

# Vision Tracking

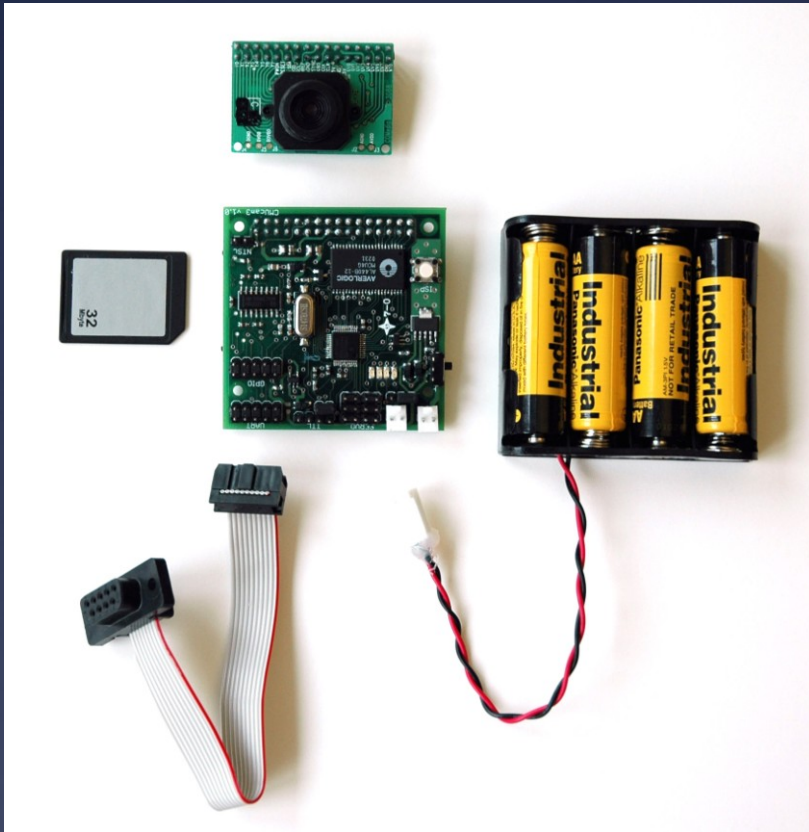
Benjamin  
Newman

3pm, 28 April 2011  
Cofrin Hall, rm 209

# Original idea

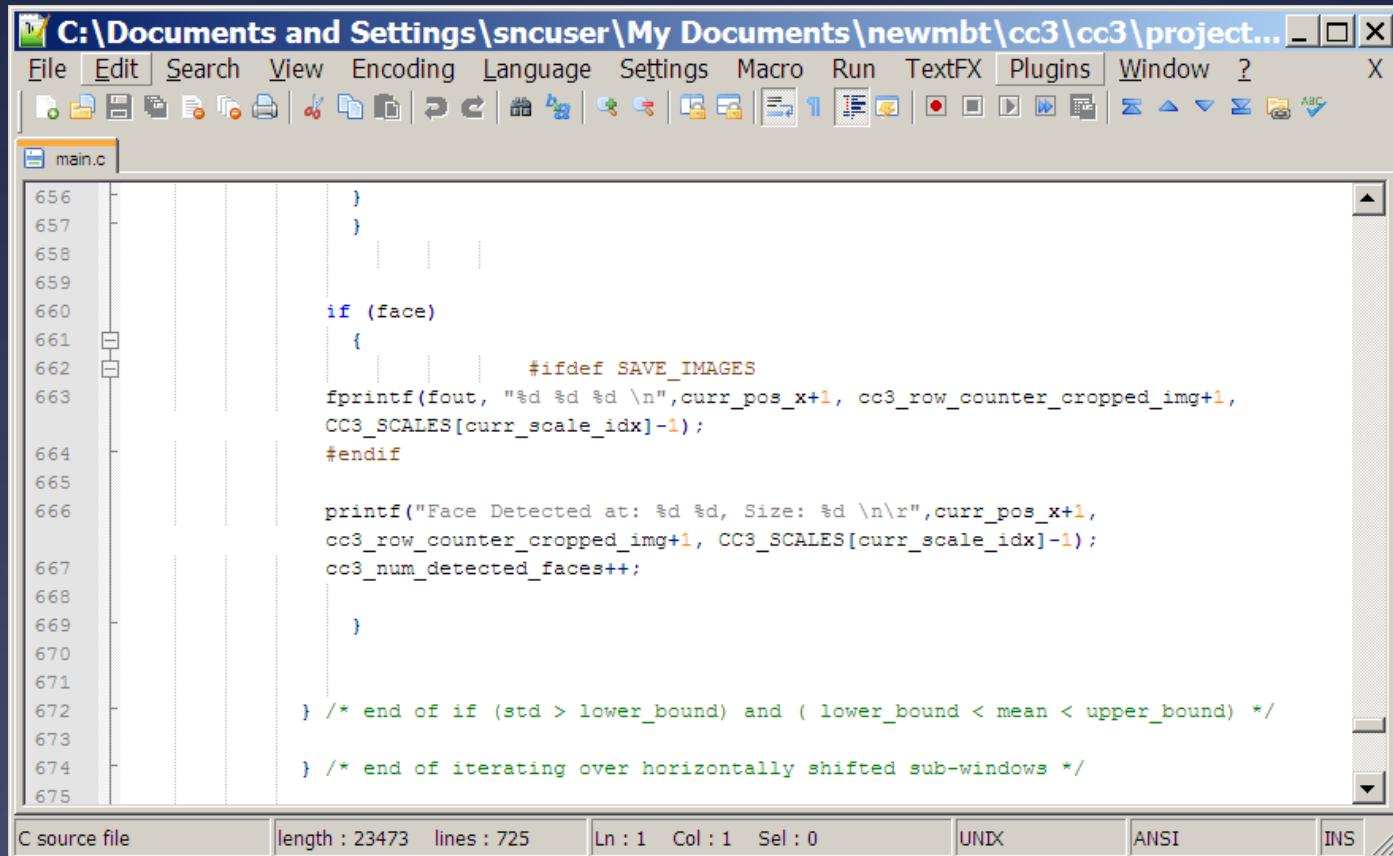
A robot that  
tracks faces

# CMUcam3



- \* Camera and microcontroller
- \* Programmable
  - \* Code and compile on PC

# Code



```
C:\Documents and Settings\ncuser\My Documents\newmbt\cc3\cc3\project...
File Edit Search View Encoding Language Settings Macro Run TextFX Plugins Window ? X
main.c
656     }
657     }
658     .
659     .
660     if (face)
661     {
662         #ifdef SAVE_IMAGES
663         fprintf(fout, "%d %d %d \n", curr_pos_x+1, cc3_row_counter_cropped_img+1,
        CC3_SCALES[curr_scale_idx]-1);
664         #endif
665
666         printf("Face Detected at: %d %d, Size: %d \n\r", curr_pos_x+1,
        cc3_row_counter_cropped_img+1, CC3_SCALES[curr_scale_idx]-1);
667         cc3_num_detected_faces++;
668
669     }
670
671
672     } /* end of if (std > lower_bound) and ( lower_bound < mean < upper_bound) */
673
674     } /* end of iterating over horizontally shifted sub-windows */
675
```

C source file    length : 23473    lines : 725    Ln : 1    Col : 1    Sel : 0    UNIX    ANSI    INS

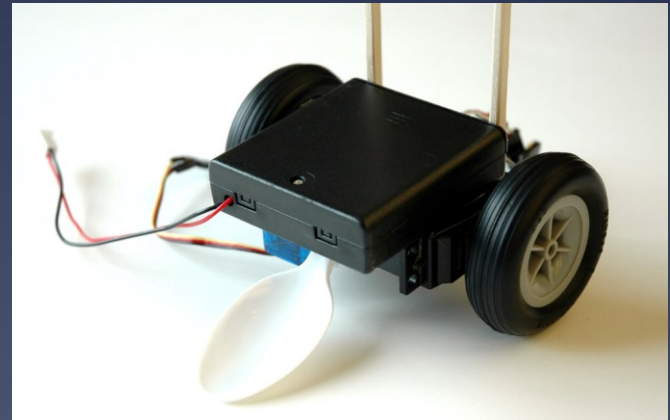
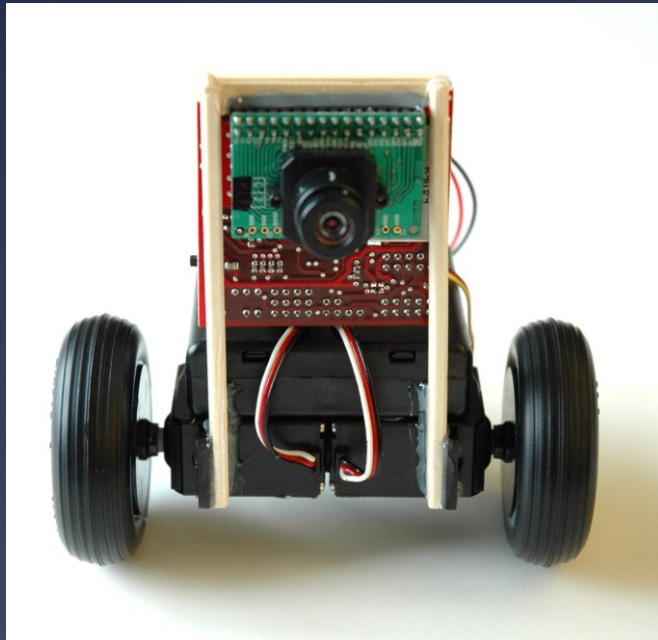
# Compile

```
/cygdrive/c/Documents and Settings/sncuser/My Docu...
$ cd /cygdrive/c/Documents\ and\ Settings\sncuser/My\ Documents/newmbt/cc3/cc3/
projects/viola-jones/
sncuser@snc040344 /cygdrive/c/Documents and Settings/sncuser/My Documents/newmbt
/cc3/cc3/projects/viola-jones
$ make clean && make
rm -f *.hex
rm -f *.map
rm -f viola-jones_lpc2106-cmucam3
rm -f viola-jones_lpc2106-cmucam3.exe
rm -f libviola-jones_lpc2106-cmucam3.a
rm -f -r lpc2106-cmucam3_buildfiles
MKDIR    lpc2106-cmucam3_buildfiles
mkdir    lpc2106-cmucam3_buildfiles
CC       lpc2106-cmucam3_buildfiles/main.o
main.c: In function 'main':
main.c:297:8: warning: unused variable 'img_name'
CC       viola-jones_lpc2106-cmucam3
OBJCOPY  viola-jones_lpc2106-cmucam3.hex
   text    data     bss     dec      hex filename
  88144    2328    52960   143432   23048 viola-jones_lpc2106-cmucam3
sncuser@snc040344 /cygdrive/c/Documents and Settings/sncuser/My Documents/newmbt
/cc3/cc3/projects/viola-jones
$
```

# Flash to CMUcam3



# spoonBot

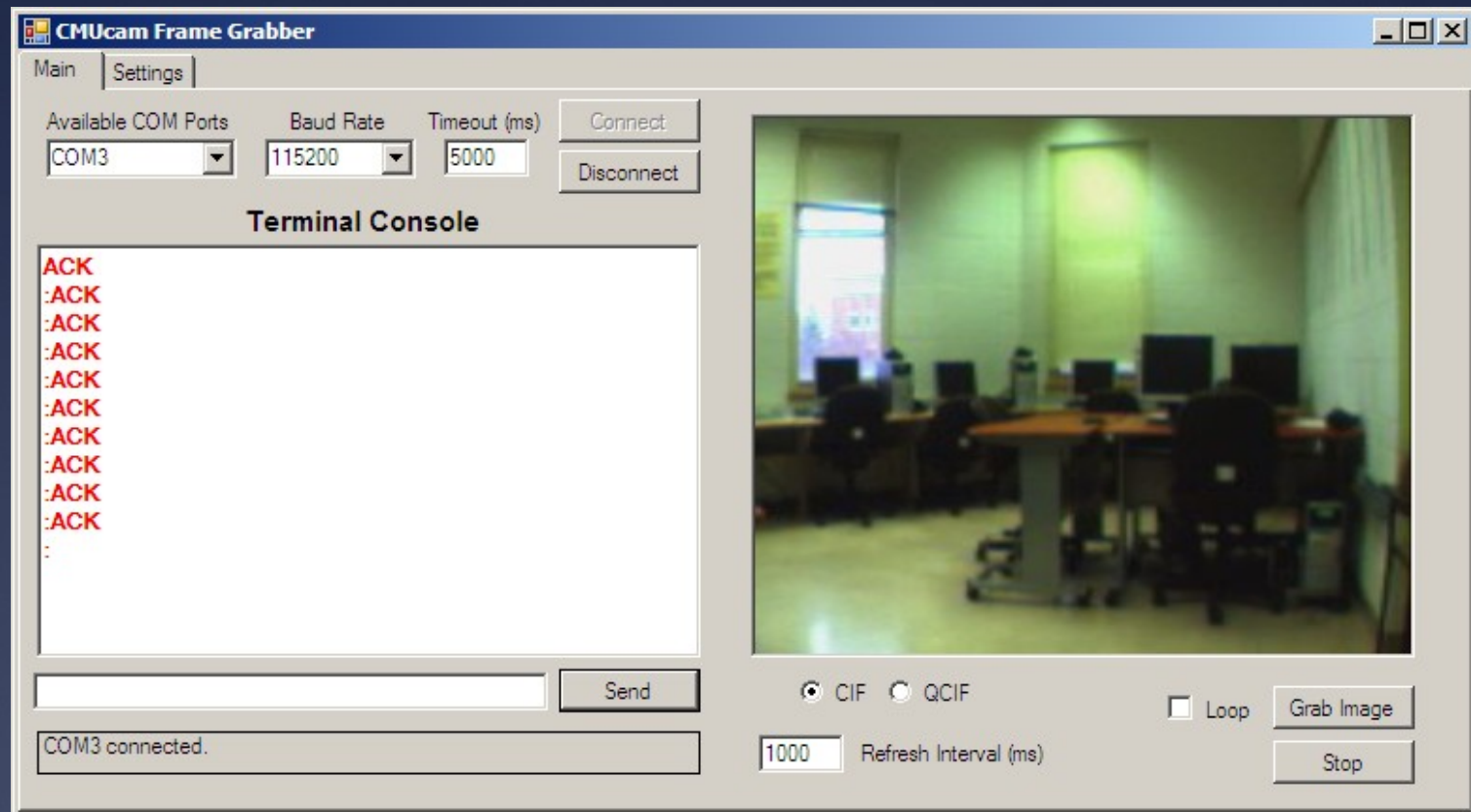


From CMU

Prior work



# CMUcam2 emulator



# CMUcam Frame Grabber

Main Settings





Low Resolution  High Resolution

RGB  YCrCb

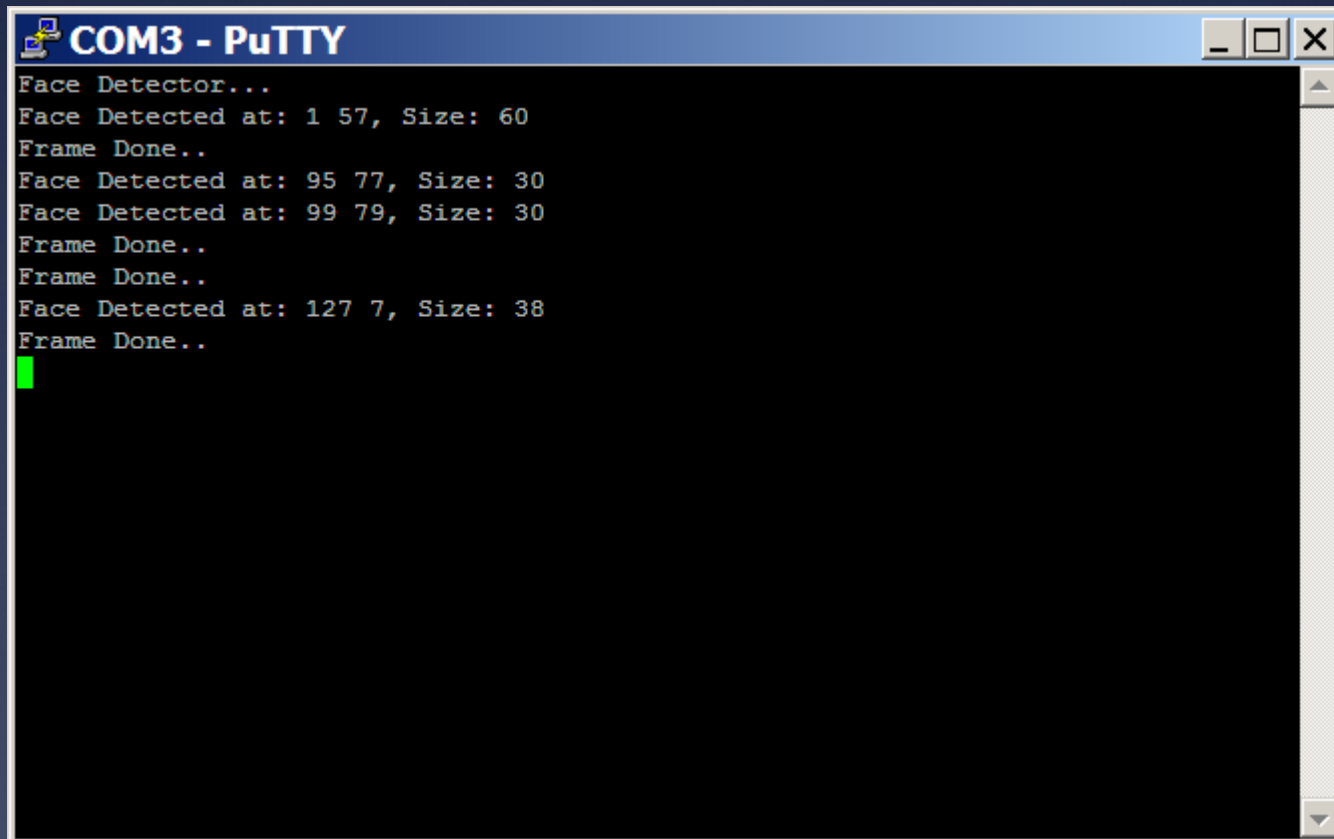
Down Sample X  Y

Window X0  Y0  X1  Y1

## Servo Controller

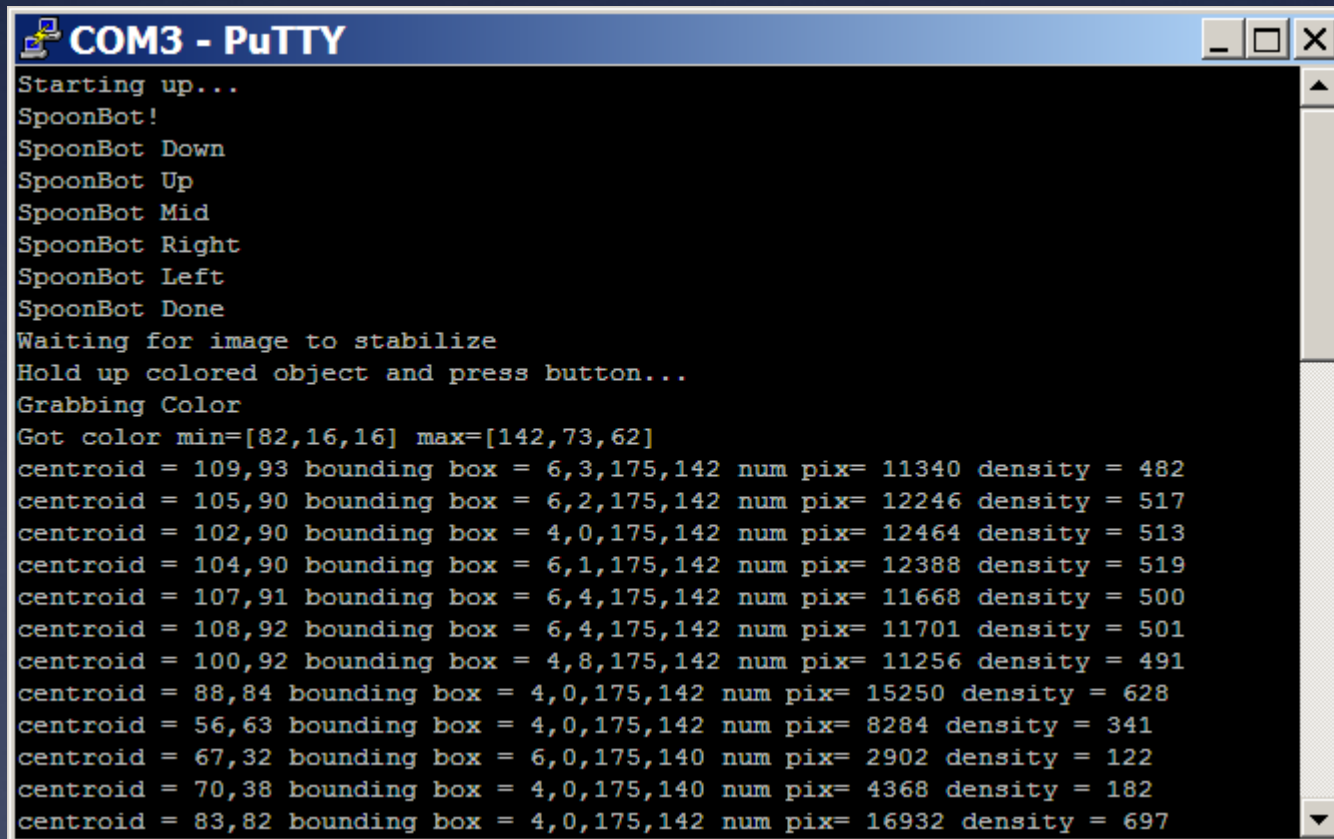
0		<input type="text" value="128"/>
1		<input type="text" value="128"/>
2		<input type="text" value="128"/>
3		<input type="text" value="128"/>

# Viola-Jones face detector



```
COM3 - PuTTY
Face Detector...
Face Detected at: 1 57, Size: 60
Frame Done..
Face Detected at: 95 77, Size: 30
Face Detected at: 99 79, Size: 30
Frame Done..
Frame Done..
Face Detected at: 127 7, Size: 38
Frame Done..
█
```

# spoonBot sample project



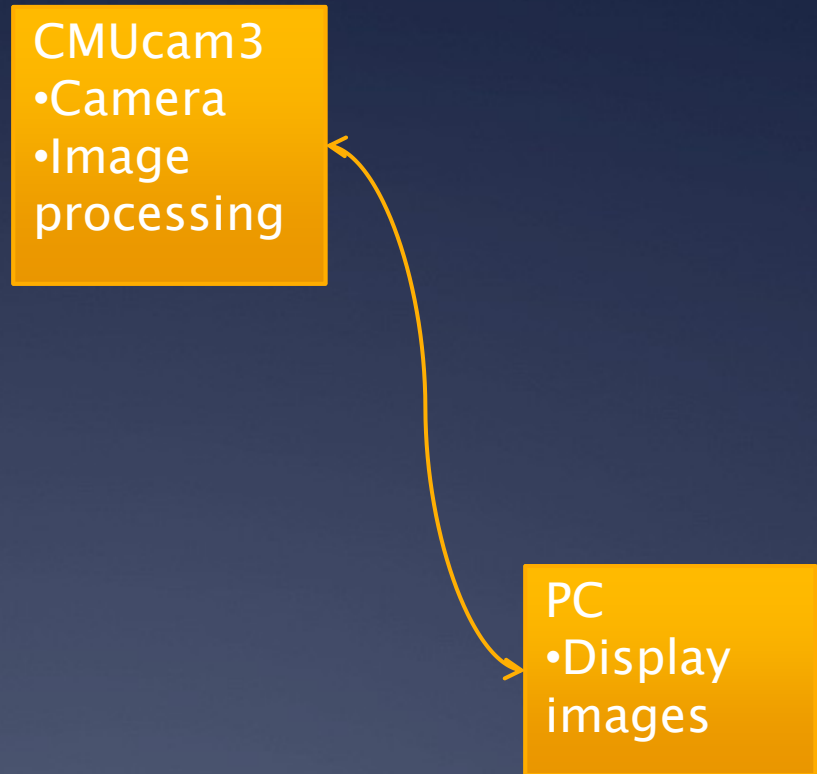
```
COM3 - PuTTY
Starting up...
SpoonBot!
SpoonBot Down
SpoonBot Up
SpoonBot Mid
SpoonBot Right
SpoonBot Left
SpoonBot Done
Waiting for image to stabilize
Hold up colored object and press button...
Grabbing Color
Got color min=[82,16,16] max=[142,73,62]
centroid = 109,93 bounding box = 6,3,175,142 num pix= 11340 density = 482
centroid = 105,90 bounding box = 6,2,175,142 num pix= 12246 density = 517
centroid = 102,90 bounding box = 4,0,175,142 num pix= 12464 density = 513
centroid = 104,90 bounding box = 6,1,175,142 num pix= 12388 density = 519
centroid = 107,91 bounding box = 6,4,175,142 num pix= 11668 density = 500
centroid = 108,92 bounding box = 6,4,175,142 num pix= 11701 density = 501
centroid = 100,92 bounding box = 4,8,175,142 num pix= 11256 density = 491
centroid = 88,84 bounding box = 4,0,175,142 num pix= 15250 density = 628
centroid = 56,63 bounding box = 4,0,175,142 num pix= 8284 density = 341
centroid = 67,32 bounding box = 6,0,175,140 num pix= 2902 density = 122
centroid = 70,38 bounding box = 4,0,175,140 num pix= 4368 density = 182
centroid = 83,82 bounding box = 4,0,175,142 num pix= 16932 density = 697
```

# Ways of proceeding

Or where to do  
the work

# Process on CMUcam3

- CMUcam3 is slow
  - Anywhere from a two to five seconds for each frame to find a face
  - One to two seconds to send an image to the computer



## Process on PC

CMUcam3 is *still* slow: One to two seconds to send an image to the computer

CMUcam3  
•Camera

PC  
•Display images  
•Image processing



Or

Something  
altogether different



# Problems

- \* The spoon really didn't work
- \* The wheels sorta' worked
  - \* AC-DC adapter limits movement
- \* The processor is *way* too slow
- \* Sending images to the PC is too slow

# Original requirements

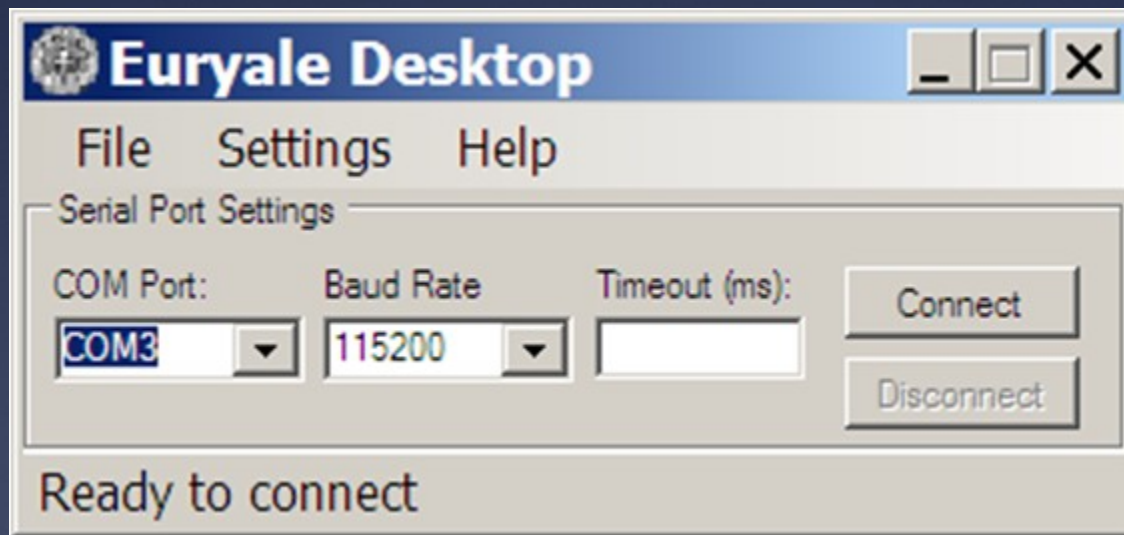
1. The bot is sensitive to at least two dimensions.
- ~~2. Detection of depth (distance).~~
- 3. The bot might look up and down as well as left to right.*
4. Warn about boundary conditions like out-of-bounds ~~and too many people.~~
- ~~5. Perhaps it keeps the person centered on a screen.~~
- ~~6. Develop a way to activate the bot for a user and to let it sleep when lonely.~~
- ~~7. Consider a playback option.~~
- ~~8. Perhaps speech output as well as visual.~~
- 9. The bot's home should be the display cabinet in Cofrin to help showcase computer science.*
10. Look into the CMUcam 3.

# What I did

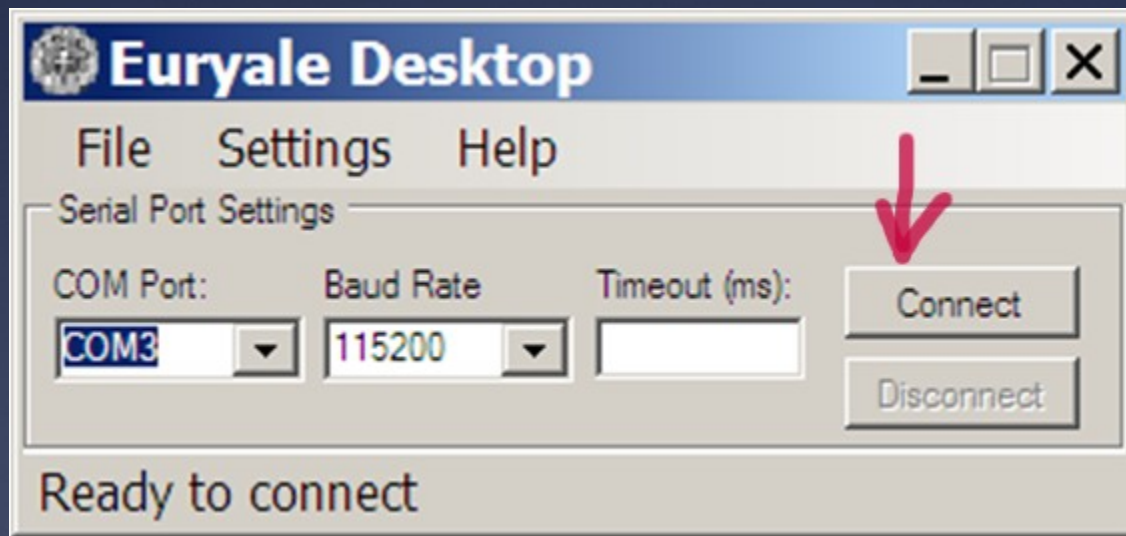
- \* Modified CMUcam3 sample project that does color tracking
  - \* Two-way communication
- \* Created a front-end for Windows
  - \* Only works “Demo Mode” (no two-way)

Demonstration

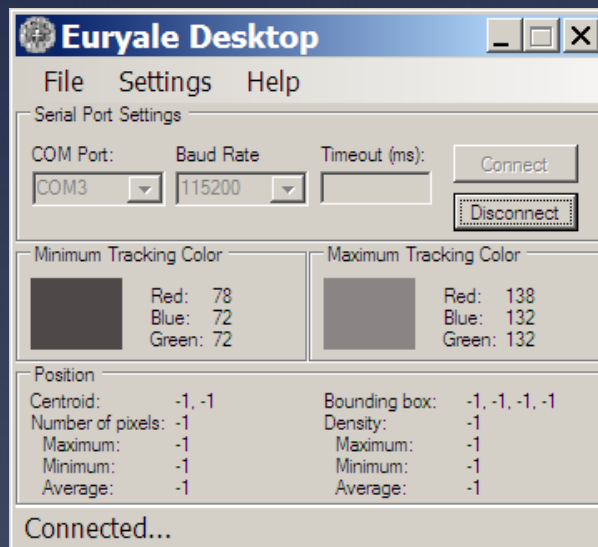
# Our first view



# Let's connect



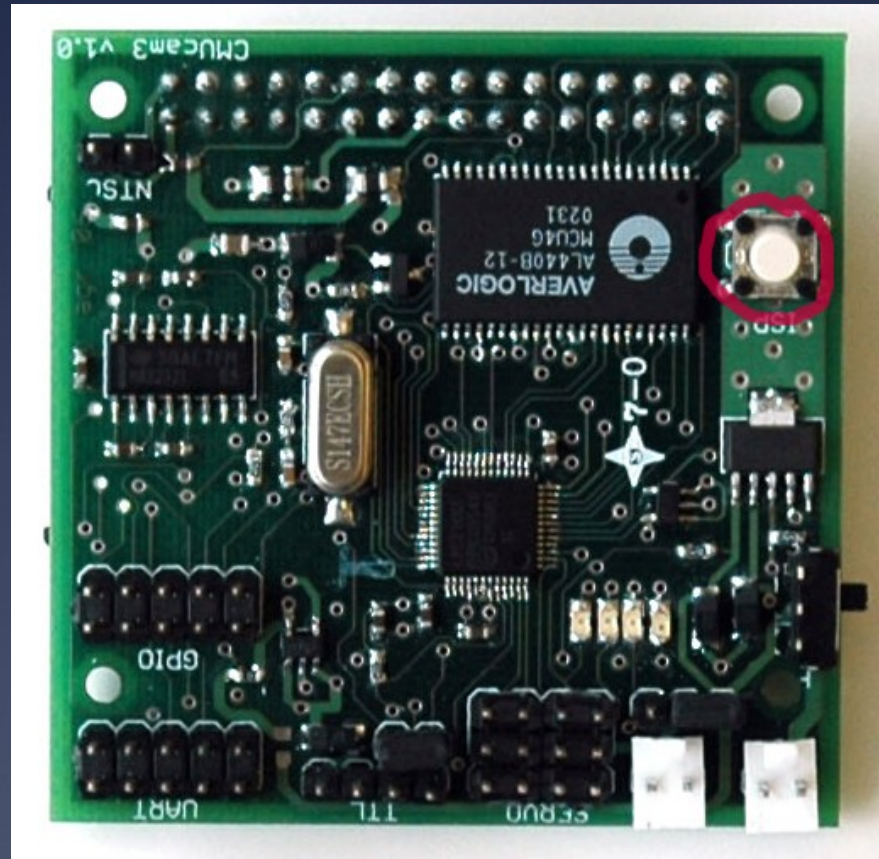
On the PC



And from the  
CMUcam3

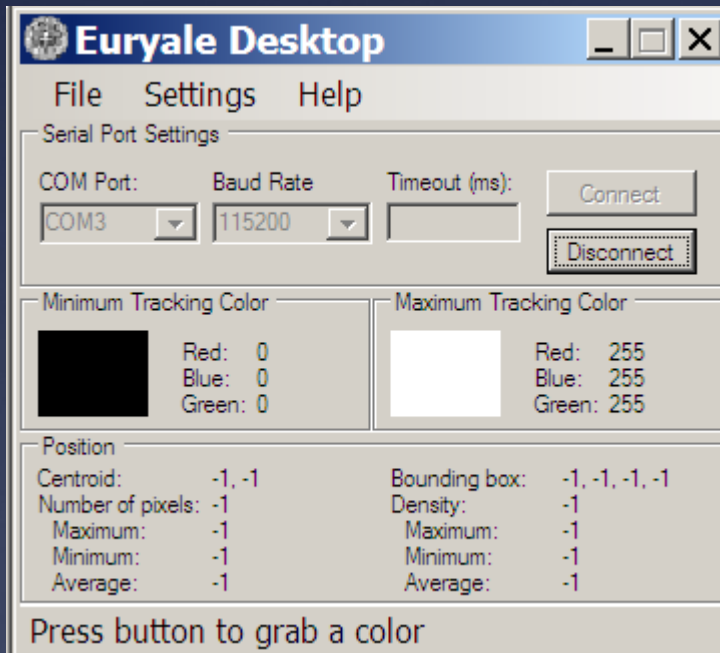


# Let's push the button

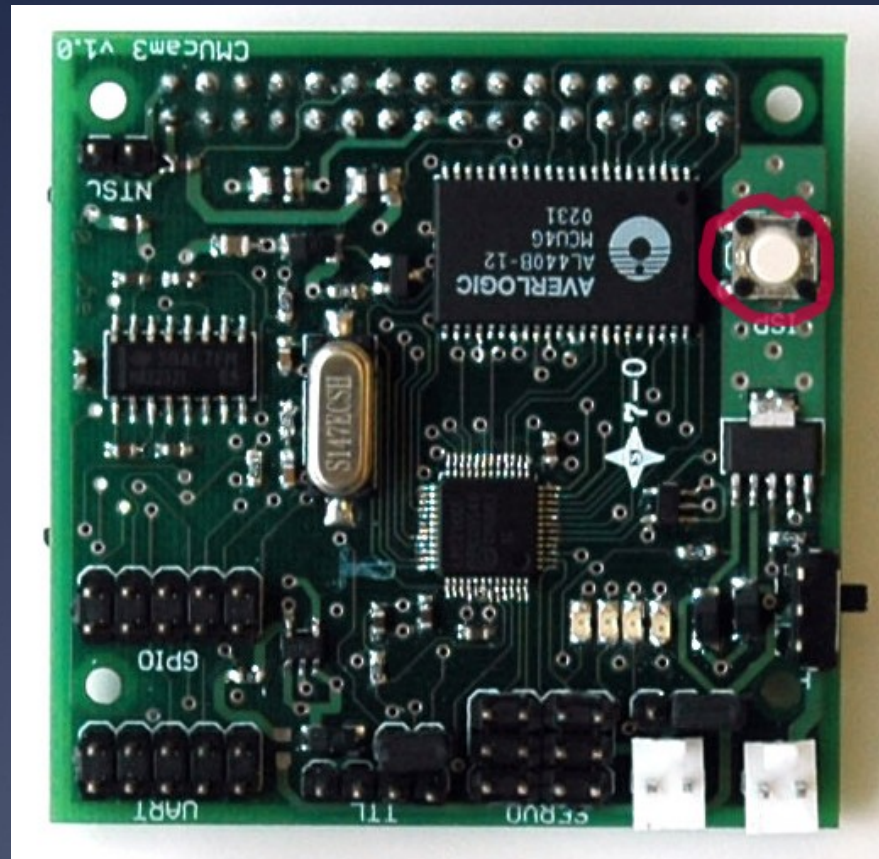




# Waiting for a button press



# And again




# A color found

**Euryale Desktop** File Settings Help


Serial Port Settings

COM Port: COM3 Baud Rate: 115200 Timeout (ms):

Minimum Tracking Color

	Red: 115 Blue: 16 Green: 16
---	-----------------------------------

Maximum Tracking Color

	Red: 175 Blue: 62 Green: 62
---	-----------------------------------

Position

Centroid: 78, 84	Bounding box: 4, 0, 175, 142
Number of pixels: 18738	Density: 771
Maximum: 19022	Maximum: 783
Minimum: 12850	Minimum: 714
Average: 16878	Average: 734

Received new position data




# A color lost

**Euryale Desktop** File Settings Help


Serial Port Settings

COM Port: COM3 Baud Rate: 115200 Timeout (ms):

Minimum Tracking Color

	Red: 115
	Blue: 16
	Green: 16

Maximum Tracking Color

	Red: 175
	Blue: 62
	Green: 62

Position

Centroid: -1, -1	Bounding box: -1, -1, -1, -1
Number of pixels: -1	Density: -1
Maximum: 21338	Maximum: 920
Minimum: 2774	Minimum: 496
Average: 16136	Average: 729

Lost object!



```
COM3 - PuTTY
euryale: starting up...
euryale: waiting for image to stabilize...
euryale: press button for demo mode: in 5 seconds
euryale: press button for demo mode: in 4 seconds
euryale: press button for demo mode: in 3 seconds
euryale: press button for demo mode: in 2 seconds
euryale: press button for demo mode: 1 second
euryale: grabbing color...
euryale: color: min=[99,124,32] max=[159,184,92]
:euryale: tracking: centroid=[61,72] bounding-box=[4,0,168,142] num-pix=15578 de
nsity=668
:euryale: tracking: centroid=[61,72] bounding-box=[4,0,167,142] num-pix=15544 de
nsity=671
:euryale: tracking: centroid=[61,72] bounding-box=[4,0,167,142] num-pix=15583 de
nsity=673
:euryale: grabbing color...
euryale: color: min=[44,32,16] max=[104,92,59]
:euryale: tracking: centroid=[108,93] bounding-box=[92,27,129,138] num-pix=317 d
ensity=77
:euryale: tracking: centroid=[134,49] bounding-box=[120,0,164,138] num-pix=631 d
ensity=103
:euryale: tracking: lost object
:NCK
:euryale: grabbing color...
```

# Two-way communication

Typing commands on the keyboard:

- PO – get position
- NC – new color



# Requirements reconsidered

1. The bot is sensitive to at least two dimensions.
  - \* Height and width, yes
  - \* Depth based on relative size of object
2. –
3. The bot might look up and down as well as left to right.
  - \* It can, sorta’.
4. Warn about boundary conditions like out-of-bounds and too many people.
  - \* It knows when it has lost the object (or it gets too dark)
5. –
6. –
7. –
8. –
9. The bot’s home should be the display cabinet in Cofrin to help showcase computer science.
  - \* TBD
10. Look into the CMUcam 3.
  - \* Yes!

# What can still be done

- \* Increase communication
  - \* *Choose a new color*
    - \* From camera
    - \* From PC
  - \* Display color
  - \* Disable or enable servos
  - \* Send *some* images to PC
    - \* Initial image
    - \* When object lost
- \* Better display
  - \* Graphs: Time versus maximum number of pixels etc.
  - \* Drawings: Just how big is 4, 0, 175, 142?
- \* Face tracking
  - \* Is the delay worth it?

# Strategies, etc.

## Read

- \* CMUcam3 documentation
  - \* It exists
  - \* A little scattered
  - \* A little holey
- \* Sample code

## Just do it

- \* Trial and error
  - \* Especially with spoonBot
  - \* Experience hardware limitations



# Knowledge

- \* Machine Organization
  - \* RFID reader project: Microcontroller
    - \* Where to hook things to
- \* Prof. Blahnik... (Or Event Programming)
  - \* User interface design
  - \* Event programming
- \* Operating systems
  - \* Serial ports
  - \* Race conditions
- \* Client-Server model

# Advice

- \* Start early
  - \* The term only gets busier
- \* Recognize when you are stuck
  - \* Requirements
  - \* What to do
  - \* Syntax mistakes
- \* Ask for help when stuck
- \* Ask for advice and feedback, even if not stuck

Start early and  
keep moving

Advice



# Questions Accepted

Answers  
possible