# CSE 276A
# Introduction to Robotics

- Henrik I Christensen



## Welcome

- Lecturer / TAs
- What is a robot?
- A bit of history
- Example use-cases
- Course content



## Lecturer

- Henrik I Christensen
- Professor @ CSE
- Director of Robotics - cri.ucsd.edu
- Theme: “Real Robots for Real Applications”
- Research: Autonomous Driving & Home Robots
- History: first autonomous vacuum cleaner, numerous robots in industry use today
- Spin-offs: Robust.AI, Robo-Global, SMC-II, …



## TAs

- Seth Farrell - swfarrel@ucsd.edu
- Narayan Elavathur Ranganatha (Naru) nelavathurranganatha@ucsd.edu

- Office Hours to be decided

# Lectures

- Tuesday & Thursday 3:30-4:50
- All lectures audio pod-cast and available on canvas
- All material on canvas

- Any and all feedback, … is most welcome



# What is a robot?

- A goal oriented machine that can sense, plan and act



# Characteristics of robots

- Consistent
- Accurate
- Reliable

- Do things that people
  - can't do
    - space, deep sea
  - won't do
    - boring, dull
  - shouldn't do
    - dangerous, unhealthy, risky



# A bit of background and history

Why do we call them robots?



# Robot: the word

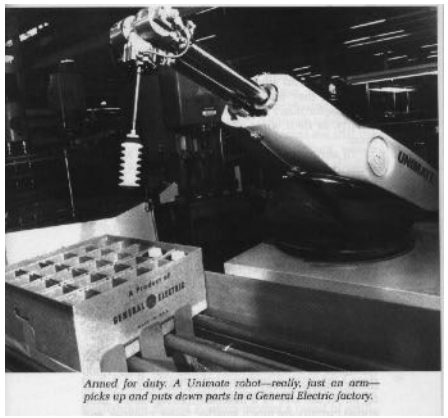

- In 1921, the Czech author Karel Capek produced his best known work, the play *R.U.R. (Rossum's Universal Robots)*, which featured machines created to simulate human beings.
- The term "*robot*" was derived from the Czech word *robota*, meaning "work", "forced workers" or "slaves."
- His robots eventually rebelled against their creators, ran amok, and tried to wipe out the human race.

Karel Čapek



**1921**

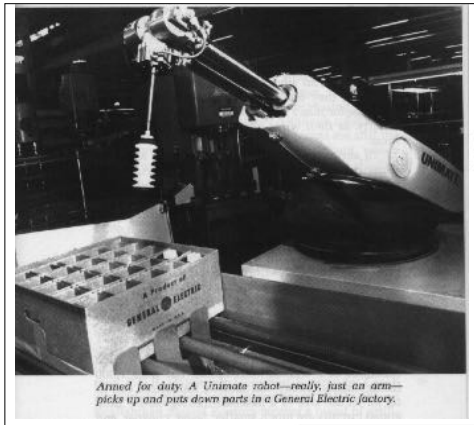
# Joe Engleberger (1925-2015)



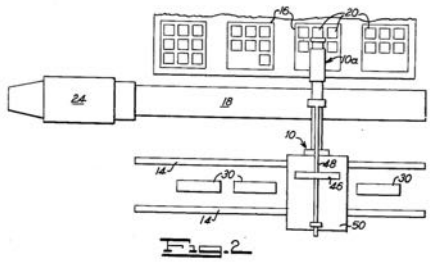
*Armed for duty. A Unimate robot—really, just an arm—picks up and puts down parts in a General Electric factory.*

Unimation Inc. 1956



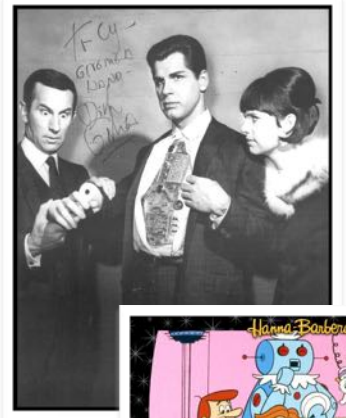


*Armed for duty. A Unimate robot—really, just an arm—picks up and puts down parts in a General Electric factory.*





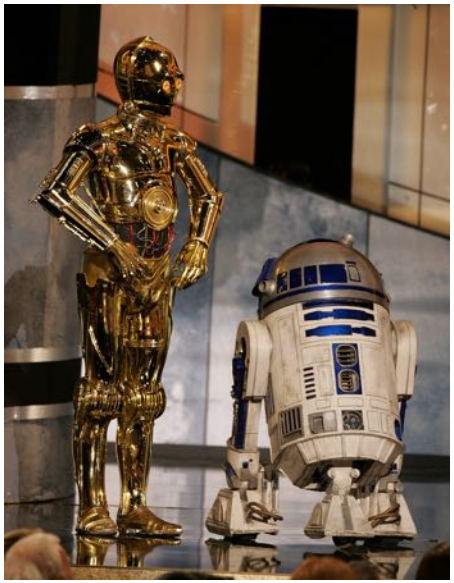

**1956**




Hanna-Barbera







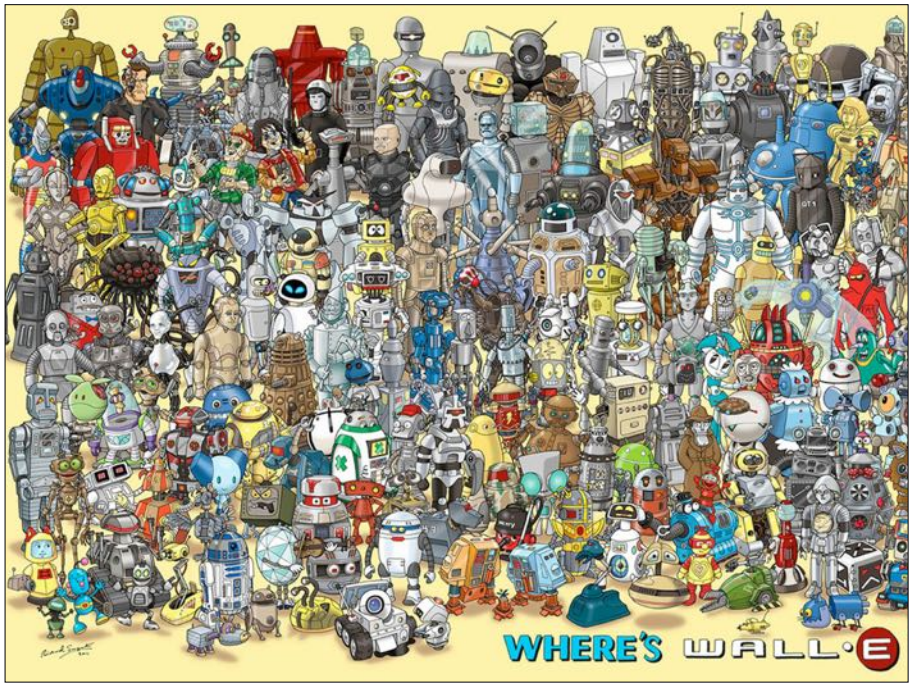


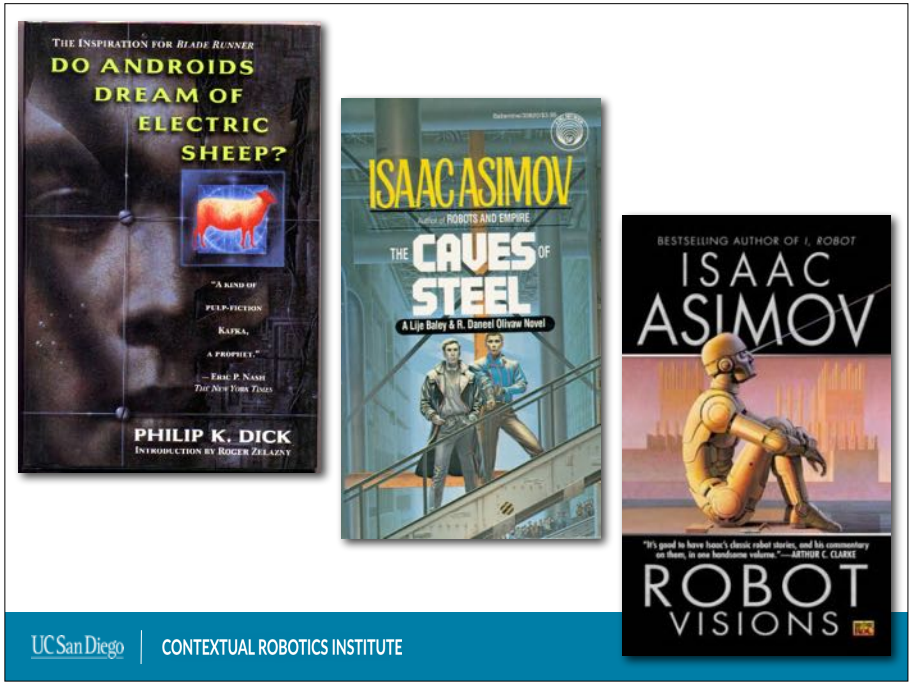

FRITZ LANG'S CLASSIC
METROPOLIS
FROM OUT OF SPACE.... A WARNING AND AN ULTIMATUM!
THE DAY THE EARTH STOOD STILL
MICHAEL RENNIE · PATRICIA NEAL · HUGH MARLOWE
MGM PRESENTS
FORBIDDEN PLANET
AMAZING!
WALTER PIDGEON · ANNE FRANCIS · LESLIE NIELSEN
ROBBY THE ROBOT
CINEMASCOPE COLOR



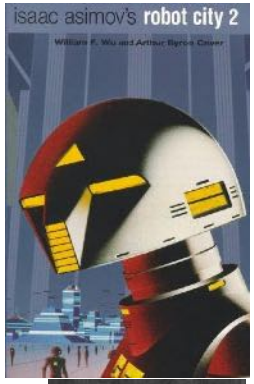

WILL SMITH
I, ROBOT
ALL-ACCESS COLLECTOR'S EDITION
SCHWARZENEGGER
PART MAN, PART MACHINE, ALL COP.
WALL·E
FOREVER YOUNG
SHORT CIRCUIT
PG




WHERE'S WALL·E


THE INSPIRATION FOR BLADE RUNNER
DO ANDROIDS DREAM OF ELECTRIC SHEEP?
PHILIP K. DICK
ISAAC ASIMOV
THE CAVES OF STEEL
A Lije Baley & R. Daneel Olivaw Novel
BESTSELLING AUTHOR OF I, ROBOT
ISAAC ASIMOV
ROBOT VISIONS

# The Laws of Robotics



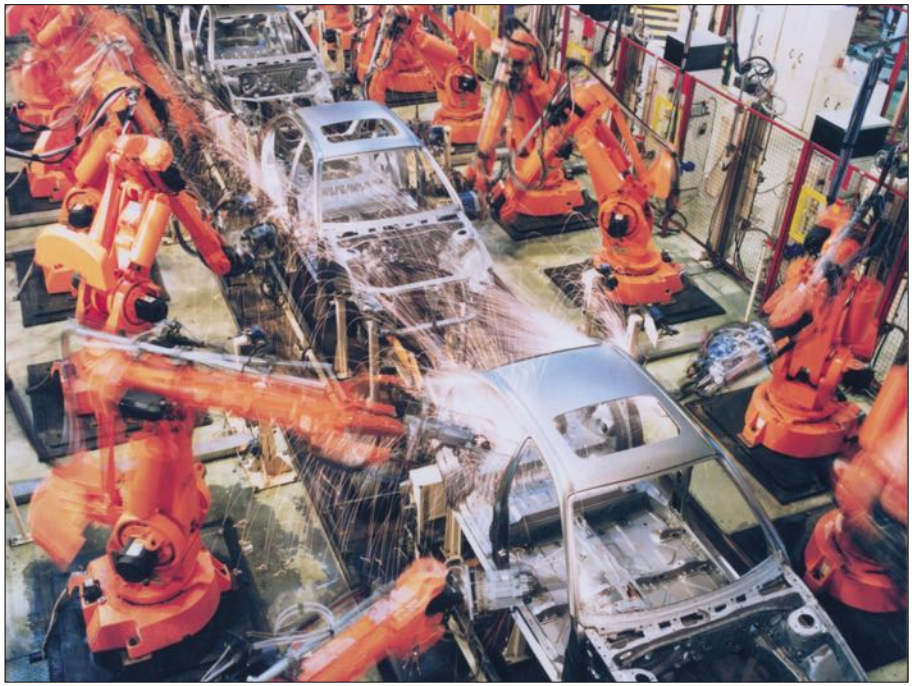

- **First Law:** A robot may not injure a human being, or, through inaction, allow a human being to come to harm.
- **Second Law:** A robot must obey orders given it by human beings, except where such orders would conflict with the First Law.
- **Third Law:** A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

1940-1992



# What do you think of as a robot?

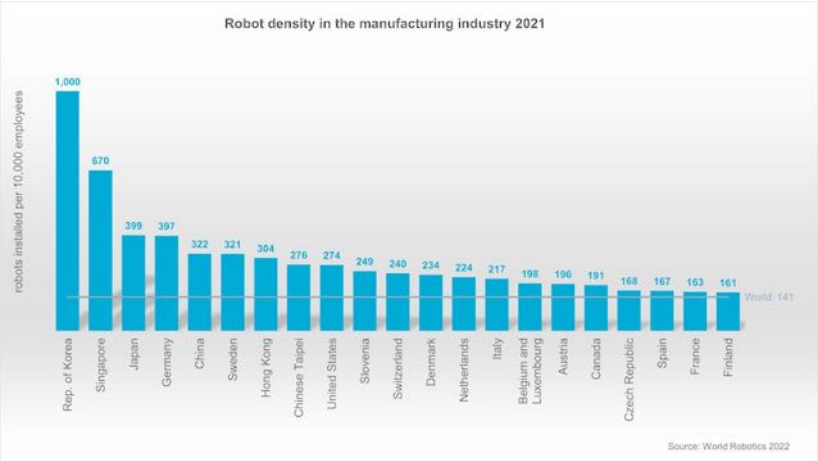




# How big is the industry penetration?

- How many robots are in use in industry / worker
- Say NN robots / 10,000 workers
  - In automotive
  - In general
  - In US
  - In China?

# Robot Density




SRC: World Robotics 2021, IFR, Germany

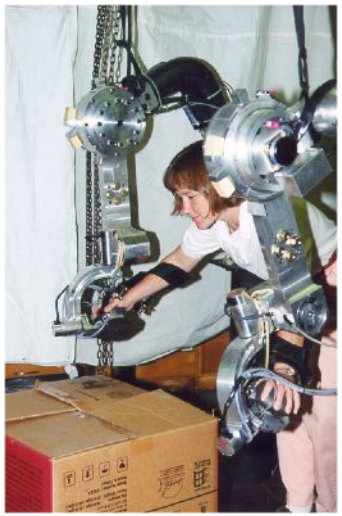


# KIVA - Example



Consider robots as
**extenders** of human ability

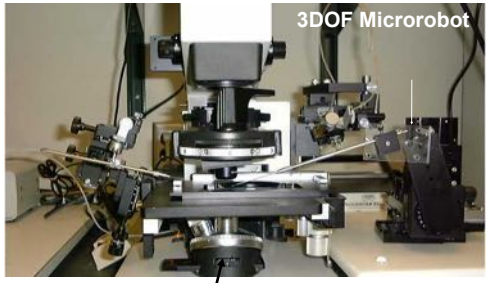
# Stronger



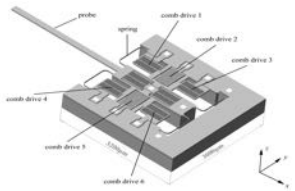


# Put us "inside" people

# Let us handle tiny things




Vision Feedback

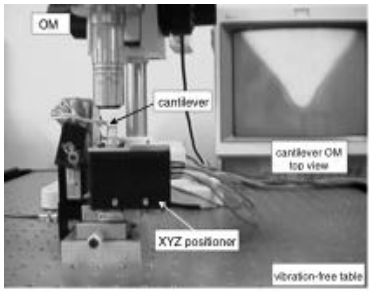


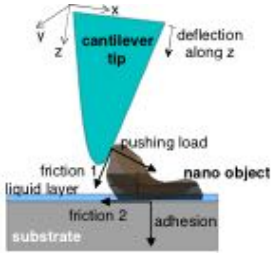
Force Feedback

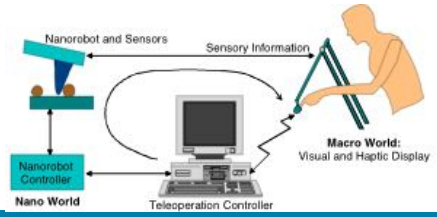
IRIS Institute of Robotics and Intelligent Systems
Swiss Federal Institute of Technology (ETH), Zürich



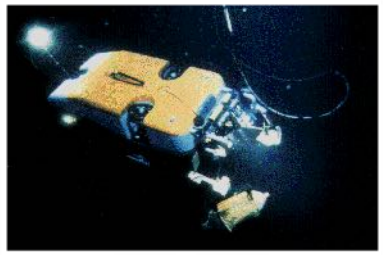
# and even nano things

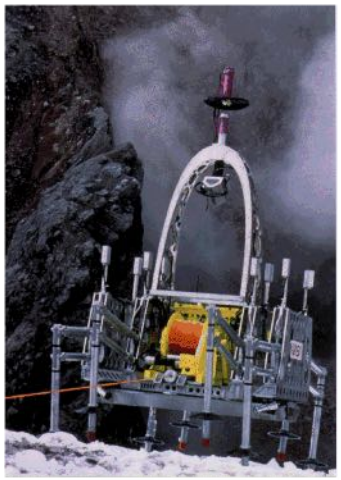


# Extending our reach

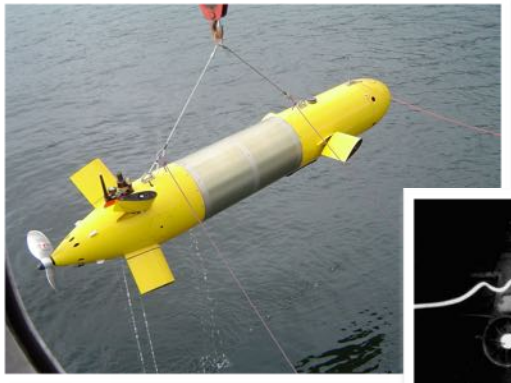






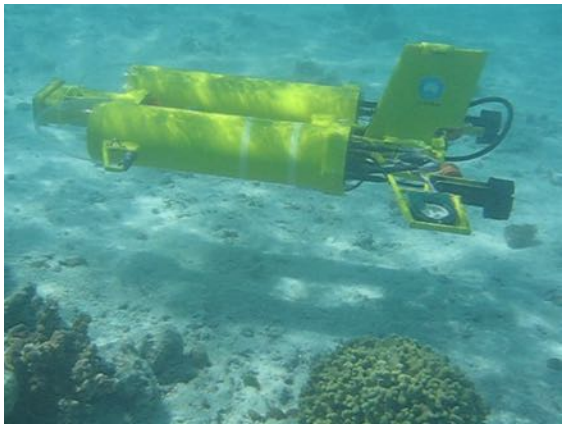
# Extending exploration








# Robots underwater



Courtesy of CSIRO

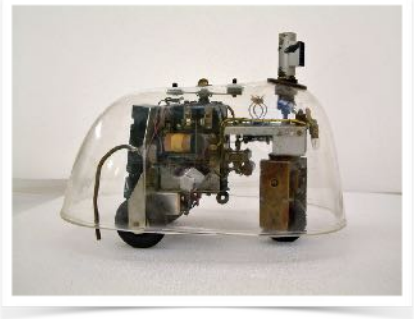
# Autonomous Boats - Seahunter



Courtesy of CSIRO



# Mobile robots



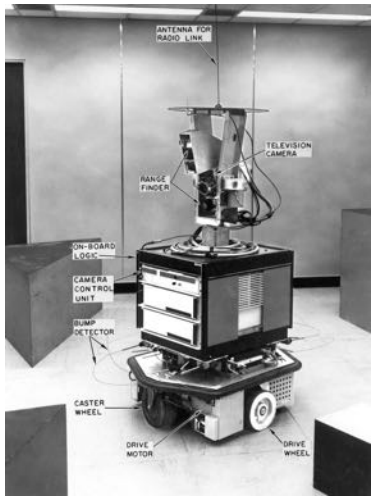
A light seeking "tortoise".



# Mobility

Morovec's Stanford rover

1964



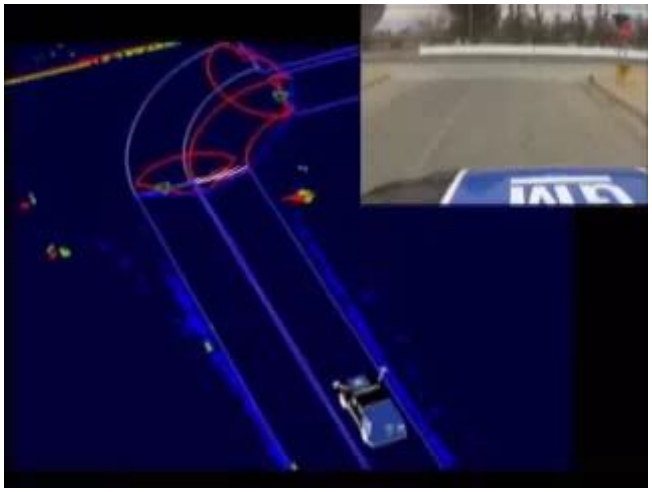

SRI's Shakey

# Robots that drive



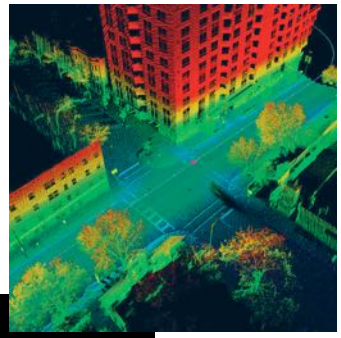



# robot's eye view





# The Google car

# Are we in for a revolution?

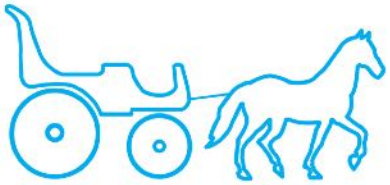
1898

1915



11.8mph

Average speed in London 2016



17mph

Average speed in London 1916



Average Commute Speed in 2015

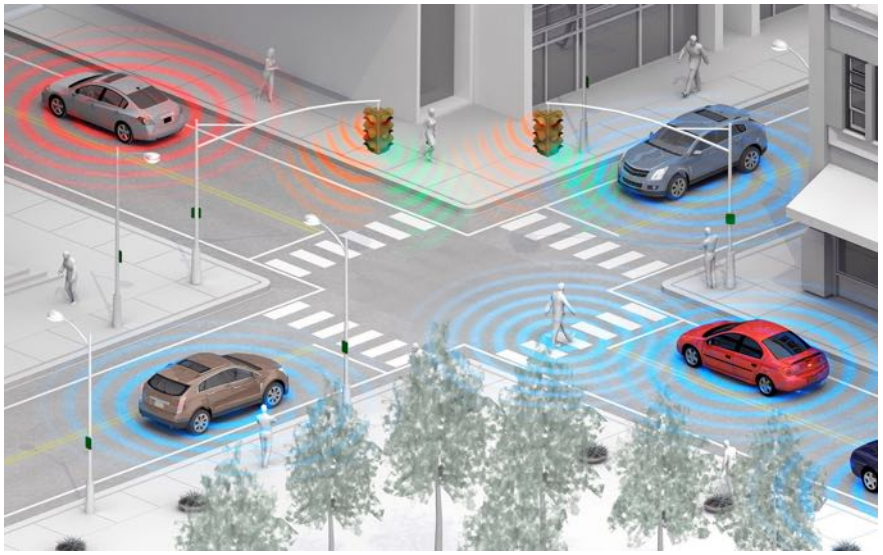
9.6mph

11.8mph

20.5mph



# Driverless cars





## A small challenge



## How safe is this?



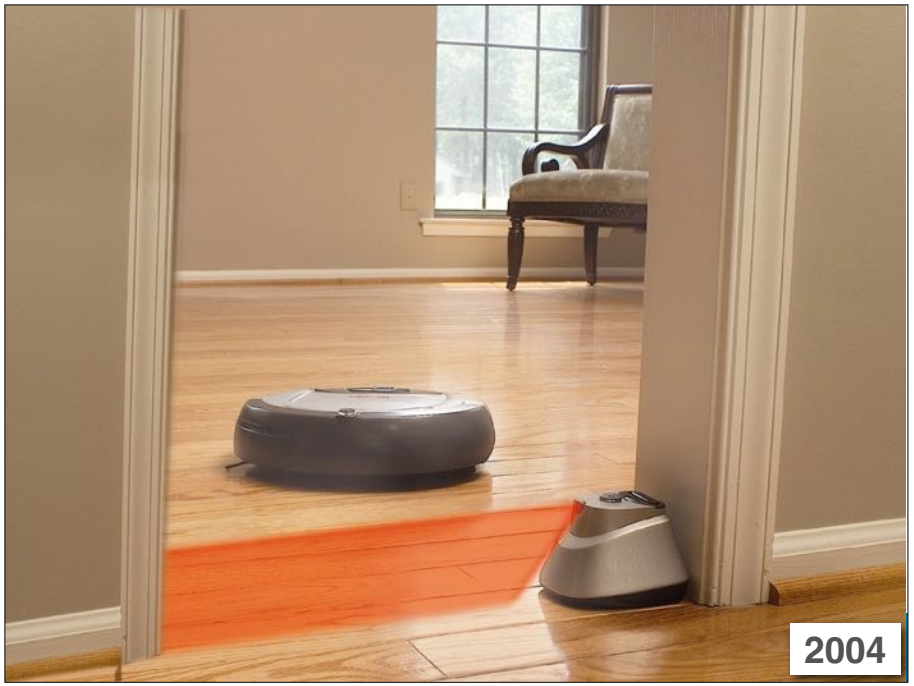
## Autonomous Driving @ UCSD

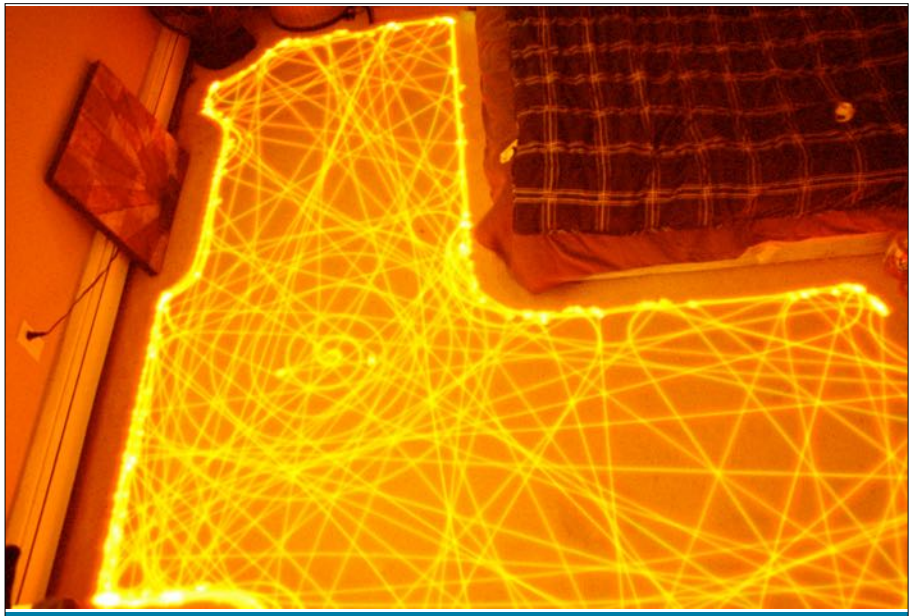
# Spot

- Now a dog like commercial platform

- Very impressive performance







## Before Roomba

(Grinter & Christensen, 2009)

Two weeks after



Six months after



# CERO System

- Mobile platform
- Box for deliveries
- A simple user interface
- Design is crucial

(Eklundh & Christensen, 2006)



# CERO Interface

(Eklundh & Christensen, 2006)





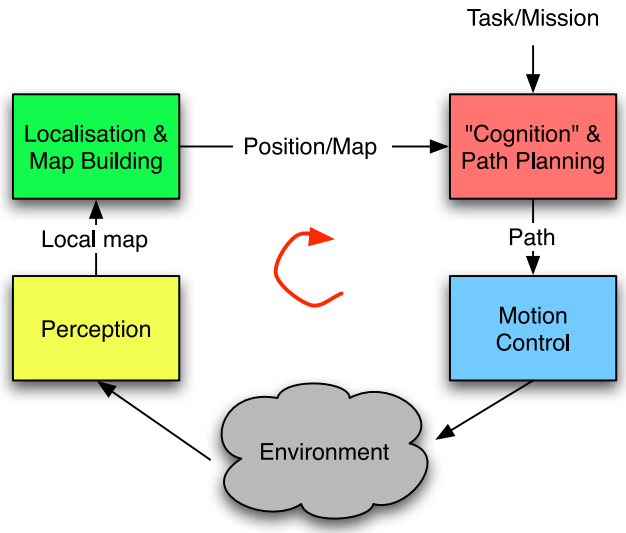


Questions?



# CSE276A Class Structure

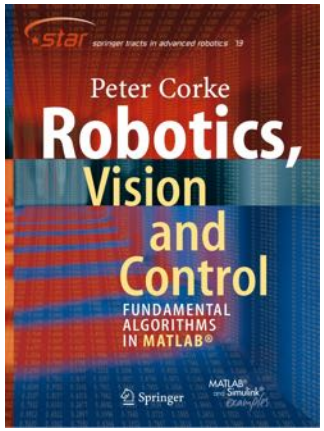
- Introduction
- Kinematics / Mobile Robots
- Sensing / Estimation / GPS
- Image Processing
- Mapping
- Visual Tracking / Servoing
- Geometric Spaces / Path Planning
- Grasping and Hands
- Human Robot Interaction
- Perspective






# Class Material

- Robotics, Vision and Control, P. Corke, Springer Verlag (2011, 2017, & 2023)
  - Most material adopted from the book
  - Will provide fairly comprehensive lecture notes
  - Most programming in Python / C++
  - ROS - Robot Operating System






# Class Material

- Qualcomm RB5 Platform
- MegaBot mBot
- Power Cell
- Robot Operating System

- 1-2 students / robot



# Homework

- A new homework every two weeks
  1. Drive the robot to 5 way points
  2. Use vision to drive the robot to a landmark
  3. Build a map of the environments
  4. Navigate within your map
  5. Integrate to achieve a Roomba like system!
- THE END

# Schedule

| Date | Week | Topic | Corke | Quiz | Assignm |
|---|---|---|---|---|---|
| Sep 28 | 1 | Introduction to Robotics | Chapter 1 | | |
| Oct 3 | 2 | Space and Time | Chapter 2+3 | | |
| Oct 5 | 2 | Robot Operating Systems (part b) | | | |
| Oct 10 | 3 | Mobile Robotics / Test system for class | Chapter 4 | | |
| Oct 12 | 3 | Sensing / GNSS | | | |
| Oct 17 | 4 | Images | Chapters 10 | | A1: Basic motion |
| Oct 19 | 4 | Image Processing | Chap 12 and 13 | | |
| Oct 24 | 5 | Visual Servoing | Chapter 15 | | |
| Oct 26 | 5 | Kalman Filtering SLAM | Chapter 6 | | |
| Oct 31 | 6 | Localization | Chapter 6 | | A2: Closed loop/td> |
| Nov 2 | 6 | No Class | | | |
| Nov 7 | 7 | KALMAN / SLAM | | | |
| Nov 9 | 7 | Extended Kalman Filter | | | |
| Nov 14 | 8 | Planning - Geometry / Sampling based methods | | | A3: Localization |
| Nov 16 | 8 | Grasping & Hands | Chapter 8 | | |
| Nov 21 | 9 | Human Robot Interaction | | | |
| Nov 23 | 9 | No lecture - Thanksgiving | | | |
| Nov 28 | 10 | Architectures | | | A4: Planning |
| Nov 30 | 10 | No Lecture | | | |
| Dec 5 | 11 | Robot Ethics | | | |
| Dec 7 | 11 | Wrap-up | | | A5: Coverage Robot |



# Teaching team

- Lecturer:
  - Henrik I Christensen - hichristensen@ucsd.edu
- TA:
  - Seth Farrell - swfarrel@ucsd.edu
  - Narayan Elavathur Ranganatha (Naru) nelavathurranganatha@ucsd.edu

UC San Diego | CONTEXTUAL ROBOTICS INSTITUTE
JACOBS SCHOOL OF ENGINEERING
DIVISION OF SOCIAL SCIENCES

# Questions?

UC San Diego | CONTEXTUAL ROBOTICS INSTITUTE
JACOBS SCHOOL OF ENGINEERING
DIVISION OF SOCIAL SCIENCES