# The Scarabs RoboCup 2002
# Rescue Robot Team

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## Introduction

In the fall of 1999, a group of high school and junior high students from Los Angeles took on the enormous challenge of competing against some of the top robotics and artificial intelligence researchers in the world in the RoboCup middle (F2000) league. After over two years of hard work, funded on a shoestring budget (mostly out-of-pocket), the Scarabs robotic soccer team has:

- field-tested a color-tracking system at RoboCup 2000 in Melbourne, Australia;
- designed and built a prototype vehicle and omnidirectional vision system; and
- successfully demonstrated this vehicle / vision system combination in the Rescue Robot competition at RoboCup 2001 in Seattle, Washington.

Fig. 1: Founding Scarab team members with Dr. Wei-Men Shen and his staff at the USC Information Sciences Institute.

The goals of the Scarabs RoboCup team are: to build viable robots at minimal cost; to learn about math, computer science, electronic engineering, physics, artificial intelligence, system integration, international relations, character development, and teamwork; to have fun (!); and to make a positive difference.

The team is still dedicated to competing in the mid-league. However, after seeing how well our prototype performed, Rescue Robot League Chairman Adam Jacoff (NIST, USA) invited the Scarabs to participate both at RoboCup 2002, and at the American Association for Artificial Intelligence (AAAI) convention in Edmonton, Alberta. Also, creating search-and-rescue robots has taken on added significance and urgency following the events of September 11, 2001.

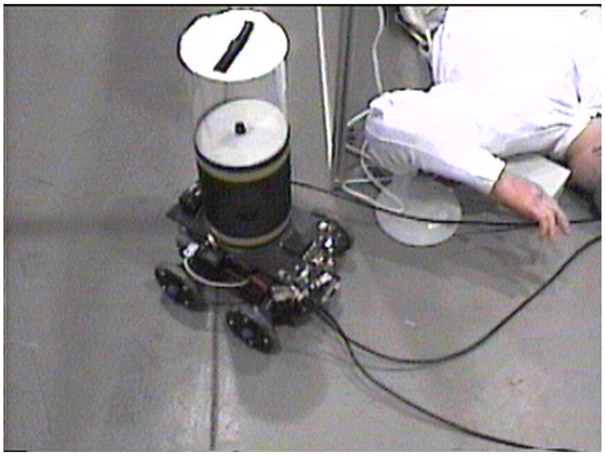

Fig. 2: The Scarabs prototype robot searching the RoboCup 2001 rescue course.

Fig. 3: Prototype robot sporting the cap it retrieved from one of the course "victims".

To produce viable search and rescue robots, we focused on the issues of reliability, agility, cost, position mapping, and single-operator deployment.

## Vision System

The custom-built omnidirectional vision system uses a color video camera facing upwards, looking directly into a 5.75 in. diameter convex mirror. The mirror radius of curvature is also 5.75 in. The camera / mirror combination produces a 360 degree view, from a few degrees above horizontal down to the vehicle. The camera / mirror system is elevated inside a clear plastic tube to a height of about 20 inches to provide a more unobstructed field of view.

Previously, we used the CBC America CEC100-L38 video camera (chosen for its small size, NTSC output and 71.5 degree field of view). However, we have converted to the Axis 2120 Network Camera (www.axis.com). The 2120 features: direct connection with a 10/100 MBit Ethernet network; built-in Linux web server, with 2 Mb memory available for html files; an onboard 100 MIPS RISC processor; real-time hardware-compressed JPEG video output; and an additional 9-pin serial interface.

These features provide tremendous advantages: a single Ethernet cable for video and robot control; the ability to generate the operator interface as a web page; 30 frames/sec. digital video output, with a bandwidth of as little as 90kb/sec.; simple vehicle control via serial interface; and the future possibility of running Carnegie Mellon University's CMVision color-tracking software inside the camera (http://www-2.cs.cmu.edu/~jbruce/cmvision/).

## Data Transmission

Previous experience has shown that radio interference can be a significant problem, particularly when video transmission is involved. Data transmission via cable offers the advantages of: reliability; simplicity; low cost; distance and direction measurement (see below); a guideline for rescuers / victims; and manual robot retrieval (in the event of mechanical problems).

To avoid tangling, a reel on the robot will deploy and take up the cable as the robot moves. The cable will be marked at 0.5 m intervals: this will allow the operator to determine how far the robot has traveled simply by counting marks with the omnidirectional vision system. Robot direction can also be determined by observing the direction of cable deployment.

## Command System

A laptop computer will provide the operator interface. Custom software will make it possible for the robot to be operated and mapped by a single person. The software will consist of three parts: robot control, mapping, and printing.

ASCII control characters (input by the operator via the computer keyboard) will be carried by the Ethernet cable to the Axis camera on the robot. There, the characters will be forwarded via the camera's 9-pin RS-232 serial interface.to the robot's BASIC Stamp II microcontroller.

The operator can also input information about the robot's movements. The mapping portion of the software will log this information, and translate it into a map. Victim status (alive, dead, moving, not moving, etc.) and obstacle information can also be recorded. The program will automatically time-stamp all operator input.

Finally, the Print function can output a map with a legend indicating the position and status of each victim, and the location and nature of any obstacles.

## Vehicles

We are fielding two radically different robots: an updated version of the prototype we ran at RoboCup 2001; and Morph-Dragon, a sophisticated six-wheeled robot designed to compete on the Robotica television program.(described below). Both robots will use the same vision and control systems.

The four-wheel drive prototype robot chassis is light, simple, strong and cost less than $200 to build. The left and right drive trains, motors, and wheels came from Nikko Hercules R/C cars. A platform connecting the drive trains was constructed from 1/8 inch sheet aluminum and attached to the using custom-milled aluminum "L" brackets.

The left and right sides of the robot are individually driven by 7.2 volt DC motors. Two Traxxas electronic speed controllers provide fine motor speed (over 500 levels) and direction. These inexpensive controllers can handle 75 Amps continuous current (we estimate actual draw of 10 A or less from the motors).

A Parallax Basic STAMP II microcontroller/ Board of Education is used to receive and interpret commands from the operator computer, and generate PWM signals to communicate desired speed / direction to the Traxxas controllers.

Morph Dragon was originally designed to compete on the Robotica program. It is 39" wide, 30" long and the box is 8" high. It weighs about 200 pounds. It has six high-grip wheels, each driven by a 1.6 horsepower wheelchair motor. Each pair of wheels has a drill motor that can control the vertical location of its axis with respect to the bottom of the body. This permits the robot to be very close to the ground or to be as far as 5.5" from the ground. Because the wheels heights are independent, it can function as a 2-, 4-, or 6-

wheeled robot. The body can be level or slanted. A BASIC Stamp processor receives user controls for wheel configurations and adjusts their heights as necessary. There is also a lifting arm at the front of the robot.

## Conclusion

Pursuing the RoboCup mid-league, and now the Rescue Robot League, has been an invaluable educational experience for the team members. In light of September 11, creating search and rescue robots has taken on added significance and urgency. We demonstrated last year that a very inexpensive teleoperated vehicle could effectively locate "victims" in a "disaster" scene. The vehicles we are fielding this year should be even more effective, particularly in the more difficult Orange and Red levels. For more information about the Scarabs team, please visit our website (www.samohi.net/robocup), or email Team Coordinator Michael Randall (mr_mr@earthlink.net).