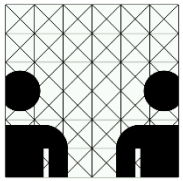

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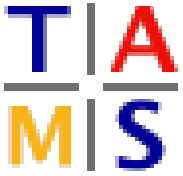

Arbeitsbereich
Technische **A**spekte
Multimodaler **S**ysteme

Overview of Localization and Path Planning in Robotics

26. Mai 2016

Jeremias Hartz
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Overview

- **Localisation**
  - **Basics**
  - **Landmark based methods**
  - **Other Methods**
  - **Least Mean Squares correction**
  - **Mapping**
    - **Monte Carlo particle filter**
- **Path planning**
  - **Sampling-Based Algorithms**
  - **Grid-Based Search**
  - **Potential Fields**

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Localisation Basics

- General questions to answer:
  - 1. „Where am I?“
  - 2. „What is my orientation?“
- Goals:
  - Minimize difference -
    calculated and actual position
  - Minimize time - localisation

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Localisation Basics

- Types of Sensors:
  - Ultrasonic
  - Infrared
  - Laser
  - Magnetic
  - Radio frequency
  - Image
  - Touch
  - Sonar, …

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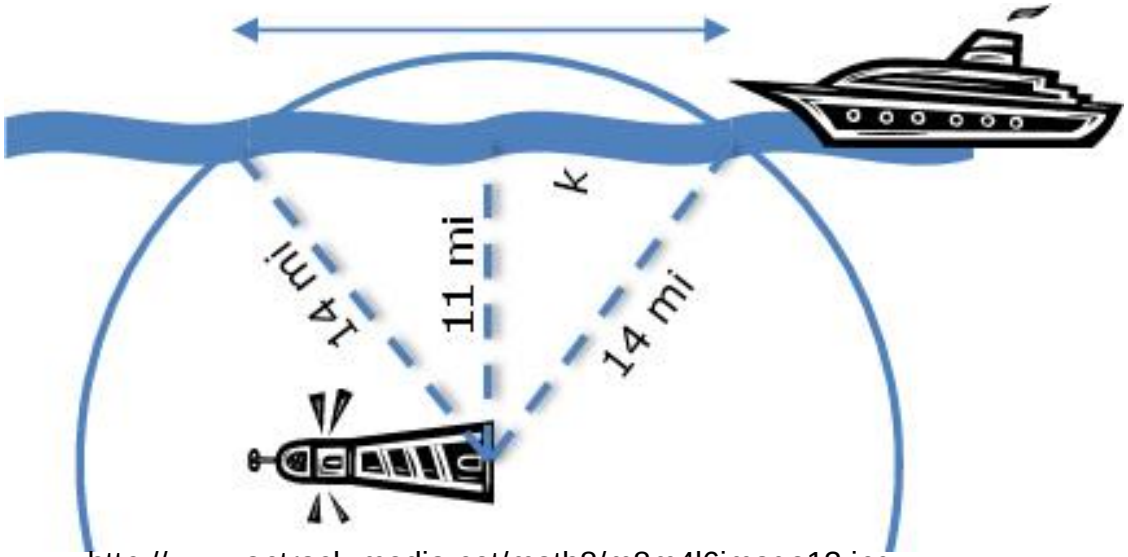
Landmarks

- Active or passive beacons
- Sensors capture signals
  - Get time difference / angle
- more landmarks → better accuracy



http://www.ontrack-media.net/math8/m8m4l6image13.jpg

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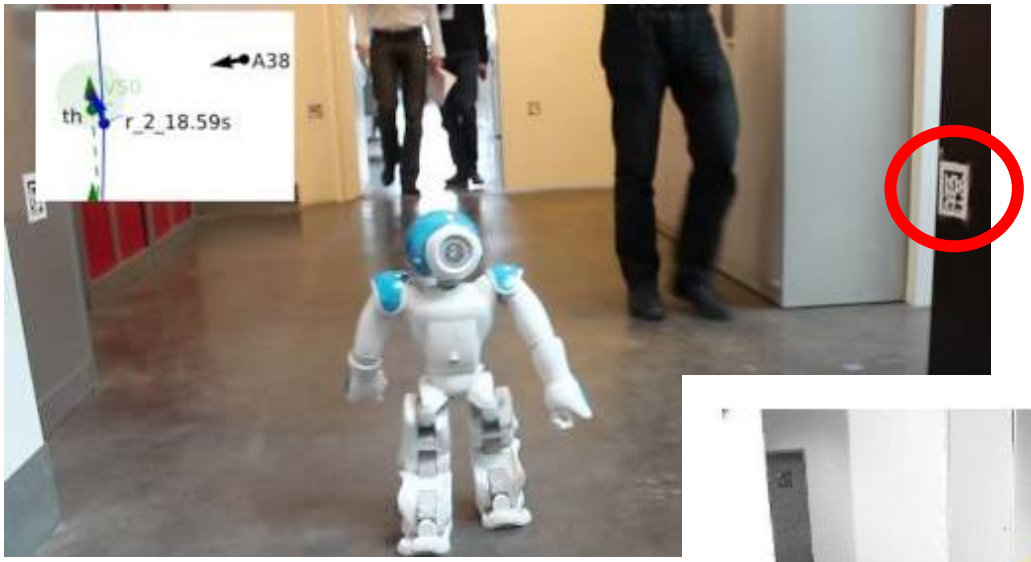
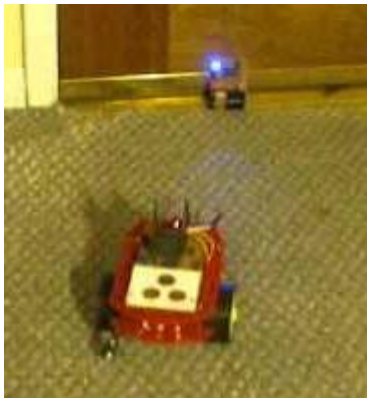
Landmarks - Examples

- Bar-Codes



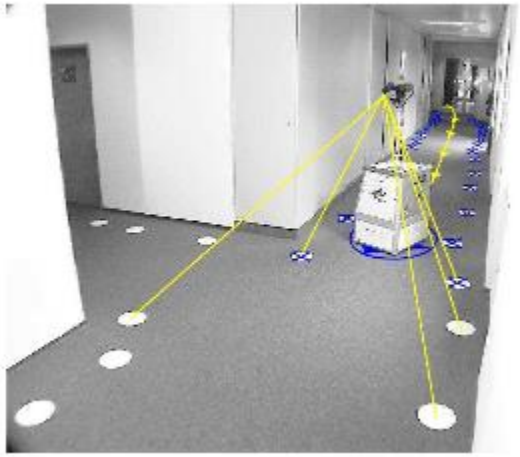
http://www.i-programmer.info/news/169-robotics/6665-robot-navigation-made-easy-with-qr-codes.html

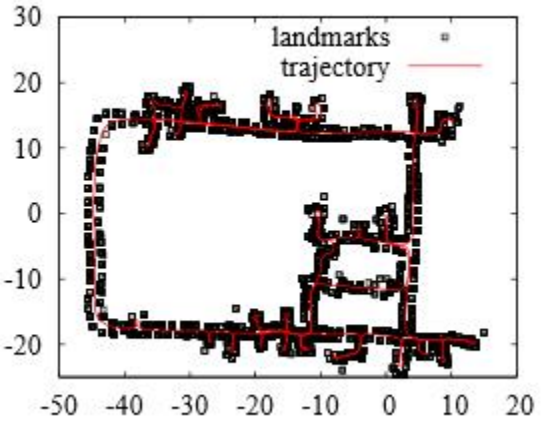
- IR



http://www.botmag.com/picaxe-part-4/

- White circles





http://www.dis.uniroma1.it/~grisetti/teaching/lectures-ls-slam-master_2014_15/web/reading_material/grisetti12stest.pdf

Line following

- Accurate and cheap
- Infrared sensors or regular camera
  - High contrast color line (black&white)

http://inhabitat.com/the-largest-second-generation-robot-restaurant-is-now-open-in-china/

https://www.kickstarter.com/projects/653648655/drink-runner

- Magnetic sensors
  - Electric cable line
- Intersections not as simple

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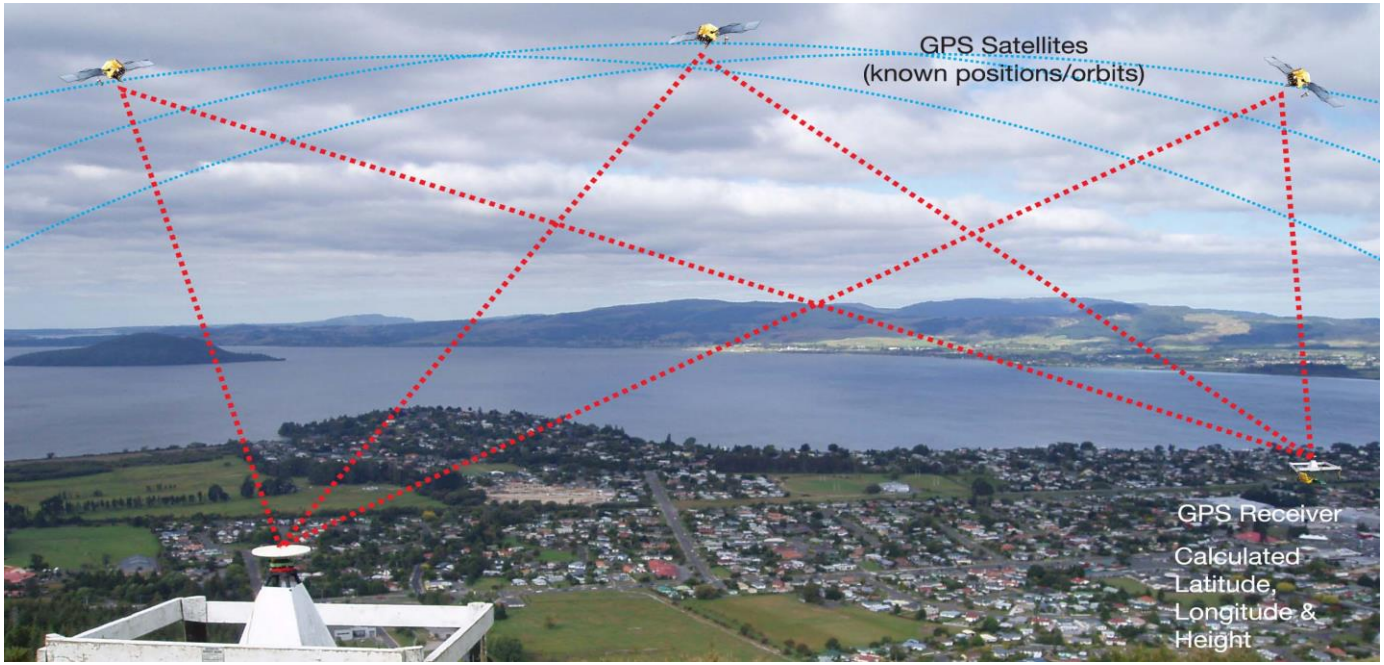
GPS / GPS-like Systems

- GPS → large outdoor areas
- GPS-like systems → indoors
- At least 2 active beacons



http://www.icsm.gov.au/mapping/web_images/figure_24v3.jpg

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Dead Reckoning

- Use of odometry
- Example: Turtlebot
  - Wheels Ø: 7cm, forward rotations: 10 = Distance: π * 7 * 10 ≈ 220[cm]
- High error rate:
  - Weight distribution, wind, surface, not exact measures, geometry and hardware problems
- Constrain: initial position has to be known

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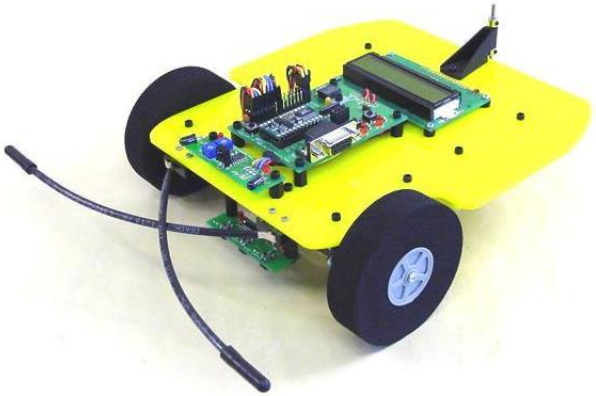
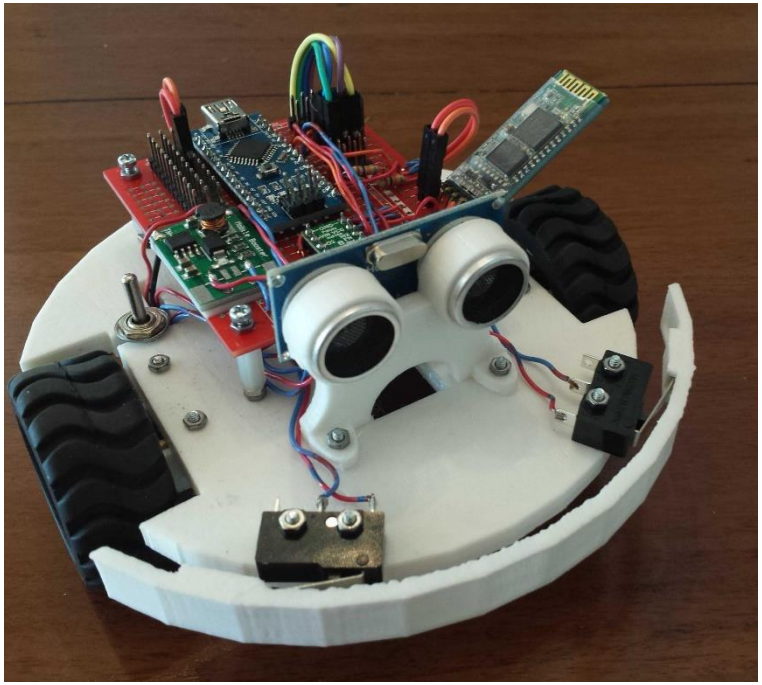
Short Range Localisation

- Bumper sensor
  - Accurate sensor data – not much filtering needed
  - Protection
  - Incomplete map



http://www.robotshop.com/media/files/Images/rblyn28_on_robot.jpg



http://robot50.net/category/bootstrap/

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Current Heading

- Compass sensor
  - Magnetic field sensors
  - Easily disrupted
    - Weak magentic field
  - Self recovery

http://www.robotshop.com/en/magnetic-sensors-compass.html

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Current Heading - Example

- Compass example:
- With Arduino and HMC-Sensor

```
#include <Adafruit_Sensor.h>
#include <Adafruit_HMC5883_U.h>
```


```
while (diff_heading > 0 && !target_reached) {

  // Move & stop
  if (turn_direction) {
    right(50);
  } else {
    left(50);
  }
  delay(100);
  right(0);
  delay(100);

  // Measure heading again
  float heading = get_heading();

  // Calculate heading difference
  if (turn_direction) {
    diff_heading = target_heading - heading;
  }
  else {
    diff_heading = heading - target_heading;
  }

  // Target reached ?
  if (diff_heading < 0 && !target_reached) {
    target_reached = true;
    turn_init = false;
    diff_heading = 0;
  }
}
```

Compass Tutorial: https://openhardwarerobots.com/digital-compass-arduino-robot-navigation/

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Ultrasonic & Bumper Example

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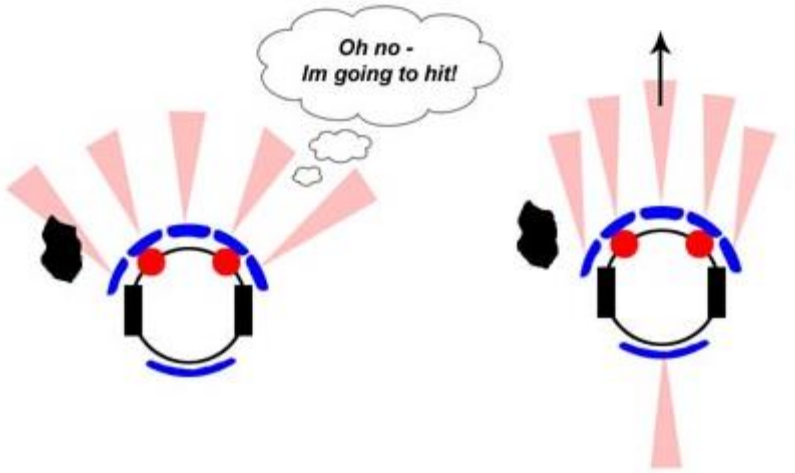
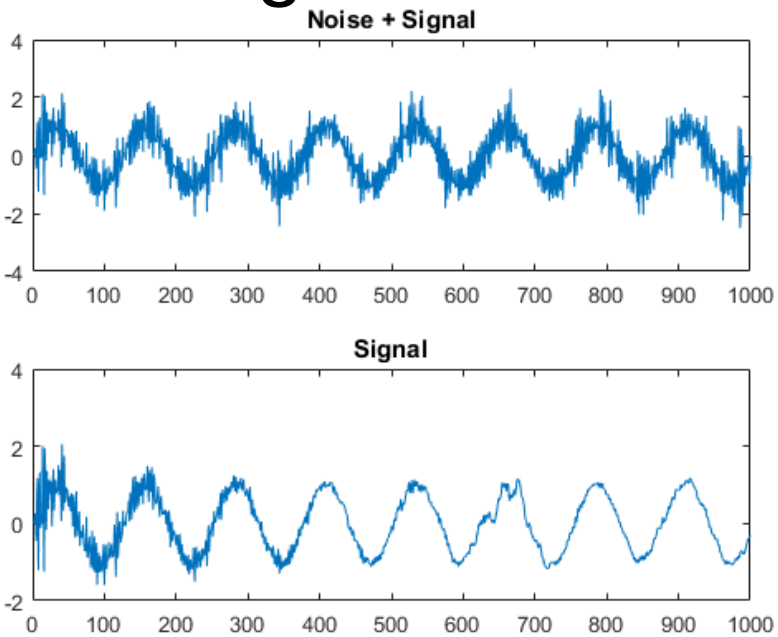
Least Mean Squares

- Calculate the position with the smallest difference based on real data
- Good for autonomous learning in different environments



http://www.schursastrophotography.com/robotics/irproxlogic.html



http://www.mathworks.com/help/examples/dsp/CancelNoiseUsingLMSFilterExample_01.png

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Mapping

- Map construction (2D/3D)
- Localisation in that map
- Simultaneous localization and mapping
  -> SLAM Problem:
  - Unprecise localisation leads to wrong map
- Recognizing known maps

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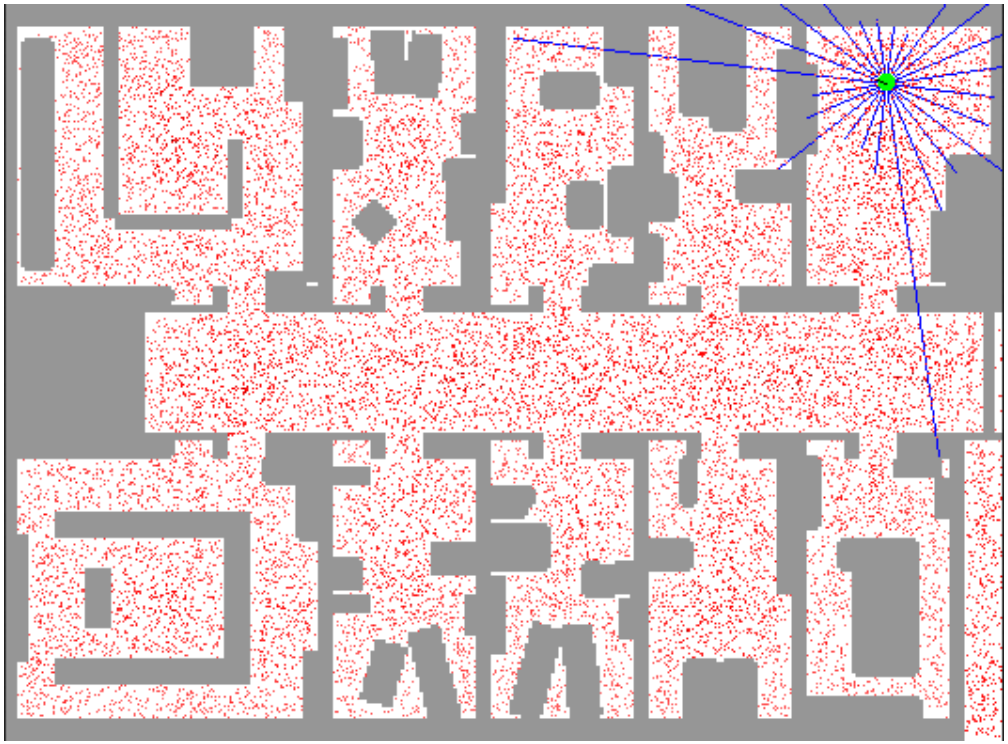
Mapping - Monte Carlo particle filter

- Weighing points using data
- Resample
- Propagate in time



https://rse-lab.cs.washington.edu/projects/mcl/animations/global-floor.gif

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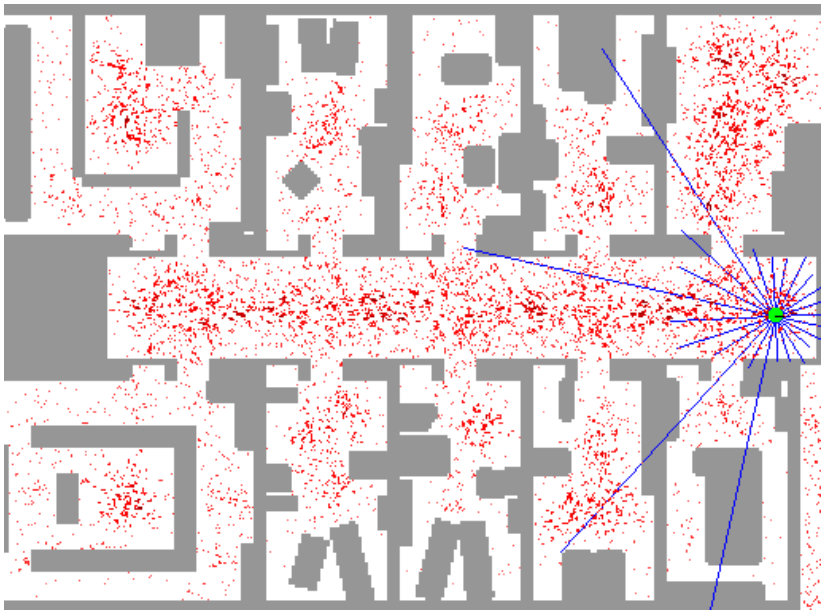
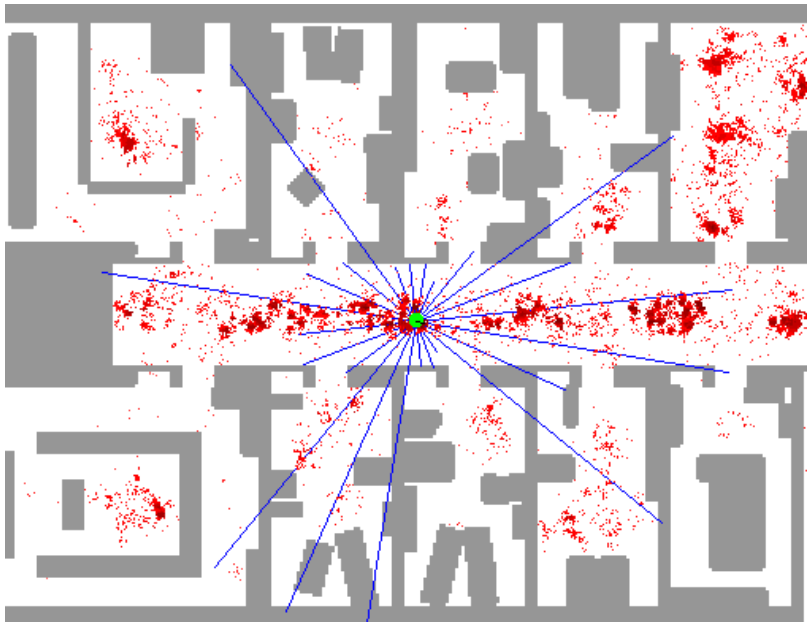
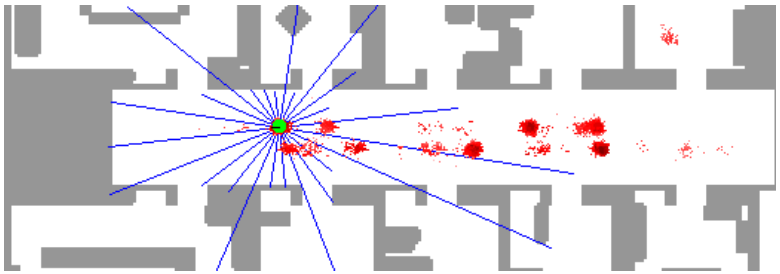
Mapping - Monte Carlo particle filter







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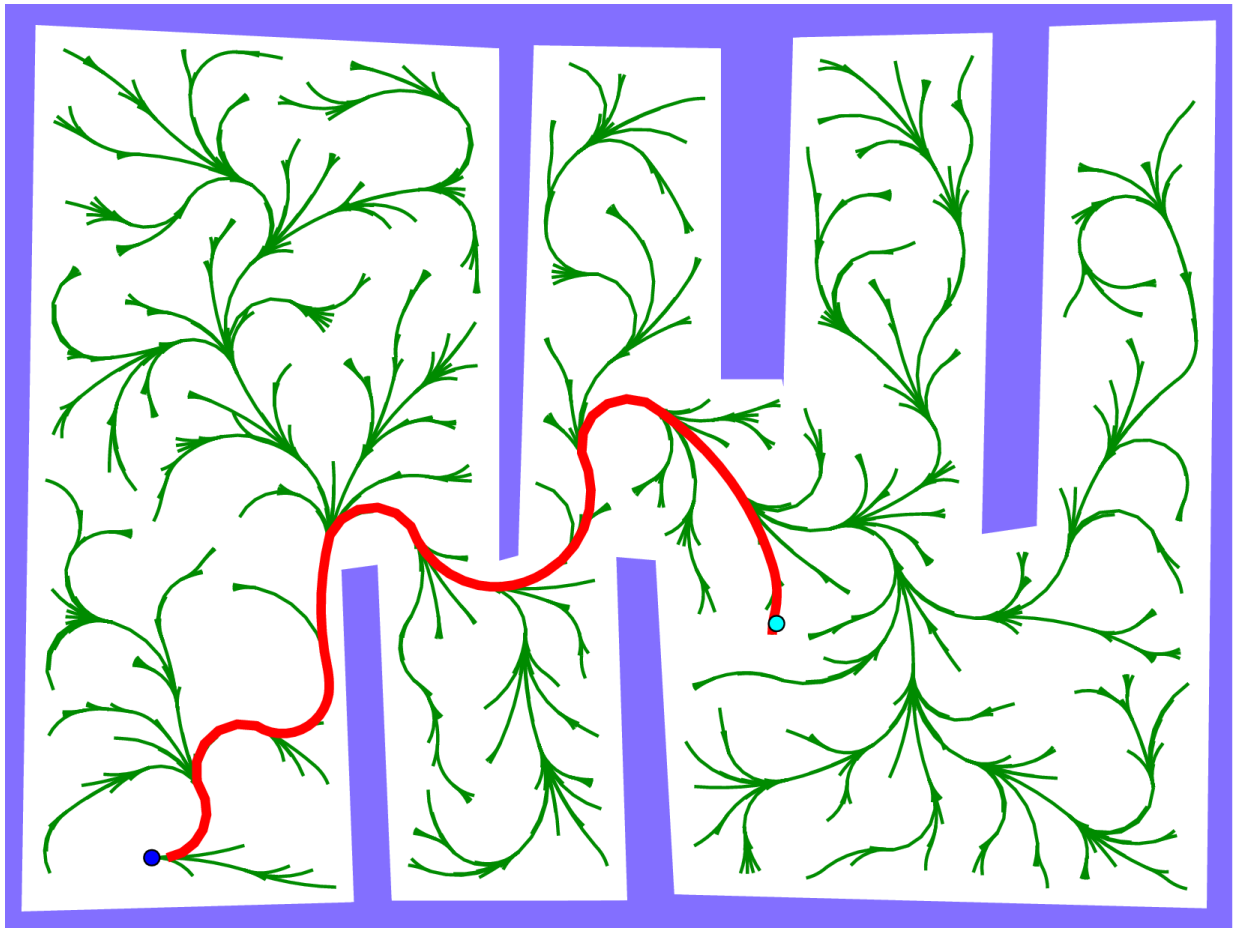
Path planning



http://mrs.felk.cvut.cz/research/motion-planning

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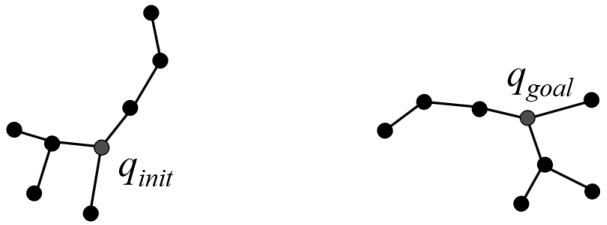
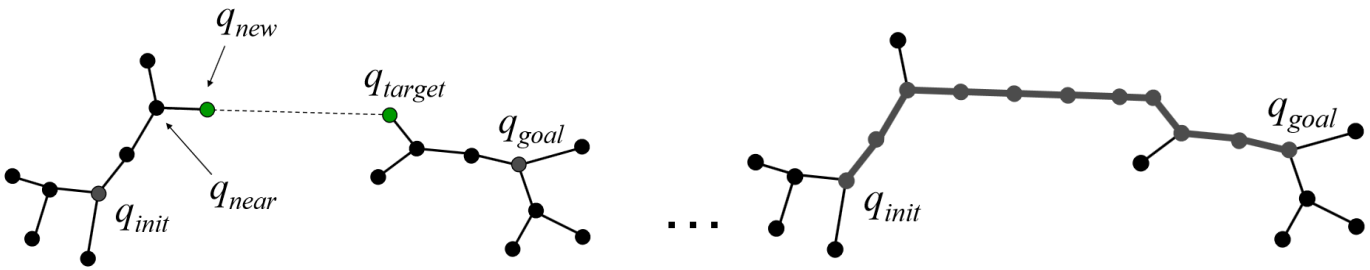
Sampling-based algorithms

- Random tree structures



- Nearest nodes between two trees - expand until all are connected and path is found



http://www.cs.cmu.edu/~motionplanning/lecture/Chap7-Prob-Planning_howie.pdf

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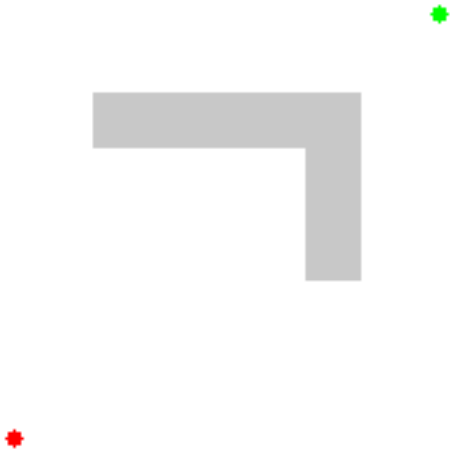
Grid-Based Search

- Creating grid points in direction of goal
- Obstacle is in the way
  - adjustant grid point
- Costly in complex enviroments



https://en.wikipedia.org/wiki/A*_search_algorithm#/media/File:Astar_progress_animation.gif

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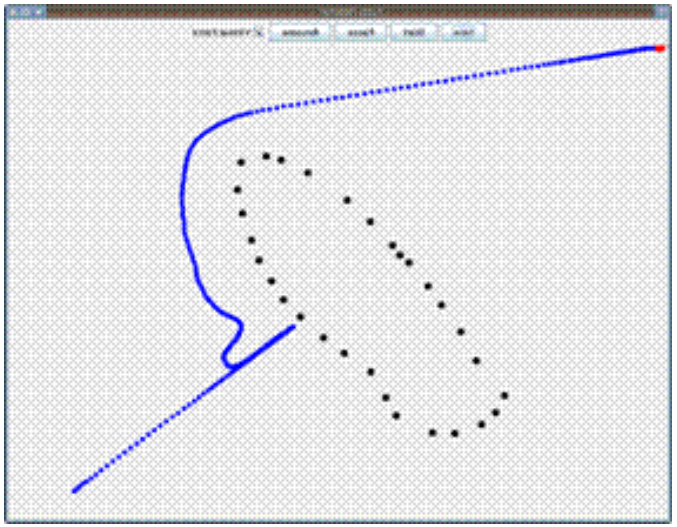
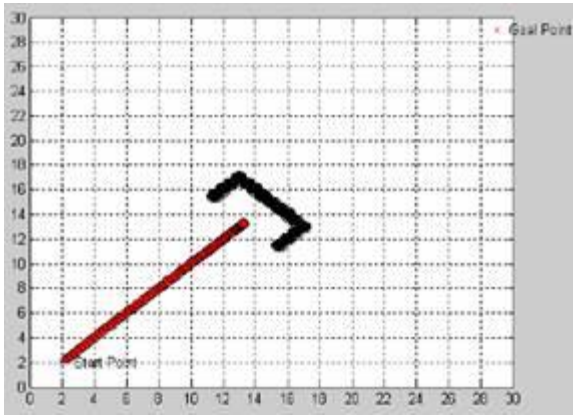
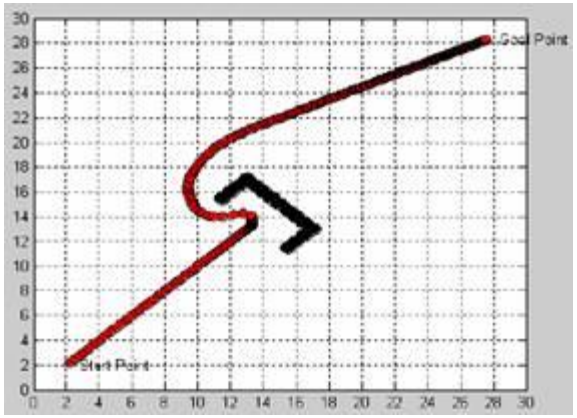
Potential Fields

- Simple approach:
  - Attraction by goal
  - Repulsion from obstacles
- Problem:
  - Robot can get trapped







http://www.cs.mcgill.ca/~hsafad/robotics/

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Thank you! Questions?

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Sources

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