How-To

Construct a Robotic Weapon System Controlled by Synthetic Vision

For less than $200

By Joshua Montgomery

Introduction
In July of 2006 I was sitting in my office looking at the Defcon site and thinking about attending the world’s best computer security conference. I run a municipal WiFi project in Lawrence, Kansas and am always trying to keep up to date on the latest threats to my facilities and users, so Defcon is a must any year I can make it.

If I was going to go, I wanted to enter a competition. Last year I wrote and SBIR for the US Navy for rapid cooling of a soda can, so the beer cooling challenge was very tempting, however, while reviewing the possibilities, I noticed “Defcon Bots”. Curious, I took a look at the site and was astonished at Kallahar’s video.

Looking into the matter a little further, I began to assemble an idea and made a parts list. To do it I would need:

1. RC Airplane Servos
2. A Servo Controller
3. An Airsoft Gun
4. A USB Desk Camera

Looking at the scattering of parts on my desk, there I saw….everything I needed. OK, yes it is very weird for a guy to have a servo controller on his desk, but we were working on an LDAP enabled door lock and…..The air soft gun? You have to keep your employees disciplined some how….
Hardware Selection & Assembly

For this project I wanted to build a system that was low cost, functional and as fail safe as possible. To do this I decided to make use of cheap off the shelf components:

Parts Required

<table>
<thead>
<tr>
<th>Part</th>
<th>Supplier</th>
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<tbody>
<tr>
<td>Tower Hobbies TS-53 Servo Standard U</td>
<td>Tower Hobbies</td>
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<tr>
<td>Pololu USB 16-Servo Controller</td>
<td>Pololu</td>
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<tr>
<td>Logitech QuickCam Communicate STX</td>
<td>Amazon.com</td>
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<td>Switch (Radio Shack 275-016A)</td>
<td>Radio Shack</td>
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<td>Du-Bro 212 Large Threaded Couplers</td>
<td>Tower Hobbies</td>
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<td>Du-Bro 109 2-56 Spring Stell Kwik Links</td>
<td>Tower Hobbies</td>
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<tr>
<td>0.072” Piano Wire</td>
<td>Ace Hardware</td>
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<tr>
<td>Carl Goldberg No. 403 1/8” Aileron Horns</td>
<td>Tower Hobbies</td>
</tr>
<tr>
<td>1 1/2” Length 5/16” Hex Bolt</td>
<td>Ace Hardware</td>
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<tr>
<td>5/16” Nylon Insert Lock Nuts</td>
<td>Ace Hardware</td>
</tr>
<tr>
<td>5/16” Fender Washers</td>
<td>Ace Hardware</td>
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<tr>
<td>5/16” Washer</td>
<td>Ace Hardware</td>
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<tr>
<td>5/16” ID - 1.125” OD Bearing</td>
<td>Ace Hardware</td>
</tr>
<tr>
<td>Lazy Suzan Bearing</td>
<td>Home Depot</td>
</tr>
<tr>
<td>1 1/2” Angle Brackets</td>
<td>Home Depot</td>
</tr>
<tr>
<td>1/2” Copper Pipe Clamps</td>
<td>Home Depot</td>
</tr>
<tr>
<td>D-Cell Battery Holder</td>
<td>Radio Shack</td>
</tr>
<tr>
<td>1/4 Sheet of 1/2” MDF</td>
<td>Home Depot</td>
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NOTE: I made use of batteries rather than AC adapters throughout the construction process. This was due to issues I kept having with the servo controller (it kept crashing). I am pretty sure that this was actually a coding problem and that an AC adapter would power all of this just fine.
Figure 2: Additional Parts

Figure 3: Nuts, Bolts, Washers & Bearings

Figure 4: Battery Holder, Lazy Suzan, Angle Brackets, Servo Controller, Pipe Holders
Tools Required

<table>
<thead>
<tr>
<th>Tools</th>
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<tbody>
<tr>
<td>Table Saw</td>
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<tr>
<td>Drill Press</td>
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<tr>
<td>Screw Driver</td>
</tr>
<tr>
<td>Hot Glue Gun</td>
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<tr>
<td>Ruler</td>
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<tr>
<td>Sharpe</td>
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<tr>
<td>Hand Held Jig Saw</td>
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<tr>
<td>1.125” Paddle Bit</td>
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Construction Process

To build your computer controlled gun, you must first cut the air soft gun down so that it can be easily mounted. To do this, first you must remove the stock, the handle and the faux clip. Be sure to remove the internal mechanisms before sanding it down.

You can also remove the battery compartment. Power will be supplied from the D-cell batteries.

![Figure 5: Cut Down Airsoft Gun](image)

Next, go ahead and open up the camera and remove the CCD board, and lense from the housing.

![Figure 6: CCD Camera with Housing Removed](image)
Now we are going to go ahead and build out the frame. In our case we cut the MDF into 7 discrete pieces. Please note that these sizes were determined by the size of the lazy suzan bearing.

These are cut as follows:

Three [6” by 6”] - A
Three [6” by 10 ¼”] - B
One  [5” by 3”] - C

Now we are going to cut the holes to seat the bearings. These holes are cut with a 1 1/8” paddle bit and go through two (2) of the A boards. The larger board shown is just there to prevent tear out.

In order to allow the vertical servo arm to function, we are going to need to cut a chunk out of the “C” board to allow the arm to pass. This is done with a 3 1/8” hole saw (commonly used for door handles) but could just as easily be done with a jigsaw.
Now the vertical carriage is assembled using the angle brackets. In my case I also used hot glue for the joints, but this is optional.
Next we assemble the horizontal carriage. At this point the servos are also installed.

!!!IMPORTANT!!! – You want to make sure that the center of the servo horn is aligned with the center of motion.

!!!IMPORTANT!!! – Be sure to drill the 5/16” holes for mounting the Vertical Carriage. These can be centered with a ruler and Sharpe.

To install the servo, simply drill a ½” hole in the CENTER of the servo placement, then use a jigsaw to cut out the rest of the hole. Be sure to leave a little notch to allow the servo cable to exit the hole.

You are going to mount 2 servos at this point. One for Horizontal motion and one for Vertical Motion. Be sure to leave ½” below the Vertical servo to allow for the bottom of the Horizontal Carriage.
Now the aileron horns are mounted. These are used to connect the servos to their respective carriages. I found that the easiest way to do this was to:

1. Cut the horn down to about 1”.
2. Thread the unthreaded branch of the horn.
3. Screw the horn into the carriage.
4. Mount a ½” pipe holder over the horn to prevent it from turning.
Now go ahead and mount the rest of the Horizontal Carriage, the instantaneous switch and the battery compartment.

![Figure 14: Horizontal Carriage Fully Mounted](image1)

Now we can mount the aileron arm on the Vertical Carriage. Since we can’t put this one in the center, we are going to go ahead and mount it off center. Be sure to mount it so that it is on the center LINE however.

![Figure 15: Vertical Carriage Complete](image2)
Next we go ahead and mount the servo for the firing switch. Remember to put a toggle switch into this circuit to meet this year’s safety requirements.

![Servo Operates Instantaneous switch](image16)

**Figure 16: Servo Operates Instantaneous switch**

That is pretty much it for major construction. Now we go ahead and mount the airsoft gun onto the Vertical Carriage.

![Airsoft Gun Mounted with Hot Glue](image17)

**Figure 17: Airsoft Gun Mounted with Hot Glue**
Then we mount the camera on the airsoft gun. Don’t kill yourself trying to get this aligned perfectly straight, we are going to correct for pointing errors in software.

Figure 18: Camera Mounted

Last, but not least, hook up the control arms and electronics. Be sure not to fry anything by hooking up too much voltage. This 9V, for example, would fry these servos. It is being used to power the serial adapter, not the servos.

Figure 19: Wiring Complete
Figure 21: Front View
That is it, hook the unit up to your computer, figure out what COM port it is on, compile the software, connect the camera and have fun!

The software is mostly documented in the code itself. Have a look at Targit.cpp. Everything else is from either a serial demo I dug up on the internet somewhere or from the Intel OpenCV library, which is readily available on the Internet.

**My Kludged Together Code**
http://www.middlebrow.com/solution1.zip

**OpenCV**
http://sourceforge.net/projects/opencvlibrary

Once you have installed OpenCV, be sure to include the required directories, otherwise the build process will be REALLY short. For my build environment these were:

- `C:\Program Files\OpenCV\otherlibs\highgui`
- `C:\Program Files\OpenCV\cxcore\include`
- `C:\Program Files\OpenCV\cvaux\include`
- `C:\Program Files\OpenCV\cv\include`

![Figure 25: Be sure to put the OpenCV directories in the "Additional Include Directories"](image)

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