Individual Writing Assignment  
Technology Review of Sonar Sensing and its Limitations

Due Date: Monday, September 29, by 3:00pm; submit directly to Kevin Johnson in Van Leer E276. No late papers

Length: ~5 pages, but there is no minimum. 10 pages maximum, not including figures (or cover page or references).

Timeline of Assignment Deliverables and Milestones:

- September 4-5: Assignment covered in lecture; students learn how to write the document
- September 8-11: Students sign up for required writing consultation with GTAs (more info forthcoming)
- September 9-28: Students write the technical review paper
- September 12-25: Required 30-minute individual writing consultations with GTAs; students will bring a completed draft of their paper to be reviewed by the GTA. All consultations will take place in the ECE Communication Studio, Van Leer C448.
- Monday, September 29: Reports are due no later than 3:00pm (submit directly to K. Johnson in VL E276)

Overview and Rationale
No designs are created in a vacuum. Most designs are improvements or modifications of existing designs or products, possibly undertaken to incorporate the latest technology, improve performance, or add features. Often new designs are undertaken as a way to obtain a needed capability without having to buy it from someone else. Thus, it is important to perform a literature review at the beginning of any new design, both to learn what is already available and to better understand the underlying technology. Information learned from such a review invariably leads to a much better design, particularly in regards to setting realistic specifications and incorporating required codes and standards.

What a Technical Review is NOT
- It is NOT a proposal of what you’d like to work on for a future project.
- It is NOT a recommendation to do something one way or another.
- It is NOT an opinion paper. Stick to the facts.
- It is NOT “busy work.” This information will be useful for the ECE2031 design project.

What a Technical Review IS
- It IS a concise, fact-based summary of a specific aspect of a specific technology.
- It IS written to briefly convey what has been done to date and how the technology works.
- It IS a useful way to research what’s going on with a specific technology and to quickly get up to speed, or get others up to speed, on a technology or product.
- It is an original technical document, and must show critical thinking and analysis on your part. Simply compiling pieces of other documents, even if they are properly cited, does not fulfill the requirements of this assignment.

This is an individual assignment; the report itself must be prepared by you alone with no assistance from your classmates. You are free to discuss the technology among yourselves to help each other understand it better. However, sharing sources, figures, or text is not allowed.
Focus of Your Review: Sonar Sensing and its Limitations
You will soon be on a design team about to embark on a project utilizing a mobile robot that uses sonar sensors to detect objects, obstacles, and the world in general. In preparation, you have been asked to write a technical review of sonar sensing and its limitations so that your team can quickly get up to speed on the technology.

Background Information:
Sonar Sensing with Ultrasonic Range-Finders
You will focus on a specific type of sonar sensor called an ultrasonic range-finder. These devices emit a short burst of sound (called a “ping”), wait for that ping to bounce off of an object and return, and use that time-of-flight to calculate the distance to the object.

Although these sensors are simple, inexpensive, low-power, and quite accurate in ideal conditions, they suffer from limitations:

- In general:
  - Low measurement rate (generally no more than 25 measurements/second)
  - Low angular resolution (generally around 20°)
  - Difficulty sensing small objects
- In specific circumstances:
  - Errors when not perpendicular to a flat surface
  - Errors when facing in to a right-angle corner

What You Should Write About
The goal of the paper is to provide the information necessary to make informed design decisions about sonar sensing. It should at least include:

- A brief coverage of the theory behind sonar sensing from a functional standpoint. Detailed information about wave shapes, transducer technologies, air pressure, waveform processing, etc. should not be covered.
- A discussion of the limitations of sonar sensing, mainly from a functional standpoint but including the underlying reasons that these limitations exist. The bullet points above are a good starting point.
- A discussion of anticipated problems in a specific example situation (more information below).

Note that this is not a ‘checklist’ that should be addressed in sequential order. Organize your paper in a logical way. The document should be written for a technical audience who is educated but unfamiliar with this particular topic.

What Not to Write About
These exclusions are for your benefit in keeping the paper focused.

- Focus only on ultrasonic range-finding. You don’t need to discuss any other forms of sonar sensing, or other sensing in general. This includes side-scan sonar, sonar imaging, medical ultrasound, echo sounding, or laser, IR, or optical range-finding.
- You don’t need to go extremely in-depth about theory. Remember the audience: engineers who are about to use this technology in an already-manufactured, commercial form, not researchers trying to create a new sensor.
- You don’t need to justify using sonar sensors. The technology is already chosen; your job is to inform the reader about its use and limitations so that they can make realistic design decisions.
- Do not consider actual implementation. Some examples of what to avoid:
  - the specific type of ultrasonic range-finder being used
  - how to interface with the sensors, electrically or logically
  - anything about software
  - specific uses of sonar range-finding: localization, mapping, object recognition, etc.
- Do not discuss anything related to history. Consider what the intended audience wants from this paper.
**Required Sections for the Technical Review Paper**

The technical review paper will have two main sections: the introduction and the body. The body will also have two main sections: one for the technical information and one for an application discussion.

1. **Introduction.** In the first sentence or two, explicitly state what is being reviewed, and the extent of the paper – the introduction should fully inform the reader whether or not this paper is pertinent to their needs. Define the technology and its use: this section should provide any information that will be necessary to understand the content of the paper but does not belong in the technical body.

2. **Sonar Principles and Limitations.** Explain and show how ultrasonic range-finding works and is used. Include visual information wherever possible to most effectively convey the information. This section must be organized using headings and subheadings – consider the most effective layout of information.

3. **Application-Specific Concerns.** Use the provided diagram of an anticipated situation to identify points where the robot will likely be unable to provide an accurate measurement, describing why each point will cause problems.

Notice that there is no conclusion. You are not concluding anything about the technical information nor about your investigation, so there is no reason to have a conclusion section.

**Specific Application Situation:**

This diagram shows a typical situation that your team will encounter. The eight bold lines, labeled A-H, show the directions that sonar sensors are currently facing, and the cones show the approximate width of the sonar beams. Using the information that you have gathered, consider what distance each sonar sensor will likely measure relative to the actual centerline distance, identifying problem areas and discussing the cause of these errors for each case. You should assume that the walls here:

1. will reflect ultrasonic waves at the same angle as they arrive, but
2. absorb enough of the sound energy that a ping is unlikely to survive more than two reflections.

This image is available in several formats on the UPCP site. You may assume that you or your team created it; it does not need to be cited.
Initial Source
As with most subjects, there are slight variations to how sonar sensing can be explained. To ensure that all students start with appropriate information for this assignment, we will provide a source of good background information on the UPCP site.

Additional Assignment Details
1. Locate at least one source of information in addition to the provided source. Examples of source types include: (1) refereed journal articles, (2) conference proceedings, (3) trade magazines, (4) books, (5) company sales literature, (6) company technical reference manuals, (7) web sites, (8) lecture notes, (9) interviews, (10) data sheets, (11) codes and standards, and (12) patents.

**NOTE: Wikipedia is NOT a respected, credible source and should not be used as a cited source.**

2. Write the report, with figures interspersed, summarizing your findings. Describe the required information completely. The reader needs to be convinced that you have truly searched the literature and are competent enough to implement what you learned.

3. Cite all of your sources using IEEE documentation style – see the UPCP site for details.

4. Use figures and tables liberally. Be sure to include information on any relevant codes and standards.

5. The paper format is double-spaced Times New Roman, 11 point font. Follow the report template (online); it is preformatted for your convenience.

6. There is no minimum length. The maximum length is 10 pages of text (i.e. not including figures). Do not include the cover page or the references as part of the page length – you will create a separate References page for works consulted and works cited.

7. Section headings are required as they help the reader navigate your paper. You will also need to create descriptive subheadings within the headings.

8. This assignment is due by 3:00pm on Monday, September 29th. Late papers will not be accepted.

9. Repeating some rules stated earlier: *This is an individual assignment and the report itself must be prepared by you alone with no assistance from your classmates.*

10. Attach the Technical Review Paper Evaluation Sheet from the UPCP site. Fill in the pertinent info at the top of the form.