Detection and Simulation of Hand Shaking for Mobile Displays

Joel Wang and Peter Liu

June 17, 2010

Outline

- Goal
- Finished Sub-projects
  - Face Tracking
  - Hand Shake Simulation
  - User Study
- Conclusion

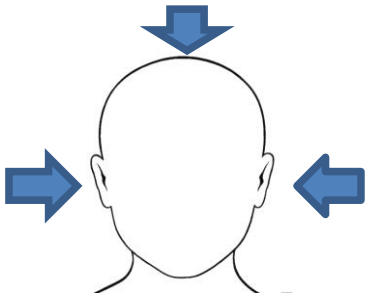
Project Goal

- Essentially, we are trying to observe and analyze specific points on head, captured by a camera that is attached to a mobile device, which, in our case, would be an iPod Touch.
- Pixel vs. Distance Relationship by analyzing the viewing angle
- This program can be applied to analyzing a subject in a video recorded with the webcam. We will be able to take the video, convert it to still images, and analyze the change in positions of each point.

FACE TRACKING – FINDING THE FACE LOCATION IN ORDER TO DETERMINE THE VIEWING ANGLE

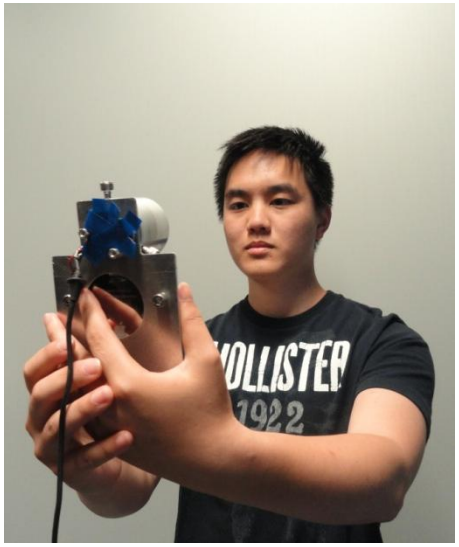
Approach

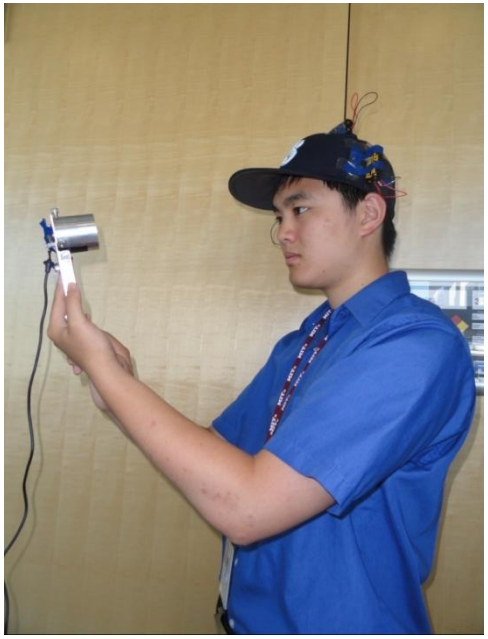
- We use 3 infrared LEDs and place them around the subject's face, one on each ear and another on the top of his head.

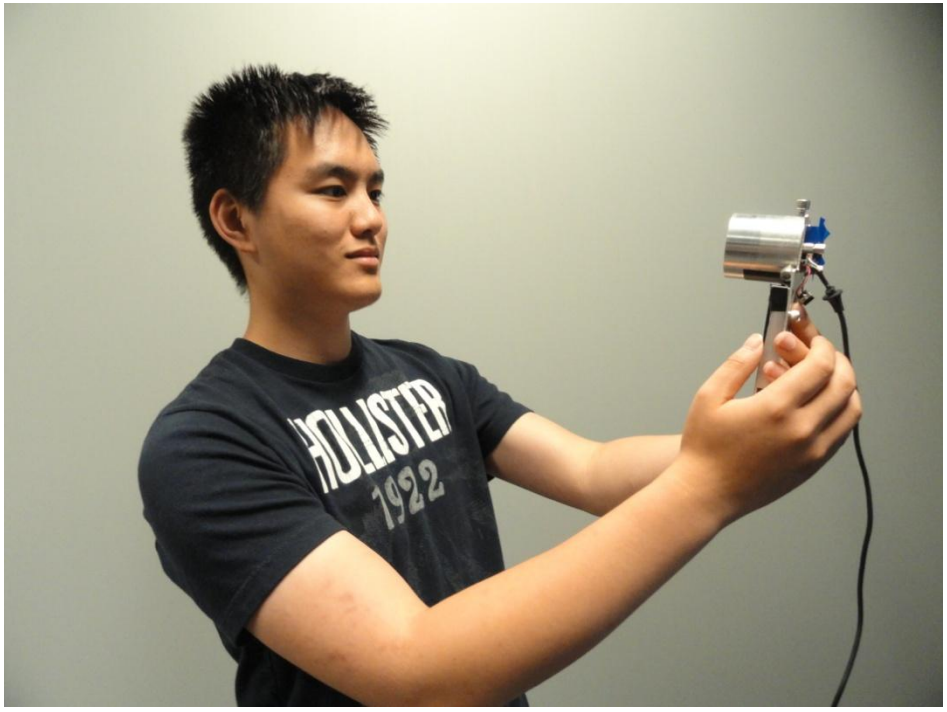


iPod Holder

- We designed a chassis that allowed us to mount an iPod touch and a modified webcam to it, which is models a mobile device with a front-facing camera.



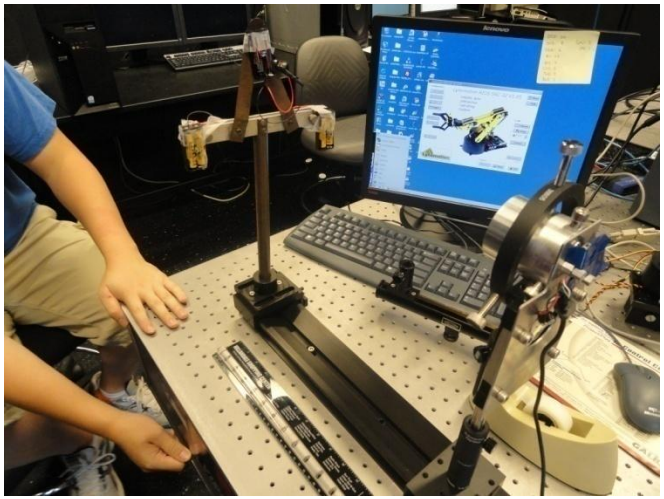


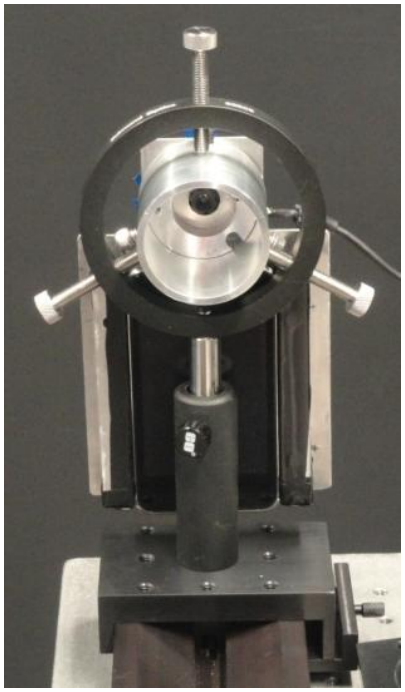


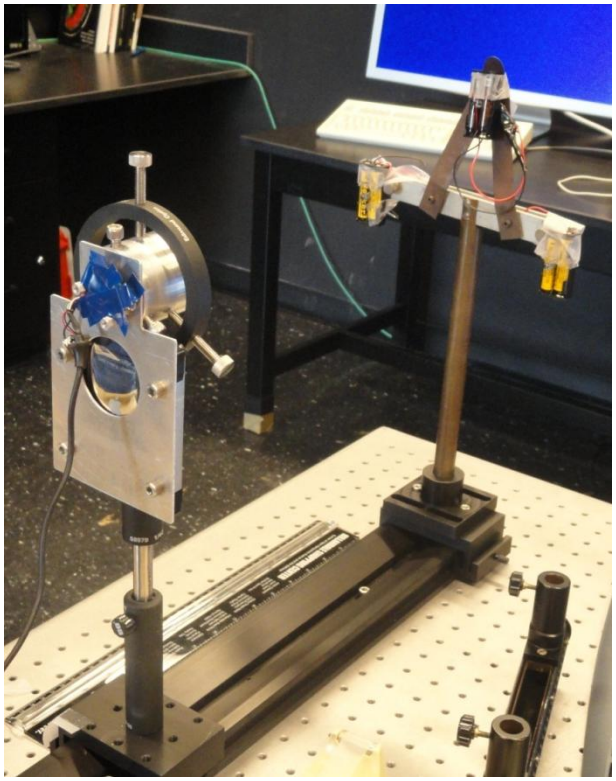
Distance vs. Pixel Characterization

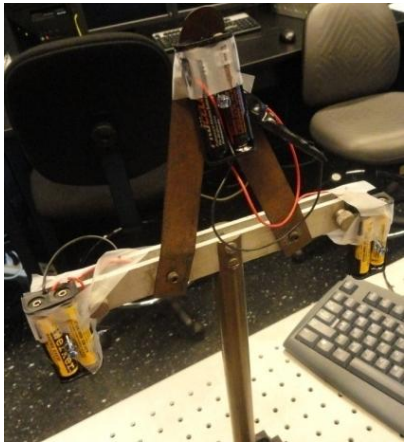
We created a simulation apparatus.

On one side is the camera, and on the other is a model head.







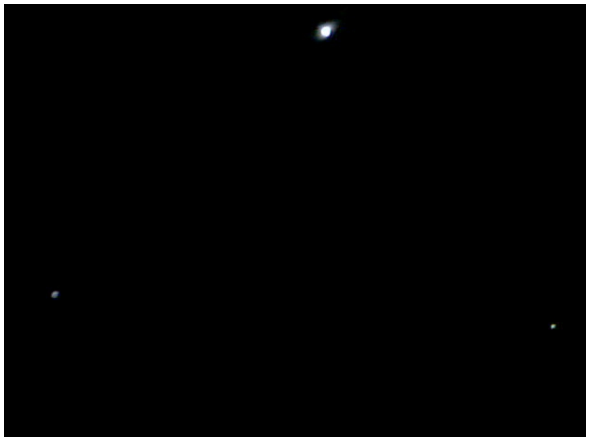


Apparatus designed by Joel Wang

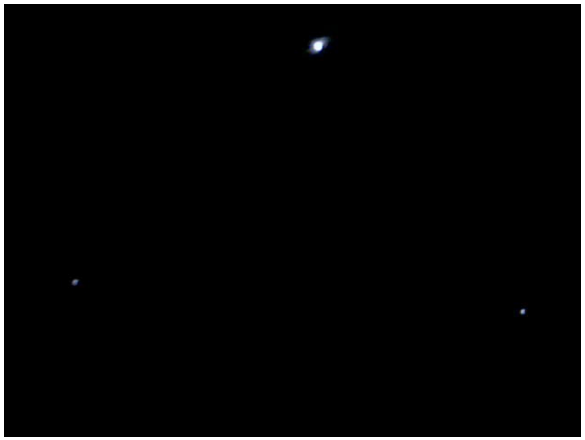
Next we use an IR filter on the camera to block out all non-infrared light. From there we set the distance from the camera to the light plane to a variable distance of 10-20 inches. From each of the distances, we take pictures so that we can later analyze them to find a suitable function to predict unknown distances.

Sample Captured Images

- The images taken by the camera using the apparatus.



10 inches



12 inches

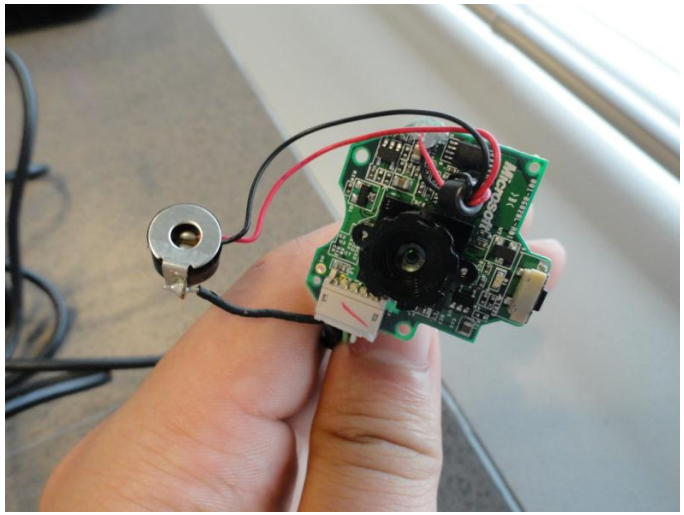
15 inches

- We took pictures from 10 to 20 inches

Infrared Marker Detection

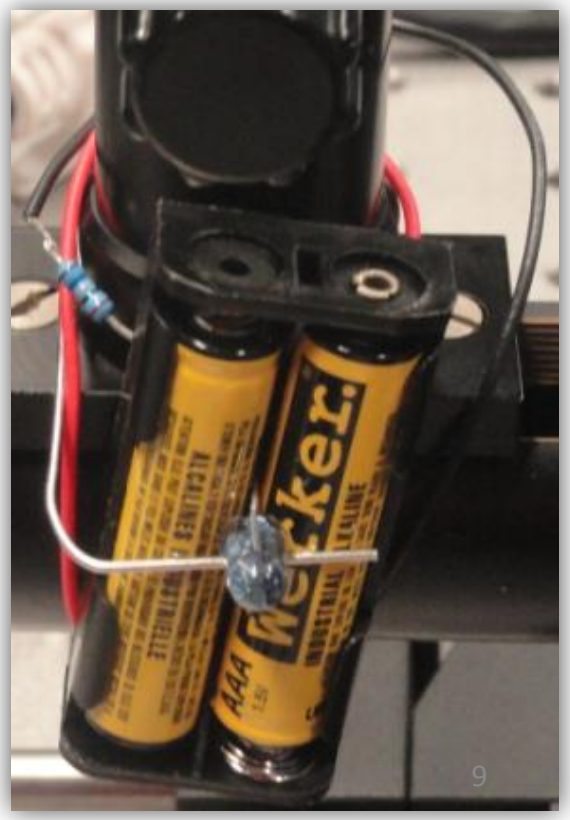
- The program collects all the points in the image in which the average RGB values is above a threshold of 200 and stores the coordinate of each.

Source Code: http://bit.ly/cixjZW



Webcam

Infrared light

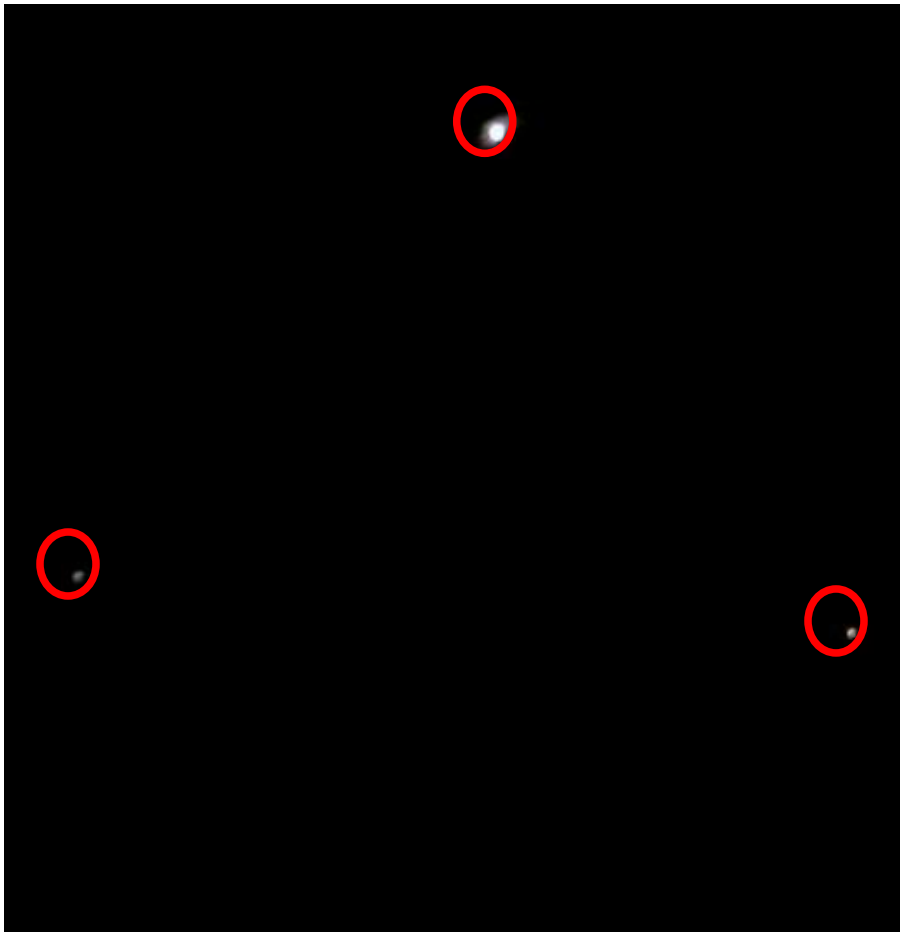


Center-of-mass Detection Algorithm

- After searching and finding an array of points that are above the 200 threshold, the program will sort through the points and group them by those adjacent to one another within a 30 pixel radius distance.
- After the points are grouped, they are “removed” from the arraylist and the program traverses through to the next set of points.
- After sorting the pixels into the groups, each group is put into a separate arraylist, from which we can calculate the midpoint of the LED light.

$$\text{Midpoint} = \frac{\qquad\qquad}{\qquad\qquad}\ \frac{\qquad\qquad}{\qquad\qquad}$$

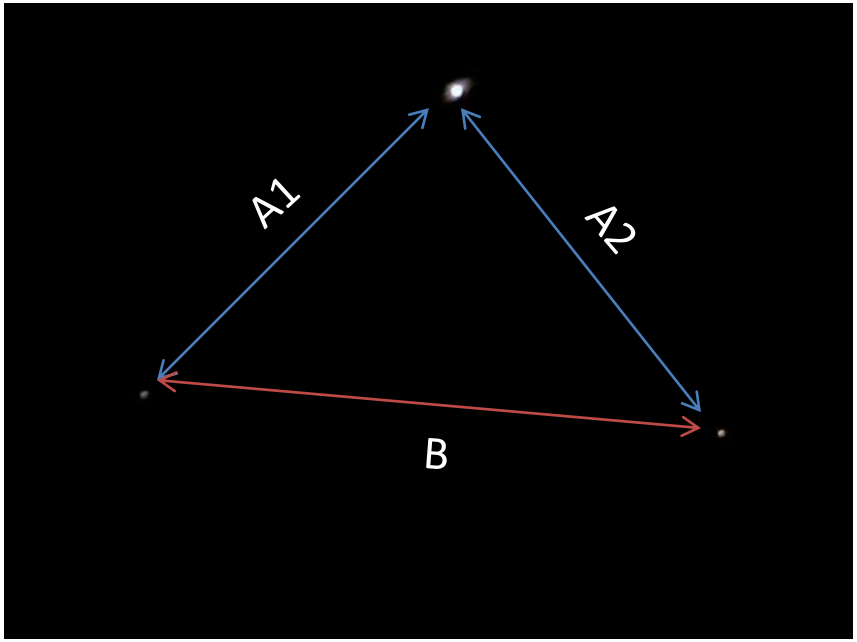
Grouping Algorithm



- After searching through the picture to find all the points with an average RGB value over 100, we figured out another algorithm to sort them.
- We looked at the first point as a base point. If the next point is within a 30 pixel radius of the first point, it is added to the same group/list as the first point. If not, the point is added to a secondary list. After finding all the points belonging to the first light grouping, we run the same algorithm test on the secondary list, thus creating another light grouping list. And so on until we have grouped all the “light” pixels by their correct group.

Infrared Markers

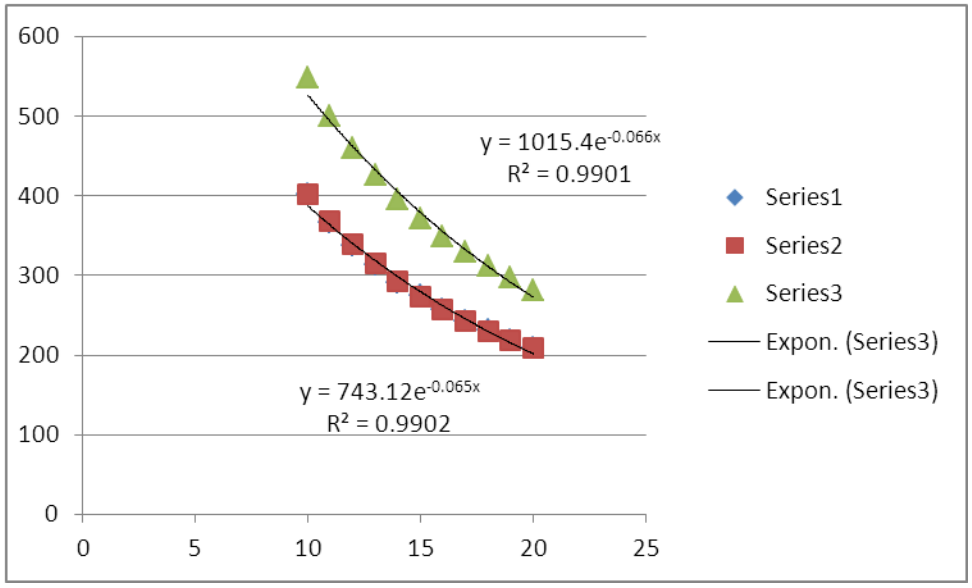
- After the picture collection is done, we wrote a program to calculate the Euclidean distances between each of the light sources



Pixel distance = $\sqrt{\quad}$

Distance vs. Pixel Characterization

- We used the distance formula to calculate the distances between each of the 3 points.



	A1	A2	B
10 in.	401	401	547
11 in.	366	367	499
12 in.	337	337	459
13 in.	312	313	425
14 in.	290	290	395
15 in.	273	273	370
16 in.	256	257	348
17 in.	241	241	328
18 in.	230	229	311
19 in.	218	218	296
20 in.	207	207	281

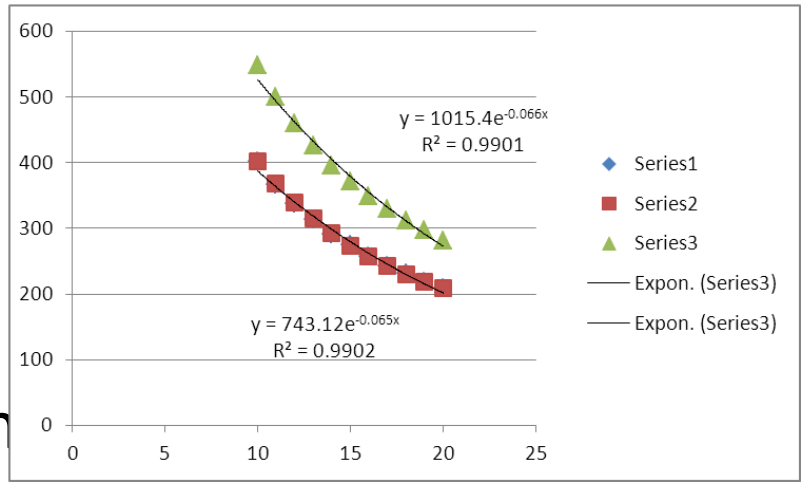
Regression

- Exponential Regression

$B = 1015.4 * 10^{-0.066x}$

$A = 743.12 * 10^{-0.065x}$

where x is physical distan

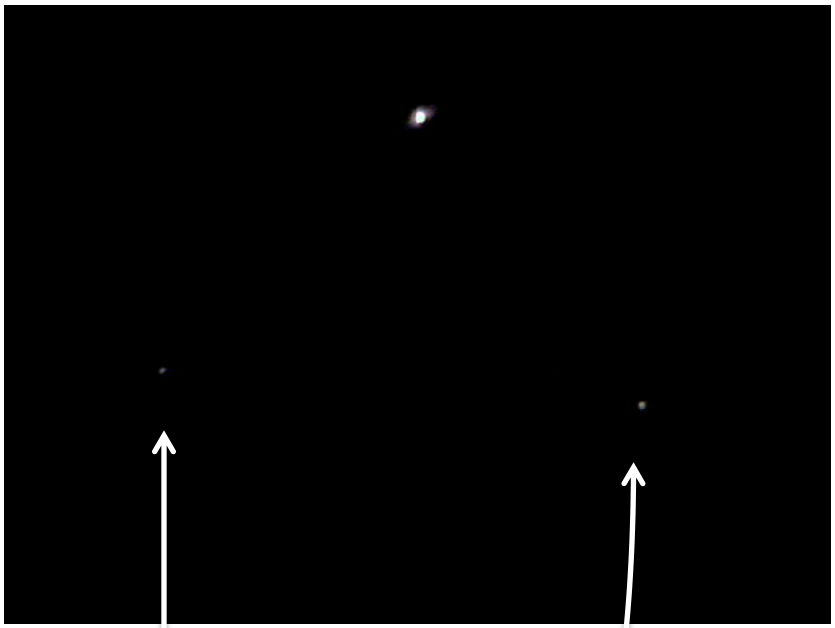


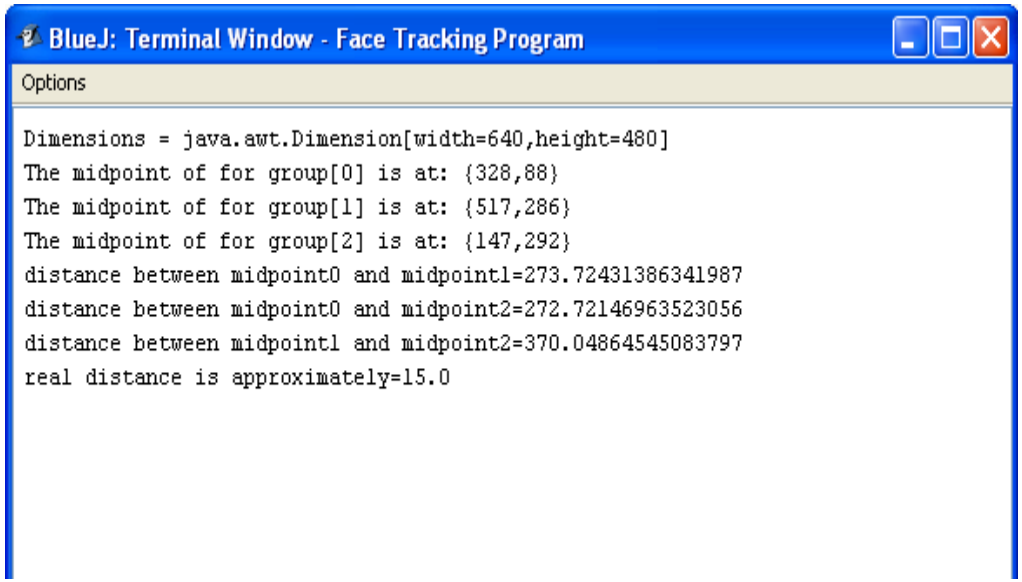
( )

( ) ( )

Program Results

- This program combines and displays all of the previously described algorithms.



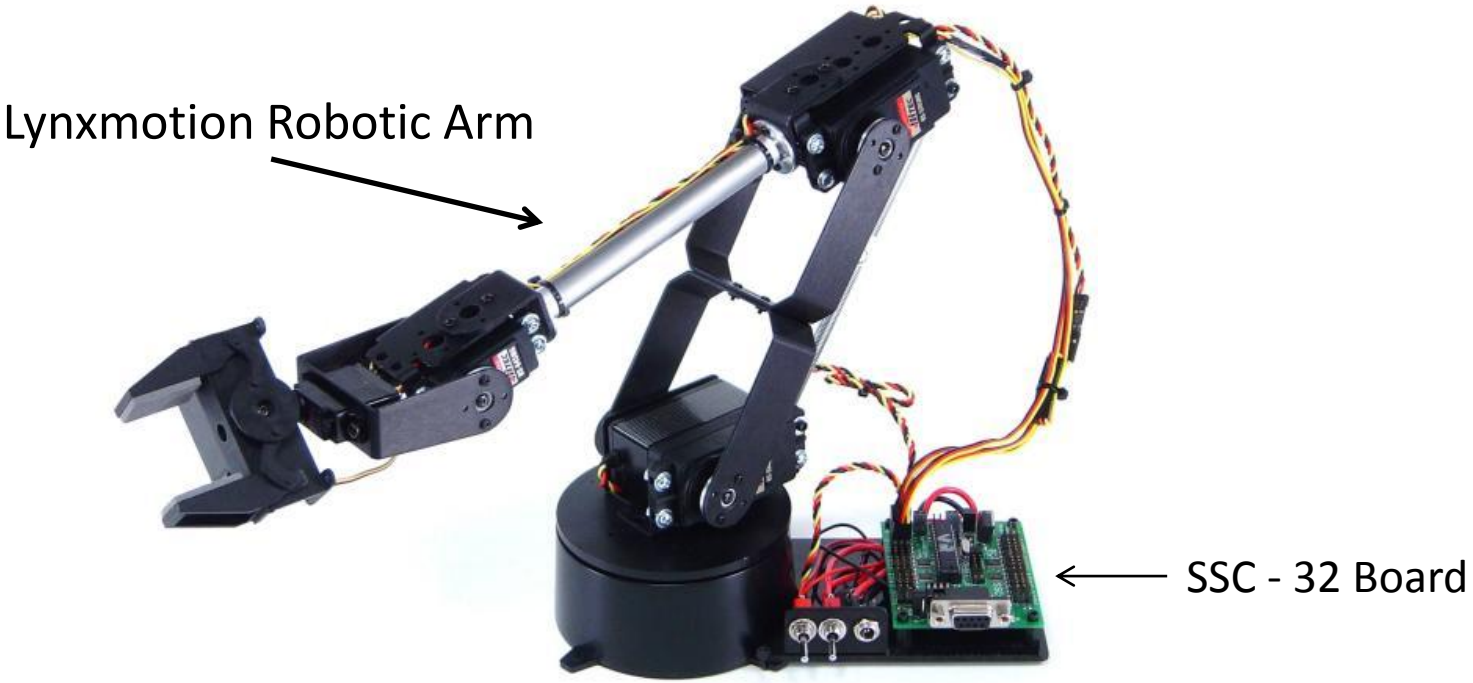


Future Work

- Our next step is to calculate and determine the user's face direction based on the position of the 3 IR lights and the approximate viewing angle, as well as accounting for variations in the tilt of the display.

HAND SHAKE SIMULATION

Robot Hardware



Robot Software (RIOS)

Main Controls

Robot Controls

Import/Export Projects

Edit Projects

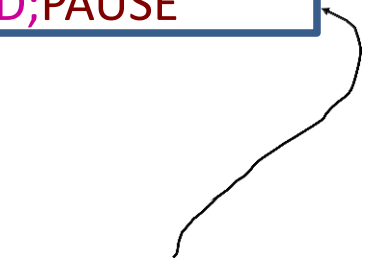
Play projects

Connect/Disconnect to robot

Control Robot Movements by Scripts

- After examining several scripts, I learned the basic format for creating basic movements for the robot.

```
PROJECT;SEQUENCE;STEP;MOVEKIND;BASE;SHOULDER;SPEED;PAUSE
ROBODEMO;000001;000001;2;90;0;30;1000
ROBODEMO;000001;000002;2;-90;0;20;1000
ROBODEMO;000001;000003;2;0;0;20;1000
ROBODEMO;000001;000004;2;0;-6;20;1000
ROBODEMO;000001;000005;2;0;20;20;1000
ROBODEMO;000001;000006;2;-90;20;20;1000
ROBODEMO;000001;000007;2;90;-6;20;1000
ROBODEMO;000001;000008;2;0;20;20;1000
ROBODEMO;000001;000009;2;-90;-6;20;1000
```

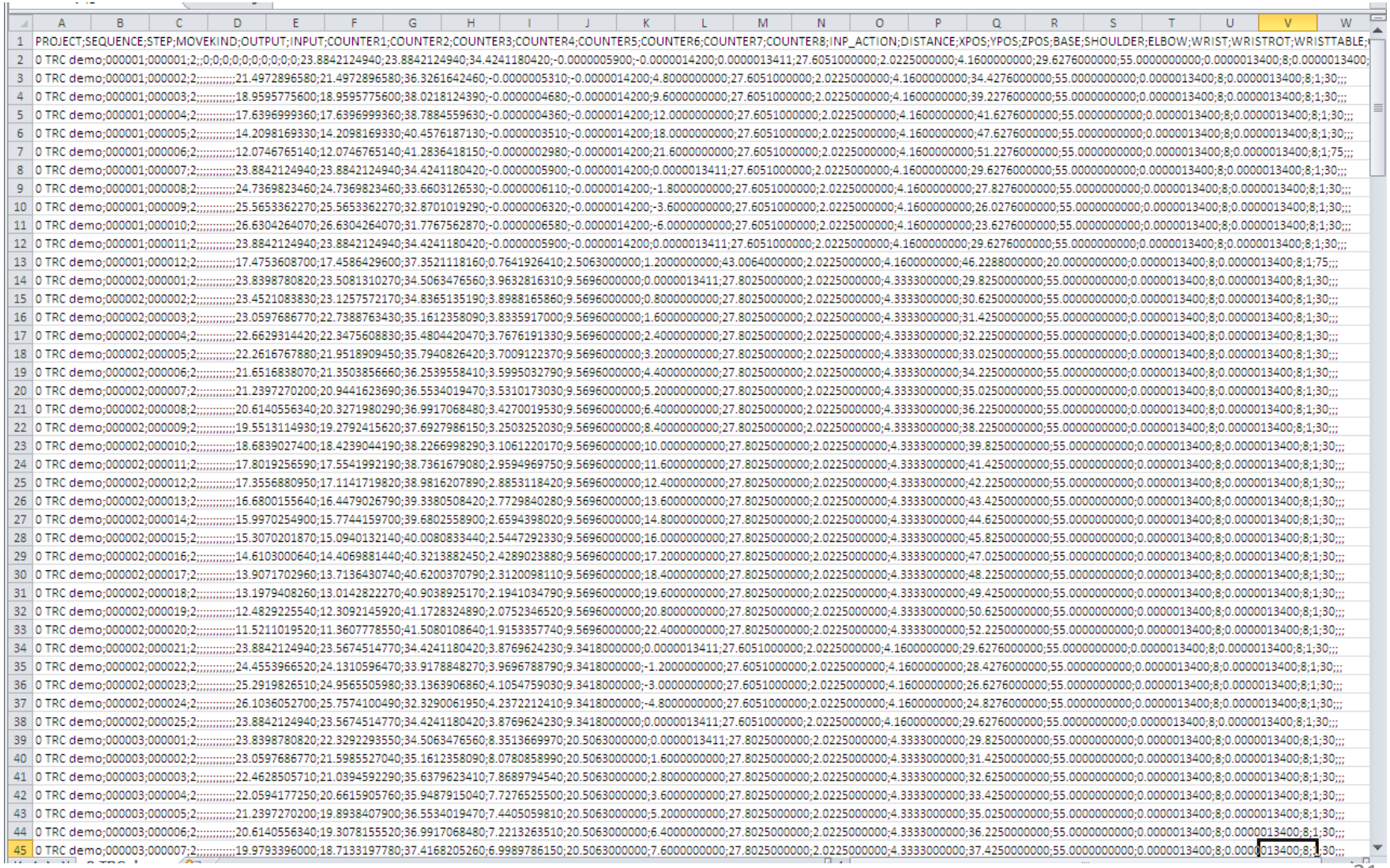


format order

Note: A project is composed of sequences. A sequence is composed of steps.

Thus “ROBODEMO” is the project name. “SEQUENCE” is the sequence number. “STEP” is the step in the sequence. “MOVEKIND” is the style/type of movement programmed. “BASE” is the angle that the base servo must move to. “SHOULDER” is the angle the shoulder servo must move to. “SPEED” is the speed at which the servo moves. “PAUSE” is how long the servo waits between steps.

Create Complicated Script with Excel



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1	PROJECT;SEQUENCE;STEP;MOVEKIND;OUTPUT;INPUT;COUNTER1;COUNTER2;COUNTER3;COUNTER4;COUNTER5;COUNTER6;COUNTER7;COUNTER8;INP_ACTION;DISTANCE;XPOS;YPOS;ZPOS;BASE;SHOULDER;ELBOW;WRIST;WRISTROT;WRISTTABLE;T																						
2	0 TRC demo;000001;000001;2;;;0;0;0;0;0;0;0;0;0;0;23.8842124940;23.8842124940;34.4241180420;-0.0000005900;-0.0000014200;0.0000013411;27.6051000000;2.0225000000;4.1600000000;29.6276000000;55.0000000000;0.0000013400;8;0.0000013400;																						
3	0 TRC demo;000001;000002;2;;;;;;;;;;21.4972896580;21.4972896580;36.3261642460;-0.0000005310;-0.0000014200;4.8000000000;27.6051000000;2.0225000000;4.1600000000;34.4276000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
4	0 TRC demo;000001;000003;2;;;;;;;;;;18.9595775600;18.9595775600;38.0218124390;-0.0000004680;-0.0000014200;9.6000000000;27.6051000000;2.0225000000;4.1600000000;39.2276000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
5	0 TRC demo;000001;000004;2;;;;;;;;;;17.6396999360;17.6396999360;38.7884559630;-0.0000004360;-0.0000014200;12.0000000000;27.6051000000;2.0225000000;4.1600000000;41.6276000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
6	0 TRC demo;000001;000005;2;;;;;;;;;;14.2098169330;14.2098169330;40.4576187130;-0.0000003510;-0.0000014200;18.0000000000;27.6051000000;2.0225000000;4.1600000000;47.6276000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
7	0 TRC demo;000001;000006;2;;;;;;;;;;12.0746765140;12.0746765140;41.2836418150;-0.0000002980;-0.0000014200;21.6000000000;27.6051000000;2.0225000000;4.1600000000;51.2276000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;75;;;																						
8	0 TRC demo;000001;000007;2;;;;;;;;;;23.8842124940;23.8842124940;34.4241180420;-0.0000005900;-0.0000014200;0.0000013411;27.6051000000;2.0225000000;4.1600000000;29.6276000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
9	0 TRC demo;000001;000008;2;;;;;;;;;;24.7369823460;24.7369823460;33.6603126530;-0.0000006110;-0.0000014200;-1.8000000000;27.6051000000;2.0225000000;4.1600000000;27.8276000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
10	0 TRC demo;000001;000009;2;;;;;;;;;;25.5653362270;25.5653362270;32.8701019290;-0.0000006320;-0.0000014200;-3.6000000000;27.6051000000;2.0225000000;4.1600000000;26.0276000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
11	0 TRC demo;000001;000010;2;;;;;;;;;;26.6304264070;26.6304264070;31.7767562870;-0.0000006580;-0.0000014200;-5.4000000000;27.6051000000;2.0225000000;4.1600000000;23.6276000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
12	0 TRC demo;000001;000011;2;;;;;;;;;;23.8842124940;23.8842124940;34.4241180420;-0.0000005900;-0.0000014200;0.0000013411;27.6051000000;2.0225000000;4.1600000000;29.6276000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
13	0 TRC demo;000001;000012;2;;;;;;;;;;17.4753608700;17.4586429600;37.3521118160;0.7641926410;2.5063000000;1.2000000000;43.0064000000;2.0225000000;4.1600000000;46.2288000000;20.0000000000;0.0000013400;8;0.0000013400;8;1;75;;;																						
14	0 TRC demo;000002;000001;2;;;;;;;;;;23.8398780820;23.5081310270;34.5063476560;3.9632816310;9.5696000000;0.0000013411;27.8025000000;2.0225000000;4.3333000000;29.8250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
15	0 TRC demo;000002;000002;2;;;;;;;;;;23.4521083830;23.1257572170;34.8365135190;3.8988165860;9.5696000000;0.8000000000;27.8025000000;2.0225000000;4.3333000000;30.6250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
16	0 TRC demo;000002;000003;2;;;;;;;;;;23.0597686770;22.7388763430;35.1612358090;3.8335917000;9.5696000000;1.6000000000;27.8025000000;2.0225000000;4.3333000000;31.4250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
17	0 TRC demo;000002;000004;2;;;;;;;;;;22.6629314420;22.3475608830;35.4804420470;3.7676191330;9.5696000000;2.4000000000;27.8025000000;2.0225000000;4.3333000000;32.2250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
18	0 TRC demo;000002;000005;2;;;;;;;;;;22.2616767880;21.9518909450;35.7940826420;3.7009122370;9.5696000000;3.2000000000;27.8025000000;2.0225000000;4.3333000000;33.0250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
19	0 TRC demo;000002;000006;2;;;;;;;;;;21.6516838070;21.3503856660;36.2539558410;3.5995032790;9.5696000000;4.4000000000;27.8025000000;2.0225000000;4.3333000000;34.2250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
20	0 TRC demo;000002;000007;2;;;;;;;;;;21.2397270200;20.9441623690;36.5534019470;3.5310173030;9.5696000000;5.2000000000;27.8025000000;2.0225000000;4.3333000000;35.0250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
21	0 TRC demo;000002;000008;2;;;;;;;;;;20.6140556340;20.3271980290;36.9917068480;3.4270019530;9.5696000000;6.4000000000;27.8025000000;2.0225000000;4.3333000000;36.2250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
22	0 TRC demo;000002;000009;2;;;;;;;;;;19.5513114930;19.2792415620;37.6927986150;3.2503252030;9.5696000000;8.4000000000;27.8025000000;2.0225000000;4.3333000000;38.2250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
23	0 TRC demo;000002;000010;2;;;;;;;;;;18.6839027400;18.4239044190;38.2266998290;3.1061220170;9.5696000000;10.0000000000;27.8025000000;2.0225000000;4.3333000000;39.8250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
24	0 TRC demo;000002;000011;2;;;;;;;;;;17.8019256590;17.5541992190;38.7361679080;2.9594969750;9.5696000000;11.6000000000;27.8025000000;2.0225000000;4.3333000000;41.4250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
25	0 TRC demo;000002;000012;2;;;;;;;;;;17.3556880950;17.1141719820;38.9816207890;2.8853118420;9.5696000000;12.4000000000;27.8025000000;2.0225000000;4.3333000000;42.2250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
26	0 TRC demo;000002;000013;2;;;;;;;;;;16.6800155640;16.4479026790;39.3380508420;2.7729840280;9.5696000000;13.6000000000;27.8025000000;2.0225000000;4.3333000000;43.4250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
27	0 TRC demo;000002;000014;2;;;;;;;;;;15.9970254900;15.7744159700;39.6802558900;2.6594398020;9.5696000000;14.8000000000;27.8025000000;2.0225000000;4.3333000000;44.6250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
28	0 TRC demo;000002;000015;2;;;;;;;;;;15.3070201870;15.0940132140;40.0080833440;2.5447292330;9.5696000000;16.0000000000;27.8025000000;2.0225000000;4.3333000000;45.8250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
29	0 TRC demo;000002;000016;2;;;;;;;;;;14.6103000640;14.4069881440;40.3213882450;2.4289023880;9.5696000000;17.2000000000;27.8025000000;2.0225000000;4.3333000000;47.0250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
30	0 TRC demo;000002;000017;2;;;;;;;;;;13.9071702960;13.7136430740;40.6200370790;2.3120098110;9.5696000000;18.4000000000;27.8025000000;2.0225000000;4.3333000000;48.2250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
31	0 TRC demo;000002;000018;2;;;;;;;;;;13.1979408260;13.0142822270;40.9038925170;2.1941034790;9.5696000000;19.6000000000;27.8025000000;2.0225000000;4.3333000000;49.4250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
32	0 TRC demo;000002;000019;2;;;;;;;;;;12.4829225540;12.3092145920;41.1728324890;2.0752346520;9.5696000000;20.8000000000;27.8025000000;2.0225000000;4.3333000000;50.6250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
33	0 TRC demo;000002;000020;2;;;;;;;;;;11.5211019520;11.3607778550;41.5080108640;1.9153357740;9.5696000000;22.4000000000;27.8025000000;2.0225000000;4.3333000000;52.2250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
34	0 TRC demo;000002;000021;2;;;;;;;;;;23.8842124940;23.5674514770;34.4241180420;3.8769624230;9.3418000000;0.0000013411;27.6051000000;2.0225000000;4.1600000000;29.6276000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
35	0 TRC demo;000002;000022;2;;;;;;;;;;24.4553966520;24.1310596470;33.9178848270;3.9696788790;9.3418000000;-1.2000000000;27.6051000000;2.0225000000;4.1600000000;28.4276000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
36	0 TRC demo;000002;000023;2;;;;;;;;;;25.2919826510;24.9565505980;33.1363906860;4.1054759030;9.3418000000;-3.0000000000;27.6051000000;2.0225000000;4.1600000000;26.6276000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
37	0 TRC demo;000002;000024;2;;;;;;;;;;26.1036052700;25.7574100490;32.3290061950;4.2372212410;9.3418000000;-4.8000000000;27.6051000000;2.0225000000;4.1600000000;24.8276000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
38	0 TRC demo;000002;000025;2;;;;;;;;;;23.8842124940;23.5674514770;34.4241180420;3.8769624230;9.3418000000;0.0000013411;27.6051000000;2.0225000000;4.1600000000;29.6276000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
39	0 TRC demo;000003;000001;2;;;;;;;;;;23.8398780820;22.3292293550;34.5063476560;8.3513669970;20.5063000000;0.0000013411;27.8025000000;2.0225000000;4.3333000000;29.8250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
40	0 TRC demo;000003;000002;2;;;;;;;;;;23.0597686770;21.5985527040;35.1612358090;8.0780858990;20.5063000000;1.6000000000;27.8025000000;2.0225000000;4.3333000000;31.4250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
41	0 TRC demo;000003;000003;2;;;;;;;;;;22.4628505710;21.0394592290;35.6379623410;7.8689794540;20.5063000000;2.8000000000;27.8025000000;2.0225000000;4.3333000000;32.6250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
42	0 TRC demo;000003;000004;2;;;;;;;;;;22.0594177250;20.6615905760;35.9487915040;7.7276525500;20.5063000000;3.6000000000;27.8025000000;2.0225000000;4.3333000000;33.4250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
43	0 TRC demo;000003;000005;2;;;;;;;;;;21.2397270200;19.8938407900;36.5534019470;7.4405059810;20.5063000000;5.2000000000;27.8025000000;2.0225000000;4.3333000000;35.0250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
44	0 TRC demo;000003;000006;2;;;;;;;;;;20.6140556340;19.3078155520;36.9917068480;7.2213263510;20.5063000000;6.4000000000;27.8025000000;2.0225000000;4.3333000000;36.2250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						
45	0 TRC demo;000003;000007;2;;;;;;;;;;19.9793396000;18.7133197780;37.4168205260;6.9989786150;20.5063000000;7.6000000000;27.8025000000;2.0225000000;4.3333000000;37.4250000000;55.0000000000;0.0000013400;8;0.0000013400;8;1;30;;;																						

Discussion

- RS-232 / SSC-32 problem
- Experiment
  - Simulation and replaying of hand movements
  - Facilitate repeat of hand movements

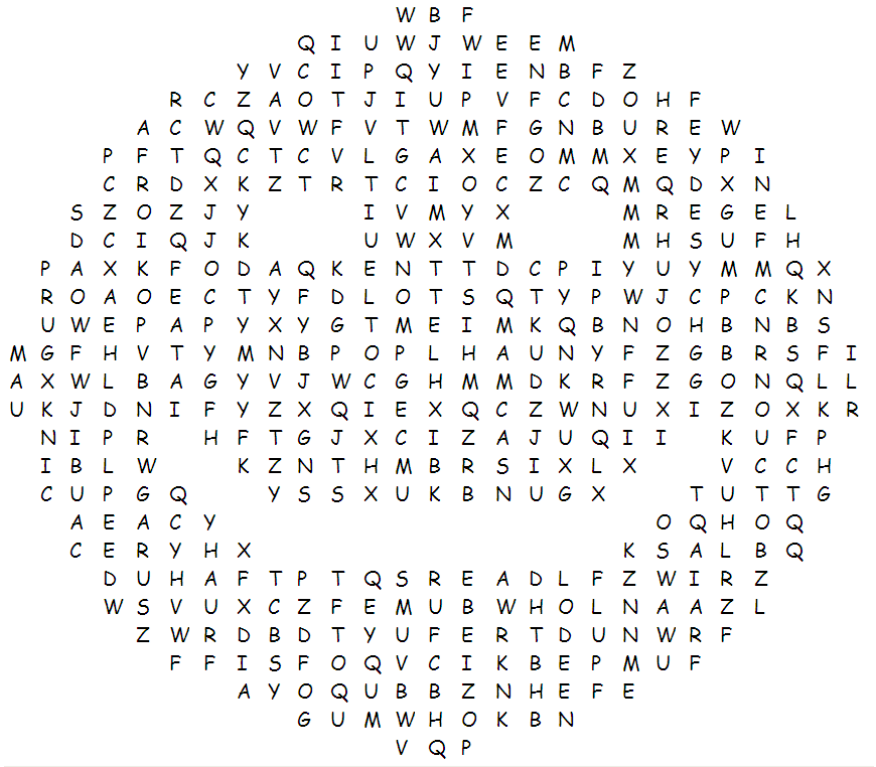
USER STUDY

Motivation

- Design “realistic” tasks consisting of image viewing and touch-panel operations, which result in viewing angle changes

Sample Task

- Task: Find 3 consecutive ‘Y’s in diagonal
- Results:
  - 5 zoom-in
  - 3 zoom-out
  - 27 pan



Discussion

- iTunes compression problem
- App for optimized viewing of uncompressed images
- Trace user input events

Future Work

Viewing Angle Detection

User Study Design

Viewing Angle Characterization

Image Viewer

Viewing Angle Compensation

User Event Logger

User Study Experiments

Hand Movement Simulation

: finished

: to do

: external