RoboCup Rescue 2016 Team Description Paper

IXNAMIKI NAHUI

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***Abstract*— This paper presents IXANAMIKI NAHUI, a prototype of rescue robot developed at the MCS Mobile Robotics Group to compete at RoboCup Rescue Robot League. IXNAMIKI NAHUI consists of a track wheel type structure. With double front and back flippers, it is capable of moving, climbing and collapsing rough terrain. IXNAMIKI NAHUI 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.**

Keywords—Robot; Software; Electronics; Ixnamiki;

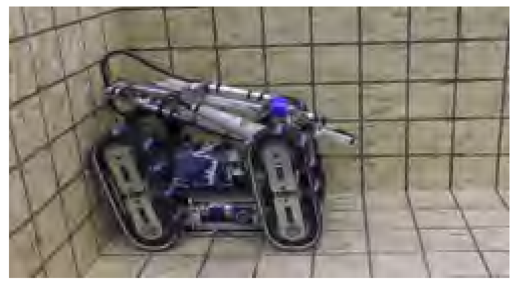
I. INTRODUCTION

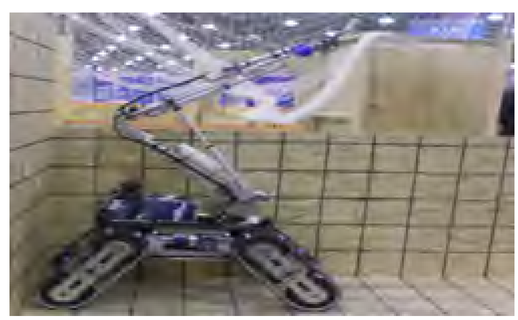
The RoboCup Rescue competition aims at boosting research in robots and infrastructure able to help in real rescue missions. The task is to find and report victims in areas of different grades of roughness, which are for the competition purposes currently indoors. It challenges the mobility of the mechanical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

IXANMIKI NAHUI 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 NAHUI design, main modules and first prototype.

Here its showed some pictures in different positions of IXNAMIKI NAHUI





II. SYSTEM DESCRIPTION

A. Hardware

Rescue robot IXNAMIKI NAHUI is a tracked wheel vehicle. It is relatively lightweight (about 50kg) and have 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 which use for the locomotion are double tracks (wheel track and flipper track). They are very useful for climbing over the file collapse.

-Electronic and electromechanical hardware was designed and bought 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 24V DC type. Four of them have very high power consumption (up to 7KW in stall condition) and are used for tracks and flippers. The rest of them are low power motors (maximum 500W), and are used exclusively for manipulator.

-Current is provided by 4 rechargeable LiPo batteries. They are connected in parallel to get a total of 24V, 20000Ah. This amount of power is more than enough for the robot to last at 15 minutes mission, but is overpowered to handle peak power consumptions such a case where all motors are demanding maximum current. And 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 three main areas.

--Motor drivers. As there are not too many motor drivers rated at more than 300A continuous, and the ones in the market are ridiculously expensive, custom motor drivers based on the OSMC project are designed and assembled by electronic area of the team.

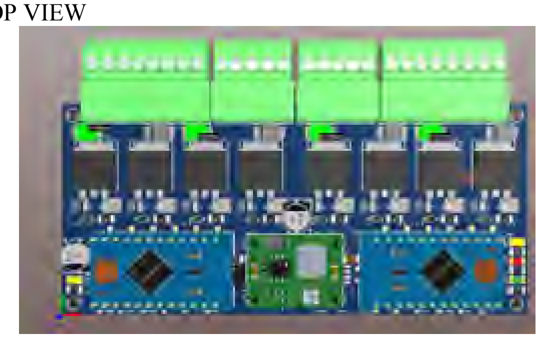
--Power management. Switched mode voltage regulators are used to improve efficiency and current capability. Voltages needed in robot are 24V for motors, 12V for cameras, and 5V for TCP/RS232 Bridge and Ethernet switch, 15V for bullet. A single custom made board was designed with TI's TPS5450, including fixed 5V and 12V, and variable voltage output version.

Two motor drivers are used:

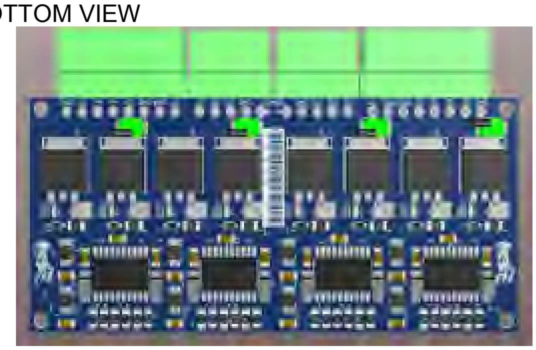
1.- IXNMASDRIIIEX3

- # 4 channels.
- # 75A @25°C per channel.
- # No parallel option.
- # 2 arduino Pro mini (One for each 2 channels) microcontroller.
- # RS485 half duplex @115200 baud.
- # 110mm x 50mm PCB size
- # $100 USD approx. each PCB.}

TOP VIEW



BOTTOM VIEW

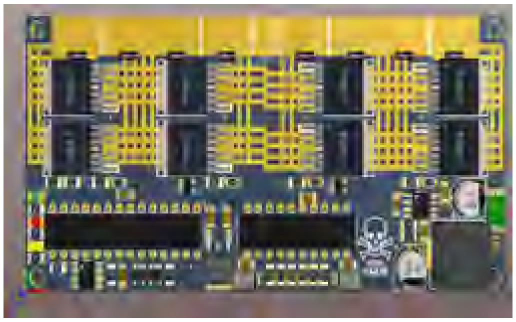


2.-IXNMASDRIVER3

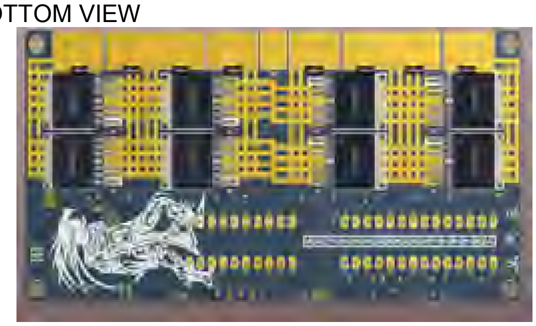
- # 1 channel.
- # 960A @25°C per channel.
- # Current sensor.
- # ATMEGA328 microcontroller.
- #RS485 half duplex @115200baud.

2oz cupper gold immersion.
#110mm x 50mm PCB size.
$100 USD approx. each PCB.

TOP VIEW



BOTTOM VIEW



For further information and schematic, please refer to OSMC project (Open Source Motor Controller).

-Sensor. General description. It is an electronic system capable of measuring CO2 levels in the air as well as measuring the temperature environment as well as an object without physical contact. This in order to be able to detect the presence of living people in places where a person or a regular camera can´t be introduced in the disaster areas, such as a person under the rubble.

The system printed circuit board has two fundamental sensors.

The first sensor is TGS4161 manufacturer FIGARO. CO2 is a solid electrolyte sensor which offers miniaturization and low power consumption. A range of 350 ~ 10,000ppm of carbon dioxide can be detected by TGS4161. The CO2 sensitive element consists of a solid electrolyte FORMED Between two electrodes, together with a printed heater (RuO2) substrate. By monitoring the change in electromotive force (EMF) generated between the two electrodes, it is possible to measure CO2 gas concentration.

Measurements by the microcontroller control system are based on the analog channel. The signal is processed with the microcontroller after conditioning the signal sensor output.

The main reasons for this sensor was chosen were:

- Good resolution in measurements.
- Reliability under extreme conditions.
- Quality measurement of the amounts of CO2 present in the air.

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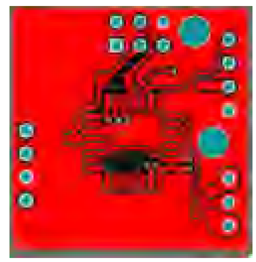
The second sensor is MLX90614, used to measure both ambient temperatures in which the system and the robot will be exposed to remotely measure the temperature of objects (in this case mainly people).

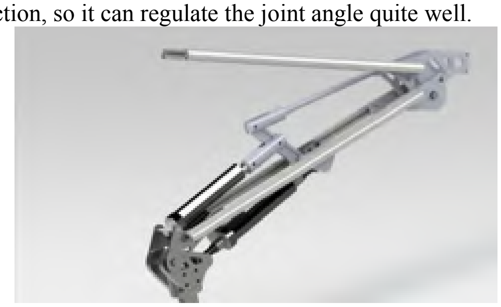
The temperature measurements of the object can range from -70 to 382.2 ° C (-94 to 719.96 ° F), while reading the ambient temperature ranges from -40 to 125 ° C. Both temperatures have a resolution of 0.02 ° C.

Control system.

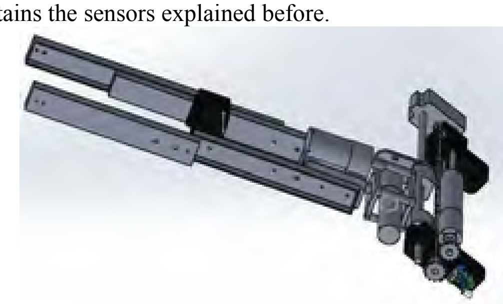
The control system was mounted on a microcontroller AVR, model ATMEGA328P with Arduino boot loader. This system is responsible for processing real-time readings of both sensors to be sent to the central control system of the robot.



-Manipulation: IXNAMIKI NAHUI 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. Next picture shows a conceptual design and prototype of the mechanical arm which has 7 degrees of freedom. Because of the payload at the top of arm, the arm was designed with lineal motors with gear reduction, so it can regulate the joint angle quite well.



The gripper is situated on the top of the arm. The gripper contains the sensors explained before.



B. Software

All of the motor control and sensor data acquisition is programmed in assembly code for optimal performance, the communication is done with a header to detect the start of transmission and the next data are values of motor speed or the specific value of a sensor.

The control application is programmed in C# with visual studio express, using an Xbox joystick and the XNA library we acquire the operator commands and send them through an emulated serial COM port. For the video and audio, we use the RTSP protocol, and we decode it with VLC library.

Mapping-Map generation method in IXNAMIKI FURY 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.

IXANAMIKI FURY relies on 2 items for mapping generation:

- Wheel encoders: To measure the translational and rotational speed of IXNAMIKI FURY, 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

C. 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 we prefer fast video response rather than quality, also the operator has the ability to control 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.

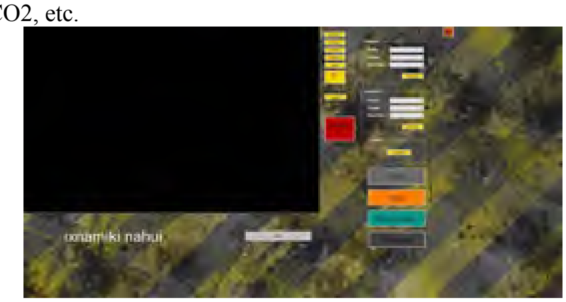
D. Human-Robot Interface

IXNAMIKI NAHUI 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 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.



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 NAHUI can be carried by 2 persons. So, to start/end a mission, a minimum of 2 people are needed to carry the robot and control equipment.

B. Mission Strategy

We are focused on giving 3 water bottles per mission, 2 in orange zone and 1 in the red zone, the rest of the time has to be spent on finding most of the victims.

C .Experiments

We have tested our robot simulating a disaster zone (Red Zone) in which we have to move pieces of woods with a weight of 2 kilograms, open valves, and climbing stairs.

IV CONCLUSION

The team can conclude that IXNAMIKI NAHUI is a very good prototype that can be used in a disaster zone which is the 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 aluminium for the chasis. 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 lifes when a disaster occurs.

TABLE I
Manipulation System

Attribute	Value
Name	Ixnamiki Nahui
Locomotion	4 Ampflow F30-150
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	2 minutes
Power Consumption	In movement 1200W, standby 40W
Battery endurance	25 minutes
Maximum Speed	15 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	6S3P 15000mah LiPo
	2 chargers of 250W
Support; charge time batteries	1 Hour to full charge
Cost	10,000 dollars

Team Members and their Contributions

Daniel Arriaga	Team captain, manufacturing and mechanics design
Fernando Ochoa	Manufacturing and Mechanics
Santiago Machen	Sensors and electronics design
Fernando Dávalos	Sensors and electronics design
Cynthia Veronica	Control central and sponsorship
Irving Ávila	Programming and communications
Juan Echavarría	Programming and communications
Francisco Velazquez	Team advisor
Dr. Ramiro Velázquez	Faculty advisor

TABLE II
Hardware components list

Part	Brand & Model	Unit Price	Num.
Drive motors	Ampflow F30-150	200 USD	4
Drive gears	P60 Banebots	75 USD	4
Drive encoder			
Motor drivers	Custom	100 USD	6
DC/DC			
Battery Management			
Batteries	LiPo	600 USD	3
Micro controller			
Computing Unit			
WiFi Adapter			
IMU			
Cameras	IP	100 USD	4
PTZ Camera			
LRF			
CO2 Sensor	TGS4161,MLX90614	224 USD	2
Battery Chargers			
6-axis Robot Arm			
Laser	HOKUYO URG-LX04	3900USD	1
Kinect for PC		250 USD	1
Rugged Operator Laptop	Alien ware	800 USD	1

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