Individual Writing Assignment
Technology Review of Differential Drive Movement, and Recommendation for Robot Movement Methods

Due Date: Friday, July 8, by 2:40pm; submit directly to Kevin Johnson at Van Leer E276 or in lecture.
Length: Approximately five pages, but there is no minimum. Provide the required information as clearly and concisely as possible. Seven pages maximum in the body, not including figures.

Timeline of Assignment Milestones and Deliverables:

June 17: Assignment covered in lecture; students learn how to write the document.
June 20-26: Students wrote a full draft of the technical review paper and sign up for a consultation period.
June 27-30: Required 30-minute 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.
July 8: Reports are due no later than 2:40pm.

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 a major detriment to your grade.

Appointments with your GTA will be available from June 27 through June 30. 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. Appointments must be made by the end of Thursday, June 23. and 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 (though note that the second section of your document *will* make a recommendation based on the technical review).

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.

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 differential drive works, and how its capabilities and limitations will affect movement strategies. 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.

The DE2Bot user's manual is available online, and a DE2Bot will be available in the lab for you to view. You should assume that your audience is familiar (as you should be) with basic robot parameters.

Focus of Your Review: Differential Drive Locomotion

You will soon be on a design team embarking on a project utilizing a mobile robot that uses differential drive to move around. In preparation, you have been asked to write a technical review of differential drive movement so that your team can quickly get up to speed on the technology.

What You Should Write About

The goal of the paper is to provide the information necessary to make informed design decisions about controlling a differential drive robot. It should at least include:

- A brief coverage of differential drive locomotion.
- An introduction to differential drive dead reckoning odometry.
- A few of the benefits and limitations of this type of movement.

Note that this is <u>not</u> 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.

- Advanced kinematics. Some mathematical modeling and explanation is necessary to describe the topic, but the DE2Bot is programmed in assembly (the lowest low-level language), so complicated mathematical processing is impractical, and this document does not need to cover it.
- In-depth discussion of other forms of wheeled movement, such as omni-wheels, tracks, tricycle steering, or Ackermann steering. It is fine to mention them if it is useful to the discussion (e.g. when discussing benefits and limitations of differential drive movement), but they should not be the focus of any part of the document.
- Control theory. Some aspects of control theory will necessarily play a role both in this document and the final project, but not to an extent that it requires formal coverage here.

Sources

This is not an unexplored topic in engineering, so you can **and should** find sources of information that will save you from repeating already-solved problems. When summarizing well-established topics like this, you should strive to find highly reputable sources such as published books or technical journal articles. Exploring the literature is an important part of starting any engineering project, and we encourage you to do so. Just be sure to **cite all sources that you use**!

Required Sections for the Technical Review Paper

The technical review paper will have 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.

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. **The introduction includes "spoilers"**. Its purpose is to inform, not entice.

Technology Review of Differential Drive Movement. Explain and show how differential drive locomotion works. Include visual information wherever possible to most effectively convey the information. This section must be organized using headings and subheadings. **Think about the most effective layout of information**. In this section, you are likely not creating information yourself; your job is to get the information you find into the best form for your audience. Be sure to cover the requirements listed earlier.

Application to Movement of the DE2Bot. Apply your findings from the technical review to the information in the section below, and based on your findings, describe what you think will be the best approach to controlling the DE2Bot to reach a specific destination. Your thoughts here (and those of your future team mates) will help guide your design decisions during the beginning of the final project. You are not limited to one absolute choice; if you think that different methods would be appropriate depending on other factors, then discuss that.

Notice that this document has 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:

As discussed earlier and in lecture, you and your team will be creating methods to get the DE2Bot to specific locations. The purpose of the technical review portion of this document is to get everyone on your team familiar with the basic movement of the robot so that you can make informed design decisions about the project. Now it is time to actually consider some of those decisions.

In final projects over the last several years, teams have usually ended up controlling the robot in one of two ways:

1. Orthogonal X-Y movement. In this approach, the robot is kept oriented along the X or Y axis when moving forwards. The robot only ever turns in 90º increments.
2. Point-and-shoot movement. Once the DE2Bot was given the ability to calculate the arctangent (specifically atan2) and Pythagorean distance, it became possible to turn directly to a destination and move to it.

The main benefit of orthogonal movement is its simplicity:

- Turns are always 90º or 180º, so those turns can be tuned to be quick and accurate.
- The stop conditions are easy to detect, because they are always a comparison with one coordinate.

The main benefit of point-and-shoot movement is that it is usually faster, but your goal in this section is to evaluate how much faster the point-and-shoot method will be in typical DE2Bot applications. This is not the same as simply finding the ratio between the L1 and L2 norm, because you must consider the time it takes the robot to rotate. However, for simplicity:

a. Assume that the robot only moves forward and turns in place.

b. You can ignore acceleration (but if you do want to consider it, assume that it is $1ft/s^2$).

c. Assume that the robot moves at 1ft/s and rotates at 45º/s.

d. Assume that the robot moves in the most efficient path (e.g. it won't turn +270º if it can turn -90º).

You should consider at least the following destinations, assuming that the robot starts at $(X,Y,\theta)=(0,0,0)$, and that it does not matter what the final orientation is:

- Moving "short" distances to (2,0), (2,2), (0,2), (-2,2), and (-2,0).
- Moving "long" distances to (12,0), (12,12), (0,12), (-12,12), and (-12,0).

This section is not asking for a table of answers, and the specific answers to these coordinates don't even have to be in the document. Consider what your audience wants: they (including you) are trying to decide if it is worth extra time and effort to implement a more complicated type of movement. You should discuss your findings and organize this section in a way that fits that goal.

Additional Assignment Details

- Even though groups and teams have been mentioned several times, **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 7 pages of text (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 cited.
- Section headings are required as they help the reader navigate your paper. You will also need descriptive subheadings within the headings.
- Attach the Evaluation Sheet from the UPCP site when submitting your paper. Fill in the pertinent info at the top of the form.