SCHOOL BOT • RISCBOT • LAPTOP BOT • MOVIE BOTS

# SERVO MAGAZINE

FOR THE ROBOT EXPERIMENTER

March 2006

## Assimilate Your Robot With the BoRG BOARD

## Jasper the 3D Movie Bot

## Give Your Microcontroller More Drive

## Portrait of the Artist as a Young Robot

U.S. $5.50 CANADA $9.25

03>

0 74470 58285 4

www.servomagazine.com

# SERVO

## Features & Projects


**30 Give Your Microcontroller More Drive**
*by Tom Napier*
An addressable latch lets microcontrollers set and clear individual output bits but also generate short pulses.

**32 Radio Communication Basics for Robots**
*by Steven Schmitt*
Design a custom radio control system using serial link modules.

**37 RISCBOT**
*by Tarek Sobh, Sarosh Patel, and Rajeev Sanyal*
An experimental telerobotic system.

**42 Quick and Easy Autonomous Operation for FIRST Robots**
*by Brian Cieslak*
Making the first 15 seconds of a match count.

**47 Intermediate Robots**
*by Dave Shinsel*
Building a Laptop- or PDA-based Robot — Part 3.

**54 2005 Robot Soccer Championships**
*by Dave Calkins*
Part 2: FIRA Singapore.

**58 The BoRG**
*by L. Paul Verhage*
The Boise Robotics Group has developed its own BoRG board to incorporate into a series of educational robotic projects.

**68 KIT KOLLEGE**
*by Dave Prochnow*
Lecture 8: JoinMax Digital Robot Dog.


## ON THE COVER

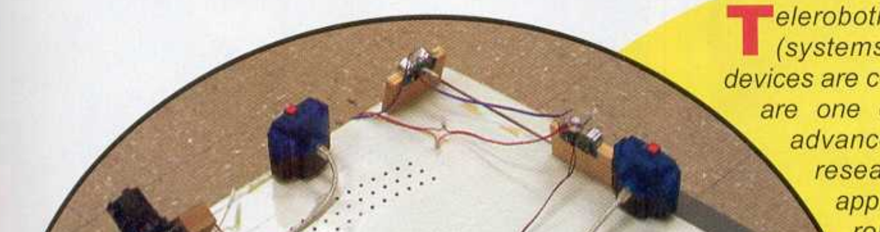
**Meet the BoRG — The Boise Robotics Group**



*SERVO Magazine* **(ISSN 1546-0592/CDN Pub Agree#40702530)** is published monthly for $24.95 per year by T & L Publications, Inc., 430 Princeland Court, Corona, CA 92879. APPLICATION TO MAIL AT PERIODICALS POSTAGE RATE IS PENDING AT CORONA, CA AND AT ADDITIONAL ENTRY MAILING OFFICES. POSTMASTER: Send address changes to **SERVO Magazine, P.O. Box 15277, North Hollywood, CA 91615** or Station A, P.O. Box 54, Windsor ON N9A 6J5; cpcreturns@servomagazine.com

# RISCBOT

by Tarek Sobh, Sarosh Patel, and Rajeev Sanyal of RISC, Laboratory University of Bridgeport, CT



*Telerobotic systems (systems in which robotic devices are controlled from a distance) are one of the modern marvels of advanced interdisciplinary scientific research and development. The application spectrum of these mobile robots ranges from autonomous museum guides to space exploration and remote surveillance, and from hazardous material handling to running errands. With the advent of the Internet, telerobotics has received a major boost.*

***RISCBOT**'s design commenced with a vision to provide a simple, fast, and reliable telerobotic system. Today, it can be commanded via the Internet to move to particular offices in the Engineering Technology Building of the University of Bridgeport, CT.*

***RISCBOT** localizes and fulfills online user's requests of navigating to desired rooms with a visual door ID character recognition algorithm. Online users receive real time video feedback from the robot and can also view the robot position.*

**This article describes RISCBOT's architecture, its modules, applications, and, finally, future proposed enhancements.**

## Mechanical Construction

RISCBOT is the experimental telerobotic system we built. It is modular in structure. Pro Engineer (ProE) was used to design and visualize various configurations of the robot in the initial design phase. The best design was selected based on stability criterions, speed, floor clearance, turning radius, and appearance. RISCBOT has been built with T-slotted aluminum extrusion rods as it provides the liberty of altering the design and making changes with ease. Figures 1 and 2 show views of RISCBOT during the initial ProE design phase.

RISCBOT navigates using a front end differential drive, implemented with two 4" wheels (see Figure 3) and a rear caster wheel for support, as shown in Figure 4. Two 12V DC servomotors (Pittman) drive the wheels. An ATM103 MCU controls the ultrasonic sensors and the two motors. The PC sends commands to the MCU through the serial port. Atmel's ATM 103 (see Figure 5) is an eight-bit RISC MCU being used to control the DC motors and interface with the PC board (serially) and the ultrasonic sensors.

The data from the ultrasonic sensors is monitored in an interrupt based embedded C code on the ATM 103. The main program running in the eight-bit CPU for controlling the motors depends on the instructions sent serially from the PC. A nine-volt Panasonic battery (see Figure 7) with an inverter (see Figure 8) serves as the power house for the robot.

The PC cabinet housing the WLAN card and an NM 6403 DSP board (see Figure 6) is mounted on top of the base. Three ultrasonic sensors, two Logitech cameras, and an NTSC camera are mounted on the PC cabinet. The NM6403 DSP board performs a visual recognition algorithm when signaled by the PC. The NM6403 is a high performance dual core micro-

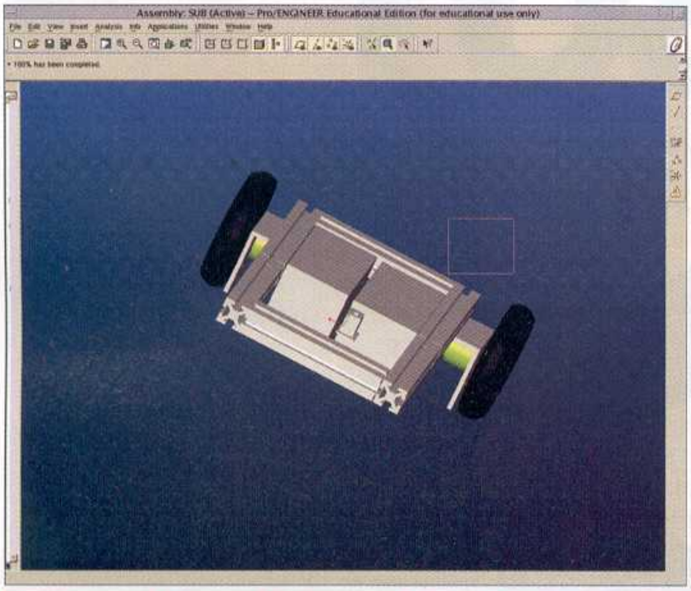



**Figure 1.** Top view of RISCBOT.

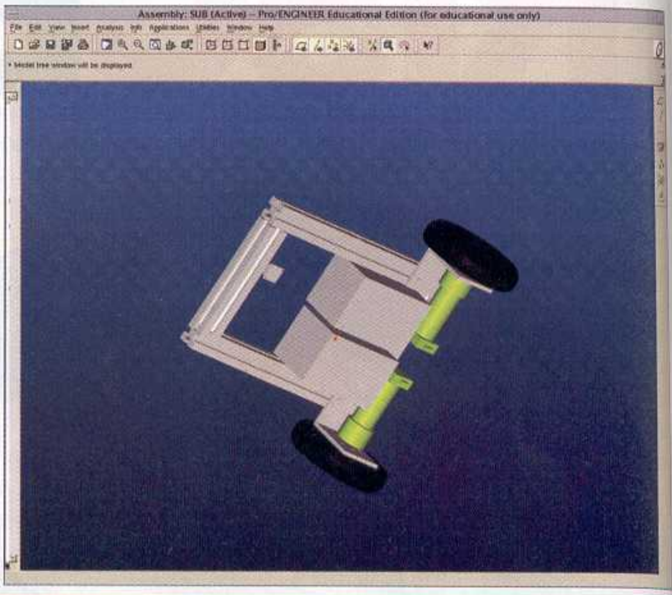



**Figure 2.** Bottom view of RISCBOT.

processor with a combination of VLIW/SIMD architectures.

The architecture includes two main units: a 32-bit RISC Core and a 64-bit VECTOR co-processor to support vector operations with elements of variable bit length. The NM6403 based reconfigurable high-performance multi-DSP development set consists of four NM6403 DSP processors, 16 MB asynchronous SRAM, 16 MB SDRAM, 1 MB Flash, NTSC, and PAL video decoder and PCI host interface. The PC and the NM6403 share 4 MB SRAM.

## Navigation Module

The robot waits until it receives information from the server. Once it receives a command from the server, it starts searching for the requested room. The robot navigates along the wall to the left side of the corridor. With the help of the onboard ultrasonic sensors (see Figure 10), the robot maintains a safe distance of 45-50 cm from the wall. If the robot gets closer to the wall, it turns right, if it gets farther away, it turns to the left, and if the distance from the wall is within 45-50 cm, the robot continues to move straight.

If the robot encounters a wall right in front of it (example, at corners), it takes a right turn. The image processing program checks for doors continuously. Once the program detects a door, it signals the NM6403 DSP board to check for the room ID. If the room ID matches the requested ID, the robot stops. If not, the robot continues moving until it finds the desired room. Figure 9 shows the control flow diagram for the navigation module.

## Image Processing

The door recognition algorithm is computationally fast, so that doors can be recognized in real time and appropriate commands can be sent to the Navigation module to stop the robot in front of the desired door. Our algorithm employs edge detection to differentiate between the wall and the door. We used various filtering techniques for edge detection. The best results were obtained using a Gaussian — a Laplacian filter — also commonly known as the Log filter. This module is programmed in MATLAB.

Images from the camera are captured on the run from the mounted webcams (see Figure 11). Figures 12-16 show a set of images captured by the camera and Figures 17-21 show

## RISC Laboratory

### *University of Bridgeport, CT*

The Interdisciplinary RISC lab resides in the Computer science and Engineering department at the University of Bridgeport, CT. It was formed in 1995 by its founder and coordinator, Professor Tarek Sobh, in order to do research in a variety of robotics-related fields, and as a step towards the development of commercially-applicable projects.

Their research interests include reverse engineering and industrial inspection, CAD/CAM and active sensing under uncertainty, robots and electromechanical systems prototyping, sensor-based distributed control schemes, unifying tolerances across sensing, design and manufacturing, hybrid and discrete event control, modeling, and applications, mobile robotic manipulation, developing theoretical and experimental tools to aid performing adaptive goal-directed robotic sensing for modeling, observing and controlling interactive agents in unstructured environments.

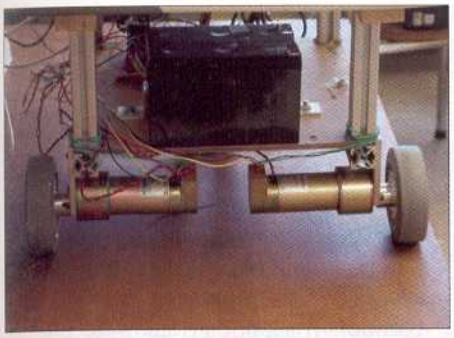


**Figure 3.** Front end differential drive.

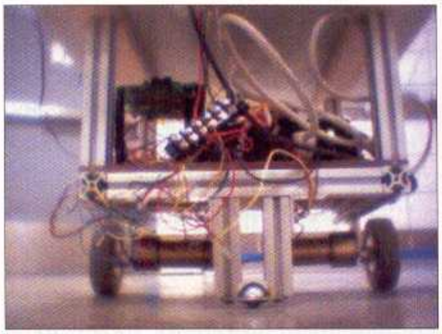


**Figure 4.** Rear castor wheel.

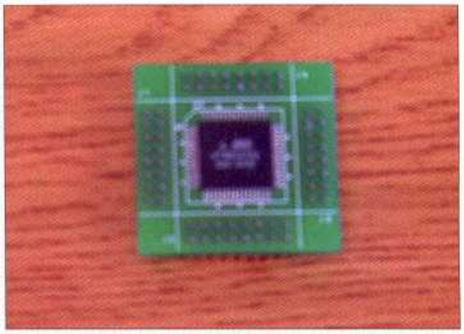


**Figure 5.** Atmel ATM103 MCU.

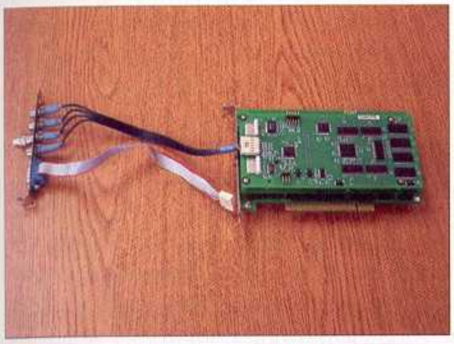


**Figure 6.** NM 6403 DSP board.


**Figure 7.** Panasonic 9V battery.

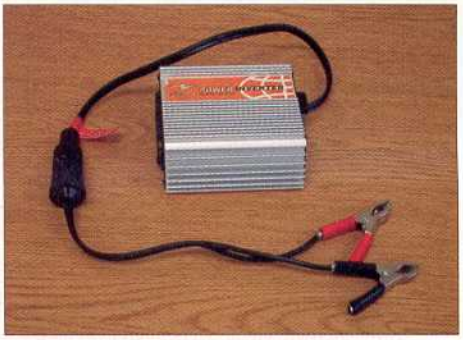


**Figure 8.** The inverter.

some results of the edge based door recognition algorithm. These images are converted to gray scale and then filtered to recover the edges.

By monitoring the relative percentage change in the edges, a door is recognized. When a drop in the relative percentage below a particular threshold (-0.03) is recognized, the robot is assumed to have encountered a door.

Figure 22 shows a plot of recognized doors. The program maintains an internal count for the doors encountered, if the door recognition algorithm fails. In addition, adequate measures have been incorporated so that when more than one image of the same door is captured, the robot does not treat them as two different doors.

Once a door is recognized, the control is passed to the Recognition Module in order to recognize the door. For more information on the edge detection algorithm, please visit the RISCBOT website listed at the end of the article.

## Door ID Recognition

As the robot passes a door, it scans images for locating the door plate. The door images are acquired using the NTSC camera mounted on the side (see Figure 23). Once the door plate has been located, the numeral character is extracted. The extracted character is then scaled to a standard size and topological features of the character are calculated and compared with elements of a library (trained set of features).

A match of a library bit string

**Figure 10.** Ultrasonic sensors.

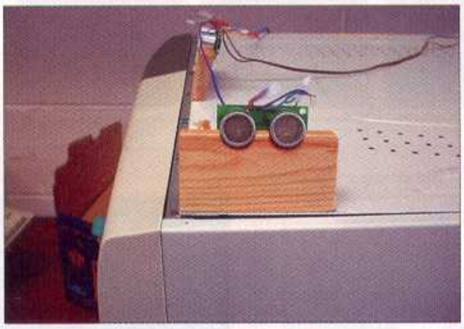


**Figure 11.** Onboard camera.

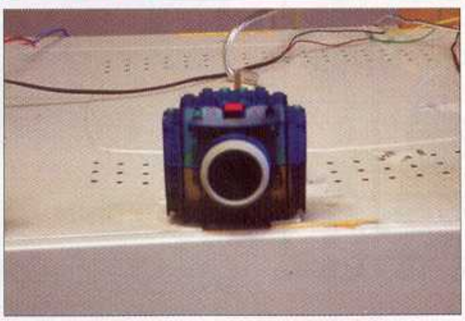
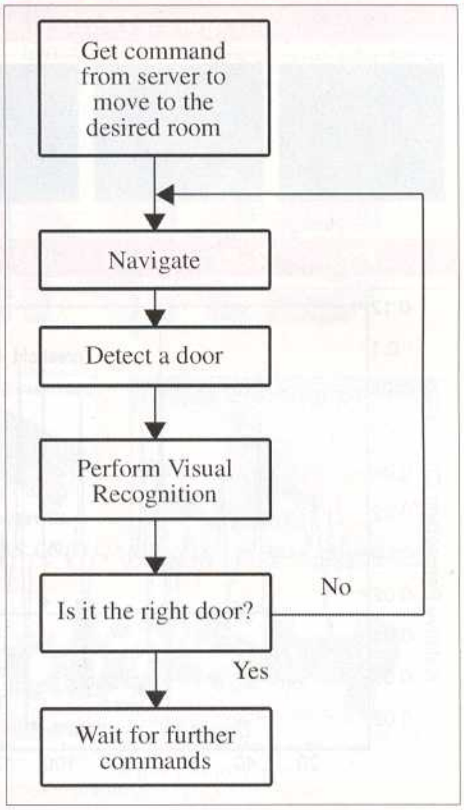


**Figure 9.** The navigation chart.



against an input string results in the corresponding digit class being assigned to the input digit. If this digit is the same as the desired door number, the robot stops or else continues to move towards the desired door.

## The Web Interface

The web interface is an integral part of the mobile navigation and identification process. The mobile robot is connected to the Internet through an onboard WLAN 802.11b card which connects to the nearest wireless service providing an access point.

The robot can be controlled and viewed from the Internet, through the RISCBOT website. Updates on the web services and server availability information will be posted on the website. Users can also download videos and pictures of sample navigation and recognition tasks performed by the robot.

The RISCBOT web interface is simple, consisting of three windows: the control window, top view window, and the camera window. Figure 24 shows a view of the web interface while the robot is navigating.

The control window shows the instantaneous position of the RISCBOT. Once logged on, any remote user can command RISCBOT to move to a desired door by selecting one of the 11 listed doors on the right of the control window. When the user presses the MOVE button, the respective door number is sent to the RISCBOT server which then sends the command to the RISCBOT computer via the wireless link. The RISCBOT website is hosted on a Microsoft IIS Server supporting ASP for user interaction with the robot.

The main purpose of the other two windows are as follows: The top view window and the cam window provide visual feedback. The top view window shows the position of RISCBOT in the corridor. This view is the same as that on the command window. This video is provided by a network camera mounted on the ceiling of the corridor.

The cam view window provides a head-on real time video feedback from the robot as it moves through the corridor. The onboard camera continuously grabs image frames from the USB camera and wirelessly transmits them to the server. This feedback has been implemented using Microsoft Media Encoder.

## Computational Time and Efficiency

The speed of the robot varies from 50 cm/s to 1 m/s, depending on the battery condition. The wall detection

**Figures 12-16.** Images captured by the robot.

**Figures 17-21.** Images after edge detection.

**Figure 23.** NTSC camera used for character recognition.

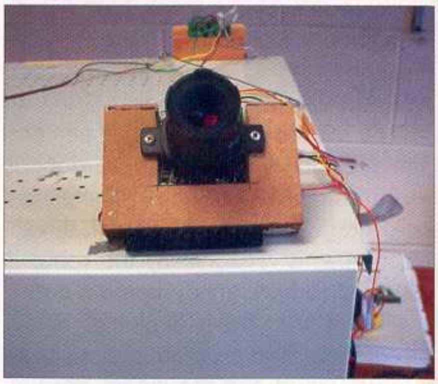


**Figure 22.** Plot showing the doors recognized.

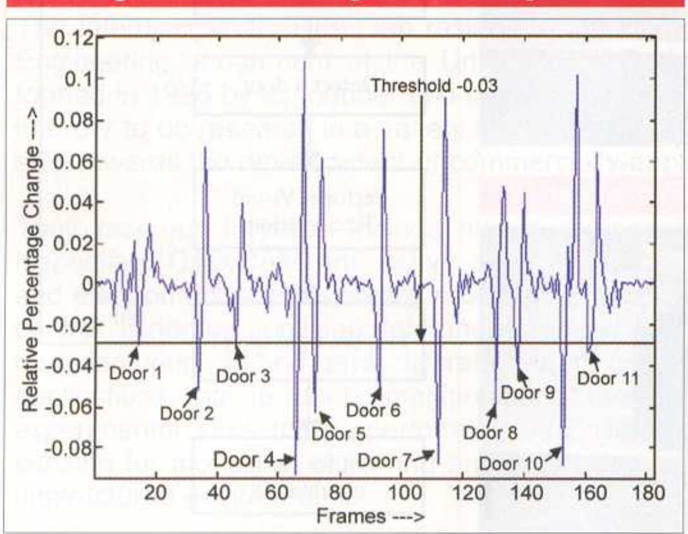



**Figure 24.** The RISCBOT website.

time using the ultrasonic sensors varies from 75 ms to 100 ms, depending on the distance of the robot from the wall. A time lag of 10 ms was employed between the firing of two successive ultrasonic sensors to avoid crosstalk.

Experimental results with the door ID recognition algorithm running in isolation under ideal conditions showed an efficiency of 99%. Experimental results with the character recognition algorithm running on the robot showed an efficiency of 80%. The failures (no decision on a particular door ID) were due to partial or no acquisition of the door plate, due to the proximity of the robot to the door.

However, while the robot catered to the requests of online users, an efficiency of 95% was recorded. An internal door count algorithm running in a MATLAB program overcame any failure of the character recognition algorithm. For more information and publications about RISCBOT, please visit **www.bridgeport.edu/sed/risc/html/proj/RISCBOT/index.htm**

## Future Work

We are in the process of building RISCBOT II to collaborate with RISCBOT. RISCBOT II will have greater sensing and manipulative capabilities. We plan to incorporate the following features in RISCBOT II:

- Implementing data transfer algorithms for faster transfer of high priority data packet.
- Developing fast computing algorithms for the image-processing module.
- Exploring ways to enhance RISCBOT's cognitive and sensing capabilities.
- Implementing a DC-DC (ATX power supply) converter circuit that will increase the power conversion efficiency and thereby the operational time for the robot.
- Permitting the robot to recharge itself by plugging into wall outlets.
- Mounting a manipulator on the mobile platform for implementing mobile manipulation tasks.

## Concluding Note

This article described the incipient developments in RISCBOT, a mobile robot platform developed at the University of Bridgeport. Researchers at the RISC lab are currently working on an arm to be fitted on the robot and further developing the vision and control algorithms that will enable the robot to plug itself to various power outlets. Readers are welcome to pose any queries or make suggestions to the authors. **SV**


## About the Authors

*This project idea has been conceived, guided, and supervised by Dr. Tarek Sobh. Dr. Tarek Sobh is the Dean of the School of Engineering at the University of Bridgeport and also heads the RISC lab. You can email him at sobh@bridgeport.edu*

*Sarosh Patel worked on the mechanical design and construction, web user interface of RISCBOT, wireless LAN interfacing, and image processing algorithms of the RISCBOT. He is pursuing his Master of Science in Electrical Engineering and Technology Management at the University of Bridgeport. You can email him at saroshp@bridgeport.edu*

*Rajeev Sanyal has worked on the embedded software, electronic hardware, mechanical design and construction, and image-processing software associated with RISCBOT. He recently graduated from the University of Bridgeport with a Master of Science in Electrical Engineering. You can email him at rajeevs@bridgeport.edu*