RoboCup Rescue 2018 Team Description Paper X-kau ITNL

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Info

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RoboCup Rescue 2018 TDP collection: https://to.be.announced.org

***Abstract*—The present work describes Iktan Robot (Teleoperative) and three robots (autonomous) Frida, Topo and 19S. They work together to try to search victims in few time. Each one has abilities, Iktan is the leader and is a mobile robot, it read QR codes, has gas sensors and receive information from the cameras of the other robots: Frida,Topo and 19S to make the reconstruction of the place and the send the map, the information about state of victims and the danger places. Frida is a mobile robot, it search victims with a termal sensor, it carry water to victims. Topo is a mobile robot too and is robust than Iktan and Frida to enter to difficult places. Finally, 19S is a quadricopter to takes information of the top view of the place.**

***Index Terms*—RoboCup Rescue, Team Description Paper, Automatic Control, Collaborative robots, Aerial Robot.**

I. Introduction

X-KAU team is highly motivated by the receant earquake of the september 19th 2017 in Mexico City (19S), though this team is lately formed, it has a synergy of students with good technical experience in building and programming robots and the experience of their mentors about the knowledge of robotic advanced (mathematical modelling for non inertial robots and non-linear controls), [1]. All the mobile robots are builded by the students. The goal of this team is that the students adquired the knowledge of advanced robotics and, at the same time, apply this knowledge to solve the problems to navigate, colaborate and send information in a disaster environment.

In the robotics laboratory of the ITNL, where the proyect has been taking, it is growing a new generation of students that are concern about solving problems where the robotics can help. At the same time, they know that the real problems has dynamics, constrains, undesairable noise, delays, unkown environments and they know that they need advanced strategies to tackled them. In that sense, X-kau team is searching to solving each one of this problems. The implemented solutions and the solutions in developing are thinked in the problem of searching victims as soon as possible, know the state of them and if it is possible to help them. The description of the system is detailed below.

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Fig. 1. Iktan robot. Teleoperative robot.

II. System Description

The Iktan robot has been focused to navigate in non uniform terrains, up stairs. The improvements, since it was started to move, have been focused in its mobility and to reduce its weight. It has an articulated arm to interact. Iktan robot has a kinematic control, but the other mobile robots are being developed using dynamic controls.

A. Hardware

The information of the Hardward is in the Tables I, II and III in the Appendix.

- Locomotion: The teleoperative robot is a tracked mobile robot and its size is 63 cm long, 45 cm wide and 54 cm of height in their compact configuration, for operation size, the long side grow up 20 cm, see Figure 1. Its weight is 35 kg. Iktan robot has 2 flippers and the position of the flippers for navigation is at 45 , similar to a militar tank. The mobile robot has caterpillar wheels and has three

Fig. 2. Frida robot. Autonomous robot.

motors, one for the flipper. The maximum speed is 1.5 m/s. The Figure **??** shows how Iktan robot up a stair.
- Power (Batteries): the system has three batteries at 5V 2.1A, the main consumption is the mini PC, the robot arm and the mobile robot.
- Electronics: the motors are controlled by two H bridge each one. The state of the motors and
- Manipulation/ directed perception: The system has a robot arm has 6 DoF. The wrist is showed in Figure 4. The first 3 DoF are driven using 3 electric pistons. The wrist has 3 DoF, and each joint has a motor.
- Sensors: the system has 2 sensors, see Figure 6. One of them, a sensor to monitor gases: carbon monoxide (CO), oxygen (O_2), fluorine, chlorine and dioxide, this sensor is mounted in the body of the mobile robot. The other sensor is a temperature sensor, the goal of this sensor is to measure the victim's body temperature; this sensor is mounted in the robot arm. A camera is mounted in the robot arm, and their function is to send information to a mini computer (mounted over the mobile robot) to mapping the environment, see Figure 5.
- Computation: the system has a mini PC mounted in the body of the mobile robot. It has a weight of 0.3 kg. The OS is Ubuntu 16.04. All the main processes (control, mapping and reconstruction) are carried out here.
- Communication: a Xbee module is used for unwired communication. The advantage of the Xbee is that the range of operation inside of a building if of 90 m, for outdoor operation the range is broader.
- Quadricopter: for aerial monitor a phantom (19S) is used, see Table II for the characteristics of the phantom. The goal of the 19S robot is to take pictures of the environment and to send this information to the Iktan Robot. The mapping of the top area is reconstructed in the mini PC.

B. Software

Refer to Table V in the Appendix.

The vision system uses Ubuntu SO. There is a camera and a kinect where a picture of the environment is adquired and send

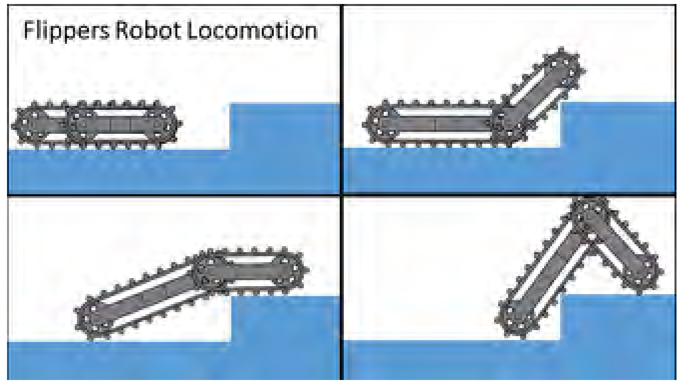

Fig. 3. The flippers robot locomotion

Fig. 4. Gripper design

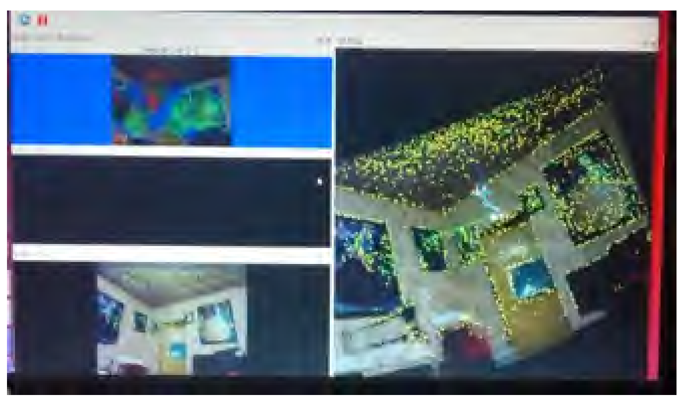

Fig. 5. Reconstruction of the environment

it to a small PC, the libraries of OpenCV and an algorithm is used in the small PC to map the space when the next image is received. This part of the vision system is able to extract the main information to send them to the block of the Base of operation, see Figure 9. In the small PC the information of the sensors, the state of the position and speed of the motors is used to send them to the Base of Operation. The robot is teleoperative, for that reason the control is carried out by the human. It is planned that there will be loop of automatic control that receives the position and velocity that the operator wants, and this information serves as reference.

Fig. 6. Sensors

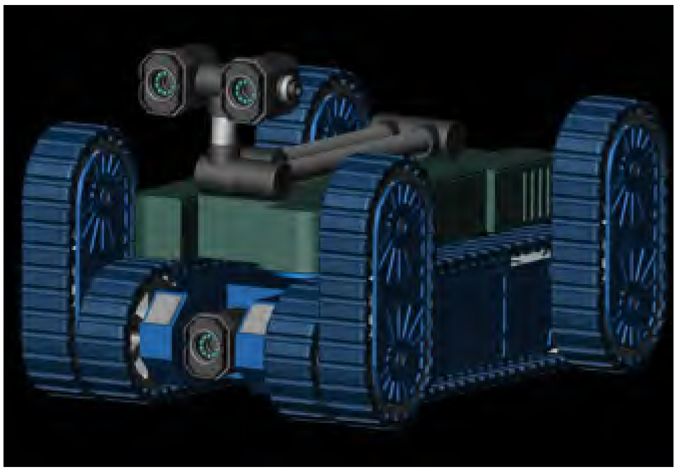

Fig. 7. Topo robot. Autonomous robot.

Fig. 8. 19S robot. Quadcopter

C. Communication

For communication the Xbee system is used for the communication between robots. The idea is to improve the communication using this system. The communication between the Iktan Robot and the Base of Operation uses WLAN.

D. Human-Robot Interface

In the area of vision we have 2 computers that operate in communication: Operator-machine. A mini PC brand Racing p1, mounted whit the robot and 2 web cam of PS3, one for the detection of codes and the other for QR codes, in

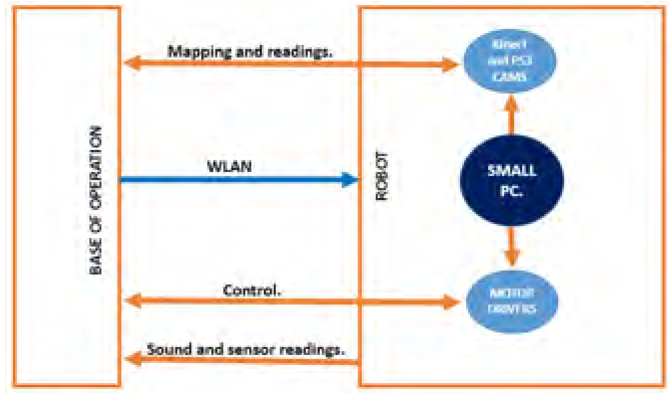

Fig. 9. Diagram of the system

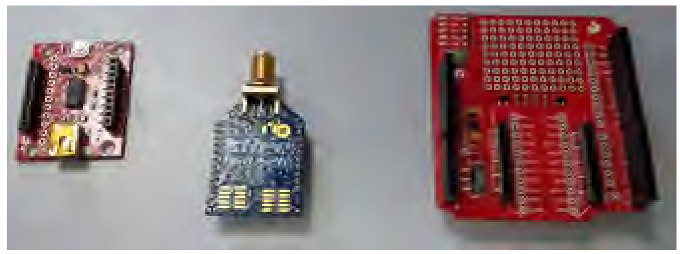

Fig. 10. Xbee electronic board for communication system

addition to the Kinect Xbox 360 that helps to map and send all information to the operator's computer. The operating systems of both computers is Linux Ubuntu. And they operate through a communication node made in ROS and Rviz, which are software with auxiliary libraries in the robot communication. All this connected to WLAN between a modem and a router.

III. Application

The advantage of Iktan robot is the ability to navigate in difficult terrains. This makes that Iktan robot can be used not only for one kind of disaster. The idea of use three robots is to open the possibility to broad the applications.

A. Mission Strategy

The strategy is to use 3 robots to work collaboratively. The master (teleoperative robot) are guided by a human. The slaves are autonomous. In order to reach this characteristic the mathematical model of each robot is required to implement an automatic control. The kinematic and dynamic model are obtained. Simulations of the performance are taken in Matlab. Each robot has cameras to explore and reconstruct the environment. The communication net builded using the Zigbee allows to reconstruct the environment, this is because the master robot receives the information of the autonomous robots and send this information to the operation station and map all the place.

B. Experiments

Iktan robot was tried in difficult terrains, stairs of different size, passing throgh some obstacles and making some tasks of manipulation of heavy things. The vision system was probed to see the reconstruction of the space. The experiments helped to improve the selection of the material of the wheels, many types of plastics were tried until the last one supported the stairs. The consumption of batteries was another problem, when the weight of the robot started to up, a more powerfull baterries were required.

For the experiments in task of manupulation a wrist with 2 DoF was used, but there were constraints of dexterisity. For that reason a new design of wrist was required, but the weight and the transmission in a present problem.

X-kau team is working to improve practically in all the areas. The vision system requires a SLAM algorithm to navigate. The communication algorithms have been improving. An autonomous control for the quadricopter control, [2].

C. Application in the Field

Iktan robot was builded thinking in the application of rescue and to search victims. The disadvantage of Iktan is that the motors are operated by the user, however X-kau team is working in the mathematical model of the robot to implement advanced controls to increment the performance and dexterisity, [3]. The control loops of the motors have been modified to implement dynamic controls, i.e. to be controlled by the current and not by the voltage.

IV. Conclusion

X-kau team are been working to have robust mobile robots, and to have a good strategy to rescue and search victims. The performance of the robots are pursuited, the experience of the team members in the technical area and the control assure to have a good result. The motivation to do this work is to really help people and learn about real difficulties for robotics. During the lately months X-kau team learn that it is required members that do not give up with the first problems, starting with the finance. Some of the used materials are recicled, the ingenius of some of the members are awesome. Right now a first robot were builded, it has to be improved but the fact that this robot is a real working platfom, it has gained the support of some institutions, that will make that the next robots have better performance.

Appendix A
Team members and Their Contributions

- Daniel Pescador — Controller development
- Luis Aguilar — Mechanical design
- Francisco Perez — Vision and SLAM algorithm
- Orland Contreras — Sensors
- Lourdes Bolanos — Mechanical design
- Katia Rocha — Electric design
- Neftali Zavala — Human interface
- Irving Rangel — Communication system
- Dulce Martinez-Peon — Mathematical model and automatic control

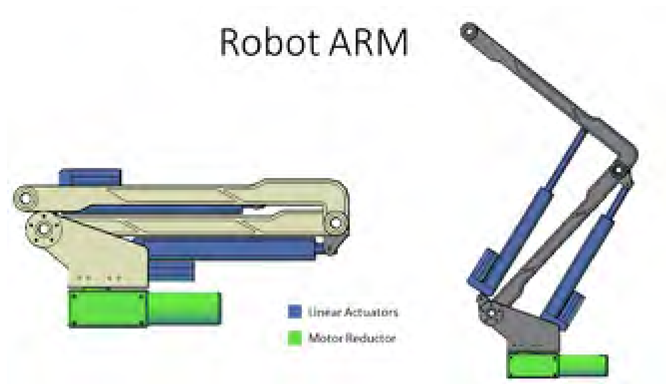

Fig. 11. CAD of robot arm of Iktan robot

TABLE I
Manipulation System

Attribute	Value
Name	Iktan
Locomotion	tracked
System Weight	35 kg
Weight including transportation case	50 kg
Transportation size	0.54 x 0.63 x 0.45 m
Typical operation size	0.54 x 0.83 x 0.45 m
Unpack and assembly time	180 min
Startup time (off to full operation)	15 min
Power consumption (idle/ typical/ max)	ND
Battery endurance (idle/ normal/ heavy load)	ND
Maximum speed (flat/ outdoor/ rubble pile)	1.5 m/s
Payload (typical, maximum)	5 kg
Arm: maximum operation height	1.5 m
Arm: payload at full extend	7kg
Support: set of bat. chargers total weight	ND
Support: set of bat. chargers power	ND)
Support: Charge time batteries (80%/ 100%)	ND
Support: Additional set of batteries weight	3kg
Cost	1000 USD

Appendix B
CAD Drawings

Some of the CAD drawing are showed in Figures 11, 4, 2 and 7.

Appendix C
Lists

A. Systems List

The information of System List is showed in Table I in the case of Manipulation System. Table II for Aerial Robot. The Table III shows the detail of Operation Station.

B. Hardware Components List

The list of hardware components for Iktan Robot is showed in Table IV.

C. Software List

The Table V has the details of the software.

Acknowledgment

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TABLE II
AERIAL VEHICLE

Attribute	Value
Name	19S phantom
Locomotion	quadcopter
System Weight	1.388kg
Weight including transportation case	2.5kg
Transportation size	22.5cm x 39cm x 33cm
Typical operation size	50cm x 50cm x 20cm m
Unpack and assembly time	5 min
Startup time (off to full operation)	2 min
Power consumption (idle/ typical/ max)	100 / 150 / 100 W
Battery endurance (idle/ normal/ heavy load)	30 / 20 / 15 min
Maximum speed	20 m/s
Payload	0.15 kg
Any other interesting attribute	?
Cost	2000 USD

TABLE III
OPERATOR STATION

Attribute	Value
Name	Frida
System Weight	13kg
Weight including transportation case	5kg
Transportation size	0.6 x 0.6 x 0.6 m
Typical operation size	0.4 x 0.4 x 0.4 m
Unpack and assembly time	3 min
Startup time (off to full operation)	3 min
Power consumption (idle/ typical/ max)	60 / 80 / 90 W
Battery endurance (idle/ normal/ heavy load)	10 / 5 / 4 h
Cost	2000 USD

TABLE IV
HARDWARE COMPONENTS LIST

Part	Brand & Model	Unit Price	Num.
Robot structure	X-kau ITNL	111 USD	1
Drive motors	Electric char motor	110 USD	3
Drive gears	-	-	-
Drive encoder	Omron rotary encoder	120 USD	3
Motor drivers	H bridge	70 USD	6
DC/DC	Regulator	40 USD	1
Battery Management	ND	-	-
Batteries	Acid	40 USD	2
Micro controller	Pic	22 USD	1
Mini PC	Mini PC Racing p1	166 USD	1
Computer	Samsung NP305v4A	277 USD	1
Kinect Xbox 360	-	16 USD	1
Camaras PS3	PS3	13 USD	2
Router Tp link	tl-Wa701nd	3 USD	1
Electric pistons	-	415 USD	3
Temperature Sensor	LM35	192 USD	1
Aerial Vehicle	Phantom 4	1,660 USD	1
Raspberry pi 3	-	67 USD	1
Rugged Operator Laptop	-	-	-
CO_2 Sensor	-	-	-
Power Banks	-	83 USD	3
Reception antenna	TP-LINK modelo TL-wn720nd	9 USD	1
Robotic WiFi camera for wifi monitoring	-	83 USD	1

TABLE V
SOFTWARE LIST

Name	Version	License	Usage
Ubuntu	16.04	open	
ROS	jade	BSD	
OpenCV [4], [5]	2.4.8	BSD	Haar: Victim detection
Rvis Rtabmap	-	-	-
X-kau Mapeo 3D	-	-	3D Mapping

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