RoboCup 2013 – Rescue Robot League
<UP-Robotics (México)>

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Abstract. This paper presents IXANAMIKI ÖME and IXNAMIKI TOPO the second and third prototype of rescue robot developed at the MCS Mobile Robotics Group to compete at RoboCup Rescue Robot League. IXNAMIKI ÖME consists of a track wheel type structure. With double front flippers, it is capable of moving, climbing and collapsing rough terrain. IXNAMIKI ÖME also encompasses a 6-joint mechanical arm which can be deployed not only for surveillance from the top view but also for easier and faster access to the victims. Video cameras and a set of sensors are set up at the tip of the mechanical 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. IXNAMIKI TOPO consists of a free wheel type structure. The back traction is a two free-wheel based traction. It is capable of moving precisely in a soft terrain. It have a little tower for sensors and cameras.

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 difficulty. It challenges the mobility of the mechanical platforms as well as the autonomy of their control and sensor interpretation.

For the 2013 competition, the MCS Mobile robotics group proposes the prototype IXNAMIKI ÖME (which means "people finder the second" in Nahuatl, ancient Aztec language) and IXNAMIKI TOPO.

IXANMIKI ÖME is a robot capable of traversing, sensing and mapping a 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 the other functionality is fully automatic i.e. image acquisition, sensing, and mapping.

This paper presents a technical overview of IXNAMIKI ÖME and IXNAMIKI TOPO: design, main modules and first prototype.

1. Team Members and Their Contributions
- Roberto Lozano Team captain and manufacturing
- Daniel Duran Design and Manufacturing
- Ricardo Rangel Design and Manufacturing
- Maximiliano Ruiz Sensors and electronics
- Santiago Gonzalez Electronics design
- Juan Echavarría Control station, sponsorship and aesthetic design
- Bárbara Muñoz Sponsorship
- Fernando Arreola Programming and communications
- Hugo Labra Programming
- Guillermo Medina Team advisor
- Dr. Ramiro Velázquez Faculty advisor

2. First prototype: IXNAMIKI ÖME

2.1 Operator Station Set-up and Break-Down (10 minutes)
Our system consists of a compact (55 x 95 x 29 cm), lightweight (40 kg) robot that can be remote controlled via wireless LAN. The whole control equipment easily fits into a standard backpack and IXNAMIKI ÖME can be carried by 2 people. So, to start/end a mission, a minimum of 4 people are needed to carry both robot and control equipment.

2.2 Communication
Our main design concept is simple but highly effective and reliable. The block diagram of the rescue robot IXNAMIKI ÖME is shown in Fig. 1.

Here, the robot encompasses a set of key items such as a temperature sensor, a CO2 sensor, 4 analog video cameras, a laser, the motor driver and the mechanical arm. All of these are controlled by the operator computer and either plugged directly to the computer or previously conditioned through a micro-controller. The computer communicates with the robot converting RS-232 data to Ethernet using a serial server and then this data is sent via wireless LAN network. At the remote station, the operator is able to take decisions and send back to the robot controlling commands for both robot and mechanical arm. For the laser, the mapping sensor, an accelerometer is included as stabilizer. This stabilization is processed locally at the robot.

Our system uses a communication frequency of 5.8GHz, no special channel or band is needed, and adheres to 802.11a standards.

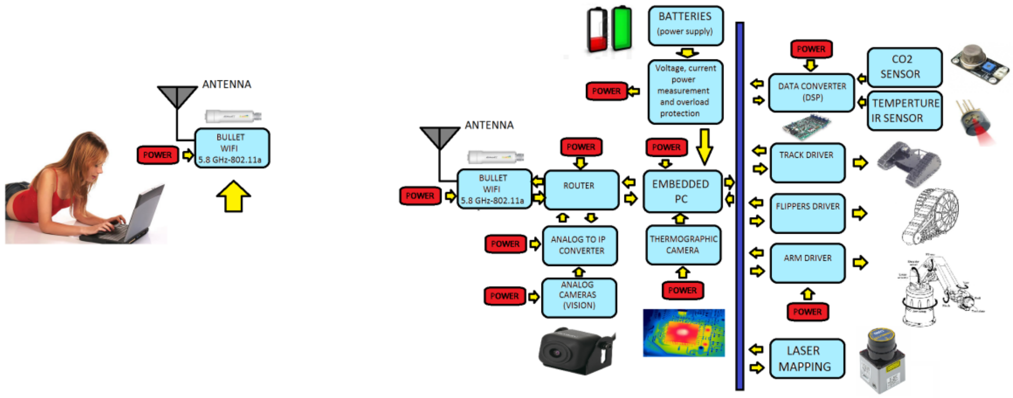


Fig. 1 Block diagram of the rescue robot IXNAMIKI ÖME.

Rescue Robot League

IXNAMIKI ÖME(México)

Frequency	**Channel/Band**	**Power (mW)**
5.8 GHz - 802.11b/g	any	1000

2.3 Control Method and Human-Robot Interface

IXNAMIKI ÖME is remotely controlled by the operating station via keyboard and game controller. 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 the 2D laser scanning Information from other sensors: Other sensor information will also be displayed.
- For example: temperature, CO2, etc.

Fig. 2 shows a snapshot of the user interface.

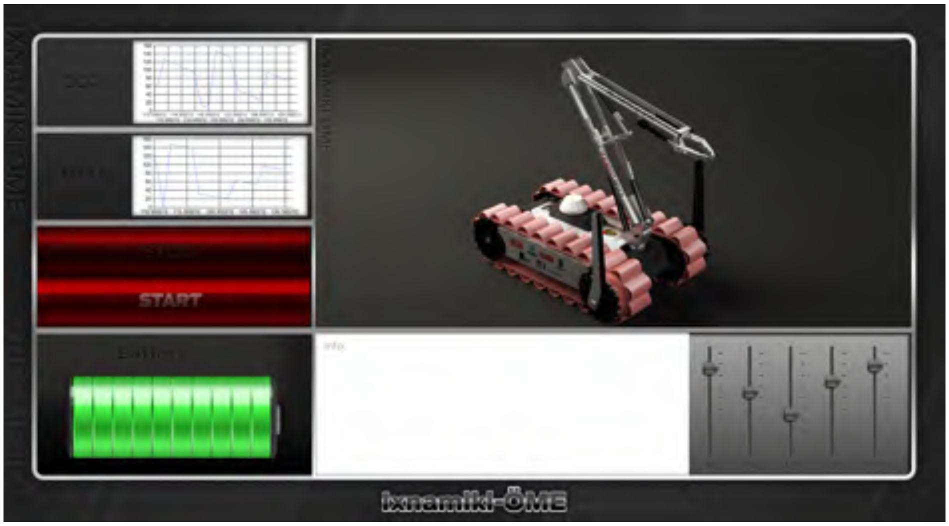


Fig. 2 The user graphical interface displaying key features for IXANAMIKI missions.

2.4 Map generation/printing

Map generation method in IXNAMIKI ÖME 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. 3).

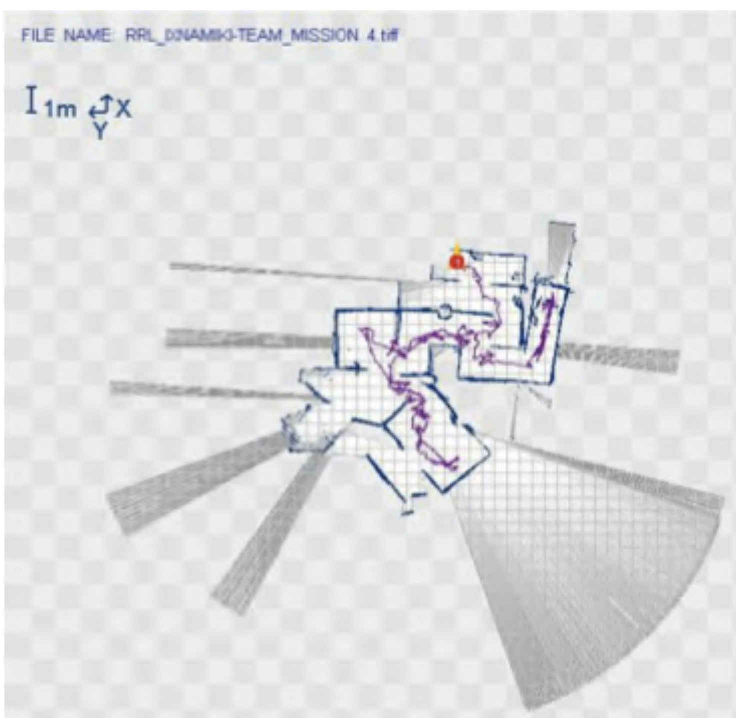


Fig. 3 Example of a map obtained by the laser sensor.

2.5 Sensors for Navigation and Localization

IXANAMIKI ÖME relies on 2 items for mapping generation:

- Wheel encoders: To measure the translational and rotational speed of IXNAMIKI ÖME, all wheels are equipped with incremental optical encoders. This odometer data is used especially for indoor navigation, but due to the inaccuracy additional feedback from other sensors is needed.
- Laser scanner: The Hokuyo URG04-LX laser scanner covers an arc of 240° 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.

2.6 Sensors for Victim Identification

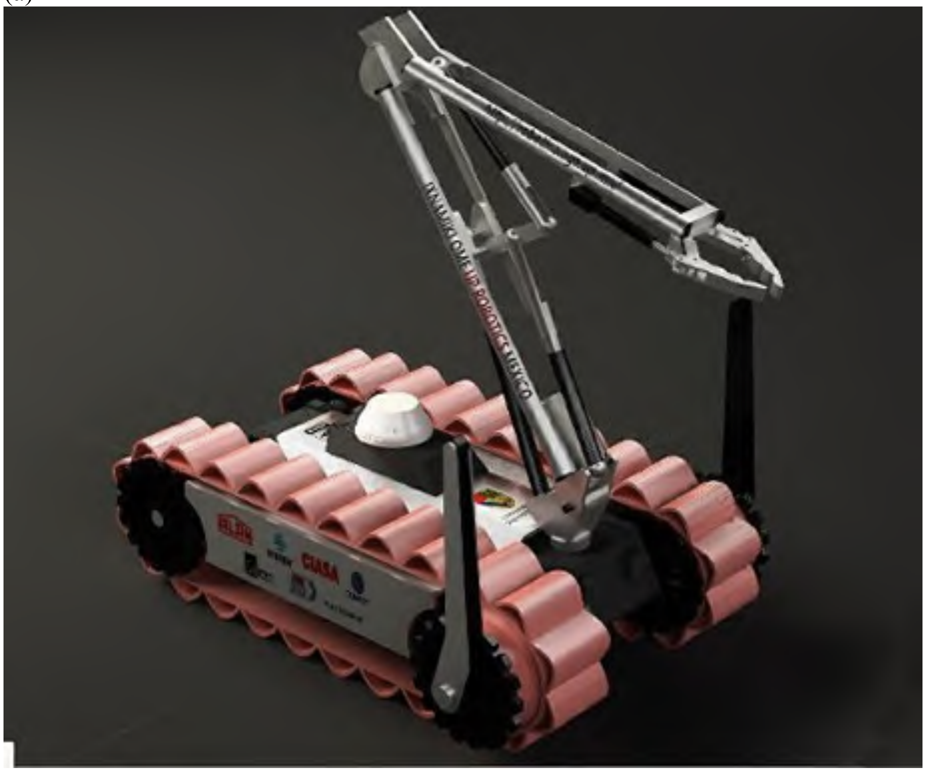
Victim detection will be approached from several sensors:

- Video camera: The video camera located at the tip of the mechanical arm is being used to stream real-time video. Video processing is done on the base station to detect any victim or motion. There are also additional cameras in other parts of the robot's body to help the operator to navigate trough the arena.
- Thermal sensor to detect victims autonomously by their body heat. The mechanical arm moves the thermal sensor to create a 2D image. Thermal image is created with colors depending on the temperature values. The sensors data is sent to the base station where this image is created.
- CO2 sensor to confirm the deal/live status of a victim found.
- 2-Way Audio communication to know talk with the victim and know its situation.

2.7 Robot Locomotion

Rescue robot IXNAMIKI ÖME is a tracked wheel vehicle. It is relatively lightweight (about 40 kg.) and have small dimensions (55 x 95 x 29 cm). 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, for example in the robots of Team Freiburg, Robhaz, Casualty, IRL and IUB [1-5]. The track wheel robots which mentioned above are variety designs. Each design has dif- ferent good points. In this robot, the tracks which use for the locomotion are double tracks (wheel track and flipper track). They are very useful for climbing over the pile of collapse.

(a)



(b)

Fig. 4 Tracked wheel rescue robot IXNAMIKI ÖME: (a) design and (b) prototype.

2.8 Other Mechanisms

IXNAMIKI ÖME includes a mechanical arm. It helps the robot to explore in many ways such as, from high level, going to narrow space and able to get vital signs of victims easier and faster. Fig. 5 shows both conceptual design and prototype of the mechanical arm which has 6 degrees of freedom. Because the pay load at the tip of arm is small and the arm structure weight is not much, linear motor with gear set still can regulate the joint angle quite well.

(a)

(b)

Fig. 5 (a) Design and implementation of a 6-DOF mechanical arm.

2.9 Team Training for Operation (Human Factors)

• Practice with locomotion controls (joystick)
• Interpretation and navigation using streaming video

2.10 System Cost

2.10.1 Mechanics

Part name	Quantity	Cost (USD)
Anaheim Motors	3	$1,080
Linear Motors	2	$600
Dynamixel AX-12	2	$100
Dynamixel RX-24	2	$280
Chains and mechanisms	-	$150
Aluminum and other material	-	$350

TOTAL $2,560

2.10.2 Electronics

Part name	Quantity	Cost (USD)
Laser HOKUYO URGLX04	1	$3,900
Driver RoboteQ AX-3500	2	$1,200
Sensors	-	$224
Batteries	2	$400

TOTAL 5,724

2.10.3 Total

Mechanics $2,560
Electronics $5,724
Others $1,000
TOTAL 9,284 USD

3. Second prototype: IXNAMIKI TOPO

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

Our system consists of a compact (65 x 45 x 45 cm), lightweight (10 kg) robot that is able to work autonomously. This robot is able to send data to the operator station when a victim is found.

3.2 Communication

Our main design concept is simple but highly effective and reliable. The block diagram of the rescue robot IXNAMIKI TOPO is shown in Fig. 6.
Here, the robot encompasses a set of key items such as a temperature sensor, a CO2 sensor, theramla camera, 2 digital video cameras, a Kinect sensor, the motor driver and a mechanical tower. All of these are controlled autonomously by an embedded computer and either plugged directly to the computer or previously conditioned through a micro-controller. The computer sends images and the victim status when a victim is detected by the system. At the remote station, the operator is able to know the victim status. The kinect sensor is assisted by an accelerometer so the computer can calculate the appropiate distances. All this processes are made locally at the robot.
Our system uses a communication frequency of 5.8GHz, no special channel or band is needed, and adheres to 802.11a standards. This is used to send all the necessary data to the operator station.

Rescue Robot League

IXNAMIKI TOPO(Mexico)

Frequency	Channel/Band	Power (mW)
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3.3

The robot, based on the Kinect laser and acelerometer data, using an SLAM (Simoultaneous Localization and Mapping) algorithm builds in real time a 2d map. Calculating over this map, the robot must be able to navigate.
A parallel vision system is looking for victim holes, when a hole is found the robot move towards the found hole to find more vital signs. If more than one vital sign is detected, the robot will notify the operator.

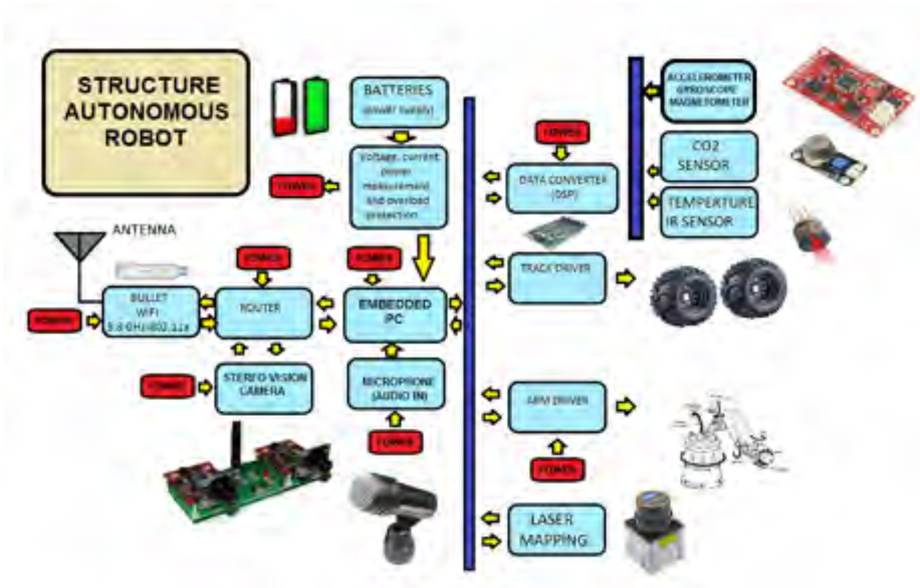

Fig. 6 Block diagram of the rescue robot IXNAMIKI TOPO

3.4 Map generation/printing

Map generation method in IXNAMIKI TOPO 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, a thermal camera and a C02 sensor that provide enough information to detect vital signs.

3.5 Sensors for Navigation and Localization

IXANAMIKI TOPO relies on 2 items for navigation and localization:

• Wheel encoders: To measure the translational and rotational speed of IXNAMIKI ÖME, all wheels are equipped with incremental optical encoders. This odometer data is used especially for indoor navigation, but due to the inaccuracy additional feedback from other sensors is needed.

• Laser scanner: The Hokuyo URG04-LX laser scanner covers an arc of 240° 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.

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• Video camera: The video camera located at the tip of the mechanical arm is being used to stream real-time video. Video processing is done on the base station to detect any victim or motion. There are also additional cameras in other parts of the robot’s body to help the operator to navigate through the arena.

• Thermal sensor to detect victims autonomously by their body heat. The mechanic arm moves the thermal sensor to create a 2D image. Thermal image is created with colors depending on the temperature values. The sensors data is sent to the base station where this image is created.

• CO2 sensor to confirm the deal/live status of a victim found.

• Kinect sensor: to help the robot to detect the yellow area, holes, motion and for mapping.

3.7 Robot Locomotion

Rescue robot IXNAMIKI TOPO is a 4x4 tracked wheel vehicle. With a gear motor per wheel. The system is a two back omnidirectional wheels and two frontal wheels traction. This system ables the robot to rotate on its frontal axis.
It was designed with a suspension system that gives the ability to move softly in uneven terrains.
The little tower in its top, is able to reach 60cm tall, moving the sensors up and down. Implementing a worm-gear system.

(a)

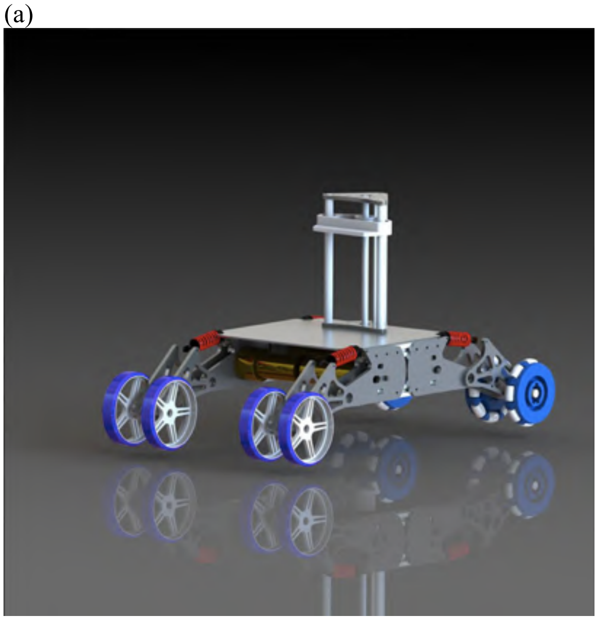

Fig. 7 Tracked wheel rescue robot IXNAMIKI TOPO: (a) design

3.8 Tests for development

• In-campus test arena, for developing and testing robot performance.

3.9 System Cost

3.9.1 Mechanics

Part name	Quantity	Cost (USD)
Motors	5	$250
Shock absorber	4	$100
Chains and mechanisms	-	$150
Aluminum and other material	-	$350

TOTAL $850

3.9.2 Electronics

Part name	Quantity	Cost (USD)
Embedded Computer	1	$1,000
Laser HOKUYO URGLX04	1	$3,900
Driver RoboteQ AX-1500	1	$250
Sensors	-	$224
Batteries	2	$400
Kinect for PC	1	$250
Thermal Camera	1	$9,000

TOTAL $15,024

3.9.3 Total

Mechanics $850
Electronics $15,024
Others $5,000
TOTAL $20,874 USD

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