ECE 442/510 – Internet of Things and Cyber Physical Systems
Summer 2022

Design Project
Final Report Due: Thursday, June 23rd 2022, 11:59PM

IMPORTANT:	**You must sign and date below acknowledgment statement. Failing to do so, or any violation of this rule will result in an automatic failure for this course.**
Acknowledgment:	I acknowledge all works including figures, codes and writings belong to me and/or persons who are referenced. I understand if any similarity in the code, comments, customized program behavior, report writings and/or figures are found, both the helper (original work) and the requestor (duplicated/modified work) will be called for academic disciplinary action.

Design an embedded system that would be an IoT device by retrieving, analyzing, and graphically/numerically displaying information based on the sensor data. Sensor data should be retrieved and analyzed on single board computer(s)/microcontroller(s), then sent to a server over any type of Internet connection, where your output will be displayed.

This is an open-ended project. Your group is free to choose any topic/theme. Topics are not limited to the following:

- Smart Lighting, Smart Parking, Smart Workout Detection System
- Home Automation System using Machine Vision and Distributed Sensors
- Remote Patient Healthcare System, Fall Detection System
- Computer Vision System for Assisting Visually Impaired Individuals
- Air Pollution Monitoring System, Smart Irrigation System, Smart Greenhouse System

Visit ECASP Research Laboratory (http://ecasp.ece.iit.edu) for more student projects in IoT, computer vision, embedded systems and more.

You'll need to follow requirements below for this Design Project:

1. You are required to work in groups of two. Members of your group **must submit their own independent reports** except Proposal Reports and Video Recordings of your Presentation and Demo. *(Submitting identical two reports NOT ALLOWED for Progress Report and Final Report)*
2. You must use at least **one Raspberry Pi** and at least **one Arduino** for this project. You are welcome to use additional single board computers/microcontrollers within your project. You may use any Raspberry Pi equivalent and/or any Arduino equivalent device(s) for this project, but you must have the instructor's approval.

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3. Use any programming language that you are comfortable with. (C, JAVA, Python, etc.)
4. You must use **at least three different types of sensors/actuators** for this project, where they would be connected to either Arduino or Raspberry Pi in low-level peripheral interfaces (I^2C, SPI, GPIO, USB, ADC, PWM, Audio, etc.). *Your sensors should correlate each other to represent meaningful data.*
5. Communication between the Arduino and the Raspberry Pi must be **wireless**, and you must transfer sensor data from/to Arduino and Raspberry Pi. This can be done using either Bluetooth, Wi-Fi, ZigBee or any other wireless protocol.
6. All sensor data/information must be displayed graphically/numerically on an Internet-accessible server. The server can be your laptop/desktop (e.g., client-server application), web server solution stack (e.g., XAMPP), or web application solution (e.g., ThingSpeak). The server cannot be the Raspberry Pi that you connect with Arduino.
7. **YOU MUST MEET THE DEADLINE!! NO LATE SUBMISSIONS WILL BE ACCEPTED**

Part 0. Preliminary Project Proposal (Due: Wednesday, May 25th, 9 AM; Points: 5)

- Prepare a brief report describing your group's project topic
- Your report should be 2 to 5 pages, and should include the following:
  - Your choice of Project Topic
  - Describing briefly on approach towards your design including hardware and software components
  - Group member listing
- ***Submit to Blackboard, and prepare for an in-class discussion***

Part 1. Topic Selection (Due: Thursday, May 26th, 9 AM; Points: 5)

- Submit a brief report describing your project topic to the Blackboard
- Your report should be 3 to 6 pages, and must include the following:
  - Problem statement (describe your topic)
  - Hardware and software components that you will use
  - Describing the approach towards your design
  - Specific timeline of work
  - Group member listing and work distribution
- ***Submit to Blackboard, and prepare for an in-class discussion***

Part 2. Progress Report & Presentation (Due: Wednesday, June 8th, 9 AM; Points: 15)

- Submit a progress report detailing progress you/your group has made, **including a 10-minute video slide presentation.** (A follow-up **5-minute Q&A in class**)

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- Purpose of this progress report is to assure your project can be completed before the due date
- Your progress report (minimum 7 pages) must include the following:
    - Summary of your project and technical aspect of your project
    - Describe the hardware that you are using, including the single board computer/microcontroller, sensors, desktop/laptop…
    - Describe the software tools that you are using for your project
    - Any current results to share? Show your current results
    - List of materials, milestone, team member tasks and work distributions
    - Lessons Learned and Future Work to complete your project
    - Conclusion
    - References
- ***Submit to Blackboard, and prepare for an in-class discussion.***

Part 3. Final Presentation and Demo (During Class Time, June 22nd & 23rd, TBD; Points: 30)

- You/your group will have 20-25 minutes to present your project.
    - 10 minutes in-class PowerPoint presentation, 5 minutes of recorded demo, 5-10 minutes Q&A session.
- You/your group **must be able to demonstrate** your system in your recorded demo. It is required that your system is integrated and running as a whole/one system.
- Timeslots of your presentation will be announced later.
- Your presentation should have the following information (but not limited to):
    - Brief overview of what your IoT device does and how it works
    - A summary of the hardware used, including the single board computer/microcontroller
    - Specific timeline of work, and work distribution within your group
    - Describe the sensor hardware and how you interfaced them.
    - Describe how you approached to display the output
    - A summary of the operating system (if applicable), programming language(s) that you used, any frameworks, and etc. Explain why you chose them
    - Hardware constraints; describe any power concerns, processing limitations, etc.
    - Software constraints; describe any real-time constraints, security concerns, etc.
    - List any challenges you faced in this project
    - Team Member Work Contributions
    - Future work; things you would add more feature/functionality to this project
- ***Submit your presentation (PPTX or PDF) to the Blackboard with your recorded demo video***

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Part 4. Final Report (Due: Thursday, June 23rd, 11:59PM; Points: 45)

- Submit your final report in a PDF form to the Blackboard by the above deadline
- Your report should be minimum of 15 pages (excluding title page, and your code which should be attached as an appendix) and must contain the following sections:
    - Abstract of your report
    - Introduction
    - Description of your topic/IoT Device, system flowchart
    - Hardware
        - Description on the single-board computer/microcontroller that you used
        - Description of the sensors that you used
        - Description of how you interfaced the sensors to the single-board computer/microcontroller
        - Include a link or append any datasheets for hardware that you used
        - Schematic of any circuit that you designed
    - Software
        - Programming language: which one did you use? Why? Briefly explain the tradeoffs between the language you chose, and other languages that you may have chosen for this project
        - Real-time: Does your device have real-time constraints? What would happen if your code encounters an unexpectedly large delay?
        - Security: Describe any security issues that might encounter on your system.
        - Explain how much of the code is original to you or your group
    - Related work
        - Has anyone done a project like yours? Find any similar projects and describe them.
        - How does your project compare to those you find similar?
    - Results and Discussion
        - Show your results and describe your system
        - Provide a link to your recorded demo video
            - You can either upload to the Blackboard
            - Or use Google Drive and share the link
        - Discuss any issues that you faced, any improvement made since the progress report, etc.
    - User's Manual for usage of your IoT system
    - Team Member Work Contributions
    - Conclusion
    - Future Work
    - List of references

        - Write one paragraph about each of the references and its relevance to completing your project.
    - Appendix
        - Entire Source code of your project with comments
        - Other documents such as bill of materials (BOM), sensor specifications, cost evaluation, power usage, ….

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Places to purchase sensors/embedded systems

- https://www.adafruit.com/
- https://www.sparkfun.com/
- https://www.amazon.com/
- https://www.digikey.com/
- http://www.newark.com/

Good reference websites for project ideas

- https://create.arduino.cc/projecthub/projects/tags/iot
- https://www.hackster.io/raspberry-pi/projects
- https://www.electronicshub.org/iot-project-ideas/

Resources for IoT project using Raspberry Pi

- https://developer.android.com/things/get-started/
- https://www.raspberrypi.org/

Raspberry Pi SPI and I2C Tutorial

- https://learn.sparkfun.com/tutorials/raspberry-pi-spi-and-i2c-tutorial
- https://projects-raspberry.com/interfacing-an-spi-adc-mcp3008-chip-to-the-raspberry-pi-using-c-spidev/
- https://learn.adafruit.com/raspberry-pi-analog-to-digital-converters/mcp3008
- https://michael.bouvy.net/blog/en/2013/04/02/raspberry-pi-xbee-uart-serial-howto/
- http://www.brettdangerfield.com/post/raspberrypi_tempature_monitor_project/

Useful Tutorials

- https://howtoraspberrypi.com/how-to-install-web-server-raspberry-pi-lamp/
- https://www.1and1.com/digitalguide/server/tools/xampp-tutorial-create-your-own-local-test-server/
- https://www.youtube.com/watch?v=e1c1EwFHHss
- https://www.pubnub.com/blog/2015-08-04-tutorial-building-raspberry-pi-smart-home-part-1/
- https://circuitdigest.com/microcontroller-projects/controlling-raspberry-pi-gpio-using-android-app-over-bluetooth
- http://electronicshobbyists.com/?_nozc_=1
- http://www.instructables.com/id/Arduino-Bluetooth-RC-Car-Android-Controlled/
- http://www.python-exemplary.com/index_en.php?inhalt_links=navigation_en.inc.php&inhalt_mitte=raspi/en/communication.inc.php
- https://pimylifeup.com/raspberry-pi-mysql-phpmyadmin/

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Sample Parts List

Name	Manufacturer	Part Number	Specifications
Raspberry Pi		Raspberry Pi 4	Raspberry Pi 3 or 4 Kit with 8 GB microSD card and USB reader, HDMI cable, 2.5A power adapter, clear case
ELEGOO Mega 2560 Project The Most Complete Ultimate Starter Kit		Arduino ATmega2560 Mega 2560 and Sensors Kit	Arduino Mega 2560 with Sensors of various types
Breadboard	Elegoo	EL-CP-003 (MB-102)	630 tie-point IC-circuit area plus 2x100 tie-point distribution strips providing 4 power rails
USB Webcam	Microsoft	LifeCam HD-3000	USB Webcam (720p)
LDR Sensor	eBoot	GM5539	Photoresistor/Photo light sensitive resistor/light dependent resistor
Barometric Pressure and Altitude Sensor	Adafruit	BMP280	I2C or SPI interface
Ultrasonic Sensor		HC-SR04	Detection distance 2cm to 5m (resolution 0.3cm)
802.15.4 Module	Digi	XBee Series 1/2/3	Requires XBee Explorer Regulated Breakout Board or XBee USB Dongle
IR Motion Sensor	DIYmall	HC-SR501	
ADC	Microchip	MCP3008-I/P	10-bit ADC with SPI
Accelerometer	Adafruit	ADXL345	I2C or SPI interface
Accelerometer	HiLetgo	GY-291 (ADXL345 equivalent)	I2C or SPI interface (different voltage than ADXL345)
Accelerometer+ Gyroscope+ Temperature Sensor	Adafruit	10 DOF	L3DG20H gyroscope + LSM303DLHC accelerometer compass + BMP180 barometric/temperature sensors
Temperature and Humidity Sensor	Gowoops	DHT22	
Soldering Iron Kit			https://tinyurl.com/yanupbfe