RoboCup Rescue 2017 Team Description Paper IRSE

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Info

Team Name:	IRSE
Team Institution:	ISLAMIC AZAD UNIVERSITY (SOUTH TEHRAN BRANCH)
Team Leader:	ASHKAN SAFAVI SOHI
Team URL:	-

Abstract— The concentration has been on designing different robots for assistance in diverse situations.

Index Terms—RoboCup Rescue, Team Description Paper,IRSE, iRAD651,iRUE212

I. Introduction

IRSE Team is Islamic Azad University (South Tehran Branch)'s robotic team which has started it's work with UAV robots in 2013.It has taken parts in DIGI KALA 2016 (UAV_PAYLOAD) (First Place), IRANOPEN 2014 (Second Place at "Best Operational"), AUTCUP2015 (Fourth Place) and so on.

Since, according to reports, Iran is the third country in the world which has the most number of the buried mines, we started working on deminer robots about a year and a half ago and participated in several competitions. Meanwhile, we started working on rescue robots, too because nowadays disaster rescue is one of the most serious social issues which involves very large number of heterogeneous agents in the hostile environment. The intention of IRSE team is to develop robots helping to improve rescue missions so people who are stuck in dangerous or inaccessible situations will be rescued with no harm to any further human who would go to rescue them. Our robots perform tasks with the help of image processing (such as detecting QR code, color recognition, face detection, 2D and 3D mapping,…),different sensors(to detect heat ,gas,…) described in details below.

Fig. 1 iRUE212

Fig.2 iR651

Fig.3 The CAD drawing of iRUE212

II. System Description

A. Hardware

- **Locomotion:**
  Two different robots are designed for diverse situations. iRUE212 robot uses two dc BMW motors which control the legs movements and two 24 dc motors for CW and ACW movements. Also, this robot's mechanic is designed particularly to move forward using straps instead of wheels for a long period of time and it can pass small and considerable high obstacles easily. iRAD651 rescue robot can automatically take off and place in an appropriate height in order to scan the ground map and send it to the operator easily.

Fig.4 Some of the mechanical Parts

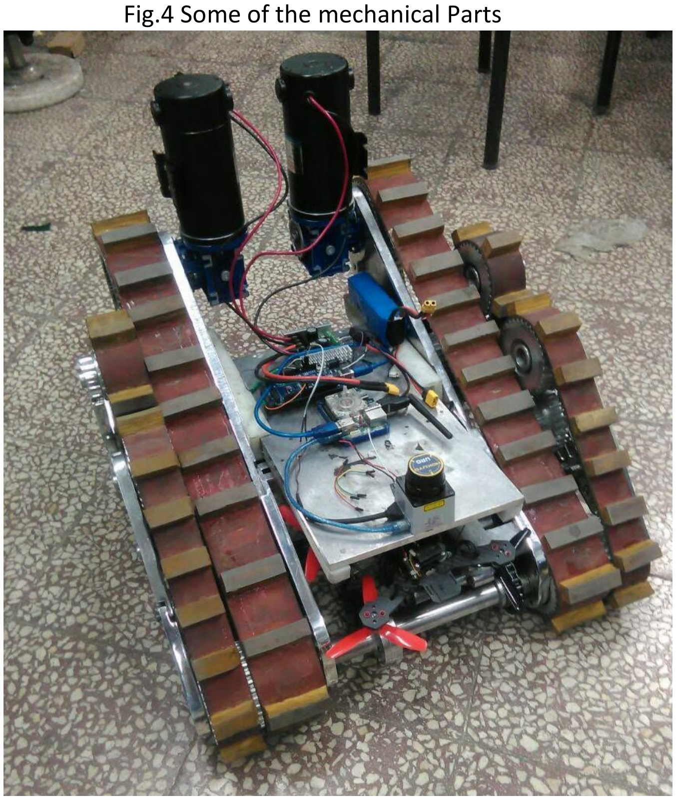

Fig.5 The robot(not complete)

- **Power (Batteries)**

Lithium polymer battery (Lipo battery):
A lithium polymer battery, or more correctly lithium-ion polymer battery (abbreviated variously as LiPo, LIP, Li-poly and others), is a rechargeable battery of lithium-ion technology using a polymer electrolyte instead of the more common liquid electrolyte.

Batteries used in the robot:
- Lipo 6cell 6000mAh
- Lipo 4cell 6200mAh
- Lipo 3cell 10000mAh

- **Electronics, including micro-controllers, etc.**

Microcontrollers used in the robot:
- Samsung Exynos5422 Cortex™-A15 2Ghz and Cortex™-A7 Octa core CPUs (XU4 Odroid)
- Atmega2560 (Arduino Mega)

Motor driver module:
- Sabertooth 2x32A
- Monster VNH2SP30
- LMD5560 80A Single Channel

Voltage reducer modules:
- XL4016E1 CC&CV Reducer
- XL4005E1 CC&CV Reducer

USB 3 hub:
- TP-LINK UH700 USB 3.0 7-Port Hub with 12V/2.5A Power Adapter

Camera:
- IP Camera (Network Camera)
- Odroid Camera (Ocam)
- Kinect 360

- **Manipulation/ directed perception**
  The manipulator has 7 DOFs which is capable of reaching 110 cm higher than the robot and can handle up to 2 kg of payload. It consists of CO_2 sensor, temperature sensor and a camera.

- **Sensors**

- Laser Scanner
  2D and 3D map of the environment will be generated using a Hokuyo URG-04LX mounted on a stabilizer.

- Thermal sensor

One TPA81 sensor is used which is none contact.

- CO_2 sensor

  The CO2 sensor used is MQ9 that has the ability to measure CO_2 and combustible gas levels up to 1000 ppm.

- **Communication**

  Robot is controlled by a joystick connected to operator's computer. Next, controlled data are sent to mini PC and with the help of ROS we send it to the AVR microcontroller which will send the needed commands to the drivers and Motors.

  Also, collected data from the sensors and the cameras are sent to the micro controller and then to the mini PC which will be processed with ROS.

B. Software

1) SLAM( ): both our aerial and ground robots are chiefly using ROS software. Hector_slam package is used to generate a 2D map on the ground rescue robot using Hokuyo scanning range finder. Hokuyo scanning range finder is used to measure the distance of the robot's surroundings at 180 degrees. No odometry is needed for 2D mapping with Hector_slam package. Also, the software package used for 3Dmapping is RTAB-Map. There are three inputs for RTAB-Map package. Xtion PRO LIVE 3D sensor is used to get the visual odometry and for more accurate odometry we managed to use wheel encoder to calculate the distance that the robot has traveled. The robot is able to measure its orientation by an inertial measurement unit (IMU). A Kalman filter has been implemented to get the best possible odometry. Furthermore, we have planned to generate 2D and 3D map on the aerial robot using Realsense 3D camera and IMU. For this purpose, we use RTAB-Map package software under ROS.

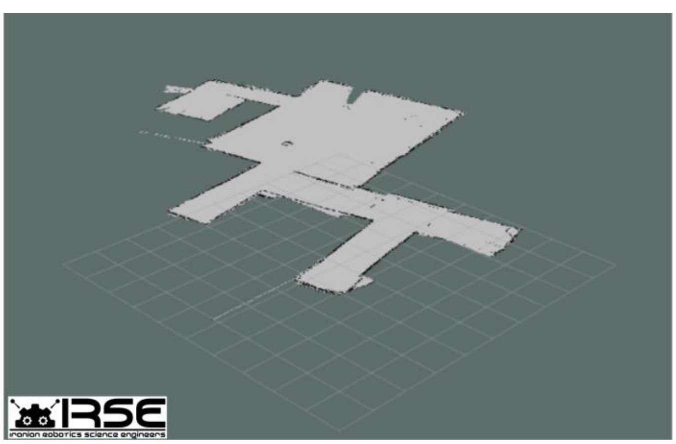

Fig.6 Shows a 2D map using Hector_slam

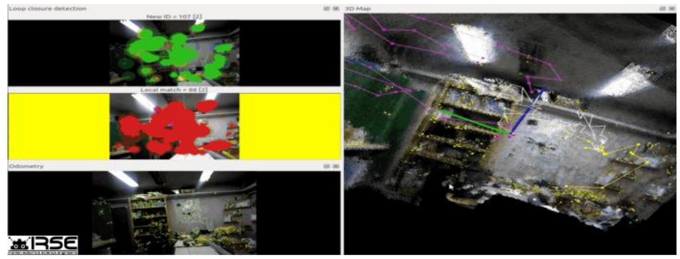

Fig.7 Shows a 3D map using RTAB-Map package on ROS

2) navigation: In this section, we use data from Hokuyo scanning range finder and Xtion PRO LIVE 3D sensor. Firstly, we use RTAB-Map package software and thereafter, 3D map cloud and some other outputted messages are used for navigation and collision avoidance. In parallel with navigation using ROS packages, we planned to implement another algorithm for the same purpose. Since laser scanner outputs vast data and navigation needs to be without delay, we use both vector space and wighted mean. by using this combined output and some other parameters such as distance and derivative of laser scanner's datum and some more statistics' data, we are able to define Heuristic function and then we use them all in A* algorithm. This enables the ground robot to navigate even if there is no map of the environment.

3)victim detection: detecting victims are of high importance in case of disaster so that we have made significant progress in it. Our robot is able to use vision, heat, CO2 based victim detection and we have managed to add voice recognition to our ground robot, too. both our aerial and ground robots are capable of detecting QR code and face as well as recognizing face and object using OpenCV libraries on Intel Up Board mini pcs. The aerial vehicle can also track moving platforms and objects. thermal based detection comes from the custom designed thermal camera sensor which is implemented on the ground robot. This sensor is designed using Ocam 5MP camera and tpa81 thermal sensor. And for detecting CO2 the ground robot has been outfitted with MQ9 Sensors. All these data are sent to the hector-object-tracker so that the robot is capable of keeping track between victims and it will update the map each time.

Fig.8 Tracking QR code

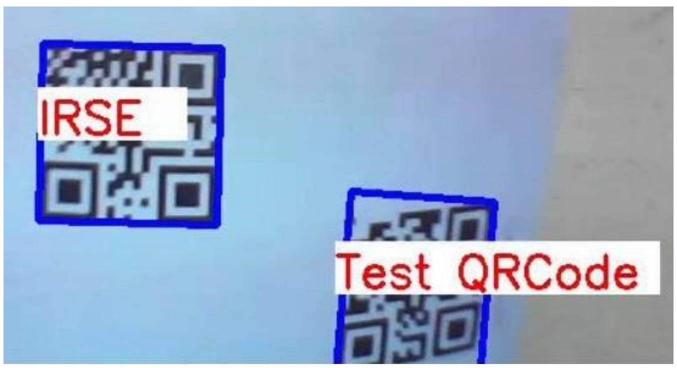

Fig.9 Detecting QR code

C. Communication

The connection between the station and the robot is via WIFI which will be 2.4GHZ or 5 GHZ due to the condition. An access point on the robot will be as a repeater and all of the data will be sent or received with an AC5300 router.

D. Human-Robot Interface

The control method and human-robot interface is split into two parts. 1) Control and interface on an unmanned aerial vehicle (UAV) 2) Control and interface on an unmanned ground vehicle (GUV). This mixed ground and aerial robotic platform is discussed in more detail below.

III. Application

A. Set-up and Break-Down

The set-up and break down time is less than 5 minutes. Also, roller tool boxes are designed to put everything on them for fast handling. Finally, a joystick connected to laptop is used for robot's movements.

B. *Mission Strategy*

The robot moves around autonomously outdoors and for other missions in which the robot is operated by the operator, Logitech joystick sends data using joy package software under ROS and we are able to use this data by connecting Arduino to ROS and generating pulses.
but by using data of several sensors such as GPS and some other sensors using for collision avoidance, we are able to control the robot full autonomous outdoors. our robot is also capable of navigating through indoor environments using laser scanner and 3D camera sensors.

C. Experiments

First, we do our primary tests in gazebo on our robot and after reaching the desirable output and the least possible number of bugs, testing will be started in the real world.

D. Application in the Field

The robot is fully implemented in the ROS environment.
All programs written for the robot in the form of ROS nodes have implemented. that simultaneously they run to the ROS environment. and they are in contact with each other.
The processing nodes has benefited from Comprehensive OPENCV library.
As well as the output data of the RTABMAP package nodes, the route and extraction of the 2D and 3D maps is used.
The advantages of ROS environment is the concurrent and optimum implementation of the written application
Also the existing open source packages that at any moment are being optimized is the other benefits of this environment.
All operations are performed automatically(autonomous) and according to Artificial algorithms (al)

IV. Conclusion

This is our first year that we are participating in the competitions with this robot so we don't have any serious experiences. Although this robot has been built with the help of investigating, researching and our experiences in other fields, we know that the important aim is to speed up helps in urgent disaster times with less time waste and most efficiency.

TABLE I
MANIPULATION SYSTEM

Attribute	Value
Name	iRUE212
Locomotion	tracked
System Weight	50kg
Weight including transportation case	70kg
Transportation size	0.6 x 0.6 x 0.5 m
Typical operation size	0.5 x 0.8 x 0.4 m
Unpack and assembly time	240 min
Startup time (off to full operation)	Max 5 min
Power consumption (idle/ typical/ max)	60 / 200 / 800 W
Battery endurance (idle/ normal/ heavy load)	240 / 120 / 20 min
Maximum speed (flat/ outdoor/ rubble pile)	3 / 2 / 2 m/s

Payload (typical, maximum)	200g/2 kg
Arm: maximum operation height	160 cm
Arm: payload at full extend	2kg
Support: set of bat. chargers total weight	3kg
Support: set of bat. chargers power	220-110v
Support: Charge time batteries (80%/ 100%)	40-60min
Support: Additional set of batteries weight	2kg
Any other interesting attribute	?
Cost	?

APPENDIX A
TEAM MEMBERS AND THEIR CONTRIBUTIONS

Ashkan Safavi sohi: Team leader and programmer
Mohsen Zaj chenari: Electronic designer and programmer
Mahmoud Vatani: Mechanical Designer
Arash Pour Hassan Nejad: AI programmer
Hossein Asghari: Electronic programmer
Atefeh Mehrani: Mechanical Designer
Zahra Shahi: Mechanical Designer
Ghazaleh Hossein Gholi Zade: Electronic programmer
Maryam Farahani: Electronic designer
Ghazal Kianmehr: Electronic programmer
MohammadReza Nasiri: Supervisor

APPENDIX B
CAD DRAWINGS

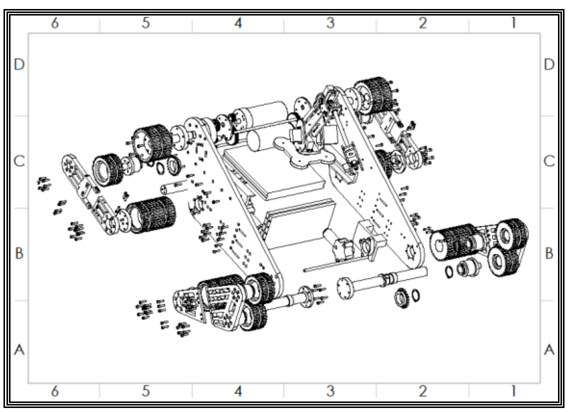

Fig.10 Exploded-view drawing

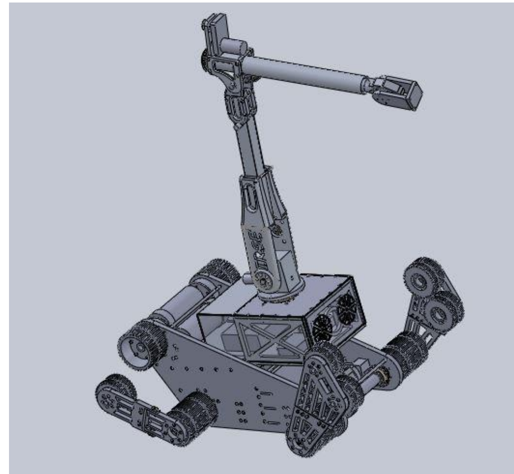
Fig.11 CAD drawing of the robot

APPENDIX C
LISTS

TABLE II
AERIAL VEHICLE

Attribute	Value
Name	iRad651
Locomotion	quadcopter
System Weight	750g
Weight including transportation case	720g
Transportation size	30 x30 x10 cm
Typical operation size	0.6 x 0.6 x 0.2 m
Unpack and assembly time	60 min
Startup time (off to full operation)	15 sec
Power consumption (idle/ typical/ max)	100/ 2400/5600 W
Battery endurance (idle/ normal/ heavy load)	60 / 15/ 10 min
Maximum speed	7 m/s
Payload	200 g
Any other interesting attribute	?
Cost	?

TABLE III

OPERATOR STATION

Attribute	Value
Name	Handmade
System Weight	3KG
Weight including transportation case	7KG
Transportation size	?
Typical operation size	?
Unpack and assembly time	4min
Startup time (off to full operation)	3min
Power consumption (idle/ typical/ max)	?
Battery endurance (idle/ normal/ heavy load)	?
Any other interesting attribute	?
Cost	?

TABLE IV
HARDWARE COMPONENTS LIST

Part	Brand & Model	Unit Price	Num.
Drive motors	Buehler	90 USD	3
Drive gears	?	?	?
Drive encoder	Internal Encoder	50 USD	11
Motor drivers	SABERTOOTH	130 USD	2
DC/DC	XL4005/XL4016	9 USD	2
Battery Management	IRSE BOARD	20 USD	?
Batteries	3cells,4cells,6cells(TATTU)	30-60 USD	3
Micro controller	ATMEGA2560 + Intel Processors	500USD	3
Computing Unit	Odroid XU4	59 USD	1
WiFi Adapter	MIKROTIK METAL SHP 52 AC	150 USD	1
IMU	Mpu9250	20 USD	1
Cameras	Odroid Camera-PS3	100 USD	3
PTZ Camera	-	-	-
Infrared Camera	Xiaomi	40 USD	-
LRF	Hokuyo URG-04LX	1000 USD	1
CO_2 Sensor	MQ9	5 USD	1
Battery Chargers	X200	200 USD	?
6-axis Robot Arm	Handmade	700 USD	1
Aerial Vehicle	iRAD651	1000 USD	1
Rugged Operator Laptop	ASUS G551VW	1200 USD	1

TABLE V
SOFTWARE LIST

Name	Version	License	Usage
Ubuntu	14.04	open	Operating system
ROS	jade	BSD	middleware
PCL [9]	1.7	BSD	ICP
OpenCV [10]	2.4.8	BSD	Victim detection
OpenCV [12]	2.4.8	BSD	LBP: Hazmat detection
Hector SLAM [13]	0.3.4	BSD	2D SLAM
RTAB-map	0.11.14	BSD	3D Mapping

A movie of the robot has been made which is uploaded to a site for download. The address files are shown below:

High quality: 168,469 KB
http://s9.picofile.com/file/8284396376/Rescue_IRSE.mp4.html
Normal quality: 22,397 KB
http://s8.picofile.com/file/8284395926/Rescue_IRSE.mkv.html