. The system accuracy in this state is 42 millimeter so is a fit convenient.

The control board received information is sent to the system moving motor in 2 bytes and in a defined language so the below code is explaining that.

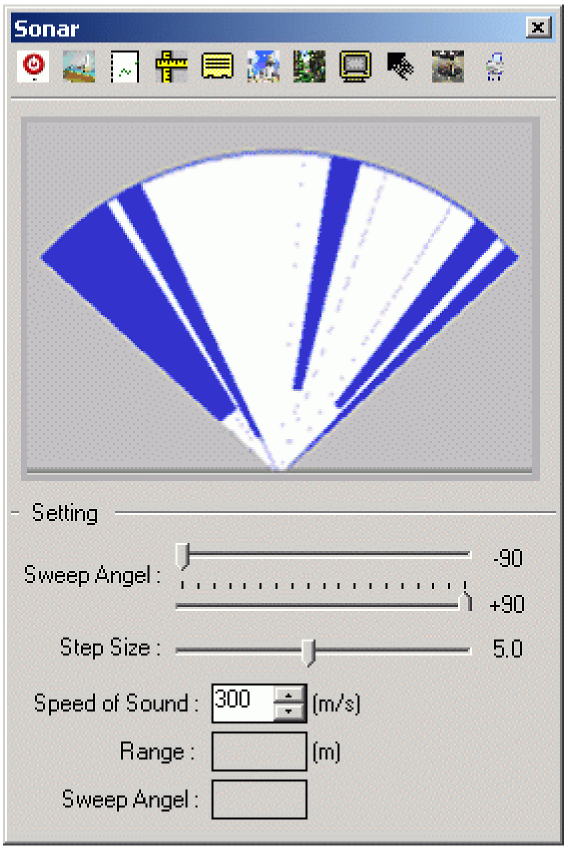


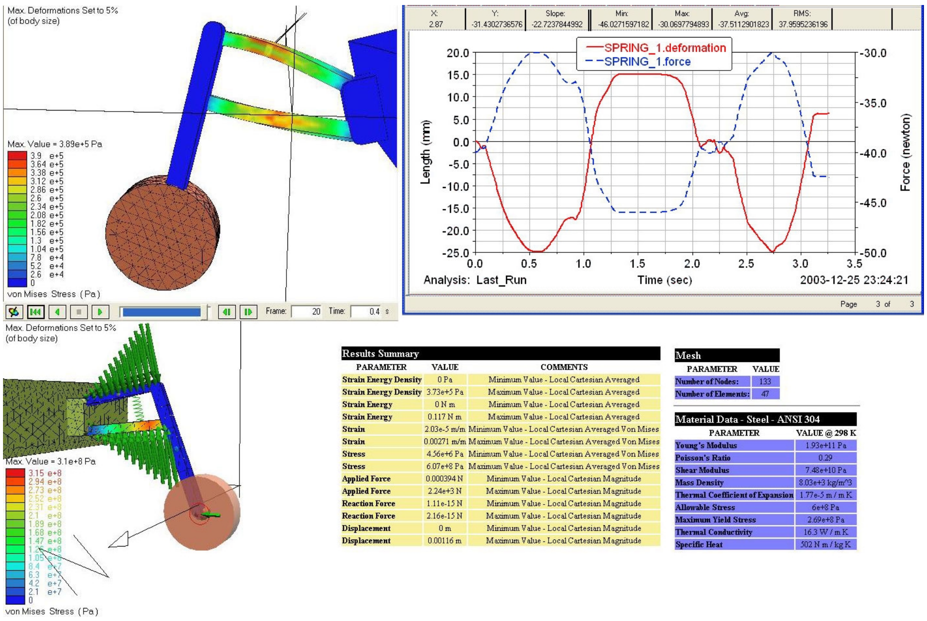
Fig. 7.6.3

8. Robot Locomotion

Our robot's locomotion uses six wheels for locomotion (see Fig. 8.1). All six wheels have independent motors that improves moving mechanism for better obstacle passing. Two additional motors are placed for the front and rear wheels for simple turning. One major specification of this locomotion mechanism is its flexibility with anonymous environments. This mechanism also reduces energy consumption and simplifies robot control system. We made some changes to this mechanism after making the sample robot using software analysis. The major changes are:

- Increasing our robot's load capacity more than 15kgs
- Providing more free space to place additional devices
- Increasing the robot's speed and better navigation
- Better efficiency

Fig. 8.1



Results Summary		
PARAMETER	**VALUE**	**COMMENTS**
Strain Energy Density	0 Pa	Minimum Value - Local Cartesian Averaged
Strain Energy Density	3.73e+5 Pa	Maximum Value - Local Cartesian Averaged
Strain Energy	0 N m	Minimum Value - Local Cartesian Averaged
Strain Energy	0.117 N m	Maximum Value - Local Cartesian Averaged
Strain	2.03e-5 m/m	Minimum Value - Local Cartesian Averaged Von Mises
Strain	0.00271 m/m	Maximum Value - Local Cartesian Averaged Von Mises
Stress	4.56e+6 Pa	Minimum Value - Local Cartesian Averaged Von Mises
Stress	6.07e+8 Pa	Maximum Value - Local Cartesian Averaged Von Mises
Applied Force	0.000394 N	Minimum Value - Local Cartesian Magnitude
Applied Force	2.24e+3 N	Maximum Value - Local Cartesian Magnitude
Reaction Force	1.11e-15 N	Minimum Value - Local Cartesian Magnitude
Reaction Force	2.16e-15 N	Maximum Value - Local Cartesian Magnitude
Displacement	0 m	Minimum Value - Local Cartesian Magnitude
Displacement	0.00116 m	Maximum Value - Local Cartesian Magnitude

Mesh	
PARAMETER	**VALUE**
Number of Nodes:	133
Number of Elements:	47

Material Data - Steel - ANSI 304	
PARAMETER	**VALUE @ 298 K**
Young's Modulus	1.93e+11 Pa
Poisson's Ratio	0.29
Shear Modulus	7.48e+10 Pa
Mass Density	8.03e+3 kg/m^3
Thermal Coefficient of Expansion	1.77e-5 m / m K
Allowable Stress	6e+8 Pa
Maximum Yield Stress	2.69e+8 Pa
Thermal Conductivity	16.3 W / m K
Specific Heat	502 N m / kg K

Fig. 8.2 Front wheel links analysis

The theoretical analysis of robot front spring using ADAMS and Working Model software is as follows:

$$\tau = K\frac{8FD}{\pi \cdot d^3} \tag{166}$$

τ = Maximum Spring Stress
K = Wahl Coefficient
F = Load
D = Spring diameter
d = Wire diameter

$$K = \frac{4C-1}{4C-4} + \frac{0.615}{C} \tag{17}$$

K = Wahl Coefficient

$$C = \frac{D}{d} \tag{18}$$

D = Spring diameter
d = Wire diameter

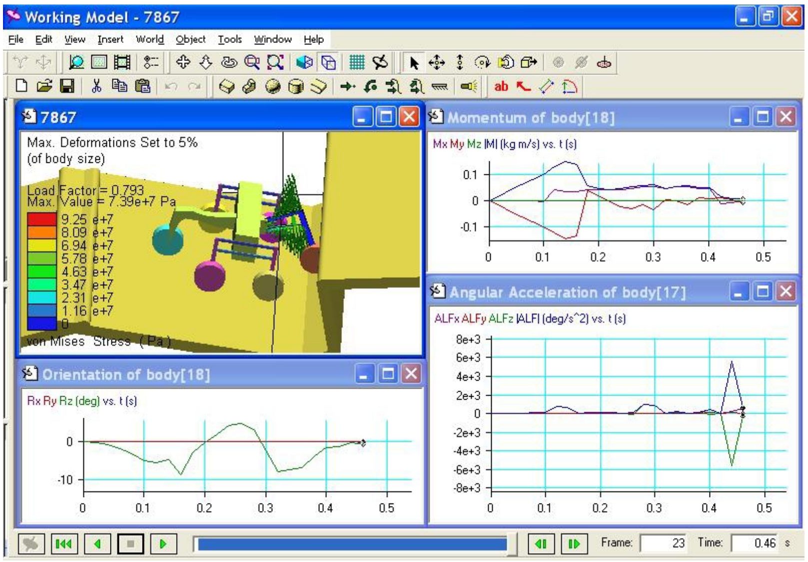


Fig. 8.2

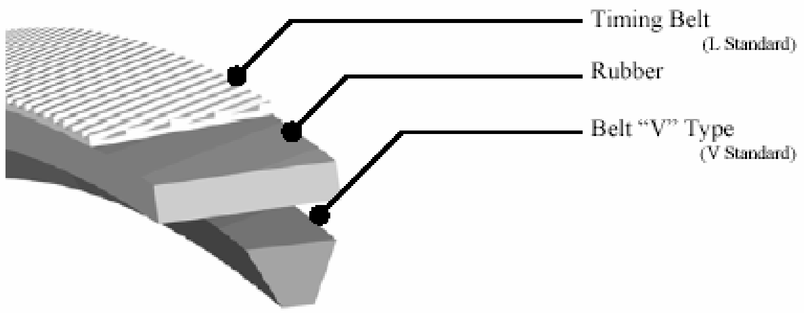
8.1 Wheels, belts and glue

One of the basically factors for motion system design is type, scale and Shape. Motion system mechanical and type of wheel was designed base on motion of disability and ulcerous people and using them from wheelchair. This design specialty is high utility, easy control in the rough route and bumps. Also some changes in wheels are considered for better motion.

Robot wheels were made by Pulley 'V' Type with six spoke, 100mm diameter and aluminum material that there are three layer belts inside.

Wheel edges like chute and ability in affix the layers can assure us non-disengage in every situation. For better competence of tire in contact with sharp impedimenta like stair head, curbstone and … we used a three-layer belt on the wheels. An inferior belt stratum is "V" shape (to put in the wheels groove), medium layer is spongy (to absorb strike and increase give) and external layer is a timing belt from L2 series.

These layers are stickled by adhesive SC2000 together.



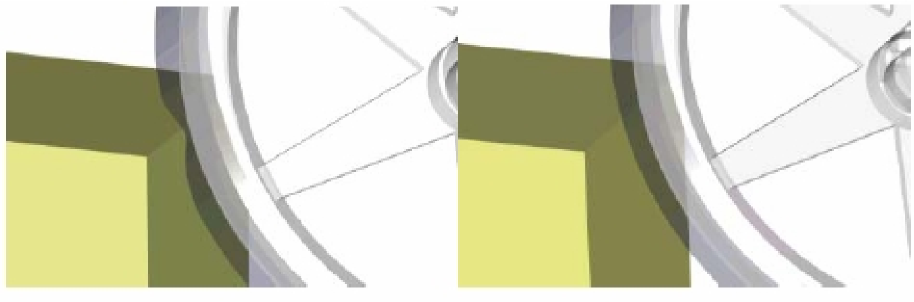


Fig. 8.1.2

8.2 Force system and motors

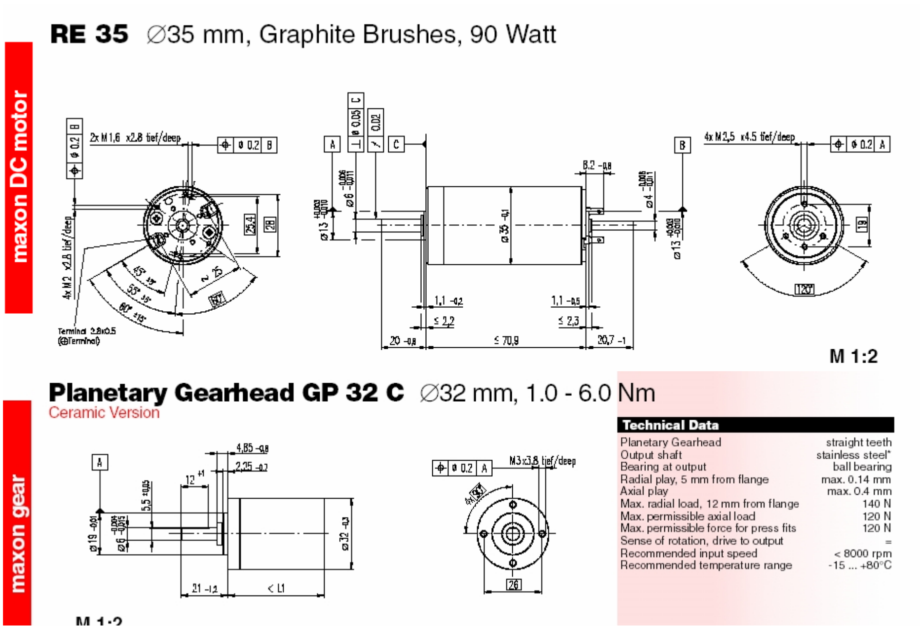


Fig. 8.2.1

9.1.1 The robot controlling software systems

All the robot operations are being executed via this soft ware the operation s such as:

- Controlling the robot motors
- Controlling the forth camera’s motion
- Representing the camera’s photos

- Representing and controlling the motional and victim recognizing sensors
- The plane map generating
- Preparing the print layout

And etc.

This soft ware is connected to the whole input and out put ports such as the lpt, COM analog inputs and out puts. We have tried to put floating windows with hiding ability, docking and also the transparency in graphic user interface. This soft ware is controlling by the operator remotely.

9.1.2 The software robot testing system

This software will run automatically when the robot computer is being set up. This soft ware can be run also un automatically.

One of these soft wares responsibilities is to test the hard ware, mechanical and connection systems automatically. These considering sequences will be available for the operator in the voice messages and interpretation statements.

Which can be also used manual.

9.1.3 The log and black box soft ware system

Is preparing from all the log operating system steps. The log fields in the preferences part in control robot program are selectable. It is possible to use the prepared logs in order to considering the robot operations and the operation performance during the rescue. And also can be used to consider the robot hard ware, mechanical, and connections problems this soft ware will be run contemporaneous with the robot controlling soft ware. The information are preparing as xml that can be used by other analyzing soft wares. Even if the robot stops after an indicated duration and if the robot connection interrupts with controlling system the black box soft ware will start running automatically.

This software will record all the camera photos, motor conditions and the sensors information of robots situation during the interruption. this soft ware can simulate as interpretation such as the air plains black boxes .by the renewed operator connection with the robot we are able to find the disconnection's reason by considering the robot photos and condition.

9.1.4 The connecting soft ware system

In simple words this soft ware is transferring the robot desktop computer to the control computer. The famous example of this soft wares are called the remote desktop connection which are executing so easily on the operating systems such as windows 2000 windows XP. There are many kinds of this soft wares are available such as the Linux and Unix samples which are able to auto rate a computer controlling that are based on windows remotely. According to this there will be no more limitations for using the various operating systems on the operator computer part. To enumerate this kind of soft wares abilities:

- Transferring the mouse and keyboard information's.
- Making connection with all network protocol kinds
- Regulating the send and receive information bandwidth automatically and etc.

9.1.5 The robot management software system

The robot soft ware systems are all designed as stand alone applications and are doing their duties as well as possible. but from where the whole robot soft wares are running automatically here is needed to a systematic progress in the closed layers to the kernel the operating system is needy to synchronization of all the running soft wares. This soft ware is and service application.

After this software installation on the robot computer this service will be added to the other operating system services list. This service will be active when the operating system has start working such as the other services.

At the beginning this service will automatically actives the robot testing soft ware. After the success of running the automatically robot test program, it will run the robot controlling program. Protecting the network connection and reading lots of the control board commands are a part of this service's responsibility. The mentioned service will activate the log and black box operator system but interrupting the connections between the robot and us. Totally the automatic intelligent management task is this service's duties.

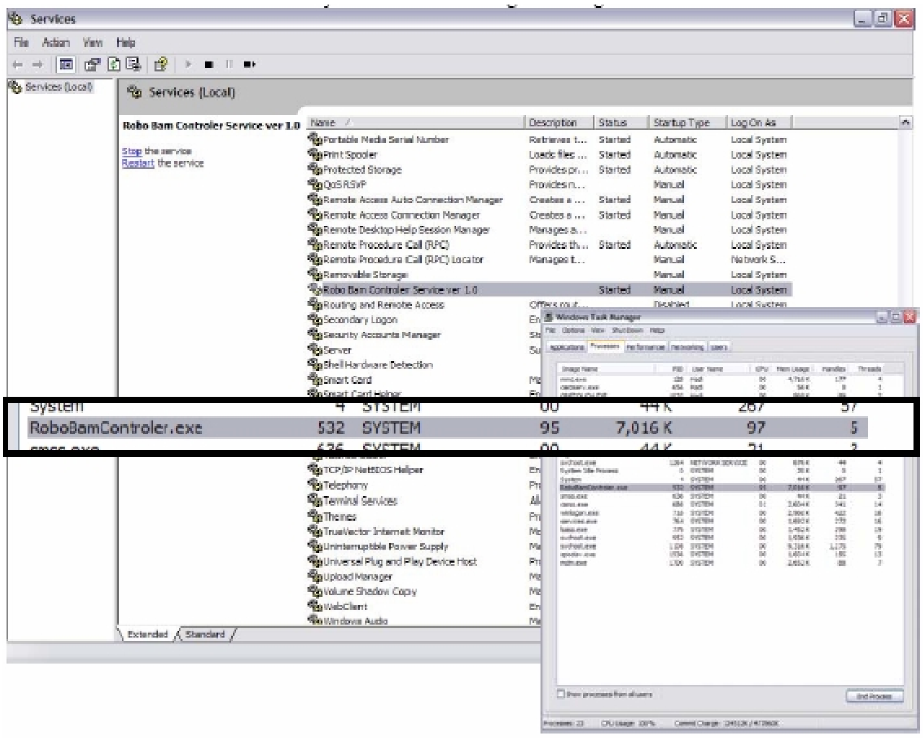


Fig. 9.1.5.1

9.1.6 Other soft ware systems1

The other soft ware has been implemented to help the different investigations groups' process such as power and the connection.

9.1.6.1 The connection to ports

The control port program can send and receive the information by making connection with the lpt1 and COM ports. The graphical shape and the information entrance via mouse and keyboard are the soft wares abilities. This soft ware is being used for the electronically boards test and examinations.

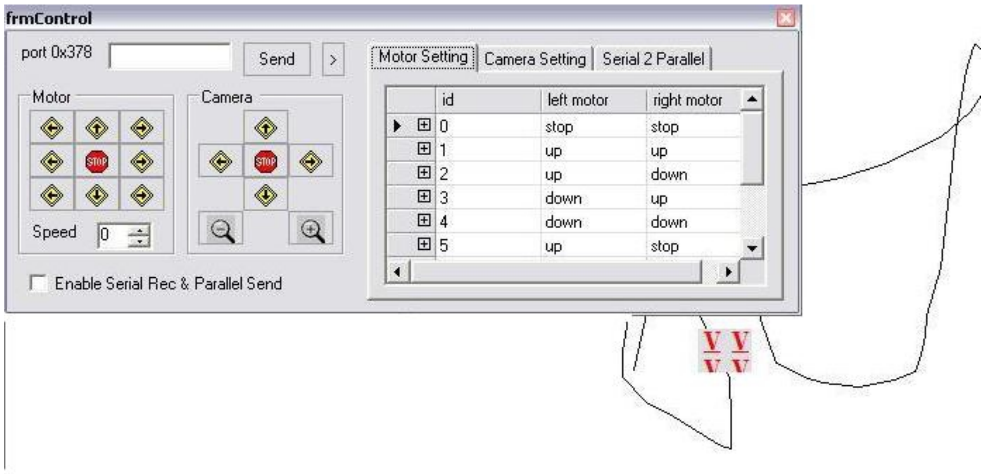


Fig. 9.1.6.1.1 Motors Speed Control and Navigation Control

9.1.6.2 Signal Watch

The signal watch program can represent the information transferred kind and amount by reading the in formations on the parallel port. This simple soft ware's usage is to test the ports pedestals, giving helps to the electronically investigation team and to represent the ports activities redundancy.

In the third generation of the our rescue robot the robot operation simulating is able by using the black box and log system archive in formations.

10. Team Training for Operation (Human Factors)

The Persian Gulf rescue robot can be operated in two ways: automatically and manual.

The soft ware systems have been designed and developed by using the new methods in user-friendly design. In other side representing the help as a tool tip will help much more get acquainted with the system faster. For the practicable robot usage there are published user manual notes with explanations and also designed sites in order to remove the probable problems are the thought predicts And also we are deciding to use a pocket pc controller in the third rescue robot generation, which it is so easy to use, and to get familiar to the small details.

And also making a supported film, which is taken from the robot operation and the realistic abilities representation, must be one of the best remote operator trainings

11. Possibility for Practical Application to Real Disaster Site

The practicable request for the real disaster site probability.

According to that the our rescue robot has been designed and built in order to the practicable usage in the damaged sites. All the systems must be designed with an practicable and non competitional ideas.

- The robot designing in the most powerful condition with high performance
- Increasing the equilibrium by using the angled wheels and also using the moving robot flexible chassis.
- Designing a two layer control system and the ability to operate the robot in the worst conditions such as disconnections and the computer systems burnt.
- Utilizing the digital connection system (low frequency) with three frequencies and two modulations.
- Using the intelligent soft ware systems such as the black box log and etc.
- Utilizing the two layer management soft ware system.
- Os services

And many other plans and explained ideas which has been illustrated upper has been designed and implemented in order to practicable usage of robot in the disaster sites.

12. System Cost

In the table below we have considered and explained tool, instrument and system kinds comprehensively with each parts specifications and the company names. Also the using reasons are available.

The whole system's expenses are mentioned here

Communication	Analog Transmitter	Rayroshd	1000
Communication	Wireless LAN Card (D-Link)	Etc	150
Communication	3 Communication module (Digital Transmitter)	AUREL	72
Electronic	Infrared Motion Detector (MK677)	Englance	16
Electronic	Infrared Thermometer	Raytek	1000
Electronic	Ultrasonic Detection	Polaroid	159
Electronic	Infrared Gas Analyzer	Qubit	1000

Electronic	Microphone	Teac	20
Electronic	Camera 1, 2	Velleman	450
Electronic	Industrial Mother Board (PCM6892)	AAEON	1000
Electronic	Notebook (COMPAQ Prsario1700)	compaq	700
Electronic	6 Robot Motor	maxon	300
Electronic	Camera Motor (for "L" type)	maxon	300
Electronic	Digital Encoder	maxon	50
Electronic	Battery	-	300
Electronic	Lazer scanner		
Electronic	DDS(DIRECT DIGITAL SYNTHESIS)	Analog devices	45

Fig. 12.1

Referring to that a complete set of different engineering systems such as computer, connection, control, electronic and mechanics are taking part in the investigations, designs and built activities and it is so difficult to make a final cost list with a less error percent .

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