CSE4421/5324: Introduction to Robotics

Contact Information

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- CSE4421/5324
  lectures Monday, Wednesday, Friday 2:30-3:30PM (ACW305)
  labs Thursday 11:30-1:30, Prism 1006B
  www.cse.yorku.ca/course/4421
  (web site not complete yet)

Graduate Studies in Computer Science & Engineering

York University

Why a Master's degree?

- Job titles: Computer systems analyst, computer programmer, computer scientist, computer systems designer
- Bachelor's degree salary: $50,985
- Master's degree salary : $72,515

Source: http://msn.careerbuilder.com/Article/MSN-1817-Salaries-and-Promotions-Bachelors-vs-Masters-How-Does-Your-Salary-Stack-Up/

But I can't afford grad school ...

We'll pay you to study

- $25,000 / year
- Many will be awarded an entrance scholarship of $6,000 on top of the above $25,000.
- Excellent applicants will be awarded an entrance scholarship of $10,000 on top of the above $25,000.

What will I do for my Master's?

- 5 terms (20 months) of full-time study
- Complete 5 courses (15 credits) with a GPA of at least B+
- Complete a research project and write and successfully defend a thesis
- Work as a TA (conducting labs/tutorials, marking, lab monitoring)
- Have fun (ski trips, movie nights, foosball tournaments, Halloween/Christmas parties, conferences, etc.)

How good am I to be admitted?

- An undergraduate honours degree in Computer Science or Computer Engineering
- Minimum GPA of B+ in the last 2 years of study
- Research aptitude (just as important as GPA)

- The above requirements are minimum requirements and do not guarantee admission

Research Aptitude

- Take project courses: CSE4080, CSE4081, CSE4082, CSE4083, CSE4084, CSE4090
- To find out if you are good at doing research
- To get to know professors (potential future supervisors and/or referees)
- To find a suitable research area/topic for your Master's thesis

How to Apply?

- Online applications only

http://futurestudents.yorku.ca/graduate/programs/computer-science-and-engineering

http://futurestudents.yorku.ca/graduate/programs/computer-engineering

- Deadline: January 16, 2013 for 2013-14 admission
- We accept late applications until February 18. Email Ms. Ouma Paul Gill (gradasst@cse.yorku.ca) for permission to apply late.

A little investment goes a long way ...

- Bachelor's degree salary : $50,985
- Master's degree salary : $72,515

For more information ...

- **Information session**: **Friday, January 11, 2:30-3:30**

  Location: LAS-3033 (Comp Sci & Eng Building)

- Web: www.cse.yorku.ca/grad/faq.html

- E-mail:
  - Graduate program assistant: Ouma Paul Gill
    gradasst@cse.yorku.ca
  - Graduate program director: U. T. Nguyen
    utn@cse.yorku.ca

General Course Information

- The course introduces the basic concepts of robotic manipulators and autonomous systems. After a review of some fundamental mathematics the course examines the mechanics and dynamics of robot arms, mobile robots, their sensors and algorithms for controlling them.
- two robotic arms
- everything in Matlab (and some Java?)
- required textbook
  - Thrun, Burgard and Fox, Probabilistic Robotics, The MIT Press, 2006
- other references
  - see course web page

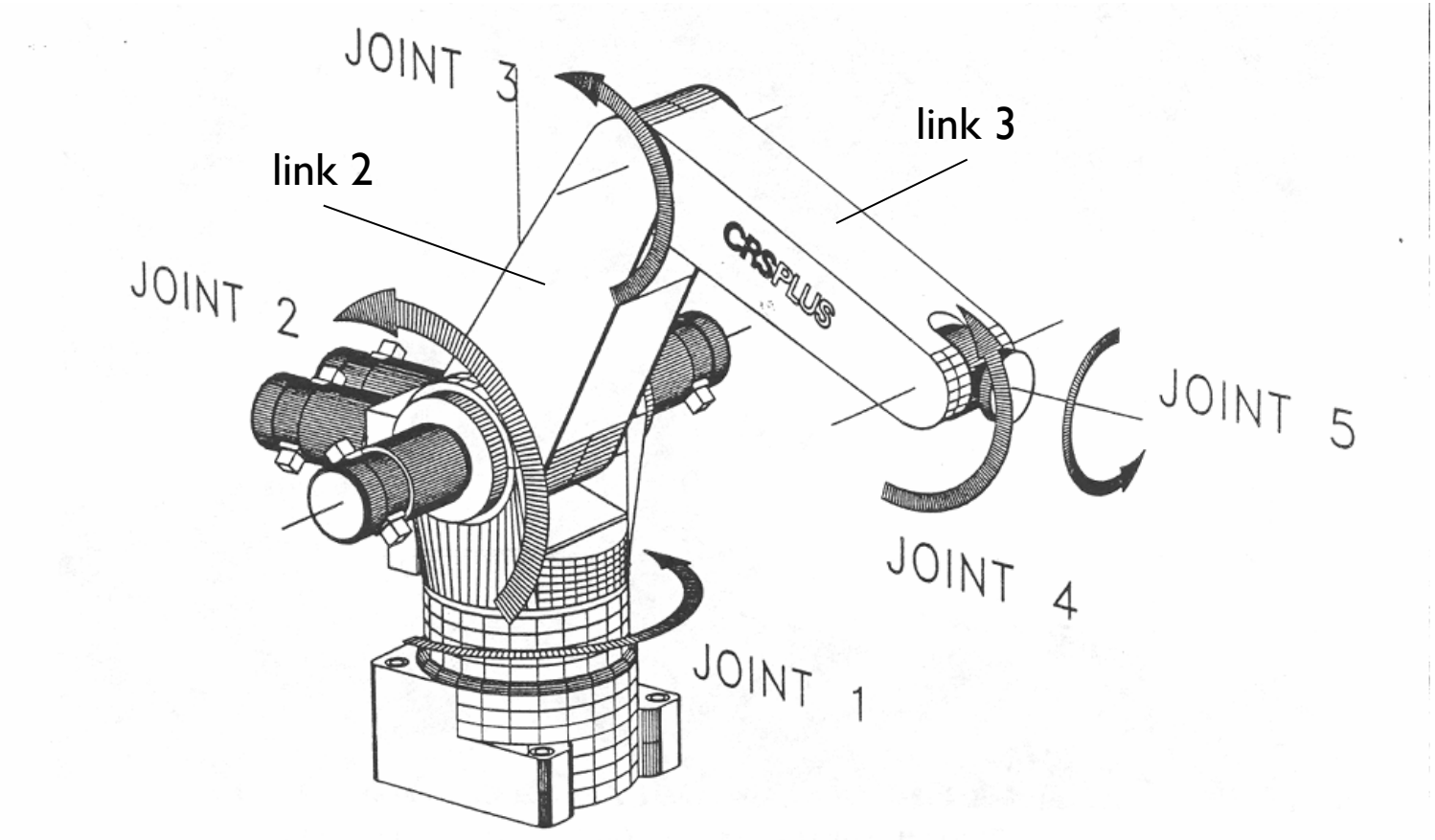
Labs

- six 2-hour labs
  - Thursday 11:30-1:30 in Prism CSEB1006B
  - different lab sections alternate between weeks
    - except for Lab 01!
  - first part of Lab 01 already posted and must be completed prior to lab

Assessment

- labs
- assignments
- midterm
- exam
- independent learning module?

A150 Robotic Arm



Kinematics

- the study of motion that ignores the forces that cause the motion
  - "geometry of motion"
- interested in position, velocity, acceleration, etc. of the various links of the manipulator
  - e.g., where is the gripper relative to the base of the manipulator? what direction is it pointing in?
  - described using rigid transformations of the links

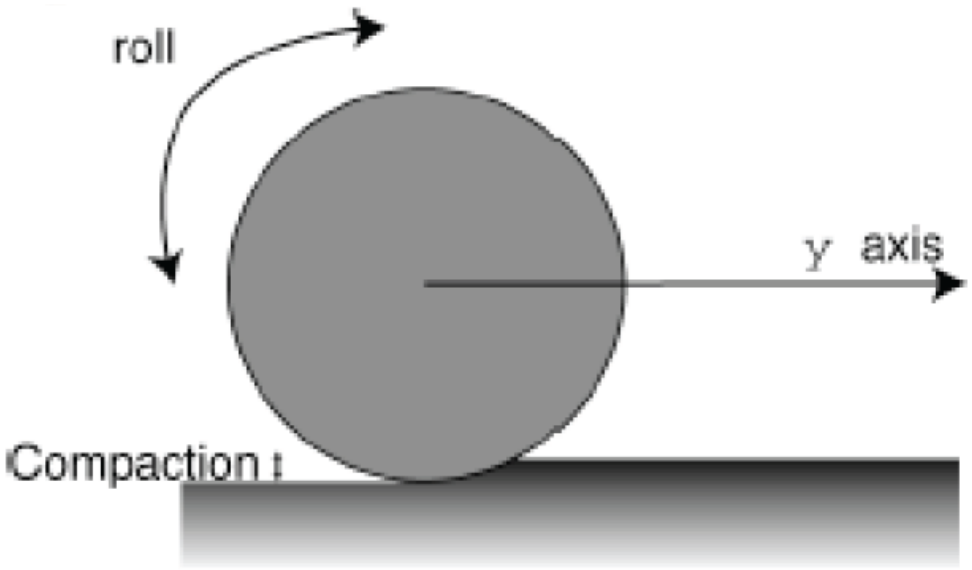
Kinematics

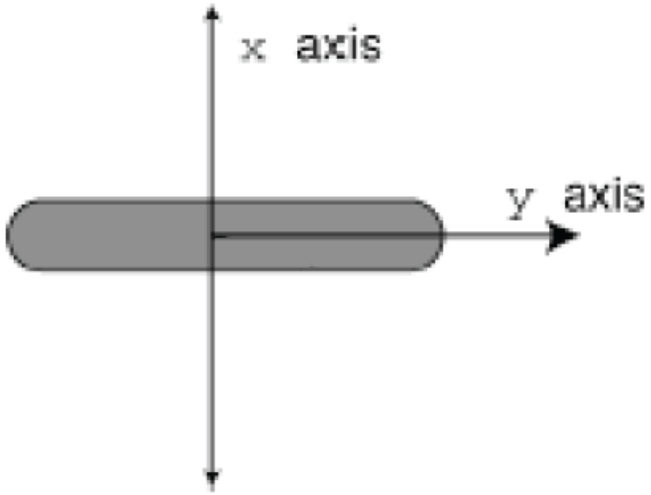
- forward kinematics:
  - given the link lengths and joint angles compute the position and orientation of the gripper relative to the base
    - for a serial manipulator there is only one solution
- inverse kinematics:
  - given the position (and possibly the orientation) of the gripper and the dimensions of the links, what are the joint variables?
    - for a serial manipulator there is often more than one mathematical solution

Wheeled Mobile Robots

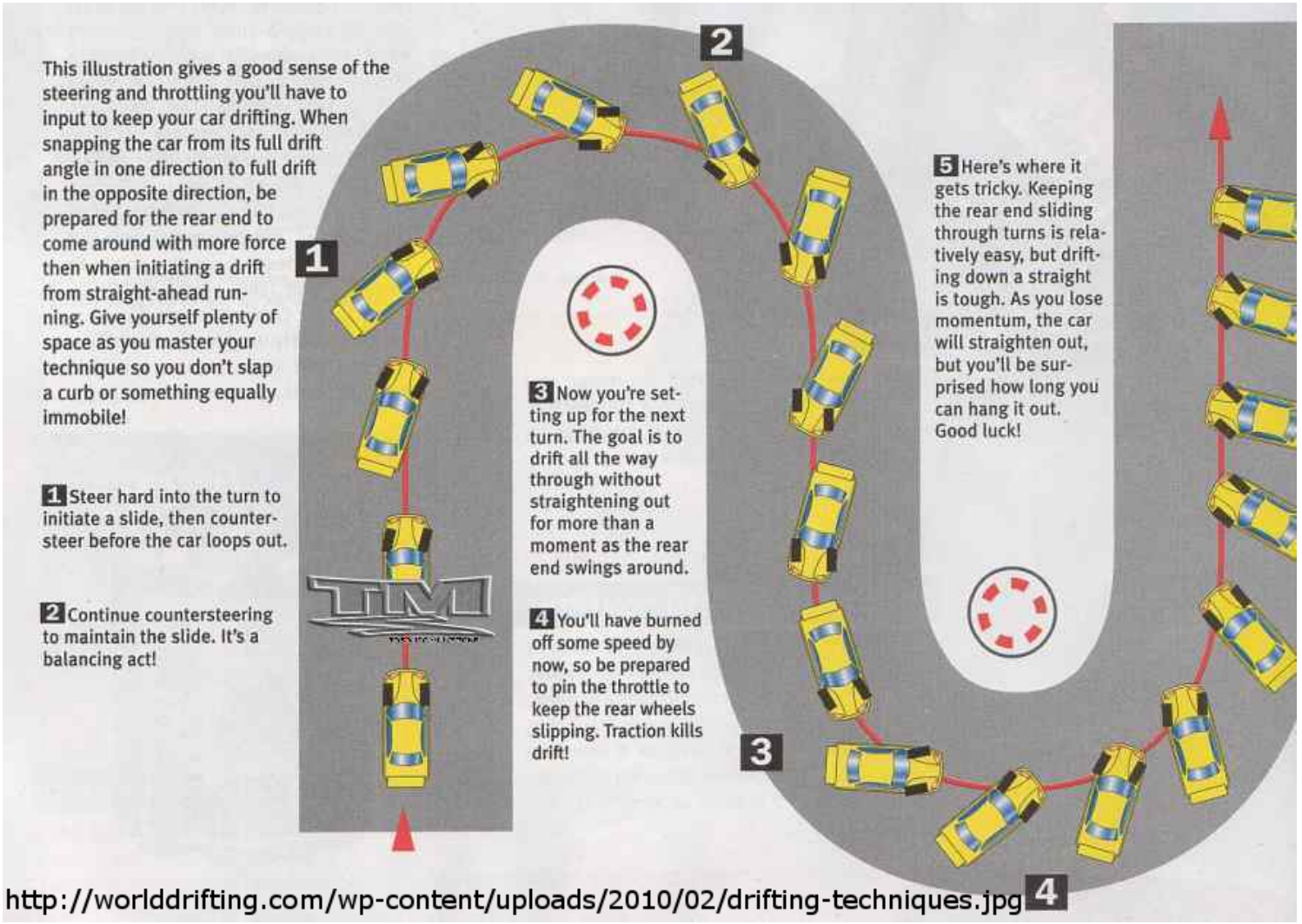
- robot can have one or more wheels that can provide
  - steering (directional control)
  - power (exert a force against the ground)
- an ideal wheel is
  - perfectly round (perimeter $2\pi r$)
  - moves in the direction perpendicular to its axis

Wheel



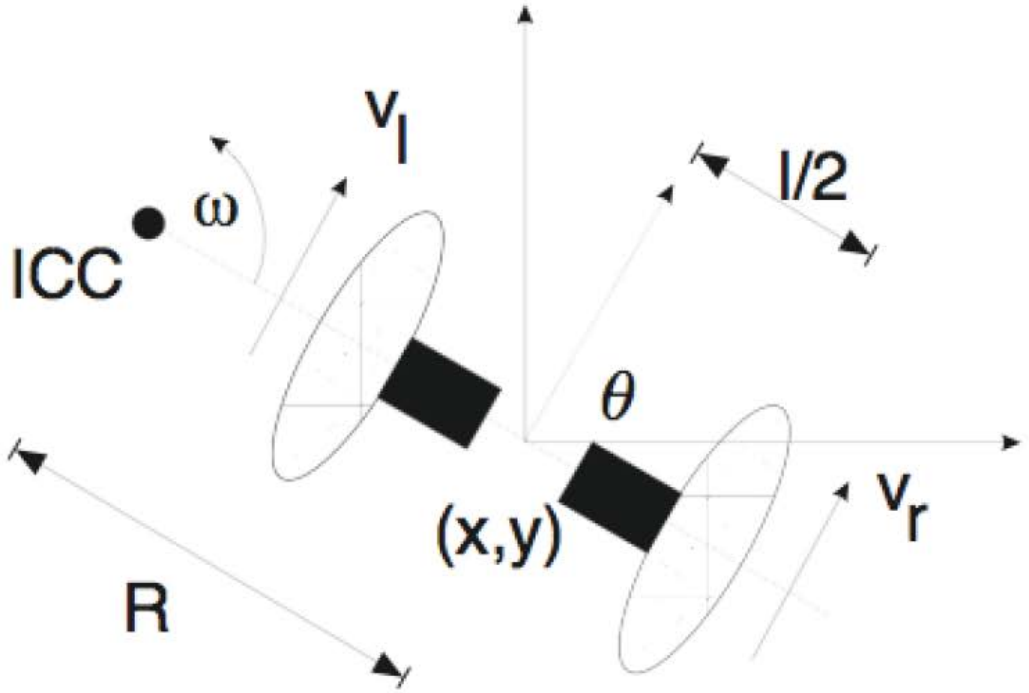


Deviations from Ideal

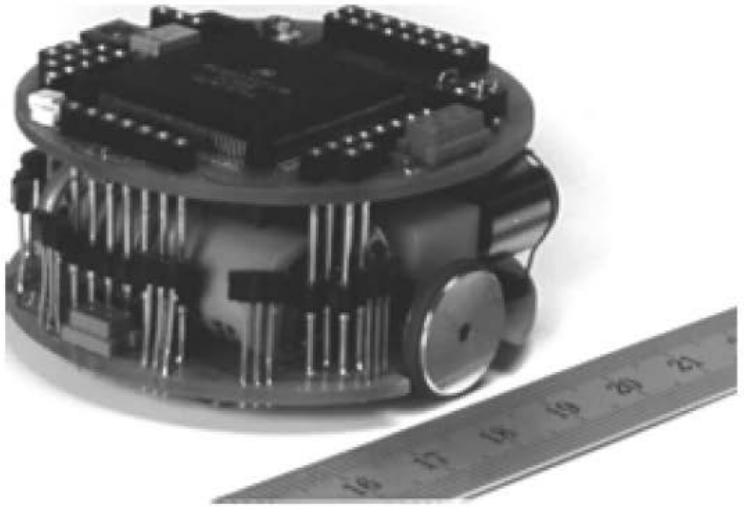


Differential Drive

- two independently driven wheels mounted on a common axis



(a) Differential Drive



(b) Khepera Robot

Forward Kinematics

- for a robot starting with pose $[0 \;\; 0 \;\; 0]^T$ moving with velocity $V(t)$ in a direction $\theta(t)$:

$$x(t) = \int_0^t V(t)\cos(\theta(t))\,dt$$

$$y(t) = \int_0^t V(t)\sin(\theta(t))\,dt$$

$$\theta(t) = \int_0^t \omega(t)\,dt$$

Sensitivity to Wheel Velocity

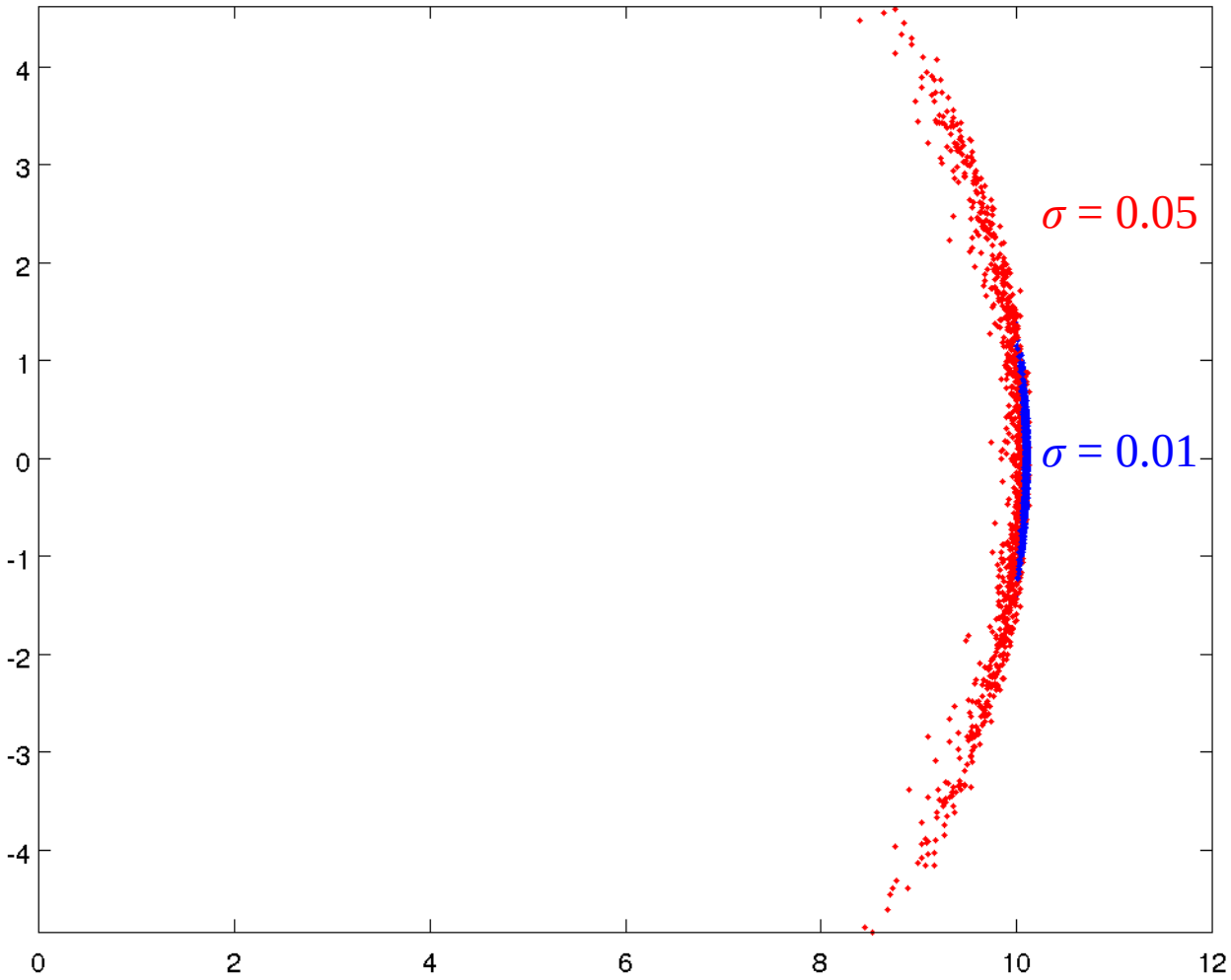
$$v_r(t) = 1 + \mathcal{N}(0, \sigma^2)$$

$$v_\ell(t) = 1 + \mathcal{N}(0, \sigma^2)$$

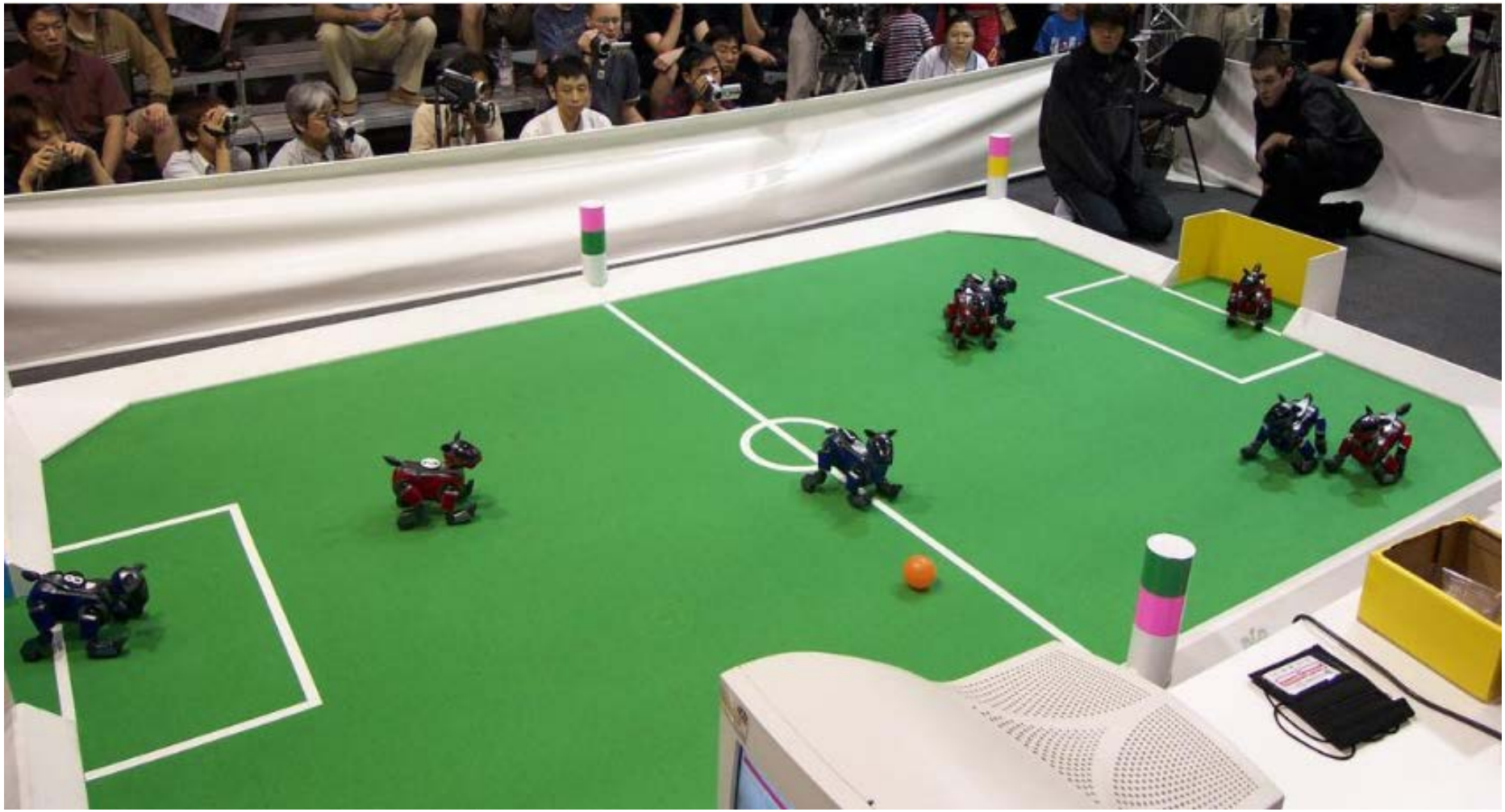
$$\theta(0) = 0$$

$$t = 0 \ldots 10$$

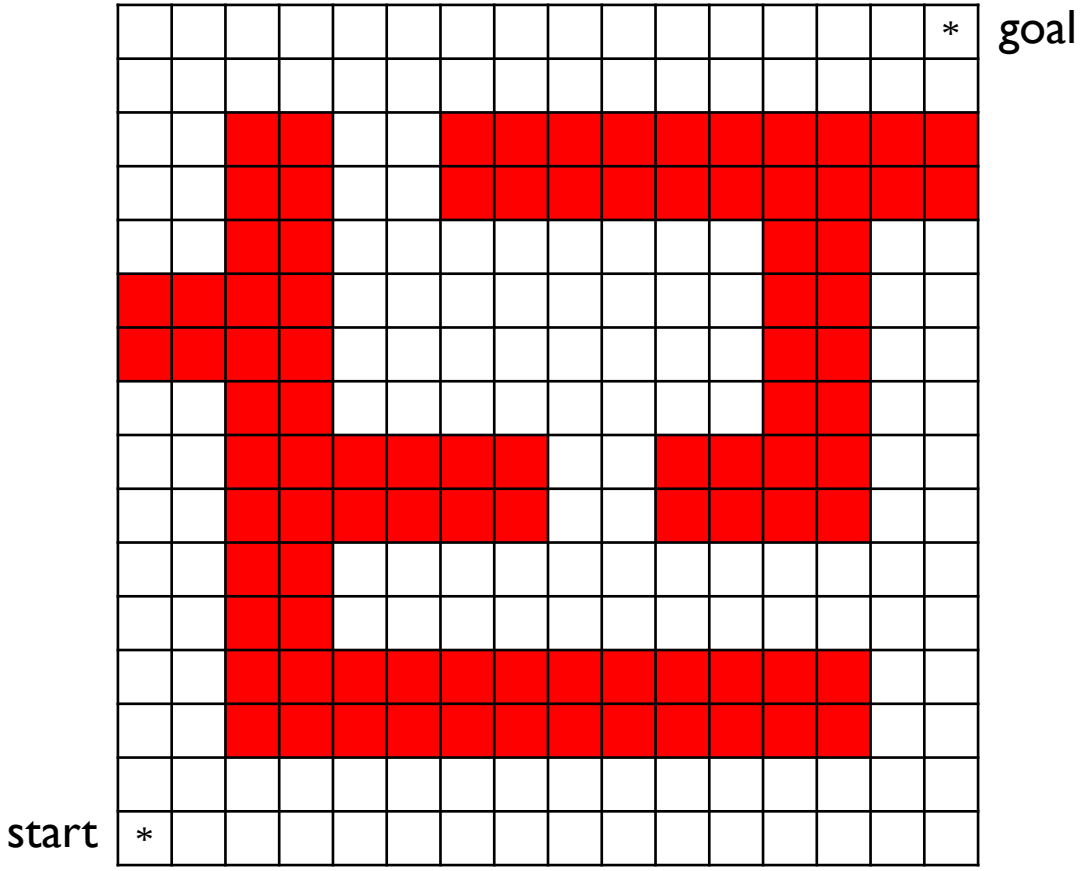
$$\ell = 0.2$$



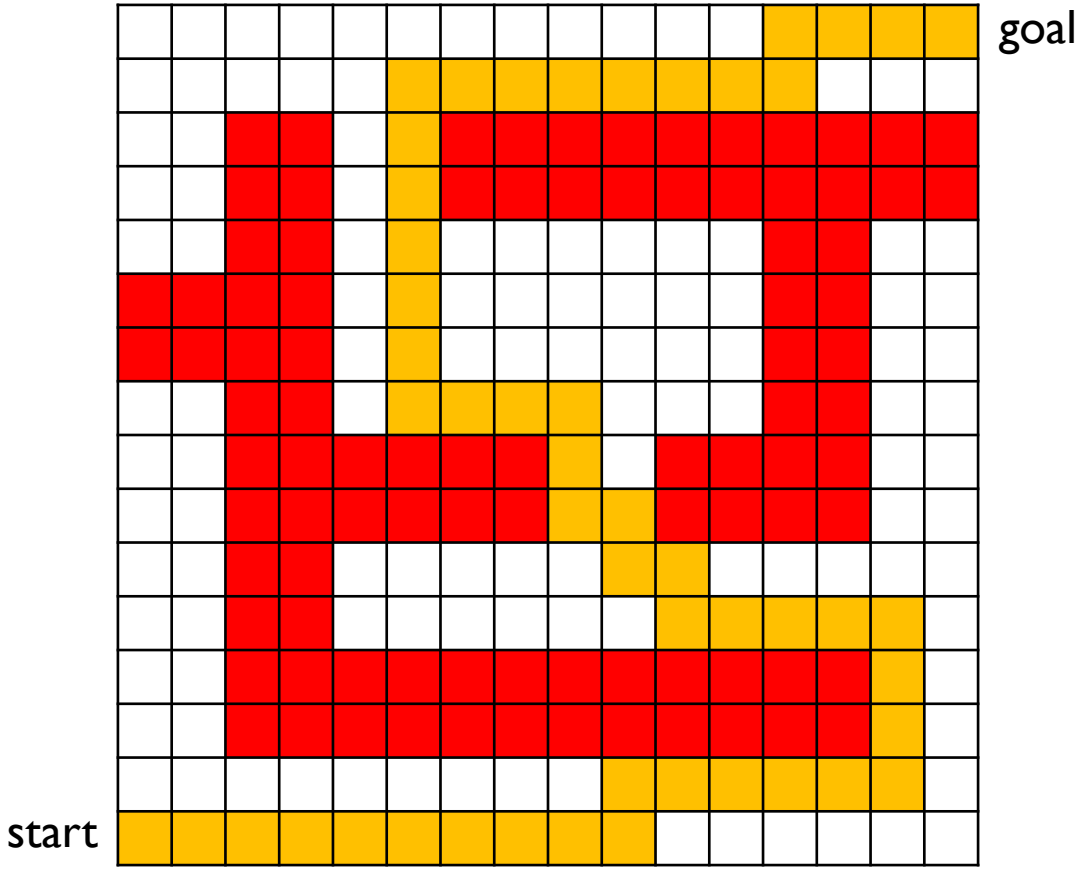
Localization using Landmarks: RoboSoccer



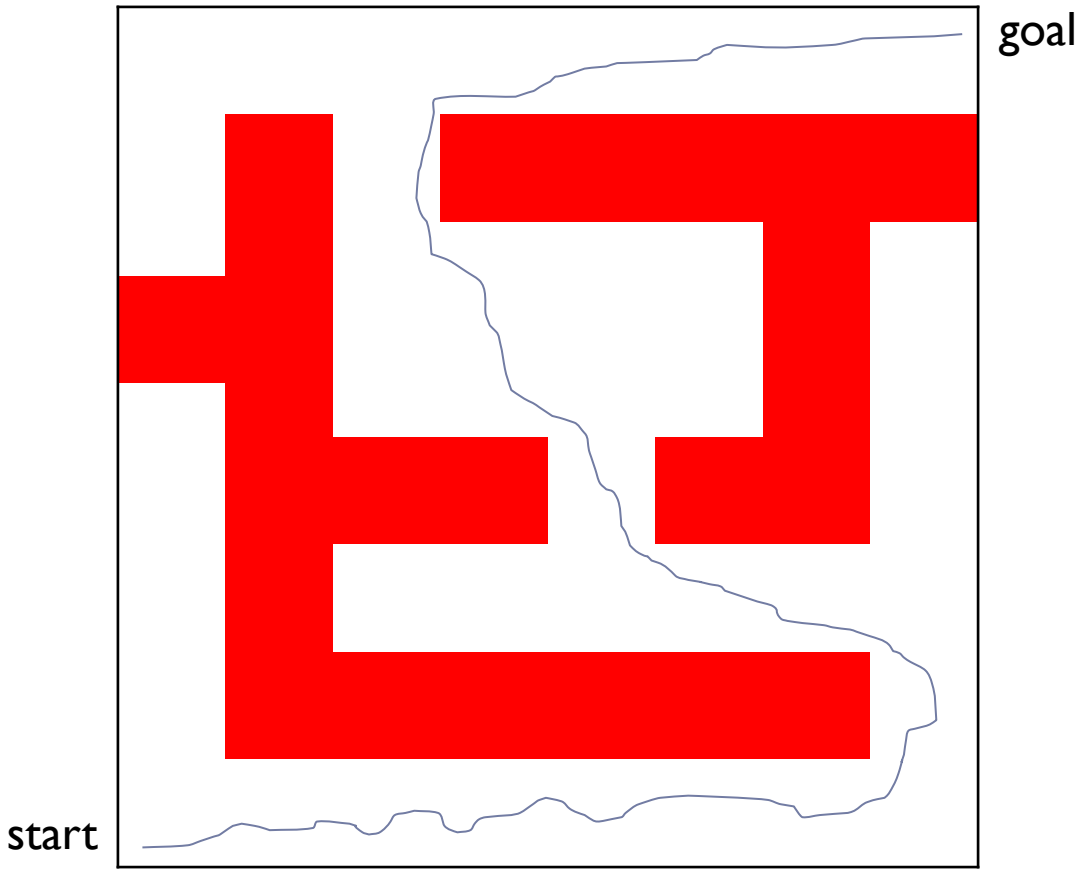
Maps



Path Finding



Localization

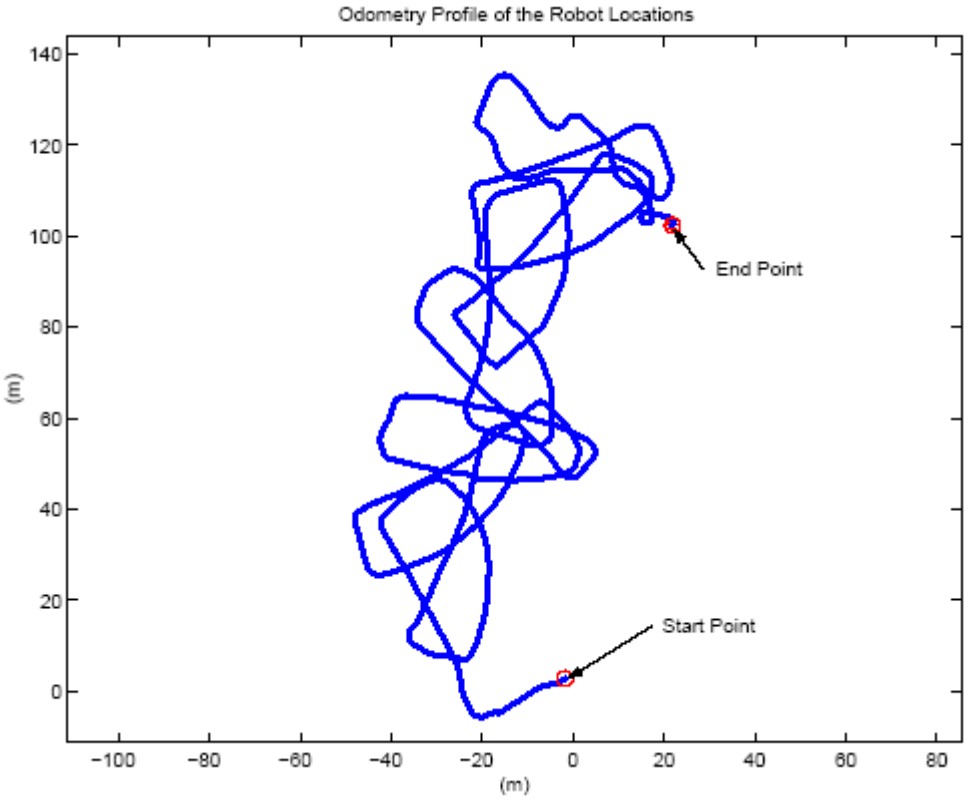


EKF SLAM Application

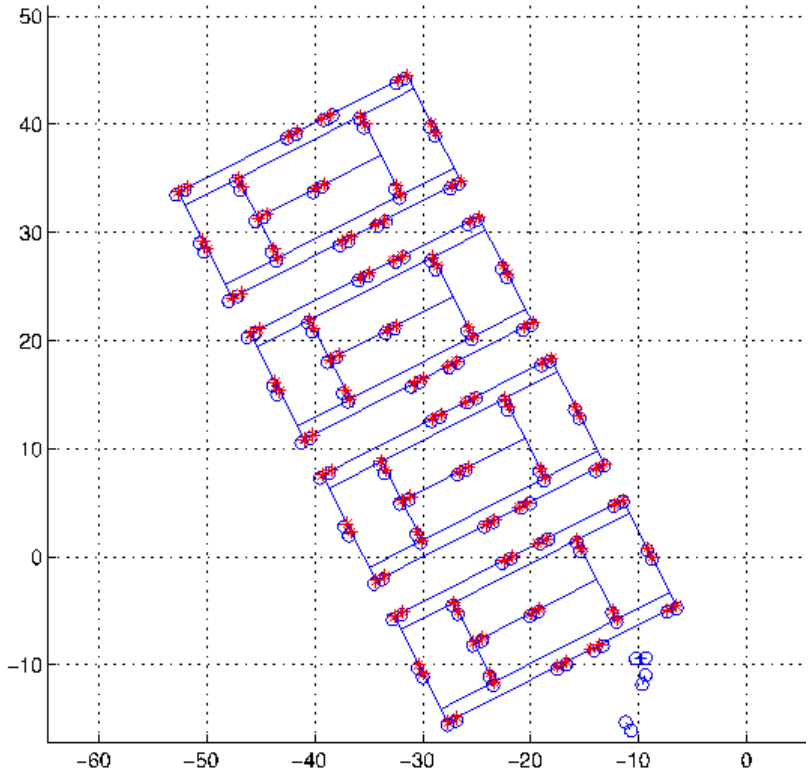
www.probabilistic-robotics.org

[MIT B21, courtesy by John Leonard]

EKF SLAM Application



raw odometry



estimated trajectory

www.probabilistic-robotics.org

[courtesy by John Leonard]