RoboCup Rescue 2016 Team Description Paper Red Knight RoboRescue squad

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Info

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Team URL: www.bsmschool.org/acs

RoboCup Rescue 2016 TDP collection:

Abstract.

Our primary goal is to generate a cost effective and highly functional mobility base, which can be operated with minimal training Many developers of rescue and other robot systems have a price points that make them impractical for mass-market distribution. Secondly many platforms are difficult to control without hours of practice.. These aspects set our robot apart from the competition.

Introduction

Our focus is on developing an advanced mobility, intuitively controlled, significantly cost effective robot transport system. Our latest platform continues in the line of our robot platforms from the 2011 to 2016 RoboCup entries, incorporating targeted improvements documented from robot performance at previous RoboCup events.

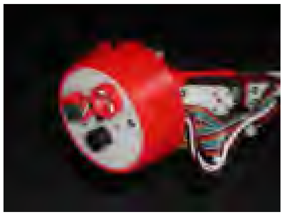
We continue our dedication to fixed climbing arms. Fixed arms increase control simplicity for the driver/operator compared to the complexity presented by arms that require driver-managed control. We also continue our commitment to abdominal belts, giving our robot a significant force transmitting surface area and a minimum amount of static lower structure. This minimizes the potential for chassis hang on undulating surfaces. We have gone through several motor/gearbox designs with our fully custom solution first tested at the 2013 German Open. The design we have settled on offers significant improvement with no motor overheating so we have retained this power train. The radio upgrade we debuted in Mexico City continues to prove effective so we will retain this system for 2016. We will continue our portable, modular command center, which debuted in 2015. For 2016's competition our team is designing treads better suited for a wider range of terrains. Secondly our team is going to be using a gimble-stabilized LIDAR mapping system instead of the previous fixed-orientation ROS based mapping. The final change to our robot is the inclusion of a manipulator arm for opening doors, and completing additional advanced tasks.

System Description

Hardware

Robot Locomotion:

Our fixed climbing arm continues to be well received. We feel we have equal mobility to a managed climbing arm system but with a significant reduction in user complexity. Our fixed arm system only requires basic differential drive control awareness so



the user only needs to know forward, reverse, spin left, spin right, turn left, turn right maneuvers. Going with a fixed climbing arm also significantly reduces the cost of the robot base. With fixed arms there is no longer any need for arm motors, speed controllers, position encoders, etc. Fewer high-torque demands such as comes with climbing arms also means extended operation time of the robot as there are now fewer demands on the battery system.

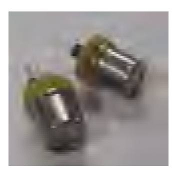
We have retained abdominal drive with our new mobility base. Abdominal drive makes almost every bit of the lower surface of the robot a force-delivery mechanism, minimizing opportunity to get stuck on a ledge or rubble that can hold robot wheels/treads off the ground. Belts for this year have been changed due to continuing issues that occurred in previous years. Rubber belts presented multiple problems, so we transitioned away from rubber belts and to a 'chain-belt' system from Intra-lox (Intra-lox manufactures plastic conveyor chain). This too presented issue with the gumming up of the joints when driving in sand. This has been solved with our new design, eliminating points at which the belt failed. The newly developing a new belt system using cables and cleats. With the cable belts there will be no joints for sand to gum up and a very open architecture to allow larger debris to fall through and not conflict with the drive interface between the sprockets and cable belt.

Other Mechanisms:
We currently retain our arm and sensor head fitted with a set of the victim ID sensors and a high power LED spotlight to illuminate dark areas. We have a new arm design that includes a multi-axis manipulator for grasping objects and opening doors and an extension component to improve reach.

<u>Software</u>
Mapping:
Following the 2012 RoboCup in Mexico City we began investigating the ROS based mapping of Team Hector-Darmstadt. In 2013 in Eindhoven we had mapping working on our laptops but could not get Hector SLAM to run on an embedded system (BeagleBone) on the robot due to inadequate processing power. Last year we upgraded our robot hardware to a new Intel NUC i5 and all tests have been successful, however this mapping system needed improvements to be successful i in the competition. We now are planning on using a LIDAR mapping system on a gimble. We believe that it will be more reliable readings, and allowing us to implement technologies similar to SLAM without changing our embedded system.

Victim Detection:
Victim identification incorporates five primary data groups (motion, thermal, CO_2, form, sound). We get motion and form direct from the OV7725 color CMOS camera and the SRV-1 camera/control board.
Thermal comes from our custom designed thermal sensor that uses a Perkin Elmer A2TPMI334-L5.5 OAA060 single pixel thermopile sensing element.

CO_2 detection comes from our custom designed CO_2 sensor using a Heimann CO_2 Gas Sensor element.



Auditory is also undergoing an improvement process. We have used an Audio-Technica ATR35s Lavalier Microphone with some success, but we are pursuing a much smaller device for easier inclusion in our arm head used to insert into smaller access cracks.

Navigation:

Teleoperative navigation is managed through visual data streamed through the OmniVision OV7725 camera and our LabVIEW vision interface. From the camera we can get edge, horizon and obstacle detection data as well as images.

Continuing this year we are investigating autonomous navigation. We are planning on using a perimeter detection system that will set off warnings at the control console if an unseen obstacle penetrates our Clearance Zone. The Clearance Zone represents the area around the robot that must be clear in order for the robot to make clean turns and navigate through doorways, paths, etc. We are experimenting with Sharp digital and analog IR sensors and short range Maxbotix ultrasonic sensors as detection devices.

Once we have the perimeter detection system working we will begin to integrate code to get the robot to move through the arena based solely on the data received through the perimeter detection sensors. Elements of difficulty will include interpreting skewed data from when the robot is on uneven terrain which we plan to mitigate by putting this sensor on a gimbal.

<u>Communication</u>

The integrated multi-frequency radio (802.11 a/b/g/n) allows for expanded flexibility to meet the requirements of different locations. The radio maximizes performance on congested frequencies. We use the same components at both the robot and operator station:

MikroTik RouterBOARD RB/433AH
MikroTik R52Hn 802.11a/b/g/n 320mW mini PCI card (MMCX connectors)
MikroTik 2.4/5GHz 3dBi Omni Swivel Antenna (MMCX connector)

Rescue Robot League		
RKRS (USA)		
Frequency	**Channel/Band**	**TX Power (mW)**
5.0 GHz - 802.11a	Multiple Channel Options/Assigned channel can be set	316
2.4 GHz - 802.11b/g		
2.4 GHz – 802.11n		

Table 1. Communication protocols under testing and available for use.

Human interface

We control the team RKRS robot through both teleoperation and autonomous functions. Teleoperation is currently managed by our custom LabVIEW control interface MainController.vi but we are investigating a move to a ROS based control interface.

From our MainController.vi we simply input the robot IP address and connect. We can then drive motors, monitor sensors, monitor video and access video analysis protocols including horizon, edge, obstacle and motion (differencing) detection. We switch the robot into autonomous mode via our LabVIEW Main-Controller.vi by loading and executing picoC code.

We have a semi-functional interactive mode in our firmware that allows for simultaneous running of autonomous functions and tele-operative controls, but it still needs more work. We also have the potential to run autonomously with Robo-realm machine vision software running remotely on the control console computer but we have not yet implemented this functionality. This year, we will work with our programming team to develop more robust autonomous functions for the robot to compete in additional arenas.

Application

Set-up and Break-Down (3 minutes)

With the addition of an independent power source, setting up the team RKRS operator station should be as simple as flipping a switch. The control console has an integrated WiFi router, antenna, control computer and monitor(s) as well as control devices (joystick, mouse, etc.) so it is an all-in-one control console solution. Communication and application programs should start automatically upon boot saving time over computer boots where applications must be launched manually. Operator station break-down is simply shutting down the control console.

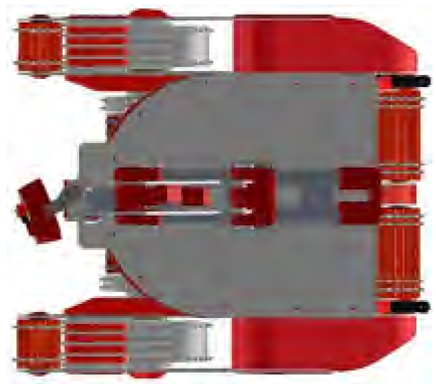
Experiments

We constructed a RoboCupRescue test arena in our lab. Students take what time they need on the course to test design concepts and evaluate ease of use and control accuracy of our robots and data systems.

Conclusion

Team members: Kirsten Hoogenakker, Peter Kirwin, and the Engineering 3 Seniors

CAD



Drawing
Top View

Bottom View

Side View

Cost	3000 USD

Table I
Manipulation System

Attribute	Value
Name	DengR
Locomotion	Treads
System Weight	35.48Kg
Weight including transportation case	?
Transportation size	?
Typical operation size	?
Unpacking and assembly time	?
Startup time (off to full operation)	?
Power consumption (idle/ typical/ max)	?
Battery endurance (idle/ typical/ heavy load)	?
Max speed (flat/ outdoor/ rubble pile)	?
Payload (typical, maximum)	?
Arm: typical operation height	?
Arm: payload at full extend	?
Support: set of bat. chargers total weight	?
Support: set of bat. chargers power	?
Support: charge time batteries (80%/ 100%)	?
Support: additional set of batteries weight	?
Any other interesting attribute	?
Cost	2000 USD

Table II
Operator Station

Attribute	Value
Name	CCTDengR
System Weight	?
Weight including transportation case	?
Transportation size	?
Typical operation size	?
Unpack and assembly time	3 min
Startup time (off to full operation)	?
Power consumption (idle/ normal/ max)	?
Battery endurance (idle/ normal/ heavy load)	?
Any other interesting attribute	?

Table III
Hardware Components List

Part	Brand & Model	Unit Price	Num
Computer	1 Intel NUC i5/Windows Computer	800 USD	1
Monitors	Insignia™ - 19" Class LED	200 USD	2
External Controls	?	150 USD	?
Radio	MirkroTik	250 USD	1
Power Supply	?	250 USD	1
Backup Battery	DuraComm	150 USD	1
Mounting Stand	?	400 USD	1
Axels	?	30 USD	?
Acetyl Plates	?	150 USD	?
Printed Parts	Custom Made	450 USD	?
Fasteners	?	100 USD	?
Router	MikroTic RB/433 AH	126 USD	2
PCI card	MikroTic mini PCI card	80 USD	2
Antenna	MikroTic Omni-Swivel	38 USD	2
Laser Scanner	Hokuyo URG	2375 USD	1
IMU	CHR-UM6	199 USD	1
Range Finder	MaxSonar EZMB 1340 Ultrasonic	150 USD	5
IR Range Finder	Sharp GP2D12	?•13 USD	?
MiniIMU	Pololu	20 USD	1
RCM	Blackfin	350 USD	1
Color Image Sensor	Omni Vision OV7725	?	?
CO_2 Sensor	Heimann	35 USD	1
Thermal Sensor	PerkinElmer Single Pixel	25 USD	1
Motors	CIM	56 USD	2
GearBox	Custom made	1600 USD	2
Wheels	AndyMark Omni wheels	38 USD	2
Belting	Intralox Chain-Belting	300 USD	?
Motor Controller	Talon SR Motor Controller	130 USD	2

Board Batteries Wiring	ACS Buss Board LiFePO4 Batteries ?	35 USD 338 USD 50 USD	2 2 ?
Robotic arm Servo Motors	HSR- 5980SG Servo motors	327 USD	3
Bright LED Lens Control Analog devices	Star Bright LXHL-LW6C Fraen Medium Beam LuxDrive Buck-Puck 700mA AD5241 Digital Potentiometer	27 USD 3 USD 18 USD 3 USD	1 1 1 1

Table IV
Software list

Name	Version	License	Usage
Labview	?	?	