\[ \chi_{i,j}^p = \chi_{i,j} \alpha_{i,j}^p \] where \( \chi_{i,j} \) is the number of vehicles within \( R \) traveling from \( i \) to \( j \). Equation (2) therefore can be rewritten as

\[ \Theta_i = \sum_{p=1}^{n_p} \sum_{j=t+1}^{n_d} \chi_{i,j} (\delta_{i,p} - d_{i,j}) \alpha_{i,j}^p. \] 

The minimization problem can be cast as a linear programming problem to solve for \( \alpha_{i,j}^p \)'s with the cost function in Eq. (3) subject to the following constraints:

1. Non-negativity: \( \alpha_{i,j}^p \geq 0 \),

2. Maximum platoon size: \( \varepsilon_p + \sum_{j=t+1}^{n_d} \chi_{i,j} \alpha_{i,j}^p \leq \Upsilon \), where \( \varepsilon_p \) is the current size of platoon \( p \), and \( \Upsilon \) is the maximum platoon size (the number of vehicles a platoon can accommodate).
Outline

- What’s Left in E11?
- Technical Writing
- E11 Final Report
Lectures Left in E11?

- **Next Week:**
  Competition!

- **Second Last Week:**
  Robotics S&T, Eng&CS Outlooks,

- **Last Week:**
  Final Presentations
There are several common elements to technical documents (not exactly what you will include in your document for E11):

- Abstract
- Introduction
- Background
- Description of Technical Approach
- Description of Experimental Technique
- Description of Results
- Findings and/or Conclusions
  - Recommendations for Future Work
Abstract and Introduction

- **Abstract**
  - Typical abstract includes
    - Description of problem or task
    - Description of approach (major component)
    - Significant finding (1/2) and conclusion or statement

- **Introduction**
  - Describes problem or task
  - Avoid too much detail, but include some
  - Outline the technical content for the reader
Background (Context)

- Background (i.e. context for problem/task)
  - Describes related technical accomplishments by the authors or other companies, researchers, colleagues.
  - Provides relevance of the document with respect to the technical achievements of others.
  - Care must be taken to reference other work appropriately so as not to conduct plagiarism.
  - Often ends with a transition sentence, using a comparison with related work to describe the upcoming technical content of the document.
Description of Technical Approach

- This section describes any technical procedures, design, analysis, new mathematical theory, etc.
- This section contains the most technical details.
- Often is the longest section
- Can be the easiest to write (for engineers)
Description of Experimental Technique

- Describes details of an experimental setup/testbed/equipment (including figures where necessary).
- Describes implementation details of a new design or prototype.
- Clearly states any assumptions or deficiencies in testing procedures.
Description of Results

- Contains plots, tables, figures describing the performance of the technical content presented in the previous section.
- All figures should be referred to in the text, have axis labeled with units, have font that is readable.
  - Color multiple line plots? Line styles? 12 vs 14 vs 18
- Any claims on performance should have clearly defined metrics (e.g. cost functions with units).
Normal Max El. 571.5'

Crack Location

Piers snaps back at EL 545'

Arch 53 Crest - Stream Direction Response

WANAPUM MONOLITH 4
Findings and/or Conclusions

- Findings and/or Conclusions
  - Summarize content and results within the higher level context

- Recommendations for Future Work
  - Describe next steps for design, experiments, theories, manuals
Due on Sakai, December 7\textsuperscript{th}, 11am.
Template is posted on the website lab page.
5 page limit (appendices not included)
Includes sections:
\begin{itemize}
\item An overview of your autonomous vehicle and your strategy
\item A description of your (customized) modification(s)
\item An explanation of your game-playing algorithms
\item A summary of the robot performance, including how it did during your tests, the scrimmage, and the final game, discrepancies with the intended algorithm, limitations you have observed, and concrete recommendations for improvements.
\item A summary of the main lessons you have learned from the project.
\item An appendix listing your Arduino code (pages 6+)
\end{itemize}
Writing Techniques

- Present vs. Past Tense
  - For most of the document, the present tense is preferred.

  *The robot’s locomotion is actuated by two DC motors.*

  - The past tense is used when describing experiments that took place.

  *The AUV was deployed at 7:30am in Carnegie Lake, NJ on March 21, 2011.*
Active Voice vs. Passive Voice

A passive construction occurs when you make the object of an action into the subject of a sentence.

Why was the road crossed by the chicken?

- Passive can be unclear.
- Active voice is (often) preferred.
Passive Example:

A new process for eliminating nitrogen oxides from diesel exhaust engines is presented.

Active Example:

This paper presents a new process for eliminating nitrogen oxides from diesel engine exhaust.
Writing Techniques

- Ambiguity
  - In technical documents, ambiguity can lead to poor decision making, dangerous situations, and lawsuits.

We examined neat methanol and ethanol and methanol and ethanol with 10% water.

v.s.

We examined four fuels: neat methanol, neat ethanol, methanol with 10% water, and ethanol with 10% water.
Writing Techniques

- Conciseness
  - Use as few words as possible
  - Don’t repeat – often students rewrite the same fact multiple times.
## Writing within a Team

### Group Writing Method

<table>
<thead>
<tr>
<th>Step</th>
<th>Method</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>One person from the group writes the entire report with little help from anyone else.</td>
<td><em>You won’t have to worry about agreeing on a single voice.</em>&lt;br&gt;<em>If this person is a good writer with a good understanding of the project, the report will be pretty decent.</em></td>
<td><em>This person will hate everyone else on the team.</em>&lt;br&gt;<em>This person will not get a lot of sleep before the report is due (especially if it’s a long report).</em>&lt;br&gt;<em>Nobody else has a say in what goes in the report.</em>&lt;br&gt;<em>Everybody’s specialized technical knowledge will get lost forever.</em></td>
</tr>
<tr>
<td>2.</td>
<td>The group leader splits the report into sections and divides it out to the group members. Each person writes their own section, then the sections are cut-and-pasted together.</td>
<td><em>Each person contributes more or less equally.</em>&lt;br&gt;<em>Nobody ever has to read the entire report.</em></td>
<td><em>The person receiving the report will hate all of you.</em>&lt;br&gt;<em>Whoever has to edit the report before it’s completed (your advisor, liaison, professor, etc.) will get little sleep.</em>&lt;br&gt;<em>Your report will likely lack quality, integrity, and coherence.</em></td>
</tr>
<tr>
<td>3.</td>
<td>Same as 2, except that also have the best writer in the group read and edit the entire report before turning it in.</td>
<td><em>The report will have a single voice.</em>&lt;br&gt;<em>Everyone’s specialized technical knowledge and/or unique perspectives will be included.</em></td>
<td><em>A tremendous amount of time will be needed to edit everything.</em>&lt;br&gt;<em>Your chosen editor may be a poor editor.</em></td>
</tr>
<tr>
<td>4.</td>
<td>The group writes an extensive outline together and decides up front: audience, tone, information to include, organization. Each person writes his/her section. Finally, everyone takes a turn reading/ commenting on the entire report and a final editor cements suggested changes.</td>
<td><em>Relatively little time is necessary in the editing stage.</em>&lt;br&gt;<em>The workload is pretty equal and nobody gets stuck doing the lion’s share.</em>&lt;br&gt;<em>Everybody has a say in what information goes in the final report and how it’s presented.</em>&lt;br&gt;<em>Having everyone edit virtually guarantees a correctly spelled title.</em></td>
<td><em>This method takes a lot of time on the frontend. Granted, it’s well worth it, but if you’re late getting started this may be a difficult method to implement at the last minute.</em>&lt;br&gt;<em>You will spend lots of time in a room together with your team. Order pizza.</em></td>
</tr>
<tr>
<td>5.</td>
<td>The group writes the intro, conclusion, and all transitions together. The rest is the same as 4.</td>
<td>See Method 4.</td>
<td>See Method 4. But order Chinese food instead.</td>
</tr>
<tr>
<td>6.</td>
<td>The group locks themselves in a room and writes the entire report together.</td>
<td><em>The report has a single voice.</em>&lt;br&gt;<em>Everyone has a say in what the final report looks and sounds like.</em>&lt;br&gt;<em>Everyone suffers equally.</em></td>
<td><em>Order pizza and Chinese food. This is a huge time commitment.</em>&lt;br&gt;<em>It’s difficult to remain sensitive to others’ feelings when stuck in a small room for long periods of time. You may all hate each other before you are done.</em>&lt;br&gt;<em>This may not be fun, and the resulting report may show it.</em></td>
</tr>
</tbody>
</table>
Abstract – The goal of this lab is to implement and test odometry as a method of estimating the position of a mobile robot. Odometry position estimation was implemented on a differential drive mobile robot, and tested while the robot followed a variety of simple paths. Results indicate that position estimate errors grow unbounded with distance travelled.
Abstract - This lab was designed to introduce and test a particle filter. The particle filter was used to determine a robot’s position in a predefined world. The filter was tested multiple times in both physical and simulated environments. Performance of the particle filter was also tested when the robot was moved unexpectedly or ‘kidnapped’. It was found that the particle filter is a good method of robot positioning and that it is superior to positioning based on odometry.
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Introduction - This experiment aimed to predict the motion and location of an X80 robot based on odometry—the use of data from moving sensors to estimate position over time—and then characterize the error of motion. In our case we are using the encoders on the wheels to tell the robot how far each wheel has travelled. From that information we calculate where the robot should be. After predicting where the robot should be, we measure where the robot actually is in the physical world. The difference between these values would categorize the error from environmental factors like slipping, wheel radius, unsynchronized motors etc.
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Introduction - Odometry is a method for predicting the position of a robot by using wheel sensors to calculate the expected distance the robot has traveled in a global coordinate frame. The particular sensors used in this lab are incremental encoders, shown below in Figure 1, which measure the signal from photo detectors located on one side of a transparent disk. As the disk rotates with the wheel shaft, the photo detectors will detect a signal that will oscillate between high and low, corresponding to a 1 or 0, respectively. This change in signal is due to the black lines etched onto the transparent disk. These changes in signal values are counted in sequence and correspond to an angular motion of the wheel. These encoder counts, as they are often called, are used in calculating the angular displacement of the wheel, which is then multiplied by the wheel radius to calculate the distance the robot has traveled.
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