RoboCup Rescue 2017 Team Description Paper
Red Knight Rescue Squad

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Info

Team Name: Red Knight RoboRescue Squad
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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.

1. 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 are moving away from 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 contro, however, with the increased mobility challenges, it does not seem to meet requirements for the competition. We will 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 implemented a new RaspberryPi/RoboPi computer system for manual and autonomous control. Our team is going to be pursuing a gimble-stabilized LIDAR mapping system instead of the previous fixed-orientation ROS based mapping. We are also including a multi-axis manipulator for rotating and extending the arm, as well as a graper located on the end of the arm for performing dexterity tasks.

2. System Description

A. Hardware

Robot Locomotion:

We have changed our drive train to a flipper drive train. It consists of the main drive train with two "flipper arms" with drive treads that will flip out from the main drive train to a) extend the drive train over a greater surface area, and b) to enable the robot to climb up stairs and other surfaces by positioning the flipper arms so that they can "drive" the robot up those surfaces. 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 in 2013 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 year we will be researching new drive materials and testing out both wheels and treads.

Other Mechanisms:
We have a new arm design that includes a multi-axis manipulator for rotating and extending the arm, as well as a grasper located on the end of the arm for performing dexterity tasks. Design TBD.

Sensors:
Thermal
Thermal comes from our custom designed thermal sensor that uses a Perkin Elmer A2TPMI334-L5.5 OAA060 single pixel thermopile sensing element. We are still working on IR Imaging.

CO2 detection comes from CO2 Meter's SprintIR sensor

Auditory is also undergoing an improvement process. For Audio receiving, we have been using the network cameras mounted in our chassis and for sending audio into the test suite, a small, commercial portable speaker is used.

B. Software
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 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.

Navigation:
Teleoperative navigation is managed through visual data streamed through a website-based RaspberryPi/Robopi system. This system is compatible with standard network cameras, which will provide us with edge, horizon and obstacle detection data as well as images. Cameras are mounted to move for better visual acuity. Small pinhole type cameras will also be mounted in the grasper part of the robot for ease of use with the dexterity tasks. All data will be transmitted through a website interface detailed below.

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. In addition to a perimeter detection system, we are pursuing a LIDAR mapping system as well. LIDAR mapping systems provide us with a constantly updated layout of our surroundings using infared radiation.

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 gimble.

C. Communication
We will be communicating with our robot hopefully using a wi-fi connection on the 5GHz band. Ideally, we will increase our use of autonomous communication, but may need to tether if connection is poor.

D. Human Interface
Our operator will be able to control our robot with a laptop utilizing a keyboard and separate mouse. Part of this is to increase usability of the robot and promote a user-friendly robot. Robot will be controlled with a web-based team-created platform with video feed and visuals from sensors.

3. Application

A. 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 (laptop mouse/keyboard 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.

B. Mission Strategy
Our strategy for this year is to utilize more autonomy throughout the tasks. With the new manipulator and arm, we should be able to perform more of the dexterity tasks, and with our new drive train we hope to be more competitive in the maneuvering and mobility tasks. Our new designs have not been tested out yet, so specific tasks will be based on our testing this spring. We have no intention of competing in the blocks with ramps.

C. 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. We have a number of computers, RaspberryPi/RoboPi's available for them to work on and test out code. They have smaller robots to prototype designs and programming on as well.

While we may not have standard test methods at this time, we are attempting to accomplish tasks laid out by RoboCup.

D. Applications in the Field

This particular system continues in line with having a more inexpensive but robust robot. Ideally, this will be an open source project where parts are mostly made from 3D printed and laser cut parts. With that, we know some structural pieces may not be as intense as some other teams, however, we feel that if a robot can be left in a disaster site, it will be more appealing to the market. Additionally, our goal is to require little training to use our system, and I feel we have continued that by using control features that people are used to using, such as a laptop.

Conclusion

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

APPENDIX A

Team Members and Contributions

Kirsten Hoogenakker	Mechanical
Peter Kirwin	Software
Paul Wichser	Mechanical
BSM Graduating classes of ‘17 & ‘18	

APPENDIX B

CAD Drawings

Under development

Table I
Manipulation System

Attribute	Value
Name	RKRS
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	2000 USD
weight	
Any other interesting attribute	
Cost	

Table II
Operator Station

Attribute	Value
Name	CCRKRS
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	3000 USD
Cost	

Table VI
Hardware Components List

Part	Brand & Model	Unit Price	Num
Computer	1 Intel NUC i5/Windows Computer	800 USD	1
Monitors			0
External Controls		150 USD	?
Radio	Router	100 USD	1
Power Supply	?	250 USD	1
Backup Battery	DuraComm	150 USD	1

Mounting Stand	?	400 USD	1
Axels Acetyl Plates Printed Parts Fasteners	? ? Custom Made ?	30 USD 150 USD 450 USD 100 USD	? ? ? ?
Router PCI card Antenna	MikroTic RB/433 AH MikroTic mini PCI card MikroTic Omni-Swivel	126 USD 80 USD 38 USD	2 2 2
Laser Scanner IMU	Hokuyo URG CHR-UM6	2375 USD 199 USD	1 1
Range Finder IR Range Finder MiniIMU	MaxSonar EZMB 1340 Ultrasonic Sharp GP2D12 Pololu	150 USD ?•13 USD 20 USD	5 ? 1
MicroComputer Color Image Sensor CO_2 Sensor Thermal Sensor	RaspberryPi RoboPi Controller Heimann PerkinElmer Single Pixel	100 USD ? 35 USD 25 USD	1 ? 1 1
Motors GearBox Wheels Belting Motor Controller	CIM Custom made Talon SR Motor Controller	56 USD 1600 USD USD USD USD	2 2 2 ? 2
Board Batteries Wiring	LiFePO4 Batteries ?	35 USD 338 USD 50 USD	2 2 ?
Robotic arm Servo Motors	HSR- 5980SG Servo motors	327 USD	6
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 V
Software list

Name	Version	License	Usage
Web2Pi	?	?	