CS123 - Introduction
Programming Your Personal Robot
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Course Description

An introduction to the programming of a sensor-rich personal robot. This course extends programming from the virtual environment into the physical world, which presents unique challenges. Focus is on three areas of intellectual discourse that are fundamental to the programming of physical devices: communication with the devices; programming of event driven behaviors; and reasoning with uncertainty. The concepts introduced will be put into practical use through a series of class projects centered around programming your personal robot. This course also serves as a good introduction to Experimental Robotics by exposing students to basic concepts and techniques that are relevant for real world robot programming.
Is This Class For Me?

CS157
CS225A  CS123
FRENLANG 60D
CS221  CS223A
What It Is Not

• It’s not about programming a “humanoid” robot
• It’s not about low level robot control (i.e. dynamics and kinematics)
• It’s not about AI (e.g. motion planning)
What It Is

• An introductory class for students who have no (or very limited) experience of programming robots (physical devices) but are interested in learning more.

• A “sampler” (overview): we will cover a range of fundamental topics of robot programming, but we will not be able to go into any specific topic in depth.
  - Communication, Behavior, Uncertainty, Extension, Team

• It’s a good preparatory class for “Experimental Robotics”

• A very hands-on class (learning by doing)
Why Physical Device Programming

• Traditional computer (i.e. workstations, desktops, laptops) have very limited I/O (e.g. keyboards/monitors) and are constrained physically (offices/home)

• Smart Phones have “liberated” computer - can be taken almost everywhere and have more sensors (camera, GPS, G-sensors, and etc.)

• “Smart Device” is “the next big thing”– rich with I/O and connecting to the internet or other computing devices (phone and computer), these smart devices reach further into our life
What Are Smart Devices?
Robots Are Also Smart Devices (That Can Move)
What are Robots Essentially?

- Computers with
  - More sensing - Get more (information) from the environment
  - More actuation - Interact more with the environment
Unique Challenges

- Communication has limits
- Sensing is imperfect
- Control is inaccurate
- Knowledge of the world incomplete
  - Not available
  - Impractical
- In fact, human has the same limitation
The World is “Messy”
A Simplified Paradigm

Virtual World

Computers
programs, data

abstract models

commands

sensor feedback

Sensors

Robots

actions

internal robot states

objects
e.g. work pieces, tools, etc.

Work space

Real (Physical) World
Introducing Hamster
“Karel” Comes Into the Physical World

Karel (Virtual Robot):
• Perfect communication
• Perfect knowledge
• Perfect sensing
• Perfect (accurate) control
• High-level abstraction

Hamster (Real Robot):
• Limited communication
• Incomplete knowledge
• Uncertainty in sensing
• Imperfect control
• Low-level access
What You Should Know

• CS106
  • OOP
• CS107 a plus
• Python
  • Basic understanding
• Enjoy programming in general
  • Very hands-on
Syllabus

• Part 1 - Communicating with robot (2 weeks)
  • BLE communication and robot API
• Part 2 - Event Driven Behavior (2 weeks)
  • Finite State Machine (Behavior Tree)
• Part 3 - Reasoning with Uncertainty (2 weeks)
  • Dealing with noisy data, uncertainty in sensing and control
• Part 4 - Extending the robot (1 weeks)
  • I/O extensions: digital, analog, servo, pwm, etc
• Part 5 – Putting it together (including UI/UX) (3 weeks)
  • Design and implement of final (group) project
  • Encourage you to go “above and beyond”
Course Structure

• Lectures
  • Cover basic concepts

• Readings
  • Provide background and deeper knowledge on relevant topics

• Projects
  • Hands-on experience, learning by doing

• “Freestyle”
  • Going beyond class material on your own. Hamster is an open platform
Grading

• This class will be project base only
  • No exam 😊
• There will be 4 individual projects and 1 team (final) project
  • Project #1 (Communication) – 20%
    • 2 weeks
  • Project #2 (Finite State Machine) - 20%
    • 2 weeks
  • Project #3 (Uncertainty) - 20%
    • 2 weeks
  • Project #4 (Robot Extension) - 10%
    • 1 week
  • Project #5 (Final, Group project) - 30%
    • 3 weeks
    • Design your (team) project (need to get approval)
About US

• Instructors
  • Dr. Kyong-Sok “KC” Chang
  • Dr. David Zhu

• TA
  • Jocelyn Neff
  • Kornel Niedziela
Dr. Kyong-Sok “KC” Chang

• CS Ph.D. 2000 Stanford (Robotics)
• Professional Interest
  • Software framework for efficient modeling, simulation, and control of robotic systems
  • SimLab: Robotics Company (Korea)
    • Quadruped
    • Robotic Hand
    • Mobile base
    • Humanoid: DRC
Dr. David Zhu

- CS Ph.D. ’91: Stanford (Robotics)
- Professional Interest
  - Games
  - Toys to Life
  - Robots For Education
  - China
Jocelyn Neff

• BS CS 2015, MS MS&E 2016
• Professional Interests
  • Autonomous Cars
  • Smart Home
  • Wearables
  • Geo
  • Knowledge Graph
Kornel Niedziela

- B.ASc in Mechatronics Eng., U of Waterloo
- MSME, Stanford – Design Methodology focus
- Interested in:
  - Robotics
  - Product Design
  - Automotive
Logistics

• Getting your own Hamster
  • Sign-up sheet
• Programming environment
  • Mac
  • PC
• Website for the class
• TA sessions (office hours)
  • Location
  • Time
• Emails
Feedbacks Are Appreciated
Calendar

Part 1

Part 2

Part 3

Part 4

Part 5

KC Teaching

David Teaching

Stanford University (cs123.stanford.edu)
BLE: Hamster

Generic Apps: connecting to Hamster
-- iPhone, iPad, Mac: LightBlue
-- Android: nRF Master Control Panel

Sensors: (UUID: 0x00009001...)
-- Read data (20 bytes) from Hamster.
(in hex)
1st byte: version/topology
2nd byte: network ID
3rd byte: command/security
4th byte: Signal Strength (-128~0)
5th byte: Left Proximity (0~255)
6th byte: Right Proximity (0~255)
7th byte: Left Floor (0~255)
8th byte: Right Floor (0~255)

Effectors: (UUID: 0x0000A000...)
-- Write 11 bytes to Hamster.
<0000103232020300000040>
(in hex)
0x00: version/topology
0x00: network ID
0x10: command/security
0x32: left wheel speed (50: -100~100)
0x32: right wheel speed (50: -100~100)
0x02: left LED color (green: 0~7)
0x03: right LED color (blue: 0~7)
0x00: buzzer high
0x00: buzzer middle
0x00: buzzer low
0x40: musical note (C4: middle C: 0~88)
BLE: Reading

This week's (and future) reading for BLE.

“Getting started with Bluetooth Low Energy” by Townsend, Davidson & Akiba, O’Reilly