Robocup 2015 – Rescue Robot Team
AriAnA (IRAN)

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Abstract. This document describes the approach of AriAnA rescue robot team for Iranopen 2015. The team is active in RoboCup Rescue since 2006.This year we have focused on new tele-operated system Robot and Flying Robot .

Introduction

AriAnA rescue robot team represents IAUCTB (Islamic Azad University of Central Tehran Branch) and develops mechatronical layers of high mobility rescue robots (i.e. hybrid locomotion, semi-active controlling and power management) since 2006. The team began cooperating with an industrial group (AVA Strategic Alliance) in 2009 which led to participating as a joined multi-national team in RoboCup 2009 and 2010.We continued the collaboration up to the end of 2010 and won first place award of Khwarizmi National Robotics Competitions1 within this year. Our team won third place in part of remote control robot successfully in 2012 and in 2013 placed second in Iranopen competitions of Rescue Robots and can take part successfully in 2013 Netherland Robocup matches and placed third in Iran open matches in 2014. Fig.1 shows the robots built by AriAnA rescue robot team since 2006

Fig. 1. Our robots: (1) ARIAN-2006, (2) META-2007, (3) ALPHA-2008, (4) BETA2009, (5) DELTA-2009 and GAMMA-2010, (7) DIAMOND-2011-12,(8,9)TITAN-2012-14

1. Team Members and Their Contributions

From the following list only nine people will be attending in Iran Open 2015

• Dr.Alireza Mohamadiun	Team Leader
• Reihane Amiri	Technical manager
• Alireza Amini sohi	Electrical design ,Operator
• Afshin Ariyaee Nejad	Electrical design
• Mohsen Zarin zad	Software,Mechanical design
• Mahdieh Asl Khiabani	Mechanical design
• Raheleh amiri	Software (Infrastructure)

- Elmira Imanlou Software (Infrastructure)
- Hamed Sabti Software (Infrastructure)

And many appreciations to all former members of AriAnA rescue robot team.

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

As in previous years, we use a custom designed OCU (Operator Control Unit) for fast set-up and break-down. This OCU currently consists of a laptop, gamepad, access point, ethernet switch, power system and a pair of antennas. We will carry the OCU and kafin to warm zone (next to the arena) using a trolley five minutes before each mission. Then we will turn the entire system on to perform automatic system check up. The system will remain powered up on "hot stand-by" until our mission starts. This

set-up strategy is similar to what had been applied in 9/11 USAR (Urban Search And Rescue) missions].When a mission starts, two team members put the robot in start point and other two members carry the OCU to operator control station. Once whole devices are placed in their right places, the operator starts controlling. This is done in less than 2 minutes.At the end of each mission, the operator has two specific tasks: stopping the system and delivering mission data while two members are taking the robot out of the arena. The break-down procedure takes about 5 minutes.

3. Communications

All our robots have a 5 GHz IEEE802.11a Access Point/Bridge with a pair of external antennas to exchange data (e.g. high level control commands, sensor data and digital audio/video) with another one in OCU.We use channel 36 as our default setting (Table 1) but it can easily be changed to any possible channel if it is needed

Table 1. Used communication frequencies

Rescue Robot League		
AriAnA (IRAN)		
Frequency	**Channel/Band**	**Power (mW)**
5.0 GHz - 802.11a/g	36ch (selectable)	10mW

The second one consists of a high power, industry grade video transmitter with radiofrequency of 72 MHz besides an RF modem which utilizes 120 MHz radio frequency.

4. Control Method and Human-Robot Interface

As stated before, we will deploy only one robot to perform autonomous navigation and victim detection within the yellow, orange and radio drop out zones. This robot is very similar to Titan from electrical viewpoint. Fig.2 illustrates hardware block diagram of Kafin.

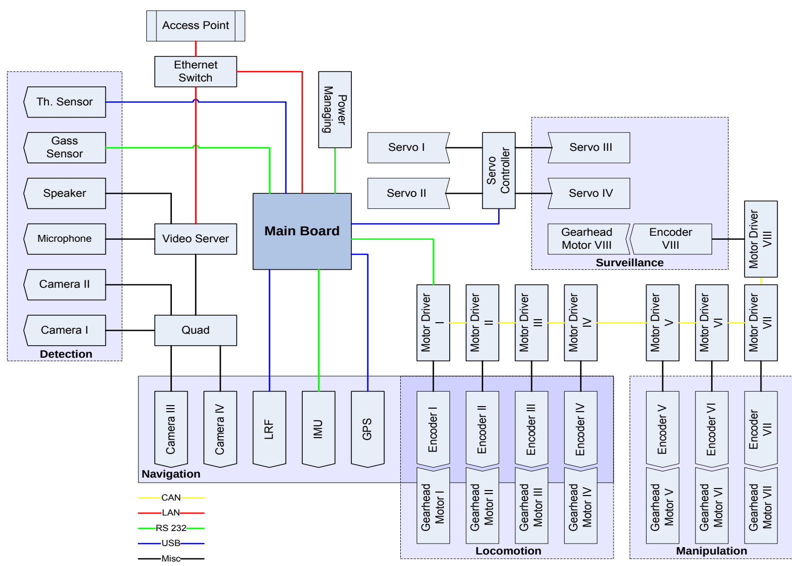

Fig.2 Hardware block diagram of onboard system

The core of this block diagram consists of an FPGA based controller and a main board

According to hardware block diagram (Fig.2), the onboard power management system should:

1. feed all onboard devices including
    a. up to 8 motor drivers
    b. 4 RC servo drivers
    c. 4 cameras + 1 quad + 1 video server
    d. all mentioned sensors
    e. 1 industrial mother board
    f. 1 Ethernet switch + 1 access point
    g. 1x 24v-10A payload bay
2. show battery life time
3. have current limit option
4. interface via RS232 with Main boar

4.1. Robot Operating System

Our team has done basic changes in software part and has decided to have a program under windows. As you observed all parts of robot can be observed and controled through TCP_IP. As well, it is possible to access different parts of module. This program is written in language of c#.

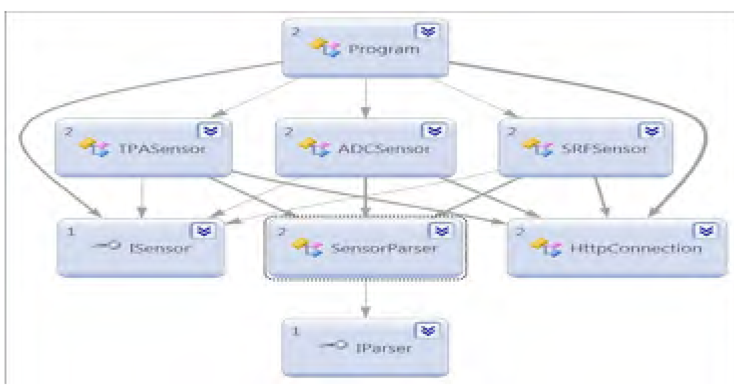

Fig. 3. Software architecture of cuffin

4.2. HRI

Obviously, design of HRI (Human Robot Interaction) directly affects the ability of operator to understand the current situation, make decisions and provide high level commands to the robotic system. Therefore the operator's requirements and the way of presenting them to him/her should be emphasized [6].
Our GUI (Graphical User Interface) is developed since 2012 to support adjustable Tele-Operation. It allows the operator to use identical GUI's to control robots with different levels of Tele-Operation. As it is shown in Fig. 4, the GUI has 4 different panels:

- **Drive:** *a video centric GUI[7] for tele-operation*
- **Report:** *to record victims' information*
- **Map:** *a map centric GUI for autonomous controlling with selectable autonomy*
- **Log:** *shows recorded logs of mission (i.e. sensor data and control commands)*

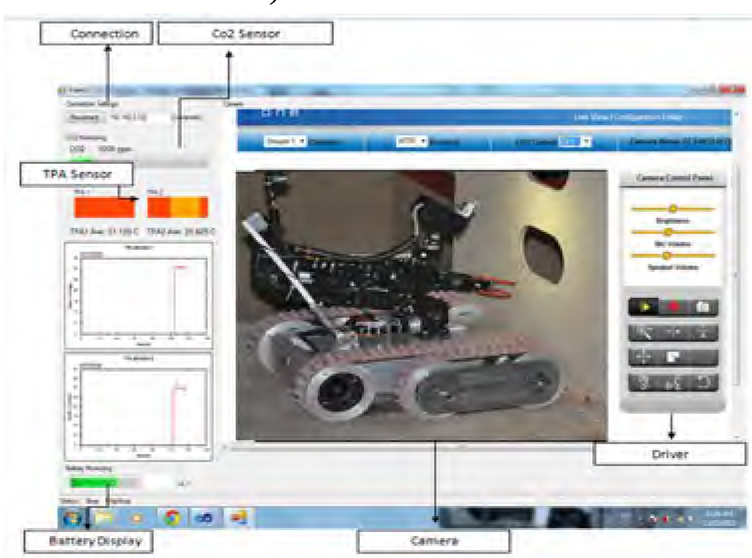

Fig. 4. Our GUI in RC13

5. Map generation/printing

Teams are supposed to present a 2D map after each mission containing information about the location of detected victims. We have developed a fast and robust laser scan-matching algorithm that builds a map based on the past several scans, by aligning incoming scans to this map at the 10Hz scan rate. This scan-matching algorithm is an improved version of the algorithm presented by Olson et al. To find the best rigid-body transform to align a new laser scan, we score candidate poses based on how well they align to past scans. Laser scanners usually provide individual point measurements, and because successive scans will in general not measure the same points in the environment, attempting to correspond points directly can produce poor results. However, if we know the shape of the environment, we can easily determine whether a point measurement is consistent with that shape. We model the environment as a set of polyline contours, and these contours are e tracted using an algorithm that iteratively connects the endpoints of candidate contours until no more endpoints satisfy the joining constraints. With the set of contours, we generate a costmap that represents the approximate log-likelihood of a laser reading at any given location. We create our cost-map from a set of previous scans, where new scans are added when an incoming scan has insufficient overlap with the existing set of scans used to create the cost-map. For each incoming scan, we compute the best rigid body transform (x, y, θ) relative to our current map. Fig. 3 shows the result of our ICP scan matching algorithm.

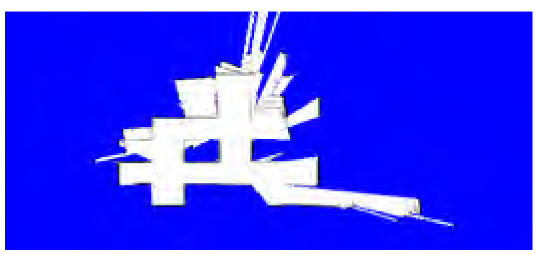

Fig. 5. Map of our test arena using ICP scan matching algorithm

6. Sensors for Navigation and Localization

As stated before, Titan and Cuffin are very similar to each other in terms of hardware and sensor arrangement.

Camera

Two identical wide angle 1/3" high resolution Sony CCD color cameras provide a fine environmental awareness for tele-operation. Videos of these cameras are converted to MPEG-4 format and streamed over Ethernet with Real Time Streaming Protocol(RTSP) by means of a Hi vision (4chanal) video server.

LRF

Our robots are equipped with Hokoyo UTM-30 LX scanning LRF. This long range (up to 30 m), wide angle (270°) and fast (40 Hz) LRF is mounted on a gyro controlled gimbal-type servo mechanism to stay horizontal (in world frame) while scanning

IMU

Each robot has an IMU (Xsens MTi) to measure its 3 DOF orientation and 6 DOFaccelerations.

Ultrasonic Ranger

Twelve Devantech SRF08 ultrasonic sensors are placed around the autonomous robots for more reliable collision avoidance

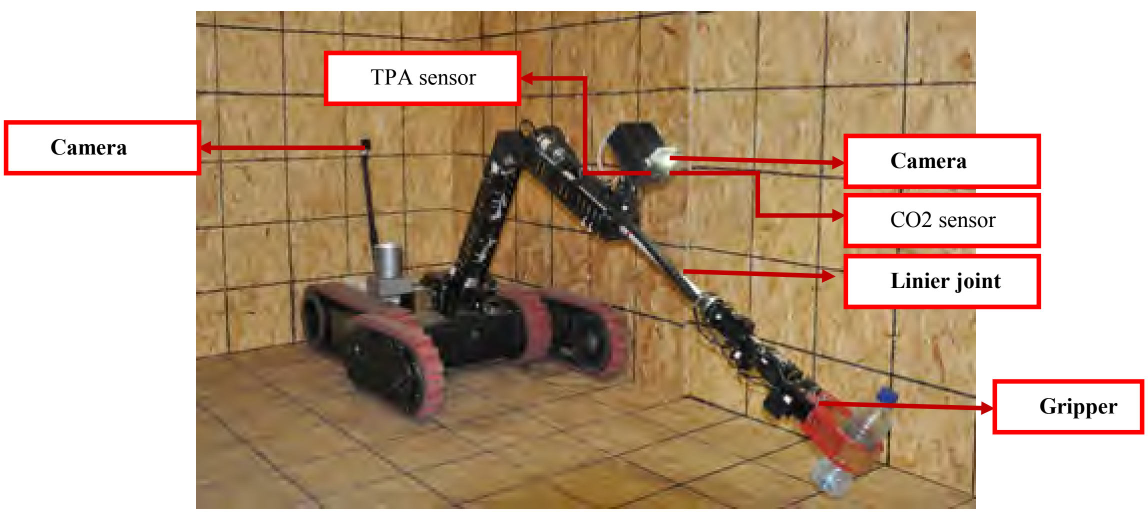

Fig. 6. Sensor arrangement of Titan(Robocup 2014)

7. Sensors for Victim Identification

We have built a 3 DOF manipulator to hold all victim detection sensors. These sensors are packed in a pan/tilting end effecter called Victim Detection Package (VDP). The VDP equipped with these sensors:

Zoom camera

This camera provides fine images of environment even in almost absolute darkness.

Temperature Sensor

An 8×1 pixels temperature sensors from Devantech mounted on the end effector to detect temperature of simulated victims.

CO2 Sensor

We've equipped both robots with CO2 sensors to sense the exhaled CO2 from victims. They have a response time of about 20 sec. which is common in most CO2 sensors.

Microphone

A sensitive microphone and small speaker is used to have a bi-directional communication between operator and victim.

8. Robot Locomotion

As mentioned, all our robots are differentially steered tracked vehicles. They havedifferent locomotion characteristics to make them suitable for their specific tasks.

Cuffin

This robot is steered at maximum speed of 1.2 m/s using a pair of velocity-controlled 350 W DC motors while four highly accurate position-controlled 200 W brushless DC motors rotate its triangular frames.
Fig. 7 illustrates its overall dimensions.

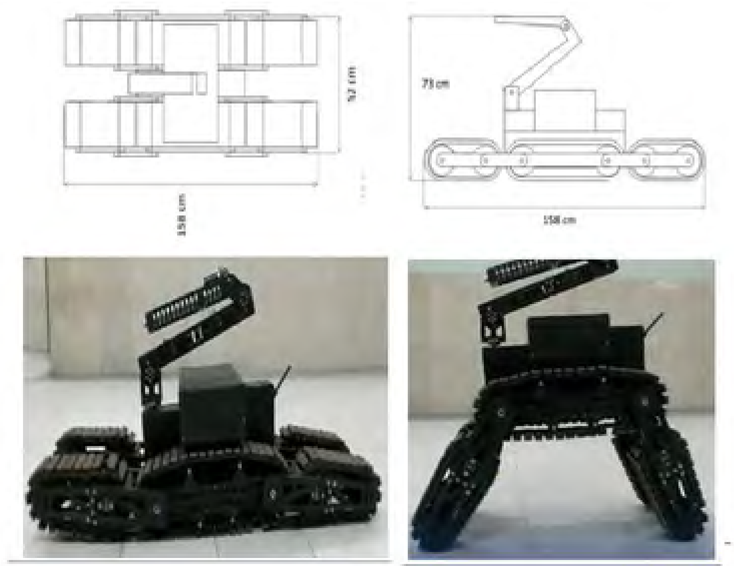

Fig. 7. Overall dimensions of tele-operated robot

9. Other Mechanisms

Power Management System Our robots utilize a custom designed power management system for remote supervisory control (e.g. switching devices on/off, voltage-current monitoring and limiting).The power manager is the only device that a user can directly turn it on/off. When it booted up, it follows a step by step procedure to turn on and test the required devices to be wirelessly connected to the OCU (i.e. Ethernet switch and Access Point) and if anything goes wrong, it begins blinking an LED and alarming.Once the wireless connection is established, the power management system waits for operator’s commands to turn on/off any requested onboard device even the industrial computer. This is a useful capability especially when there is no direct access to a robot that may commonly happen in real USAR missions.

Manipulator's and Gripper

Almost all sensors of **Cuffin** are placed on its surveillance manipulator. The end effector of this 2DOF manipulator contains a pan/tilting Victim Detection Package (VDP) and a roll/pitching laser stabilizer servo mechanism. The end effector is also connected to an orientation correction mechanism to stay horizontal in robot's frame ofreference. This correction mechanism is actually a combination of two parallelogram four-bar linkages with flexible links and applies a function of rotations of manipulator's joints to the end effector (Fig. 8). Our team consists of 6 DOF gripper that can easily pick up objects .With this gripper can also be opened and closed

Fig. 8 manipulator and Gripper Titan(Robocup 2014)

10. Team Training for Operation (Human Factors)

Although we do our best to make our HRI more and more user friendly, but it still needs about one day of familiarization to drive the robots properly. After becoming acquainted with robot controlling, it will be quite similar to game playing.

Furthermore, our GUI automatically saves all video streams sent to the OCU. This simple, useful feature lets us to analyze operator's performance. Certainly, our selected operator spends considerably more time for practicing in our USAR test arena to achieve the best possible result in the competitions.

11. Possibility for Practical Application to Real Disaster Site

We yet have no practical experience with real disaster sites. However, we consider the practical application when design the robot, such as compact mechanism, modular design, less operator station setup time.

12. System Cost

The following tables list approximate cost of our system.

Table 1. Price list of a typical platform

Device	Company	Model	QTY	Unit Price(USD)
Mech.componets	Damavandi.co	---	1	8000
Buhler 350W			8	200
Motor driver	Sabrtooth	2*25 QE	6	250
Control board	Roboland.co	---	1	250
Power manager	Roboland.co	---	1	200
Ethernet switch	PLANNET	SW802	1	20
Access point	PLANNET	WDAP-2000PE	1	120
Antenna	PLANNET	ANT/OM5A	2	13
Video server	High vision		2	250
Camera (wide)	Telecom	---	4	32
Battery	Kinetic	Li-Poly	4	370
Battery Charger	Thunder Power	TP-1010C	1	200
Other electronics	---	---	---	200

Total price 14,124 ±0.5% USD

Table 2. Price list of sensor payload

Device	Company	Model	QTY	Unit Price(USD)
LRF	Hokuyo	UTM-30LX	1	5,590
LRF	Hokuyo	URG-04LX	1	2,375
IMU	Xsens	MTi	1	2,550
IMU	MicroStrain	3DMGXI	1	1494
Stereo vision	Videre	STOC-6cm	1	1520
Ultrasonic ranger	Devantech	SRF08	12	64
CO2 sensor	Vaisala	GMM	1	925
Temperature sensor	Devantech	TPA81	2	112
Thermal camera	Ann Arbor Sensor system	AXT100	1	5995
Camera	Telecom	---	2	32
Microphone	---	---	1	8

Total Price 21,514±0.5% USD

References

1. Olson, E.: Robust and Efficient Robotic Mapping. PhD thesis, MIT, Cambridge, MA, USA (2008)
2. Soltanzadeh, A. H., Chitsazan, A.: Mobile Robot locomotion based on Tracked Triangular Wheel mechanism. Final thesis for B.Sc. degree, Mechanical Engineering Department. IAUCTB (2006)
3. Mahbadi, H., Soltanzadeh, A. H., Emami, M., Soltanzadeh, M.: TDP of AriAnA (Iran). RoboCup Rescue Robot League (2009-14)

Appendix

Qualification Videos (YouTube)

https://www.youtube.com/watch?v=AxvQeBIOgcQ&feature=youtu.be
http://www.youtube.com/watch?v=NULIFi2mhzQ
http://www.youtube.com/watch?v=iNBSpAXKmqY
http://www.youtube.com/watch?v=K8dKR98Oc-g