RoboCup Rescue 2017 Team Description Paper

IXNAMIKI OLINKI

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***Abstract*— This paper presents the prototype IXANAMIKI OLINKI V2, a rescue robot developed at the MCS (Mobile Robotics Group) of Universidad Panamericana (Aguascalientes, Mexico) to compete at the RoboCup 2018 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 an 8-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 real-time scanning provided by a Kinect sensor.**

Keywords — Robot; Software; Mechanics; Development; Research; Electronics; Ixnamiki.

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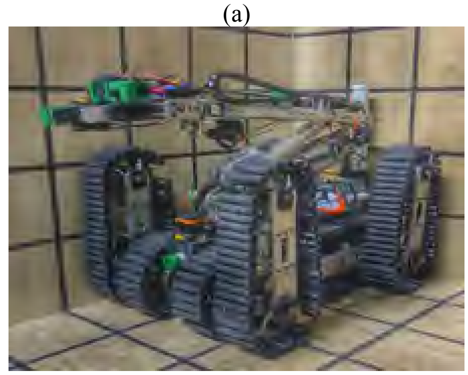

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(c)

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 with different grades of roughness, which for the competition purposes are 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]. All of this in conjunction with the operator's dexterity and abilities.

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 second prototype. Figure 1 shows rescue robot IXNAMIKI OLINKI from multiple angles.

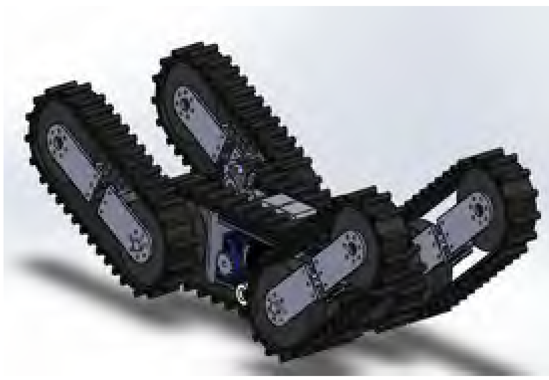
Fig. 1. Rescue Robot IXNAMIKI OLINKI.

II. System description

A. Hardware

Rescue robot IXNAMIKI OLINKI is a tracked wheel vehicle. It is relatively lightweight (about 60 kg) and has small dimensions (50cm x 70cm). 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-synchronized flipper tracks and wheel track, Figure 2. This system is very effective in traversing through rough terrain.



(a)

(b)

Fig. 2. Traction and body implemented in IXNAMIKI OLINKI.

Electronic and electromechanical hardware was designed and implemented to meet highly demanding environments. Most of the time, hardware is overdesigned to reduce unwanted behaviors such as overheating, body ruptures, delays, erroneous readings of the sensors, or 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 8 cell batteries, connected in parallel to get a total of 24V, 16Ah. This amount of power is more than enough for the robot to last a 40-minute mission, but it is overpowered to handle peak power consumptions for cases when all motors are demanding maximum current. It is also enough to complete the highly demanding “Best in Class Mobility” mission.

Once the mission is finished, batteries are recharged and balanced to reduce degradation and operating problems, as well as to reduce the risk that handling this type of batteries involves. For this, IXNAMIKI OLINKI has a circuit developed specifically for the battery’s requirements.

Electronics: Electronic hardware is divided and assembled in six 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 the electronics area of the team.

Two motor drivers are used:

1.- IXNBLDCDRV2.0

1 channels.
200A @25°C.
3 Phase BLDC.
60Vmax.
RS422 full duplex @115200 baud.
2oz copper gold immersion PCB.
50mm x 70mm PCB size.
$150 USD approx. each PCB.

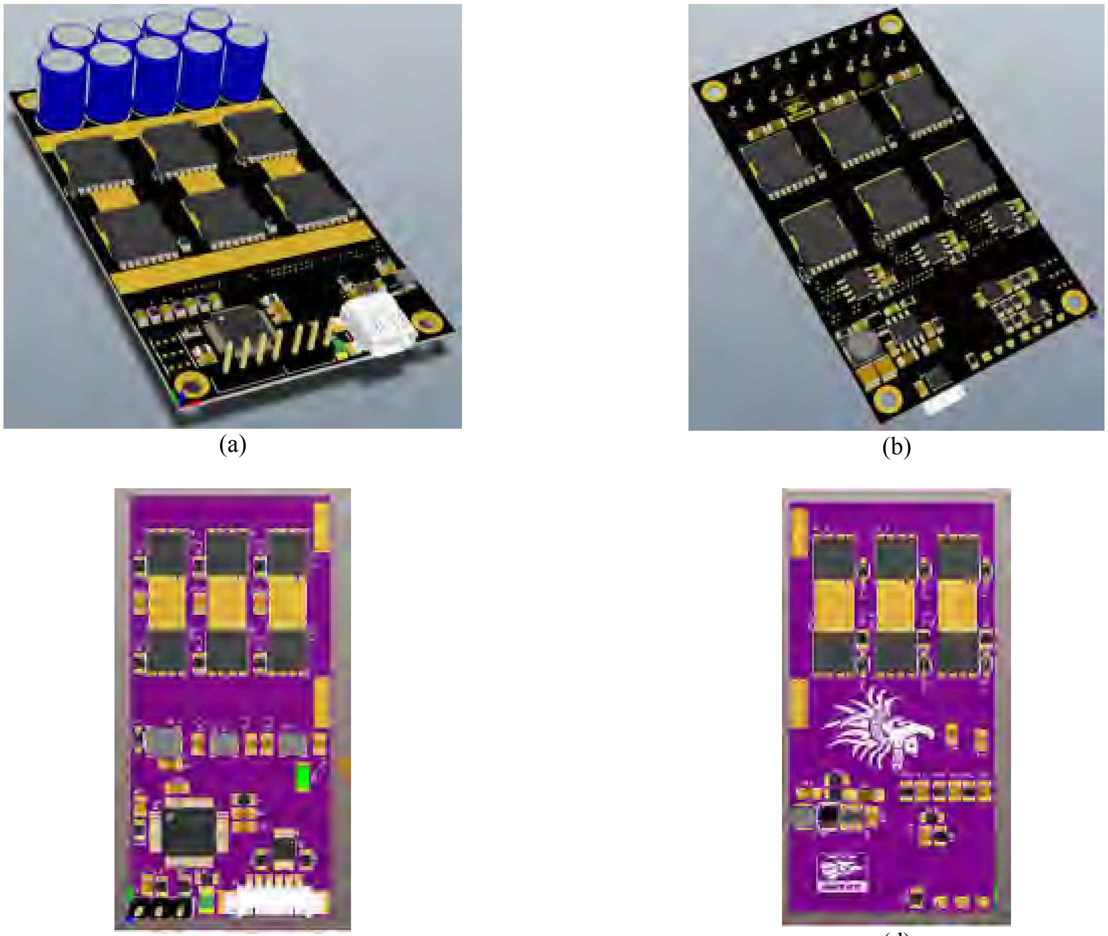
2.- IXNMNBLDCDRV3.0

1 channel.
25A @25°C.
RS422 full-duplex @115200baud.
25mm x 50mm PCB size.
$40 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 and TVOC levels in the air. CCS811 gas digital sensor is a common type with a very small size sensor, good selectivity, non-oxygen dependent and ultra-low power, with a measuring range from 400 to 8192 ppm. This to be able to detect the presence of living people in places where a person or a regular camera could not be introduced in disaster areas, such as a person under rubble.

Measurements by the microcontroller control system are based on I2C communication (between microcontroller and sensor) and serial communication to main controller system (after it is converted to RS-422 by a ISL3177EIUZ Renesas's transceiver). Data is processed with the microcontroller by a sequence of commands by the RS-422 bus.



(a) (b) (c) (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 choosing this sensor were:

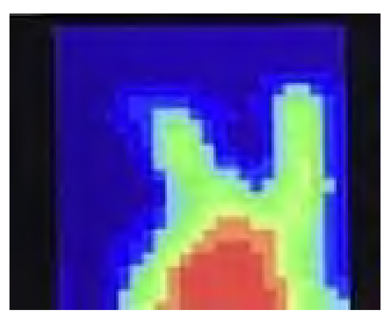
- Very good resolution in measurements.
- Reliability under extreme conditions.
- Anti-water vapor interference.
- No poisoning.
- Very low power consumption.
- Expandable for future applications.
- Quality measurement of the amounts of CO2 present in the air.

C. Thermal camera. IXNAMIKI OLINKI is equipped with a micro thermal camera. AMG8833 Panasonic® is a radiometric-capable LWIR camera solution that is smaller than a dime.

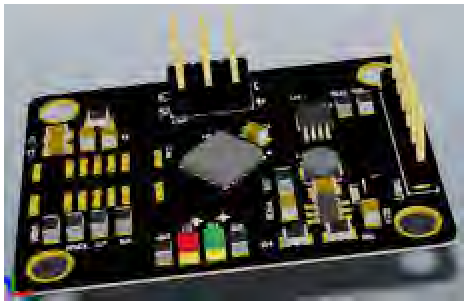
The main reasons for this camera was chosen were:

- Very low cost.
- Enhanced digital sensor.
- Ease of integration.
- Pixel size 17µm.

Fig. 4 (a). Shows an image example obtained with the thermal camera and (b) shows physical camera.



(a)



(b)

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 conversion. As a battery charger, it equips a 24 Vin stage that creates 8 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 Microsoft Kinect, a video camera, a temperature sensor and a C02 sensor that provides enough information to the operator station.

The Microsoft Kinect signals will be projected onto an object and the resulting distance is reconstructed in the user interface at the operator station (Fig. 5).

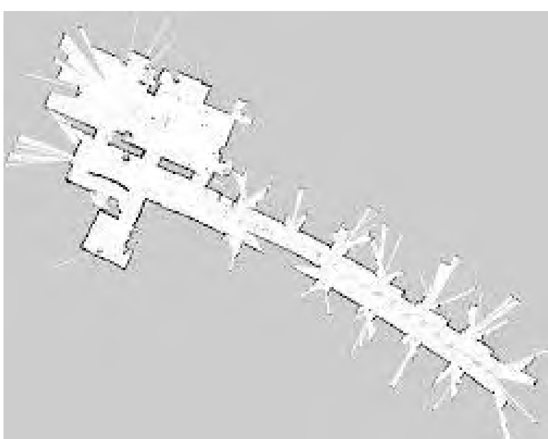


Fig. 5 Example of a map obtained by the kinetic sensor.

IXANAMIKI OLINKI relies on an item for mapping generation:

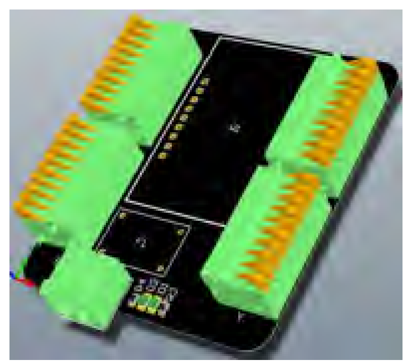
• Environment scanner: The complementary nature of the depth and visual information provided by the Kinect sensor opens new opportunities to solve fundamental problems in computer vision. With its scanner, we can do RGB-D mapping, using depth cameras for dense 3D modeling of indoor environments.

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 adapter: Wiznet WIZ550S2E.

Fig. 5 (a). Wiznet module (b) communication board designed for the module.

(a)



(b)

The cameras work through UDP because fast video response is preferred rather than quality, also the operator can control the quality of the video in the case of lag or disconnection.

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 collected 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 RS422 to avoid interferences produced by the PWM of the motors. Fig. 6 shows the communication architecture.

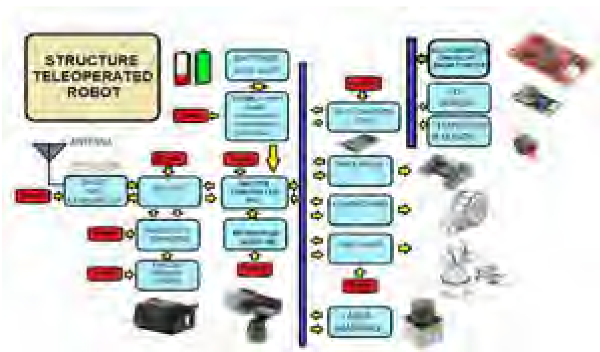


Fig. 6. IXANAMIKI OLINKI communication architecture.

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 Kinect sensor and remote control relies on wireless communication with the command center.

The command center encompasses 3 main elements: laptop computer, a game controller and a bullet transmitter. 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 using the Kinect scanning information. Other sensor information will also be displayed, such as temperature, CO2, etc.

- Thermal imaging whit enough resolution necessary to detect victims.

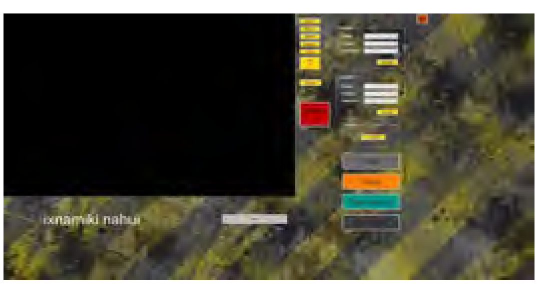


Fig. 7. User interface for IXANAMIKI OLINKI.

III APLICATION

A. Set-up and Break-down

Our system consists of a compact (50 x 70 x 45 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 is needed to carry the robot and control the equipment.

B. Mission Strategy

We are focusing on being able to complete all Dexterity missions and identification of victims.

C. Experiments

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

D. Application in the Field.

We participated in rescue work in disaster areas caused by an earthquake in Mexico City in September 2017.

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 would be very close to a working one by improving simple but expensive things like waterproofness or more rugged aluminum for the chassis. Also, if needed for a real disaster we would need a broader signal range, that can be achieved by connecting the robot to a 4G network, with this we can conclude on the possibility of making use of robots, rather than human lives, in the case of disaster.

Team Members and their Contributions

Gilberto Castañeda	Team captain, sensors & electronics design.
David Medel	Manufacturing & Mechanics.
Adonai Chavez	Manufacturing & Mechanics.
Janet Hadad	Project Managing.
Ricardo Bustos	Project Managing & Software Architecture
Bryan Lopez	Programming & 3D Mapping.
Rodrigo Reyes	Programming & communications.
Sahid de la Rosa	Programming & Testing.
Jesús Rojas	Programming & Computer Vision.

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	58.2 kilograms
Weight including Transportation case	98 kilograms
Transportation size	1 meter x 50 centimeters
Typical operation size	70 centimeters x 45 centimeters
Unpack and assembly time	3 hours
Startup time	1 minutes
Power Consumption	In movement 1200W, standby 40W
Battery endurance	40 minutes
Maximum Speed	25 Km/h
Payload	50 Kg
Arm; maximum operation height	1.5 meters
Arm; payload at full extend	1 Kg
Support; set of bat, chargers total weight	1.8 Kg
Support; set of bat, chargers power	Graphene 6S 8000mAh LiPo 2 chargers of 250W
Support; charge time batteries	1 Hour to full charge
Cost	5,000 dollars

TABLE II
Hardware components list.

Part	Brand & Model	Unit Price	Num.
Drive motors Drive gears Motor drivers	Turnigy Glow 160 IXN_BLDC motor driver	70 USD 150 USD	4 4
DC/DC Battery	Graphene 6S 8000mAh LiPo.	600 USD	2
Mini controller Computing Unit	Intel Nuc	490 USD	1
Wi-Fi Adapter	Rocket AC PTMP	300 USD	2
IMU Cameras PTZ Camera	IP	100 USD	4
Battery Chargers	Turnigy	80 USD	1
6-axis Robot Arm			
Co2 sensor	CCS811	6 USD	1
Kinect for PC		250 USD	1
Thermal camera.	AMG8833 Phillips	35 USD	1
Rugged Operator Laptop	Acer gamming	1180 USD	1

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