Internet Controllable Robot with Live Video Feed

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***Abstract*-- An internet controllable robot was constructed to highlight The Citadel's Electrical Engineering department. The robot is accessible via webpage, which provides near real-time video and control using split channel communication links.**

The user computer communicates LabVIEW virtual instrument file control commands via the Internet to the server. The server passes the commands via Bluetooth radio frequency (RF) link to the LanBOT's onboard BASIC-Stamp microcontroller. The microcontroller interprets received commands and applies output voltages to its appropriate I/O pins. The I/O pin voltages are passed on to the LanBOT's motor controller. This process provides electrical power for turning the gearmotors that move the robot forward, backward, left, and right.

A color infrared (IR) camera transmits a video signal over a separate RF link, from that used for control signals to an RF receiver at the server. This signal is passed to a GrabeeX+ A/V video frame grabber. The video frame grabber converts the signal from analog to digital and passes the signal to the server. The server passes the signal via the Internet to the user computer.

The robot has proven fully functional as a viable alternative to the unsafe practice of human surveillance and intervention techniques currently in use.

***Index Terms*— BASIC Stamp, BlueTooth, Board of Education, color IR camera, gearmotor, GrabeeX+, Internet, LabVIEW, LanBOT, motor controller**

***Nomenclature*—**

a) BASIC Stamp – Main processor circuit card assembly.
b) Board of Education – platform for BASIC Stamp and blutooth tranciever
c) Color IR camera – color Infrared camera transmits video at 30 frames per second (fps) via 1.2 GHz RF signal.
d) Gearmotor – Direct current (DC) Motor with reduction gearbox attached.
e) GrabeeX+ A/V video frame grabber – RF receiver (and software) receives, captures video, and converts RF NTSC signal to USB 2.0.
f) LabVIEW virtual instrument file - provides control button display to user for interface to the server.
g) LanBOT – Internet controllable robot.
h) Motor controller – transistor/miniature relay circuit card assembly.

I. Introduction

SINCE the advent of the worldwide web people from across the world have had access to endless amounts and types of information. Today the Internet is something many people find they can not live without. This is also a time when business owners, teachers, parents, managers, and people in all walks of life find they need to be in two places at once. However, a device to fill this need is not currently available.

From this need spawned the conception, development, and production of an internet controllable robot. With the advent of an internet controllable robot being in two places at once is a realizable task. The internet controllable robot allows anyone, with a personal computer, to have a remote controlled surveillance device. The user may monitor their home, office, or any other desired location from anywhere in the world.

Early robots were slow, hard to control, and required extreme amounts of processing power. In ways similar to the Mars robots, the early internet controllable robots were hard to use because the software used was multilevel and required extreme amounts of processing power to produce a video feed. This resulted in badly disjointed video feedback from the robot due to large frame delays which ultimately resulted in an uncontrollable robot. In order to combat these problems, early designers were driven to severely reduce wheel drive motor speeds resulting in a slow and unpredictable user experience.

The Citadel provided The Sofa Kings with the opportunity to create a new internet controllable robot. The prototype, called LanBOT, allows internet users to tour The Citadel's Electrical Engineering department on the third

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floor of Grimsley Hall without leaving their chairs in a user friendly and enjoyable way.

Figure 1 is a high level block diagram of the basic functions and components of the LanBOT. LanBOT uses a color IR camera capable of transmitting up to 30 frames per second (fps). The color IR camera transmits a video signal over a 1.2 GHz RF link to an RF receiver. The receiver is connected to the server via a GrabeeX+ A/V video frame grabber.

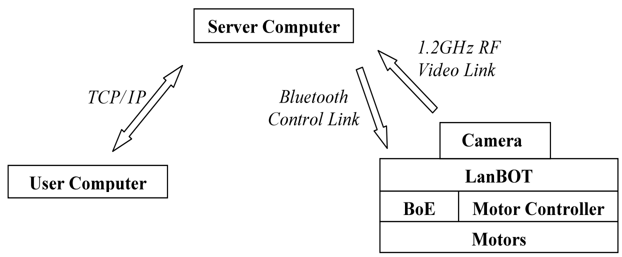

Fig. 1. LanBOT Functional system block diagram

LanBOT controls are internet based and available via the website http://lanbot.citadel.edu/. The controls are manifest as control buttons on the user computer monitor, and provide the user with the following motion controls; Forward, Reverse, Left, Right, Wide Left turn, Wide Right turn, Wide Reverse Left turn, Wide Reverse Right turn, Stop, Camera Tilt, and Stop Tilt. The control buttons are connected from the user via the Internet[1] to the server. The server passes the control button commands via a Bluetooth RF link to the BASIC Stamp microcontroller on the LanBOT. The microcontroller converts control button commands to voltages which are provided to I/O pins. The I/O pins are connected to the motor controller.

The motor controller contains the drive circuitry controlling the gearmotors for all 4 wheels and the camera tilt assembly. The motor controller drives the LanBOT forward, backward, left, and right and tilting the camera up and down.

In conclusion, the LanBOT is an internet driven surveillance device for the average consumer. It is: easy to install, simple to use, affordable, and requires low maintenance. The LanBOT's agility, near real-time video feed, and simple controls will impress any user. More importantly, the LanBOT is fun to use.

II. Technical Work Preparation

A. Video

LanBOT video is transmitted through a 1.2GHz RF link from the color IR camera to a RF receiver tuned to the same frequency. The received National Television Standard Code (NTSC) video signal is converted to USB 2.0 and connected to the LanBOT server via the GrabeeX+ USB 2.0 A/V frame grabber. The LanBOT server, located on the 3rd floor of Grimsley Hall in room 330, hosts the website http://lanbot.citadel.edu/. The received video is available for viewing upon accessing the website. The website is available and may be accessed by anyone with a compatible internet browser.

B. Control

The controls consist of control buttons displayed on the user computer monitor. The buttons are mouse selectable allowing Forward, Reverse, Left, Right, Wide Left turn, Wide Right turn, Wide Reverse Left turn, Wide Reverse Right turn, and Stop movement control. Additional Camera Tilt display buttons are provided allowing Camera Tilt, and Stop Tilt control. All control buttons are displayed and located to the right of the video display frame on the website.

Control is accomplished via a LabVIEW virtual instrument file named "lanbotcontrol.vi". The user's LABVIEW control display buttons interface through the Internet[1] to the server. When the control buttons are selected the control button commands are interpreted and sent from the server via a 2.4 GHz BlueTooth[2] RF link to the LanBOT.

The BlueTooth signal is received by LanBOT through the EB500 EmbeddedBlue Transceiver CCA. The transceiver demodulates and converts the received signal to its original digital form and passes it to the microcontroller. The microcontroller uses assembly level code to convert the digital signal to a 5 VDC output voltage available at the appropriate individual I/O pins on the Board of Education.

Physical motor control is accomplished through the interfacing of the "Board of Education" to the motor controller. The "Board of Education" I/O pins 7, 8, 9, 10, and 11 are connected through current limiting resistors by a wiring harness assembly to the 5 motor control circuits on the motor controller circuit card assembly CCA. Four motor controller circuits are composed of 8 NPN transistors controlling 8 miniature relays. The remaining motor controller circuit uses only 1 NPN transistor. Each motor controller circuit controls a single gearmotor. The gearmotors drive the 4 wheels and camera tilt mechanism. The appropriate motor controller circuits are connected to the appropriate gearmotors by a wire harness assembly. Each gearmotor drives an individual wheel or the camera tilt assembly.

C. Software

All software and the basic function each performs for the LanBOT is listed below.

Windows XP …………….Server operating system
Windows Internet………..Internet access between
Explorer………………….Browser
HTML…………………....Server Webpage Display
Dorgem/JAVA…………..Server Video Processing
BlueTooth………………..Server access to LanBOT
LabVIEW ……………..Web site publishing and LanBOT control vi

The operation and use of the server operating system, internet browser, and BlueTooth software are normal and therefore are not remarkable herein. The software considered key to LanBOT internet control, operation, and video feedback are the LabVIEW web site publishing tool and LanBOT control vi, and Dorgem. In conjunction with these software packages the LabVIEW, HTML, JAVA, and PBASIC code resident to the BASIC Stamp also perform key tasks. A short description is provided herein. The USB video is recognized by the Dorgem software, which projects the video onto the CPU monitor. The Java programming code applet, running on the web browser, captures and mirrors the image onto the web page. The video feed image is constantly refreshed by the HTML programming code, thus creating the "streaming" effect.

The BASIC Stamp code is assembly level code and is used for turn the motor controller and camera tilt motor drive circuits on or off in accordance with the commands provided by the user.

D. Power

Electrical power for all components, except the BASIC Stamp and Board of Education, onboard the LanBOT is provided by a 12 VDC, 8 AH closed cell battery. The Battery is be mounted slightly aft and athwart centerline onboard LanBOT during operation. It is easily removable for recharging as the need arises. The BASIC Stamp and Board of Education are powered by a standard 9V battery.

E. Mechanical

Gearmotor mechanical interface is provided between the drive motors and wheels by pre-fabricated gear boxes installed on the reversible drive motors during the manufacturing process of the motors hence the name “gearmotor”. The rotational speed of the wheel drive motors is reduced through the gear box by a ratio of 146:1 to 50 rpm. The rotational speed is transferred to the wheels via the 8 mm wheel mounting shaft of the gearmotor. This rotational speed, in conjunction with the 17.9 cm diameter wheels, drives the LanBOT at an approximate speed of 28.1 meters per minute.

$$50\text{rpm} \times 0.179\text{m} \times \pi \cong 28.1\text{m/min}$$

Mechanical interface is provided between the Camera tilt mount assembly and its associated gearmotor by an armature assembly fabricated locally by the LanBOT team. The rotational speed of the gearmotor is reduced through its gear box by a reduction ratio of 1217:1 to 4.5 rpm. The rotational speed is transferred to the camera tilt mount assembly by the 8 mm mounting shaft of the gearmotor. This rotational speed in conjunction with the camera armature assembly act to tilt the Camera and its mount approximately 90°, from -45° through level to +45°, at an approximate speed of 30° per second.

F. Miscellaneous

The interface between the user computer and the server computer is accomplished via the Internet[1].

The interface between the server computer and the Board of Education BASIC Stamp comply with requirements contained in BlueTooth[2].

III. References

Standards:

[1] *IEEE Standard for Information Technology – Telecommunications and Information exchange between systems – Local and Metropolitan area networks – Specific Requirements*, IEEE Standard 802.3-2005, Dec. 2005.

[2] *IEEE Standard for Information Technology – Telecommunications and Information exchange between systems – Local and Metropolitan area networks – Specific Requirements*, IEEE Standard 802.15.1-2005, Jun. 2005.

IV. Biographies

Shaun Chronister was born in Charleston, South Carolina, on November 30, 1979. He was raised in Charleston, SC and graduated from Middleton High School. He is currently attending The Citadel’s Electrical Engineering program and will graduate on May 6, 2007.

His fields of interest include microcontroller engineering, programming, electronics, and mechanical engineering.

Upon graduating from The Citadel, He will become an entry level electrical engineer for the Savannah River National Laboratory at the Savannah River Site.

Douglas Knapman was born in Flint, Michigan on April 18, 1956. He studied at Lansing Community College, Trident Technical College, and will graduate with a Bachelors of Science degree in Electrical Engineering from The Citadel, Charleston, South Carolina in May 2007.

His employment experience includes the United States Marine Corp, United States Navy, TRACOR, Marconi Electric Systems, BAE Systems, and Space and Naval Warfare Systems Center Charleston, South Carolina. His special fields of interest include radio communications, electromagnetic compatibility, and testing instrumentation.

William Mohseni was born May 17, 1985. He studied at Trident Technical College, and graduated from The Citadel, Charleston, South Carolina in May 2007.

His employment experience includes the Space and Naval Warfare Systems Center Charleston, South Carolina. His special fields of interest include communications and automated controls. Upon graduation he will be working with the Automated Fuel Handling Equipment Maintenance group with the Space and Naval Warfare Systems Center in Charleston, South Carolina.