Session 12-6

Network Controlled Data Acquisition Drone

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Abstract

This paper describes the result of the senior project completed in December 2007 and shows the details of the subsystems along with future enhancement to the drone. The project is currently being reviewed by the office of Intellectual Property Management at the University of Houston for potential patent.

The network controlled data acquisition drone (drone) is a device that can be remotely controlled from almost any other device with an HTML browser. This device will also have the ability to take measurements from an array of sensors that will be displayed on the HTML interface. Most of the similar devices on the market are controlled via radio frequency and satellites. This limits the ability to control these similar devices to a single control station and also the distance at which the control station can be from the device. Because the drone will be controlled over standard networking protocols and operates with an HTML interface, this makes the device controllable from thousands of different products such as computers and cell phones. Also, with the help of the World Wide Web, it possible to host the interface over the Internet so the range between the drone and the controlling station will never be a factor. These are great advantages over similar products already available on the market today. The drone consists of several subsystems where each serves as an important function to achieve the specifications for the drone. The subsystems used in the prototype of the drone are a microcontroller, wireless system, drive system, video system, sensor system, and power system.

Introduction

A drone is a guided vehicle which is can be used for military purposes for gathering information as well as for combat operations. The usage of a drone is very limited as it caters only to military applications. The design proposed in this technical paper is flexible; incorporating many different technologies as well as allowing it to be used for many tasks. This flexibility provides a marketable strategy which will be attractive to the corporate market. The respective target audiences are for the military specific uses, corporate security surveillance, and scientific research and potentially can be applied to many others.
The military specific drones cost several thousand dollars because of high-end, specific military requirements. The technology put into these drones far surpass the needs of most corporations and end users today. The proposed drone is very similar in function and in designed to be an

affordable alternative to the military specific drones. The drone here uses some of the latest technologies like Active Server Pages (ASP), web based micro-controller and communication via the (Wireless Fidelity) Wi-Fi network.

The entire operation of the proposed drone is controlled remotely using a Wi-Fi network which ensures the availability locally and does not require licensing that the (conventionally used) satellite and high frequency radio requires from the (Federal Communications Commission) FCC. Also the Wi-Fi is even beginning to become available city wide in many of our major urban areas thereby giving the drone a wide range. The proposed drone is such that it could be guided to move and acquire data across any kind of terrain. The concept diagram in Figure 1 shows versatility of the drone in terms of its operation terrain. Thus, the proposed design for the network controlled drone is a simplified version to that of the military and is more versatile and affordable for commercial use.

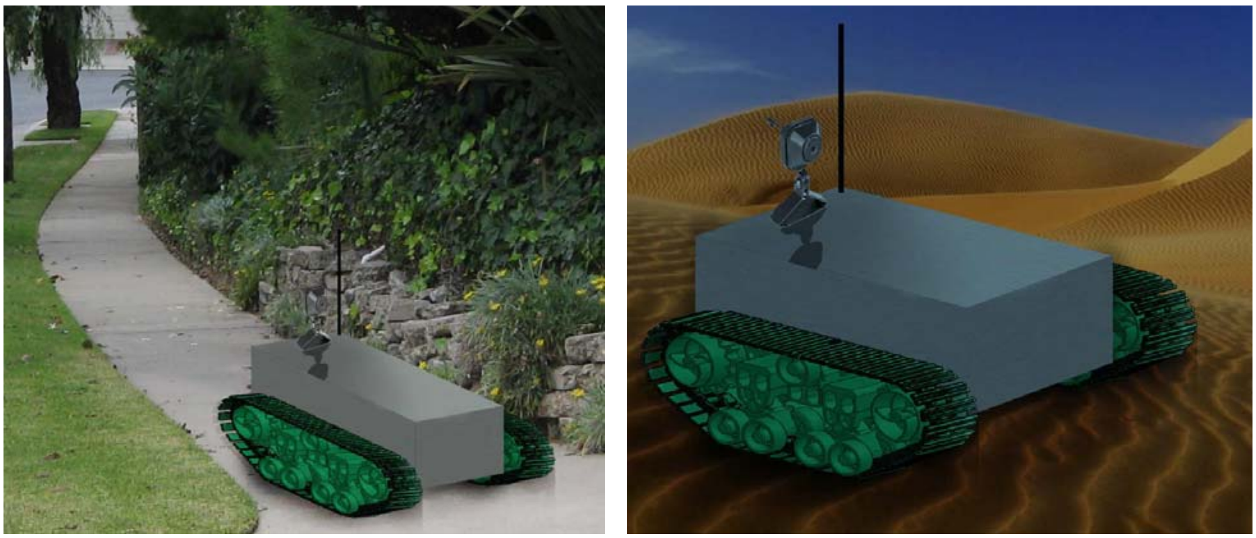

Figure 1. The proposed drone can be used for an all-terrain operation

System Overview

The proposed drone is a multi-role vehicle that is outfitted with various sensors that will transmit data using an existing wireless network over the Internet and allows the control of the drone remotely using a web interface. The drone can be controlled over standard network protocols and operates with the HTML interface which makes the drone controllable from thousands of different products like computers, cell phones, etc.

The proposed drone design has the following capabilities:

- Network connectivity
- Data gathering sensors
- Network control capability

- Transmission of data over network infrastructure
- HTML interface

Network Connectivity
The drone is implemented in such a way that it connects via Wi-Fi network using IEEE 802.11 Standards.

Data Gathering Sensors
The drone contains an array of sensors which can be used to collect data from its surroundings; the outfit can be used with multiple sensors at a time and can be interchanged.

Network Controller Capability
Users have the capability to control the drone over the network infrastructure to send commands to control motion and trajectory of the drone as well as camera motion. This gives the user complete control over the drone from a remote location using the Wi-FI connection.

Transmission of Data Over Network Infrastructure
The data being collected by the drone can be transmitted over the Wi-Fi connection to the remote locations for analysis.

HTML Interface
The interface is HTML-based to give any controller with a computer full access to the controls and data being collected by the drone. The software based interface makes it easier since the only hardware needed will be the one embedded within the drone.

Based on the above capabilities, the entire system can be divided into these subsystems as shown in Figure 2.

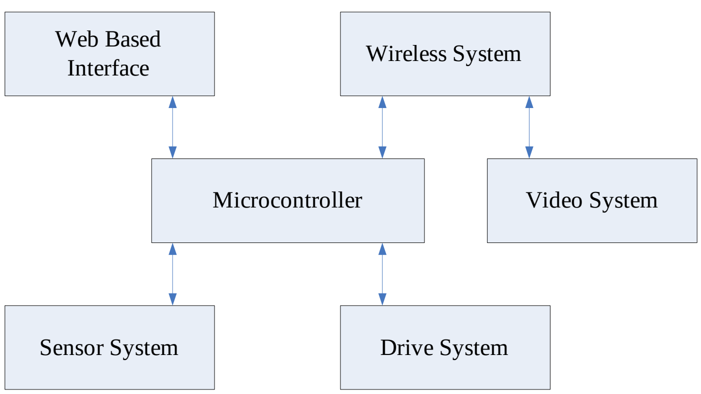

Figure 2. Subsystem Block diagram

- **Microcontroller:** Apart from controlling the operations of the drone, the microcontroller also serves as the web server that hosts the HTML page.

- **Wireless System:** Connects the drone to the wireless network.

- **Drive System:** Consists of H Bridge Circuit to control movement of DC Motors[1].

- **Video System:** Provide Live Feed which help in navigating Drone
- **Sensor System:** Array of Sensors for data collection.
- **Web based Interface:** An HTML interface for controlling the drone by the end user.

Design Specifications

Hardware Design

Figure 3 shows the hardware design of the entire network controlled drone subsystem. The arrows indicate the interfacing between the parts. Each of the part is listed explained.

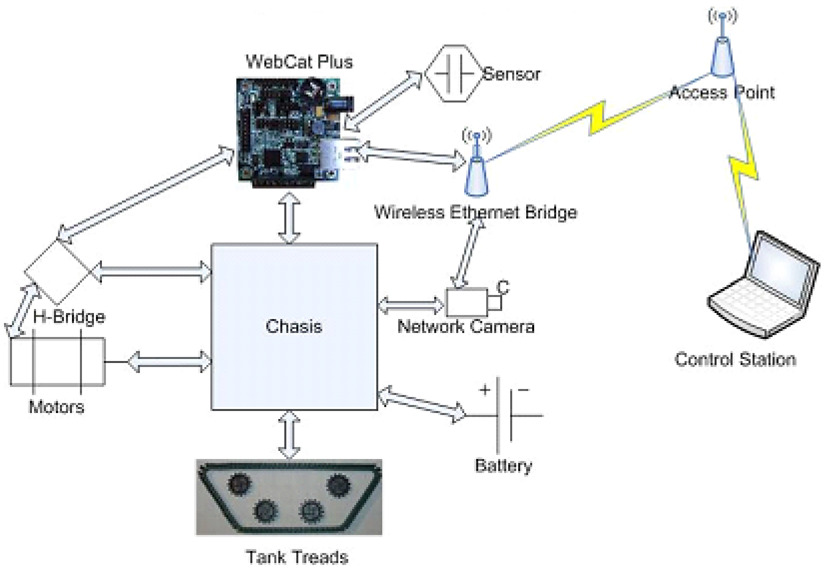

Figure 3. Hardware Design for the network controlled data acquisition drone

The main components and hardware devices used in the building of the prototype for the proposed drone as shown in Figure 3 are:

- **Chassis:** This is made out of aluminum and is built to support and carry the microcontroller with peripherals, battery and network camera.
- **DC Motors:** 12 V, 30 RPM, high torque gear motors are used in the drone system**.** Each motor is 64.2mm x 25mm x 25mm in size and weigh 3.0 oz each.
- **Tank Threads and Bogie Wheels:** These provide the drone with capabilities to pass through just about any course with ease. They are made of delrin plastic and have tread width 1.5 inches.
- **Relay:** Peripheral board with 2 power relays provides power to the H-Bridge once the drone is initialized[1].

- **WebCATPlus:** Microcontroller board that has an Ethernet port and a complete Web server application package[2].
- **Network camera:** D-Link DC-900 Ethernet camera.
- **Sensor:** Connected to the drone is a SHT71 digital sensor that measures humidity and temperature[3]. This is interchangeable with any sensor(s) there by giving the drone a flexibility of performing different data acquisition operations.
- **Batteries:** One 12V 5AH battery that drives microcontroller, drive system and wireless system and one 6V 4.5AH battery which supplies video system with power.
- **Wireless Bridge:** Linksys WRT54GL open source router with DD-WRT custom firmware used to create a virtual transparent bridge[4].

The **Access Points** make possible the communication between the WebCatPlus web server[2] and the control station.

Tank treads are mounted on the chassis. Camera and sensor and are placed on the top while everything else above listed (except the access point) sits firmly inside of chassis. The relay board sits on the top of the microcontroller board connected through an expansion port. The Sensor and H-bridge uses digital input pins from the relay and microcontroller boards while the wireless bridge is connected to the microcontroller through an Ethernet port. Network camera is connected to one of the Wireless bridge Ethernet ports. H-bridge is connected to the DC motors and batteries enabling movements in all directions.

The WebCatPlus[2] is a microcontroller developed by BiPOM which incorporates all the features of a standard ARM Microcontroller as well as has the capability of hosting web pages over the internet because of its built in web server. An Ethernet camera is used in the prototype as it proves to be a reliable solution using secure wireless connection as well as providing independent circuitry for processing the live video feed as compared to the possibility of overloading the microcontroller's processor.

The above proposed hardware design also uses an All-in-one H-Bridge circuit for controlling the drone movement. The Advantage of the H-Bridge[1] is that it accepts the microcontroller's output signals which allow controlling the direction of the motors.

Software Design

The software for the system acts as the backbone for the entire working of the system. Right from controlling the drone to getting live feed from the drone via the webcam to acquiring the data through the sensors, everything is programmed in the system. The hardware system as shown in Figure 3 is integrated with backing software whose flowchart is shown in Figure 4.

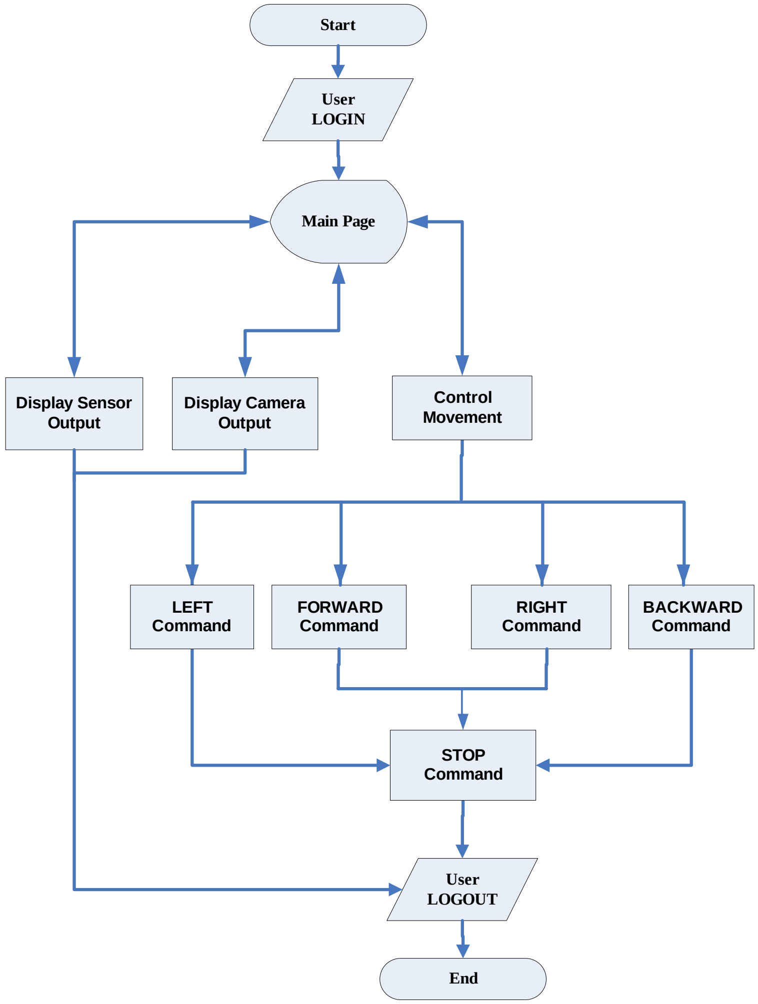

Figure 4. Flowchart for the software design of the system

The entire software, that is the Graphical User Interface (GUI), has been programmed using HTML which is embedded with JavaScript[5] and Visual Basic code. These technologies are used in the designing of the web interface which gives the control of the drone to the end user. Another necessary tool is the WebCatPlus publisher which makes the uploading of the HTML web pages and the code on the microcontroller board. The system contains several web pages as shown in the above diagram (see Figure 4). These include:

- User log in page that incorporated necessary security
- Log in failure notification page
- Main page that included three frames and provided user-friendly interface for controlling and monitoring (shown in Figure 5).
- Log out notification page

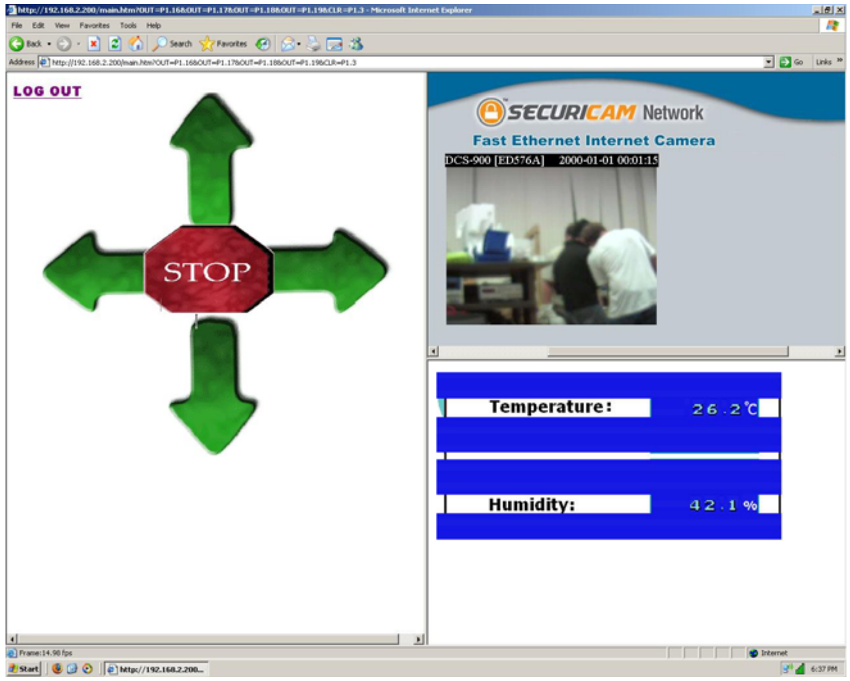

Figure 5. The main page

Design Description

The drone is powered by two different power supplies, 6V 4.5AH and 12V 5AH batteries. This kind of setup minimizes the load on each of the batteries. Since the Ethernet camera puts the largest load on the power source, the power to the camera is regulated using a separate 5V voltage regulator and a 6V battery. Everything else on the drone is powered directly from the 12V battery. The drone can be easily configured to any wireless access point by connecting the Ethernet cable to one of the available Ethernet port on the wireless bridge.

The drone contains two power switches located between the antennas on the end of the drone. Turning the green switch on provides power to the Ethernet camera, while turning the blue switch on provides power to the wireless Ethernet bridge, microcontroller, and the relays connected to the H-Bridge.

When you first pull up the drone control interface in your HTML browser, you are presented with a login page. This page serves two purposes; the first is to provide a layer of security so an unauthorized person cannot gain control of the drone. Second, it serves as an initialization script for the drones microcontroller and relay system. When you enter incorrect login information, an error message appears and brings you back to the login page to try again. When a successful login is detected, it runs the initialization script.

When power is first applied to the microcontroller, all the digital input/output pins are set as input by default. This means each of the digital pins that are connected to the H-Bridge are all receiving a high. This could potentially damage the H-Bridge because no more than two of the four pins on the H-Bridge should be high at any time. To prevent damage, the H-Bridge is connected to a relay so when everything is powered on, the H-Bridge still does not have power until the relay is activated. When the initialization script is run, it first sets the 4 pins connected to the H-Bridge as an OUT, so now each pin is set to a LOW. At that point, the relay connected to the H-Bridge is activated and power can safely be sent to the H-Bridge.

The controls of the drone are fairly simple. Depending on the direction chosen, the microcontroller will activate the proper pins on the H-Bridge, which will set each individual motor in a forward, reverse, left or right direction. For example, if forward direction is chosen, both the left and right motors must go forward. The left motor uses pins 1.16 and 1.17, and the right motor uses pins 1.18 and 1.19 to move forward and reverse respectively. To move forward pin 1.16 must be set to HIGH, pin 1.17 to LOW, pin 1.18 to HIGH, and pin 1.19 to LOW. These pins will set the same TTL states to the H-Bridge and moves each motor in the respective motion.

Construction Details

The network controlled data acquisition drone consists of the following parts:

Body
For the prototype body aluminum sheets are implemented to make the protective walls of the drone. Aluminum allowed for a lightweight body which was essential because of the weight of the batteries. The CAD drawing (shown in Figure 6) illustrates the design of the body as well as placement of components.

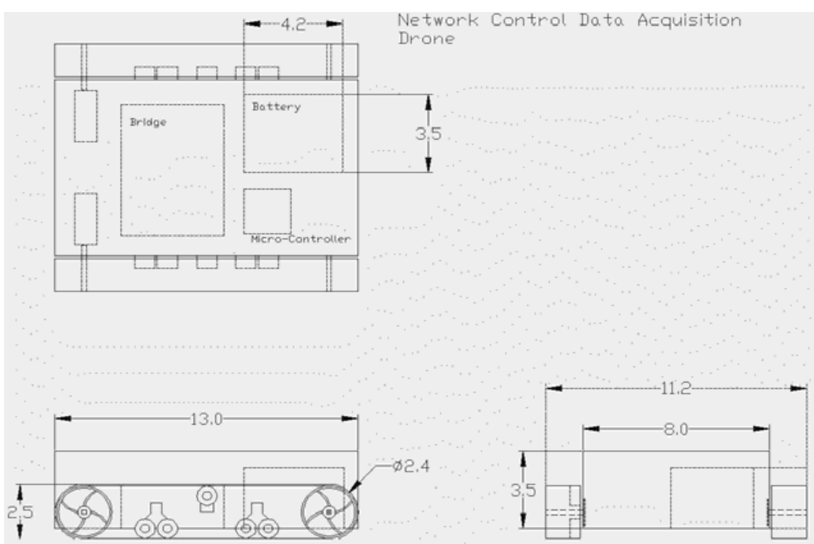

Figure 6. CAD generated diagram for the body of the drone

Vex Robot Thread Kit
A shown in Figure 7, **t**his kit allows the drone to traverse over hard and uneven terrain.

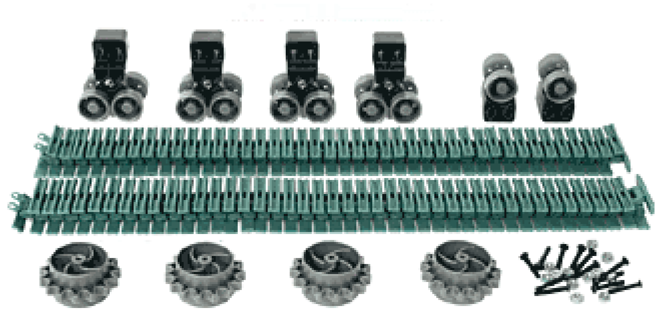

Figure 7. Vex Robot Thread Kit

WebCatPlus
As shown in Figure 8, the WebCatPlus acts as the heart of the system. It performs many functions such as the access to sensors, remote operation of the movements and hosting the web pages (GUI) that can be accessed via the internet[2].

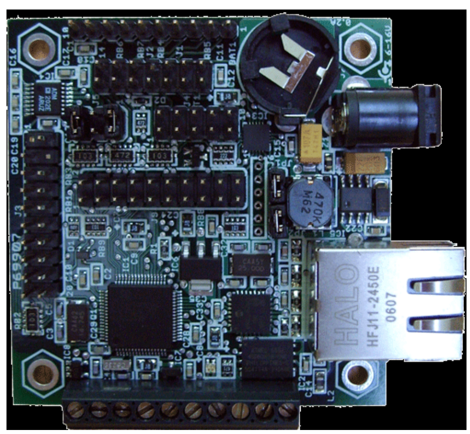

Figure 8. WebCatPlus Microcontroller Board

D-link DCS-900 Ethernet Camera
The D-link DCS camera is used to allow video to be transmitted via the wireless connection (see Figure 9).

Figure 9. Ethernet Camera

6V Lead Acid Battery & 12V Lead Acid Battery

To power the components within the drone two batteries are used as shown in Figure 10. The 6V is used to power the camera while the 12V is used to power the micro-controller, router and the motors. The 12V located on the left and the 6V on the right.

Figure 10. The 8V and 12V battery

Sensors System (Sensirion SHT71 Sensor)

This sensor[3] provides the digital reading of both temperature and humidity as shown in Figure 11.

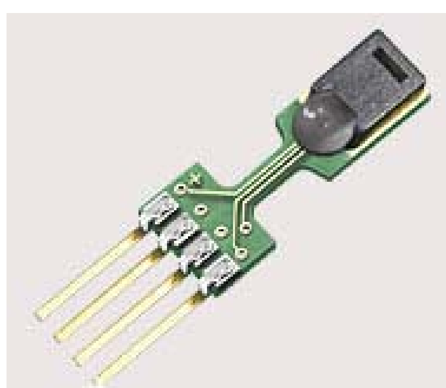

Figure 11. Sensirion SHT71

L298N Dual H-Bridge IC

H-Bridge IC (D95IN240A) is a dual full-bridge IC which has a L298 circuit that contains a 15-lead Multiwatt and PowerSO20 IC. The H-Bridge can operate with the supply voltage up to 50 volts and the total DC current of up to 4A. The H-Bridge is used for the two DC motors connected to the outputs of the IC. The H-Bridge allows for the forward and reverse movements of the drone. The H-Bridge IC accepts TTL logic signals from the microcontroller to control turning ON and OFF the transistors integrated inside the IC[1].

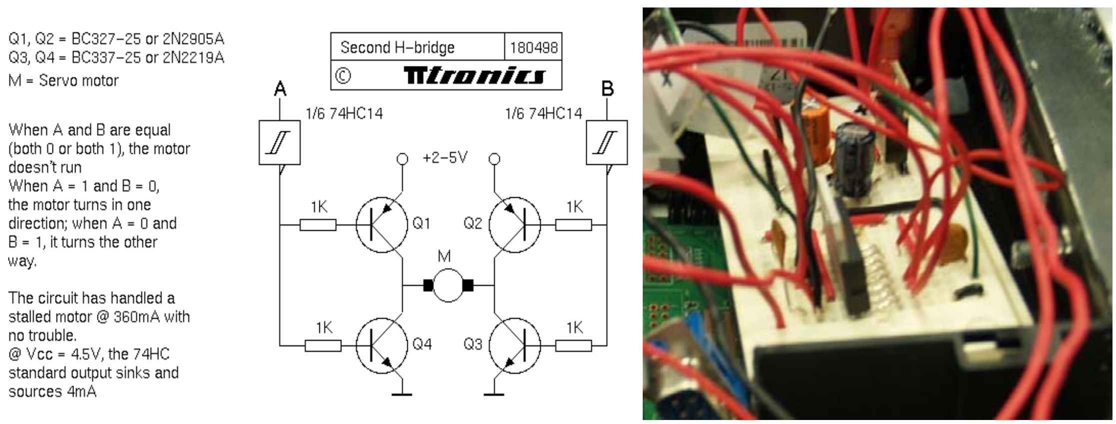

Figure 12. Circuit Diagram for L298N Dual H-Bridge IC

Graphical User Interface

The user interfaces with the system using HTML pages which send the commands to the drone. The first page that is reached is the login page that requires the user to enter a correct username and password in order to proceed. This is achieved by using Java script function where the appropriate values are hard-coded. If the incorrect values are entered, user is notified of it and given the chance to re-enter the credential. If the credentials are correct, user is redirected to the main page and in same time set the necessary pins as output. Main page consist of the three frames, accommodating all intended functionality. Those are three separate pages displayed as one web page. The network camera has its own IP address so it is displayed on a different page which is reached through a separate frame. That is why the camera frame address is set to view.htm, which is a default page for live stream. Finally, third frame displays the sensor reading. The feature called embedded HTML tags is used for this purpose. This feature allows easy controlling of the peripherals:

^SHT7XTEMP^ // Temperature value of digital sensor SHT7X

^SHT7XHUMI^ // Humidity value of digital sensor SHT7X

These tags return a digital value that is used for the calculation of the real values.

By passing the *t* (digital value of temperature) and *rh* (digital value of humidity) parameters to these functions, real value is calculated and then displayed on the sht7x.asp page which is refreshed every 5 seconds.

From here, the user has the option to log out from the main page which automatically turns off all pins that are involved in the drone movement control. By logging out, the user is redirected to the page that notifies of logging out and gives an option to log in again.

Conclusion

The product is intended to improve the design of the drone in order for it to be more efficient at a consumer based level as compared to the expensive military drone. The military drone costs thousands of dollars because of its high-level military requirements. The technologies put into these drone also far exceeds most of the corporations and end users today. This is the area of concentration where our proposed design of the drone finds its market. Being equipped with the industry standard technology, ease of operation and affordable cost, the network controlled drone is very suitable for all kinds of operations and finds its application in both the military as well as industry.

The prototype for the proposed design was successfully completed and the demonstration showed all the capabilities of the drone to a very interested audience. The prototype moved smoothly in all directions while faultlessly transferring video and sensor readings. The prototype design still can be improved with things such as more powerful motors, better speed control, hosting over Internet, data logging and more. However, given the constraints, the design of the network controlled data acquisition drone has proved to be successful and new, as well as interesting, to many people.

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