RoboCup Rescue 2018 Team Description Paper BSM Robotics

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Info

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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 control, however, with the increased mobility challenges, it did not seem to perform well in the competition tasks. 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 grasper located on the end of the arm for performing dexterity tasks.

2. System Description

A. Hardware

Robot Locomotion:

We have changed our drivetrain 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 drivetrain to a) extend the drive train over a greater surface area, and b) enable the robot to climb up stairs and other surfaces by positioning the flipper arms so that the treads can apply sufficient force in a greater variety of situations. Belts for this year have been changed due to continuing issues that occurred in previous years (e.g., infiltration by debris, misalignment in conditions with sheer force, etc). 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 new 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.

Speaker

Sensors:
Thermal Camera
FLIR Camera

Distance Sensor

CO2 detection comes from CO2 Meter's SprintIR sensor.

Auditory sensing 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:

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 SLAM technologies 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 and RasPi 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. Smaller 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. If possible, we may transition to a gaming controller if it seems easier.

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 infrared 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 video game controller 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 Red Knight 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 the control device, 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 using inverse-kinematics, 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.

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 Seniors and Juniors

APPENDIX A

Team Members and Contributions

Kirsten Hoogenakker Mechanical
Peter Kirwin Software
Paul Wichser Mechanical
BSM Graduating classes of ‘18 & ‘19

APPENDIX B

CAD Drawings

Under development

Table I
Manipulation System

Attribute	Value
Name	Red Knights
Locomotion	Treads
System Weight	36.25 Kg.
Weight including transportation case	66 lbs
Transportation size	?
Typical operation size	?
Unpacking and assembly time	3 min
Startup time (off to full operation)	2 min
Power consumption (idle/ typical/ max)	?
Battery endurance (idle/ typical/ heavy load)	? ?
Max speed (flat/ outdoor/ rubble pile)	?
Payload (typical, maximum)	?
Arm: typical operation height	4 in
Arm: payload at full extend	24 in
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	2000 USD
Any other interesting attribute	
Cost	

Table II
Operator Station

Attribute	Value
Name	Red Knights
System Weight	2.38 lbs
Weight including transportation case	3.30 lbs
Transportation size	13 in x 8 in x 2 in
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)	3000 USD
Any other interesting attribute	
Cost	

Table VI
Hardware Components List

Part	Brand & Model	Unit Price	Num
Computer	MacBook Air	1200 USD	1
Monitors			
External Controls	Router	150 USD	1
Radio			
Power Supply	?	250 USD	1
Backup Battery	DuraComm	150 USD	1
Mounting Stand	?	400 USD	1
Axels	?	30 USD	?
Acetyl	?	150 USD	?
Plates	Custom Made	450 USD	?
Printed Parts	?	100 USD	?
Fasteners			
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
MicroComputer	RaspberryPi	100 USD	1
	RoboPi Controller	?	?
Color Image Sensor	Heimann	35 USD	1
	PerkinElmer Single	25 USD	1
CO_2 Sensor	SprintIR	155 USD	1
Thermal Sensor	RaspberryPi	7.99 USD	1
		7.99 USD	
Speaker	Hamburger Mini Speaker		1
		39.99 USD	
Thermal Camera	FLIR Lepton Thermal Camera 1.4		1
Motors	CIM	56 USD	2
GearBox	Custom made	1600 USD	2
Wheels			2
Belting	Tslibaki RS41 Roller Chain	50 USD	4
Motor		1137.15 USD	4

Controller	Maxon motor RE65 353295 + gear GP81 110412 Talon SR Motor Controller		
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	Python2.7	BSD	1