



# Raspberry Pi Wifi-Controlled Cat Laser Toy

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<https://learn.adafruit.com/raspberry-pi-wifi-controlled-cat-laser-toy>

Last updated on 2024-06-03 01:23:01 PM EDT

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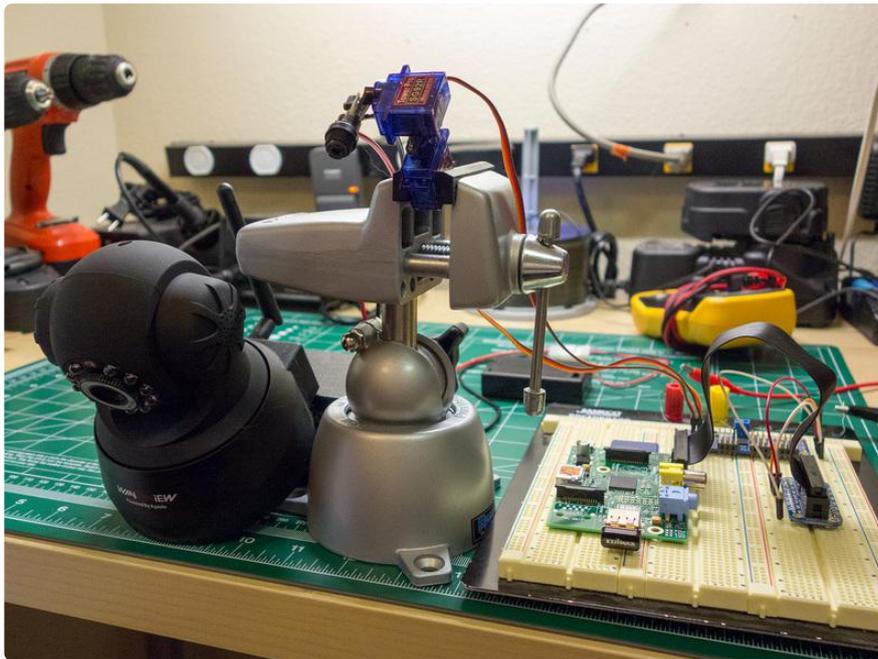
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# Overview and Requirements

This project will show you how to create a laser toy for your cat which is controlled over the web with a Raspberry Pi. The project demonstrates using a web application to control servos with the Raspberry Pi and an excellent way to keep your cat exercising when you're umm busy playing minecraft.

You can see an early version of the project on the [September 7th adafruit Show and Tell show \(~12 minutes into the show\)](https://adafru.it/cFL) (<https://adafru.it/cFL>)!



## Requirements

To build this project you will need the following:

- Raspberry Pi (either [model A](http://adafru.it/1344) (<http://adafru.it/1344>) or [B](http://adafru.it/998) (<http://adafru.it/998>) will work).
- Two servos, like [these micro servos](http://adafru.it/169) (<http://adafru.it/169>).
- Laser diode. You can [buy one](http://adafru.it/1054) (<http://adafru.it/1054>) or scavenge one out of a laser pointer (what I've chosen to do in this project).
- [PWM/servo controller](http://adafru.it/815) (<http://adafru.it/815>) based on the PCA9685 chip.
- Network camera that can output a MJPEG video stream. I use this [Wansview camera](https://adafru.it/cFM) (<https://adafru.it/cFM>), but [check for support](https://adafru.it/cFN) (<https://adafru.it/cFN>) from other brands such as Axis, Foscam, etc. See the note on video streaming below to understand why a network camera is used instead of a webcam or other video source.

You will also need basic tools and supplies such as a hot glue gun (or other means of fastening servos and laser diode), a power supply for your laser diode and servos (your Pi's 5V output is not powerful enough alone--use a battery pack, wall wart, or bench supply), and wires to connect the Raspberry Pi GPIO to the servo controller board. A breadboard and [Pi Cobbler \(http://adafru.it/914\)](http://adafru.it/914) [breakout \(http://adafru.it/914\)](http://adafru.it/914) are perfect for this project.

This project assumes your Raspberry Pi is running the Raspbian operating system, is connected to your network, and is setup to enable I2C communication. If you use a distribution such as [Occidentalis \(https://adafru.it/aNv\)](https://adafru.it/aNv) much of this setup is done for you already. However if you need to setup your Raspberry Pi, follow these guides:

- [Lesson 1. Preparing an SD Card for your Raspberry Pi \(https://adafru.it/aWq\)](https://adafru.it/aWq)
- [Lesson 2. First Time Configuration \(https://adafru.it/aUa\)](https://adafru.it/aUa)
- [Lesson 3. Network Setup \(https://adafru.it/aUB\)](https://adafru.it/aUB)
- [Lesson 4. GPIO Setup \(https://adafru.it/aTH\)](https://adafru.it/aTH)

Finally, the web application that is used in this project will only work on Chrome, Safari, or Firefox web browsers. Unfortunately Internet Explorer does not support MJPEG video streams in image tags, which is a required part of using the application.

## Video Streaming Note

In building this project I found network video cameras, such as those used for security and monitoring, work best for streaming video. I attempted to use a webcam that streamed video to sites such as Ustream or Livestream, but found the latency of those streams was extremely high--on the order of 10-15 seconds. With such high latency it is not possible to control the laser through the web in real time. I even tested setting up my own video streaming server with Amazon EC2 CloudFront, but still could not get a low enough latency video stream.



In addition to high latency, I also found embedded video streams (such as from video streaming web services) are not easily adapted for the control needs of this project. The problem is that web browsers enforce a strict cross-domain security model which does not allow a video embedded in an iframe or object (the typical means for embedding web video) to expose click and other events to the parent web page. This means targeting the laser with clicks on the video is not possible (at best you could present a 'track pad' target area below the video, or a joystick/direction pad control for manual movement--neither is as ideal as targeting directly from the video).

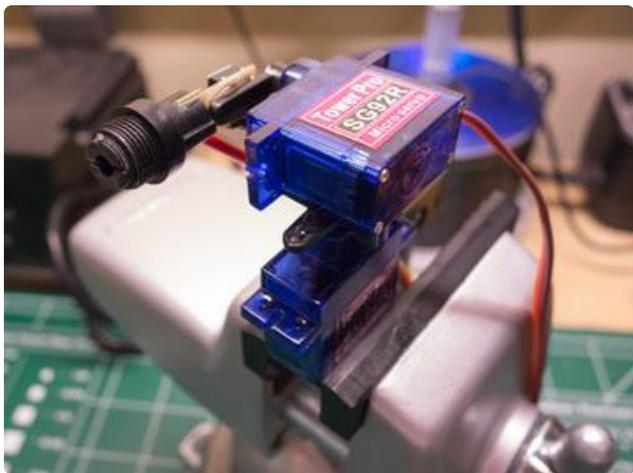
Using a network video camera that outputs an MJPEG video stream solves both these problems by having low latency encoding (at the expense of higher bandwidth compared to more modern video codecs), and the ability to embed directly in an image tag which is not subject to as strict cross-domain security restrictions.

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# Hardware Setup

## Servos and Laser

Attach one servo to the other at a 90 degree angle, and the laser diode to the arm of the top servo. This setup will allow the bottom servo to control laser rotation left and right, and the top servo to control laser rotation up and down. See the photo on the left for what you want to create. Perfect alignment of the servos and laser are not critical as the software will calibrate the aim of the laser.



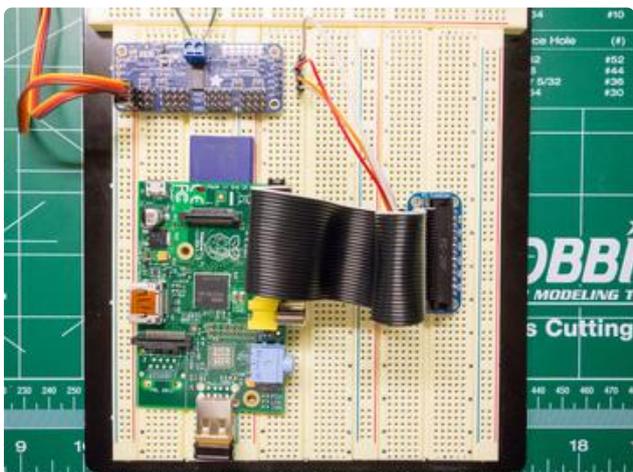
To attach the servos and laser I found hot glue was the simplest method. You can later [remove the hot glue \(https://adafru.it/cFO\)](https://adafru.it/cFO) using rubbing alcohol when you're done with the project.

Mount the servo & laser assembly onto something which allows you to angle the setup up and down, such as a [small vise \(http://adafru.it/151\)](http://adafru.it/151). You will want to angle the laser assembly down towards the floor at roughly the same angle as the camera--this will improve the accuracy of target clicks to actual laser position.

## Servo Controller and Raspberry Pi

Hook up the Raspberry Pi to the servo controller, and the servos to the servo controller. [Follow this servo controller tutorial \(https://adafru.it/cFP\)](https://adafru.it/cFP) if you are unsure of the exact steps.

You will want to hook up the top servo (up/down movement) to channel 0, and the bottom servo (left/right movement) to channel 1 of the servo controller.





## Hardware Setup

Finally place the laser assembly and camera near each other and aimed down at the floor. You will want the camera and laser to both be at about the same angle to the floor.

When the servos are in their center position (a value of 400 pulses high with the 12bit PWM/servo controller) the complete setup should look like the image on the left.

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## Software Setup

### Dependencies

To setup the software you'll need to install the following dependencies on the Raspberry Pi:

- [Python \(https://adafru.it/cFQ\)](https://adafru.it/cFQ)
- [Flask \(https://adafru.it/cFR\)](https://adafru.it/cFR), a python web application framework.
- [NumPy \(https://adafru.it/cFS\)](https://adafru.it/cFS), a python library for numeric computing.
- [Git \(https://adafru.it/cFT\)](https://adafru.it/cFT), revision control system to download the code used by this project.

Fortunately the installation of these dependencies is easy by installing pre-built packages. To install these packages connect to your Raspberry Pi in a command line session and execute the following command:

```
sudo apt-get install python python-flask python-numpy python-smbus git
```

You might already have some of these dependencies installed on your Raspberry Pi. If a command exits with an "already the newest version" message you can ignore it and move on.

### Code

Now you can download the software for the project [from GitHub \(https://adafru.it/cFU\)](https://adafru.it/cFU) by executing the following command. This will create a 'pi-catlaser' folder in your current directory which will contain the code for the project.

```
git clone https://github.com/tdicola/pi-catlaser.git
```

Navigate inside the newly created pi-catlaser folder to continue the software setup.

For reference some of the important files in the pi-catlaser directory are:

- **server.py**: The main web application python code. At the top of this file is a small set of configuration values for the I2C address of the servo controller, channels for each servo, and min/max/center servo values.
- **model.py**: The code for moving, targeting, and calibrating the laser.
- **modeltests.py**: Python unit tests for validating the model's functionality.
- **servos.py**: Code to interface with the servo controller and move the servos.
- **Adafruit\_I2C.py & Adafruit\_PWM\_Servo\_Driver.py**: Code from the [Adafruit Raspberry Pi python code library \(https://adafru.it/aOg\)](https://adafru.it/aOg) to interface with the PCA9685 servo controller board.
- **templates/main.html**: The HTML code for the web application. The image tag which contains the MJPEG video stream for the network camera is in this file beneath a comment near line 19.
- **static/js/calibration.js**: The javascript code to calibrate and overlay graphics on the video.
- **calibration.json**: This file will initially not exist, but after calibration this file will save the calibration values.

At a minimum you will need to edit templates/main.html to set the URL for your network camera's MJPEG video stream. Edit this file (using a text editor on the Raspberry Pi such as 'nano') and change the src attribute of the img tag on line ~19 to your camera's MJPEG stream URL. You can usually [find the MJPEG stream URL for your camera on the web \(https://adafru.it/cFN\)](https://adafru.it/cFN).

If your servo controller is not on the default 0x40 I2C address or your servos are not hooked up to channels 0 and 1 of the servo controller, edit server.py (using a text editor on the Raspberry Pi such as 'nano') and adjust these values at the top of the file.

With any changes to the code made, you're ready to start the server, test the servo movement, and calibrate the laser.

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# Calibration and Play

## Running the Server

Before starting the server, make sure the servos and laser diode are hooked up to power. Then start the server by executing the following command in the pi-catlaser directory on the Raspberry Pi:

```
sudo python server.py
```

You should see the server start with the following message:

**Reseting PCA9685**

**Setting PWM frequency to 50 Hz**

**Estimated pre-scale: 121**

**Final pre-scale: 121**

**\* Running on http://0.0.0.0:5000/**

**\* Restarting with reloader**

You can stop the server at any time by pressing **Ctrl-C**, and restart the server with the same command used to start it.

Now navigate to the web application in a web browser from a computer on your network. You will want to access **http://your\_raspberry\_pi\_IP\_address:5000/** (if you don't know the IP address of your Raspberry Pi, run the command 'ifconfig' and look for the 'inet addr' value--likely something within 192.168.1.\*).

For example if your Raspberry Pi's IP address is 192.168.1.120, you would access **http://192.168.1.120:5000/** in a web browser.

Raspberry Pi Cat Laser



If everything is setup correctly you should see a page with your camera's video stream load.

If you see an error message or no response, check that the server started successfully and that the previous steps were completed successfully.

Note, you might need to be logged in to your network camera before accessing the web page so the video will load.

## Servo Positions

X Axis Servo

Y Axis Servo

## Calibration

## Servo Control

In the top right of the page you will see the raw X and Y axis servo values, and controls to manipulate these values up and down. You can also type a servo position value directly into the input control and tab to another control to update the servo.

Try changing the servo values to verify the servos and laser move.

## Calibration

Click the 'Start Calibration' button to walk through the calibration of the target area and the laser. See [this video \(https://adafru.it/cFV\)](https://adafru.it/cFV) for an example of running the calibration.

The calibration process works by finding a transformation between a quadrilateral on the screen (the red target area) to a quadrilateral in laser servo coordinate space (the X and Y servo values together define a 2D coordinate system). Plugging these quadrilaterals into a perspective projection equation and solving for the coefficients allows the server to transform clicks inside the target area to servo positions that aim the laser. You can find more [details on this process here \(https://adafru.it/cFW\)](https://adafru.it/cFW).

Once the calibration is done you're ready to play! Click inside the red target area and the laser should be moved to aim at the location of your click. Have fun making your cat chase the laser around over the web!

Remember to demonstrate proper laser safety when playing with the cat laser. Do not shine the laser into human or animal eyes. Always supervise any animals playing with the toy.

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## Future Work

You can follow and contribute to this [project on Github \(https://adafru.it/cFU\)](https://adafru.it/cFU).

Some interesting ways to consider extending the project are:

- Automatic calibration by detecting the position of the laser dot on the video and automatically moving the laser into the position of the corners.
- Using a transistor to turn on/off the laser pointer, to extra-confuse-ify the cat!

- Limiting the target clicks to only fall within the target area.
- Building a public, internet-facing layer on top of the web application which would allow people on the internet to take turns playing with your cat.
- Build the laser toy into a stand-alone enclosure with a [servo controlled treat dispenser](https://adafru.it/cFX) (<https://adafru.it/cFX>) to reward kitty's play.
- Integrate [cat face detection](https://adafru.it/cFY) (<https://adafru.it/cFY>) to prevent targeting the cat's face.
- Use the Raspberry Pi camera and an MJPEG encoder to capture video directly from the Raspberry Pi. Serve the video through web sockets to add support for IE.

What can you think of to extend the project?