ENGR 131 In-Class Activity: TI KIT – Early Warning System Part 2

Instruction

This in-class activity guides you through designing an early warning system that integrates ultrasonic range sensing selection structure logics. There are **five (5)** deliverables.

Purpose of this project: The purpose of this activity is to guide you in designing a simple early warning system, inspired by the real-world failure of the Taum Sauk Reservoir, where human error and lack of safeguards led to disaster. Using an ultrasonic ranger, you will measure the distance to an object and apply a selection structure in your code to decide whether to trigger a buzzer alert when the object gets too close. This hands-on project shows how sensors and logic can work together to prevent accidents by warning operators before a threshold is crossed. To evaluate how reliable your system is, you will also test its fidelity by calculating the percent error and sum of squared errors (SSE) between your measured distances and the theoretical threshold. Through this, you'll not only practice programming and hardware integration but also see how engineers assess accuracy and safety in real systems.

Your Task: Your task is to demonstrate that you can control the microcontroller, as well as its add-ons(). You will also show your understanding of the selection structure logics and the ability to apply it to the microcontroller. You will then analyze the errors in the model.
You must accomplish the following:

1. Illustrate a block diagram that correctly represents the microcontroller setup with its connected components.
2. Develop a clear pseudocode that captures the logic of the warning system using a selection structure.
3. Implement and modify code so that the system produces a sound alert when an object crosses the threshold distance.
4. Accurately record measured distances at the point of alert, and compare them with the theoretical threshold you defined.
5. Analyze the accuracy of your system by calculating percent error and SSE, and reflect on what the error analysis reveals about system reliability.

Organizing Your Work
Pay attention to how you format and organize your work in your Excel file and Word document. Below are some general instructions:

- Insert your diagram, pseudocode, and final code into your Word file.

Submission Instructions:

- Complete this assignment as **a team**. One team member of your team must submit your work on Brightspace, listing each member of your team in the submission process. All team members should review and approve the submission.

Deliverables

- **Word file (with diagram, pseudocode, final code, and picture of your board).**
  Name your Word file: ENGR131_ICA_Taum_Sauk_Part2_TeamNumber.docx

Submit your work through the designated **Brightspace In-Class Activity Drop Box**.

Deliverables:

1. Draw a block diagram for a microcontroller set up.
2. Write a pseudocode for the warning system logics.

3. Modify the code such that it alerts with sound when an object gets too close.
4. Record distances measured when hearing the alert, compare these values to the theoretical threshold you defined, and analyze the errors.
5. Comment on your error analyses.

Background/Technical Content:

Ultrasonic ranging is a technique for measuring distance by transmitting high-frequency sound waves (above 20 kHz) and detecting their echo. The sensor emits an ultrasonic pulse into the air; when this pulse strikes an object, it reflects back to the sensor. The system measures the "time of flight" between emission and reception and calculates distance using the relation (TI instrument, 2021):

$$Distance = \frac{Speed\ of\ Sound \times Time}{2}$$

The division by two accounts for the round trip of the wave. Because the speed of sound in air is well known (approximately 343 m/s at room temperature), ultrasonic ranging offers a simple and robust way to measure distances .

The ultrasonic transducer is the key component of the ultrasonic ranging system. The system measures the ultrasonic wave transmitted and received by the transducer and converts it into distance measurement to complete the function of the ranging system. The ultrasonic transducer transmits ultrasonic waves and receives echo reflected from the object by either the same transducer, pulse-echo mode or by another transducer as pitch-catch mode(Qiu et al., 2022). The ultrasonic sensor in your kit has a pair of the transducers are configured in pitch-catch configuration. Separating the transmit and receive functions improves signal clarity, minimizes interference, and allows the sensor to more reliably distinguish between sending and receiving events.

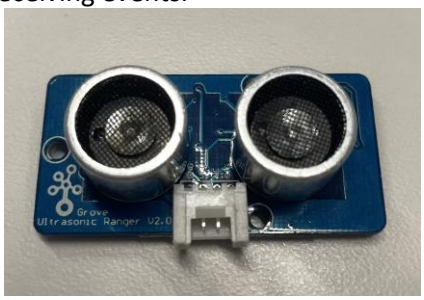

Figure 1. Grove Ultrasonic Ranger Sensor

Ultrasonic sensors are used in a wide range of applications. In the automotive industry, they power parking assistance systems and collision-avoidance alerts. In robotics, they are critical for navigation and obstacle detection in environments where cameras may not work reliably (Chandrasekaran et al., 2020). Industrial applications include liquid-level measurement in tanks, conveyor belt monitoring, and quality control processes. Their robustness, low cost, and ability to work independently of lighting conditions make them a staple of many engineering systems.

References

Chandrasekaran, R., Payan, A. P., Collins, K. B., & Mavris, D. N. (2020). Helicopter Wire Strike Protection and Prevention Devices: Review, Challenges, and recommendations. *Aerospace Science and Technology*, *98*, 105665. https://doi.org/10.1016/j.ast.2019.105665

Qiu, Z., Lu, Y., & Qiu, Z. (2022). Review of ultrasonic ranging methods and their current challenges. *Micromachines*, *13*(4), 520. https://doi.org/10.3390/mi13040520

Texas Instruments. (2021). *Understanding ultrasonic sensing using the MSP430™ MCU* (Application Report No. SLAA907D). Texas Instruments. https://www.ti.com/lit/an/slaa907d/slaa907d.pdf

Learning Objectives Your work will be graded on demonstration of proficiency of the following learning objectives:	**Did you address this?**
UC02 – Describe systems or processes using schematic diagrams with inputs, outputs, and accumulations	
IF03 – Generate testable prototypes for a set of potential solutions.	
DV01 – Efficient use of engineering tools for basic statistics (Excel functions)	
PC05 - Fully address all parts of assignment by following instructions and completing all work.	
TW02 - Document all contributions to the team performance with evidence that these contributions are significant.	