RoboCup Rescue 2023 Team Description Paper

IXNAMIKI OLINKI

UP Robotics
Universidad Panamericana. Campus Aguascalientes
Christian Eduardo Márquez Reyes
Aguascalientes
Email: 0237109@up.edu.mx

***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 2023 Rescue Robot League. The 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 victims. Video cameras, a thermal camera, and a set of sensors are set up at the tip of the arm to aid the operator with rescue decision making. Mapping is not included due to budget limitations.**

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

I. Introduction

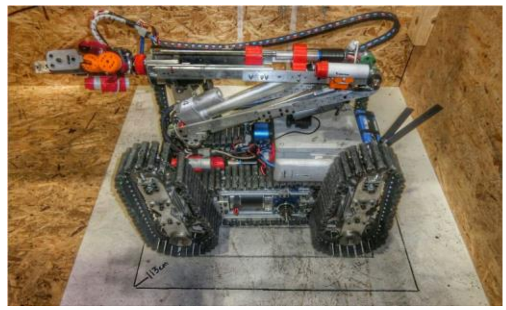
The RoboCup Rescue competition aims to boost research in robots and infrastructure to help in real rescue missions. The task is to find and report victims in areas of different grades of roughness, which are currently indoors for competition purposes [1,2]. The task challenges the mobility of the mechanical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

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

It requires one operator, who 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 the IXNAMIKI OLINKI's design, main modules, and first prototype. Figure 1 shows the rescue robot IXNAMIKI OLINKI

.



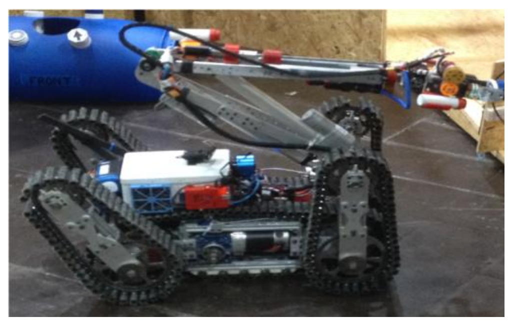


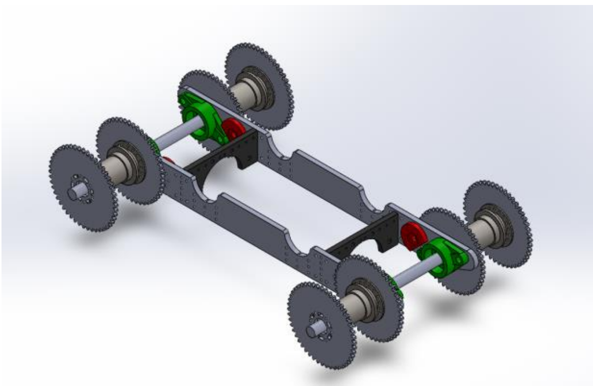
Fig. 1. Rescue Robot IXNAMIKI OLINKI. from several views

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 performs well on uneven terrain.

The tracks used for locomotion are double tracks (wheel track and flipper track), as seen in Figure 2. They are very useful for climbing over the file collapse.



(a)

Fig. 2. A) New design in development
B) Traction used in IXNAMIKI OLINKI.

Special pieces of electronic and electromechanical hardware were designed and implemented to meet highly demanding environments since 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 (44V at 70A peak) and are used for the tracks and flippers. The rest are low power motors (maximum 370W) used exclusively for the manipulator.

Current is provided by two rechargeable lead batteries connected in series to get a total of 24V, 7Ah. This amount of power is more than enough for the robot to last a 30-minute mission, but it is overpowered to handle peak power consumptions for cases in which all motors demand 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.

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

A. Motor drivers. The drivers used are the following: Turnigy MultiStar BLheli_32 ARM 51A Race Spec ESC 2~6S (OPTO). They are brushless motor drivers rated at 51A.

B. Sensor. The sensor used is a MH-Z19 NDIR infrared gas module. It is a common electronic system that features a small size sensor that uses non-dispersive infrared (NDIR) principles to detect the existence of CO_2 in the air. It also has good selectivity, is non-oxygen dependent, and has measuring ranges from 0 to 5000 ppm. This in order to be able to detect the presence of living people in situations 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 is processed with the microcontroller by a sequence of commands by the serial bus.

The main reasons for why this sensor was chosen were:

- Good resolution in measurements.
- Reliability under extreme conditions.
- Anti-water vapor interference.
- No poisoning.
- Low current consumption.

C. Thermal camera. The IXNAMIKI OLINKI is equipped with the MLX90640 micro thermal camera. It has a fully calibrated 32x24 pixel thermal IR array compared to the industry standard 4-lead TO39 package with digital interface. The main reasons for why this camera was chosen were:

- Small size and low cost 32x24 pixel IR array
- Enhanced IR sensor.
- Easy to integrate.
- Relatively good resolution (32x24)
- Current consumption less than 23mA

D. Power management. Switched mode voltage regulators are used to improve efficiency and current capability. Voltages needed in robot are 44V 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, along with a variable voltage output version. For a battery charger, it is equipped with a 24 Vin stage that creates 6 isolated cell chargers to balance the battery, capable of sourcing 7A to each cell and reaching full charge.

E. 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. It then uses the IP protocol to connect cameras, onboard computer, sensors and motors through IP to serial adapters (Wiznet WIZ110R).

The cameras work through UDP because fast video response is preferred over quality. If needed, the operator is capable of controlling the quality of the video if it lags or gets disconnected.

The onboard computer is operated through SSH protocol for a secure communication and fast response to commands. If there is a need to collect information from the robot, we use the SCP protocol to download it.

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

Both the sensors and motor control work by converting the IP protocol to serial RS232 and then to RS485 in order to avoid interferences produced by the PWM of the motors.
Fig. 3 shows the communication architecture.

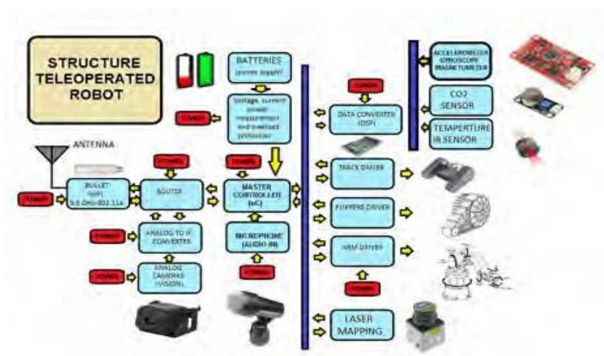


Fig. 3. IXANAMIKI OLINKI communication architecture.

G. Human-Robot Interface

The IXNAMIKI OLINKI is remotely controlled by the operating station via keyboard and game controller (Figure 4).

The command center encompasses two main elements: a 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 onboard camera. The operator will be monitoring the live feed and adding details to the map. For example: the location of victim if detected.

-Thermal imaging with enough resolution to detect victims.

- Other sensor information will also be displayed. For example: temperature, CO2 levels, etc

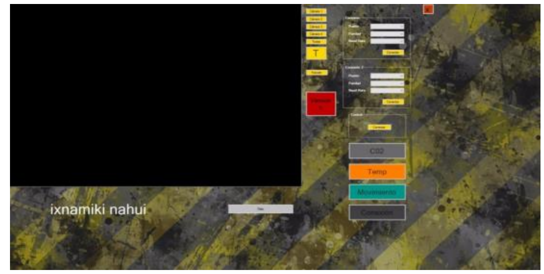


Fig. 4. User interface for IXANAMIKI OLINKI.

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. All of the control equipment easily fits into a standard backpack and the IXNAMIKI OLINKI can be carried by only two persons/people. So, to start or end a mission, a minimum of two people is needed to carry the robot and control equipment.

B. Mission Strategy

We are focusing on using three bottles of water per mission; two are placed in the orange zone and one in the red zone. The rest of the time must be spent on finding victims.

C. Experiments

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

IV. CONCLUSION

The team can conclude that the IXNAMIKI OLINKI is a very good prototype that can be used in a disaster zone, which is its principal objective. However, many electronic components are delayed to due pandemic conditions.
The robot just needs simple but expensive additions and modifications such as a new motor and their respective drivers and a new chassis.
Finally, the robot participated in a real disaster, specifically in Mexico´s earthquake 2017, finding and saving a human life, demonstrating its capabilities in a real-life situation.
Currently, the team is emphasized in seeking improvements such as waterproof technology and complete autonomy, making the robot more capable in real scenarios.

Team Members and their Contributions

Christian Marquez	Team captain, manufacturing & mechanics design
Hector Ramirez	Sensors & electronics design
Barbara Lucia	Control central & sponsorship
Sebastian Córdova	Programming & communications
Sarahy Mancilla	Programming & communications
Ángel Aguilar	Mechanics Design
Emilio Jáuregui	Manufacturing & mechanics design
Angel Jimenez	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	
• Support; set of bat, chargers total weight	• 1 Kg
• Support; set of bat, chargers power	• Lead Duravolt DS7-12 • 2 chargers of 250W
• Support; charge time batteries	• 1 Hour to full charge
• Cost	• dollars

TABLE II
Hardware components list.

Part	Brand & Model	Unit Price	Num.
Drive motors Drive gears Motor drivers	Turnigy Aerodrive SK3 - 6374-149kv sin escobillas del motor Outrunner NTM Prop Drive Serie 28-30A 1000kV / 370w Turnigy MultiStar BLheli_32 ARM 51A Race Spec ESC 2~6S (OPTO) motor driver	102 USD 21 USD 22 USD	4 5 9
DC/DC Battery	Duravolt DS7-12	600 USD	2
Micro controller Computing Unit	Raspberry Pi 4b Arduino Nano	140 USD 15 USD	1 1
Wi-Fi Adapter	Rocket AC PTMP	300 USD	2
IMU Cameras PTZ Camera CO2 Sensor	IP MH-Z19	100 USD 50 USD	4 1
Battery Chargers			
6-axis Robot Arm			
Thermal camera.	MLX90640 32x24 IR array	91 USD	1
Rugged Operator Laptop	hp pavilion	1200 USD	1

Video Links

https://www.youtube.com/watch?v=C5z2XTGWzmo
https://www.youtube.com/watch?v=X1iXC6FcCHk

References

[1] A. Kleiner, B. Steder, C. Dornhege, D. Meye Delius, J. Prediger, J. Stueckler, K. Glogowski, M. Thurner, M. Luber, M. Schnell, R. Kuemmerle, T. Burk, T. Brauer, and B. Nebel, "Robocup rescue – robot league team rescuerobots freiburg (germany)," in *Ro- boCup 2005: Robot Soccer World Cup IX*, ser. Lecture Notes in Artificial Intelligence (LNAI), I. Noda, A. Jacoff, A. Bredenfeld, and Y. Takahashi, Eds. Springer, 2006.

[2] W. Lee, S. Kang, S. Lee, and C. Park, "Robocuprescue- robot league team ROBHAZ-DT3 (south Korea)," in *RoboCup 2005: Robot Soccer World Cup IX*, ser. Lecture Notes in Arti- ficial Intelligence (LNAI), I. Noda, A. Jacoff, A. Bredenfeld, and Y. Takahashi, Eds. Springer, 2006.

[3] M. W. Kadous, S. Kodagoda, J. Paxman, M. Ryan, C. Sammut, R. Sheh, J. V. Miro, and J. Zaitseff, "

Robocuprescue- robot league team CASualty (Australia)," in *RoboCup 2005: Robot Soccer World Cup IX,* ser. Lecture Notes in Artificial Intelligence (LNAI), I. Noda, A. Jacoff, A. Bredenfeld, and Y. Takahashi, Eds. Springer, 2006.

[4] T. Tsubouchi and A. Tanaka, " Robocuprescue-robot league team Intelligent Robot Laboratory (Japan)," in *RoboCup 2005: Robot Soccer World Cup IX,* ser. Lecture Notes in Artifi- cial Intelligence (LNAI), I. Noda, A. Jacoff, A. Bredenfeld, and Y. Takahashi, Eds. Spring- er, 2006.

[5] A. Birk, K. Pathak, S. Schwertfeger and W. Chonnaparamutt, *"The IUB Rugbot: an intelli- gent, rugged mobile robot for search and rescue operations",* International Workshop on Safety, Security, and Rescue Robotics (SSRR), IEEE Press, 2006.