NA 568 Mobile Robotics: Methods & Algorithms Winter 2020 – PS4

Maani Ghaffari
University of Michigan

February 27, 2020

This problem set counts 10% of your course grade. You are encouraged to talk at the conceptual level with other students, but you must complete all work individually and may not share any non-trivial code or solution steps. See the syllabus for the full collaboration policy.

Submission Instructions

Your assignment must be received by 11:55 pm on Sunday, March 22. You are to upload your assignment directly to the Gradescope website as two attachments:

1. A `.tar.gz` or `.zip` file *containing a directory* named after your uniqname with the structure shown below.

   `alincoln_ps4.zip`:
   ```
   alincoln_ps4/
   alincoln_ps4/alincoln_ps4.pdf
   alincoln_ps4/YOUR_WORKING_CODE
   ```

2. A PDF with the written portion of your write-up. Scanned versions of hand-written documents, converted to PDFs, are perfectly acceptable. No other formats (e.g., .doc) are acceptable. Your PDF file should adhere to the following naming convention: `alincoln_ps4.pdf`.

3. Submit your complete source code. We will compile and run your code for evaluation.

Homework received after 11:55 pm is considered late and will be penalized as per the course policy. The ultimate timestamp authority is the one assigned to your upload by Gradescope. No exceptions to this policy will be made.

Pose Graph SLAM using GTSAM Library

In this homework, you're going to solve the pose graph SLAM problem using the GTSAM library. To install GTSAM, you'll have to clone the code from the repository: https://github.com/borglab/gtsam, checkout (using git) the latest version and build the library following the instruction.

After you successfully install GTSAM, write a function to read G2O [1] files and solve the graph optimization problem for both 2D and 3D cases using GTSAM. In this assignment, we use datasets provided at https://lucacarlone.mit.edu/datasets/

While GTSAM is developed using C++, it also provides both MATLAB and Python wrapper. In this assignment, you're free to use any of those languages.

Remark 1. *GTSAM requires the Eigen library. It can be downloaded and installed from here: http://eigen.tuxfamily.org/index.php?title=Main_Page*

Task 1: 2D Graph SLAM (50 points)

A. (10 pts) Write a function to read 2D `Intel dataset` [2] in G2O format. **Remark:** if you use `readG2o()` and `load2D()` functions provided by GTSAM, then you will not be able to solve the graph incrementally.

B. (20 pts) **Batch Solution:** A batch solution means when we construct the entire graph and solve it at the end altogether. Load `data/input_INTEL_g2o.g2o` and construct a 2D nonlinear factor graph using GTSAM. Use the Gauss-Newton solver. Visualize and compare the optimized trajectory against the initial trajectory. Include the plot in your pdf. Describe the graph construction process and its parameters.

C. (20 pts) **Incremental Solution:** Use ISAM2 solver to optimize the trajectory incrementally (as you build the graph gradually). Visualize and compare the optimized trajectory against the initial trajectory. Include the plot in your pdf. Describe the graph construction process and its parameters.

Task 2: 3D Graph SLAM (50 points)

A. (10 pts) Write a function to read 3D Garage G2O file [3].

B. (20 pts) **Batch Solution:** Load `data/parking-garage.g2o` and construct a 3D nonlinear factor graph using GTSAM. Use the Gauss-Newton solver. Visualize and compare the optimized trajectory against the initial trajectory. Include the plot in your pdf. Describe the graph construction process and its parameters.

C. (20 pts) **Incremental Solution:** Use ISAM2 solver to optimize the trajectory incrementally. Visualize and compare the optimized trajectory against the initial trajectory. Include the plot in your pdf. Describe the graph construction process and its parameters.

[1] https://github.com/RainerKuemmerle/g2o/wiki/File-Format
[2] https://www.dropbox.com/s/vcz8cag7bo0zlaj/input_INTEL_g2o.g2o?dl=0
[3] https://www.dropbox.com/s/zu23p8d522qccor/parking-garage.g2o?dl=0