

RoboCupRescue 2010 - Robot League Team

Red Knight RoboRescue Squad United States of America

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Abstract: High school engineering class designing and fabricating robots for use in urban search and rescue with an emphasis on generating robots that can be considered disposable.

1. Team Members and Their Contributions

- Map Generation
- Navigation and Localization
- Victim Identification
- Robot Locomotion (Control)
- Robot Locomotion (Mechanical and Electro-Mechanical)
- Robotic Arm

Elizabeth Papetti
Nathan Newell
Adeab Azadegans
Cody Smith
Maverick Mavroulis
Andrew Frenz
Matt Couri
Vincent Taffe

Robert Duffy
Jon Cotter
Marty Schmidt
Patrick Black
Alesandro Cecere
Matt Best
Cody Lynne
Kelsey Hennen

Allie Fan
Andy Kalb
Ryan Quinlivan
Rankin Ahlm
Joe Kramer
Katherine Silikowski
Jordan LaPointe
Claire Leiter

- Advisor
Timothy Jump

* Additional Recognition goes to the BSM-ACS classes of 2006, 2007, 2008 and 2009

2. Operator Station Set-up and Break-Down (3 minutes)

- Set-Up
 - Connect Regulated Power Supply to AC outlet (AC 110 volt wall outlet/US)
 - Erect and connect to regulated power supply
 - Control Station w/integrated
 - Control Station Laptop
 - Additional Monitor(s)
 - Radio Modem w/antenna
 - mouse
 - headphones
 - Boot Command Computer
 - Communication and application programs start automatically upon boot
- Break-Down
 - Shut down and Disconnect
 - Control Station
 - Regulated Power Supply

3. Communications

- Radios (Operator Station and Robot)
 - Avalan AW900mSPI
 - Wireless mini-PCI Radio
 - 900 MHz
 - http://www.avalanwireless.com/assets_v3/design_docs/AW900mSPI.pdf
- Antenna
 - Robot (Custom Design)
 - Marconi Antenna Works
 - <http://www.marconiantennas.com/>
 - Operator Station
 - 900MHz 9db Yagi
 - <http://www.titanwirelessonline.com/ProductDetails.asp?ProductCode=AT%2D9YA%2D900>

4. Control Method and Human-Robot Interface

- Control Method
 - Tele-operation
 - Operator interface-robot bidirectional wireless connection
 - Autonomy
 - Bounded
 - Retraction routine
 - With communication loss, return to previous point of known connectivity
 - Wait for prompt to proceed autonomously
 - Un-Bounded
 - Wall Follow, Collision Detection, Obstruction Avoidance
 - Victim Identification (under development)
 - Motion Detection
 - Thermal Values
 - CO2 Values
 - Sound
- Human-Robot Interface
 - Operator/Human Control
 - Keyboard/Mouse/Joystick
 - Robot Motion
 - Sensor Head/Arm Motion
 - Robot Control
 - SRV-1 Blackfin Processor/Camera w/Radio (3 Units – Front, Rear, Arm Head)
 - <http://www.surveyor.com/blackfin/>
 - SRV-1-RCM Robot Control Module
 - <http://surveyor-corporation.stores.yahoo.net/srrcmexbo.html>
 - Motion
 - Robot Motion
 - Sensor Head/Arm Motion
 - Victim Identification
 - Thermal Detection
 - CO2 Detection
 - Motion Detection
 - Sound Detection

5. Map Generation

- Data Collection and Interpretation
 - ACS IR Scanner (under development)
 - 360° sweep upon query
 - Relays readings to the onboard microcontroller
 - Extraneous readings outside the sensor's range are omitted
 - Honeywell HMC6343 Digital Compass
 - Three-axis, tilt-compensated digital compass provides three-dimensional absolute magnetic field measurement and full 360° tilt compensated bearing, pitch, and roll.
 - Returns readings to onboard microcontroller
 - http://www.sparkfun.com/commerce/product_info.php?products_id=8656
- A single set of readings from range finder and magnetometer analyzed, converted into (x, y) coordinates and plotted as a single map
 - Map sections are manually aligned by drag and drop.
- Victim Placement
 - Manual drag and drop markers for victim location and state
- Map Printing
 - GEOTIFF file delivered on jump flash drive
 - Manifold System Release 8 GIS software
 - <http://www.manifold.net/index.shtml>

6. Sensors for Navigation and Localization

- Visual and Control
 - SRV-1 Blackfin w/Omni Vision OV9655 Color CMOS Image Sensor
 - 3 Units
 - Front
 - Rear
 - Arm Head
 - <http://www.surveyor.com/blackfin/>
- Ultrasonic
 - XL-MaxSonar-EZ MB 1340 Ultrasonic Range Finder
 - Wall Follow
 - Collision Detection/Obstruction Avoidance
 - http://maxbotix.com/uploads/MB1240-MB1340_Datasheet.pdf

7. Sensors for Victim Identification

- Form/Victim State/Victim Tags
 - Omni Vision OV9655 Color CMOS Image Sensor
 - <http://www.surveyor.com/blackfin/>
 - Image processing under development (LabVIEW Robotics)
- Motion
 - Omni Vision OV9655 Color CMOS Image Sensor
 - <http://www.surveyor.com/blackfin/>
 - Motion processing under development (LabVIEW Robotics)
- Auditory
 - Audio-Technica ATR35s Lavalier Microphone
 - http://www.audio-technica.com/cms/wired_mics/742fb06dd066b3ec/index.html
 - Audio processing under development (LabVIEW Robotics)
- CO2
 - Heimann CO₂ Gas Sensor
 - http://www.heimannsensor.com/Datasheet%20HIS%20A21%20F4.26%204PIN_r01.pdf
- Thermal
 - PerkinElmer A2TPMI334-L5.5 OAA060 Single Pixel Thermal Sensor
 - <http://www.perkinelmer.com/search/Search.aspx?Ntt=a2tpmi>

8. Robot Locomotion

- **Mechanical**
 - Main Drive Blocks
 - Laser Cut Parts
 - Acetyl side plates
 - Acetyl motor mount plates
 - 3D Printed Parts
 - Main Axle Center Support
 - Side Assembly Brackets
 - Machined Parts
 - Pulleys
 - Drive Pulleys/Motors
 - Drive Pulleys/Axles
 - Drive Pulleys/Belts
 - Pulley Blanks purchased from Custom Machine and Tool
 - <http://cmtco.com/>
 - Axles
 - Purchased Parts
 - Motors/Motor Parts
 - Main Drive Motors (MP-36064-545, 64:1 motors)
 - Motor Bearing Blocks
 - <http://banebots.com/>
 - Belts
 - XL Drive Belts
 - H Tread Belts
 - <http://fnsheppard.com/>
 - SAE-841 Bronze Bushings
 - <http://www.mcmaster.com>
 - Screws

8. Robot Locomotion/Mechanical (Cont.)

- Arm Motor Drive Blocks
 - Laser Cut Parts
 - Acetyl Mounting Plates
 - 3D Printed Parts
 - Encoder Mounting Blocks
 - CPC Connector Housings
 - Machined Parts
 - Pulleys
 - Drive Pulleys/Arm Motors
 - Drive Pulleys/Axles
 - Pulley Blanks purchased from Custom Machine and Tool
 - <http://cmtco.com/>
 - Axles
 - Purchased Parts
 - Motor/Motor Parts
 - Arm Drive Motors (AME 236 Series motors)
 - <http://www.amequipment.com/PDFFiles/801-1069.pdf>
 - Belts
 - XL Drive Belts
 - <http://fnsheppard.com/>
 - Screws
- Arms
 - Laser Cut Parts
 - Acetyl Side Plates
 - 3D Printed Parts
 - Hubs
 - Machined Parts
 - Pulleys
 - Drive Pulleys/Arm Belts
 - Idler Pulleys/Arm Belts
 - Pulley Blanks purchased from Custom Machine and Tool
 - <http://cmtco.com/>
 - Axles
 - UHMW Belt Blocks
 - Arm Sleeves
 - Purchased Parts
 - Belts
 - H Tread Belts
 - <http://fnsheppard.com/>
 - SAE-841 Bronze Bushings
 - <http://www.mcmaster.com>
 - Screws

● CONTROL

- Motor Control
 - SRV-1 Blackfin microcontroller
 - <http://www.surveyor.com/blackfin/>
 - Dimension Engineering Sabertooth 2x10
 - <http://dimensionengineering.com/Sabertooth2X10RC.htm>

8. Robot Locomotion/Control (Cont.)

- Arm Positioning
 - US Digital E5S Optical Quadrature Shaft Encoders
 - <http://www.usdigital.com/products/e5/>
 - Modes
 - Rough Terrain
 - Arms set at 135° - extended from body, 45° to ground
 - Flat Terrain
 - Arms set at 0° - folded in, parallel to ground
 - Stairs
 - Front Arms set at 135° - extended from body, 45° to ground
 - Rear Arms set at 180° - extended from body, parallel to ground
 - Leveling
 - Honeywell HMC6343 Digital Compass
 - http://www.sparkfun.com/commerce/product_info.php?products_id=8656

9. Other Mechanisms

- Robotic Arm
 - Laser Cut Parts
 - Acetyl side plates
 - Acetyl motor mount plates
 - 3D Printed Parts
 - Servo Mounts
 - Machined Parts
 -
 - Purchased Parts
 - Servo Motors/Motor Parts
 - HSR-5980SG
 - <http://www.lynxmotion.com/Product.aspx?productID=574&CategoryID=38>
 - Linear Actuators
 - Firgelli L-12
 - <http://firgelli.com/products.php>
 - Screws
- Illuminators
 - LXHL-LW6C White V Portable Star white LED
 - Lambertian lens
 - 5 Watt, 120 Lumen
 - <http://www.luxeonstar.com/luxeon-v-portable-star-led-white-lambertian-120-lm-700ma-p-250.php>
 - Fraen Medium Beam Low Profile Lens
 - http://www.luxeonstar.com/item.php?id=749&link_str=121::123&partno=FLP-HMB3-LL01-0
 - ACS Illumination Control
 - LuxDrive BuckPuck 700mA Dimmable DC LED Driver
 - <http://www.luxeonstar.com/buckpuck-700ma-dc-led-driver-pcb-mount-p-31.php>
 - Analog Devices AD5241 digital potentiometer
 - <http://www.analog.com/en/digital-to-analog-converters/digital-potentiometers/AD5241/products/product.html>

10. Team Training for Operation (Human Factors)

- Practice
 - Locomotion Controls
 - Visual Interpretation/Through Camera
 - Mapping operations
 - Victim Identification

*All training occurs on full RecueRobotLeague testing arena

11. Possibility for Practical Application to Real Disaster Site

- Advanced mobility platform
 - Low Cost
 - Stable, robust
 - Easily portable/deployable
 - USB interface and driver software
 - allows robot control from any user-supplied computer
 - Short Operator Learning Curve

12. System Cost

Part(s)	Quantity	Total Cost	Internet Site
Operator Station	1	\$3000.00	Var.
Notebook Computer			
Additional Monitor(s)			
External Controls (i.e. mouse, joystick)			
Communications			
AvaLan AW900mSPI	2	\$300.00	http://www.avalanwireless.com/assets_v3/design_docs/AW900mSPI.pdf
Marconi Antenna Works	2	\$60.00	http://www.marconiantennas.com/
Mapping			
ACS IR Scanner	1	\$375.00	
Sharp GP2D12 IR	(1)	(\$12.50)	http://www.acroname.com/robotics/parts/R48-IR12.html
Honeywell HMC6343	(1)	(\$149.95)	http://www.sparkfun.com/commerce/product_info.php?products_id=8656
Digital Compass			
Moog MD6038/6043	(1)	(\$150.00)	http://www.polysci.com/docs/MD6038_6043.pdf
Slip Ring Assembly			
Gear Motor	(1)	(\$19.00)	http://www.solarbotics.com/products/gm15/
Misc. Parts			
Navigation			
XL-MaxSonar-EZ	5	\$150.00	http://maxbotix.com/uploads/MB1240-MB1340_Datasheet.pdf
MB 1340 Ultrasonic Range Finder			
Victim Identification			
SRV-1 Blackfin w/Omni Vision OV9655 Color CMOS Image Sensor	3	\$420.00	http://www.surveyor.com/blackfin/
Audio-Technica ATR35s Lavalier Mi- crophone	1	\$30.00	http://www.audio-technica.com/cms/wired_mics/742fb06dd066b3ec/index.html
Heimann CO ₂ Gas Sensor	1	\$35.00	http://www.heimannsensor.com/Datasheet%20HIS%20A21%20F4_26%204PIN_r01.pdf
PerkinElmer A2TPMI334-L5.5 OAA060 Single Pixel Thermal Sensor	1	\$25.00	http://www.alliedelec.com/Search/ProductDetail.asp?SKU=980-0049&SEARCH=&MPN=A2TPMI334+OAA060+%2F+625&DESC=A2TPMI334+OAA060+%2F+625&R=980%2D0049&sid=47D5CB8035B617F

Robot Locomotion Mechanical

MP-36064-545, 64:1 Drive Motors	2	\$80.30	http://banebots.com/osc/product_info.php?cPath=36_63&products_id=230
AME 236 Series Wiper Motors/Arm Actuation Motors	4	\$250.00	http://www.amequipment.com/PDFFiles/801-1069.pdf
Double sided H-Pitch Belts	6	\$275.00	http://fnsheppard.com/
XL-Pitch Belts	6	\$30.00	http://fnsheppard.com/
Pulley Blanks			http://cmtco.com/
H-pitch	1	\$470.00	
XL-Pitch	1	\$87.00	
Igus igluid Polymer Bearings	16	\$20.00	http://www.igus.com/igubal/igall2.asp?p=J

Fabrication Supplies

Steel Axles		\$30.00	Var.
Acetyl Plates		\$75.00	
3D Printed Parts		\$150.00	
Fasteners		\$30.00	
Misc. Supplies		\$50.00	

Robot Locomotion Control

SRV-1 Blackfin w/Omni Vision OV9655 Color CMOS Image Sensor	3	(included above)	http://www.surveyor.com/blackfin/
Dimension Engineering Sabertooth 2x10	3	\$194.97	http://dimensionengineering.com/Sabertooth2X10RC.htm
US Digital E5S Optical Quadrature Shaft Encoder	4	\$188.00	http://www.usdigital.com/products/e5/

Other Mechanisms

Electrical

Voltage Regulator	1	\$65.00	http://roboticsgroup.com/proddetail.asp?prod=RGi%2DSDPPS%2DAdj%2D1&cat=22
Circuit Buss	2	\$35.00	http://www.cooperbusssmann.com/pdf/c08d920b-d81a-4334-ba08-57bef755608b.pdf
SLA Battery	1	\$38.00	http://www.batteriesplus.com/p-34302-power-sonic-12v-105ah-scooter-battery.aspx
Battery Connectors	2	\$8.00	http://www.andersonpower.com/products/multipole-sbs.html

Other Mechanisms (cont.)

CPC Connectors	5	\$125.00	http://www.mouser.com/catalog/633/1217.pdf
Assorted Electrical Connectors/Wiring	Var.	\$50.00	Var.

Robotic Arm

HSR-5980SG Servo Motors	3	\$327.00	http://www.lynxmotion.com/Product.aspx?productID=574&CategoryID=38
Firgelli F-12 Linear Actuators	2	\$160.00	http://www.firgelli.com/products.php
Lead Screw Assembly	1	\$200.00	http://igus.bdol.com/pdf/drylinw.pdf

Illumination

Star Bright LED LXHL-LW6C	1	\$26.99	http://www.luxeonstar.com/luxeon-v-portable-star-led-white-lambertian-120-lm-700ma-p-250.php
Fraen Medium Beam Low Profile Lens	1	\$2.45	http://www.luxeonstar.com/item.php?id=749&link_str=121::123&partno=FLP-HMB3-LL01-0
ACS Illum. Control	3	\$150.00	
LuxDrive BuckPuck 700mA Dimmable DC LED Driver 3021DE700	(3)	(\$17.99)	http://www.luxeonstar.com/buckpuck-700ma-dc-led-driver-pcb-mount-p-31.php
Analog Devices AD5241 Digital Potentiometer	(3)	(\$3.00)	http://www.analog.com/en/digital-to-analog-converters/digital-potentiometers/AD5241/products/product.html

Totals

Operator Station	\$3000	
Communications	\$360	
Mapping	\$375	
Navigation	\$150	
Victim Identification	\$510	
Robot Locomotion	\$1550	*Mobile platform for future distribution
Other Mechanisms	\$1188	*Cost of lead screw assembly estimated
Combined System Costs	\$7,133	

13. Lessons Learned/Areas in Need of Improvement

- Eliminate vulnerability to water
- \$4000 robot price still too high for disposability