Individual Writing Assignment
Technology Review of Sonar Sensing and its Limitations

Due Date: Monday, February 29, by 3:00pm; submit directly to Kevin Johnson in Van Leer E276. **No late papers**
Length: Approximately 5 pages, but there is no minimum. Provide the required information as clearly and concisely as possible. 10 pages maximum in the body, not including figures.

Timeline of Assignment Milestones and Deliverables:

**January 28/29:** Assignment covered in lecture; students learn how to write the document

**February 1-4:** Students sign up for required writing consultation with GTAs

**February 1-11:** Students write a full draft of the technical review paper

**February 8-24:** Required 30-minute individual writing consultations with GTAs; students will bring a completed draft of their paper to be reviewed by the GTA. Consultations will take place in the ECE UPCP Studio, Van Leer C448.

**February 29:** Reports are due no later than 3:00pm (submit directly to K. Johnson in VL E276)

Writing Consultation: Review of Rough Draft

For this first writing assignment, 15% of the grade is awarded for reviewing a completed draft of your report with your GTA, during which they will help you revise your document to further improve your grade on the remaining 85%. Missing this consultation, or not coming prepared with a draft, is effectively a double-hit on your grade.

Appointments with your GTA will be available from February 8 through February 24. Your GTA is only available a certain number of hours during the week, so it is important that you make an appointment early to ensure that you secure a time that you can attend. Please note:

- Appointments must be made by the end of Thursday, February 4.
- Appointments cannot be canceled or rescheduled except under extenuating circumstances.

Watch for a section-specific T-Square email from your GTA with information about making an appointment.

Document 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 technology 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

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.

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 final design project.
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:

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” (actually beyond the range of human hearing, making it “ultrasound”), wait for that ping to bounce off of an object and return, and use the 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 several 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 or sonically-reflective surface
- Errors when facing an inside 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 limitations in the previous section are a good starting point.
- A discussion of anticipated problems in provided example situations (more information below).

Note that this is not a ‘checklist’ that should be addressed in sequential order. Organize your paper in a logical way.

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. Do not discuss technologies such as 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 historical development or use of sonar. Consider what the intended audience wants from this paper.
Audience

The intended audience for this document is your peers: engineers who will soon be starting a project using the DE2Bot, and need to understand how sonar works, and how its limitations will affect sensing in certain situations. Although each 2031 student is doing this assignment, in a more realistic situation, one person would do this investigation and use a document like this to disseminate their results to their team.

A DE2Bot will be available in the lab for you to view, and you should assume that your audience is familiar (as you should be) with the general shape and size of it, including a sense of dimensions such as sensor height above the ground.

Required Sections for the Technical Review Paper

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

Executive Summary. Even though it comes first, write the summary last. It summarizes the entire document, and it’s hard to summarize something that you haven’t written. Begin this section with the document purpose and scope, move on to the “big picture” (at most two sentences), and then work to summarize the main points in each section of the report. You’re not writing a mystery novel here; let the reader know your findings up front!

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.

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.

Application-Specific Concerns. Considering the situations described below, identify cases where the robot may be unable to provide an accurate measurement, describing the specific reasons for the difficulty.

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:

Consider what might happen when a DE2Bot tries to detect (and measure the distance to) the following objects using its ultrasonic rangefinders. A basic scale diagram is included on the next page.

1. A 1ft cube (around the same size as the robot).
2. An 8in-diameter sphere (center height in line with the sensors)
3. A 24in-diameter sphere (center height well above the sensors)

In each case, at a minimum, explain in what situations (distance from robot, angle from sensor, object orientation, etc.) the robot would have trouble detecting the object.

- Assume that all objects are highly reflective to the ultrasonic pings, so absorption is not a concern.
- Assume that the robot and object are on a floor, but that there are no walls or ceilings within any relevant range.
Sources

As with most subjects, there are different ways to explain sonar sensing. 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.

You must also 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.

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

In a technical review, the information that you are presenting will come from elsewhere. All information that is not common knowledge must be cited. The only original information that you are creating in this document is in the final application section.

However, as mentioned above, you are creating a new, useful document. A simple compilation of excerpts from other sources is not worth creating; neither for you nor your reader. What you are adding is critical consideration of what your audience needs and how to best organize and link information from multiple sources into one coherent document.

Additional Assignment Details

- 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.
- Cite all of your sources using IEEE documentation style – see the UPCP site for details.
- Use figures and tables liberally. Visual information makes text easier to understand.
- Follow the report template (on the UPCP website); it is pre-formatted for your convenience.
- There is no minimum length. The maximum length is 10 pages of text (not including figures). Do not include the cover page, executive summary, or the references as part of the page length – you will create a separate References page for works cited.
- Section headings are required as they help the reader navigate your paper. You will also need to create descriptive subheadings within the headings.
- Attach the Technical Review Paper Evaluation Sheet from the UPCP site when submitting your paper. Fill in the pertinent info at the top of the form.