

Camera Calibration Guide

This document will guide you through the calibration process allowing your CMUcam2 to track the five predefined FIRST competition colors. In general, the ability to track colors with the CMUcam2 is drastically effected by the intensity of the light that is reflecting off of the target. One way you can compensate for lighting variation is by adjusting the camera's exposure. The exposure of a camera controls how much light is allowed to fall on its sensor. By increasing the exposure value on the CMUcam2, more light is allowed to reach the sensor making the image look brighter. Since the colors that are to be tracked are known ahead of time, we have provided the ability to automatically calculate a correct exposure value for each particular target on the field. This automatic calibration can be found in the modified version of the CMUcam2 Graphical User Interface (GUI) available from the FIRST website. Before you begin, make sure that you have correctly installed all of the FIRST software including java.

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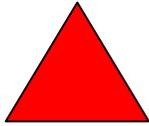
Step 5: Testing the Calibration

How Calibration Works

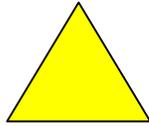
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Step 1: Setup and Position the Camera

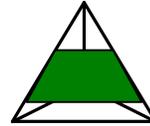
In order to be able to track all five of the FIRST specified colors, you must calibrate on three different targets shown below. The order in which you calibrate does not matter. It is best to train the target in the position it will be used on the field. If for some reason you find that your normal light is not bright enough (this can occur with certain florescent lights), consider illuminating just the target with a more concentrated external light. In general, yellow and green tend to be more robust even in lower light conditions.



Flat Red Triangle



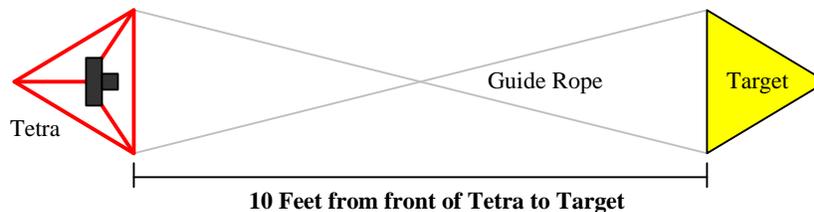
Flat Yellow Triangle



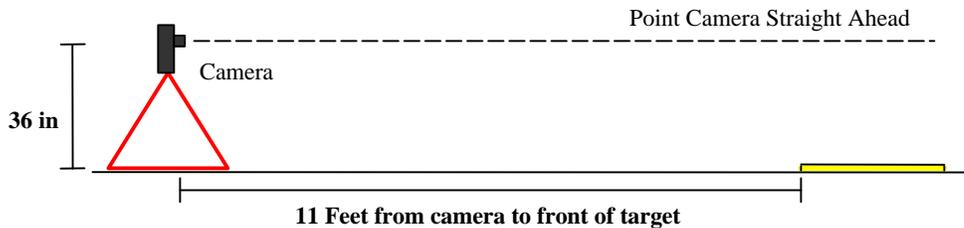
Special Green Tetra

- 1) Connect the camera to a power source (AC adapter or Battery)
- 2) Connect the serial cable from the computer to the camera
- 3) Setup the Field as shown below
 - i. Make sure the camera is 11 ft from the target
 - ii. Make sure the camera is 36 inches from the floor
- you can use two stacked tetras as a stand
 - iii. Using a piece of guide rope can help in the alignment

Top View

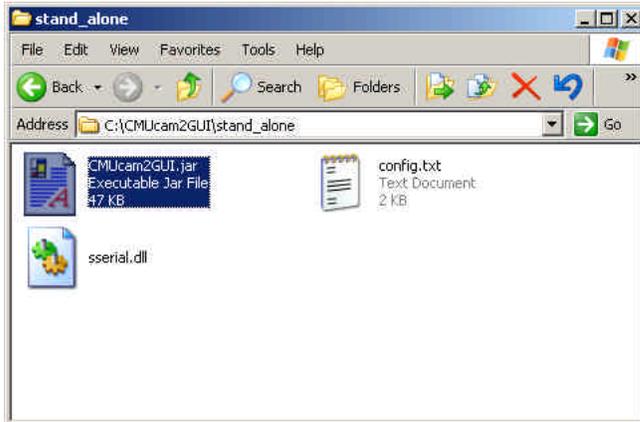


Side View

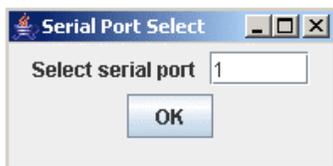


Step 2: Starting the CMUcam2 GUI

Find the **CMUcam2GUI directory** on your computer and go into the **stand_alone** subdirectory. You should see the following three files. “config.txt” contains the default camera tracking parameters that are read when the GUI initially loads (feel free to experiment with them).



Double Click on the **CMUcam2GUI.jar** file to launch the GUI. Next, you should see a dialog box like the one below asking you to select a serial port.



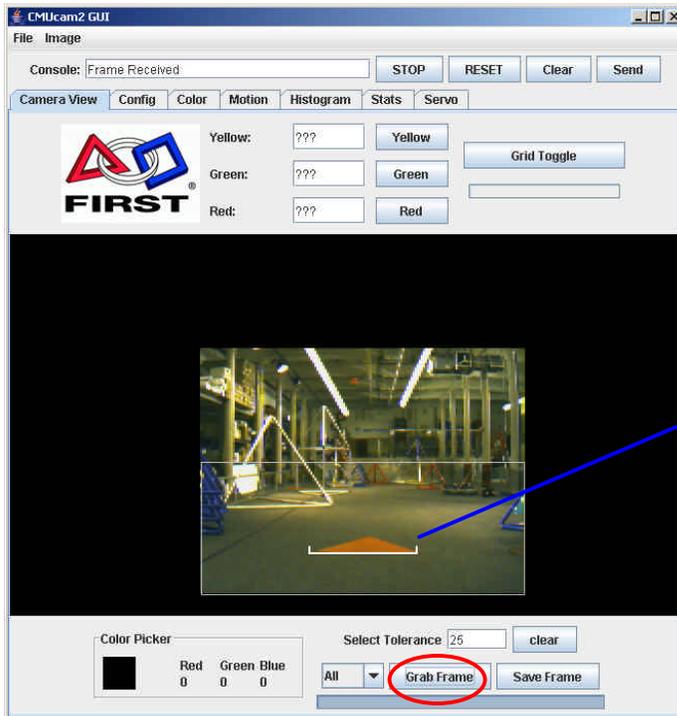
Enter the number of the **COM port** that you wish to use. For example COM1 would be “1”. After you have entered the correct COM port, **Press the OK Button** to continue.



If the camera is connected correctly, and you entered a correct COM port, you will see the message “**CMUcam Version 2 type 7 ready**” appear in the Console text box

If the camera is not found, try restarting the GUI after turning the camera on and off. Check the power, cables and make sure that you had the correct COM port entered.

Step 3: Grab a Frame and Align the Target

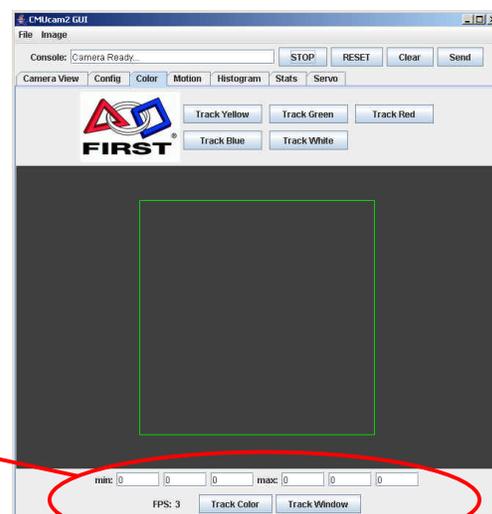
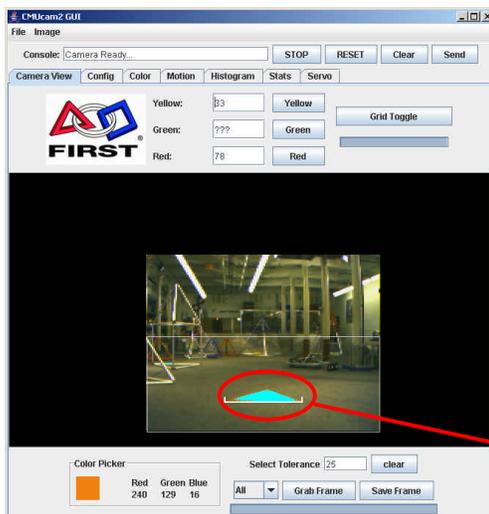


Next, Click the “Grab Frame” button (circled in red) to see where your target is located. After about 30 seconds, an image should appear in the middle of the screen.

Try to **center the target** as best as possible inside the “Alignment Bracket”. You may need to tilt the camera slightly to correct for any vertical error. Grab a few more frames to be sure.

Also, make sure that the area inside the light grey calibration bounding box is clear of colorful objects such as other tetras or targets. This is the region of the image that the camera will use for its calibration.

One useful feature to explore is the ability to scroll the mouse pointer over the image to see the Red, Green, Blue, (RGB), color values for each point in the image. These values are displayed under their titles next to the Color Picker in the Camera View window. When you click on a color, all occurrences of that color in the image are highlighted, and the colors Red, Green, Blue, (RGB), values are filled into the min. and max. boxes of the “Color” window. The min. and max. values are determined by adding / subtracting the value in the Select Tolerance text box to / from the mean values of the color the cursor was on when you clicked on it.



Step 4: Calibrating

Before calibrating the target “grab” a frame and inspect it closely for instances of glare. Shown below are two pictures; the one on the left has an excessive amount of glare, the one on the right was taken after the target was slightly rotated.

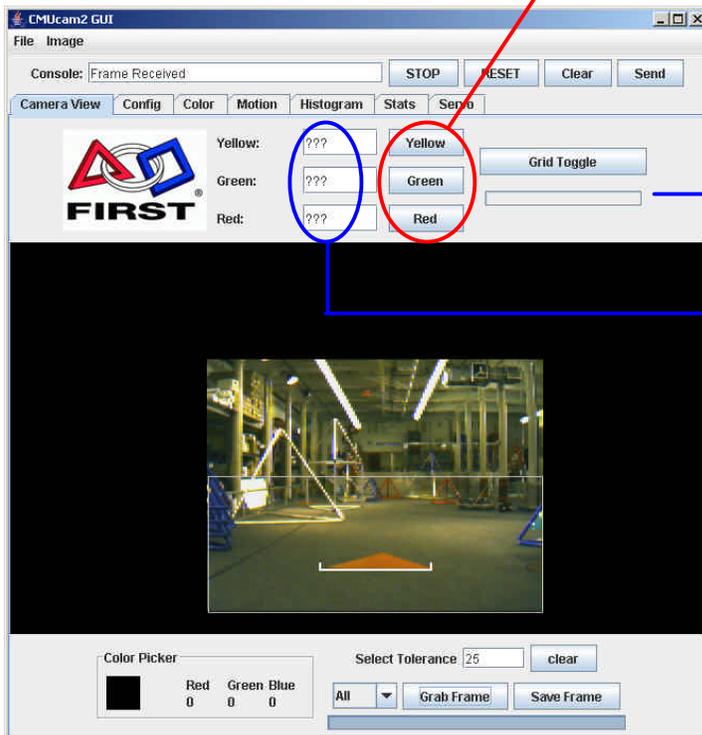


A Bad amount of glare



Target slightly rotated to remove glare

Next, **Click** on the name of the **color** target that you have centered in the screen.

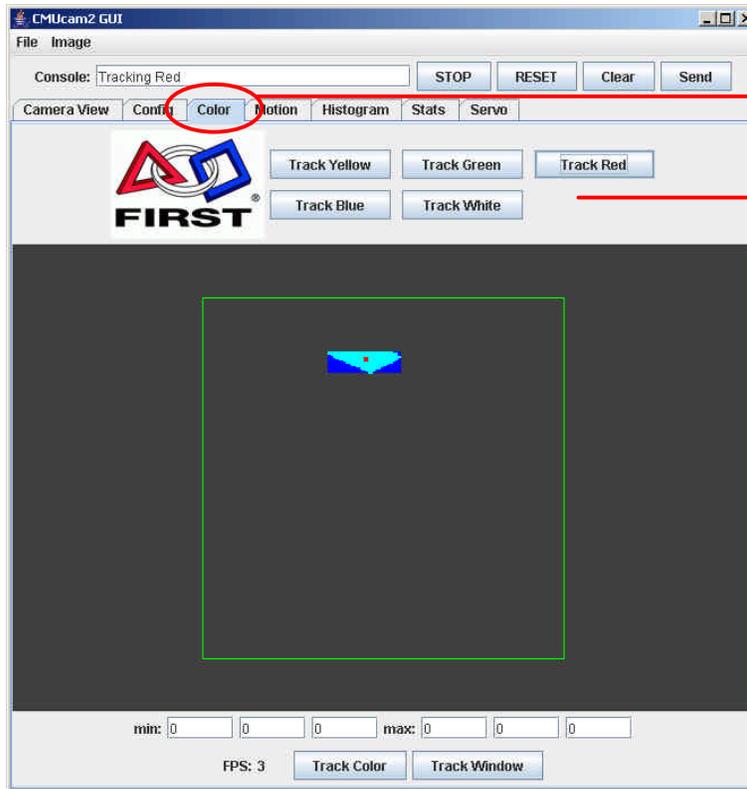


The progress bar below “Grid Toggle” should start moving as the camera is calibrating.

Upon successful completion, the “???” in the text box next to the color’s name should be replaced with the **correct exposure value**.

Step 5: Testing the Calibration

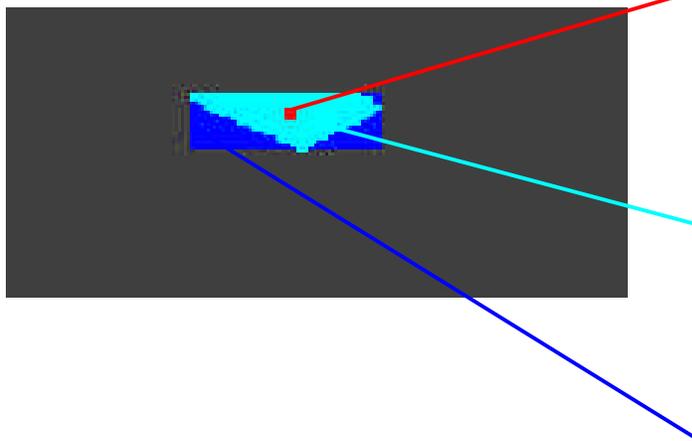
Once you have calibrated each color, you can test to see how well the calibration is working.



Click on the “**Color**” tab to switch to the color tracking panel.

Then **Click** on the **color** that you wish to track. For example, here the red target is being tracked.

*Note that if you manually enter the exposure values on the previous panel, and then you switch back to the “color” panel, your new manually entered values will be used.



The Red Dot shows the “centroid” also referred to as the middle of mass of the image. This is where the camera has calculated the center of the object is located. The middle of mass is what you should use when trying to drive towards or follow an object.

The light blue color shows a low-resolution image of the exact regions in the image the camera detects are close to the color you are tracking. Here we can see our red triangle from before. This feature of the CMUcam2 is called “linemode”.

The dark blue box shows the bounding box that contains all tracked pixels. It is the smallest rectangle that is parallel to the x and y axis that holds all of the tracked sections of the image. If this dark blue area fits tightly around the cyan colored blob, then you have a great track on the object.

How Calibration Works

The camera calibration program is given the approximate size, (in pixels), and location, (distance), of the target object. It uses this information in the process it uses to “pick” an Automatic Exposure Control, (AEC), setting. It starts off initially with the AEC set to 0. At this level, the image should be nearly black. It then uses hard coded tracking parameters for the color and checks to see if it can find the object. If it does not find the object, it increases the AEC setting and then tries again. As the AEC setting starts to get closer to a good value for the scene, the object will start to be found by the camera. The program stops the search when it can track an object that is large enough to be the target that you placed in front of it and reports the AEC setting.

Troubleshooting

The CMUcam GUI_fe will not start, or Java does not appear to work.

If this turns out to be the case, please refer to the CMUcam2_fe_manual Documentation provided by FIRST. It has a more detailed explanation of how to install and setup the camera.

The following error dialog pops-up when I try to calibrate on a color:



This error message occurs when the target fills up too much of the camera's view. This could be because the target is too close, too bright, or that the background does not have a large enough contrast with the target. Make sure that you have a dark carpet / floor underneath where you are training.

The following error dialog pops-up when I try to calibrate on a color:



This can be caused if the target was not correctly place in the training brackets. It can also be caused by too little light. Make sure that you have at least 75 foot candles of illumination on the target you are trying to train.

None of the target colors specified will not work when I try to calibrate on them:

This can happen if the lighting is insufficient for the camera to "see" the colors as they are defined for the FIRST competition field targets. If you are sure the camera is working they you should try;

- a. Increasing the lighting in the environment you are testing in.
- b. Choosing a different target color.
- c. Moving to another area to test the camera.