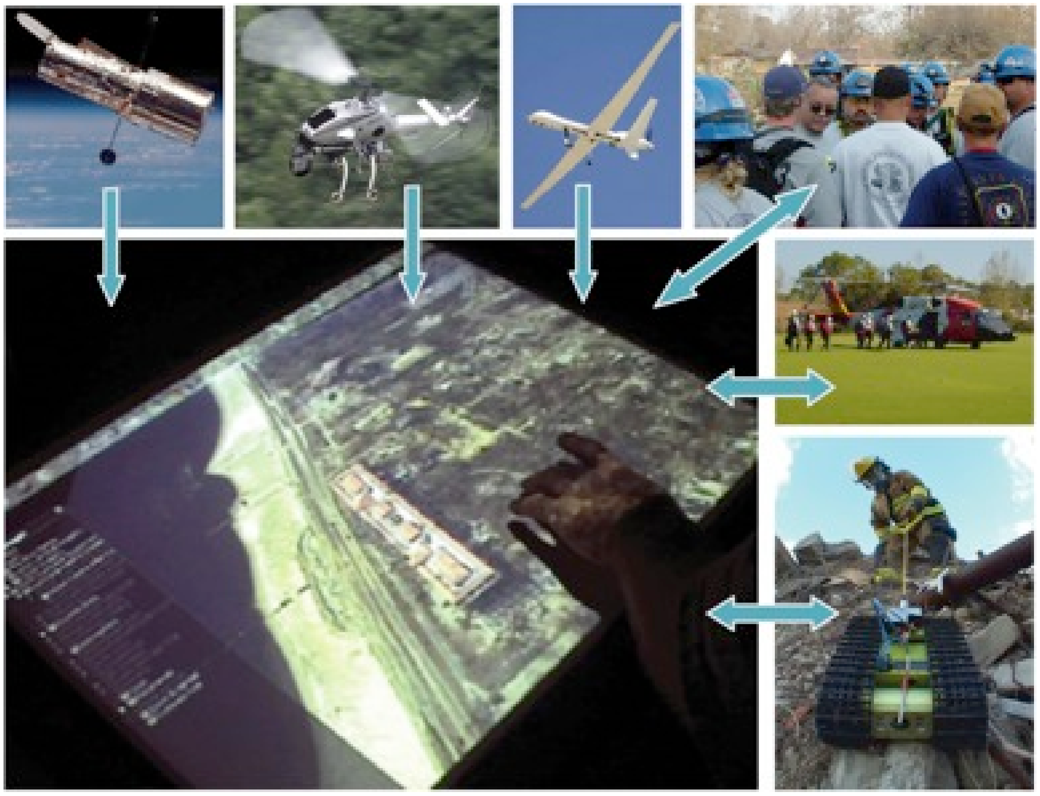
Disaster Response @ UMass Lowell

UMass Lowell Robotics Lab
Department of Computer Science
http://www.cs.uml.edu/robots



Improving Disaster Response with Mobile Robots and Multi-Touch Technologies

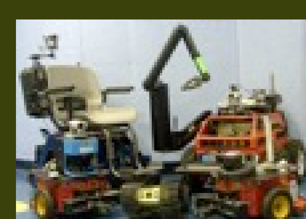
Hurricane Katrina made landfall near Biloxi, Mississippi in late August 2005. The resulting disaster response revealed a large technological gap. Although satellite and aerial information existed, it was not available to or used by search teams. Instead, during the night, US Geological Survey and state forestry personnel manually generated area maps. These maps were distributed to search personnel in the morning for the daily grid searches. When the teams returned that evening, updates were manually integrated by USGS and forestry personnel based upon search reports.

The UMass Lowell Robotics Lab envisions an intelligent command and control interface that coalesces available information, e.g. combining satellite and aerial data over time with city planning layouts (street, sewer, water, gas, electric, and communication). Our system will allow collaboration on the interface by multiple users on multiple layers. Thus, informed discussion can occur, risks can be properly assessed, a plan can be developed, and resources efficiently allocated. If a significant finding occurs in the field, the plan can be quickly modified.

UMass Lowell Robotics Lab

The Robotics Lab was founded by Dr. Holly Yanco in 2001. Research focuses on human-robot interaction (HRI), which includes interface design, robot autonomy, computer vision, and evaluation methods. Application domains include assistive technology (AT) and urban search and rescue (USAR). The Robotics Lab also has an active community partnerships program, working with K-12 students.

Research in the lab is funded by the National Science Foundation (IIS-0308186, IIS-0415224, IIS-0546309, IIS-0534364, SES-0623083, CNS-0540564) and the National Institute of Standards and Technology (70NANB3H1116). Dr. Yanco received an NSF Career Award in 2005.



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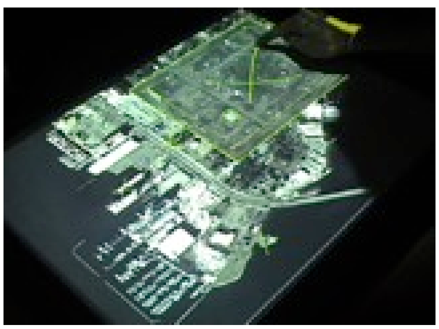
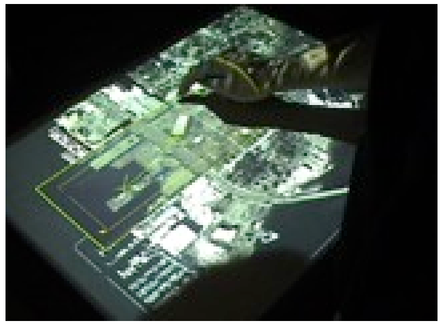
Interactive Damage Assessment

In a disaster relief effort, before and after comparisons of the area can be valuable to the command staff. Remaining structures can be annotated to indicate future search areas. Debris fields can be marked as a secondary search priority. The relocation of maritime structures and large boats may also be noted. Overall, the search space can be optimized and high priority given to areas with greatest potential for survivors.



The user marks a destroyed city block. Annotations like this can help focus search teams and optimize search time.

Mutli-touch systems have yet to be used for disaster response and robot control. One of our most recent research projects uses an interactive 2D map on the MERL DiamondTouch, providing a natural interface similar to pen and paper.



The user marks a barge moved by the storm surge. During natural disasters like hurricanes, entire structures can be moved.

Aerial photography of Biloxi, Mississippi after Hurricane Katrina is overlaid on pre-disaster satellite imagery. To reveal the post-disaster image, the user places two fingers around the area of interest. This opens a window (shown as a color specified rectangle) owned exclusively by the user. In the window, the user can adjust the zoom level and annotate the map. The user can also move the window around the map.

Damage Assessment from Multiple Perspectives

The main focus of responders is to search for survivors and victims in the aftermath of disasters. The structural integrity of a building may be severely compromised by wind, storm surge, or debris. When human or canine personnel cannot safely search, robots can be deployed instead, thus minimizing further loss of life.

One such search robot is American Standard Robotics' Variable Geometry Tracked Vehicle (VGTV), manufactured by Inuktun Services. The VGTV is a tele-operated, tethered robot. It is capable of changing its shape and is depth rated to 100 feet. It is equipped with a color zoom camera, two-way audio, and lights. The VGTV can also carry sensors and small equipment into search areas.

Our VGTV was used in Biloxi, Mississippi after Hurricane Katrina by Florida Task Force Three. Rescuers were able to search unsafe structures and experience a first-person view from the robot.

UML's VGTV, a green robot with black tracks, emerges from a partially collapsed apartment. Robots like this safely give searchers "eyes and ears" inside the structure.

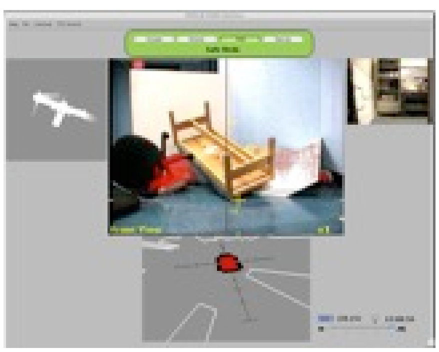
Enabling Technology: MERL DiamondTouch

Mitsubishi Electric Research Laboratories has created a touch-screen that breaks the normal monitor-keyboard-mouse paradigm. The DiamondTouch is capable of uniquely identifying multiple users simultaneously by touch. The board itself is embedded with antennas in the horizontal and vertical directions which form a grid. The antennas continuously transmit signals. When a user touches the board, the radio signal is sent to the receiver connected to their body. The board can also recognize gesture using combinations of the change in surface area, motion, and touch sequence. The DiamondTouch display is forward projected and spill resistant. It is available in two standard sizes: 32" or 42" diagonal.

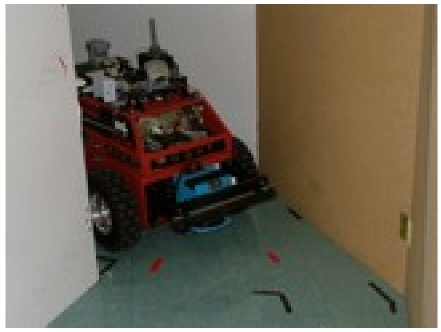
Human-Robot Interaction: Design and Evaluation

Situation awareness (SA) is critical to the successful operation of an unmanned vehicle. Since 2003, the UMass Lowell Robotics Lab has studied numerous robot control systems intended for emergency response. We have designed evaluation methods and produced design guidelines for HRI. From this, we implemented our own video-centric urban search and rescue (USAR) system.

Our platform is an iRobot ATRV-JR featuring a 2.8GHz Pentium IV processor, a full sonar ring (26 sonars), two Canon VC-C4 pan-tilt-zoom cameras (front and rear), a SICK laser, a FLIR Systems Indigo A10 thermal camera, a carbon dioxide sensor, an audio system, and a lighting system. The robot currently uses four levels of autonomy, ranging from teleoperation to a goal-centric mode.



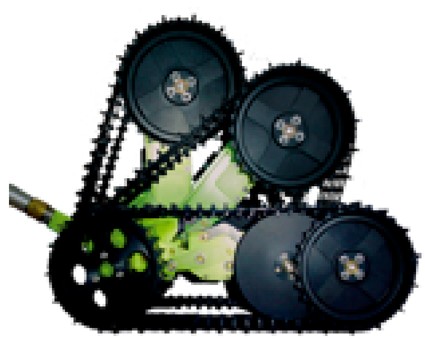
UML's USAR interface identifies a hidden victim, shown in red in the main video display. An augmented interface increases the user's situation awareness during remote operation.



A remote user drives our ATRV-JR through a narrow turn in the test arena. Situation awareness is critical to avoid collisions with the structure, which could potentially cause damage to the robot and the structure.

Our interface utilizes many novel features such as the fusion of direct sensor information to increase SA. Specifically, we combine sonar and laser ranging information to indicate obstacles near the robot (shown directly below main video display) and map the environment during operation (shown to the left of main video display). We also fuse FLIR with video (shown in the main video display), which allows the operator to easily notice hidden victims.

Other innovative features are included in our implementation. On the main video display, a cross hair indicates the current orientation of forward camera. A small, mirrored video display simulates a rear-view mirror in the upper right corner. The user has the ability to swap the front and rear camera views while the drive controls and distance information are remapped to reflect this change. This virtual exchange eliminates the need for the robot to backup, which results in more efficient operation.

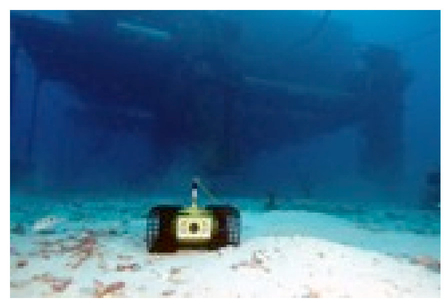


The VGTV's physical configuration ranges from laying flat to raised upright. This unique feature allows the vehicle to negotiate objects and operate in highly confined spaces.

Situation Awareness for Variable Geometry Robots

Polymorphic robots are capable of operating in dynamic environments. They can change shape to maximize their effectiveness. However, their shape-shifting ability adds complexity to situation awareness (SA) when designing an intuitive user interface.

The VGTV robot was designed to be polymorphic; the robot's physical configurations range from lying completely flat to raised upright. UMass Lowell Robotics Lab's VGTV was used in experiments conducted in conjunction with MITRE and American Standard Robotics. The experiments tested the impact of pose information on user performance and situation awareness.



The VGTV travels through aquatic and rough terrain without problems. Its sealed water-tight chassis allows it to work in difficult environments such as desert sand and snow.

The presence of pose information was found to increase SA. When the user was presented with robot pose information, we found a significant decrease in the number of times the robot tipped over or its forward motion was hindered. Without the pose display, participants were more likely to use the upright raised pose to reorient, thus requiring additional manipulation time.

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Our Collaborators

- **Florida Task Force Three (Mark Micire)**
- **iRobot (Dave Goodall, Tom Frost)**
- **Mitsubishi Electric Research Laboratories (Adam Bogue)**
- **MITRE (Jill Drury, Jennifer Casper)**
- **National Institute of Standards and Technology (Elena Messina)**
- **Idaho National Labs (David Bruemmer, Doug Few, Curtis Nielsen)**

Related Links

- **UMass Lowell Robotics Lab**
  http://www.cs.uml.edu/robots
- **DiamondTouch**
  http://www.merl.com/projects/DiamondTouch
- **VGTV-Extreme**
  http://www.asrobotics.com

Selected Publications

H. A. Yanco and J. L. Drury. "Rescuing Interfaces: A Multi-Year Study of Human-Robot Interaction at the AAAI Robot Rescue Competition." *Autonomous Robots*, to appear.

H. A. Yanco, M. Baker, R. Casey, B. Keyes, P. Thoren, J. L. Drury, D. Few, C. Nielsen and D. Bruemmer. "Analysis of Human-Robot Interaction for Urban Search and Rescue." *Proceedings of the IEEE International Workshop on Safety, Security and Rescue Robotics*, August 2006.

B. Keyes, R. Casey, H. A. Yanco, B. A. Maxwell, and Y. Georgiev. "Camera Placement and Multi-Camera Fusion for Remote Robot Operation." *Proceedings of the IEEE International Workshop on Safety, Security and Rescue Robotics*, August 2006.

J. L. Drury, H. A. Yanco, W. Howell, B. Minten and J. Casper. "Changing Shape: Improving Situation Awareness for a Polymorphic Robot." *Proceedings of the ACM/IEEE Human-Robot Interaction Conference*, March 2006.

M. Desai and H. A. Yanco. "Blending Human and Robot Inputs for Sliding Scale Autonomy." *Proceedings of the 14th IEEE International Workshop on Robot and Human Interaction Communication*, August 2005.

H. A. Yanco, J. L. Drury, and J. Scholtz. "Beyond Usability Evaluation: Analysis of Human-Robot Interaction at a Major Robotics Competition." *Journal of Human-Computer Interaction*, Volume 19, Numbers 1 and 2, pp. 117 – 149, 2004.

M. Baker, R. Casey, B. Keyes and H. A. Yanco. "Improved Interfaces for Human-Robot Interaction in Urban Search and Rescue." *Proceedings of the IEEE Conference on Systems, Man and Cybernetics*, October 2004. Selected as a finalist for the Best Student Paper Competition.

D. Hestand and H. A. Yanco. "Layered Sensor Modalities for Improved Feature Detection." *Proceedings of the IEEE Conference on Systems, Man and Cybernetics*, October 2004.

H. A. Yanco and J. Drury. "'Where Am I?' Acquiring Situation Awareness Using a Remote Robot Platform." *Proceedings of the IEEE Conference on Systems, Man and Cybernetics*, October 2004.

H. A. Yanco and J. Drury. "Classifying Human-Robot Interaction: An Updated Taxonomy." *Proceedings of the IEEE Conference on Systems, Man and Cybernetics*, October 2004.

J. Scholtz, J. Young, J. L. Drury, and H. A. Yanco. "Evaluation of Human-Robot Interaction Awareness in Search and Rescue." *Proceedings of the IEEE International Conference on Robotics and Automation*, April 2004.

J. L. Drury, J. Scholtz, and H. A. Yanco. "Awareness in Human-Robot Interactions." *Proceedings of the IEEE Conference on Systems, Man and Cybernetics*, October 2003.