Animatronic Stargate helmet

by **Honus** on November 7, 2011

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Intro: Animatronic Stargate helmet

I love the movie Stargate and when I first saw it I immediately knew I wanted to make one of the super cool Horus guard helmets. I had sketched multiple designs over the years and figured out several different methods for building it but rejected them all for one reason or another- usually due to cost or complexity of construction. Since I wanted this to be a costume helmet my requirements were that it be light weight, comfortable, have decent outward vision and be reasonably durable. I also wanted it to be buildable by anyone using simple hand tools. Most important of all I wanted it to move in a similar fashion to the movie helmets.

All of this proved to be a pretty tall order but eventually it all came together and now you can make a moving Stargate helmet of your own!

Here's a video of the helmet-

Step 1: Tools and Materials

Tools-
Saw for cutting wood/metal- I use a Milwaukee hand saw that accepts reciprocating saw blades- super handy! http://www.homedepot.com/h_d1/N-5yc1v/R-202525764/h_d2/ProductDisplay?langId=-1&storeId=10051&catalogId=10053
Cordless drill
X-Acto knife with #11 blades
Scissors- small sharp scissors make cutting the patterns easier
Glue gun
Sandpaper- small piece of 100 grit to smooth wood edges and spackling
Allen wrenches- Inch
Screwdrivers- phillips and flat head
Soldering iron
Ball point pen

Materials-
Cardstock (2pkgs) http://shop.hobbylobby.com/store/item.aspx?ItemId=168038
Newspaper
Craft foam sheet (10ea 12" x 18") http://shop.hobbylobby.com/store/item.aspx?ItemId=160137
White glue
Tacky glue http://shop.hobbylobby.com/products/clear-gel-tacky-glue-163972/
Gorilla glue http://www.homedepot.com/h_d1/N-5yc1v/R-100141832/h_d2/ProductDisplay?langId=-1&storeId=10051&catalogId=10053
Spray foam http://www.homedepot.com/h_d1/N-5yc1v/R-100068117/h_d2/ProductDisplay?langId=-1&storeId=10051&catalogId=10053
Paint- 1 can silver
1 can copper
1 can satin clear coat
Pastels- dark blue, reddish brown, black
Spackling paste http://www.homedepot.com/h_d1/N-5yc1v/R-202314762/h_d2/ProductDisplay?langId=-1&storeId=10051&catalogId=10053
Plywood- 3/32" thickness, 6" x 12" (3ea) http://www.micromark.com/Birch-Plywood-3and32-Inch-Thick-x-6-Inches-Wide-x-12-Inches-Long,6909.html

Minwax Polycrylic sealer http://www.homedepot.com/h_d1/N-5yc1v/R-202061439/h_d2/ProductDisplay?langId=-1&storeId=10051&catalogId=10053
Velcro http://www.homedepot.com/h_d1/N-5yc1v/R-202261913/h_d2/ProductDisplay?langId=-1&storeId=10051&catalogId=10053
Cotton swabs/ soft brush- for applying pastels

Electronics/Hardware-
Arduino- http://www.instructables.com/id/Arduino-animatronics-make-your-awesome-costumes-m/
Small switch (2ea)
JST female connector
JST extension wire
AA batteries
AA battery holder (4ea)
Servos- Hitec HS-81 (3ea) http://www.servocity.com/html/hs-81_micro.html
Hitec HS- 425BB (2ea) http://www.servocity.com/html/hs-425bb_super_sport_bb.html
Servo extension wire http://www.servocity.com/html/12__servo_extensions.html
Gears- 22T 32 pitch Hitec splined (2ea) http://www.servocity.com/html/32_pitch_hitec_servo_gears.html
24T 32 pitch 1/4" shaft mount (4ea) http://www.servocity.com/html/32_pitch_plain_bore_gears.html
4-40 Swivel ball links (4ea) http://www.servocity.com/html/4-40x3_16__nylon.html
4-40 threaded rod http://www.servocity.com/html/threaded_rod.html
Super Duty short control horns (2ea) http://www.servocity.com/html/306sh_short_single_horn.html
Servo shaft adapter 1/4" http://www.servocity.com/html/servo_shaft_attachment___250__.html
10-32 Rod end http://www.markwilliams.com/detail.aspx?ID=1313
10-32 tap & drill bit
10-32 bolt
10-32 nuts (3ea)
1" Aluminum angle
Nylon spacers- 1/4" ID x 1/2" OD http://www.servocity.com/html/_4_nylon_spacer.html
1/4" OD brass tubing
3/8" Aluminum rod
Aluminum mounting hubs w/bolts- 1/4" and 3/8" bore http://www.servocity.com/html/set_screw_hubs.html
10mm LEDs (2ea)
10mm LED holders (2ea)
Resistors- 100 Ohm (2ea)
Standoffs- I used standoff I salvaged from electronics I found in dumpsters but lots of places sell them online in various sizes
http://www.servocity.com/html/standoffs___spacers.html
Male/female breakaway headers
Miscellaneous wire/ small wood screws
Small piece of steel sheet
Magnet http://www.kjmagnetics.com/proddetail.asp?prod=DA2

Step 2: Printing patterns

So here we go!

The base of this helmet uses a pepakura folded paper model. If you're not familiar with pepakura it allows you to take a 3D model and essentially fold it out flat into a paper pattern. The pattern is printed on card stock and cut out, folded and glued together. It's a pretty easy way to get a general shape for a physical model. The complexity of the model can vary greatly and it's always a trick to have the minimum number of folds to reduce complexity but still allows you to have good shape and model detail. I'm using using the pepakura model provided by nintendude and movieman as a base (a HUGE thank you to you guys!)

So the first thing you want to do is download the provided patterns and open the Horus pattern using the free Pepakura Viewer, which can be downloaded here (sorry Windows only)- http://www.tamasoft.co.jp/pepakura-en/

There are additional files provided should you want to make the Anubis version or want the additional files for the neck collar, staff weapon or ZAT weapon to complete a costume. Note that I have not yet constructed these so I can't say if the animatronics will fit the Anubis head -but I'm sure there's a way to make it work. :)

After you have opened the Horus file you will see a wire model on one side of the screen and the patterns on the other side of the screen. The first thing you will notice is that if you click on a particular pattern page it will show you where that part goes in the finished model as well as what other pattern parts it mates to- this is great to back to and use as a reference when assembling the patterns.

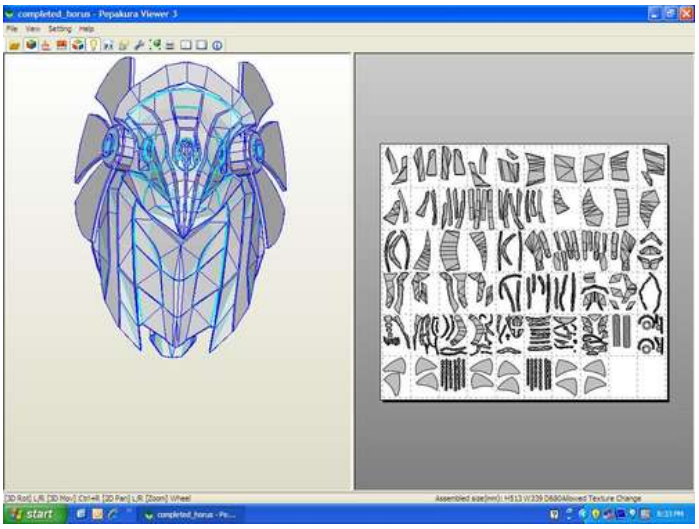
At this point what you want to do is turn off the "Set Materials To Faces" button. If you don't do that all of the pattern faces will print grey.

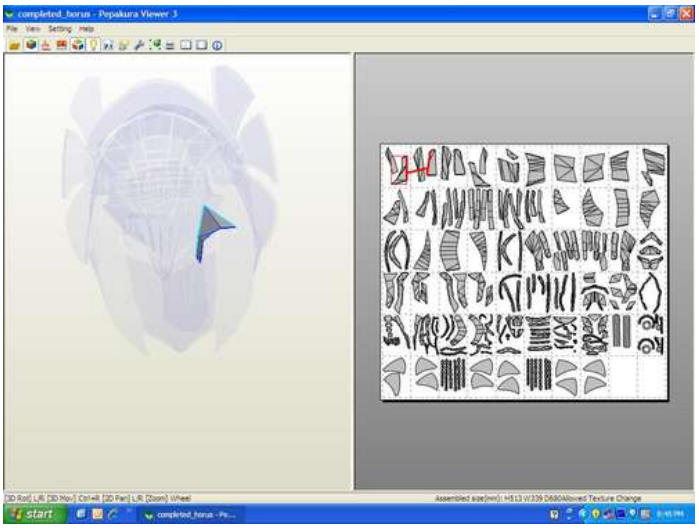
Next turn on the "Show Edge ID" button. This is a big one- when the patterns print they will have numbered edges that show what edges mate together. Without this it will be very difficult to assemble the patterns.

Now select Setting form the pull down menu and select Print Setting. I set the line thickness to 3, Print lines smoothly, transparency to 50% and Print page number.

Now select the printer icon, select your printer, select All and then OK. A window then appears asking if you if you want to adjust the scale- select NO. The reason for this is that Pepakura Viewer is set up to print on A4 paper and if you scale the model to fit on letter sized paper the patterns will be the wrong size. The down side to this is that if you are printing on letter sized paper some of the patterns can run just barely outside the borders, but it's no big deal.

So print you patterns onto card stock and get your scissors ready...


completed_horus - Popakura Viewer 3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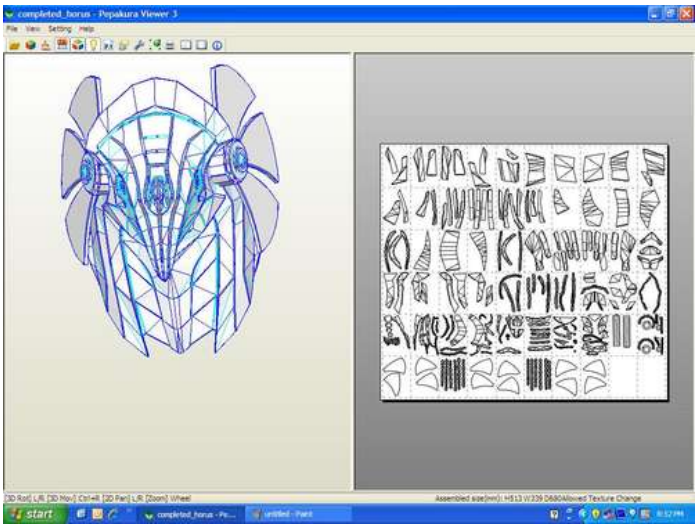
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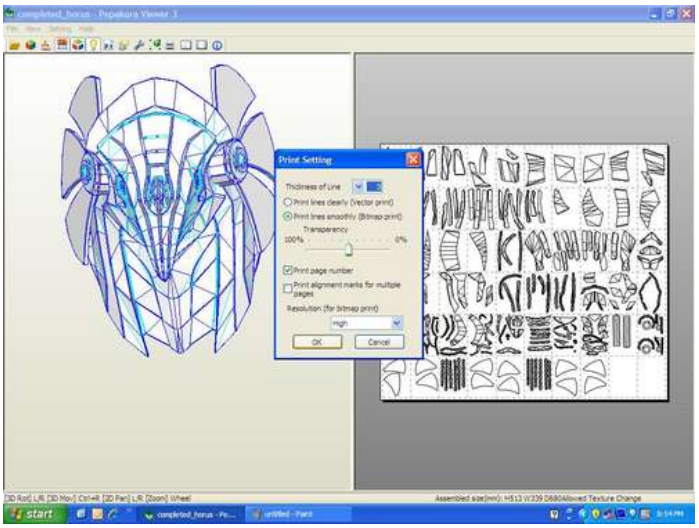
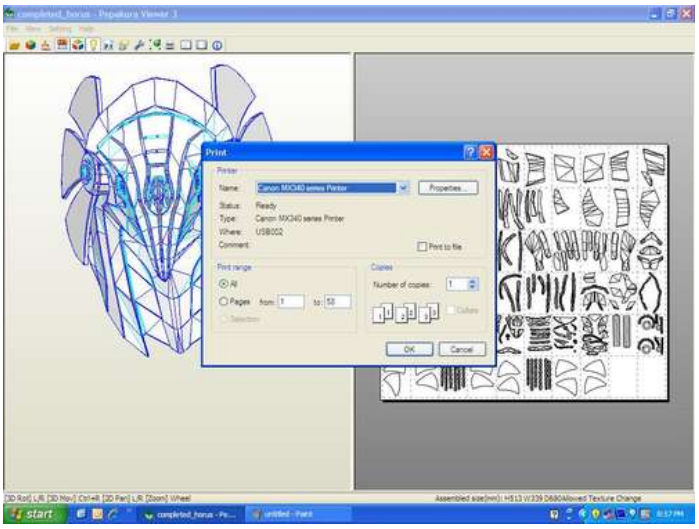

Print Setting
Thickness of Line
Transparency
Print page number
Resolution (for bitmap print)
OK
Cancel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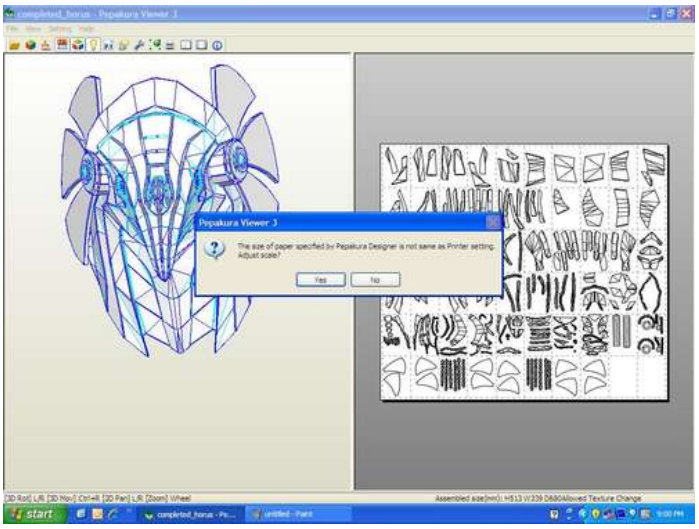

Popakura Viewer 3
Yes
No

File Downloads

Stargate Pepakura Files.zip (899 KB)
[NOTE: When saving, if you see .tmp as the file ext, rename it to 'Stargate Pepakura Files.zip']

Step 3: Cutting, folding and gluing

Time to cut some patterns!

The best thing I've used is some small, sharp scissors. Only cut out as many patterns in one sitting as you are comfortable working with. This will avoid a lot of confusion and the possibility of lost patterns. Once you've got some patterns cut you'll want to fold on marked lines. Pepakura uses a regular dashed line for mountain folds and dashed/dotted lines for valley folds. Pretty simple really.

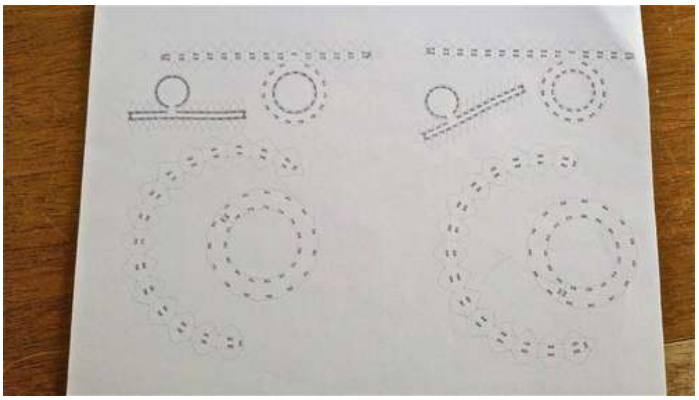
The best thing I've found for folding lines is a small 6" long steel ruler. It's long enough for that large areas but small enough for small folds when you use the end of the ruler.

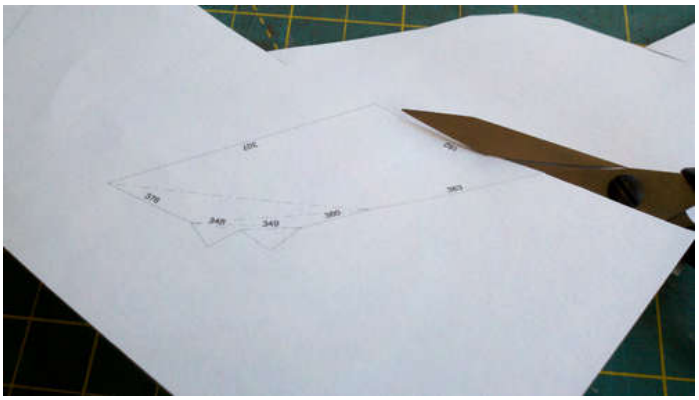
Once you've got a few pieces cut and folded glue them together on the numbered mating edges. I use Aleene's clear gel tacky glue and it works great. Just hold the edges together for a bit until the glue sets and move onto the next edge. Some of the folds are tricky and it can take a bit of fiddling to get pieces to fit together properly!

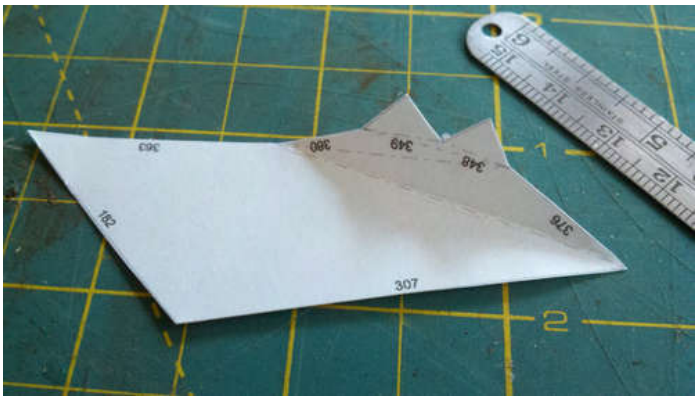
Once you get going the helmet surfaces build up pretty quick. A few notes here: for the animatronic helmet not all of the patterns will be used, namely the back of the head (since all of the servo motors go there) and only the faces of one set of fans are used as templates to cut the fans from wood. I also left off the very top part of the fan cover as I think it looks better without it.

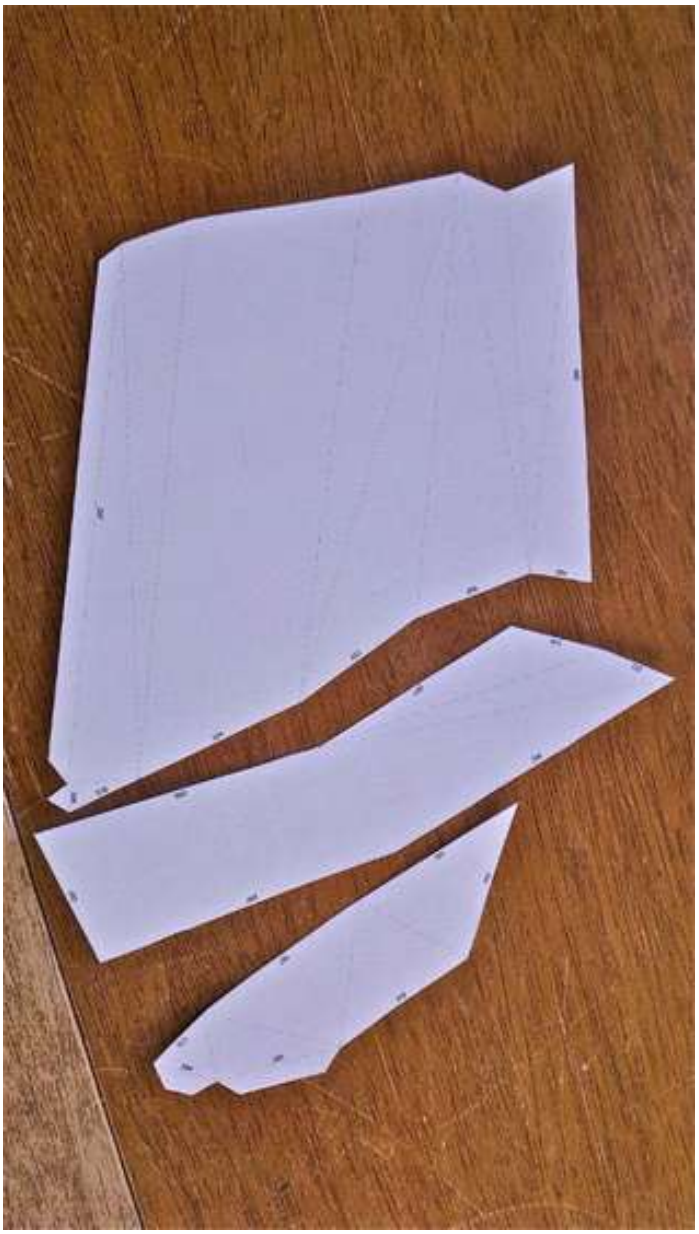
If you want to build the helmet without the animatronics then just assemble all of the parts- obviously I didn't do this so I can't give too much advice as to exactly how all the parts go together regarding final assembly (attaching head, fans, etc.) but I'll help out as best as I can!

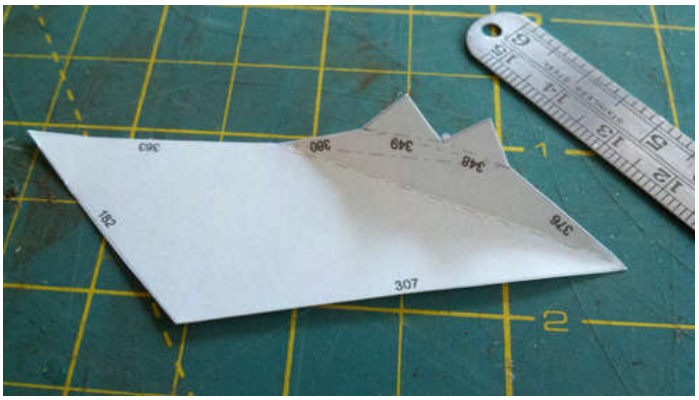
A few notes here







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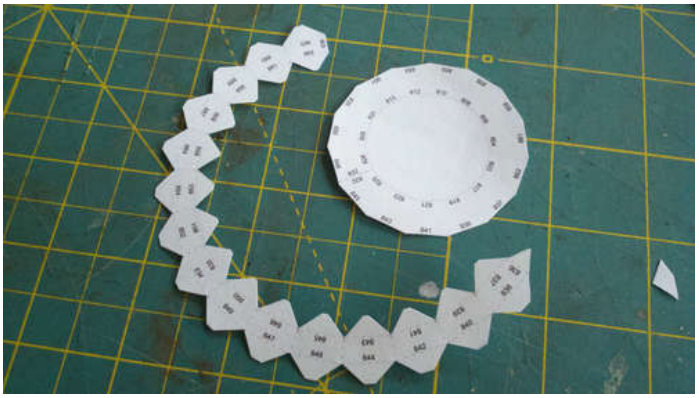
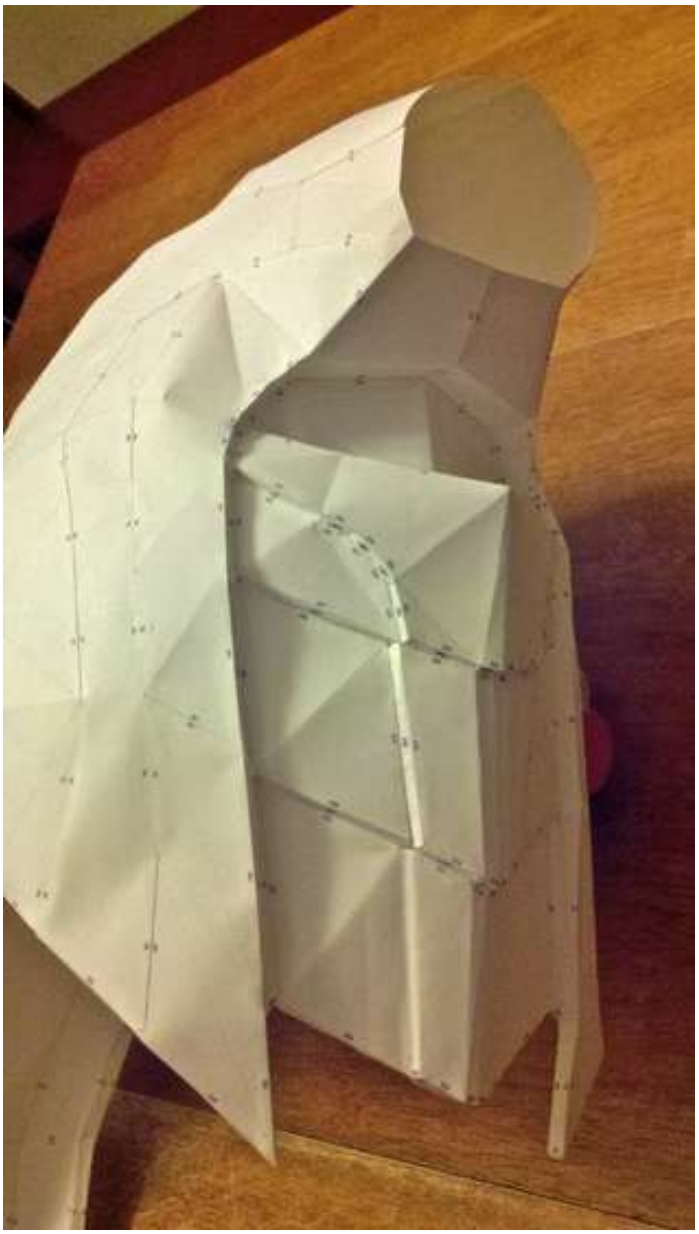




Step 4: Paper mache

The cardstock shell is fairly flimsy so we need to reinforce it with a few layers of paper mache. I used white glue with just a little bit of water to make it easier to brush on. Just tear some newspaper into small pieces, brush the glue onto the cardstock using a small brush and then start sticking down the newspaper. The trick here is to not do too big an area at once or get it too wet- this will help avoid warping. The head also requires that you paper mache the inside near the back edges on the top and bottom. This will keep the edges from curling.

I paper mached the entire helmet first and then cut the holes for the fan support tubes- it was a lot easier to do it this way as the helmet has a lot more rigidity. Then I glued in the tubes an applied paper mache to those surfaces as well.

After the helmet parts have fully dried it's time to move to foam and spackling!

Step 5: Foam is your friend- so is spackling!

I used spray foam on the inside of the helmet to fill in the area around the top where the head attaches and around the fan tubes and cavities in the sides and rear of the helmet. This adds a lot of rigidity to the helmet and gives you something solid to glue the wood head mounting plate to. You only want to spray in a bit at a time and then let it cure, especially in the top of the helmet. If you try to do it all at once only the foam on the outer surfaces will cure and you'll have a gooey mess when you go to cut the access hole for the servo wires.

When filling in the top of the helmet, cover the large hole with packing tape to keep the foam from oozing out. After the foam had cured, I cut the access hole for the servo wires using my small hand saw- just jab it through to make a good sized through hole. You can also use the saw to trim back any excess foam on the inside of the helmet and the front face of the large opening (after removing the packing tape.)

Now cut two identical pieces of thin plywood to fit the large opening at the front/top of the helmet. One of these will need a large hole cut in it to match the hole in the foam. This is then glued to the helmet using Gorilla glue. Just get the plywood slightly wet on one side, apply glue to the foam and press the wet wood side to the glued foam. Hold the plywood piece in place using packing tape until the glue sets. The second plywood piece is set aside- it's used to mount the animatronic assembly.

Now it's time to do some spackling! Light weight spackling paste is applied to the helmet to smooth out rough spots and seams in the paper mache. I use an old plastic gift card as a spatula to apply the paste. Once the spackling has dried it can be sanded smooth.

At this time you should also cut out the panel in the front of the helmet using an X-Acto knife so you can see out. I covered this with a piece of window screen scrap and glued it in place with a glue gun.

Speaking of glue guns- now is the time to start skinning the helmet with craft foam sheet. I chose gray sheet since I figured it would hide any paint mistakes best when using silver paint.

What I did was wrap the foam sheet over the helmet and then rough trim it to shape using an X-Acto knife. Keep changing the blade in the knife as it makes a huge difference as to how clean a cut you can get. Then I would glue one edge down, wait for it to set and then stretch and wrap the foam around the helmet as best as I could, gluing sections as I went. It's definitely a tricky process to try and minimize the number of seams! The process is identical for the head- the beak section is especially tricky to do- just take your time and trim the foam sheet as you go, trying to minimize the gaps.

Any gaps in the foam can now be filled with spackling paste and lightly sanded.

Step 6: Head mechanism

Now to make it move!

The head mechanism consists of two servos that move a third servo around a spherical bearing (rod end.) It's very easy to build and is pretty compact.

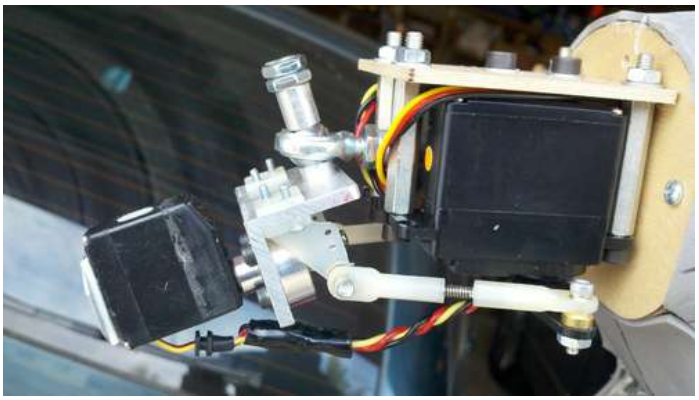
NOTE: Make sure all of your servos are in their center position before construction. This can save you some real headaches later!

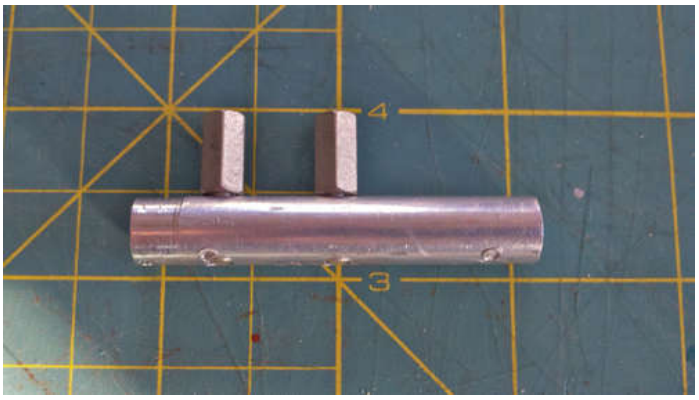
The first thing you want to make is the base plate. This uses the second piece of plywood that matches the piece at the top of the helmet. An Aluminum hub with a 3/8" hole is bolted to this and an access hole for the servo wires is drilled under the hub. Now cut a piece of 3/8" diameter Aluminum rod to 2 1/4" length. Drill and tap one end for the 10-32 rod end. Drill two holes spaced 5/8" apart on the top of the rod and mount two 1/2" long standoffs.

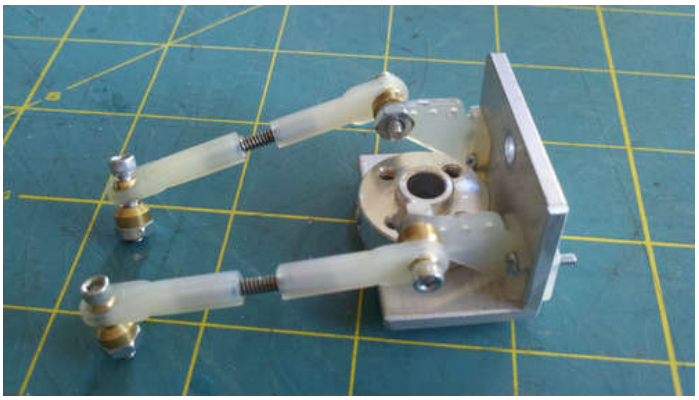
For the third servo mount cut a piece of 1" Aluminum angle to 1 1/2" length. Drill a 1/4" hole in the front and mount the 1/4" Aluminum hub. Drill a hole for a 10-32 bolt on the other face. Drill holes for the control horns and mount them as shown in the photos.
Make the control links by cutting two pieces of 4-40 rod to 1" length and then threading on the swivel ball links so there is a 1/4" gap between them. Mount the one end of each swivel link to the control horns. You'll have to drill out the hole in the control horn slightly to get the bolt through. Now attach the third servo mount to the rod end using a 1 1/4" long 10-32 bolt as shown in the photos and secure it with two nuts so it doesn't come loose. You can use a shorter bolt if you like (I just had this one on hand) and I made some spacers using scrap Aluminum tubing. You'll want to use some small washers or spacers on this bolt so you get full movement when tilting fore/aft.

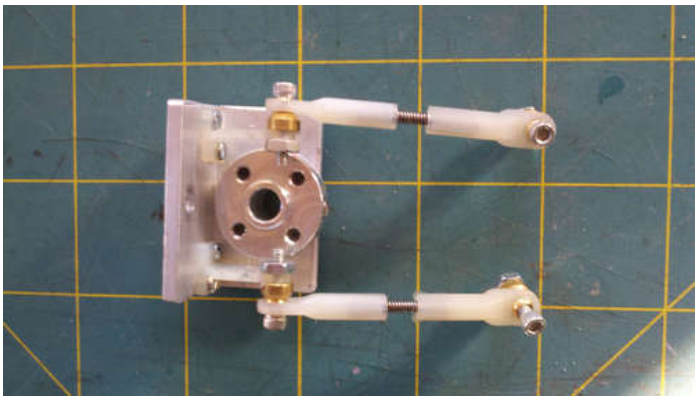
Now you need to mount the main servos. I used some 1 3/16" long standoffs (two per servo) and mounted the two servos to a thin plywood plate. The plywood plate then bolts to the two standoffs on the 3/8" Aluminum rod. Now connect the swivel links to the two servos. The third servo is mounted to the front using a 1/4" diameter servo output shaft extension. You'll probably have to cut down the mounting screw a bit like I did to get it properly fit the small servo. I cut a small piece of scrap steel sheet and attached it to the front of the servo sing double sided foam tape.

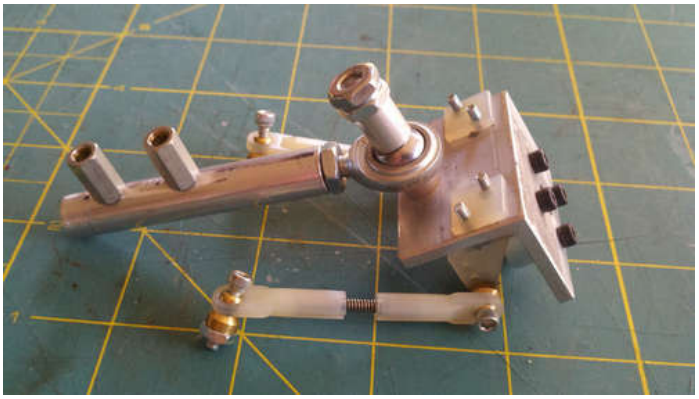
The 3/8" Aluminum rod is then secured to the base plate mounting hub and you're done!

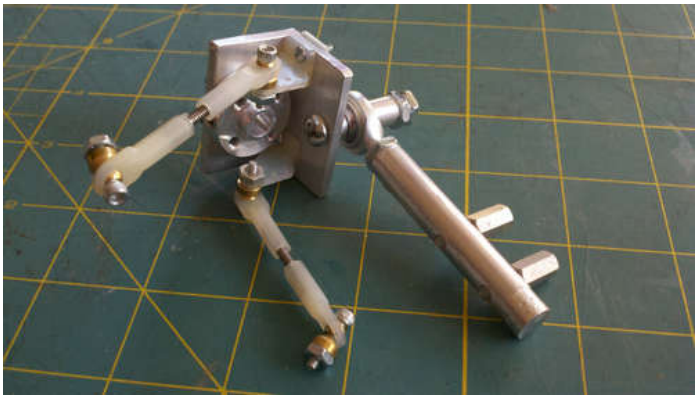


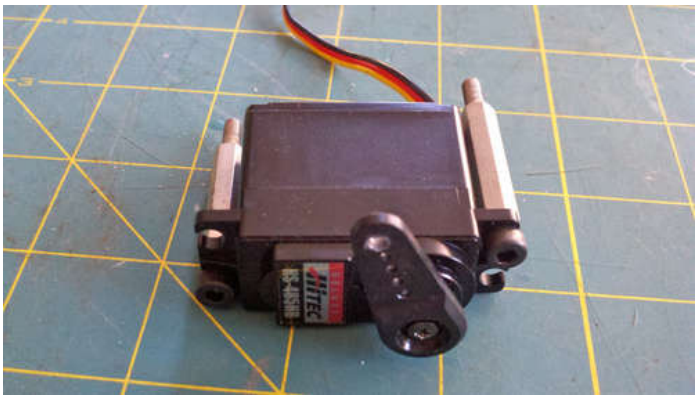


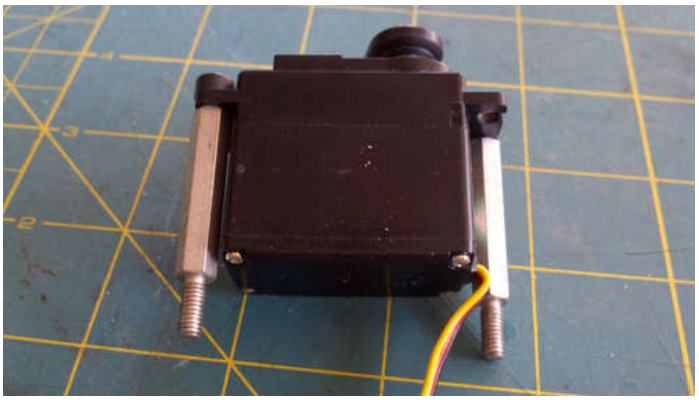


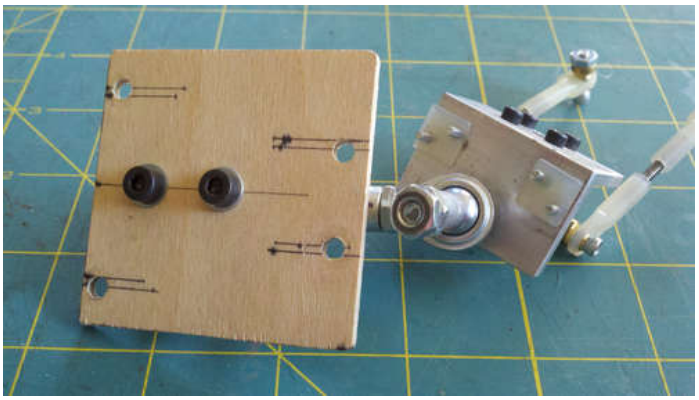


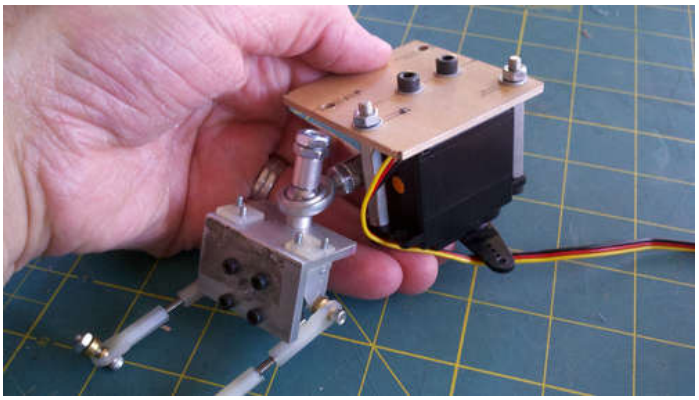


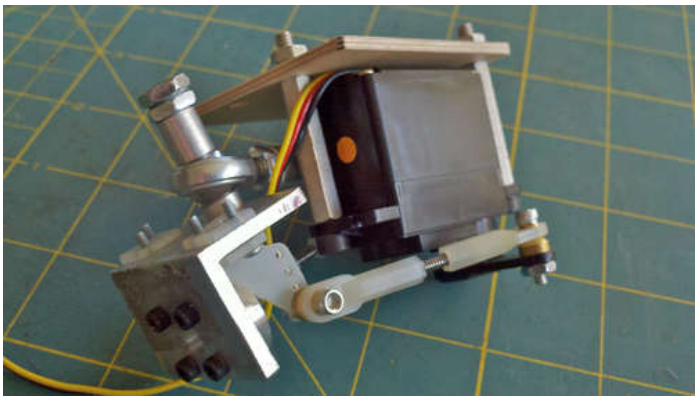




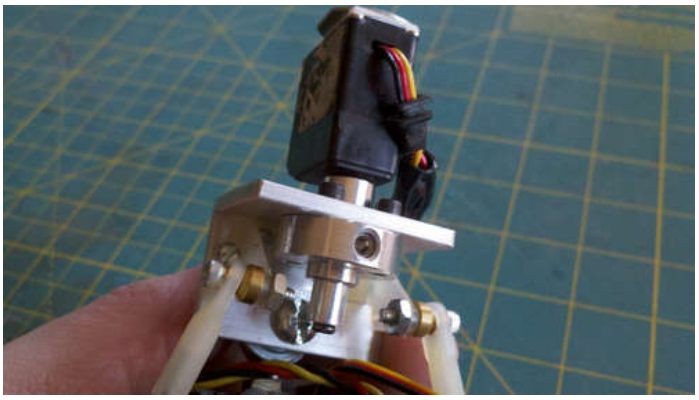


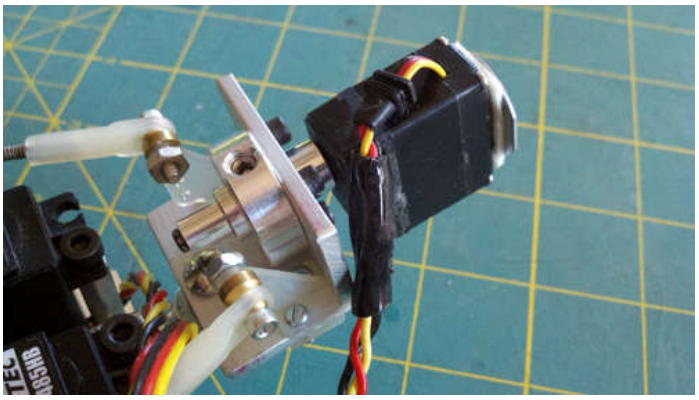


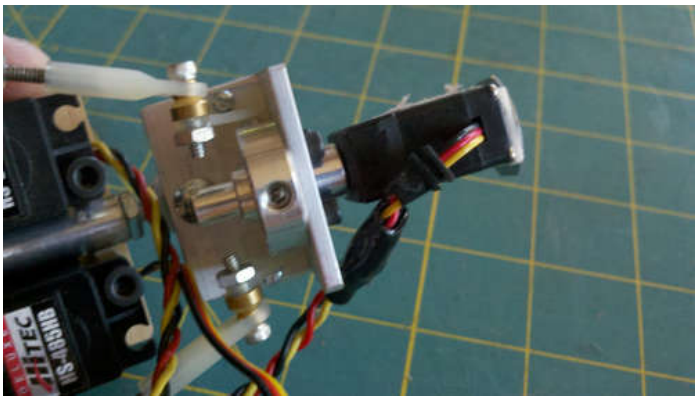





HITEC
HS-485HB






HITEC
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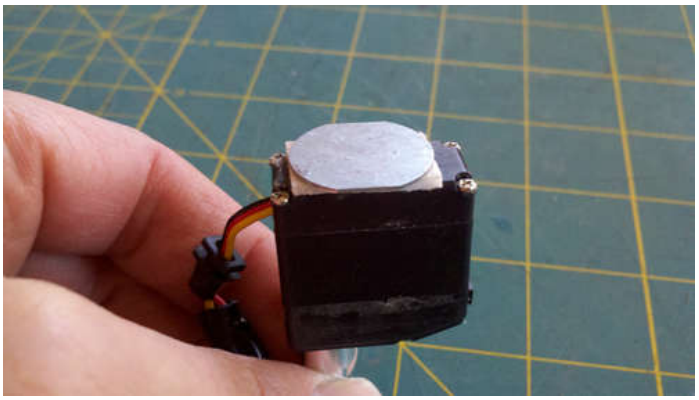
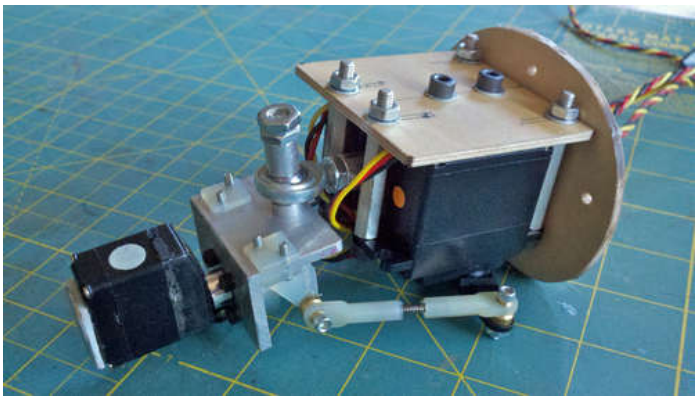
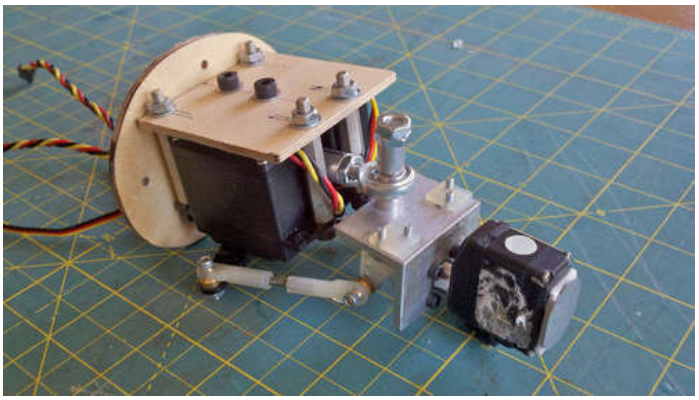






Step 7: Fan mechanism

Let's make those fans rotate! This is a really simple mechanism to build and it works well as it doesn't require much precision.

First cut four plywood discs to fit the fan mounting tubes in the sides of the helmet- they should fit pretty snug. Now cut out the fan blades from thin plywood sheet. The center fan blade is just like the template but the upper and lower blades need small extensions with 3/8" holes to allow for mounting the 24T gears. The 1/4" bore gears are press fit and glued into the holes in the upper and lower blades using Gorilla glue. Just get the wood damp first, apply some glue to the back of the gear and press it into place in the fan blade. Some glue may foam int othe gear teeth during curing- just trim it away using an X-Acto knife.

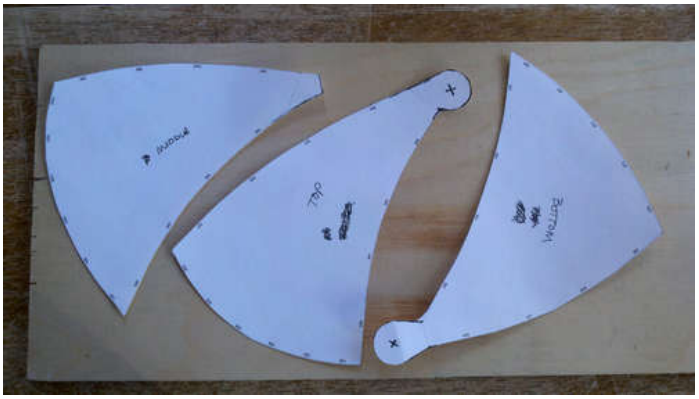
NOTE: The trick here is to get the gears properly aligned with the opposite blade. You want the gear on the right fan blade to be in the same position (rotation wise) as the gear on the left fan blade. This is important because if they are not aligned correctly it will be very difficult to get the right and left fan blades in sync when they open and close. Also note that the servo gears are on the opposite sides of the top and bottom fan blades.

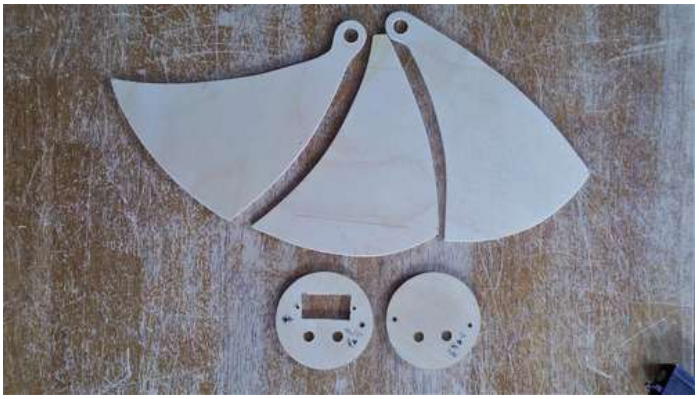
Take one of the plywood discs and cut a hole in it to mount the servo. The right and left side servo mounting plates are mirrored. Mount the 22T gear to the servo and then glue the fixed center fan blade in place using Gorilla glue. Now place the top and bottom fan blades on the servo mounting plate, holding the gears in alignment so they mesh with each other- mark their position. Note that the top fan blade gear is turned by the servo gear and the bottom fan blade gear is turned by the top fan blade gear. The bottom fan blade gear does not come into contact with the servo gear.

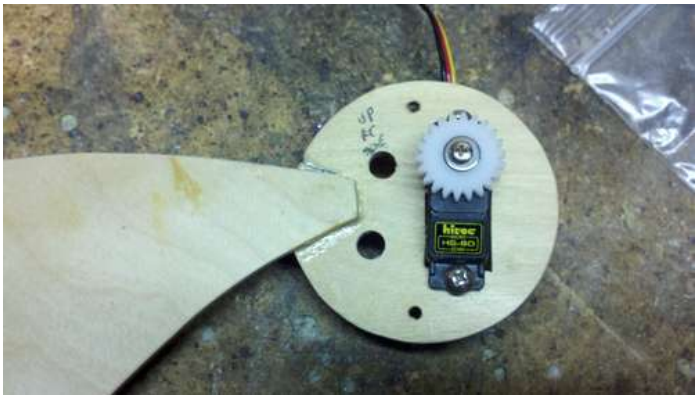
The fan blades are held in place by nylon spacers mounted on 1/4" brass tubing, which goes all the way through both plywood plates. The gears in the fan blades are designed to be press fit onto a 1/4" shaft so you have to drill them out using a 1/4" drill bit- make sure they rotate free on the 1/4" brass tube without binding.

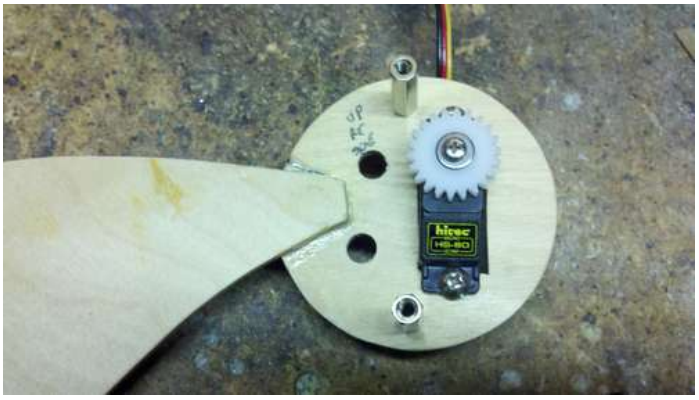
The top fan blade has a nylon spacer on both sides while the the bottom fan blade has a nylon spacer only on the inside (closest to the servo.) The exact length of these spacers depends on the length of the standoffs used to hold the plywood plates apart. They don not require a precise fit at all- just tight enough to keep the fan blades from wobbling around. The fan blades should rotate freely on the brass tubes. The spacers should fit snug onto the 1/4" brass tubing- they are what holds the tubing in place between the two plywood plates.

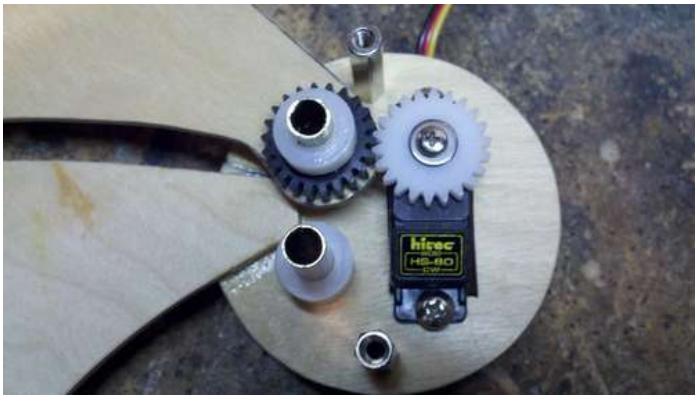
When you are finished building the fan assemblies test fit into the helmet tubes- they will require a notch cut for the center fan blade. Do not glue them to the helmet at this time.

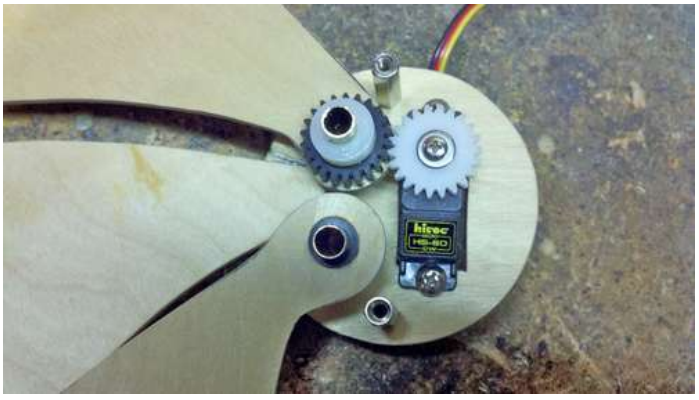


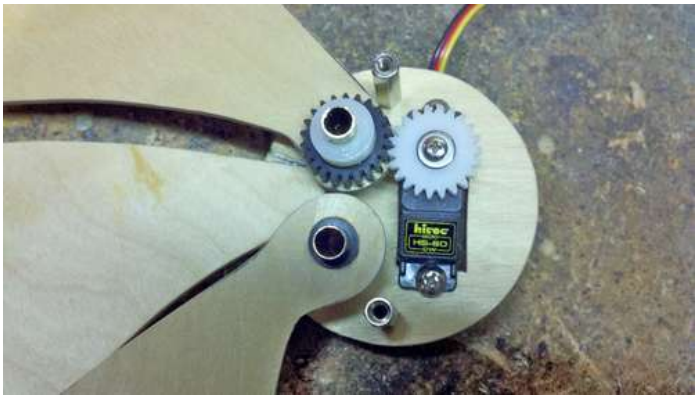








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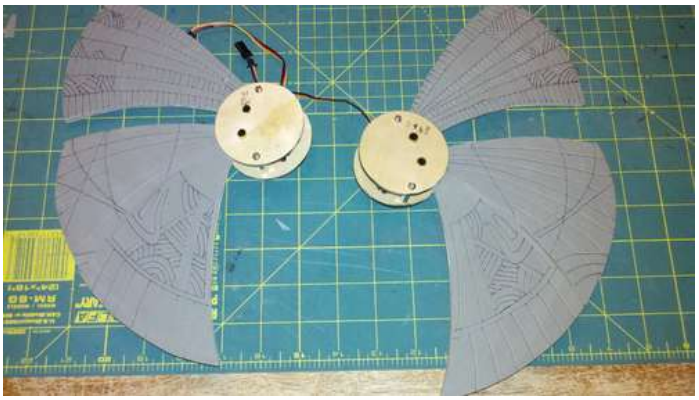
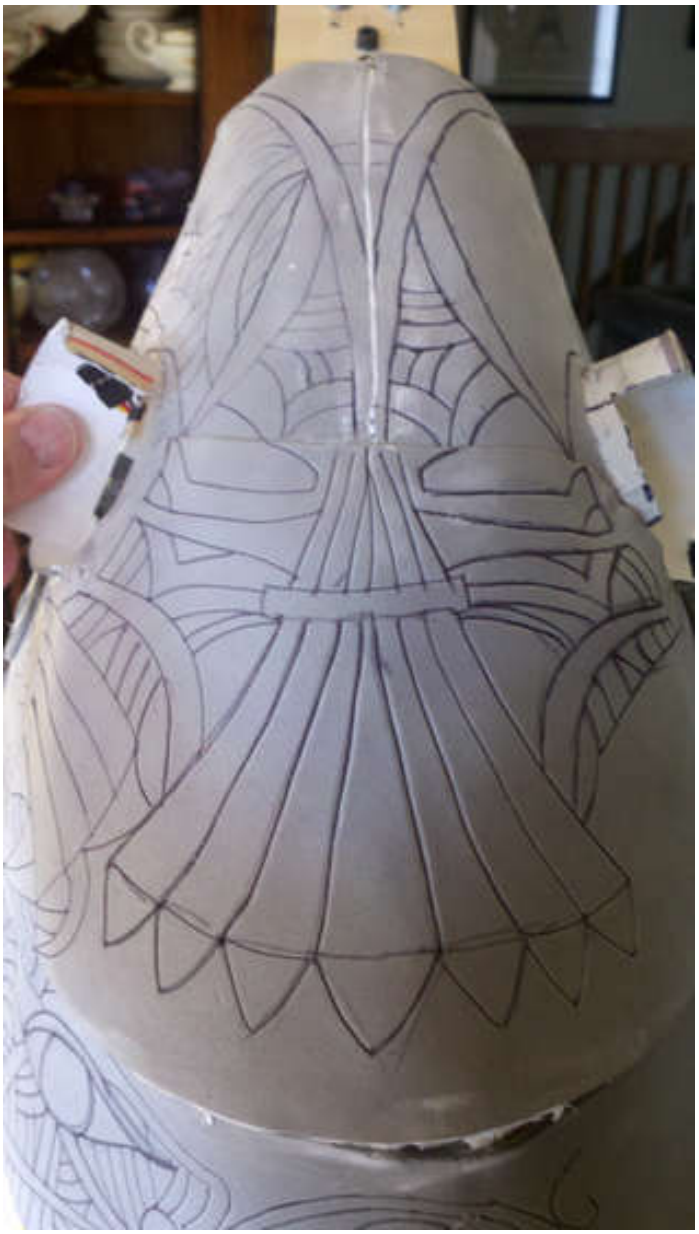


Step 8: Detailing

Now let's put it all together and see what it looks like!

Since the fan blades are temporarily mounted, mount the head by cutting a small piece of plywood to fit up in the beak section. This gets a super strong small magnet glued to it using Gorilla glue and the plate is held into the inside of the head using hot glue. The magnet connects to a small metal plate on the front of the small servo and holds the head in place. This way the head is secure but is still easy to remove and it won't damage the servo if it gets knocked around.

Now come the details! Cut the raised areas on the back and sides of the helmet using foam sheet and glue it into place with the glue gun. Now use a regular old ball point pen to draw all the engraved lines in the helmet and head. You have to press pretty hard but the lines will stay there! Also cut out foam sheet for the fan blades and secure them using a glue gun. The patterns are pretty time consuming to draw- don't be too concerned about making them perfectly match from side to side.



Step 9: Electronics!

For this project I'm using an Arduino controller board I wrote a complete instructable about here-
http://www.instructables.com/id/Arduino-animatronics-make-your-awesome-costumes-m/

This works really well for this application but feel free to use any Arduino you want. The mentioned instructable shows how to build, program and use the Arduino controller board I'm using. The servos are powered by four "AA" rechargeable batteries. I mounted a small switch for both the "AA" batteries and the LiPo cell to make it easy to turn on and off. The controller board is mounted to a small plywood plate and is secured to the inside of the helmet with velcro, as are the battery packs.

Each 10mm LED gets a 100 Ohm resistor soldered to its positive lead and then they are wired in parallel. The LEDs are glued into cut down LED holders in the head eye sockets using a glue gun.

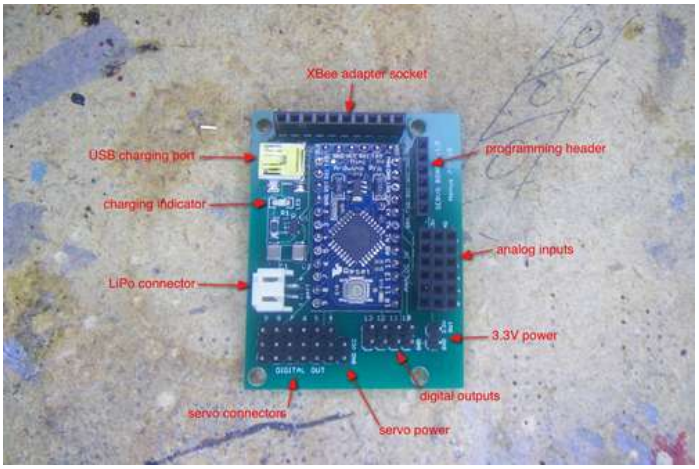
The servos connect as follows:

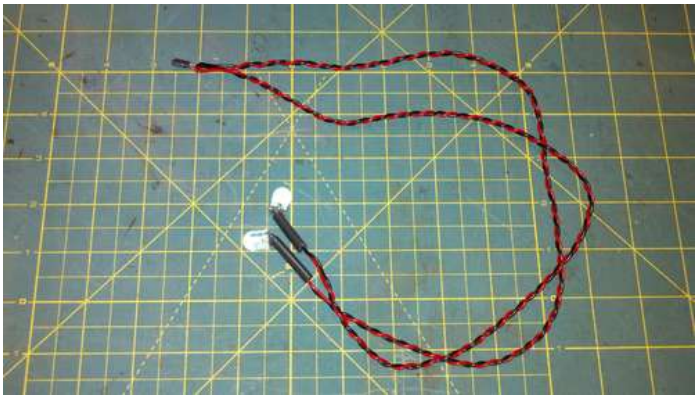
Head small servo- output pin 9
Right side head servo (looking at head)- output pin 8
Left side head servo (looking at head)- output pin 7
Right side fan servo (looking at head)- output pin 6
Left side fan servo (looking at head)- output pin 5
LED eyes- both connect to output pin 11

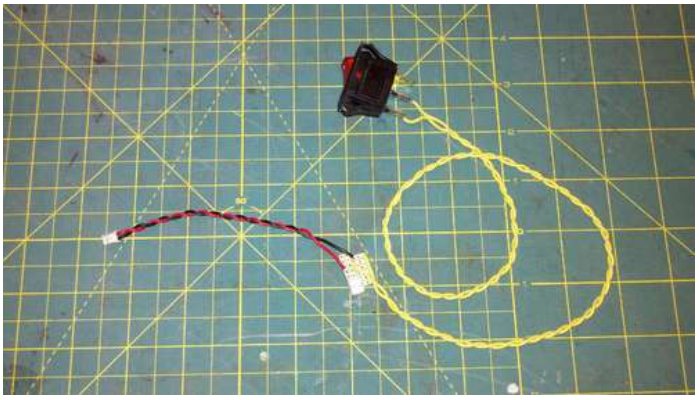
Here's the code to use- just copy and paste this into your Arduino window. This is a simple code that just runs the servos and LEDs through a sequence over and over. That way when you're wearing the helmet you don't have to worry about what it's doing- just flip the switches and you're good to go. Feel free to play around with the servo positions but be careful not to make them move too far or they will bind and possibly strip a gear.

```
#include <Servo.h> // include the servo library

Servo servo1; // creates an instance of the servo object to control a servo
Servo servo2;
Servo servo3;
```

```
Servo servo4;
Servo servo5;

int servoPin1 = 9; // control pin for servo
int servoPin2 = 8;
int servoPin3 = 7;
int servoPin4 = 6;
int servoPin5 = 5;

const int ledPin = 11;
int ledState = LOW; // variable used to store the last LED status, to toggle the light

void setup() {

servo1.attach(servoPin1); // attaches the servo on pin to the servo object
servo2.attach(servoPin2);
servo3.attach(servoPin3);
servo4.attach(servoPin4);
servo5.attach(servoPin5);

}

void loop()
{
// fade in from min to max in increments of 5 points:
for(int fadeValue = 0 ; fadeValue <= 255; fadeValue +=5) {
// sets the value (range from 0 to 255):
analogWrite(ledPin, fadeValue);
// wait for 30 milliseconds to see the dimming effect
delay(30);
}
servo1.write(90); the number in parentheses tells the servo what position to go to
servo2.write(50);
servo3.write(120);
servo4.write(90);
servo5.write(90);
delay(1000);
servo1.write(60);
servo4.write(100);
servo5.write(80);
delay(1000);
servo1.write(70);
servo2.write(90);
servo3.write(110);
delay(1000);
servo4.write(70);
servo5.write(110);
delay(2000);
servo2.write(55);
servo3.write(85);
delay(2000);
servo1.write(90);
servo2.write(90);
servo3.write(90);
servo4.write(90);
servo5.write(90);

// fade out from max to min in increments of 5 points:
for(int fadeValue = 255 ; fadeValue >= 0; fadeValue -=5) {
// sets the value (range from 0 to 255):
analogWrite(ledPin, fadeValue);
// wait for 30 milliseconds to see the dimming effect
delay(40);
}
delay(3000);
}
```







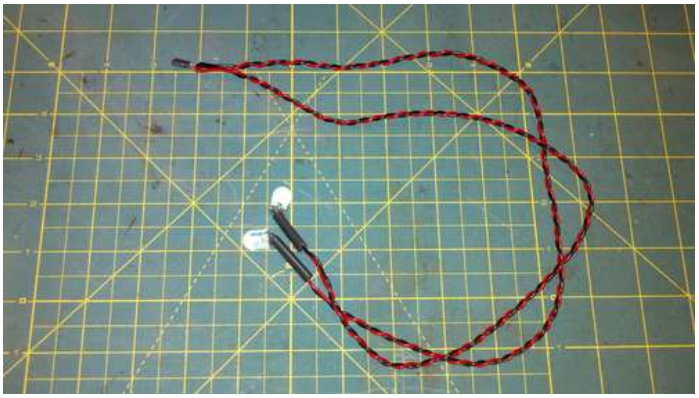
Step 10: Painting and finishing

Painting this I first gave it a coat of Minwax Polycrylic sealer. Then I sprayed the helmet and fans silver. this was followed by a coat of copper on the beak section of the head and the lower part of the helmet.

Painting was then followed with some pastel work. I first went over the helmet with some dark blue pastel powder using a small soft paintbrush and a cotton swab to blend it. Then copper areas were highlighted using a reddish brown pastel stick and that was blended in using a brush and cotton swab. Finally the entire helmet was given a satin clear coat and it was ready to go!

This project was a very long time coming and was a real challenge for me- it was a real experience seeing this come together and solving challenges along the way. I learned and awful lot building it and will be applying that knowledge to future costume projects. It was very important to me building this that I do it in a manner that so that others would be able to replicate it as well.

So go forth and build your Stargate helmet! As always, if there are ever any questions feel free to ask away. I'm here to help and nothing would please me more than to have a whole bunch of these out there. :)



Related Instructables

How to create simple animatronics- part one: using the MAKE controller by Honus

Arduino animatronics- make your awesome costumes more awesome! by Honus

cardboard Jaffa serpent gaurd costume by finbar galdeep

my halloween costume (video) by firehopper

Marvin the Martian Costume (finally!) by MarxNutz

my animatronic arm (Photos) by aceLED

Comments

3 comments **Add Comment**

mikeasaurus says:
amazing craftsmanship!

Nov 15, 2011. 8:27 AM **REPLY**

Honus says:
Thanks! I burned an awful lot of midnight oil on this one... :)

Nov 15, 2011. 1:34 AM **REPLY**

Andib says:
It is absolutely beautiful!!! I am still slightly confused about a step or two..but its a wonderful project. I already have the pepakura files. I have never seen anyone use paper mache over it before. I LIKE that! I shall have to give it a try with one of my helmets. I love how yours turned out!

Stunning.

Nov 15, 2011. 2:45 AM **REPLY**