Math Matters

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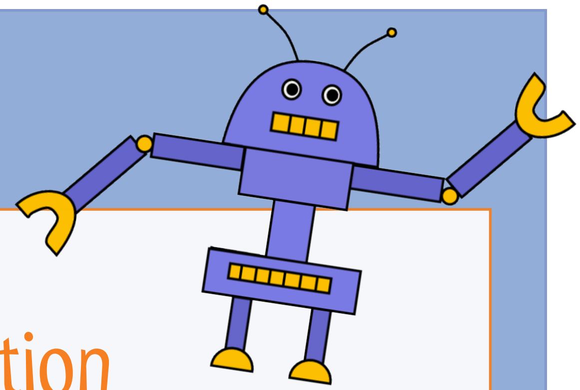


The math behind...

Probabilistic robot localization

Technical terms used:

Probabilistic methods – sampling – localization – Monte Carlo Methods – Bayes filter

Uses and applications:

Probabilistic robot localization is primarily used for mobile robot navigation. This is simply the ability of the robot to navigate in an environment. This problem becomes easier if the environment has a known map. If not, then it is being researched in the field known as Simultaneous Localization and Mapping (SLAM).

How it works:

The ability of a robot to navigate indoors is an increasingly prevalent application of robots, whether the environment is an industrial facility, house, or public space. For the robot to navigate, it must be able to determine its location, known as localizing itself. Indoors, the use of a GPS signal is eliminated and localization is a more complicated problem and requires using a number of sensors to be solved. This becomes more complicated in the case of increased uncertainty in the environment as in the case of houses which have a much larger extent of uncertainty than factories for example. This is where the probabilistic methods appear strongly for solving the robot localization problem.

One of the major methods used is that of Monte Carlo Localization (MCL). This method implements the use of Monte Carlo methods, computational algorithms based on random sampling and are used in a variety of fields. Consequently, MCL is based on random sampling and requires the knowledge of the environment map and sensor readings as input. Such sensors could be laser scanners, 3D cameras or other kind of sensors that can measure some features in the environment. Initially, the robot is assumed to be anywhere in the environment with equal probability, and thus the probability distribution is assumed to be uniform. As the robot moves, the sensor readings are inputted to the algorithm and weights are assigned for the locations. These weights explain the probability of the robot's location. The algorithm then draws another random sample, this time with the new probability distribution explained by the assigned weights. This approach is known as Recursive Bayesian estimation, or Bayes filter (relating to the English mathematician Bayes). This process is continued until the problem is solved and the algorithm converges to the true location of the robot.

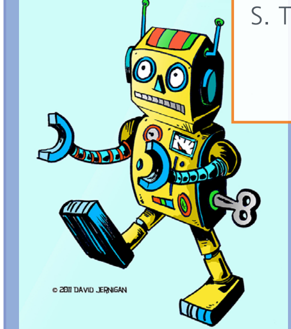
Interesting facts:

the robot tour guide in public events. Can you imagine the size of uncertainty in a complicated environment like a public exhibition? You may think that it's possible that the localization process can fail at some certain moment and you're correct! This does really happen, and is known as the kidnapped robot problem. Thankfully, MCL is a strong method that can overcome this failure by considering other locations in the re-sampling step.

References:

S. Thrun, W. Burgard, and D. Fox, Probabilistic robotics (MIT press, 2005)

Submitted by Hassan Shehawy, University of Tartu, Third Place, Math Matters, Apply it! Contest, February 2017



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