# RoboCup Rescue 2017 Team Description Paper

## IXNAMIKI OLINKI

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***Abstract***— **This paper presents the prototype IXANAMIKI OLINKI, a rescue robot developed at the MCS Mobile Robotics Group of Universidad Panamericana (Mexico) to compete at the RoboCup's 2017 Rescue Robot League. IXNAMIKI OLINKI consists of a track wheel type structure. With double front and back flippers, it can move, climb and surpass rough terrain. IXNAMIKI OLINKI also encompasses a 7-joint arm which can be deployed not only for surveillance but also for easier and faster access to the victims. Video cameras, a thermal camera, and a set of sensors are set up at the tip of the arm to aid the operator during rescue decision making. The mapping techniques included in this prototype take advantage of a 2D real-time laser scanning.**

***Keywords — Robot; Software; Mechanics; Electronics; Ixnamiki.***

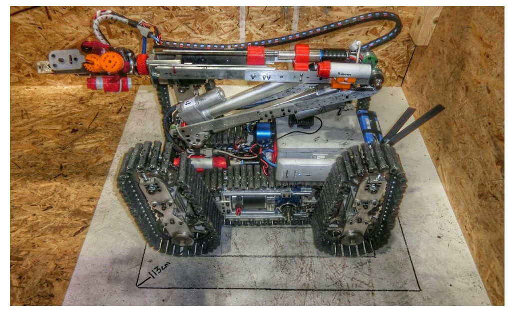
## I. INTRODUCTION

The RoboCup Rescue competition aims at boosting research in robots and infrastructure able to help in real rescue missions. The task is to find and report victims in areas of different grades of roughness, which are for the competition purposes currently indoors [1,2]. It challenges the mobility of the mechanical platforms as well as the autonomy of their control and sensor interpretation [3-5].

IXANMIKI OLINKI is a robot capable of traversing, sensing and mapping complex and unknown terrain. It is small and lightweight for maximum maneuverability. It offers all-terrain capabilities using two sets of independent flippers to move and climb over obstacles.

It requires one operator. However, the operator is aided in the maneuvering and rescue decision making by the robot. All other functionalities involve image acquisition, sensing, and mapping.

This paper presents a technical overview of IXNAMIKI OLINKI's design, main modules, and first prototype. Figure 1 show rescue robot IXNAMIKI OLINKI from several views.



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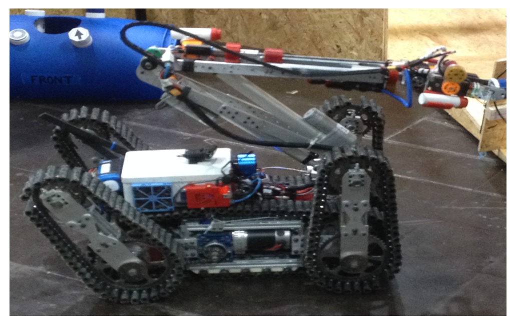

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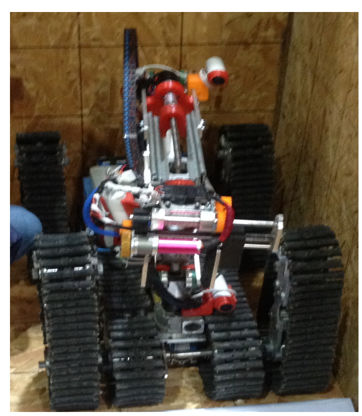

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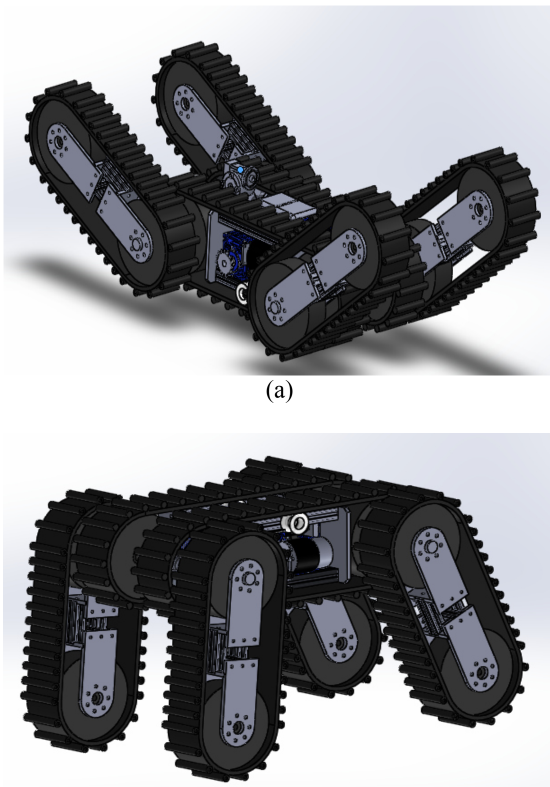
Fig. 1. Rescue Robot IXNAMIKI OLINKI.

## II. System description

### A. Hardware

Rescue robot IXNAMIKI OLINKI is a tracked wheel vehicle. It is relatively lightweight (about 70 kg) and has small dimensions. It is quite active and fast in unstructured environments and it also performs well on uneven terrain.

Tracked wheels are very popular in the RoboCup Rescue Robot League. In this robot, the tracks used for locomotion are double tracks (wheel track and flipper track), Figure 2. They are very useful for climbing over the file collapse.



(a)

(b)

Fig. 2. Traction used in IXNAMIKI OLINKI.

Electronic and electromechanical hardware were designed and implemented to meet highly demanding environments. Most of the time, hardware is overdesigned to reduce unwanted behaviors such as heating, delaying, and electro-migration.

Locomotion: All motors are brushless type. Four of them have high power consumption (24V at 100A peak) and are used for tracks and flippers. The rest of them are low power motors (maximum 500W), and are used exclusively for the manipulator.

Current is provided by 2 rechargeable Graphene batteries. They are connected in parallel to get a total of 24V, 16Ah. This amount of power is more than enough for the robot to last a 30 minutes mission, but is overpowered to handle peak power consumptions for cases when all motors are demanding maximum current. It also is enough to complete the highly demanding "Best in Class Mobility" mission.

Once the mission is finished, batteries are recharged and balanced to reduce degradation. For this, IXNAMIKI OLINKI has a circuit developed specifically for the battery's requirements.

Electronics: Electronic hardware is divided and assembled in five main areas.

*A. Motor drivers*. As there are not too many brushless motor drivers rated at more than 300A continuous, and the ones in the market are very expensive, custom motor drivers based on FOC ad Instant Spin system, were designed and assembled by electronic area of the team.

Two motor drivers are used:

1.- IXNBLDCDRV1.0

# 1 channels.
# 100A @25°C.
# 3 Phase BLDC.
# 60Vmax.
# RS485 half duplex @115200 baud.
# 2oz cupper gold immersion.
# 41mm x 50mm PCB size
# $100 USD approx. each PCB.

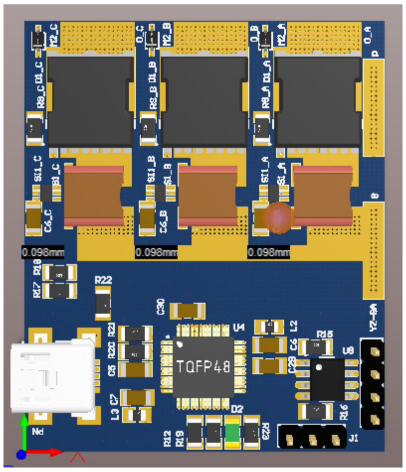
2.- IXNMNBLDCDRV1.0

# 1 channel.
# 25A @25°C.
# RS485 half-duplex @115200baud.
# 25mm x 50mm PCB size.
# $50 USD approx. each PCB.

Figure 3 shows the custom implemented PCB for the motor drivers: (a) and (b) for IXNBLDCDRV1.0 and (c) and (d) for IXNMNBLDCDRV1.0.

*B. Sensor*. General description: It is an electronic system capable of measuring CO2 levels in the air. MH-Z19 NDIR infrared gas module is a common type, small size sensor, using non-dispersive infrared (NDIR) principle to detect the existence of CO2 in the air, with good selectivity, non-oxygen dependent whit a measuring range from 0 to 5000 ppm. This in order to be able to detect the presence of living people in places where a person or a regular camera cannot be introduced in the disaster areas, such as a person under rubble.

Measurements by the microcontroller control system are based on serial communication. Data are processed with the microcontroller by a sequence of commands by the serial bus.



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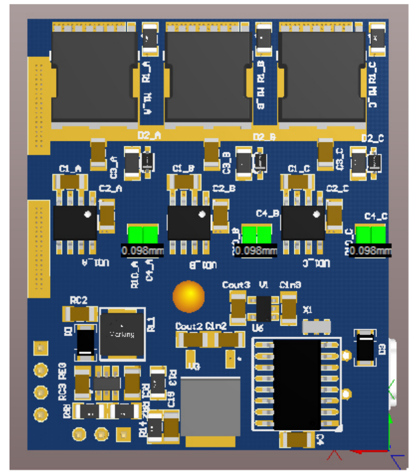

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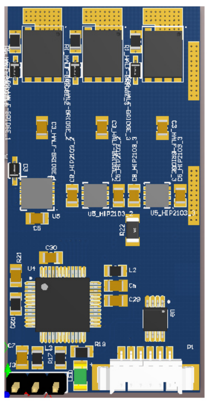

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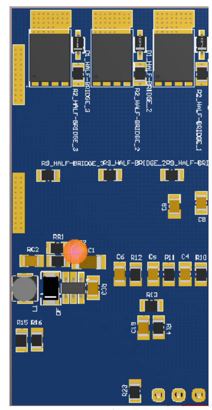

(d)

Fig. 3. Views of the PCB motor drivers: (a) top and (b) bottom view for driver #1 and (c) top and (d) bottom view for driver #2.

The main reasons for this sensor was chosen were:

- Good resolution in measurements.
- Reliability under extreme conditions.
- Anti-water vapor interference.
- No poisoning.
- Low power consumption.
- Quality measurement of the amounts of CO2 present in the air.

*C. Thermal camera*. IXNAMIKI OLINKI is equipped whit a micro thermal camera. FLIR Lepton® is a radiometric-capable LWIR camera solution that is smaller than a dime.

The main reasons for this camera was chosen were:

- Low cost.
- Enhanced IR sensor.
- Ease for integration.
- God relative resolution (80x60)
- Pixel size 17µm.

Fig. 4. Shows an image example obtained with the thermal camera.

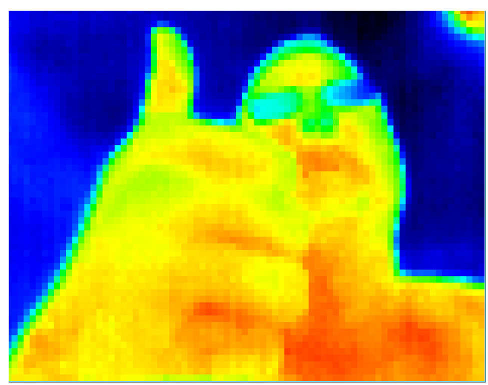

Fig. 4. Thermal image.

*D. Power management.* Switched mode voltage regulators are used to improve efficiency and current capability. Voltages needed in robot are 24V for motors, 12V for cameras, and 5V for TCP/RS232 Bridge and Ethernet switch, 15V for bullet. A single custom made board was designed with TI's TPS5450, including fixed 5V and 12V, and variable voltage output version. As a battery charger, it equips a 24 Vin stage that creates 6 isolated cell chargers to balance the battery and fully charge it capable of sourcing 5A to each cell.

*E. Mapping*-Map generation method in IXNAMIKI OLINKI is based on the operator assessment in conjunction with the collected data, which enables the operator to locate and register different object such as victims, stairs, walls and hazards. The robot has a 2D laser beam, a video camera, a temperature sensor and a C02 sensor that provide enough information to operator station.

A laser-beam will be projected onto an object and the resulting distance is reconstructed in the user interface at the operator station (Fig. 5).

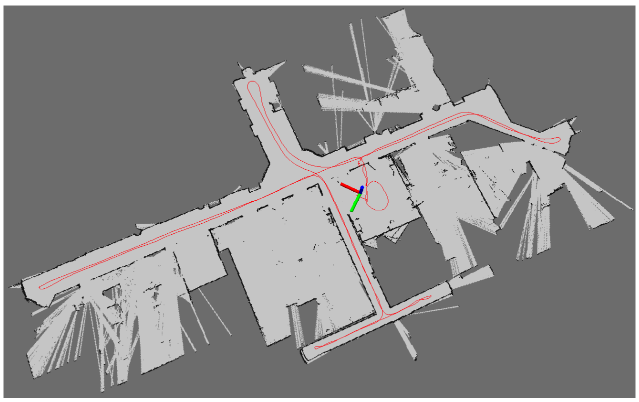

Fig. 5 Example of a map obtained by the laser sensor.

IXANAMIKI OLINKI relies on an item for mapping generation:

• Laser scanner: The Hokuyo UTM-30LX laser scanner covers an arc of 270° with 0.36° resolution per scan. It has a maximum range of 4m and a maximum sample rate of 10Hz. The scanner unit is stabilized with an accelerometer to balance the effects of uneven surfaces.

*F. Communication*

Telemetry system: The telemetry system first establishes a link at 5 GHz in a full duplex configuration using the IEEE 802.11ac standard, using UBITIQUI rocket AC Point to multipoint adapters, then using the IP protocol to connect cameras, onboard computer, and the sensors and motors through IP to serial adapters (Wiznet WIZ110R).

The cameras work through UDP because fast video response is preferred rather than quality, also the operator is capable of controlling the quality of the video if it seems to be lagged or disconnected.

For the onboard computer, it is operated through SSH protocol for a secure communication and fast response to commands, also if there is a need to get data recollected from the robot we use the SCP protocol to download it.

For the sensors and motor control we establish an emulated serial COM port with the proprietary code of Wiznet, for the sensors, the robot sends data of the sensors without waiting for a response of the monitoring central, and for the motor control, the monitoring central send the command data to the robot without waiting for a response.

Both the sensors and motor control works converting the IP protocol to serial RS232 then to RS485 to avoid interferences produced by the PWM of the motors. Fig. 6 shows the communication architecture.

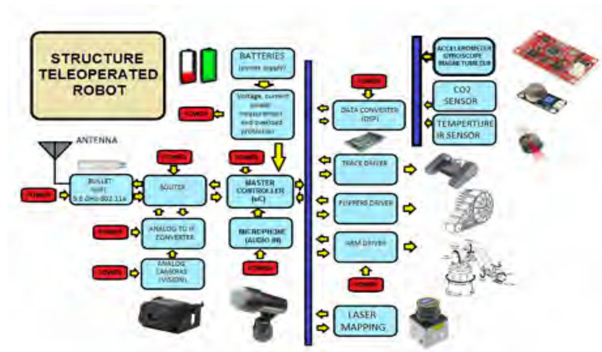


Fig. 6. IXANAMIKI OLINKI communication architecture.

*G. Human-Robot Interface*

IXNAMIKI OLINKI is remotely controlled by the operating station via keyboard and game controller (Figure 7). The autonomous mapping system relies on the on-board laser sensor and remote control relies on wireless communication with the command center.

The command center encompasses 2 main elements: laptop computer and a game controller. In the laptop computer, a human computer interface is running to display the key features of the rescue mission such as:

-Live video image: Video coming from the on-board camera. The operator will be monitoring the live feed and adding details to the map. For example: location of victim detected.

-Map being generated: Map will be generated by 2D laser scanning information from other sensors. Other sensor information will also be displayed; for example: temperature, CO2, etc.

-Thermal imaging whit enough resolution necessary to detect victims.


Fig. 7. User interface for IXANAMIKI OLINKI.

## III APLICATION

### *A. Set-up and Break-down*

Our system consists of a compact (65 x 70 x 30 cm), robot that can be remote controlled via wireless LAN. The whole control equipment easily fits into a standard backpack and IXNAMIKI OLINKI can be carried by only two persons. So, to start/end a mission, a minimum of two people are needed to carry the robot and control equipment.

### *B. Mission Strategy*

We are focusing on giving three bottles of water per mission, two in orange zone and one in the red zone, the rest of the time must be spent on finding most of the victims.

### *C. Experiments*

We have tested our robot simulating a disaster in which the robot is requested to move pieces of woods with a mass of 2 kg, open valves, and climbing stairs.

## IV CONCLUSION

The team can conclude that IXNAMIKI OLINKI is a very good prototype that can be used in a disaster zone which is its principal objective. Although this is just a prototype for a rescue robot, it is very close to a working one by improving simple but expensive things like water proof or more rugged aluminum for the chassis. Also, if needed for a real disaster we would need more signal range and this can be done by connecting the robot to a 4G network, with this we can conclude the possibility of making use of the robots rather than human life when a disaster occurs.

Team Members and their Contributions

| | |
|---|---|
| Daniel Arriaga | Team captain, manufacturing & mechanics design |
| David Medel | Manufacturing & Mechanics |
| Gilberto Castañeda | Sensors & electronics design |
| Fernando Dávalos | Sensors & electronics design |
| Luis Enrique | Control central & sponsorship |
| Gerardo Berni | Programming & communications |
| Francisco Velazquez | Team advisor |
| Dr. Ramiro Velázquez | Faculty advisor |

Tables I and II summarize the components of the manipulation system and the hardware components list.

TABLE I
Manipulation System

| Attribute | Value |
|---|---|
| • Name | • Ixnamiki Olinki |
| • Locomotion | • 4 Turnigy glow 160 |
| • System Weight | • 62.1 kilograms |
| • Weight including Transportation case | • 98 kilograms |
| • Transportation size | • 1 meter x 60 centimeters |
| • Typical operation size | • 70 centimeters x 55 centimeters |
| • Unpack and assembly time | • 4 hours |
| • Startup time | • 1 minutes |
| • Power Consumption | • In movement 1200W, standby 40W |
| • Battery endurance | • 30 minutes |
| • Maximum Speed | • 20 Km/h |
| • Payload | • 5 Kg |
| • Arm; maximum operation height | • 1.5 meters |
| • Arm; payload at full extend | • 1 Kg |
| • Support; set of bat, chargers total weight | |
| • Support; set of bat, chargers power | • Graphene 6S 8000mAh LiPo |
| | • 2 chargers of 250W |
| • Support; charge time batteries | • 1 Hour to full charge |
| • Cost | • 10,000 dollars |

TABLE II
Hardware components list.

| Part | Brand & Model | Unit Price | Num. |
|---|---|---|---|
| Drive motors<br><br>Drive gears<br>Motor drivers | Turnigy Glow 160<br><br>IXN_BLDC motor driver | 70 USD<br><br><br>150 USD | 4<br><br><br>4 |
| DC/DC<br>Battery | Graphene 6S 8000mAh LiPo. | 600 USD | 2 |
| Micro controller<br>Computing Unit | | | |
| Wi-Fi Adapter | Rocket AC PTMP | 300 USD | 2 |
| IMU<br>Cameras<br>PTZ Camera<br><br>CO2 Sensor | IP<br><br><br>MH-Z19 | 100 USD<br><br><br>50 USD | 4<br><br><br>1 |
| Battery Chargers | | | |
| 6-axis Robot Arm | | | |
| Laser | HOKUYO UTM-30LX. | 4260 USD | 1 |
| Kinect for PC | | 250 USD | 1 |
| Thermal camera. | Flir Lepton. | 350 USD | 1 |
| Rugged Operator Laptop | Alien ware | 800 USD | 1 |

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