Massachusetts Institute of Technology
Department of Electrical Engineering and Computer Science

6.829 Fall 2017 **Project Ideas** September 28, 2017

The term project is a major component of 6.829, since that's where you draw upon your knowledge and experience from the course readings and elsewhere to actually do research. This document is intended to ease the process of figuring out what to work on and writing a short proposal explaining what you want to work on. We expect teams of 3 people.

Below are some project ideas to help you with the initial proposal. Feel free to propose your own ideas. If you are interested in working on one of the suggested projects and already have a team, you can claim the project by sending an email to 6.829-fall2017@mit.edu. Start the email with a title [6.829 - project X claimed] and tell us the names of your team members.

If you are interested in working on one of the suggested projects but still looking for teammates, also send an email to 6.829-fall2017@mit.edu with a title [6.829 - project X] and briefly describe your background. People interested in the same project can reply to the email and form a team.

You can also send an email to the list with your own project ideas to recruit team members. Start the email with a title [6.829 - project YOUR-PROJECT-NAME].

Project proposal deadline: Oct. 9, 2017 23:59pm. Each team should submit only one proposal.

1 Detect Drowsy Drivers Using Wireless Signals and Machine Learning

Drowsy driving is a common cause for accidents in the US and internationally. Past work has used a camera to detect eye closure and use it as a sign of sleepiness. This approach however fails when drier wears sunglasses. It also experience errors due to shadowing.

The objective of this project is to detect a drowsy driver based on the wireless signal reflected off his body. As we saw in lectures, wireless signals can track breathing and heartrate. These signals change as the driver becomes sleepy. The project involves the following tasks

1) Use the driving simulator in professor Katabi's lab to collect drowsy driving data. You need to collect wireless signal as well as some data for ground truth. You can use a camera for the ground truth or a questionnaire.

2) Develop an ML classifier that classifies every 5 minutes of driving into one of three classes: very drowsy, OK but tired, alert. You can develop your classifier from scratch or ask us to give you an initial classifier that you then have to improve.

3) Adapt the classifier to a particular driver. Specifically, you can envision that drowsiness classifier is like Siri, the more it sees the driver the more it can adapt to how this particular person behaves when he/she is driving. The adaptive classifier should get better over time as it sees more experiments from the particular driver it is adapting to.

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2 Driverless Cars that Deal with Snow and Fog

Today's driverless cars rely on LIDAR to discover their surroundings. LIDAR however does not work well in bad weather conditions such as snow or fog. Radar technology based on radio reflections can potentially address this issue. In the WiTrack Paper, you saw how to use radar to track people indoor. A new radar device from Texas Instruments was recently proposed for tracking cars outdoors. This project explores the possibility of using such a radar to track cars and replace or help LIDAR in bad weather conditions.

In particular, check the following paper about this new radar. http://www.ti.com/product/AWR1642

The tasks in this project are as follows:

1) Use the device to reproduce the measurements presented in this white paper

http://www.ti.com/lit/wp/spyy003/spyy003.pdf

2) Use the device on one of the streets near MIT to detect moving cars (locations and speeds)

3) Try putting the device on a moving car and see if you can still detect the other objects around the car

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3 In Body Tracking using RF Signals

In class, you learnt about using RF signals to track human bodies. The question we want to answer with this project is: can we use RF signals to see inside human bodies? This has multiple medical applications. The one that interests us the most is called proton therapy. Proton therapy is a treatment for cancer located close to sensitive regions like heart and lungs. By using a more accurate beam to destroy tumor cells, it prevents damage to human body tissues. However, this approach has its own risks. If the beam misses the target, the damage to the surrounding tissues can be large. Surgeons typically insert a small metallic seed inside the tumor cells. Our goal is to use radio waves to track this small metallic seed and help guide the proton beam to the tumor cells and avoid damage to the surrounding healthy tissues.

This project has two challenges:

1) RF signal is reflected off human body. If that is the case, how can one see inside the body?

2)Wi-Track can localize with an accuracy of tens of centimeter. However, this accuracy is not enough for the Proton Therapy application (typically requires sub cm accuracy). How can we improve the accuracy by at least one order of magnitude?

Pre-requisites: You will need to understand WiTrack (FMCW). The rest of the skills can be acquired while working on the project.

Steps:

1. Understand the problem through preliminary readings

2. Understand how RF propagation characteristics change inside human body and how one can design a system to see inside human body

3. Design localization system and algorithm to track seeds inside human body
4. Test the implementation on a real human tissue phantom (we have those!)
5. Use feedback from steps 4 and 5 to improve the system

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4 Creating Large Antenna Arrays by using Multiple Access Points for Localization

In class, you learnt about ArrayTrack which uses 8-antenna, regularly spaced linear arrays to get location information about Wi-Fi devices. However, most commercial access points have three to four antenna elements. The question we want to answer in this project is: can we combine signals from antennas across multiple access points as an irregularly spaced antenna array? Doing this will allow us to deploy ArrayTrack-like algorithms in commercial access points which have 3 to 4 antennas. Alternatively, this allows us to create much larger antenna arrays than ArrayTrack and achieve higher accuracy.

There challenges in building such an antenna array are two-fold:

1) Carrier Frequency Offset (CFO): As you learnt in class, hardware variations lead to different devices having slightly different frequencies. This means the antenna array equations will not be valid if the antennas are connected to different devices. However, as you learnt (or will learn) in class, there exist techniques to deal with CFO. We will explore these techniques and identify what works for our purpose.

2) Irregular Spacing: How do antenna array equations change when the spacing is not uniform? What happens when the array is 2-dimensional and not linear?

Pre-requisites: Most of the information you need for this project was covered in Lecture 5 (Wireless localizationArrayTrack).

Steps:

1. Understand the problem through a basic simulation (We can provide basic code)
2. Read and understand Chronos (https://www.usenix.org/system/files/conference/nsdi16/nsdi16-paper-vasisht.pdf). We will use this paper as a building block in addition to ArrayTrack
3. Design localization algorithm
4. Understand implementation framework (Software radios) and learn to program them
5. Implement and test the algorithm with software radios

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5 gesture recognition using multiple RFIDs

In class we talked about localization using WiFI devices using ArrayTrack. This project involves tracking RFIDs and using them for gesture recognition. Imagine putting multiple RFIDs on the persons arm, and by tracking the locations of these RFIDs, you can learn different gestures. For example, you can feed the tracked locations into a classifier to differentiate different human gestures. In this project, you need to learn how to program RFID readers and process the data coming from them.

6 Robot Navigation using Wireless Signals

In class, we read multiple RF localization papers. One of the applications of indoor localization is robot navigation. For example, imagine a roomba that works as a postman on a particular floor of CSAIL (e.g., the 9th floor). Consider two users whose offices are on the 9th floor: Alice and Bob. To send a package to Bob, Alice uses an application on her laptop (or phone) where she enters the name of the destination person to a server. The server sends a command to the Roomba to find Alice using the WiFi signal from her iPhone. The Roomba finds Alice using an RF-localization algorithm. Once, the Roomba finds Alice, Alice places the package on the Roomba, which then find Bobs office using the WiFi signal from Bobs phone, and delivers the package.

To build this application, you need to build the following components: 1) the server; 2) an application that runs on cell phones and broadcast packets when a user is to be localized; 3) an RF-localization algorithm that is accurate enough for navigation. 4) a navigation program for the Roomba. You should consider placing a wireless transmitter/receiver (e.g., a laptop) on the robot and navigate the robot towards a phone. Most likely you will need a localization algorithm that leverages SAR (as in PinIt, https://dl.acm.org/citation.cfm?id=2486029) to navigate the robot towards the phone. To run SAR on a receiver you would require obtaining channel state information which could be done using USRPs or using Intel cards (http://dhalperi.github.io/linux-80211n-csitool/).