CIS 700/CSE 791: Mobile Technology (3 credits)

Instructor: Wenliang (Kevin) Du, Professor of EECS

Location: CST4-201

Time: Friday 10:00 – 12:30 and 2:00 – 4:00. The class will be held from May 24 to August 9 (12 weeks); however, students only need to attend 40 hours of lectures (equivalent to 9 weeks). Projects are due on August 12.

Summary: The widespread adoption of smartphones and tablets has created great demand in today's industry for developers who can develop software and hardware for mobile devices. To prepare students for this growing demand, we have developed this new course that focuses on software and hardware technology relevant to mobile systems (i.e., mobile technology). After finishing this course, students are expected to be able to use mobile systems to solve real-world problems.

This is a project-oriented course, and we will use the project-based learning, i.e., the learning is driven by projects. Within the first week of the class, students, organized in groups, need to select a real-world problem from the instructor's list, or propose their own problems. To solve this problem, students need to identify what they need to learn, and then conduct the study themselves, under the close supervision of the instructor. At the end, students need to deliver a software or hardware system or both (in most cases) to solve the problem that they select.

In each class, students will discuss their designs, present their investigation results, demonstrate their prototypes, and share their newly-learned knowledge and techniques with their fellow students. Their learning and development will be closely supervised and coordinated by the instructor, so the learning is effective, focused, and the development is right on track. There are so many things to learn about mobile technology, but it is impossible to figure out everything by an individual or a group. This course creates an environment for students to learn from one another; jointly, we will cover most of the essential technologies in mobile systems.

Students will be allowed to access the department's Computer Engineering Lab on the third floor of the CST building. They can use the equipment there to build and test hardware (e.g., soldering, building a simple circuit board, etc.).

Prerequisite: What you have already known is not important, the most important prerequisite of this class is a strong desire to learn what you don't know. Students will be asked to take on the projects that match with their background. Your grade will not be based on what projects you have worked on; instead, it will be based on how much you have improved your knowledge and skills during the summer, and how much knowledge you can share with the class. Some of the projects require knowledge from Computer Science, Computer Engineering, and Electrical Engineering, so students from all these 3 programs are welcome to join the class, forming groups with diversified background.

Scope: We use Android as our mobile platform, and the scope of this course is the following:

- **Mobile app development:** Students are expected to write mobile application for Android.
    - Android SDK: develop applications using Java and Eclipse
    - Android NDK: implement part of your apps using native-code languages, such as C and C++. This can be done using Android NDK (Native-code Development Kit)
    - Be able to test your apps on an emulator, an Android virtual machine, and a real phone.

- **Understand the mobile system:** Good system engineers know their systems, because such knowledge provides them with great insights. Moreover, many problems may not be easy to solve at the application level, due to system constraints. In these cases, it is important to be able to change the underlying system. Students are expected to learn system knowledge about the Android operating system.
    - Be able to modify Android OS for solutions that cannot be achieved by apps.
    - Be able to test your modified Android OS on an emulator, an Android virtual machine, and a real phone.

- **Communication:** To interact with the physical world, mobile systems need to be able to communicate with external sensors or devices, so they can collect data from external sensors and control the external devices. Depending on the actual devices/sensors, the communication technologies are different. Students will learn how to use these technologies in mobile systems.
    - **Wireless communication**: WiFi, Cellular, Bluetooth, NFC (Near Field Communication), Zigbee, Infrared (IR), Laser, and other technology.
    - **Wired communication**: USB interface, Serial interface, audio-jack interface.

- **Microcontroller:** Very often, it is quite difficult for mobile systems to directly communicate with external devices. To solve this problem, we often connect a mobile system to a microcontroller, and the microcontroller is connected to external devices. Microcontrollers serve as a bridge between mobile systems and external devices. Students are expected to be able to program such microcontrollers. In this course, we focus on the following two popular microcontroller boards; both are widely used in practice.
    - Arduino and Raspberry Pi.
    - The devices that we expect to control include motor, Servo, Relay, remote control, camera, and many other things that we can put our hands on.

- **Working with sensors:** although most mobile devices are already equipped with a number of general-purpose sensors, they are not equipped with special-purpose sensors. If an application needs such sensors, we need to know how to connect such sensors with mobile devices. How to reading data from sensors depends on the type of sensors, so we will study various types of sensors, and learn how to enable mobile devices to read data from them. Here are some examples, but the choice of sensors depends on the problems that we are trying to solve.
    - IR sensors, Ultrasound sensors, light sensors

    - Medical sensors: blood pressure, pulse, body temperature
    - Voltage/current sensor

- **Software Technologies**: To better interact with users and external world, mobile systems should be able to process a variety types of data from the physical world. There are software technologies and libraries that allow us to do that. Students are expected to master these technologies and apply them to solve problems. We provide an initial list here, and the list will be revised as more useful technologies are identified.
    - **Video/Picture technology:** Most smartphones and tablets have camera; we will learn the video/picture processing technologies, so we can write programs to identify objects, recognize face, detect motion, etc. We will learn how to use OpenCV library to achieve these.
    - **Voice technology:** We will learn how to use Android's voice APIs and other third-party libraries to convert human voice to text, and text to human voice.

Potential Projects: The following is just an initial list of projects, and more will be added later. Some projects may not need the entire summer, so you are expected to work on multiple projects in that case. New projects may also be proposed by students during the summer.

- **Smart Keyboard:**
    - Turn a smartphones into a programmable keyboard. When plugging our device into any computer, the device is recognized as a keyboard. However, this is not a dummy keyboard, the firing of keystrokes is fully controlled by the smartphones, and the process can be triggered by voice, vibration, sensing, etc.

- **Smart Remote Control:**
    - Turn a smartphone into a programmable remote control, so you can use many interesting ways to send commands to your TV or any device that is controllable by remote control. For example, you can speak to your smartphone, which will turn your voice into commands, and send them to the remote control.

- **Smart Camera:**
    - **Authentication using face recognition**: Use smartphone's camera to authenticate the user based on face recognition technologies.
    - **Automatic tracking:** Mount a smartphone on a platform that can rotate horizontally and vertically. The phone will control this platform, so it automatically track an object based on shapes, faces, or motions.
    - **Remote-Controllable Camera:** The above platform can also be controlled by an app, which takes its command from a remote user; this way, you can operate the camera from distance. Other than rotating the camera, it will be even better if we can control the zooming of the camera.

- **Smart Radio:**
    - Connect smartphones to a radio component, and communicate with other smartphones using the radio technologies. We are interested in several types of radios, including 900 MHz radio modem and Zigbee.

- **Smart Home:**
    - Build a smart home system, so users can monitor the situation in their houses through a smartphone, or control home appliance or devices using a smartphone. Applications include monitor flooding in the basement, control the thermostat and lights in the house, detect motions in the house, remotely view live video from your indoor/outdoor camera, and monitor the soil situation to decide whether the lawn should be watered, etc.

- **Authentication Modules for Smartphones**
    - **Authentication using face recognition**: using smartphone's camera to authenticate the user based on face recognition technologies.
    - **Authentication using voice:** using voice recognition technology.
    - **Authentication using RFID:** using NFC technology.
    - **Authentication using a smart laser pointer:** a secret code is embedded in the laser, which is beamed to a sensor attached to the smartphone.
    - **Pluggable Authentication Module (PAM):** implement a PAM framework for Android, so users can easily install new authentication module.

- **Indoor Localization:**
    - Identify and develop technologies that can be used for Smartphones to achieve indoor localization.

- **Smart Medical device:**
    - Connect smartphones to medical sensors, turning the smartphone into a smart medical device. Examples include measuring blood pressure, body temperature, pulse, etc.

- **Other projects**: Feel free to propose other interesting projects that you would like to work on. We will do a feasibility study and then decide whether we can use it from the course projects.