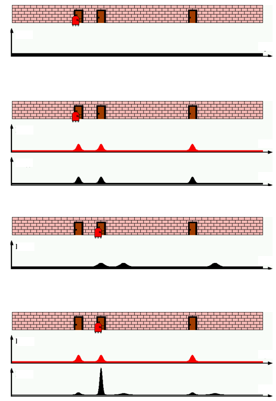
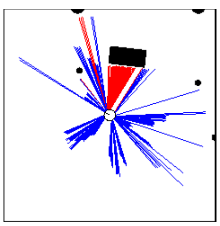
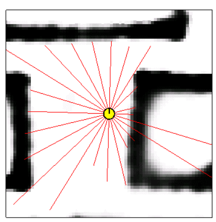
CS329 Probabilistic Robotics

Sebastian Thrun
Carnegie Mellon University
www.cs.cmu.edu/~thrun

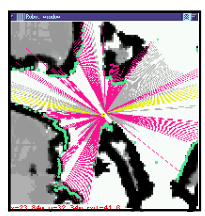


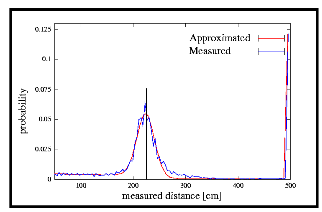
Nature of Sensor Data



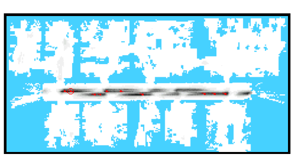


Probabilistic Range Sensing

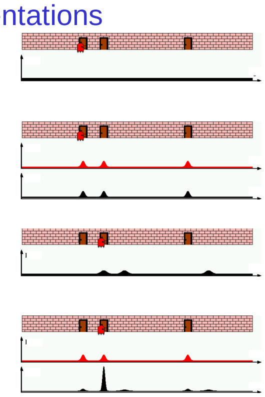




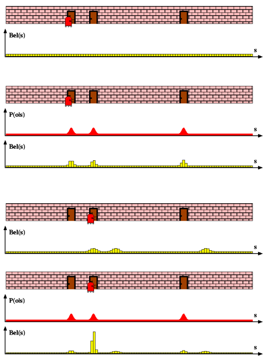
Posterior Probability (Single Scan)



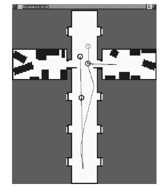
Representations

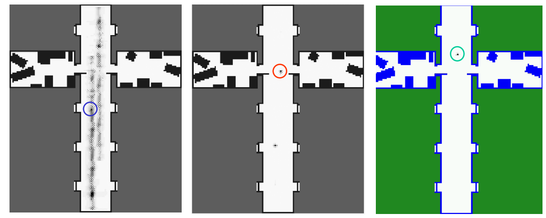


Grid Approximations

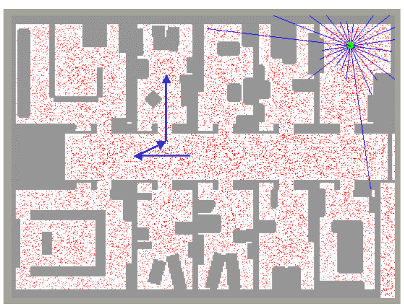


Markov Localization in Grid Map

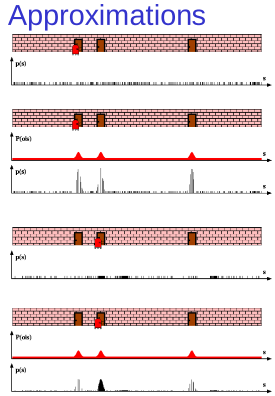




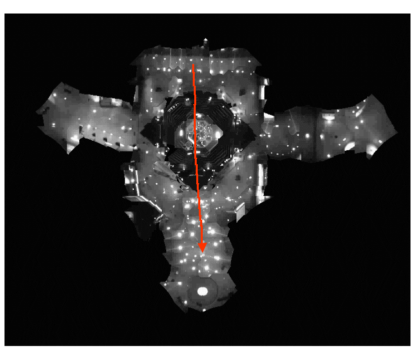
Monte Carlo Localization



Sample Approximations

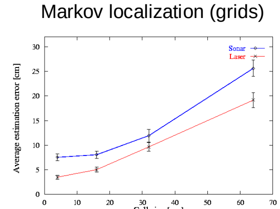


Monte Carlo Localization, cont'd

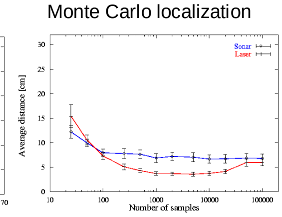


Performance Comparison

Markov localization (grids)



Monte Carlo localization



What Can Go Wrong?

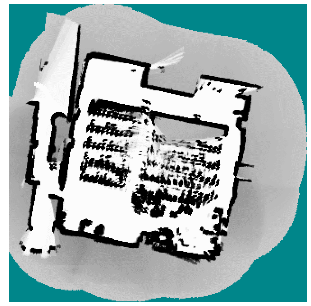
Model limitations/false assumptions

- Map false, robot outside map
- Independence assumption in sensor measurement noise
- Robot goes through wall
- Presence of people
- Kidnapped robot problem
- Invisible hazards?

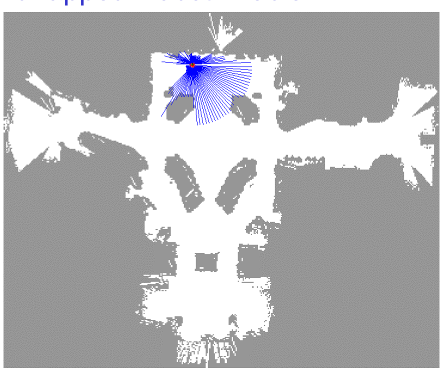
Approximation (Samples)

- Small number of samples (eg, n=1) ignores measurements
- Perfect sensors
- Resampling without robot motion
- Room full of chairs (discontinuities)

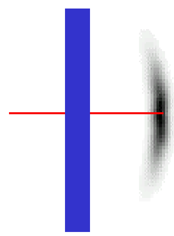
Localization in Cluttered Environments



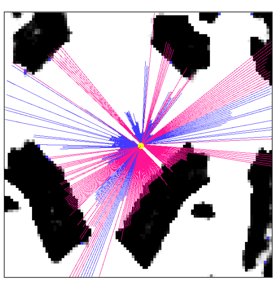
Kidnapped Robot Problem



Probabilistic Kinematics

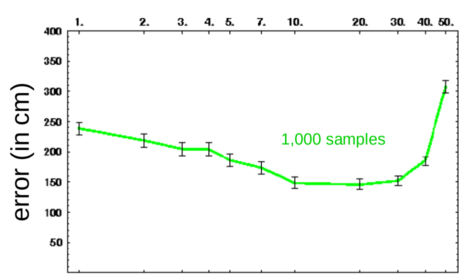


Pitfall: The World is not Markov!

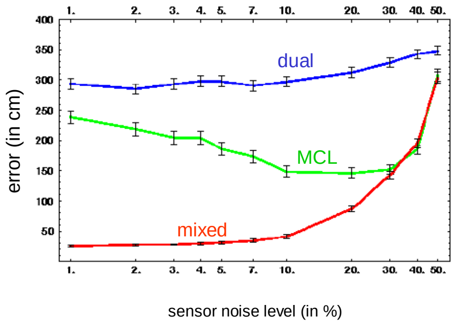


$$p(z_t \text{ is short}) = \int\int p(z \mid x_t, m)\, dz \;\; p(x_t \mid u_{1\ldots t}, z_{1\ldots t-1})\; dx_t \overset{?}{\geq} 0.99$$

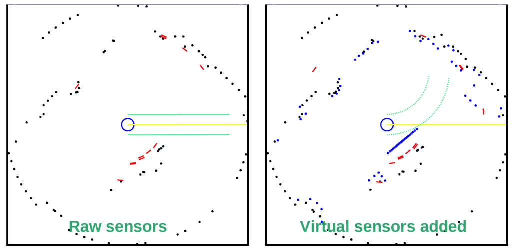
Error as Function of Sensor Noise



Error as Function of Sensor Noise



Avoiding Collisions with Invisible Hazards



$$p(z_t > a) = \int I_{\mathrm{raytrace}(z_t, m) > a} \; p(x_t \mid u_{1..t}, z_{1..t-1}) dx_t$$

$$a^* = \sup_a \{ p(z_t > a) \geq 0.99 \}$$