Albert-Ludwigs-Universität Freiburg, Institut für Informatik
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Lecture: Robot Mapping
Winter term 2013

Sheet 7

Topic: Grid Maps

Submission deadline: December, 16
Submit to: `robotmappingtutors@informatik.uni-freiburg.de`

Exercise: Occupancy Mapping Algorithm Implementation

Implement the occupancy grid mapping algorithm as presented in the lecture. To support this task, we provide a small *Octave* framework (see course website). The framework contains the following folders:

data contains the recorded laser scans and known robot poses at each time step.

octave contains the grid maps framework with stubs to complete.

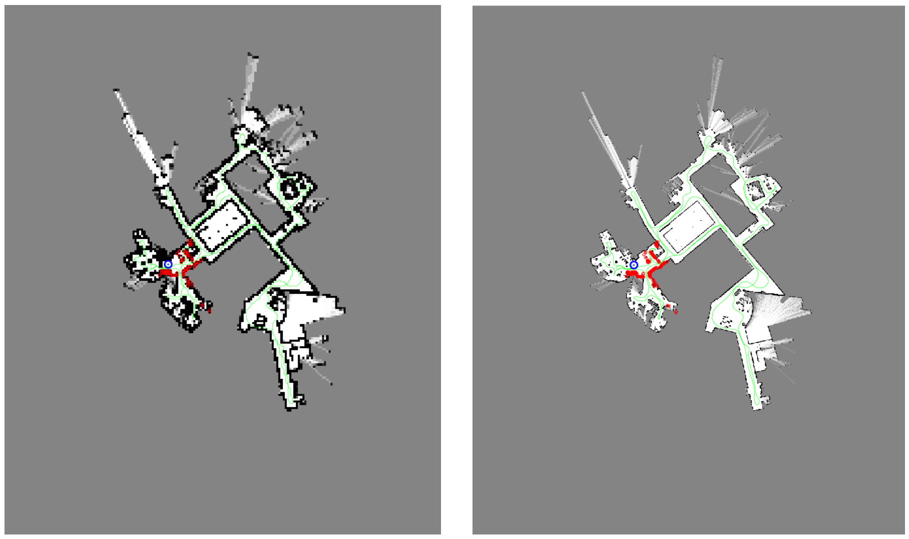
plots this folder is used to store images.

The below mentioned tasks should be implemented inside the framework in the directory `octave` by completing the stubs:

- Implement the functions in `prob_to_log_odds.m` and `log_odds_to_prob.m` for converting between probability and log odds values.
- Implement the function in `world_to_map_coordinates.m` for converting the (x, y) world frame coordinates of a point to its corresponding coordinates in the grid map. You might find the *Octave* functions `ceil` and `floor` useful.
- Implement the function in `inv_sensor_model.m` to compute the update to the log odds value of each cell in the map for a particular laser scan measurement.

After implementing the missing parts, you can run the occupancy grid mapping framework. To do that, **change into the directory octave** and launch *Octave*. Type `gridmap` to start the main loop (this may take some time). The script will produce plots of the state of the resulting maps and save them in the `plots` directory. You can use the images for debugging and to generate an animation. For example, you can use ffmpeg from inside the plots directory as follows:

```
ffmpeg -r 10 -b 500000 -i gridmap_%03d.png gridmap.mp4
```



resolution 0.5 m resolution 0.1 m

Figure 1: Examples for the final result of the occupancy mapping algorithm.

Figure 1 depicts the example images of the resulting maps using grid sizes of 0.5 m and 0.1 m.

Some implementation tips:

- Use an inverse sensor model corresponding to laser range finders (see lecture slides). The corresponding p_{free} and p_{occ} values are specified in the `gridmap.m` script. Use p_{occ} to update the occupancy value of cells that laser beam endpoints hit and p_{free} for all other cells along the beam. Use the function `robotlaser_as_cartesian.m` to compute the Cartesian coordinates of the endpoints of a laser scan. The provided `bresenham.m` function can be used for computing the cells that lie along a laser beam in map coordinates.
- Compute all occupancy value updates in log odds (not probabilities) so they can be added directly to the map.
- Test your implementation with a grid size of 0.5m. Once you are satisfied with your results, you can run the algorithm with an increased resolution (e.g. 0.1m), as this will take considerably more time.
- While debugging, run the algorithm only for a few steps by replacing the for-loop in `gridmap.m` by something along the lines of `for t = 1:10`.
- Many of the functions in *Octave* can handle matrices and compute values along the rows or columns of a matrix. Some useful functions that support this are `sum`, `log`, `sqrt`, `sin`, `cos`, and many others.

Exercise: Particle Filter

(a) Describe briefly the main differences between the particle filter and the Extended Kalman filter for state estimation.

(b) Discuss briefly the advantages of the low variance re-sampling strategy.

Exercise: Particle Filter Implementation

First, implement the prediction step of a particle by sampling the motion of a robot given the distribution $p(x_t \mid u_{t-1}, x_{t-1})$ and second, implement the re-sampling step.

(a) Implement the function in `prediction_step.m`, which samples a motion for each particle according to the motion model and the given noise parameters.

(b) Implement the function in `resample.m`, which re-samples the set of particles utilizing the low variance re-sampling method.

To support this task, we provide a small *Octave* framework (see course website). The above-mentioned tasks should be implemented inside the framework in the directory `octave` by completing the stubs. After implementing the missing parts, you can test your solutions by running the script in `motion.m` for the prediction step and `resampling.m` for the re-sample step. The script `motion.m` will produce plots of the position of the particles and save them in the `plots` directory.

Some implementation tips:

- The function `normrnd(`μ`, `σ`)` allows to draw samples from a Gaussian with mean μ and standard deviation σ.
- The function `unifrnd(`a`, `b`)` generates random samples from the uniform distribution on $[a, b]$.
- Many of the functions in *Octave* can handle matrices and compute values along the rows or columns of a matrix. Some useful functions that support this are `sum`, `cumsum`, `sqrt`, `sin`, `cos`, and many others.