Chapter 3 - Animatronics

Every kid wants to build a robot. No matter what materials are at hand, from cardboard to empty soda bottles to brooms, there's a decent chance that the shape which emerges will be named robot. With that type of enthusiasm and access to real, powerful components, the perfect kid-robot should emerge spontaneously, right?

Using context to create focus is a key to any successful work with young or inexperienced roboticists. Left to describe their dream robot, most kids will describe some fantastical blend of Byemax, Optimus Prime and Wing Gundams. Vision that expansive can limit rather than inspire when it hits the hard reality of servo motors.

This project genre focuses kids' attention on a "simple" branch of robots that move and respond to the environment for the benefit/enjoyment of an audience. Kids can think of these as interactive tops or pre-programmed puppets, or scaled down versions of Disney's audioanimatronics developed by Walt Disney Imagineering. Working at Disneyland during college on the *Mission to Mars* ride, Rick got first-hand experience with Disney's audioanimatronics brilliance. Many of the Disneyland rides both vintage and newer include this trademarked Disney technology.

We'll first start off building some puppets that make random movements, to introduce many different operations and then move on to more advanced creations that actually respond to user input. Each section will explain specific hardware needed for movements and sensing. Having a handful of custom-made RJ25 cables using the instructions in chapter will be very handy for this chapter. The short 6 inch cables that come with the mBots will seriously limit your creativity. With cables 1 to 3 feet long, you can really accomplish what you dream up. For all the projects in this chapter, the box creature bodies are just a starting point and will surely turn into whimsical creatures as kid's imaginations to wild.

Materials

- **Tools:** Hobby Knife - Masking Tape - Cutting Mat - Sharpie - Pencil -Hot Glue Gun and Glue Sticks, Scissors, Long Nose Pliers, Ruler
- **Craft Supplies**: Boxes of various size - Rubber Bands Small and Large - Feathers - Pipe Cleaners - Beads - Bling - Paint - Colorful Foam Sheets - Craft Sheets - Craft Sticks Jumbo and Regular - Paper or Plastic Cups - Googly Eyes - Colorful Construction Paper - Large Paper Clips
- **Electronics:** mCore (preferably with case)- Sensors and Motors (see below) - Connection Cables (homemade as you'll want longer ones than are in the kit) - RJ25 adapter (for using generic servos)

For Adding Sensing and Movement

- Sensors to Trigger (input)

    - Ultrasonic
    - Distance
    - Motion
    - Light Sensor
    - Line Following
    - Sounds Sensor
    - Touch Sensor
- Components to React (output)
    - Servos
    - LED's
    - Motors

Puppet Movement Without Sensors

For the first few projects in this chapter, we'll build some creations that light up, rotate and spin, but don't react to user input. Later on, we'll build some things that actually respond to user input using specific sensors.

Project: Random Light-up Eyes using RGB LED Sensor

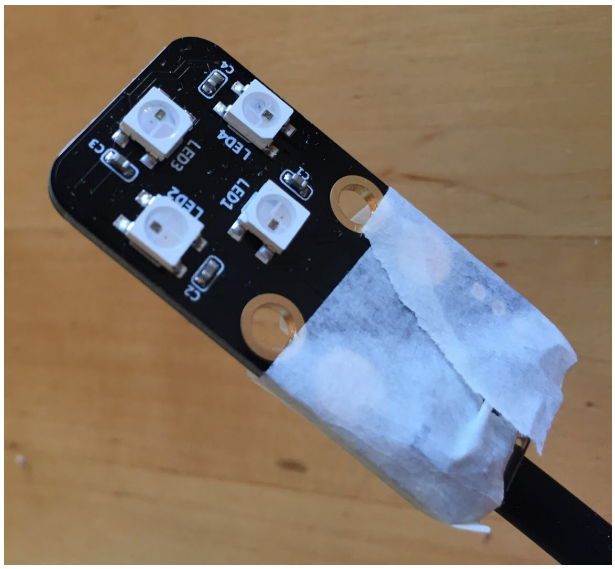
In this first project we'll create a basic cardboard box head with cut-out eyes and an RGB LED's inside.

Open the box so you can get inside. I used an empty tissue box.

[c03f001]
Cut some eye holes out with a hobby knife and then cover from the inside with tissue paper to diffuse the light.

[c03f002]

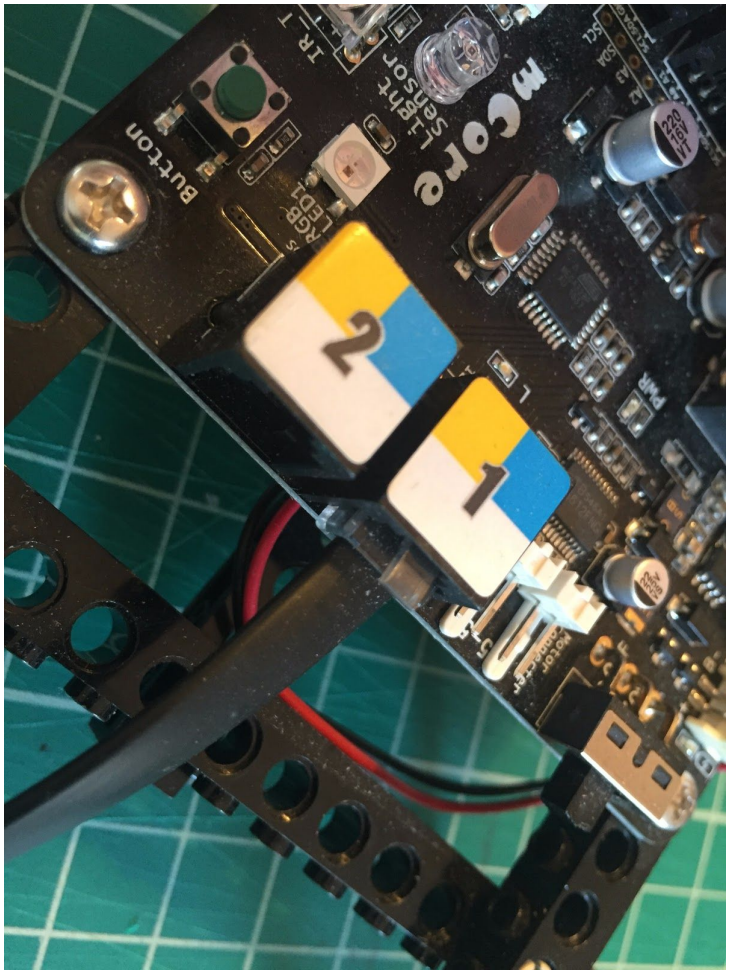
Put masking tape on the bottom part of the LED sensor. Whenever you're going to use hot glue on a sensor, add tape first to prevent damage to the electronic parts.



[c03f003]

Add hot glue to the tape on the LED sensor and stick it inside the box. Thread the RJ25 cable out the bottom of the box

[c03f004]

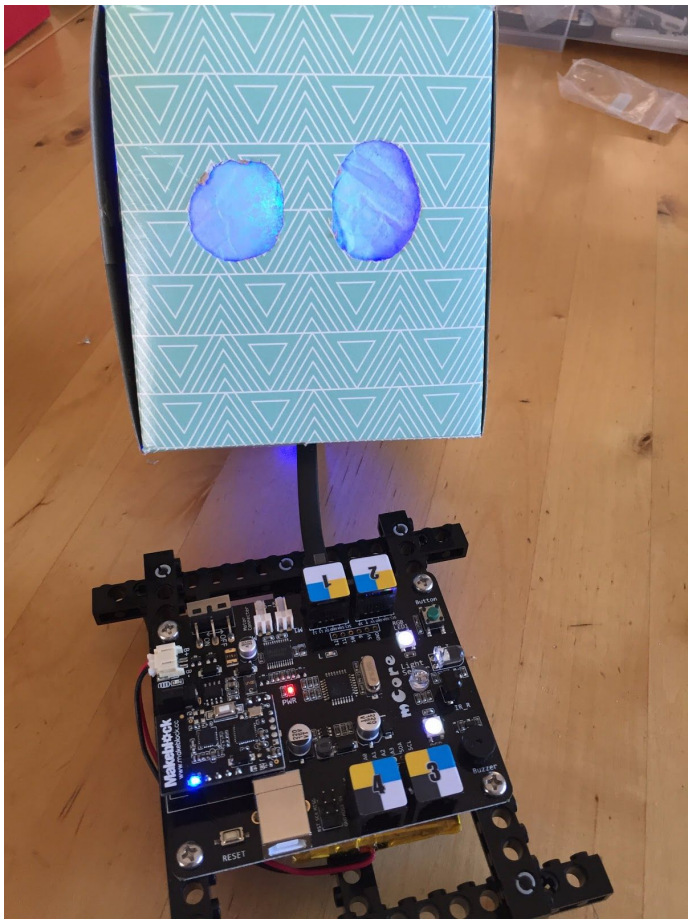


Attach the cable to Port 1 on the mCore.

[c03f005]

[c03f006]

Connect your mCore to your computer and open mBlock. Write and run the following program:



[c03f007]

This will create randomly flashing blue LED eyes that run forever after the space bar is pressed. This is just a starting point, so now it's time to get creative by modifying this code to create your own colors and blinking patterns.

Project: Head Turning Randomly using 9g Servo and RJ25 adapter

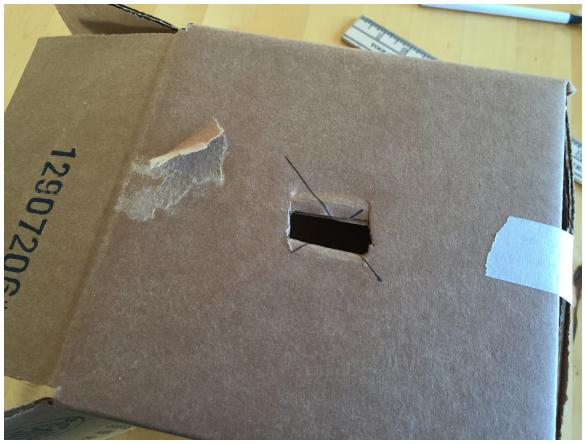
For this project if you have a lightweight “head” like the tissue box, a 9g servos will work with some modifications. If you are moving a heavier object, you might need a bigger servo like a Hi-tech HS-311 which has a higher torque. Micro servos with metal gears can also be purchased for $3 - $5 and are less likely to have gears stripped by too much weight or force.

Mount and Wire Servo

First laser cut or hand-cut a mount for the servo. If you have access to a laser cutter, use this file _____ to cut a mount from acrylic. You don’t have access to a laser cutter, you can also use this full-scale PDF to hand-cut a servo mount out of a material of your choice. Slip servo through the mount and attach using hot glue.

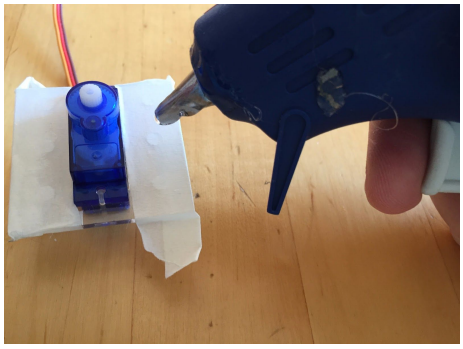
[c03f008]

Next, cut a hole in the center of the box about 3/4” x 1 1/4” to fit the servo. Push the servo up through the hole in the inside of the box.

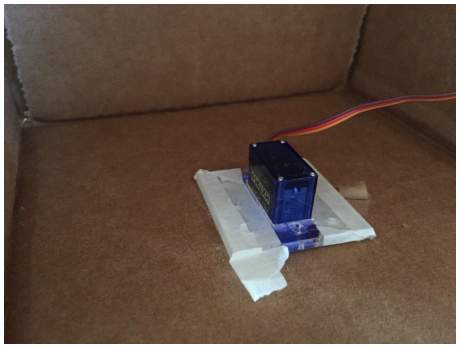


[c03f009]

[c03f010]
Once you’re sure the servo fits, put tape over the servo mount and glue to the top inside of the box.

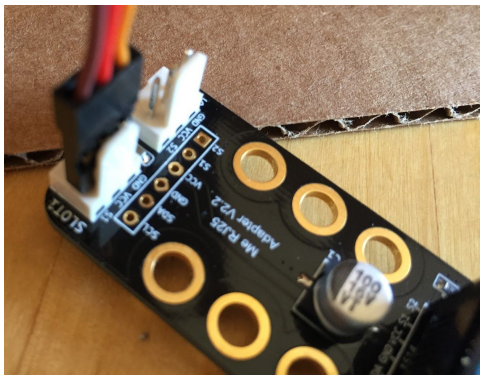


[c03f011]



[c03f012]

Feed the servo wires out the back of the box and tape the box shut. Then connect the servo to the Makeblock RJ25 adapter. The RJ25 adapter allows you to connect two servos to one port on the mCore. For this project, let's attach the servo to Slot 1 using the following guidelines:



[c03f013]

Micro 9g:

- Orange or Yellow - S1 (signal)
- Red - VCC (power)
- Brown or Black - GND - (ground)

Building Servo Arm

Mark a large craft stick in the center and drill a 1/4 inch hole.

[c03f014]

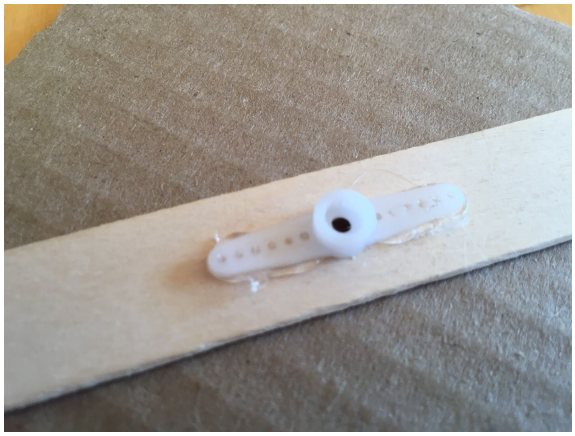
Trace on a piece of cardboard around whatever you are using for your creature's head then cut it out. I'm using the same box as the LED eyes above because I'm going to add this as the head to my creature.

[c03f015]

Hot glue the craft stick to the piece of cardboard then drill through the hole in the stick again and through the cardboard. Depending on the size of the box used for the head, you may need to trim the craft stick.

[c03f016]

Next, take the largest servo arm that came with your servo and hot glue it onto the stick, with the side that attaches to the servo facing up. You need this to stick really well, so use plenty of glue, but not so much that it goes inside the hole.

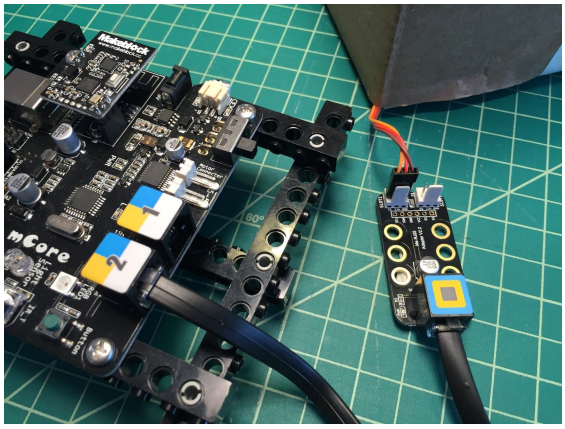


[c03f017]

We'll set this aside for now until we have the servo connected to the mCore and calibrated.

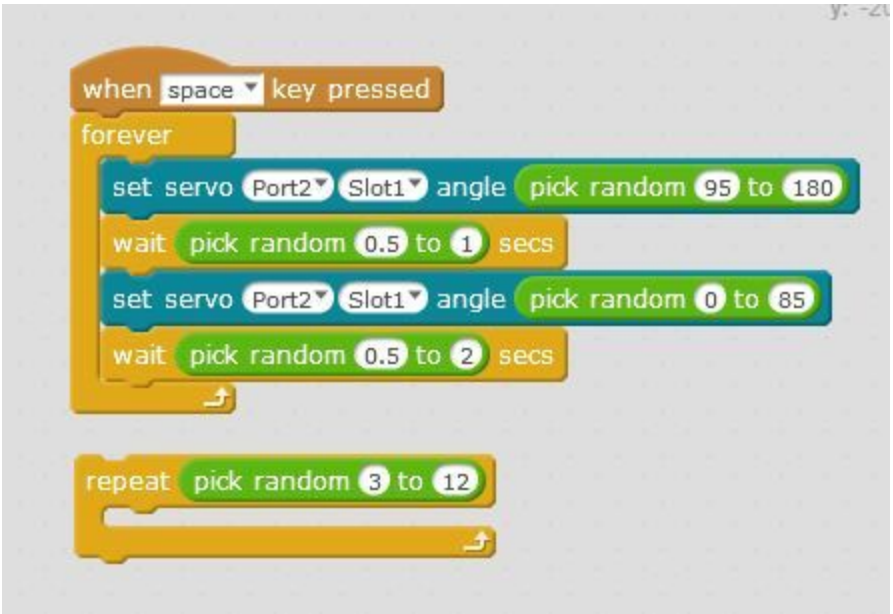
Wiring to mCore

The servo should be connected to the RJ25 adapter. Then connect the RJ25 adapter to Port 2 on the mCore using an RJ25 cable. (It's connected and programmed for Port 2 because you may want to use Port 1 for the LED eyes.)



[c03f018]

Connect your mCore to your computer and write the following code using mBlock. This will make the servo turn from 0 to 180 degrees randomly when the space key is pressed. If you want the servo to move for only a set period of time, you can swap the “forever” control out for “repeat” as shown below.



[c03f019]

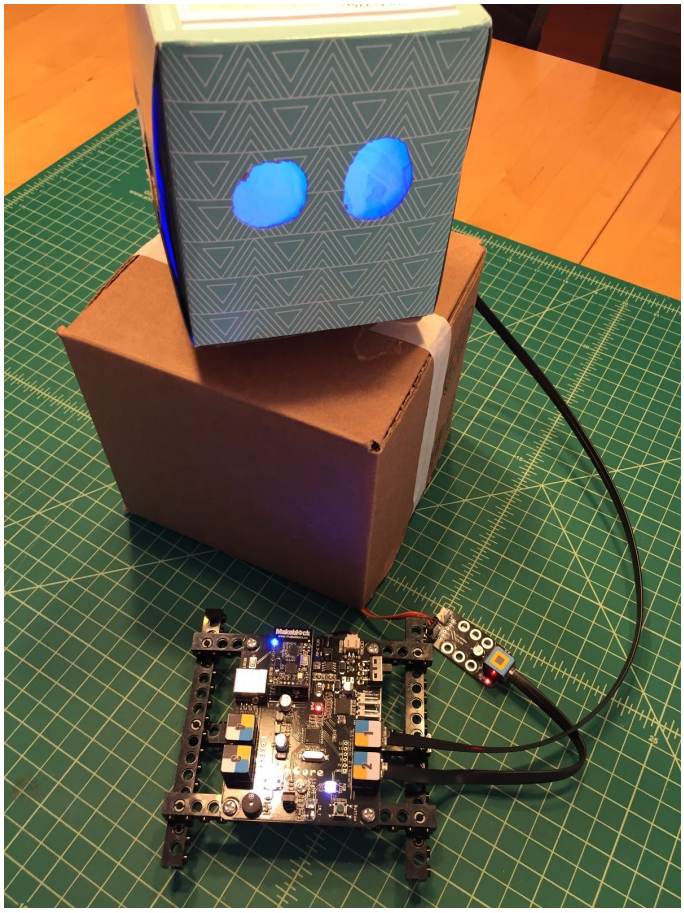
Attach Head to Body

Once the mCore is connected and programmed, attach the stick and cardboard control arm to the top of the servo and carefully screw in place using the screw supplied with the servo.

[c03f020]
Then attach the head to the servo platform using tape.

Combining the LED Eyes with the Moving Head

If your LED eyes are still inside the head, you'll need to route the cable out and to the mCore in a way that the cable does not interfere with the operation of the moving head. Using one of your custom RJ25 cables that's at least 2 inches long, plug your LED eyes into Port 1 of the mCore and combine the two programs. Now you've got a randomly moving head and blinking LED eyes!



[c03f021]

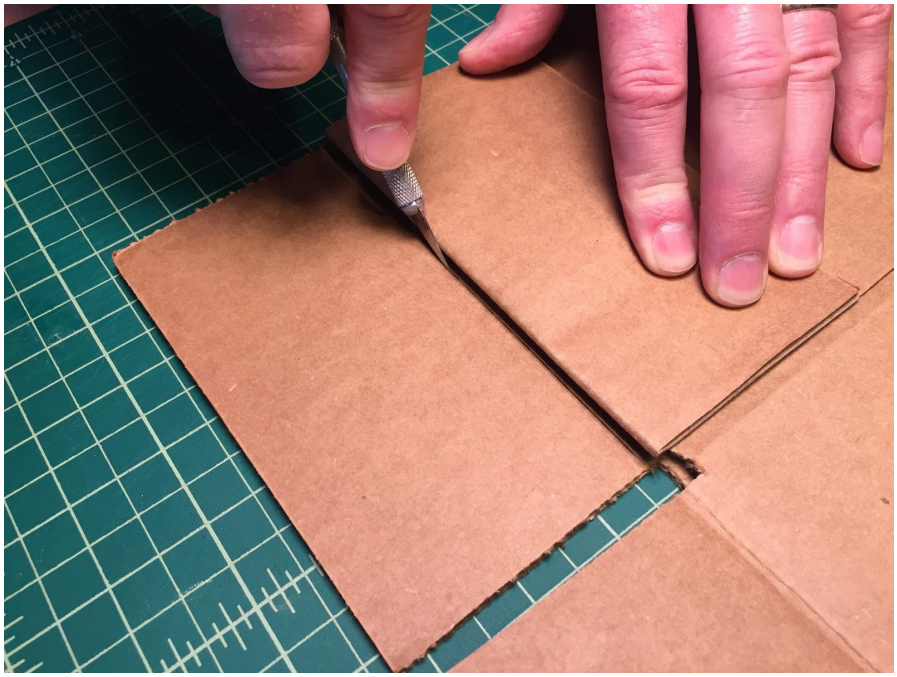
Project: Opening Mouth using 9g Servo and RJ25 adapter

The Robot Petting Zoo, which got its name in 2015 at TechHive Studio at the Lawrence Hall of Science at UC Berkeley, was the inspiration for some of the following projects. The TechHive hosted a brilliant 12 hour Makeathon with high school students. During the first ten hours, students learned about programming, electronics, prototyping and design while they built a robot pet and then spent the last two hours presenting their creations to the public. Matt Chilbert and Andrew Milne were instrumental in the event at TechHive, and Tom Lauwers is the president and chief roboticist at Bird Brain Technologies

This puppet feature uses a box, one servo, a single sided servo arm, a small craft stick and a large paper clip to operate the mouth flap.

We're going to start with a cardboard box and use one of the flaps as the mouth. For this example, we're using a 6x6x6 box from U-line.

Lay the box flat and cut the two flaps opposite of each other off.

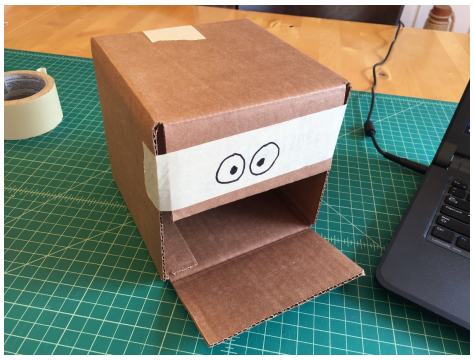


[c03f022]

Tape the side of the box with four flaps closed with a strip of masking tape.

[c03f023]

On the other side, tape just one flap down and draw eyes. The bottom flap will be our mouth.

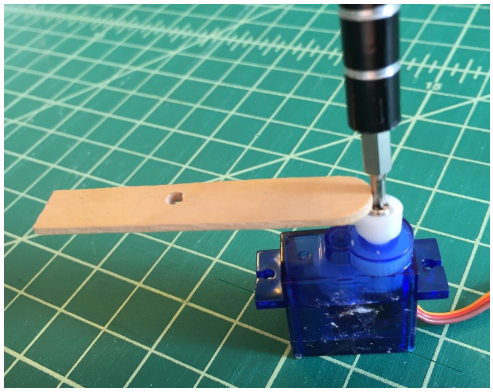


[c03f024]

Grab a 9g servo and take out the longest single-sided servo arm. We'll be extending the arm by hot gluing a craft stick to it. Cut the small craft stick down to about 2 inches, drill a small hole at 1 1/4 inch and then glue the servo horn to the stick with hot glue.

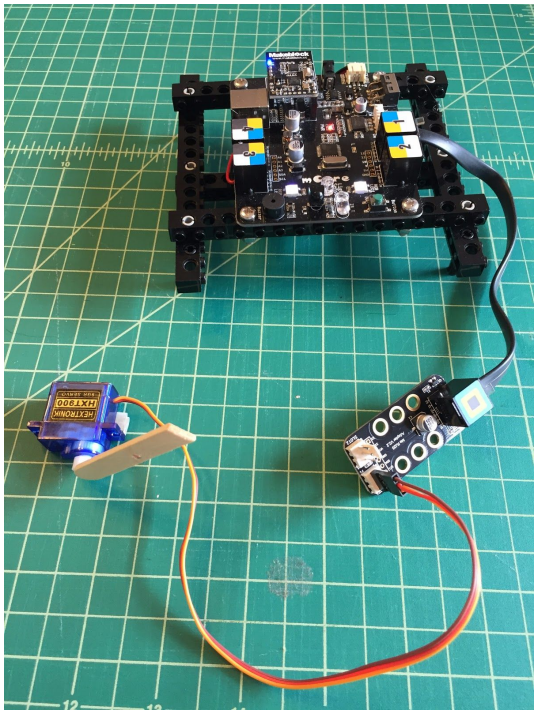
[c03f025]

Press the servo arm and stick extension down onto the servo top, and turn it all the way to the left, with the servo oriented below. Reposition the stick extension as shown below, then screw the servo arm into place, using the short self-tapping screw provided with the servo.



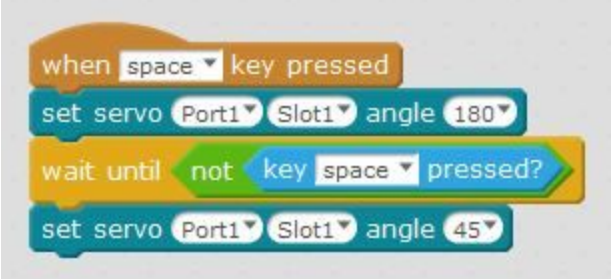
[c03f026]

Connect servo to the RJ25 adapter (see page _____) for details. Plug servo into Slot 1 and mCore Port 1.

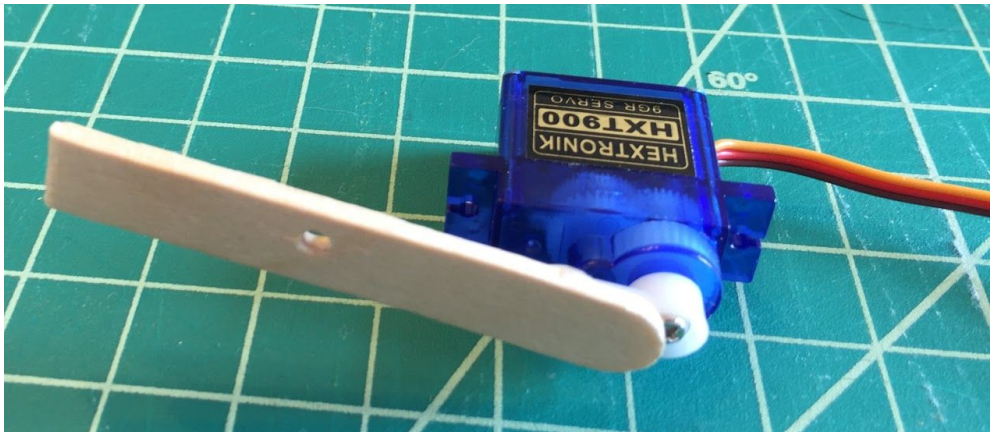


[c03f027]

Program and run the following.

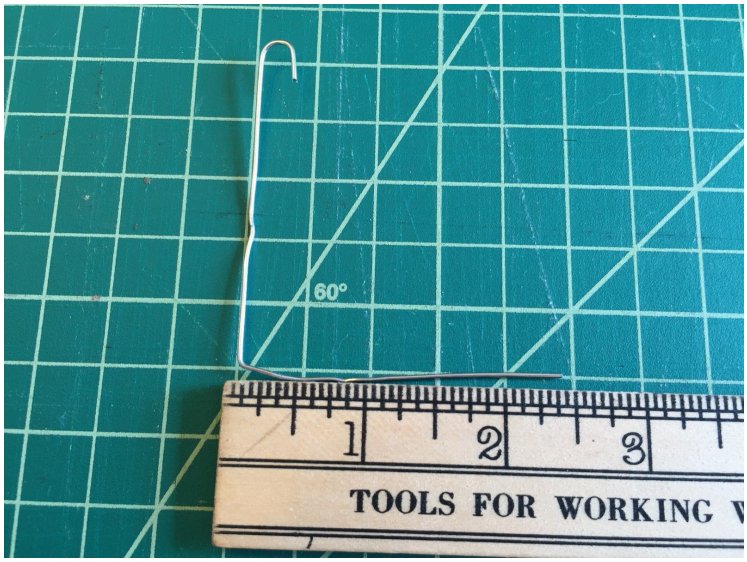


[c03f028]
The servo should rotate between the two positions



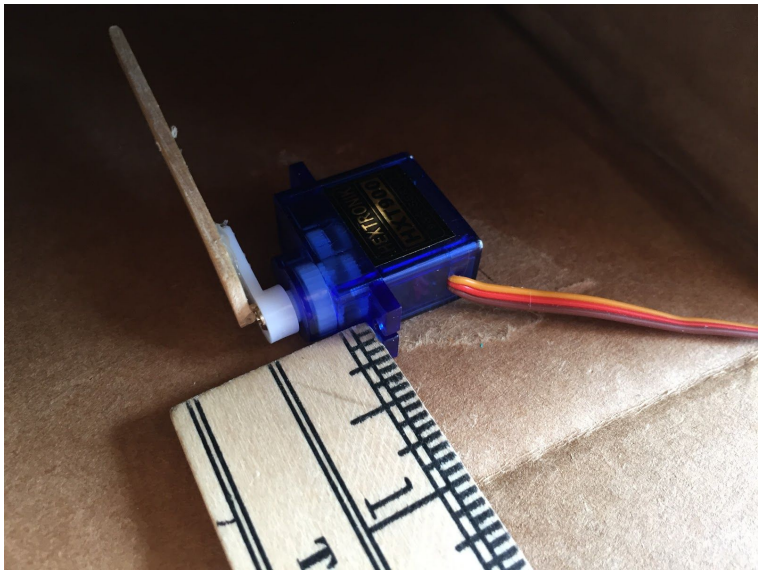
[c03f029]

Using long nose plier, bend the jumbo paperclip into the following shape with 2 1/2 inch legs on both sides.

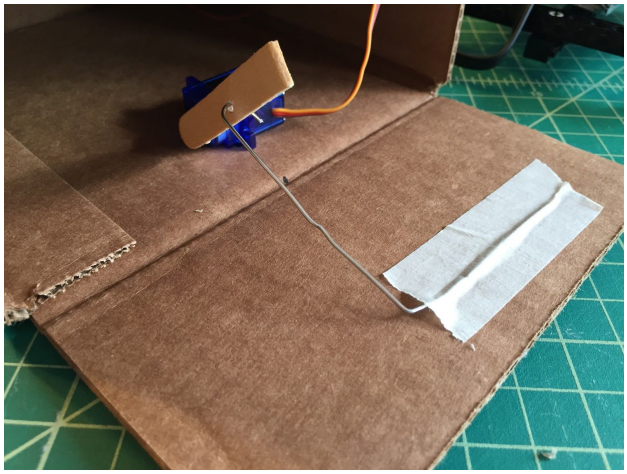


[c03f030]

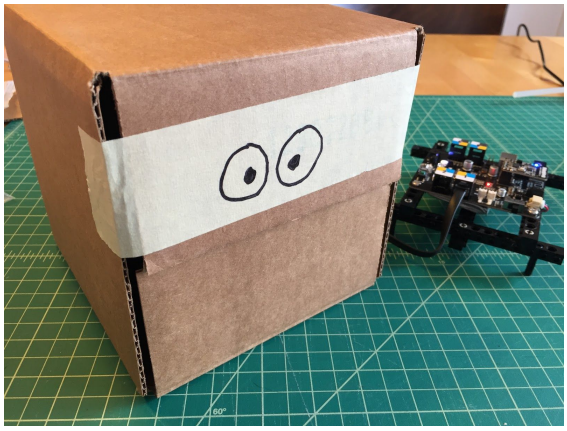
Measure 1 inch from the front of the box. Mount the servo to the inside of the box



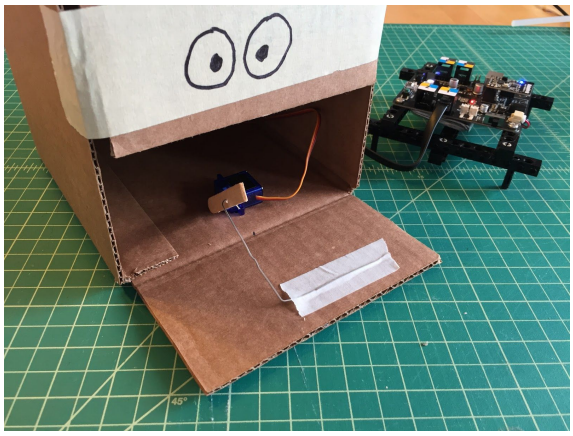
[c03f031]
Hook the paper clip through the hole in the wooden craft stick, then rotate the servo towards the front of the box. Then tape the paper clip down to the flap. Once you know your “mouth” is working correctly, you can add remove the tape and replace with a generous amount of hot glue.



[c03f032]
Your “mouth” should now open and close using your space bar as the trigger.



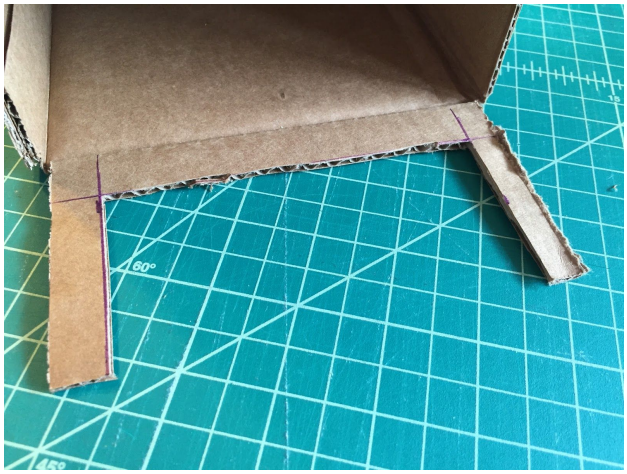
[c03f033]



[c03f034]

Project: Rotating Eyes using 9g Servo and RJ25 adapter

For this project, you'll be using the same box from the previous moving mouth project along with a cardboard toilet paper tube, servo horn and masking tape. Take the tape off the flap above the moving mouth (that has the drawn on eyes) that you built in the previous project.



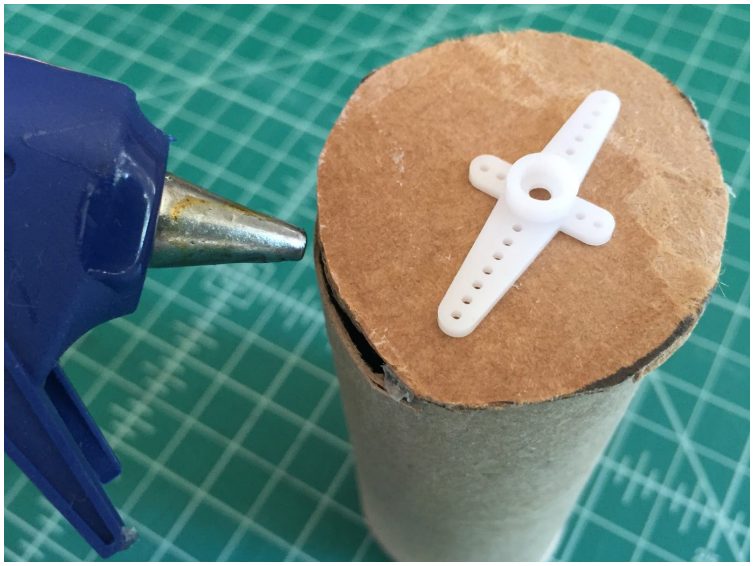
[c03f035]

Flip the box over, leave a ½ inch border on three sides of one flap as shown, and then cut out the bulk of the flap with a hobby knife as shown above. This is where you'll be building your rotating eyes. Save the scrap as we'll be using it a future step.

[c03f036]
Take a cardboard tube, trace a circle around it on another piece of scrap cardboard, and then cut out that circle.

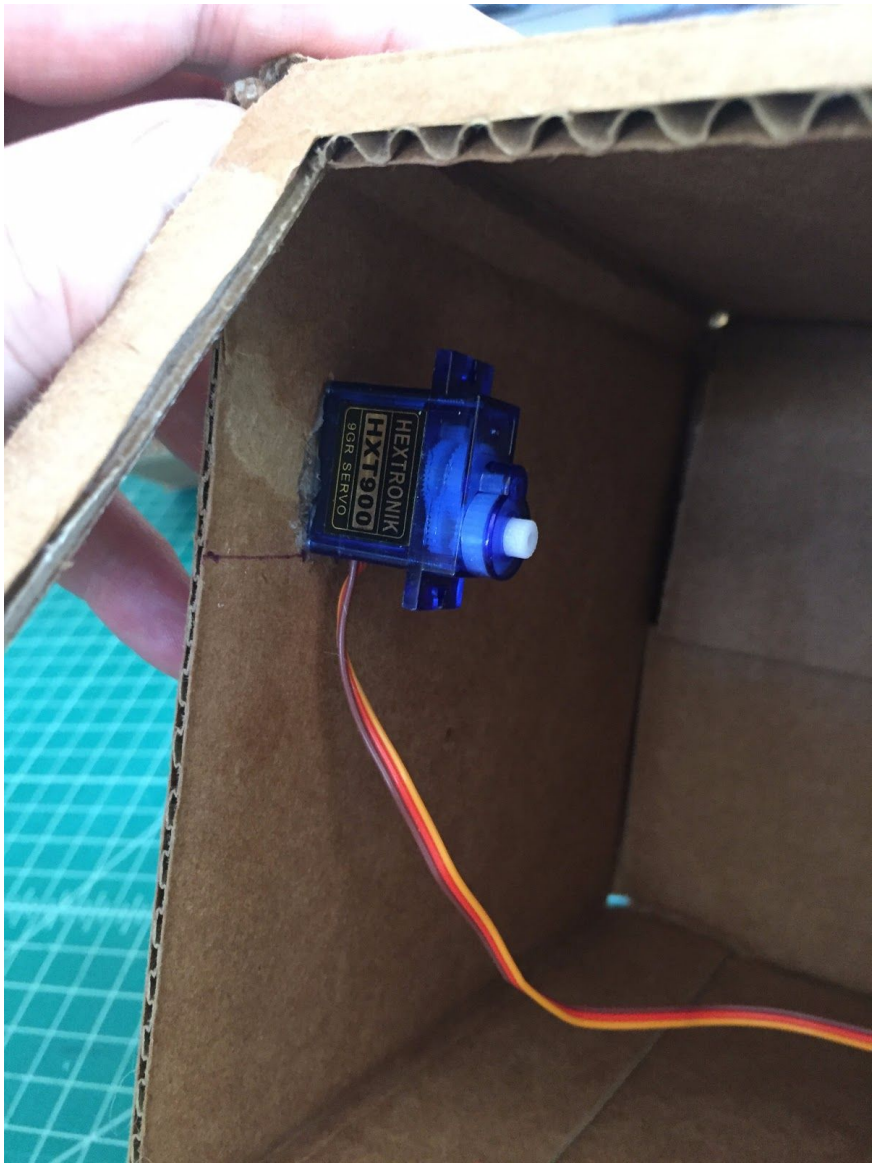
[c03f037]

Hot glue the servo horn to one side of the cardboard circle with area of the servo horn that attaches to the servo as close to the middle as possible.



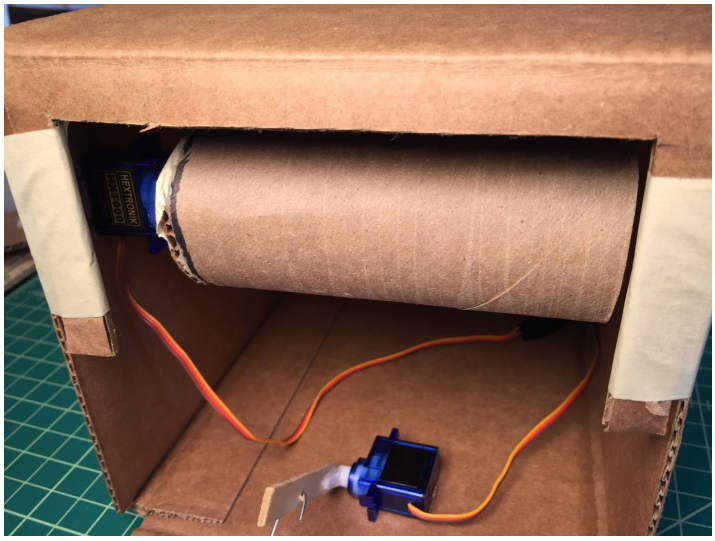
[c03f038]

Now hot glue the circle onto one end of the cardboard tube.



[c03f039]

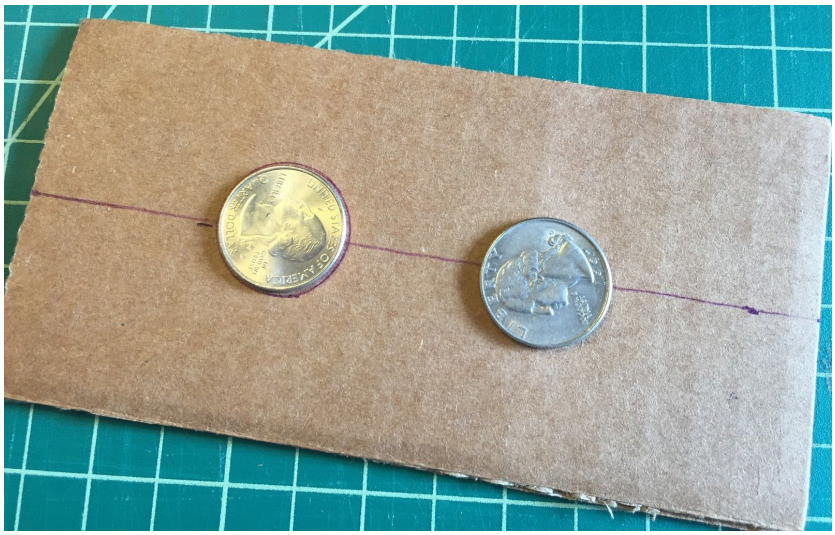
Measure and mark on the upper inside left of the box 2 ¼ inches down from the top and 1 ¼ inches in from the front. Use a generous amount of glue on the bottom of the servo and glue the servo to the side of the box lining up the bottom right side of the servo up with your mark.



[c03f040]

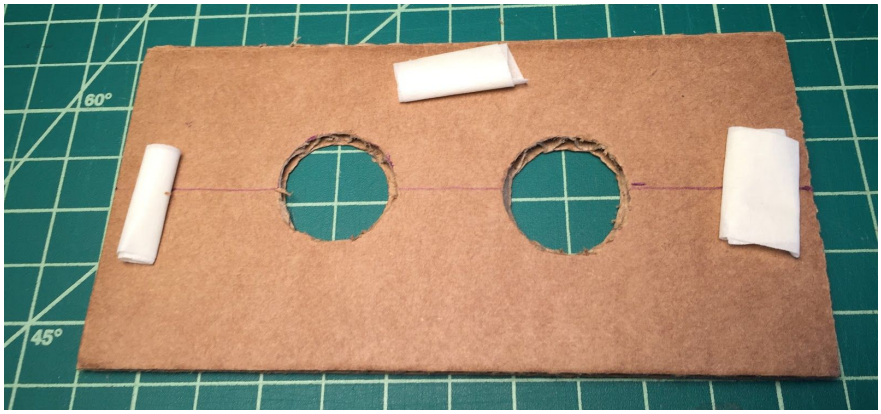
Going back to your box, flip it over then tape the flap attached to the box (opposite the moving mouth) down on each side as shown above.

.



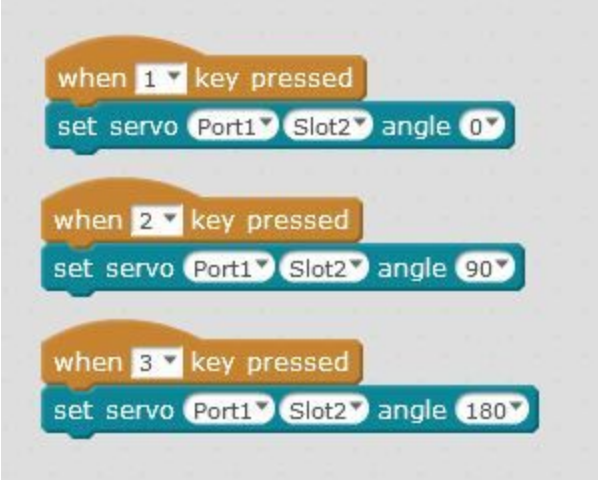
[c03f041]

On the flap scrap you cut from above, measure 1 ½ inches down on both side and draw a connecting line. Center two quarters on the line, draw a line around them and then cut holes in those locations. This is where the rotating eyes will line up.



[c03f042]
Double up tape and attach to the box over the rotating tube

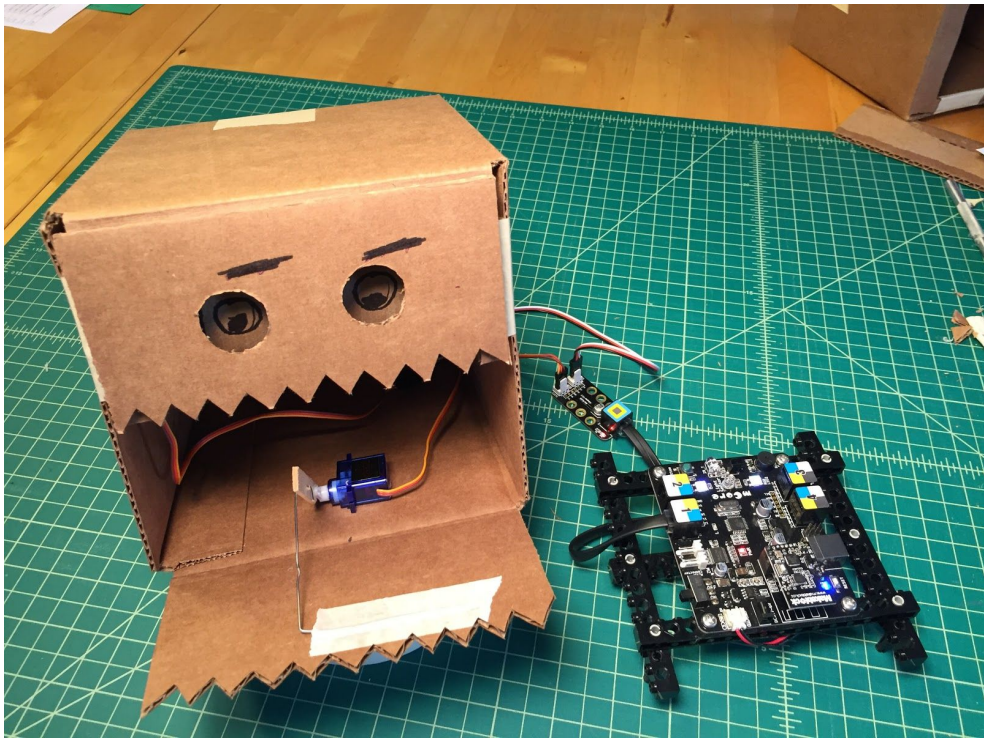
Write the code on SCRATCH and then run the program. The “eyes” will rotate between three positions.



[c03f043]
With a pencil, reach inside the eye holes and mark the eyes in each of the three positions 1-2-3. Then remove the eye holes and draw in three eye designs that you’ll switch between.

[c03f044]

Take of the eye holes and then with a Sharpie draw in three different eye shapes. Have someone hold the space bar in place as you draw in your three different eye designs that you'll switch between. Then add back the eye holes and you're done! We also added a serrated edge to the both sides for a mouth effect. Have fun customizing your own!



[c03f045]

Combine the eyes and mouth using the following code. By pressing the 1, 2, and 3 keys, you'll move the eyes into the different positions. The space key will open and close the mouth.

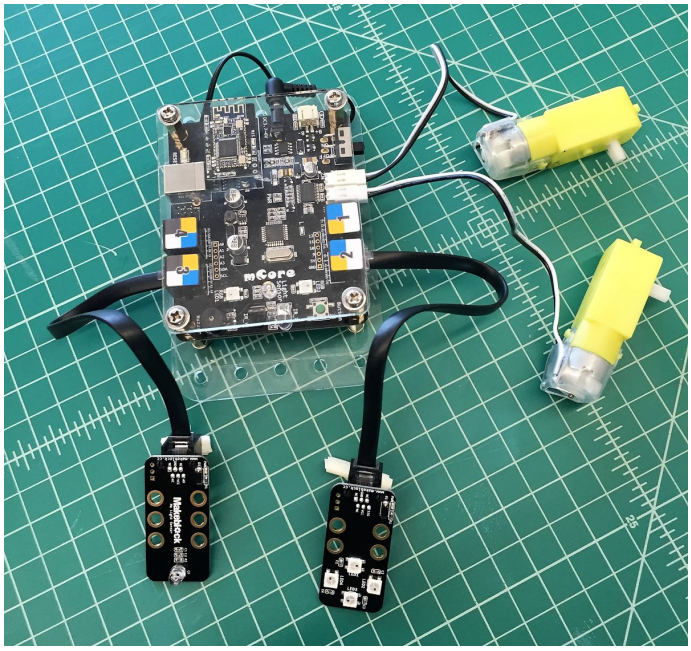
[c03f046]

Puppet Movement with Sensors

The projects so far in this chapter have been preprogrammed for random or set movements without sensors. Now we're going to add some interactivity where your creature senses the environment and responds according to your custom program

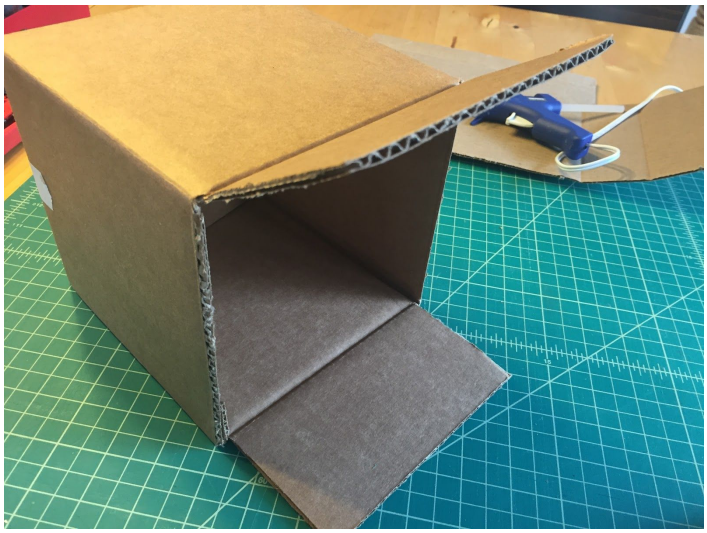
Project: "Feeding" your creature using the light Sensor

With this project, we'll use a light sensor that senses when your creature is "fed" to trigger a couple of motors to spin the ears of your creature.
For this project you'll need the two geared motors, a light sensor and an LED. We'll attach the two motors inside the cardboard box and wheels on the outside where we'll make and attach some whimsical ears to the wheels. Then we'll affix the light sensor and LED inside the "mouth". When we "feed" the creature a piece of cardboard food, the ears will spin! This is basically what the connections will look like.



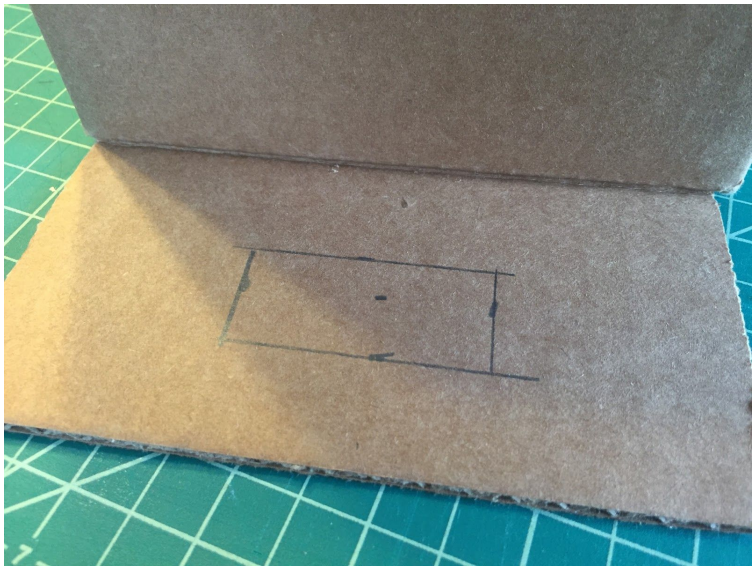
[c03f046]

Starting with a fresh 6x6x6 box or box of your choice, tape the back of the box up then cut off the side flaps on the other side as shown



[c03f047]

Cut a 3/4 inch x 2 inch hole in the bottom flap.



[c03f048]

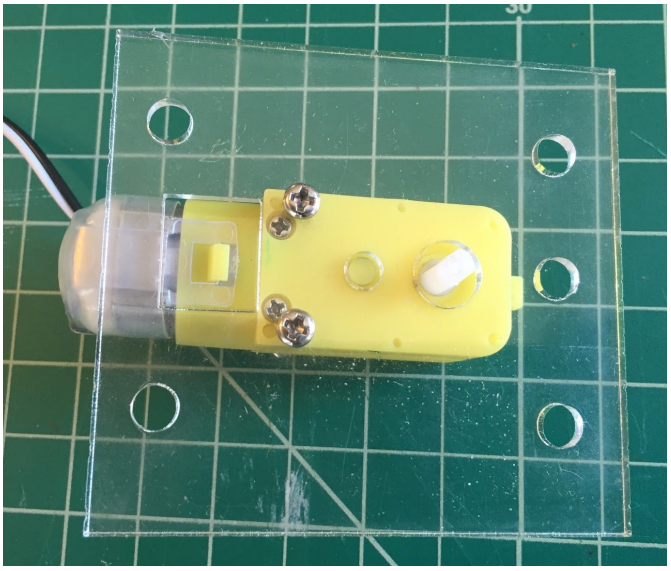
Using a 1 ½ inch hole saw, cut a hole in the upper corner of each side as shown. I measured 2 inches from the top and 2 inches from the side.

[c03f049]

You can clean up the hole with a hobby knife.

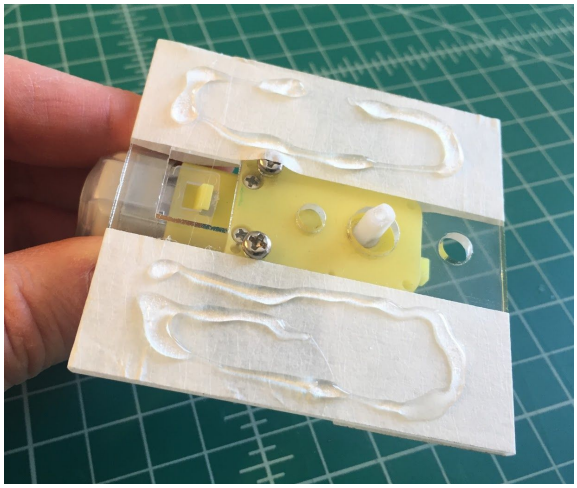
[c03f050]

It’s easier if you mount the motors to a laser cut motor mount first. Laser cut a mount out of acrylic using these _____ files. If you don’t have a laser cutter, you can print a full-scale PDF and cut by hand using a material of your choice. The additional holes in the mount are sized accordingly if you want to connect the motors to Legos or other Makeblock accessories.



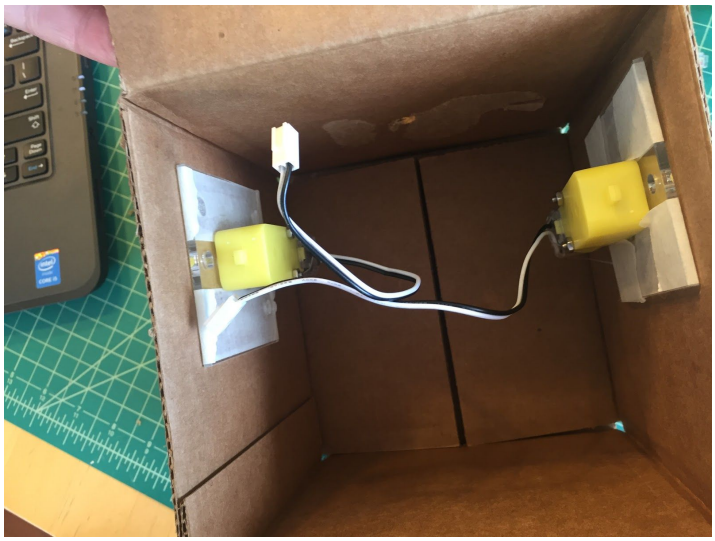
[c03f051]

Put masking tape on the acrylic motor mount so that it’s easy to remove later, then hot glue on the masking tape

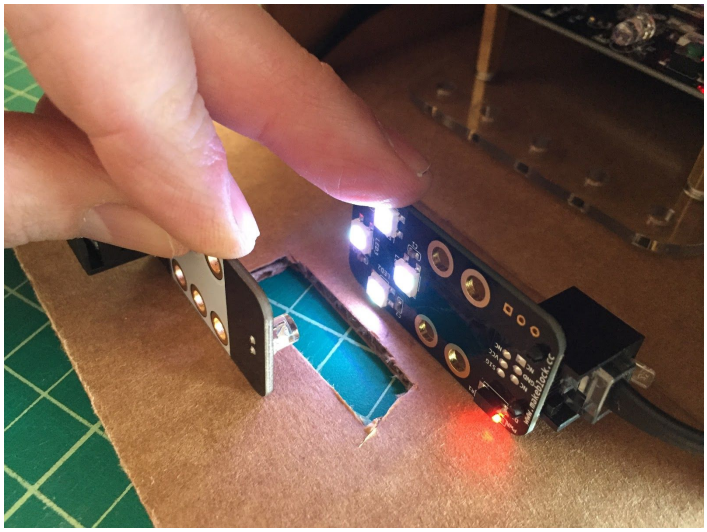


[c03f052]

Position the motor mounts inside the box with the motor hubs centered inside the holes. We'll add the white plastic wheel hubs later.

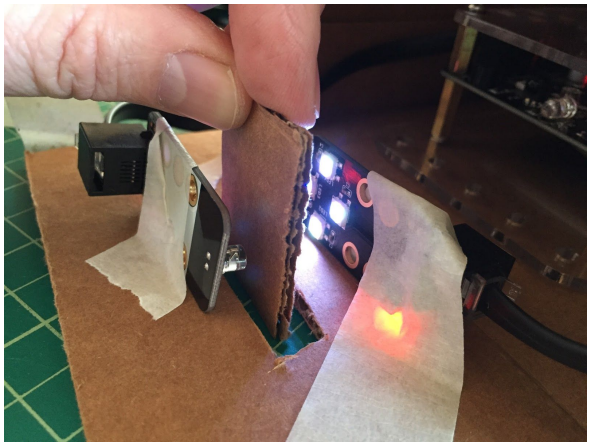


[c03f053]



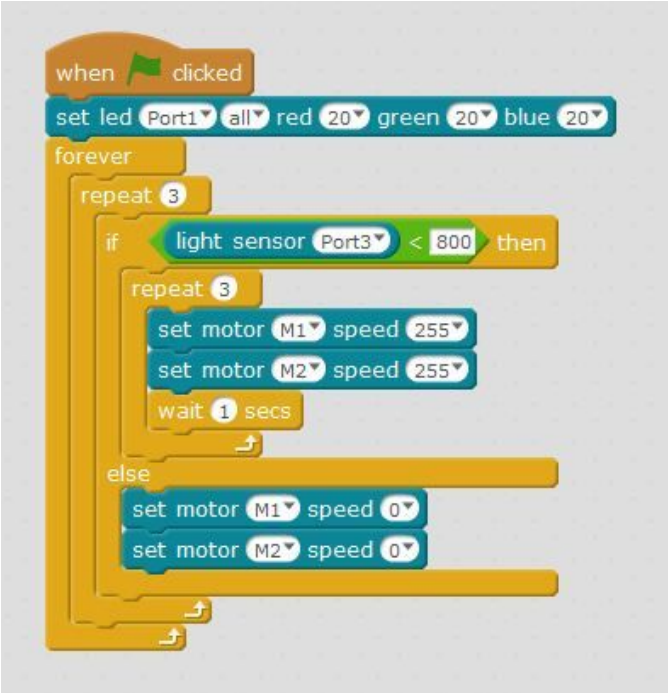
[c03f054]

The moving ears that you'll be creating, will be triggered when the light between the RGB LED Sensor and the Light Sensor is blocked by a small piece of cardboard that is the creatures "food. Once you have the LED Sensor and Light Sensor positioned, you can tape them in place. Then connect the RGB LED to Port 1 of the mCore and the Light Sensor to Port 3 of the mCore. The motors can be connected to M1 and M2.



[c03f055]

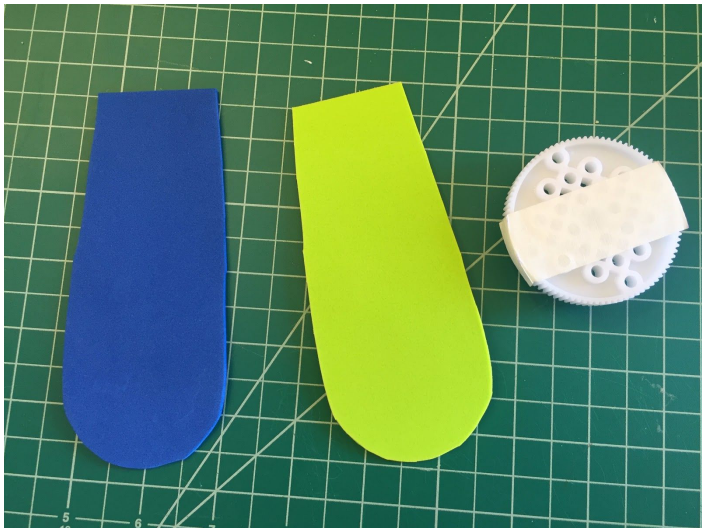
Code the following in mBlock and send to your mCore. The code will turn on the LED then trigger the motors (M1 and M2) when the light going to the light sensor is interrupted.



[c03f056]

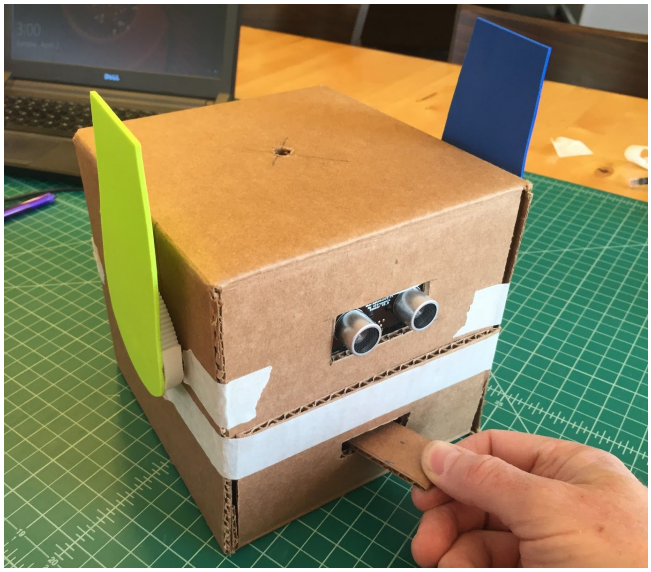
Now we'll add some fun "ears" to the wheel hubs using foam sheets. Cut the ears out of foam, apply masking tape to the plastic wheel hubs, then glue the ear on with hot glue.

[c03f057]



[c03f058]

Now when you “feed” your creature through the mouth, the ears will turn as programmed. The creature will look like the one below. Not to be confused, the picture below also has an Ultrasonic Sensor attached mounted on the front that will be part of a different project.



[c03f059]

Project: Propeller spins with Ultrasonic Sensor

For this project, you’ll need the ultrasonic sensor and one of the geared motors. When your creature is approached, a propeller on its head starts to spin!

Close up and tape one side of the box. Drill a 5/16 inch hole in the top center of a box.

[c03f060]

Mount the geared motor to a laser cut acrylic motor mount and cover the motor mount with masking tape.

3D print the gear hub to 1/4 inch dowel connector and insert onto the gear hub.

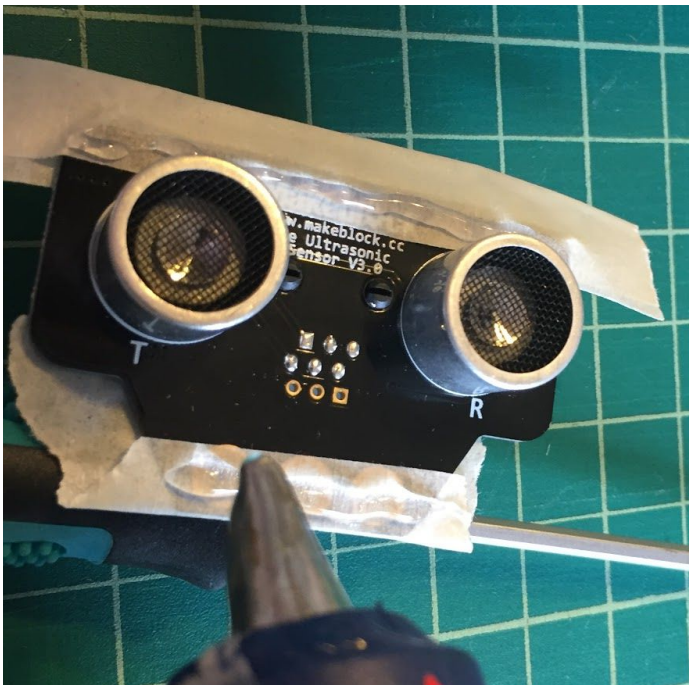
Add hot glue to the tape on the motor mount and glue to the top of the inside of your box so the 3D printed adapter sticks out the top.

[c03f061]

[c03f062]

Cut a 3/4 inch x 2 inch hole in the upper front flap.

Cover the Ultrasonic Sensor with tape, apply hot glue and attach to the inside of the flap. The tape will protect the sensor from the hot blue and allow you to easily remove it later.



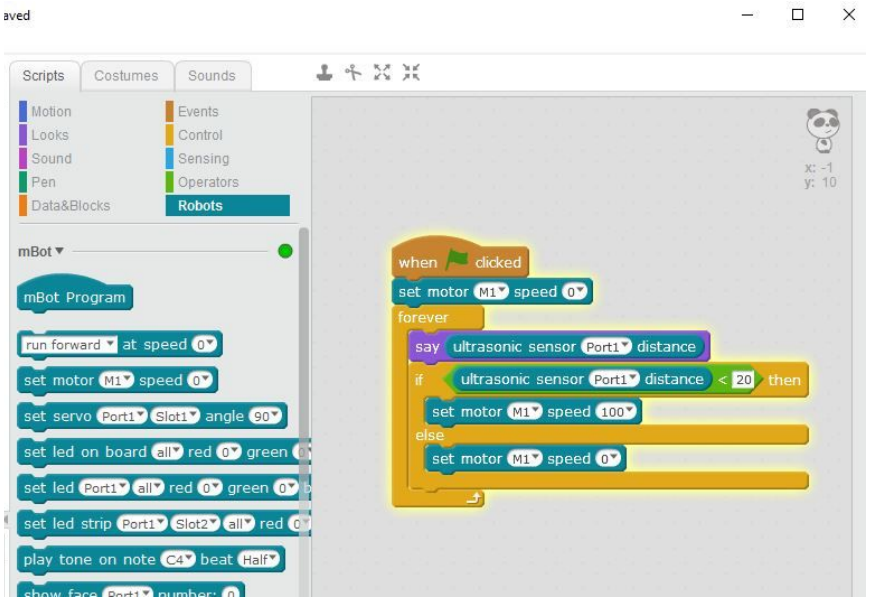
[c03f063]

Mount the Ultrasonic sensor to the front of your box so that the “eyes” are exposed.

[c03f064]

Connect the Ultrasonic Sensor to Port 1 and the Motor to M1.

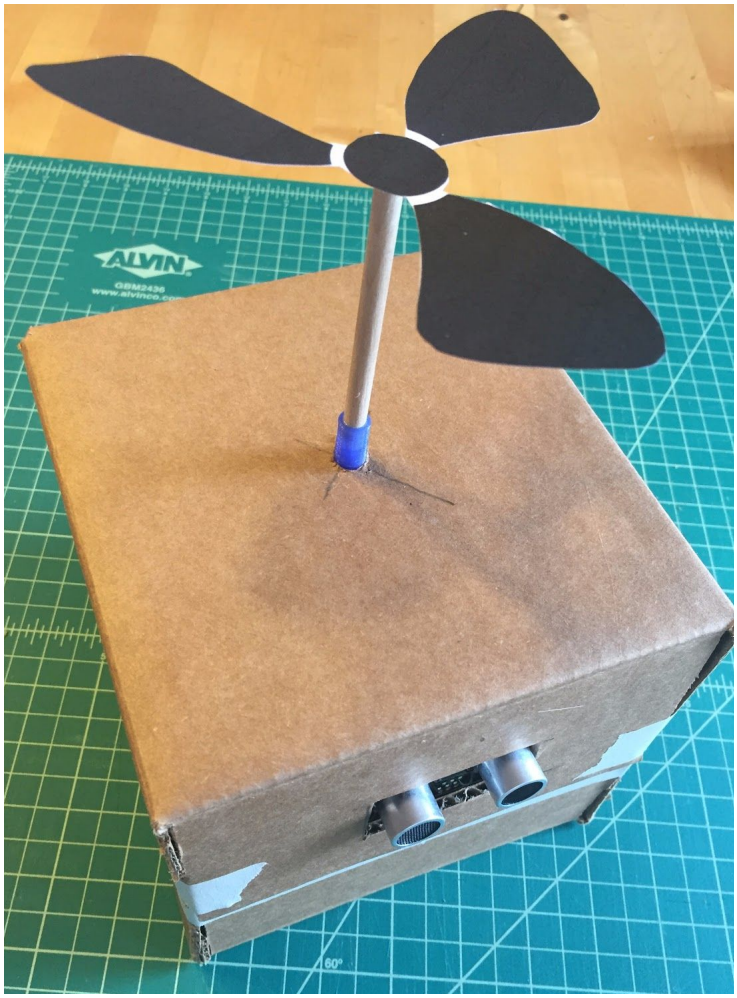
[c03f065]
Write and run the following code as a starting point. The Ultrasonic Sensor will sense your movement trigger the motors. You can adjust the distance the Ultrasonic Sensor begins to react. Here it's set at 20.



[c03f066]
If you add a "say" command to your Ultrasonic Sensor, then you'll know it's working as the data input changes in the Panda's speech bubble. This one is set to 400. As you approach your creature, the motor should turn on.

[c03f067]

I added a 6 inch long 1/4 inch dowel to the 3D printed adapter and attached a propeller printed on card stock to the top. This is where you can have fun customizing your creature with whatever your imagination come up with!



[c03f068]

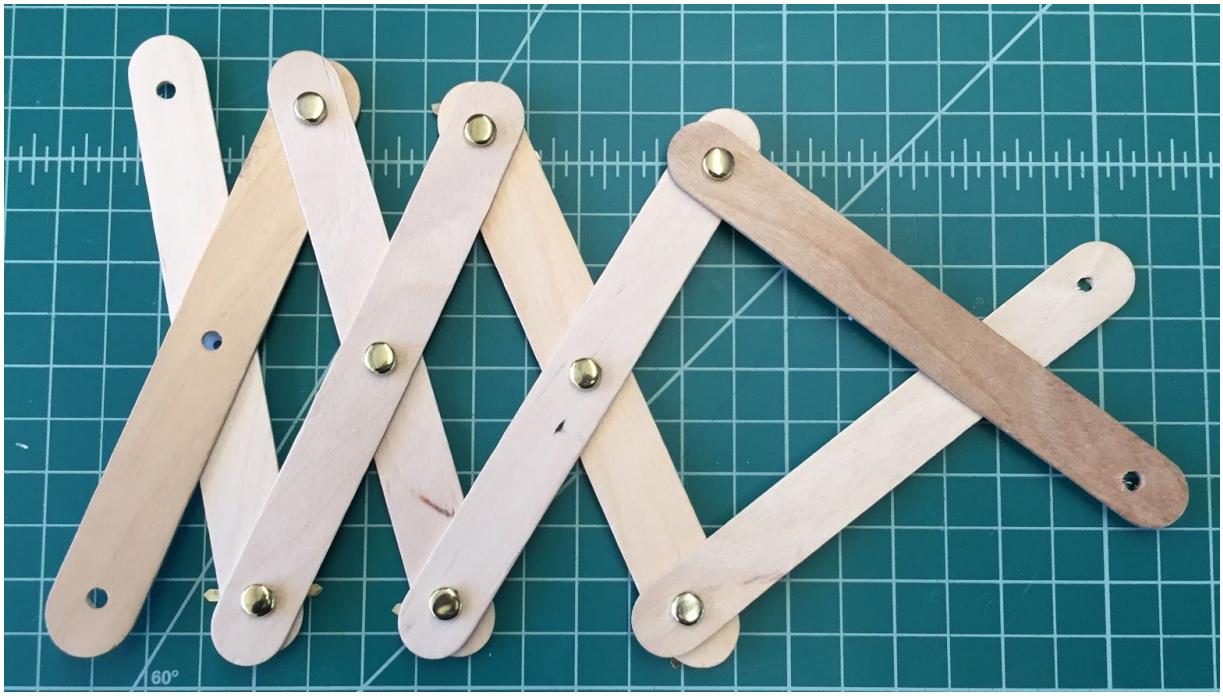
Project: Servo Arm with Paw Reaches Out when Motion is Sensed

When your creature is approached, a servo linkage arm will reach out.

Sometimes the circular motion of a servo or motor isn't exactly what you need for your creation. That's where mechanisms come in! Circular motions can be converted to all kinds of other motions. Hundreds of websites exist to show how to turn a simple circular motion into other motions. Several are listed at the end of the chapter, but the one we're going to focus here on using a scissor linkage for a hand or paw in this case, that reaches out.

Grab eight large craft sticks and some brads to build the grabber.

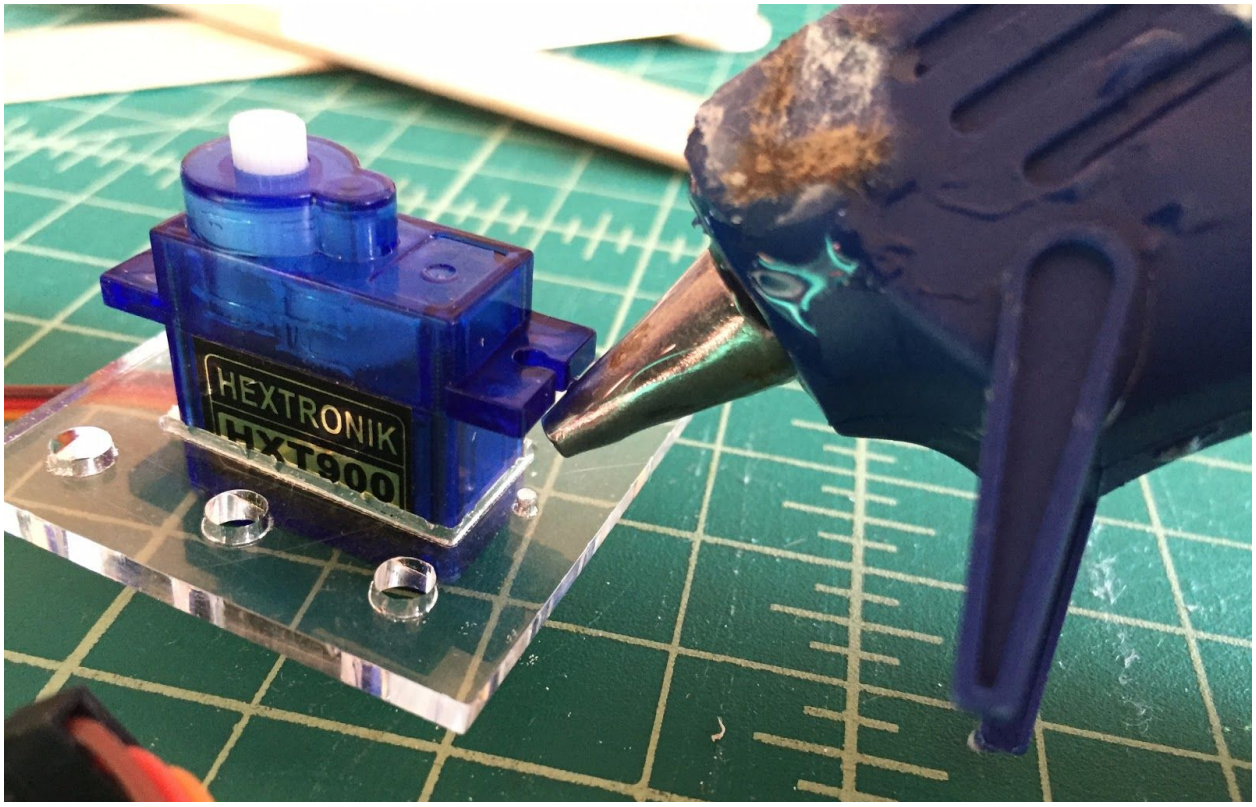
Drill 5/32 inch holes in both ends of the crafts sticks and one in the middle. It works well if you stack the sticks and drill them all together so you get the holes in the same place. Then insert brads as shown.



[c03f069]

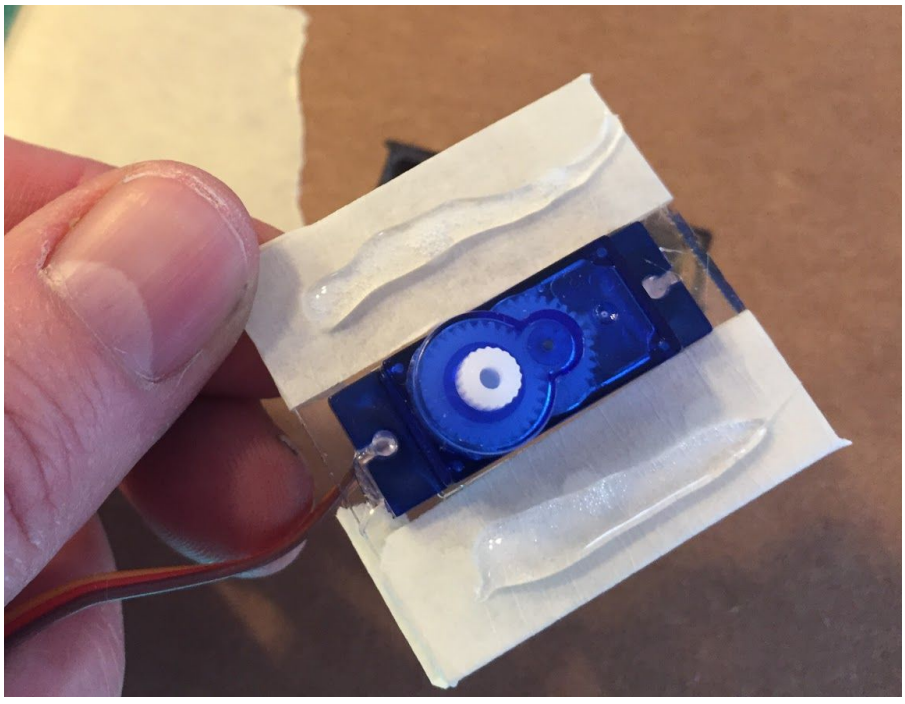
Decide which side of the box you want to attach the linkage or maybe you want them on both sides with two servos! Cut a 3/4 inch x 1 3/4 inch slot in the box near the top center as shown.

Glue your servo to a laser cut acrylic servo mount.

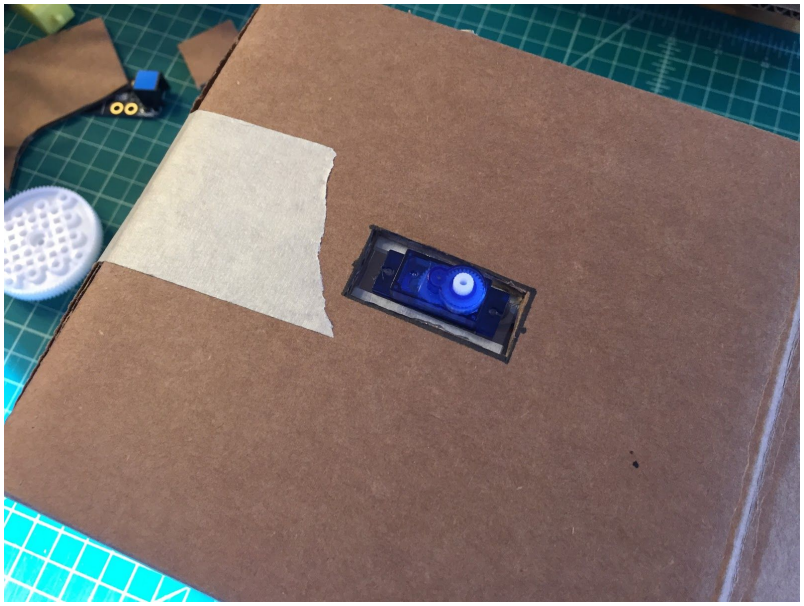


[c03f070]

Cover the servo mount in masking tape then add hot glue and tape inside the box with the servo centered.

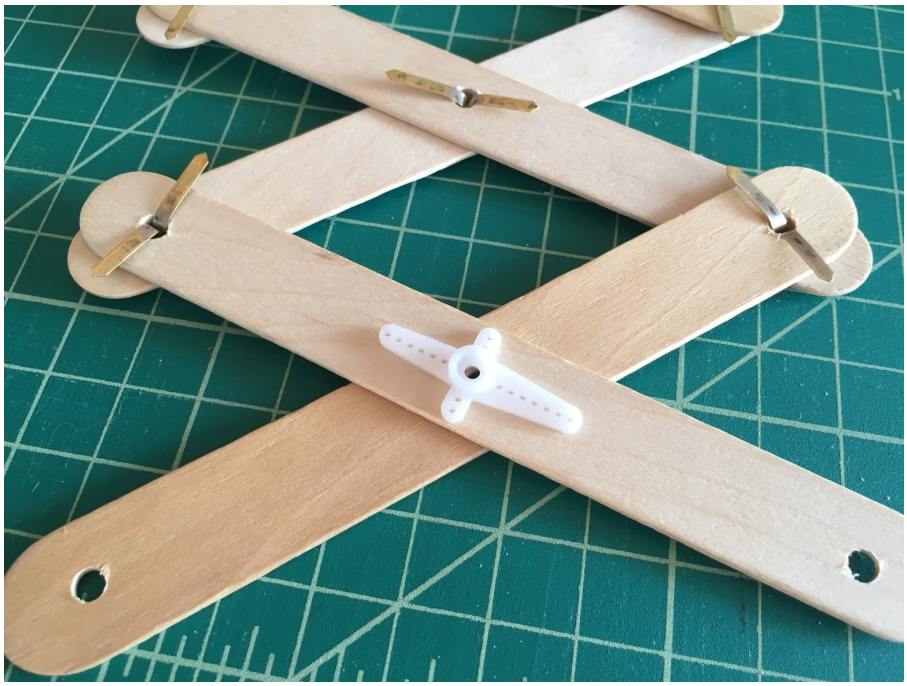


[c03f071]



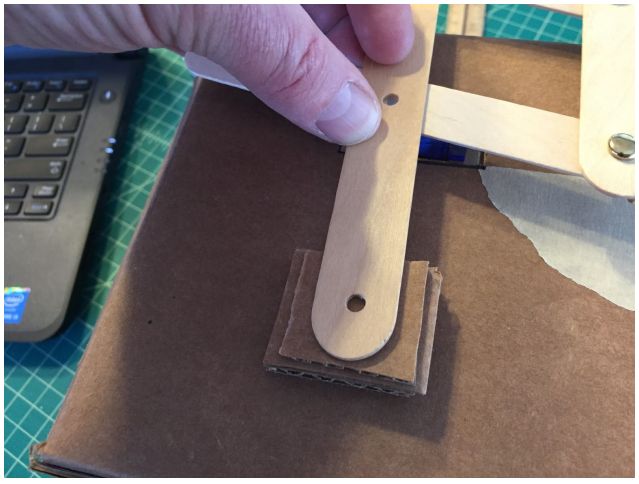
[c03f072]

Grab your servo linkage arm and a servo horn. Flip the scissor mechanism over and then glue the servo horn over the third center hole that does not have a brad. See pictures of linkage arm above.



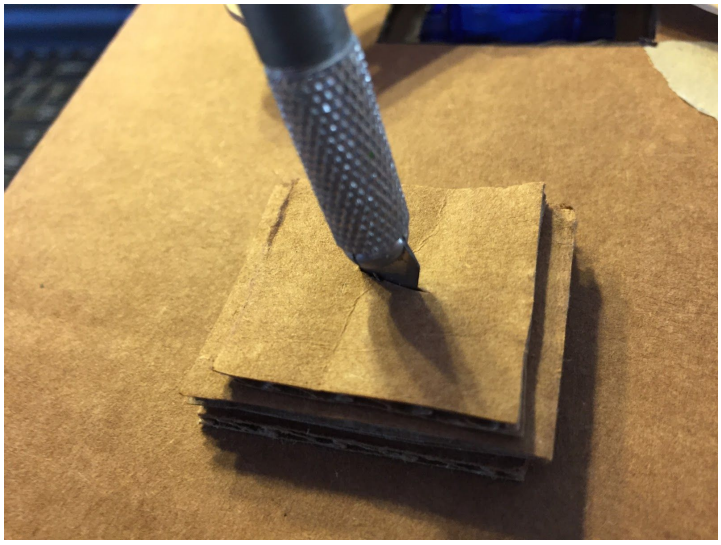
[c03f073]

Test fit the servo horn onto the servo, then on the bottom end of the same craft stick as the servo arm, stack up several layers of scrap cardboard until it is about level with the servo. Put a mark inside the hole so you know where to place a brad.



[c03f074]

With your hobby knife, cut down through the layers of cardboard.

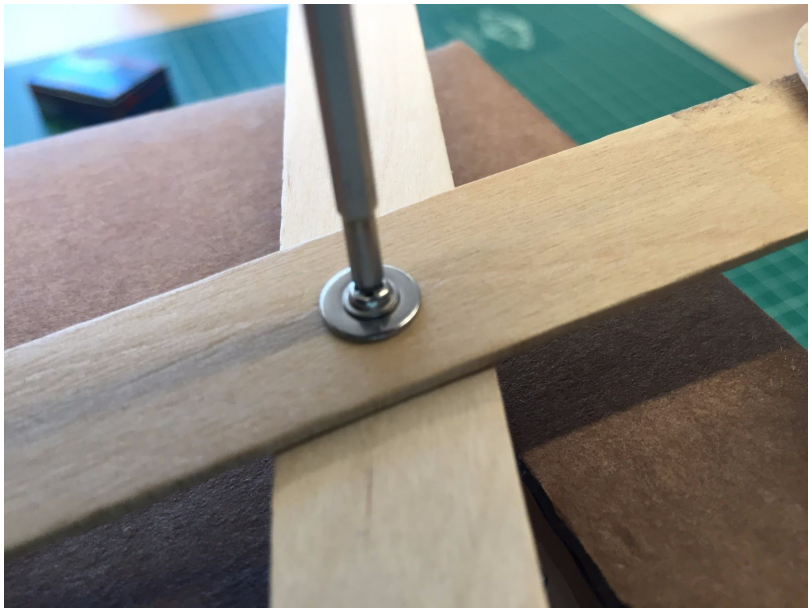


[c03f075]

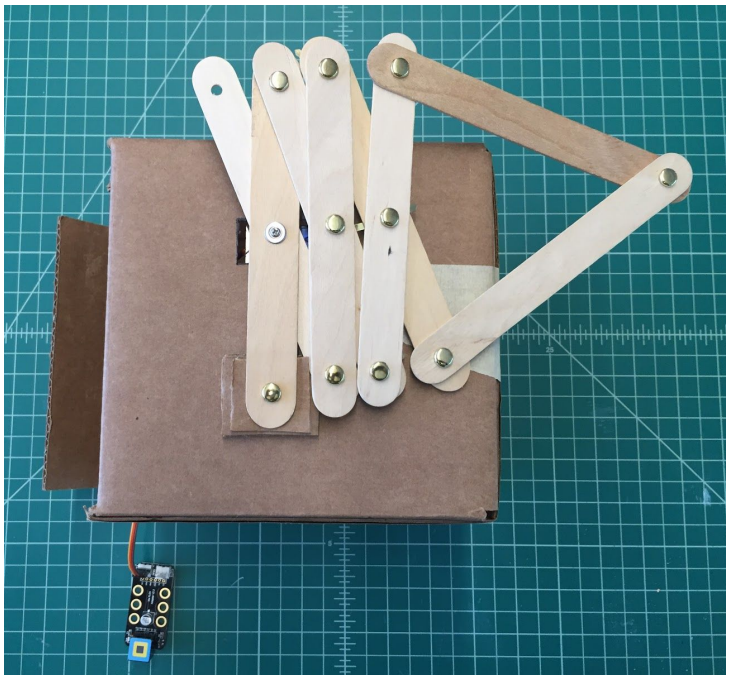
Then connect the whole assembly using a brad.

[c03f076]

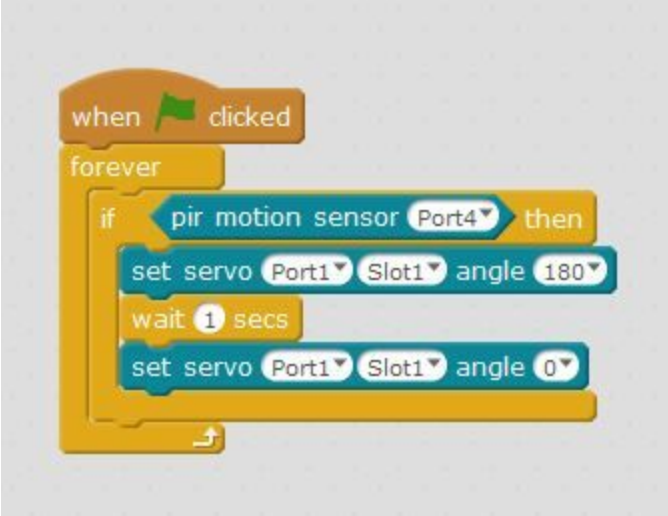
Once you have it programmed and the servo lined up, you can permanently attach the servo arm using a screw and washer.



[c03f077]
This is how it should look from the side.

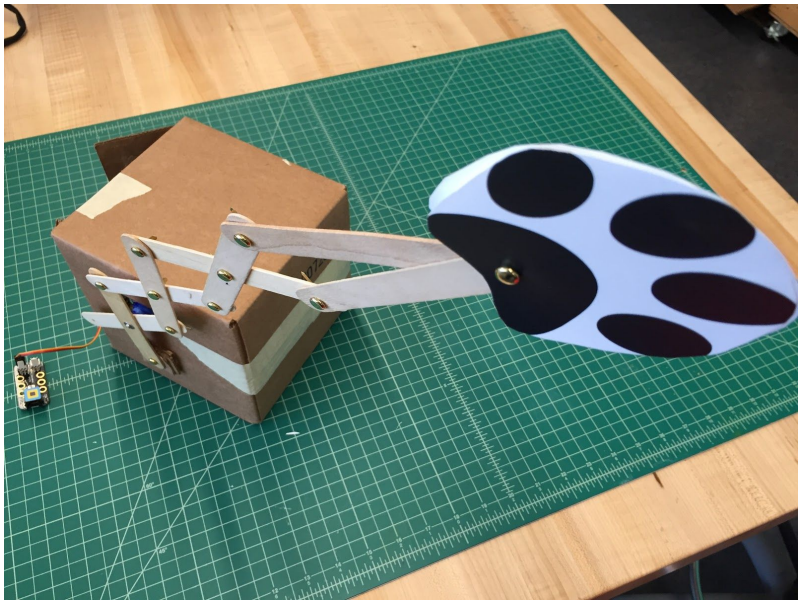


[c03f078]
Add your Motion Sensor through a hole in the front of the box and connect the servo to the RJ-25 Adapter. Next, connect the Motion Sensor to Port 4 and the RJ-25 Adapter to Port 1 on the mCore.



[c03f079]

Now attach your claw, hand or paw to the end of the scissor linkage and you're ready to go!



[c03f080]

Check the index for more linkage and mechanism resources.

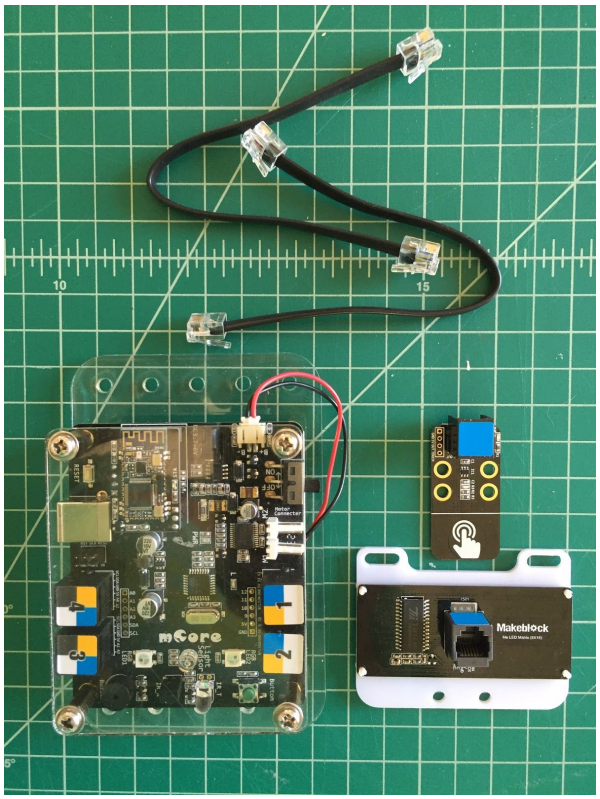
Automata - wooden/historical. Especially Tinkering Studio

http://tinkering.exploratorium.edu/cardboard-automata

Project: Touch Sensor Triggers Scrolling Message

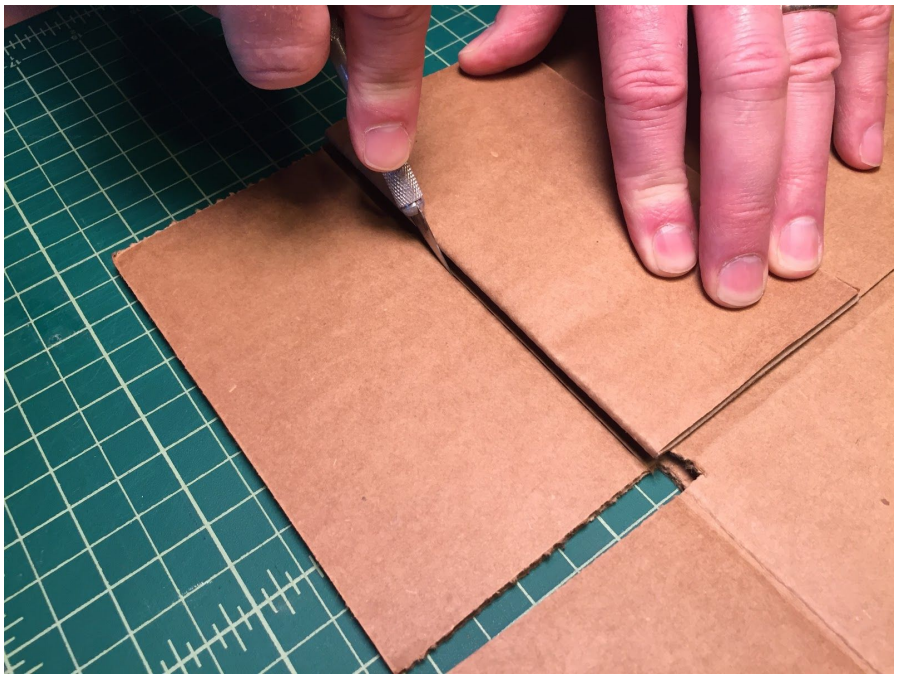
For this project when your creature is “petted”, a message appears on display! We’ll use the Touch Sensor and 8 x 16 LED Matrix display to make this happen.

Gather the following components.

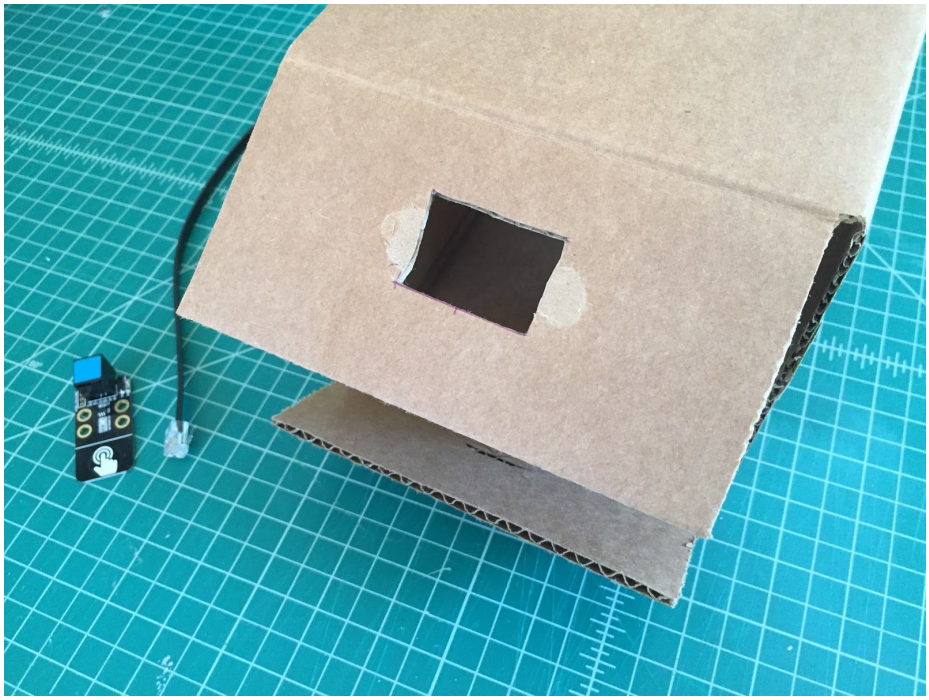


[c03f081]

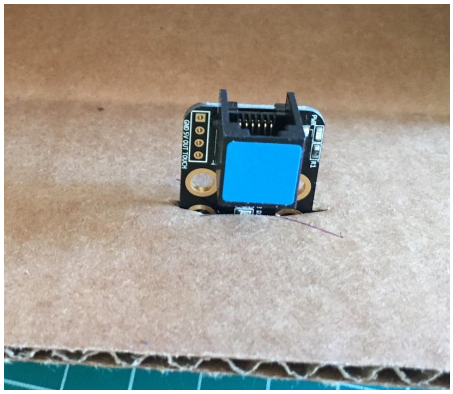
Lay the box flat and cut off the two flaps opposite of each other.



[c03f082]
Mark a 1 1/2 inch wide by 1 inch high hole in the top flap and cut out with a hobby knife. The LED Matrix will fit in here.

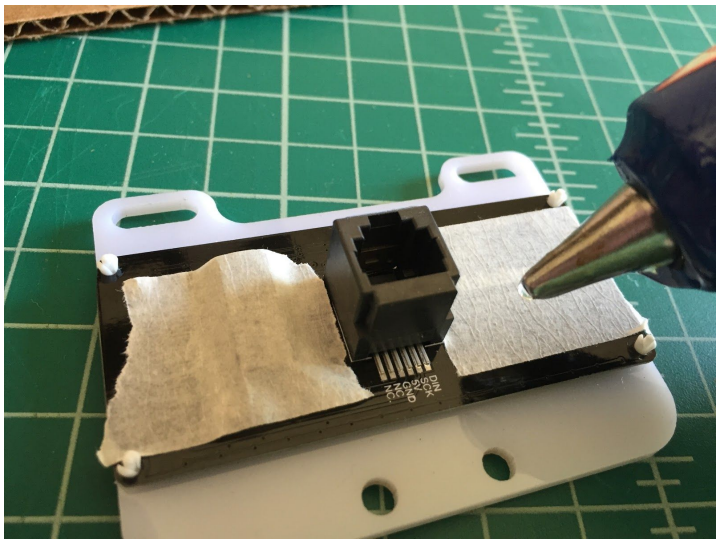


[c03f083]
In the bottom flap, cut a 1 inch wide slit in the middle with a hobby knife. The Touch Sensor will slip in here.



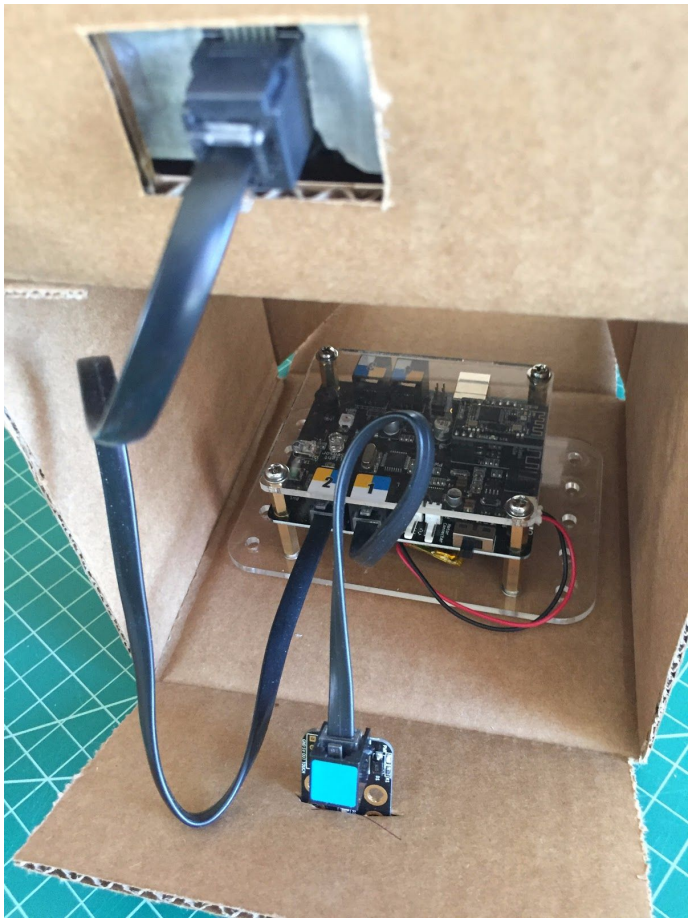
[c03f084]

Add masking tape and then hot glue to the back of the LED Matrix



[c03f085]

Plug the LED Matrix into Port 2 on the mCore and the Touch Sensor into Port 1.



[c03f086]

From the front it should look like the following.

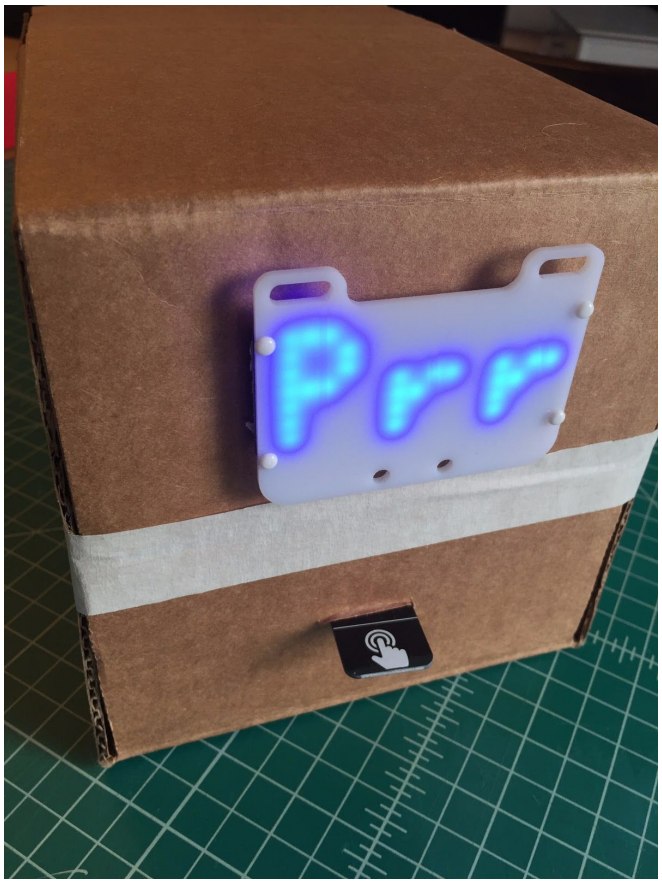
[c03f087]

Write the following code in mBlock.

[c03f088]

At this point, loading the program onto your mCore requires a bit more of an explanation. If you turn on your mCore and you hear the three tones, you have the Default Program loaded. The Default Program includes all the files for your IR remote, line following and Ultrasonic Sensor programs. These take up much space and DO NOT include the code needed to run the Touch Sensor. What you need to do is connect your mCore to your computer using a USB cable, open mBock and connect using whatever Com port is available under the Connect menu and Serial Ports. Once connected, select Upgrade Firmware on the Connect menu and it should go through the upload process to load the software needed for all the sensors including the Touch Sensor. Now when you boot up your mCore you should just hear just one short beep.

After Upgrading the Firmware and rebooting your mCore, connect your mCore via 2.4G Serial or Bluetooth. Now when the user touches the Touch Sensor ("pets" your creature) then a message will appear on the LED Matrix! Each time you touch the Touch Sensor, the message will start and stop. You have to keep "petting" to see what the entire message says.



[c03f089]

The projects in this chapter are just a starting point. Once you see how fun it is to set up and program sensors that trigger motors, servos and digital readouts, you're only

limited by your imagination. I've used a 6x6x6 cube box for most of the projects in this chapter, but you can use whatever you have available or works for your particular project. One thing I've discovered: when you give kids lots of creative supplies like colorful foam sheets, cardboard tubes, boxes of various sizes, feathers, pipe cleaners, wood sticks and other craft supplies, their minds and creativity come up with incredible things. The mCore and sensors provide the foundation for adding interaction to any creative endeavor.