RoboCup Rescue 2018 Team Description Paper XFinder Team

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Info

Team Name: XFinder Team
Team Institution: Universidad Tecnologica Emiliano Zapata (UTEZ)
Team Leader: Vazquez Reyes Martin Omar

Abstract – *T*his paper describes the construction, assembly and operative attachments of our XFinder robot, in order to participate in the TMR competition (regional tournament in which we are two times champions during 2015 - 2016) and to get a place in the RoboCup Rescue League Competition.

Our robot is a four wheeled tele-operative robotic system suitable for indoors and outdoors with high pulling force, simultaneous localization and mapping (SLAM), visual victim and QR codes also has sensors installed like CO2 sensor, fire sensor, rain sensor, temperature and humedity sensor (DHT11). The goal of this system is to recognize victims on any ground or terrain, generating a map useful for human rescue teams.

Index Terms -- RoboCup Rescue, Team Description Paper, Tele-operative Rescue Robot, 3D Mapping.

I. INTRODUCTION

The XFinder project was born originally as an “integral homework” or end course proyect, developed by four graduated students during a proyect presentation for local companies and high charge university directives. Months later the university look potential in this proyect due to many disasters produced in the near city of Cuernavaca.

In our university there are two world competitive branches called *VEX robotics* and *Nao robotics*. This project is part of the primary competition team of NAO robotics in the free category.

Fig. 1. Teleoperated robot XFinder.

During the many national competitions the XFinder has adopted many forms in relation to the teams that have worked with it, ending in our actual version, showed in the upper image. Our primary goal is to create a reliable exploration robot capable of deliver information in real time during a disaster whenever the conditions threaten the human intervention.

After many field tests and several broken mechanical pieces and burned circuitry, it’s proven that this robot is ready for the hardest conditions.

A. *Improvements over Previous Contributions*

The actual XFinder has receive mayor improvements in the software than in the mechanical field.

We are focus on implementing the 3D mapping, object recognition and navigation system granting us a better localization and information acquisition. Also we are improving our control systems to have a better and clear interaction between the operator interface and the action the robot will do.

II. SYSTEM DESCRIPTION

A. *Hardware*

1) The XFinder comes with 70 kg, 1 m long, 70 cm wide, 70 height and with help of dual electrical pistons can reach the height of 78 cm. this contributes to have a better performance in the roughest terrain due to the facility of quickly deploy these pistons to adapt to the irregular terrain.

Fig. 2. Electrical piston in the XFinder.

2) Many local competitions gave us the clear view of implementing a suspension system in the wheels, this is to grant a better impact resistance when the robot goes upstairs/downstairs or rough terrain in the existence of a ramp.

Fig. 3. Suspension system.

3) Our wheeled design make possible to choose between speed or torque, depending on the field conditions, so we added a multiple chain transmission.

Fig. 4. Chain Transmission.

4) The XFinder have three cameras mounted, the first one is to object recognition to prevent collision and monitoring direction, the second one is to real-time video transmission and one in the back to watch any possible obstacle when going backwards.

Fig. 5. Sides and back cameras.

5) To make capable our 3D mapping feature, we mounted on the front of the XFinder an Xbox 360 Kinect that also serves as a frontal camera, working cooperatively with the sides and back cameras for full vision of the surroundings and get a better map localization with real time vision besides the 3D map.

Fig. 6. Kinect sensor. (3D map)

6) The XFinder use batteries of many types, one of those is an small Lipo battery (22.2 V, 10,000 mA) to supply energy to the engine of the XFinder that is to motive of distributing more weight in the back part to get more torque to go through obstacles more easily. Also it uses 3 sealed lead acid batteries (12 V, 4.5 A) these are to supply energy to the Kinect, fans and pistons as well it uses 2 power banks to give energy to the camaras and the circuit board Arduino this with the motive of distributing more weight in the back part to get more torque to go through obstacles more easily.

Fig. 7 Lipo battery, sealed lead acid batteries and power banks. .

7) We are use radio frequency system of 2.4 GHz to control the robot remotely. Also we use the circuit board Arduino (Arduino MEGA) to control the pistons manually and the autonomous control of them and the control of the sensors. As well we made our circuit boards to control de motors.

We use an NI myRio to real-time video transmission for the backwards.

Fig. 8. Circuit boards mounted in the middle box.

B. *Software*

1) The control of the pistons is made using LabVIEW and the information is send and received by NI myRio for quick signal answer. In this control we can manipulate how much the Pistons go up or down and we can manipulate one or another also we can watch in the program how the sensors work.

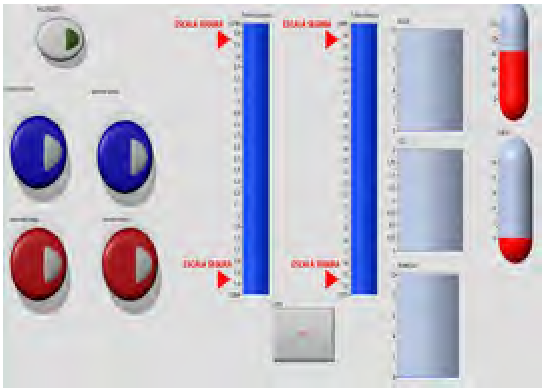

Fig. 9. Operator Control in LabVIEW.

2) The internal code made in the LabVIEW graphical code, help us a lot to do separated actions, giving us less errors or make our code less dependent on previous conditions.

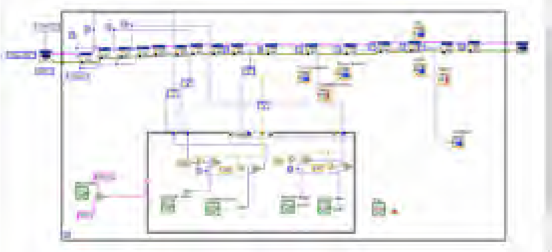

Fig. 10. Pistons and sensors code in LabVIEW.

3) Our SLAM is done using an open source program called RTABMap which uses the Kinect 360 sensor to measure and create in real time a map to locate and navigate, also we’ve used the frontal camera of the Kinect to have frontal view, this to make easier the operator interface. We are in process to add object recognition to have a 1better final map with useful landmarks.

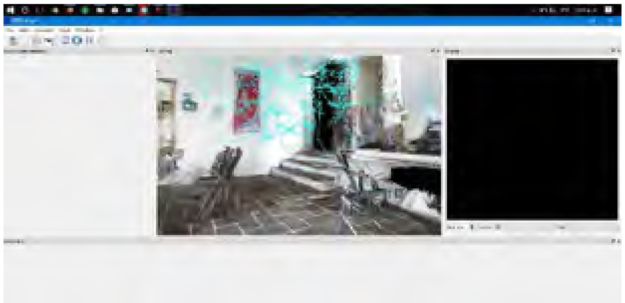

Fig. 12. 3D mapping using RTABMap.

C. *Communication*

There are three communication systems used between the operator and the XFinder. The first one is a wireless LAN based on IEEE 802.11a standard which functions as the main communication system. It controls the robot. The second LAN receives video streaming from cameras on the robot, receives and send the SLAM data for the map automatic generation.

The las one is radio frequency to get a video in real time (5.8 G), Send signals for Movement control (2.4 G) ,

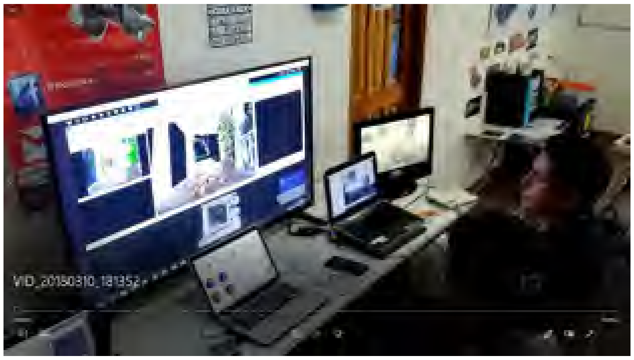

Fig.13.Our current operator station, going from left to right there are: SLAM and 3D Mapping, video stream from cameras and control of the robot.

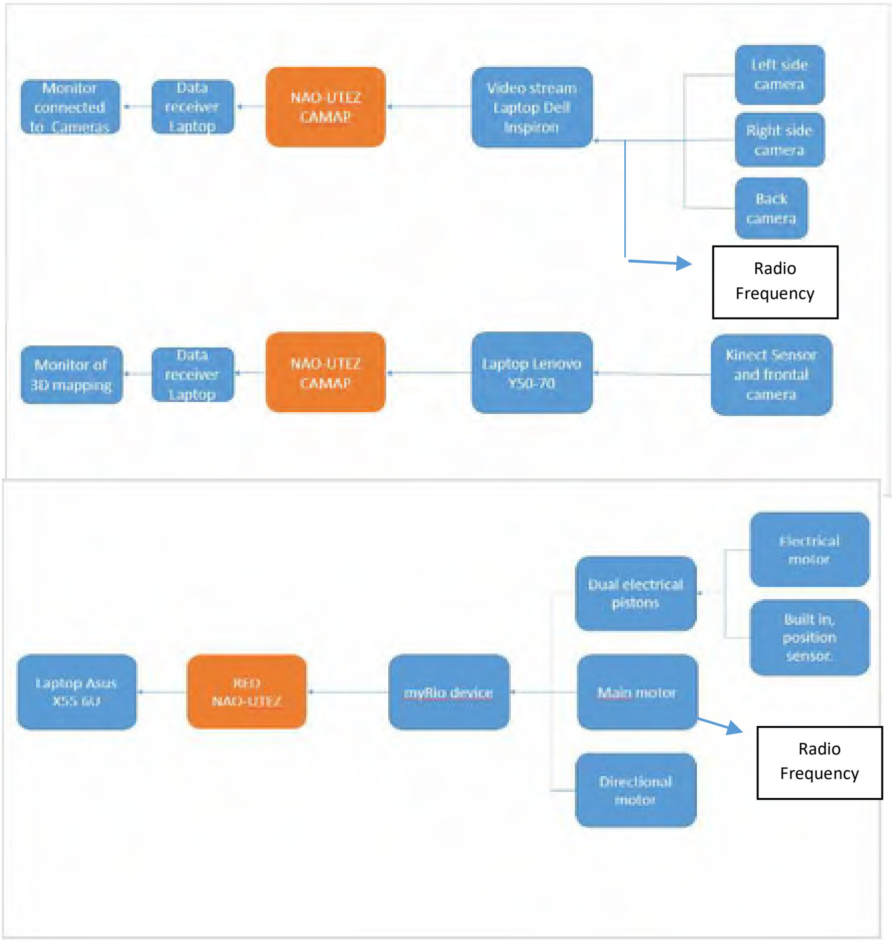

Fig. 14. Control and video system diagrams.

D. *Human-Robot Interface*

As shown in the upper diagram there exist two main communication tasks:

1) The first diagram shows the video stream from the robot in order to be able to have vision and 3D mapping, the information can also be seen in the left and middle monitors in Fig. 13. Also we have separated vision in case of some kind of error, granting us the capability of don't lose vision at all.

2) The other diagram shows the control of the robot navigation, main and directional motor, also the electrical pistons to sort rough terrain. This is because the movement is essential to complete the scout task and be able to do a map and identify victims. The controls of these motors can be seen in the right monitor in Fig. 13.

III. APPLICATION

A. *Set-up and Break-Down*

We are aware that the speed of the set-up and break-down process of each task is very crucial. The team has realizes that the faster for setup and break-down, the better time for other tasks, because of this we've simulated exercises making the deployment of the operator station due to the size of our equipment. Our equipment includes the XFinder robot, two laptops that go inside the robot to send data at our station. The whole equipment is transported to the operator station on a transport cart. Our exercises have shown that setup and break-down can be easily accomplished in a max of five minutes.

B. *Mission Strategy*

In our simulations we've created two teams, one for vision stream and navigation, and another for 3D mapping and localization. We are going to deploy the XFinder in the operation field and complete all the objectives possible in a planned routine depending on the two teams coordination, based in distance and objectives in the way.

C. *Experiments*

The experiments have been mainly mechanical due to the simulation of hard terrain, debris and different kind of materials like stones and sand and occasional circuitry fails. We expect the anatomy of the XFinder plus all of these simulations in different terrains allow us to complete yellow or red areas of the operation field. In the software area we're still developing the object recognition and the QR codes lecture.

Fig. 15. The XFinder version 6 going upstairs.

D. *Application in the Field*

The areas near our university are medium industrialized, because of this we as a college team, expect that the XFinder project could be useful in the exploration of this zones in case of disasters or contamination that could harm humans. Sending real time information to a rescue team for parallel actions and prevent human losses.

1) The robot strength relies on his movement pulling force, his size and durability to sort obstacles, due to this, the XFinder is appropriate for real scenarios.

2) Weakness: No robotic arm.

3) Some improvements we want to make are to get a better quality map and get a robotic arm.

IV. CONCLUSION

We as a new generation of NAO robotics, want to adquire the skills and knowledge from previous members and go furthermore, this will be our first big competition and we are prepared to assume the challenge. The XFinder project was born from scrap, reuse parts, funds from our college and own money sometimes, but we as a team are ready to participate and demonstrate the product of our hard work.

APPENDIX A
TEAM MEMBERS AND THEIR CONTRIBUTIONS

The XFinder robot has twelve members. Their names and responsibilities of each member are listed as follows:

1) Vazquez Reyes Martin Omar
   .-Team leader .
2) Chavarria Santiago Luis Ashmed.
   . - Mechanical Development.
3) Araujo Nieto Julio Eduardo.
   . – Mapping.
4) Diaz Altamirano Francisco Javier.
   . – System control / exploration.
5) López Basave Dilan Moisés.
   . – Structure.
6) Toledo Montealegre Leonardo.
   . – Mechanical design.
7) García Hernández Liliana.
   . – Object recognition.
8) Ruiz Contreras Jorge Valentin.
   . – Controller Development.
9) Salcedo Saavedra Brisa Isabel
   . - Software and control.
10) Salazar Cisneros Juan Daniel.
   . – Image processing.
11) Lira Alvarez Luis David.
   . – Electronic design.
12) Beltran Escobar Alberto Miguel.
   . – software and control.

APPENDIX B
LISTS

A. *Systems List*

There are four main systems:

- The manipulation System in the Table I.
- The Operator Station in the Table II.
- The Hardware Components List in the Table III.
- The Software List in the Table IV.

A*CKNOWLEDGMENT*

We want to thank to the Universidad Tecnologica Emiliano Zapata (UTEZ) for regularly supporting the XFinder robot in participating to the regional TMR and the upcoming World Robocup Rescue Robot Competition. Also we want to thank to the high charge directives that supports and believe in this project:

- M.C. Jaime Vazquez Colín.
- M.T.I. Marco Antonio Amado Gonzalez.
- M.T.I. Alejandro Rafael Caballero Morales.
- M.C. Alberto Miguel Beltrán Escobar.
- Ing. Martin Omar Vazquez Reyes.

REFERENCES

Due to our lack of help by experts in the three different areas (mechanical, electrical and programming) and the origins of the XFinder we don’t have many references, only some books from which we have took many ideas.

1) M. Labbé and F. Michaud, “Online Global Loop Closure Detection for Large-Scale Multi-Session Graph-Based SLAM,” In Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems, 2014. (From here we took our main source to make our SLAM)

2) J. Craig, Introduction to Robotics Mechanics and Control. Pearson Prentice Hall; third edition, 2005.

3) M. Rashid, Electrónica de potencia: circuitos, dispositivos y aplicaciones. Pearson Prentice Hall; tercera edición, 2004.

TABLE I
MANIPULATION SYSTEM

Attribute	Value
Name	XFinder
Locomotion	Wheeled
System weight	85 kg
Weight including transportation case	90 kg
Transportation size	1.0 x 0.6 x 0.66 m
Typical operation size	1.0 x 0.6 x 0.78 m
Unpack and assembly time	210 min
Startup time (off to full operation)	5 min
Power consumption (idle/ typical/ max)	60 / 560 / 1000 W
Battery endurance (idle/ normal/ heavy load)	60 / 40 / 20 min
Maximum speed (flat/ outdoor/ rubble pile)	0.8 / 0.6 / 0.3 m/s
Payload (typical, maximum)	NE
Arm: maximum operation height	NE
Arm: payload at full extend	NE
Support: set of bat. Chargers total weight	2.5 kg
Support: set of bat. Chargers power	1,200W (100-240V AC
Support: Charge time batteries (80% / 100%)	40 min / 60 min
Support: Additional set of batteries weight	3 kg
Any other interesting attribute	2 electrical Pistons
Cost	4000 USD

NE = Not Exist in the robot.

TABLE II
OPERATOR STATION

Attribute	Value
Name	XFinder Station
System Weight	15 kg
Weight including transportation size	30 kg
Transportation size	0.8 x 1 x 0.4 m
Typical operation size	0.8 x 1 x 0.4 m
Unpack and assembly time	15 min
Startup time (off to full operation)	5 min
Power consumption (idle/ typical/ max)	ND
Battery endurance (idle/ normal/ heavy load)	ND
Any other interesting attribute	-
Cost	500 USD

TABLE III
HARDWARE COMPONENTS LIST

Part	Brand & Model	Unit Price	Num.
Robot structure	-	2000 USD	1
Drive motors	-	500 USD	2
Drive gears	-	-	-
Drive encoder	-	-	-
Motor drivers	-	-	-
DC/DC	Regulator	-	1
Battery management	NE	-	-
Batteries	LiPO, car battery	500 USD	2
Micro controller	myRio	1000 USD	1
Computing Unit	Dual Mounted Laptops	-	2
Wi-Fi Adapter	Access point IEEE 802.11a	100 USD	2
IMU	-	-	-
VDO cameras	-	-	-
PTZ Camera	-	-	-
Infrared Camera	-	-	-
LFR	-	-	-
CO2 sensor	-	100 USD	1
Battery chargers	-	200 USD	2
6-axis robot arm	-	-	-
Aerial vehicle	-	-	-
Rugged Operator Laptop	-	2000 USD	1

TABLE IV
SOFTWARE LIST

SOFTWARE	VERSION	LICENCE	USAGE
Windows 10 Home.	1607	Closed Source.	Workstation OS.
RTABMap Project.	0.11.14	Open Source.	3D mapping.
TeamViewer.	12.0.72365.	Open Source.	Streaming between Laptops in the XFinder browser.
NI LabVIEW.	15.0.	Closed Source.	XFinder browser algorithm.
OBS Studio.	17.0.2.	Open Source.	Cameras stream installed in the XFinder.
Kinect for Windows Drivers.	1.8.0.595	Open Source.	Drivers required for 3D mapping sensor.
Kinect for Windows SDK.	1.8.0.595	Open Source.	Extra drivers for the 3D mapping sensor.
Kinect for Windows Runtime.	1.8.0.595	Open Source.	RGB camera controller integrated into the 3D map sensor.