CS 1114: Introduction to Computing Using MATLAB and Robotics

Prof. Noah Snavely
CS1114
http://cs1114.cs.cornell.edu

Robots: 2029
Robots: 2012

Sony AIBO  iRobot Create  Wowwee Rovio

Robots: cute but dumb

- What do they know about the world around them?
  - Without your help, very little
  - Can’t even notice a bright red lightstick

- Your mission: make them smarter
- Lots of interesting math and computer science, some computer programming
  - Lots of experience with programming, even with robots, won’t give you a leg up in 1114
Overview

What is CS 1114?
- An honors-level intro to CS using camera-controlled robots (Sony Aibo, Wowwee Rovio)
- An alternative to CS1112 or CS1132, to fulfill your Matlab computing requirement
- Formerly known as CS100R

Goals of CS1114

- Give you an intuition about computational problem solving
- Teach you useful (and interesting) computer science
- Give you fluency in the Matlab programming environment
- Have fun with robots
Requirements

- Exposure to programming (in any language)
- Some interest in math
  - Computer science is about much more than programming, and so is this course

Staff

- Noah Snavely – Instructor (me)
- **Consultants:**
  - Rocky Li (frl8)
  - Gautam Kamath (gck43)
  - Andrew Rzesnik (ajr234)
  - Ian Purnell (iap9)
  - Jason Boada (jwb292)
  - Markus Burkardt (mb833)
  - Madeline Burton (mrb248)
  - Margaret Scheiner (ms948)
  - Stephanie Lee (snl27)
Many options for intro computing courses

- CS1110, CS1113 – Java
- CS1112, CS1114 – Matlab

### CS111X AND CS113X

Beginning Fall 2007: every engineering student takes CS111X (4 credits) and CS113X (1 credit)

<table>
<thead>
<tr>
<th>CS1112 or CS1114 (this course). Then CS1130. Matlab, then Java</th>
</tr>
</thead>
<tbody>
<tr>
<td>or</td>
</tr>
<tr>
<td>CS1110 or CS1113. Then CS1132. Java, then Matlab.</td>
</tr>
</tbody>
</table>

*CS2110 prerequisite: CS1110 or CS1130.*
Java or Matlab?

- Both CS1110 and CS111[24] teach fundamental problem solving skills and computer science techniques
- The destination is the same...
- ... but the vehicle is different

Questions?
CS1114 Logistics

- Lectures: Tue Thu 11:15–12:05, UPS 211
- Sections:
  - Wed 1:25 - 2:15, Upson 317
  - Wed 2:30 - 3:20, Upson 317
  - Wed 3:35 - 4:25, Upson 317
  - Please go to same section for the entire course
- Sections will be led by Rocky, Gautam, and others

CS1114 Logistics

- CS1114 lab: Upson 317
- You will soon have access to the lab and passwords for the computers
- Office hours will generally be held in the lab (see staff page for hours)
Course webpage

CS1114: Introduction to Computing using Matlab and Robotics
(Spring 2012)

http://cs1114.cs.cornell.edu/

Piazza
About me

- Noah Snavely
- http://www.cs.cornell.edu/~snavely/

Research
- Computer vision
- Computer graphics

Research focus

- 3D reconstruction from unorganized image collections
  - Flickr photos ("Colosseum")
  - Automatic 3D reconstruction

- Microsoft Photosynth
What can we do with computer science and computer vision?
Robotics

NASA’s Mars Spirit Rover

Sports

*Sportvision* first down line
Nice explanation on www.howstuffworks.com

Source: S. Seitz
Face detection

- Many new digital cameras now detect faces
  - Canon, Sony, Fuji, ...

Source: S. Seitz

- What’s wrong with this picture?
Face recognition

Who is she?

Source: S. Seitz
Vision-based biometrics

“How the Afghan Girl was Identified by Her Iris Patterns” Read the story

Medical imaging

3D imaging
MRI, CT

Image guided surgery
Grimson et al., MIT

Source: S. Seitz
User interfaces

Human vision

Source: "80 million tiny images" by Torralba, et al.

Question: How many people are in this image?
Interpreting images

Q: Can a computer (or robot) understand this image?
A: Yes and no (mostly no)

Major CS1114 Projects

- From a camera, figure out the position of a bright red lightstick
  - Use this to guide a robot around

What we see

What the robot sees
Assignments

- Approximately one mini-quiz every two weeks
  - In class, usually at start of Thursday lecture
    • Corollary: be on time, or write fast...
- 5-6 robot programming assignments with multiple parts
  - You will demo each part to the lab TA’s
- 3 exams, probably in-class
- Free-form final project (required)

Major CS1114 Projects

- Robot security guard
  - Detect and track moving objects
- Object recognition – find the right DVD in your collection
- Do Something Cool (final project)
Grading

- Programming assignments (10-20%)
- In-class quizzes (15-25%)
- Exams (50-60%)

Questions?
Getting started with Matlab

Interpreting images

Q: Can a computer (or robot) find the lightstick?
A: With your help, yes!*

*Reference text
What is an image?

- A grid of numbers (intensity values)

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>62 75 25</td>
<td>119 120 105 4 0</td>
</tr>
<tr>
<td>50 10 0 62</td>
<td>12 78 24 0</td>
</tr>
<tr>
<td>19 58 157 40</td>
<td>49 0 0 49</td>
</tr>
<tr>
<td>176 136 5</td>
<td>188 191 68 0 49</td>
</tr>
<tr>
<td>0 1 1 20</td>
<td>29 27 0 77</td>
</tr>
<tr>
<td>0 89 104 147</td>
<td>187 192 82 208</td>
</tr>
<tr>
<td>255 252 0</td>
<td>156 123 0 31</td>
</tr>
<tr>
<td>85 133 107</td>
<td>17 1 0 99 30</td>
</tr>
</tbody>
</table>

- Intensity values range between 0 (black) and 255 (white)
What is an image?

- A grid of numbers (intensity values)
- In Matlab, a matrix

300 x 220 matrix

Matrices in Matlab

- 1D matrix is often called a vector
  - Similar to arrays in other languages

\[
A = \begin{bmatrix} 10 & 30 & 40 & 106 & 123 \end{bmatrix}
\]
Row vector  
(or 1 x 5 matrix)

\[
A(1) == 10 \\
A(4) == 106
\]

\[
B = [ \\
10 \\
30 \\
40 \\
106 \\
123 \\
]
\]
Column vector (or 5 x 1 matrix)
Matrices in Matlab

\[ C = \begin{bmatrix}
10 & 30 & 40 & 106 & 123 \\
8 & 49 & 58 & 112 & 145 \\
16 & 53 & 86 & 123 & 152
\end{bmatrix} \]

3 x 5 matrix

\[ C(1,1) == 10 \]
\[ C(2,4) == 112 \]

can also assign to a matrix entries
\[ C(1,1) = C(1,1) + 1 \]

For next time

- Visit the course website
  [http://cs1114.cs.cornell.edu](http://cs1114.cs.cornell.edu)
- Read the Matlab tutorial
- Attend section in the lab tomorrow