RoboCupRescue 2015 - Robot League Team <LARVIC-RESCUE (PERU)>

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Abstract.

This paper describe how we construct, program and test three different and cooperative robots to participate in the Rescue Robot League to this Robocup 2015.Our team LARVIC-RESCUE is formed with members of the LARVIC from the San Pablo Catholic University, this year is the first participation in this category last years we have been participating in another categories in the Latin American Robotics Competition (LARC). We have developed 3 kinds of Robots: One of them is the Wheeled Robot, which will perform as an autonomous robot, and will build the map to the environment, another Robot is the Caterpillar Robot which is developed for more hazardous environments which also have a robotic arm, and this will fit in most of the environments from our country, another one is an Aerial Robot that will support the work of the other robots having a larger vision from above the arena.

Introduction

The following work was developed Robotics and Computer Vision Laboratory (LARVIC) from the San Pablo Catholic University . In 2013 we organized the Latin American Robotics Symposium and the Latin American Robotics Competition (LARC) for the first time in our country, and also our Laboratory was part in Standard Education Kits (SEK) and IEEE Very Small Size categories, last year we also participated in the same categories as a “UMAYUX” team. And as part of our group

in robotics we have being working teaching robotics for children in the last years, in 2014 part of our laboratory travelled to the Robocup junior to compete in Dance and Rescue categories , obtaining the Construction Award in the category Dance Primary in Brazil.
In this work with 3 different types of robots were developed: an Aerial Robot, Caterpillar and a wheeled robot. The caterpillar is going to have sensors such as a CO2 sensor, microphone sensor, and a camera which will be capable to recognize human signs. On the other hand, the wheeled robot, works with a occupational map, to solve the SLAM problem and also odometry, all of this is needed for the recognition of obstacles and the victims. The Aerial Robot is going to be autonomous to work in the aerial arena.
This research has a group of people from different careers,from electronic engineers, mechanics, computer science until Robotics Doctors. All of this people work in the laboratory as researchers,developers or as students.
The main reason for the development of our rescue robots is the fact that in our country it doesnt exists any kind of electronic researches for victims even though we are one of the principal producers countries in minery. Also ,the different geographic areas that our country has with different types of natural disasters. In 2012 SINAI(entity in charge of the environmental information).Reported 178 deaths involving nature disasters and lost victims from minery. So we can have many kind of apply our robots to help in rescue human teams.
In order to perform our rescue robot we separated its content in different sections ,our team members and their contributions.The construction of our 3 robots and its software involved with it,a wheeled robot,caterpillar and drone.The sections introduced here are operator station set-up and break-down communications control method and Human-Robot Interface,Map generation/printing Sensors for Navigation and Localization,Sensors for Victim Identification ,Robot Locomotion, Control for locomotion teleoperated robotic arm,Team Training for Operation (Human Factors),Possibility for Practical Application to Real Disaster Site, System Cost,Lessons Learned.All of this needed in the creation of our rescue robots.

1. Team Members and Their Contributions

The LARVIC-RESCUE team from the San Pablo Catholic University (UCSP), Arequipa- Perú, consists of students and graduated members within of the Laboratory of Robotics and Computer Vision (LARVIC), their contributions stated below:

Team leader	Prof. Dennis Barrios Aranibar
Hardware and mechanical design and Mechanical construction	Rolando Alberto Cateriano Delgadillo Cesar Adolfo Laura Mamani Roger Dante Ripas Mamani

Electronic Construction, Control and Mechanical construction	Edwin Christian Bolivar Vilca
Software and hardware architecture	All Team Members
Control Method, Human - Robot Interface and Control Station	Renato Marroquin Mogrovejo Percy Wilianson Lovon Ramos Yessica Rosas Cuevas
SLAM Robot Navigation	Elizabeth Morales Muñoz Kevin Christian Rodriguez Siu Liz Sandra Bernedo Flores
Autonomous victim identification	Raquel Esperanza Patiño Escarcina María Fernanda Tejada Begazo Claudia Cervantes Jilaja
Mechanic construction , Programming the interface for the robot arm	Victor Alfonzo Cornejo Arismendi
Strategy and Planning	All Team Members

Table 1: Team Members and contributions

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

We have 3 types Robots, The Autonomous Robot (Komodo Robot), the teleoperated Robot and the aerial robot. All the robot are controlled by one Samsung Galaxy Tab 4 Tablet, this tablet is connected to a Desktop Computer which is the station control. All the commands to the robots like act as an autonomous robot, or act as a teleoperated robot are sending from the tablet. The communication of this terminals are made via Wireless supported by a Router.
In order to setup our station we are going to pack our robots in a moveable case, also our desktop computer. We estimate this task is going to be done in maximum 8 minutes.

Figure 1: Operation Station being used to pick a bottle

3. Communications

The device will be more communication with the robot track system, which will have a set of TCP / IP communication via a wireless connection to communicate directly with the robot.

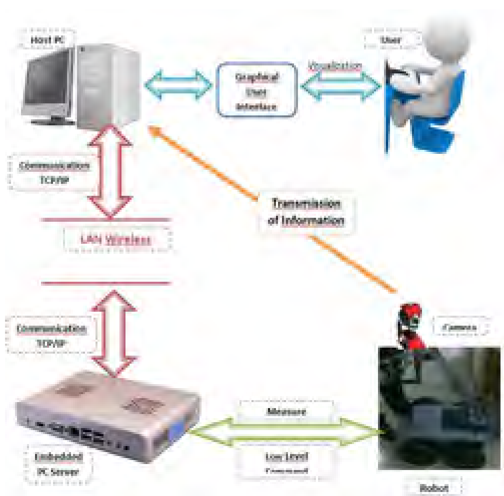

Figure 2: Communication Graph

Rescue Robot League		
LARVIC RESCUE (PERU)		
Power (mW)	**Channel/Band**	**Frequency**
--	--	5.0 GHz - 802.11a
35	6	2.4 GHz - 802.11b/g
	spread-spectrum	2.4 GHz - Bluetooth
1	Zigbee	2.4 GHz - Other
--	--	1.2 GHz
--	--	900 MHz
--	--	40 MHz

4. Control Method and Human-Robot Interface

All the robots we are using has Robot Operating System which is one of the most useful frameworks to develop software to robots [5]. ROS has been chosen because we can use the software we made in our Wheeled Robot with some little changes in our Caterpillar Robot so it can be also an autonomous robot.

As we see in figure 1, the teleoperation and all the commands for robots such us, changed from autonomous mode to teleoperated mode, moving, sensing are made from the tablet. We have used a package rosjava to communicate ROS (which is in all the robots) to our tablets (Android System Operating). The tablet have to connect to the station machine to send, and receive sensor information, this station machine is communicating with all the robots.

The interface we are using is presented in the next figure, we can changed between robots. We used fusion sensor to give more robustness in our system, as Sinamek applied to fusion data from IMU (Inertial Measurement Unit) and encoders information [6], we will used to make a estimation of the position of our robot (Wheeled Robot and Caterpillar Robot).

Currently all the joints in the robot arm are moved by two buttons, in the future we will make an animation to make movements into the Android application and this movements will updated in the real robot. In the case of the figure presents, all the information of the sensors for the Wheeled robot (the sensors that were merge are show in the top right part)
Another kind of teleoperation we will use is using a robotic arm, which is in a human person and this will imitate the movements made from the human, this will be describe in **section 9**.

Figure 3: Interface from Human in an Android Application

5. Map generation/printing

For being able to generate a map we are using 3 ultrasonic range sensors.
In the left,right and at the back,to make different types of measurements to generate a map using odometry and a SLAM technique. To obtain the data from the robot we work with WiFi connection, to receive the information from the robot, and be able to modify the occupational matrix. We are also able to create, a previous state and define the points that are generating obstacles.

The information was obtained from the 3 radars and are classified in the matrix that constantly change its states. Almost all the technique focuses to an area unknown for the robot,that with every visit increases the recognition of the place, with a previous and next state as part of the solution for the SLAM problem. The robot starts learning the information from the new place, the algorithm is capable to generate points of concentration and give more accurate positions each time with the measures it has.

All of this is possible with the grid, that represents the world the robot is learning. Each cell represent a part of the map, that every time generates new values that with this formula changes but gets more accurate each time,that includes the error obtained by the odometry. We want to see improvements over having your operator watch a video stream and draw a map. So please describe how you intend to track arena features, mark victims, and generally produce maps of the environments.First we are collecting the information from our robot with a program to make ,the information useful data.For the connection ROS is applied as the middle ware.After we are able to start recollecting the data sensors.We retrieve 3 ultrasonic information data,one in the back ,right and left.

All of this points are going to be represented in the grid to generate the position of the victims and obstacles.As part of the SLAM solution that we proposed here,each matrix has to generate and accurate position,by the repeated spots where the ultrasonics give information of obstacles or victims.

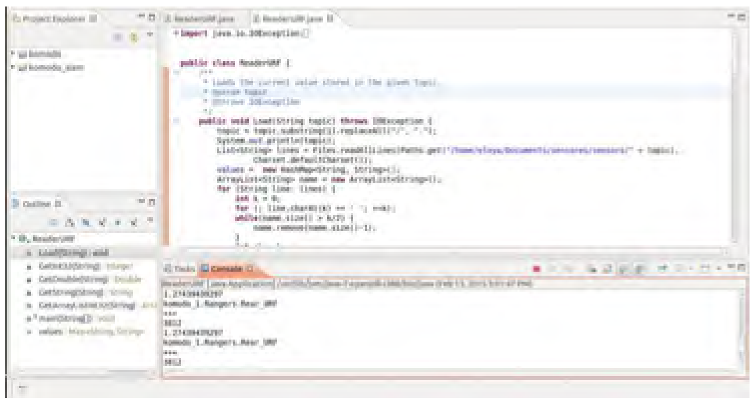

Figure 4:Obtaining information from the Rear sensor to manage the data for the Ocupational Matrix.

With the Matrix,of doubles represented we are able to start creating a representation of the world as the robot starts noticing..The next part to work with is applying k-means .With overlaping the points in the matrix for the matrix we make clusters.The size of each cluster can be modified .Each time that the robot ,starts mapping again the previous states changes with the variable of error and the data and makes best results for the future states of the ocupational matrix.

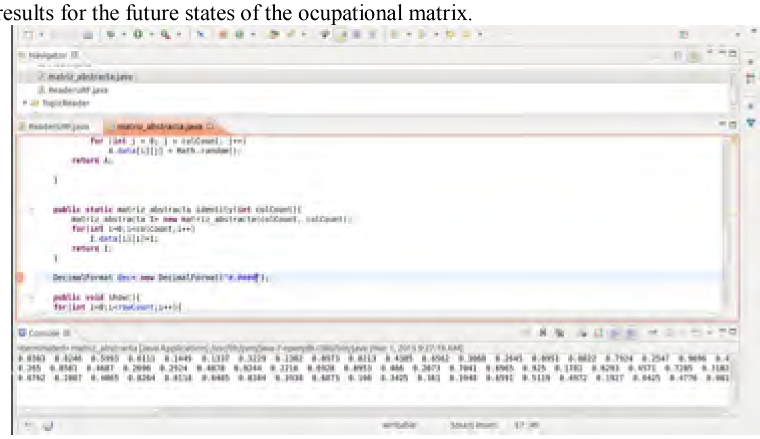

Figure 5: Matrix that starts giving accurate date to create the occupational matrix.

6. Sensors for Navigation and Localization

For navigation and location will be used odometry, given the range of 3 Devantech SRF08 ultrasonic sensors (It provides a voltage of 5V with a range of vision of 45º). With these ultrasonic building navigation maps will be performed (method is underground navigation).

Figure 6. Devantech SRF08

Infrared sensor Sharp 2y0a02
Has an analog output that varies from 2.8V at 15cm to 0.4V at 150cm with a supply voltage between 4.5 and 5.5VDC

Figure7: Infrared Sensor

Asus XTION PRO LIVE/B/U USB 2.0 and USB 3.0 RGB
Multiple sensing functions to make development easy. The Xtion PRO LIVE uses infrared sensors, adaptive depth detection technology, color image sensing and audio stream to capture a users' real-time image, movement, and voice, making user tracking more precise.

Figure 8: Asus Xtion Pro Live Sensor

7. Sensors for Victim Identification

The victims in RoboCupRescue are simulated by dolls which show signs of life as: Moving, body heat, speaking or breathing; for this, we use a camera on the arm of the robot and the CO2 sensor is near to the camera, further of the microphone in the front part of the robot; allowing the LARVIC-RESCUE robot detects and sends information to the operator's station

The types of sensors to use are:
Camera: For identification of victims with conventional camera will focus on specific characteristics such as body, hands, face, skin color and size regions. Just give us the confidence of having the presence of a victim, therefore add the CO2 sensor and microphone. For the detection of persons show the detection of pedestrians (monolithic model) being the most effective model Histograms of Oriented Gradients the (HOG) by Yao et al. [4]; however Olmeda et al. [2] and O'Malley et al. [1] present the detection of people during the night in low lighting conditions, both use infrared camera; O'Malley et al. [1] uses people segmentation based on the characteristics of growth by region in images with high intensity, using Histogram of Oriented Gradients (HOG) and Kalman Filter and Olmedaa et al. [2] includes the descriptor (HOPE Histograms of Oriented Phase Energy) and adaptation of SVM for infrared images.

Light: Light is taken into account in the top of the arm, as it may be that we are in a dark place.

CO2 sensor: CO2 sensor (Figaro CDM4161) is near to the camera located in the robotic arm, to identify the CO2 released by the human body of the victims and confirm the state of a victim found. The Carbon Dioxide (CO2) is a very reliable and accurate sensor, once the victim is detects the sensor shows the amount of the gas in ppm (its detection range is 400 to 4000 ppm, in an open environment exists default 350 ppm of CO2 and a person exhales 800ppm, therefore, check for the presence of a victim).

Figure 9: CO2 Sensor the Figaro CDM4161

Microphone:The robot is equipped with 4 microphones in front and side of the robot and can receive voices of injured-persons, further sound level around the robot and provide additional information as to the robot’s movements and environment. The audio communication between victims and the operator is established by software which uses the internal PC sound output and input on the robot (the voice is cached of the robot and sent directly to the operator's station), where the operator can hear the voices in the area and check for victims.

Figure 10: Sound Vocal Sensor Detection Module LM393 (Microphone)

8. Robot Locomotion

The mechanism is designed to carry 60krg for that the structure was designed with robust parts. Then the motors have high torque. The system of transmission is bye chains and gears, the caterpillar are put in the arm for the locomotion, the motors are put in the chassis.
The forward and reverse motion is put on two engines also placed on the chassis, for lifting the robot is preceded with movable arms that also have caterpillars. The average speed is 1.2 m / s.

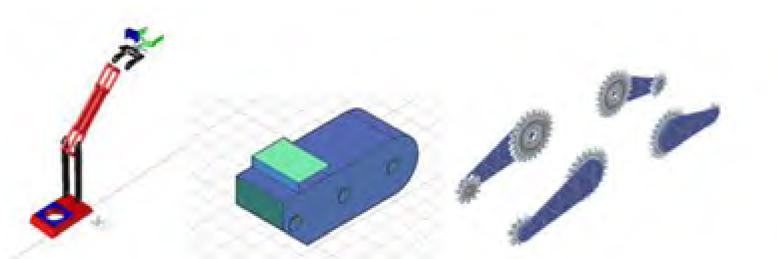

Figure 11: Parts of the caterpillar robot

The unmanned aerial vehicle has four brush less motors and a lightweight structure.
And for the other Robot it have wheels for the movement.

Figure 12: Wheel Robot

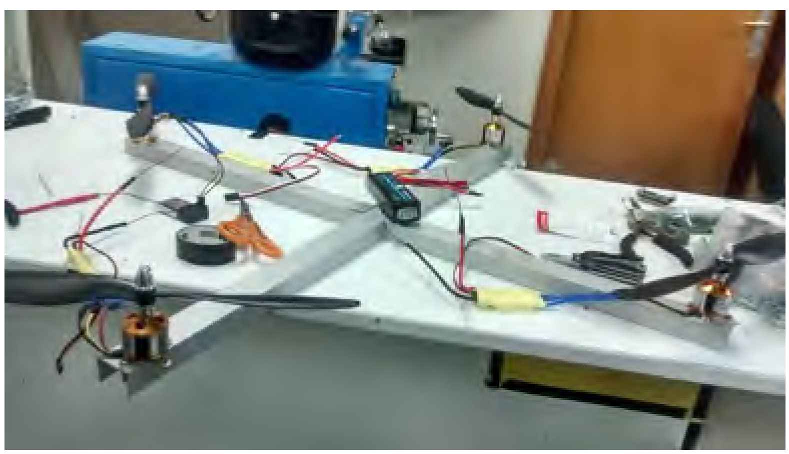

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Figure 13: Aerial Robot

9. Other Mechanisms

Control for locomotion teleoperated robotic arm

Design of passive exoskeleton

The exoskeleton is a structure that can be mounted on a human arm and which is capable of capturing all possible moves through its rotation sensors.

Using direct kinematics, the target point (the wrist of the hand) will be found through data captured rotation sensors, and used for the forward kinematics equation based on rotation matrices.

The target point is responsible for locating in a space relative to the point of the shoulder of the individual, a three-dimensional virtual point which will give a position that will be used to mobilize the objective point of the robotic arm.

The exoskeleton has the same joints that the robotic arm. shown in the following scheme joints belonging to komodo robotic arm.

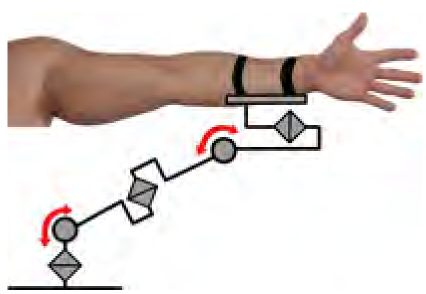

Figure 14: Schema of Robotic Arm

Operation exoskeleton

The exoskeleton can capture rotations of each sensor belonging to each target point located in three-dimensional space, that is, for each target point there is a list of degrees of rotation for each joint.

This data is stored in a uniform form database, and discretely. Then use it in a Neural Network. The neural network is responsible for interpolating the discrete points on a continuous space. the inputs of this neuronal network will point objectives and outputs the degrees of rotation of each sensor.

The neural network is interpolated using the technique of Back Propagation [10], this will take care of interpolating a nonlinear space and generate knowledge for managing robotic arm, it uses the same degrees of rotation as the exoskeleton shown in the following diagram.

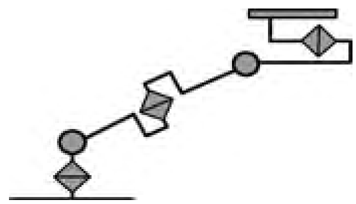

Figure 15:Degrees of rotation from robotic arm

The general operation of the exoskeleton formed by the use of spatial positioning as a model, and as training database for the neural network.

10. Team Training for Operation (Human Factors)

Has been built a RoboCupRescue test arena in our laboratory (LARVIC), where we can see the consistency of the design and construction of the robot, besides testing the developed algorithms. Therefore, each team members is responsible for their contributions and guarantee an accurate function of the developed algorithms.

Control station can switch of autonomous to tele-operated easily during different tests arenas, furthermore allows us to reassign tasks between the robots if necessary because of environment features or hardware; allowing the algorithms developed can be used anytime that the robot needed by the operator.

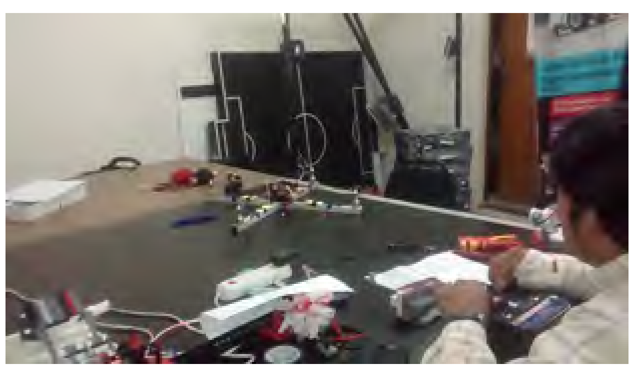

Figure 16:Testing with Aerial Robot

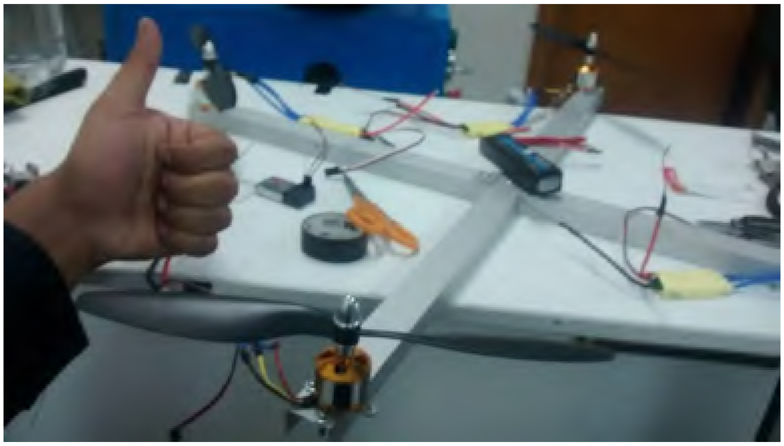

Figure 17:Testing with Aerial Robot

11. Possibility for Practical Application to Real Disaster Site

Having our rescue robots is the first goal and we are making the first steps toward a better goal. Peru is a country prone to natural disasters and national geography is broken, so that in recent times has been submitted cases of missing persons, in this sense, it is necessary to develop technology that can assist the tasks of search and rescue; streamlining processes mentioned for the well being and integrity of the persons concerned. We want to build a fleet of heterogeneous robots between autonomous and teleoperated, with the ability to cope with the various geographical environment or environments produced by the nature of our country Peru.

12. System Cost

The cost of components on each robot is listed as follows:

Wheeled Robot Cost

ITEM	PRICE ($)
1 Komodo Robot	21350

Table 3: Wheeled Robot Cost

Aerial Robot Cost

ITEM	MODEL	PRICE ($)
4 Brushless Motor Outrunner with Hélice two different sense	A2212 Motor Outrunner	56.82
1 Balance 5 Kgr	digital bascule/1g	15.87
1 Aluminum 1*1"		15.87
1 Plate Control	Hobbyking KK2.1.5	22.62
1 Battery Lipo	li-po 3s 25c	13.53
1 Accelerometer	included	0.00
1 Magnetometer	included	0.00
1 GPS	CN-06 V3 U-blox GPS module	25.79
1 Transmitter		0.00
1 Receiver	2.4g fs-ct6b tx-rx	50.58
1 Main Frame		0.00
1 Little Cables, other		63.49
Total cost		264.56

Table 4 : Aerial Robot Cost

Caterpillar Robot Cost

Item	Price ($)
Chains for caterpilar 3/16	20
HerkuleX DRS-0601	804,6
HerkuleX DRS-0201	135
HerkuleX DRS-0101 Smart Robot Servo	83
bent 1/16	12
bolts 1/4	10
Iron 1/16	32
filming 3/4	20
Motor DC	491
Gear of reduction	600
CPU Intel	756
Figaro CDM4161 CO2 sensor	566,2
TPA81 heat sensor	244,36
ultrasound distance Devantech SRF08	31
Asus XTION PRO LIVE/B/U USB 2.0 and USB 3.0 RGB (sensor de Profundidad)	169
Bateria lifepo4	470

IR sensor	60
web cam 5 MPX and microphone	23
Arduino	120
microphone	7
Total cost	**4653,16**

Table 5: Caterpillar Robot Cost

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