ECEN 5783-002, -002B Syllabus
Embedded Interface Design
Fall 2019

Instructor	Bruce R. Montgomery, PhD, PMP	**IM**	Slack: eidcufall2019.slack.com
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Office Hours	Tue 10:30-11:30 AM; Thu 1-2 PM	**Canvas**	https://canvas.colorado.edu/courses/53077

I. Overview

Lectures: Monday/Wednesday, 4 PM to 5:15 PM, ECCR 1B51

Teaching and Student Assistants:

- Student Assistant: Shubham Jaiswal (shja7942@colorado.edu)
- Student Assistant: Sharanjeet Mago (Sharanjeet.Mago@colorado.edu)

II. Projects

There are several class projects to reinforce the topics we discuss and to let you get some experience with actual and typical prototype interface development.

The projects will require use of a Raspberry Pi 3 development system; you will be provided with the following:

1) A Raspberry Pi 3
2) 8 GB to 32 GB micro SD card
3) A power adaptor for Pi (>=2 Amp USB charger with USB Type A to Micro B cable)
4) A DHT22 (aka AM2302) temperature-humidity sensor

A display is not provided for the Raspberry Pi 3. It is intended that you use your laptop as a remote display. Optionally, you may use a directly connected touchscreen, such as the Raspberry Pi 3 7" Touchscreen Display, but this is not required. For debugging and configuration, an HDMI monitor with a USB-capable mouse and keyboard for working directly with the RPi 3 may be handy.

You will need access to computer resources (such as a personal laptop) for development and as mentioned above, to use as a remote display for your RPi 3. Your laptop development environment can be based on any recent Windows, Linux, or OS X operating system release; you can also create an environment in a virtual machine. Department labs and resources may be needed for minor wiring or components required for projects.

You will need a way to write images to the micro SD card provided for the RPi 3 OS and storage – most PCs have a full size SD slot so you may require a full size SD adapter for the micro SD card. If your PC does not have an SD slot, you may need a USB adapter.

III. Rationale

Embedded systems are commonplace and ubiquitous; if you are not holding your smartphone you are interacting with your car, controls in your house, retail systems, security devices, and the like. The connected embedded devices that make up the Internet of Things (IoT) are estimated to number over 75 billion by the year 2025. In all cases, embedded devices have some sort of interfaces – a boundary between system elements where communication takes place. Such interfaces may range from:

- communications with controlled or controlling devices (Machine-to-Machine or M2M)
- connections with a cloud- or internet-based system (IoT devices, cloud-based frameworks)
- controls you manipulate directly - buttons, switches, dials, keyboards, cameras, display-based controls, or voice recognition (user interface input devices)
- and ways a device may provide information to you – indicators, displays, sounds, or voice (user interface output devices)

It is likely an embedded systems engineer will encounter a variety of such interfaces in their own careers of designing and developing prototypes and products. As a graduate engineer, the systems you create should match the information exchange requirements of your design requirements (from simple to complex), and your interfaces should be pleasant and usable for human interaction and/or efficient and maintainable for machine or network interfaces. This course will provide skills, tools, methods, and resources for design and rapid prototyping of effective and usable machine and user interfaces for embedded systems.

IV. Objectives and Expected Outcomes

The objective of this course is to provide an understanding of interface design approaches and architectures for creating embedded system prototypes and products. For both machine and user interfaces, we will look at the best practices for the interface design process, including considerations of the characteristics of the information to be transferred between devices or between a device and a user. Projects will leverage the now standard Raspberry Pi 3 single-board computer (SBC) providing a strong foundation for exploring many elements of interface design using the embedded Linux operating system, standard design languages such as Python, Node.js, and QT, and many standard messaging and connection protocols.

1. Develop an understanding of the broad nature of embedded interface design for a variety of applications.
2. Focus on Human-Computer Interfaces (HCI)
    1. Develop an understanding of human-computer interface (HCI) considerations and characteristics.
    2. Practice key elements of a user-centric design process while studying HCI design best practices.
    3. Examine common user interfaces encountered in every day interactions.
    4. Examine choices for hardware and software to develop HCI interfaces on embedded devices.
3. Focus on machine to machine (M2M) communications.
    1. Develop an understanding of interface considerations and characteristics for machine to machine (M2M) communications.
    2. Examine choices for hardware, protocols, and architectures in M2M interfaces.
    3. Extend understanding of M2M interface considerations and characteristics to cloud-based or internet-based systems (Internet of Things or IoT).
    4. Examine choices for protocols and architectures in IoT interfaces.
4. Focus on Rapid Prototyping for Interfaces and Systems
    1. Develop the understanding of embedded interface design for the purpose of creating prototypes or products for a variety of applications.
    2. Understand the considerations for various applications of connected embedded devices.
    3. Execute a number of prototype style projects using tools, languages, and techniques presented in class.

V. Requirements and Format

Prerequisites:

This course requires knowledge of programming (this course will primarily use Python and Node.JS) and basic computer architecture. Corresponding CU Boulder courses are ECEN 2120/2350 and ECEN 1030/1310/CSCI 1300. Both Python and Node.JS are straightforward languages to install, read, and apply, especially for those with existing background in other languages (like C, C++, or Java). They are also particularly suited to rapid prototype development projects such as those in this class.

Neither Python nor Node.JS programming will be taught in depth as an in-class topic, although examples and code snippets will be reviewed. Links for Python and Node.JS tutorials and support materials will be provided for students to use as needed.

The class will also provide experience with other tools and languages, including Git, HTML, UML, Amazon Web Services, QT, and others. Prior experience in these tools is not required for the class.

Attendance and Participation:

Class lectures will start promptly at the scheduled class start time. Attendance at every class is encouraged as we will conduct individual and group classroom activities, and students are expected to participate in activities and class discussions of course topics. Attendance may be recorded when classroom activities occur as part of participation grading. For classroom activities you may need paper, pen or pencil, and a connected device such as a phone, tablet, or laptop that can access the web.

Asking for an excused absence is not required. Participation grades will be tiered based on collected attendance and the professor's discretion at the end of the semester, and you can safely miss up to three classes without impacting your grade. Alternative participation/attendance exercises will be provided and used for assessing distance students.

Most class materials will be made available on Canvas, however, it is the student's responsibility to obtain materials handed out in a lecture which the student missed. Students are expected to keep up with the course material. If you fall behind or need other help, schedule an appointment with the professor or a TA/SA as soon as possible.

Students are expected to complete assignments on time. In some cases, project assignments will be accepted late, but the grade earned on the assignment will be reduced – this allowance and reduction will be made clear for each assignment.

Canvas Web-based Instruction:

Students must have access to and accounts for Canvas to find materials, get class notices, submit homework, and take quizzes and/or exams. I will use the announcements feature of Canvas for posting information on assignments and class changes. Please ensure you can reach the class Canvas site (https://canvas.colorado.edu/courses/53077). It is suggested that you sign up in Canvas account settings for instant notifications of news, class schedule or assignment changes, content postings, assignment and quiz due dates, and grade updates.

Slack Instant Messaging:

We maintain a Slack workspace for the EID class. This lets students easily contact the professor, class-staff or each other. Please use Slack for any quick questions or clarifications. It is recommended that you join the class Slack workspace at: eidcufall2019.slack.com; there is a permanent sign up link here:
https://join.slack.com/t/eidcufall2019/shared_invite/enQtNzEyNTQwNzMxNjE4LTQ4MzhmOTU3OTU0MGUxZTE2NzdkMmYzMDNhOGQ2ZDA0ZDlmZmJkNDNkYTI4ZjU0MzkyMzRmNjZlYzYzMjlhNzA

Remote Participation (ECEN 5783-002B Students only):

Students enrolled in the class through the distance section of the class, ECEN 5783-002B, are required to use the Zoom conferencing tool. To join the class synchronously, use the following Zoom meeting ID & connection information:

- Meeting ID: 663-638-682

- Join via web browser: https://cuboulder.zoom.us/j/663638682

- Join via Zoom app (using meeting ID)

- Join via One tap mobile: +16699006833,,663638682# or +16465588656,,663638682#

- Join via telephone: 1-669-900-6833 or 1-646-558-8656

For more information, visit the OIT Zoom website:
https://oit.colorado.edu/services/conferencing-services/web-conferencing-zoom/help/getting-started

This course requires the use of the Zoom conferencing tool, which is currently not accessible to users using assistive technology. If you use assistive technology to access the course material, please contact your faculty member immediately to discuss.

If you need help with getting Zoom up and running, please visit the following link:

http://www.colorado.edu/oit/services/conferencing-services/web-conferencing-zoom

NOTE: Students enrolled for ECEN 5783-002, and not the distance section -002B, should attend classes in person.

Readings:

Course materials include lecture slides, project guides, and other online materials, with frequent references to various texts and other resources. The two textbooks for the class are required resources.

- Textbook 1
    - The User Experience Team of One: A Research and Design Survival Guide
    - Leah Buley, 2013, Rosenfeld Media
    - Available at the campus bookstore, and as a paper book ($39) or Kindle e-book ($13 buy) via Amazon. The e-book is also available via O'Reilly Safari (free access to ACM members).
- Textbook 2
    - Prototyping for Designers
    - Kathryn McElroy, 2018, O'Reilly
    - Available at the campus bookstore, and as a paper book ($14) or Kindle e-book ($13 buy) via Amazon. The e-book is also available via O'Reilly Safari (free access to ACM members).
- Course lecture slides, course labs and project material, and links to web sites to support class topics and projects will be embedded in lecture slides and provided via Canvas.

Homework and Projects:

Homework and related project assignments will be provided covering material from class lectures. Students may collaborate on homework as presented in homework details; a group of students collaborating on a homework may turn in one group submission. All homework and reports must be legibly written or typed and must include the students name(s) in the submission. All homework assignments should be turned in at the due date/time presented for the assignment on Canvas. Late homework may be accepted but will be penalized as detailed in class or assignment descriptions.

Code and reports are expected to be thorough work, including proper references to any supporting materials. Whether working as a team or leveraging software designs from books, magazines, the Internet, or other sources, students are expected and required to cite and credit the source of the information clearly and completely. **Plagiarism will not be tolerated** and will be reported to the CU Honor Code Office.

Other Assessments:

There will be scheduled quizzes most weeks over material presented; these will be provided via Canvas and will be performed outside of class. All quizzes must be completed prior to the Canvas due date/time. There will also be a mid-term and final examination. The quiz and exam assessments are to be done using individual effort alone. Mid-term and final exam logistics, times, and locations will be scheduled and announced.

Extra Credit:

From time to time, there may be opportunities for extra credit. Generally, extra credit opportunities come from two sources – classroom participation and project work. In most cases, classroom extra credit will supplement overall quiz grades; distance students not in class will be given equivalent opportunities for extra credit. Project extra credit will be described in project grading rubrics and will be awarded for individual projects when projects are graded.

VI. Evaluation and Grading Procedures

Grading will be based on total points accumulated from each type of assessment and assignment used in the class. A student earning less than 60% of the points possible will be given a failing grade. In all cases, grades may be assigned based on a curve determined by the instructor. The following table shows percentage assignments for final posted class letter grades:

94 – 100	90 – 93	87 - 89	83 – 86	80 – 82	77 – 79	73 – 76	70 – 72	67 – 69	63 – 66	60 – 62	0 – 59
A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F

Make-up Exam Policy: No make-up exams are given except for medical or other similar hardships where advanced arrangements are made with the instructor; or in case of non-selective medical emergencies with physician's note or documentation. Otherwise, failure to take the exam at the scheduled time will result in a zero grade in the exam.

The overall course grade will be based on participation and attendance, homework/projects, quizzes, and exams. The grade proportions are as follows:

- Homework/projects 50% (500 points)
- Quizzes 10% (100 points)
- Mid-term and Final Exams 30% (300 points)
- Participation and attendance 10% (100 Points)

VII. ESE Program Policies

General Attendance:

Going forward, the following will be in effect for ESE program courses, as reported by ESE course instructors:

1) Students enrolled but not engaging in an ESE course for the first week will be moved to the end of any existing waitlist.
2) Students enrolled but not engaging in an ESE course for the first two weeks will be administratively dropped from the course.

Per the Registrar, administrative drops can occur for two reasons:

- nonattendance or
- missing required course prerequisites or corequisites.

ESE Academic Integrity Policy:

Any suspected violations of the Honor Code will be submitted to our Office of Student Conduct and Conflict Resolution (OSCCR). Students found responsible by our faculty for violating the cheating policy of the Honor Code will earn an automatic F in the course. A second such violation will result in expulsion from the ESE program and courses. Further non-academic sanctions may be rendered by the OSCCR. We take these issues seriously and have a responsibility to all students who uphold the Honor Code, and to the highest industry standards for which we are preparing students. If you have any questions whatsoever regarding what collaboration is permissible in the course, consult your instructor directly before proceeding. Sharing of knowledge between students is highly encouraged; however, each student is expected to independently create and implement their own project files and submit original content for all assignments and exams. Students may find that they are able to leverage software or firmware designs from books, magazines, the internet, or their work environments; however, in these cases, students are expected and required to credit the source of the information clearly and completely. Again, by default, you are expected to turn in your own original work and cite any and all portions you did not create. All aspects of the Honor Code apply.

VIII. Campus-wide Policies

Accommodation for Disabilities:

If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the Disability Services website. Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance. If you have a temporary medical condition or injury, see Temporary Medical Conditions under the Students tab on the Disability Services website.

Classroom Behavior:

Students and faculty each have responsibility for maintaining an appropriate learning environment. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. Class rosters are provided to the instructor with the student's legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records. For more information, see the policies on classroom behavior and the Student Code of Conduct.

Honor Code:

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code. Violations of the policy may include: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. All incidents of academic misconduct will be reported to the Honor Code (honor@colorado.edu; 303-492-5550). Students who are found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code as well as academic sanctions from the faculty member. Additional information regarding the Honor Code academic integrity policy can be found at the Honor Code Office website.

Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation:

The University of Colorado Boulder (CU Boulder) is committed to fostering a positive and welcoming learning, working, and living environment. CU Boulder will not tolerate acts of sexual misconduct intimate partner abuse (including dating or domestic violence), stalking, protected-class discrimination or harassment by members of our community. Individuals who believe they have been subject to misconduct or retaliatory actions for reporting a concern should contact the Office of Institutional Equity

and Compliance (OIEC) at 303-492-2127 or cureport@colorado.edu. Information about the OIEC, university policies, anonymous reporting, and the campus resources can be found on the OIEC website.

Please know that faculty and instructors have a responsibility to inform OIEC when made aware of incidents of sexual misconduct, discrimination, harassment and/or related retaliation, to ensure that individuals impacted receive information about options for reporting and support resources.

Religious Holidays:

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, please notify Dr. Montgomery at least two weeks prior to the conflicting date.

See the campus policy regarding religious observances for full details.

Use of Electronics in Class:

You will need a connected phone, tablet, or laptop to participate in some classroom activities. Cell phones (and other devices) need to be on silent and should be limited in use to allow focus on material and to avoid disturbing fellow students. Connected devices may be used in class for taking notes.

Course Concerns:

If you have any questions or concerns about the course, please discuss them with the professor or teaching assistants as soon as possible. If we cannot address your concern, the issue can be brought to the attention of the program faculty directors.

IX. Tentative Course Schedule: (Please note this can and likely will change. As the instructor for this course, I reserve the right to adjust this schedule or related assignments in any way that serves the educational needs of the students enrolled in this course.)

Week	Monday	Topic 1	Topic 2	Wednesday	Topic 1	Topic 2
1	26-Aug	Intro to Inst/EID	Syllabus/Class Projects	28-Aug	Python/Node.JS/Multithread	SMUD
2	2-Sep	Labor Day		4-Sep	Git/Dev Env	SBCs(Pi)
3	9-Sep	QT	DBs/Proj 1	11-Sep	M2M/IoT Intro, Low Level Protocols	IoT Protocols
4	16-Sep	M2M Protocols	LPWAN Protocols	18-Sep	Cloud Arch, Cloud for IoT	AWS, AWS for IoT
5	23-Sep	Alt to AWS	HTML/Proj 2	25-Sep	AWS & IoT Security	APIs & Microservices
6	30-Sep	AWS APIs/Swagger	Msg Qs	2-Oct	Intro to UX/UI	Disc/Form UX
7	7-Oct	UX Anal/Plan, Methods	WBS/Proj 3	9-Oct	UX Research, Methods	Personas
8	14-Oct	Use Cases & UML	Mid-term Review	16-Oct	Mid-Term	
9	21-Oct	UX Design, Methods	Heuristics+Laws/SP1	23-Oct	Sketching, Wireframe/Balsamiq	Cog Psych
10	28-Oct	Pugh Matrices	UX V&V, Methods	30-Oct	Surveys, Statistics	
11	4-Nov	Design Conn Prod	Proto to Product/SP2	6-Nov	Rapid Proto/Why	Design for Data
12	11-Nov	Proto Best Practices	Design for VUI	13-Nov	RF Design	Design for Wearable
13	18-Nov	Interface Components	Alt OSes, Proto Platforms/SP3	20-Nov	Hackathon?	
14	25-Nov	Fall Break		27-Nov	Fall Break	
15	2-Dec	Other UI Tools	FreeRTOS for AWS	4-Dec	Lean Product Development?	UX Evangelism?
16	9-Dec	Project Demos in Class		11-Dec	Final Review	Class Wrap-up
Finals 12/14 - 12/18			Final Exam			

Week	Monday	Assign	Due	Quiz	Readings for week	Projects	Points
1	26-Aug				Python, Node refs		
2	2-Sep			Sv1	Git Book		
3	9-Sep	Proj 1		Q1	QT, References	Git, Python, QT	50
4	16-Sep			Q2	AWS		
5	23-Sep	Proj 2	Proj 1	Q3	AWS	HTML, AWS, Node	75
6	30-Sep			Q4	Buley Intro (1-4)		
7	7-Oct	Proj 3	Proj 2	Q5	Buley Plan, Res (5-6)	AWS, API, MsgQ	100
8	14-Oct						
9	21-Oct	Proj 4	Proj 3	Q6	Buley Design (7)	Proj Design	100
10	28-Oct			Q7	Buley V&V (8)		
11	4-Nov	Proj 5	Proj 4	Q8	McElroy (1,2,3)	Proj Check in	50
12	11-Nov			Q9	McElroy (4,5,6)		
13	18-Nov	Proj 6	Proj 5	Q10		Final Proj Delivery	125
14	25-Nov						
15	2-Dec			Sv2			
16	9-Dec		Proj 6				