Disclaimer

These slides are intended as presentation aids for the lecture. They contain information that would otherwise be to difficult or time-consuming to reproduce on the board. But they are incomplete, not self-explanatory, and are not always used in the order they appear in this presentation. As a result, these slides should not be used as a script for this course. I recommend you take notes during class, maybe on the slides themselves. It has been shown that taking notes improves learning success.

Robotics

TU Berlin
Oliver Brock

Administrative Information

- **Bulletin board (Diskussionsforum) on ISIS2**
  You are expected to read this before course meetings (lecture, exercise, demo).
- Slides will be distributed via ISIS
- rbo.lehre@robotics.tu-berlin.de
- Grade: 50% exercises, 50% exam
  non-linear mapping from points in the course to the points in the Notenschlüssel might be possible
- If somebody in your group cheats, the entire group will fail this course (we treat the group as a person)
  Cheating includes using source code not written by your team members specifically for this class. It is your responsibility to ensure that no cheating has occurred on a homework with your name on it.
- Binding registration by **November 30 on QISPOS**
  (opens October 23)
- No late registrations will be accepted!

Cheating includes but is not limited to:

- using source code that was
  - written by somebody not in your team, or
  - downloaded from the web, or
  - otherwise not produced by your group members
- plagiarism
- giving non-group members access to your code or problem solutions

  (our staff is okay, of course)

Team Work

- We assign teams for each homework
  - Give everybody a fair chance
  - Learn from your team members
  - Learn to deal with team dynamics
  - You are free to discuss across teams, but please do not cheat!
  - Use Doodle!
- Deal with team dynamics as soon as possible
  - There will be problems!
  - The earlier you raise them, the easier it is to address them (if you don't do this, experience says that somebody will fail the class)
  - Nobody will have a disadvantage if issues are brought up
  - We are here to help you (facilitate, mediate, change groups, split groups, etc.)
- Please make sure that **everything** your group hands in was produced exclusively by your group members, not by anybody else

General Pattern for Exercises

- Assigned on Monday
- Tutorial (Großübung) on Tuesday
- Deadline on Sunday before the next exercise
- Demos on Thu/Fri after deadline

Preliminary Exercise Schedule

0) week 1, **C++** (1 week)
1) week 2, **DH parameters, simulator** (2 weeks)
2) week 4, **Jacobian, trajectories** (2 weeks)
3) week 6, **visual servoing** (3 weeks)
4) week 9, **mapping & localization**
   (4 weeks +2 weeks holiday break)
5) week 13**, motion planning** (3 weeks)

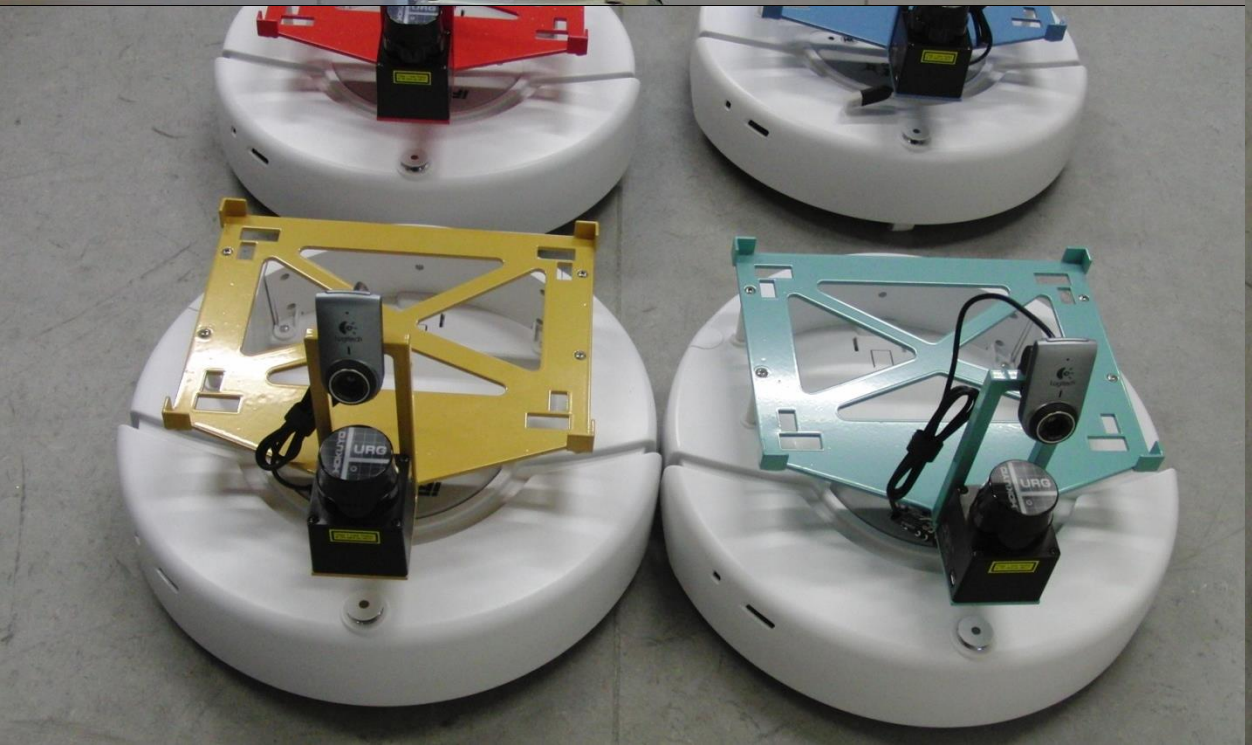
Next Meeting

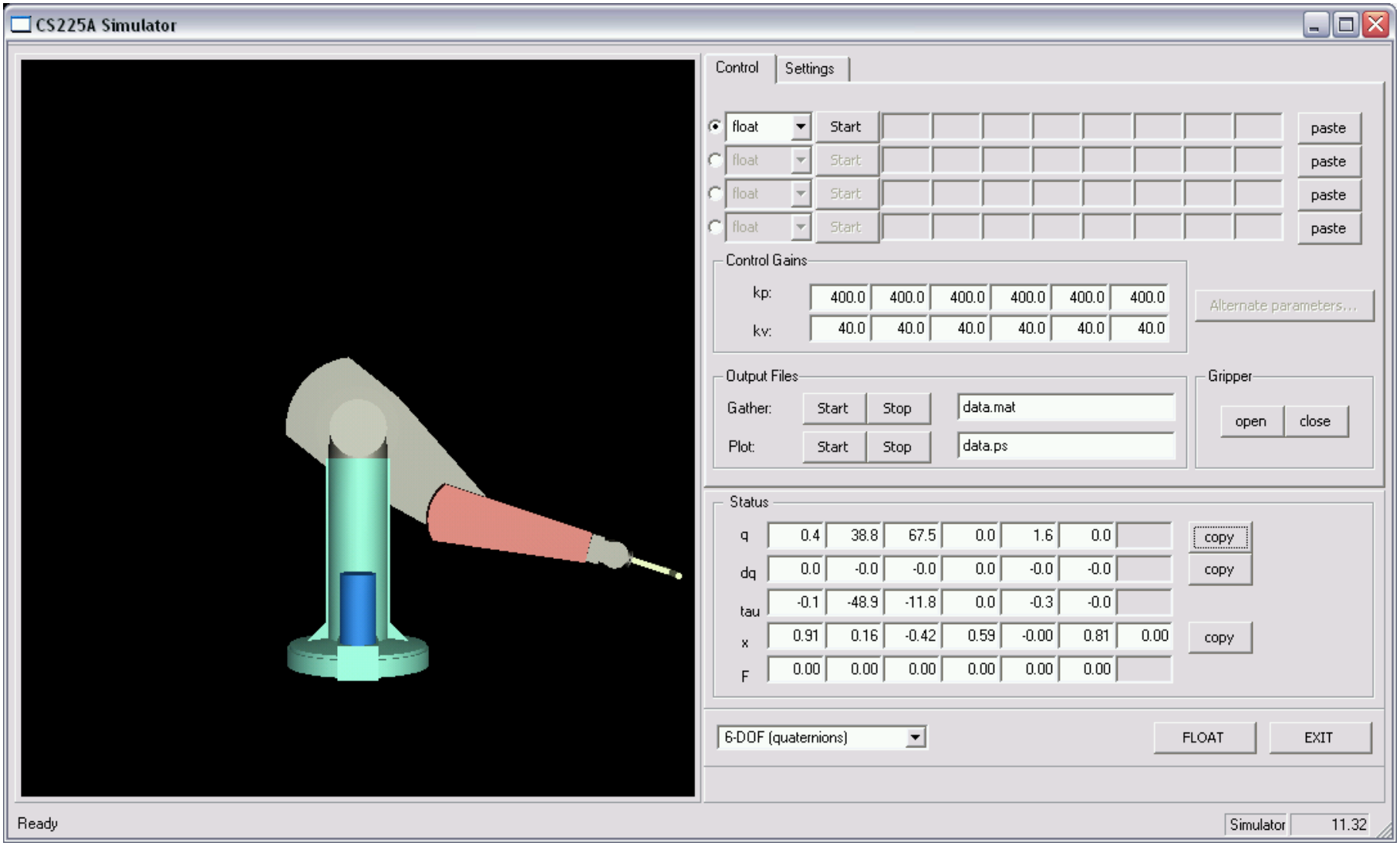
- 1. Tutorial on 16. October 2018 (Tomorrow!)
- Room MA 041 (next door)
- 14 Uhr c.t.
- Content: Orga & C++
- 0. Exercise – Individual work – deadline in one week (21. October)
- You **must** turn in exercise 0 if you want to join this course!

Exercise Demos / Supervised Work

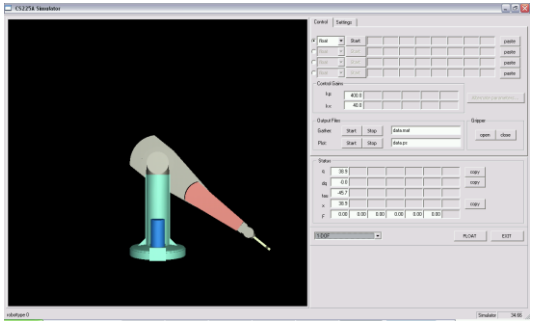
- Thursdays 2 – 4 pm
- Fridays 2 – 4 pm
- Room MAR 5.026
- You get key cards to enter the room
- 10€ deposit (bring to Tutorial of Assignment #1)

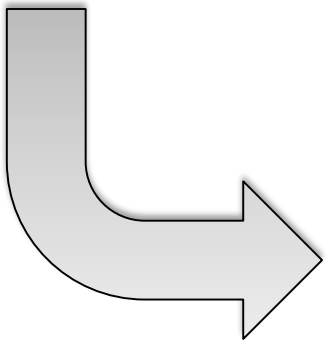

UNIMATE
PUMA 500

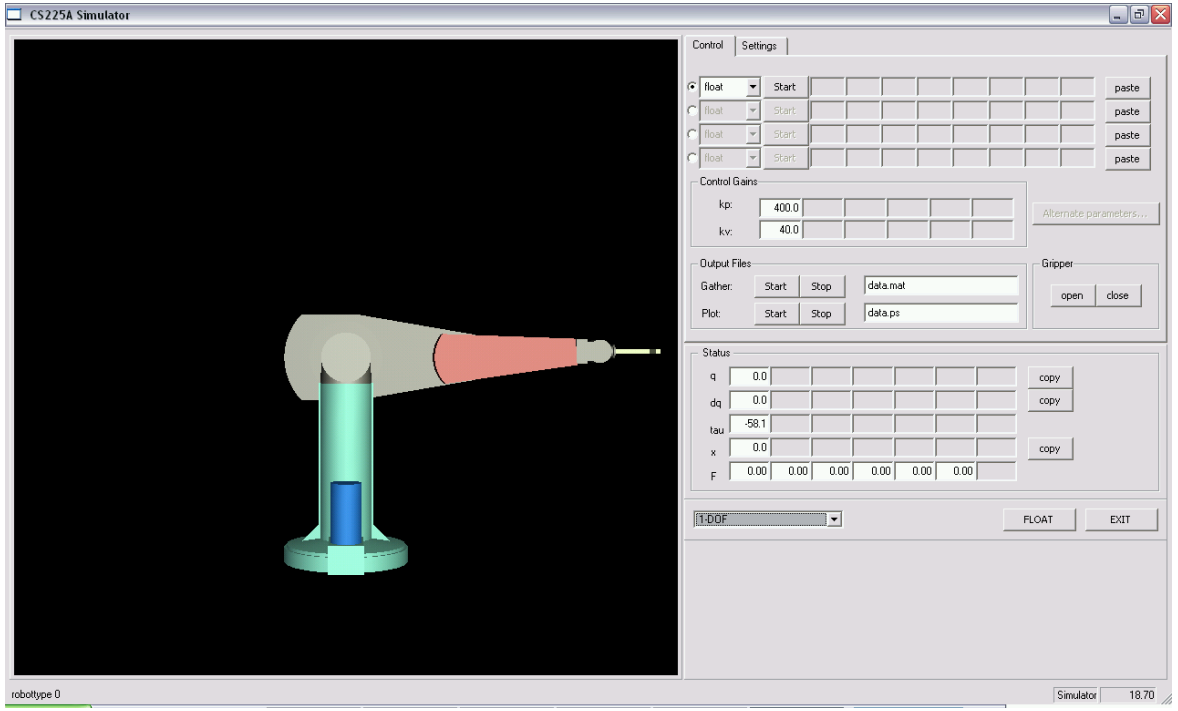



CS225A Simulator
Control
Settings
float
Start
paste
Control Gains
kp:
400.0
kv:
40.0
Alternate parameters...
Output Files
Gather:
Plot:
Stop
data.mat
data.ps
Gripper
open
close
Status
q
dq
tau
x
F
copy
6-DOF (quaternions)
FLOAT
EXIT
Ready
Simulator
11.32

Our Task: Hold Still!



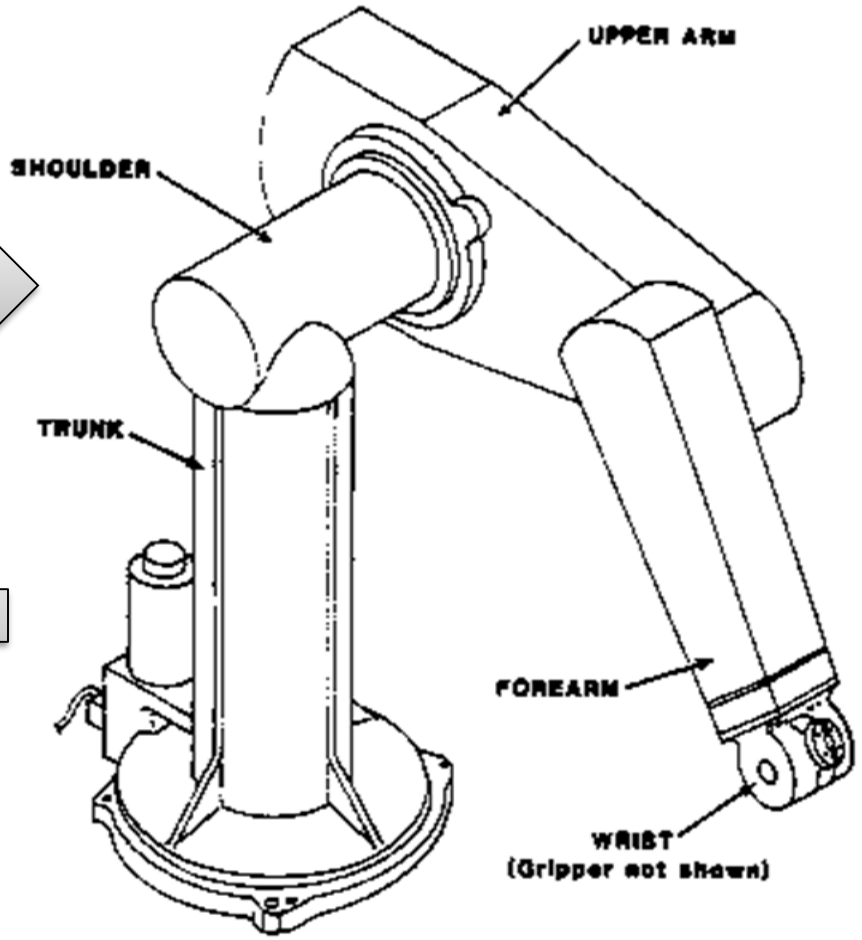




The Interface

torque / force τ (tau)
(really: current)
[Drehmoment, Kraft]

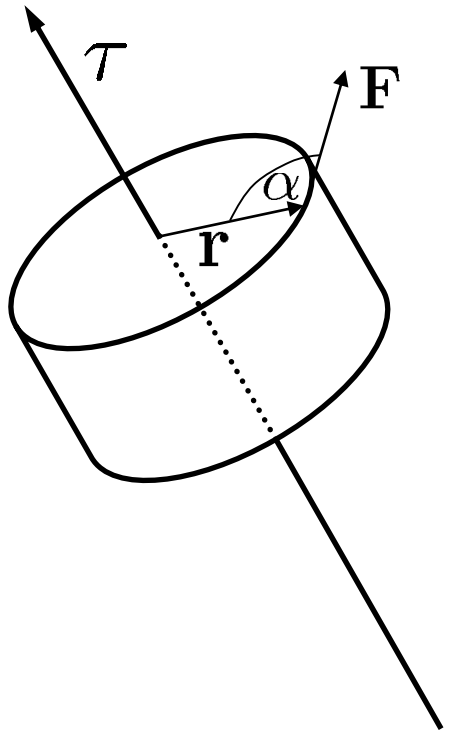
joint positions:
configuration *q*

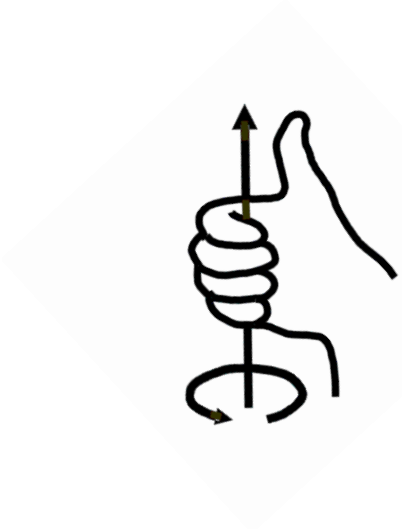


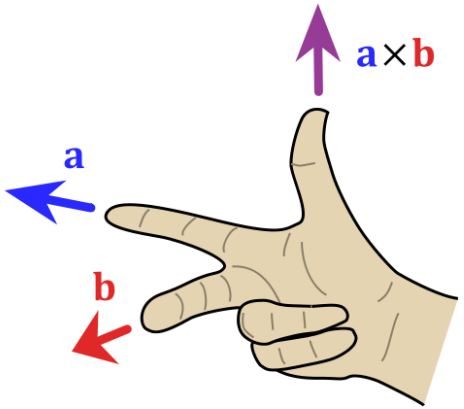
Torque [Drehmoment]

$$\tau = \mathbf{r} \times \mathbf{F}$$

$$\|\tau\| = \|\mathbf{F}\|\|\mathbf{r}\| \sin(\alpha)$$





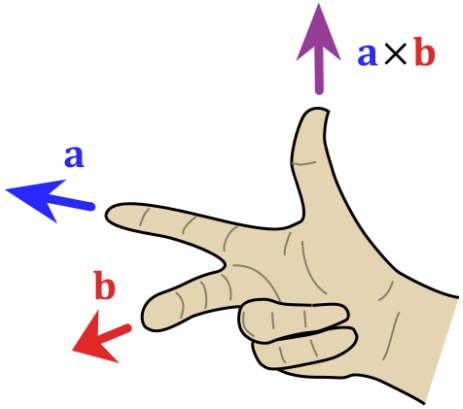


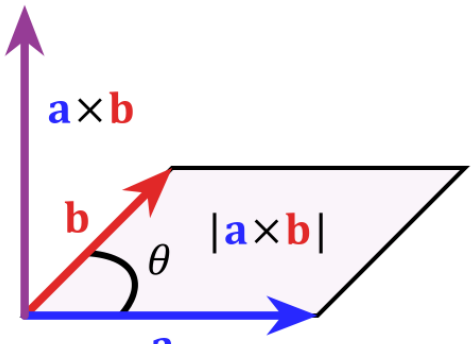
Side Bar: Cross Product

$$\mathbf{a} \times \mathbf{b} = |\mathbf{a}||\mathbf{b}| \sin\theta \, \hat{\mathbf{n}}$$

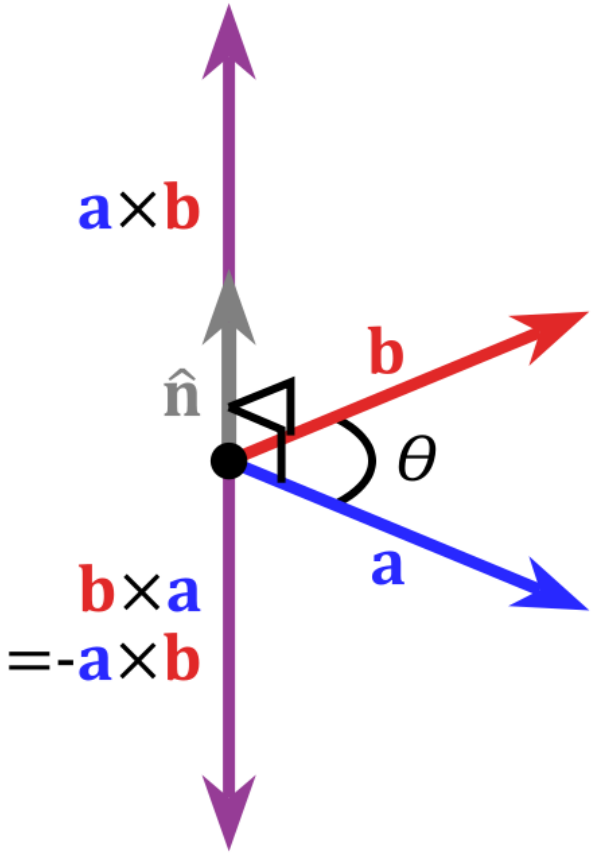
In three dimensions:

$$\mathbf{a} \times \mathbf{b} = \begin{bmatrix} a_y b_z - a_z b_y \\ a_z b_x - a_x b_z \\ a_x b_y - a_y b_x \end{bmatrix}$$





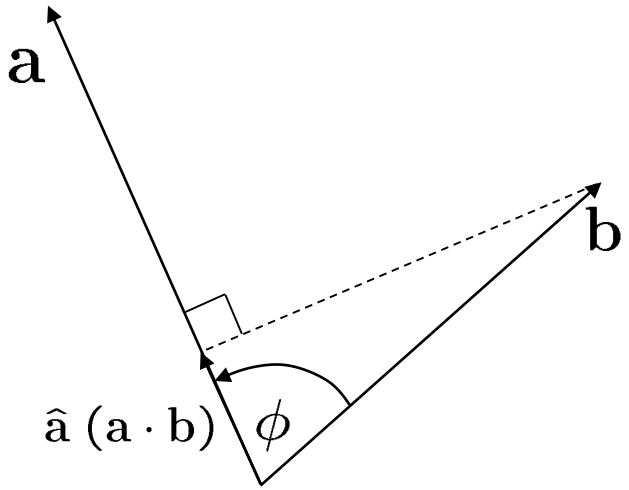
$$A = |\mathbf{a} \times \mathbf{b}| = |\mathbf{a}||\mathbf{b}| \sin\theta$$



Sidebar: Dot Product

$$\mathbf{a} \cdot \mathbf{b} = \|\mathbf{a}\| \, \|\mathbf{b}\| \, \cos\phi$$

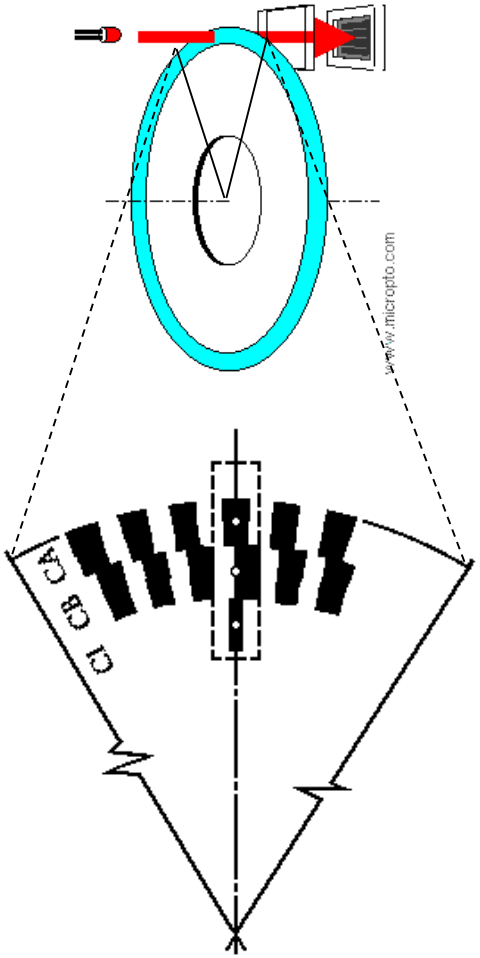
$$= \sum_{i=1}^{n} a_i b_i$$



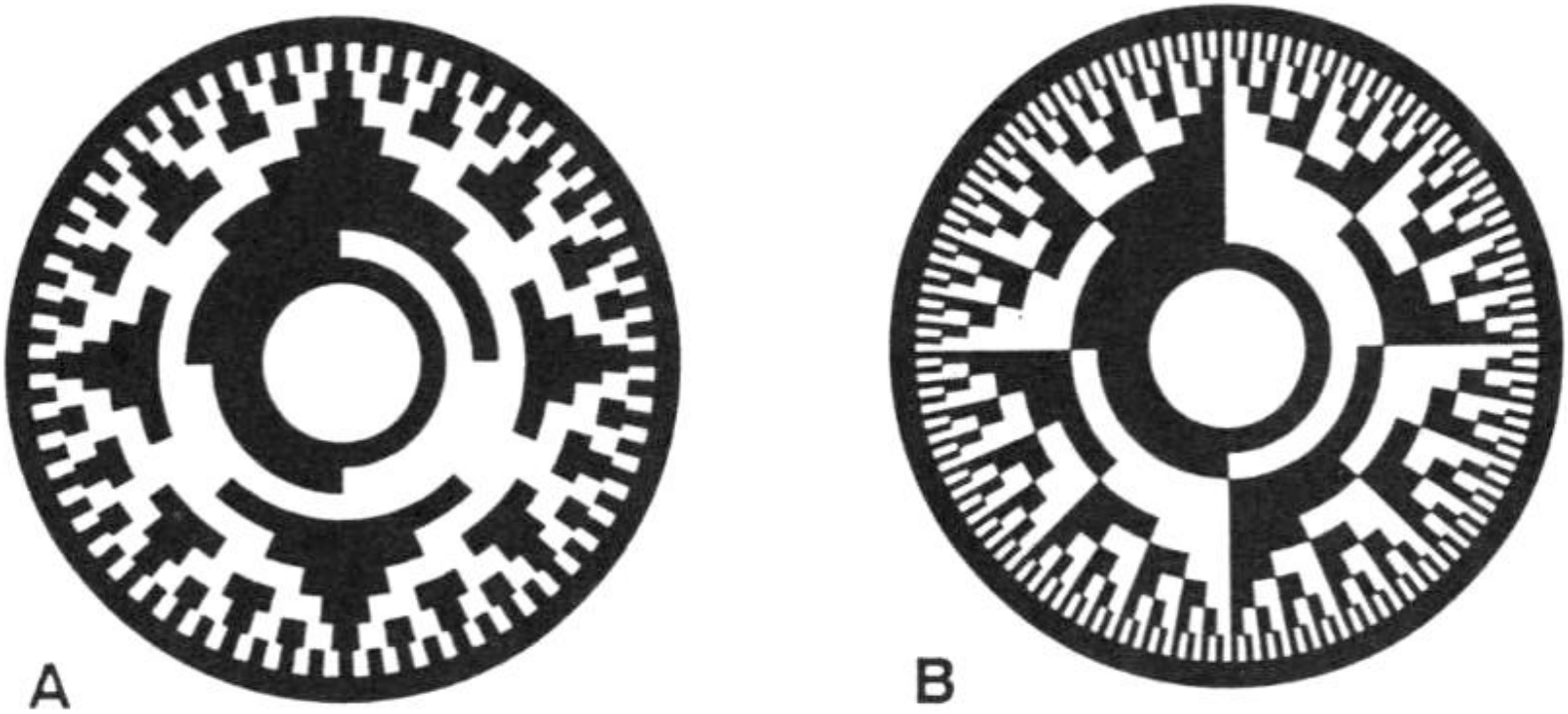
$$\hat{\mathbf{a}} = \frac{\mathbf{a}}{\|\mathbf{a}\|}$$

Relative Encoder

- Counts changes in signal
- Tracks A & B give *ticks* and direction
- Track I contains *index pulse*
- Instead of two tracks, two sensors can be used

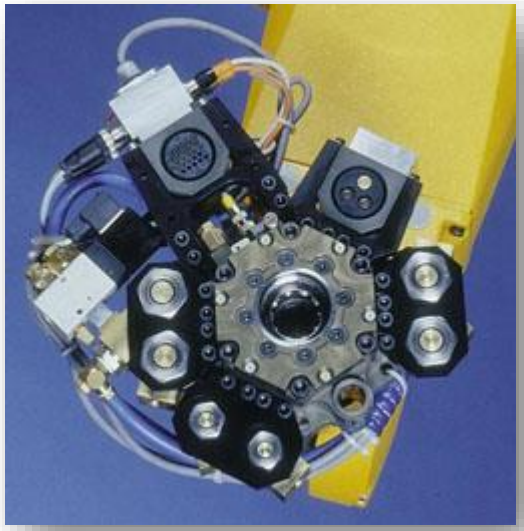


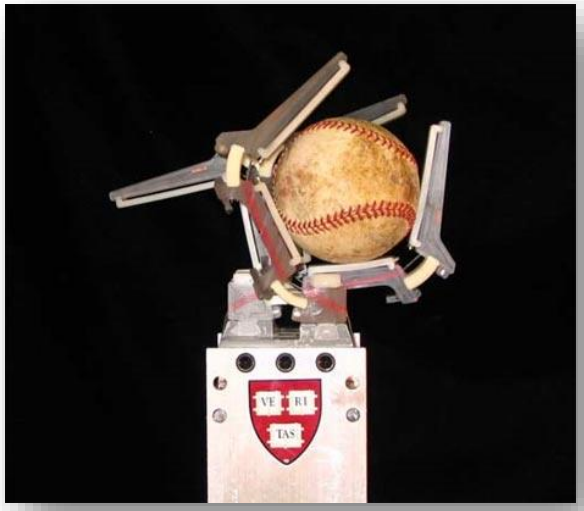
Absolute Encoder

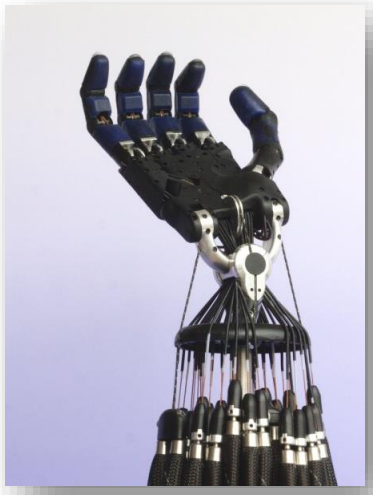


Position is encoded in several tracks; this requires many sensors.

Interface++ (Actuation)





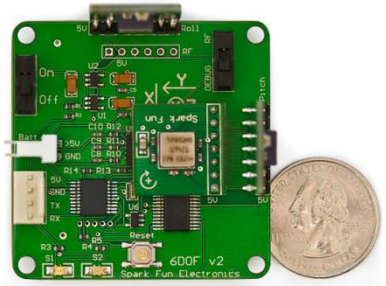


Interface++ (Sensing)

GPS

tactile arrays
"skin"

sonar



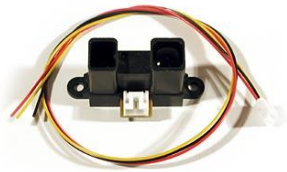
IMU (inertial measurement unit)

LIDAR (Light Detection and Ranging)

force/torque

encoder

RGB-D sensors



infrared

video cameras

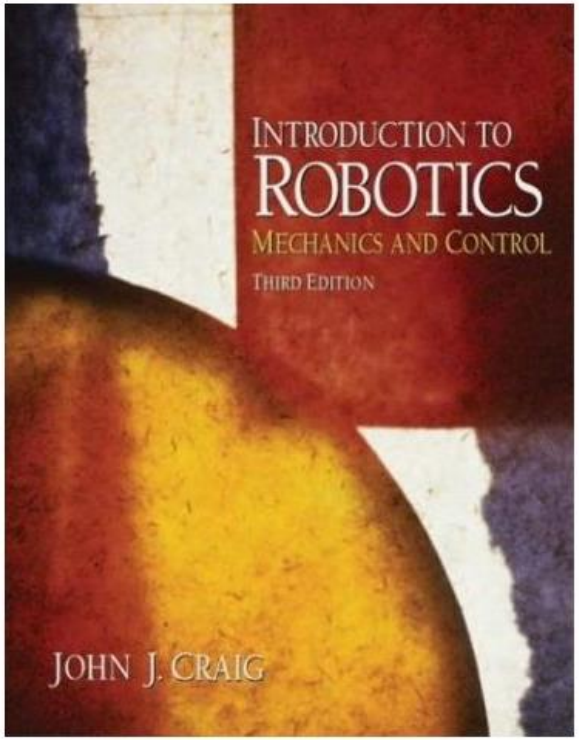
pyroelectric sensor

compass

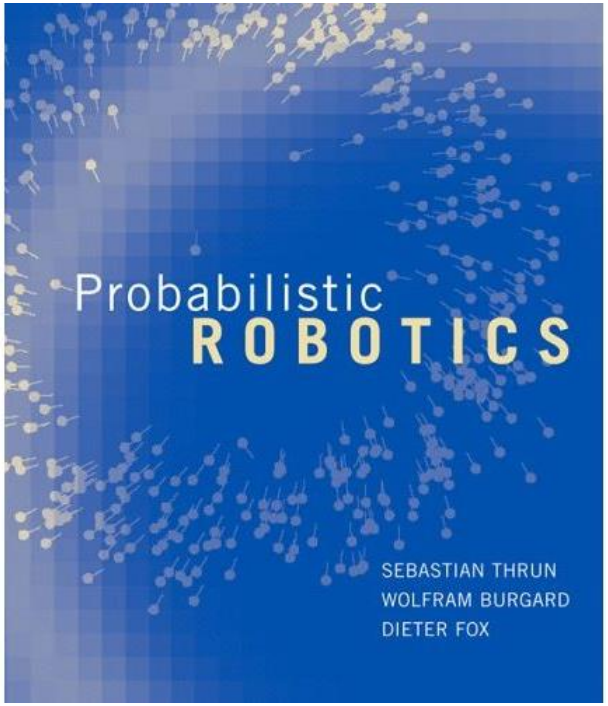
Five Chapters

- Float'n'hold
  physics, kinematics, gravity, control, DH parameters
- Track shape with end-effector
  Jacobians, singularities, dynamics, artificial potential fields,
- Visual tracking
  computer vision, image Jacobian
- Mobile robots: localize and map
  recursive estimation, simultaneous localization and mapping (SLAM), nonholonomicity, Kalman filter, particle filter
- Path planning around obstacles
  complexity, history of motion planning, sampling-based approaches, exploration versus exploitation

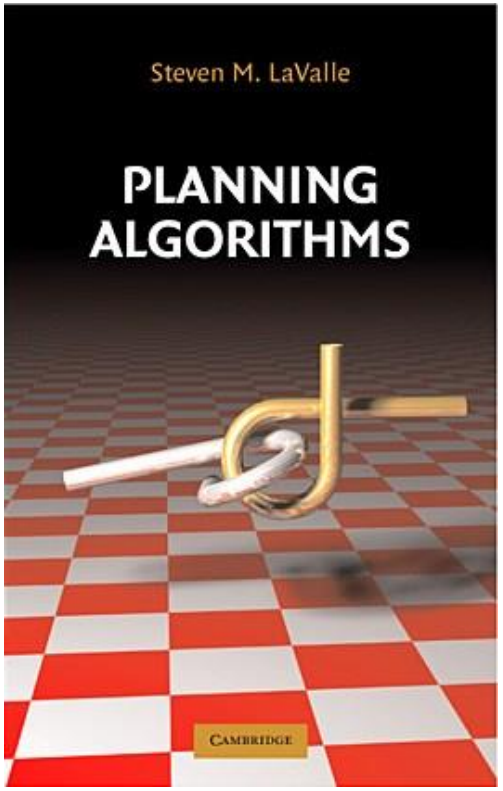
These Slides are accompanied by…



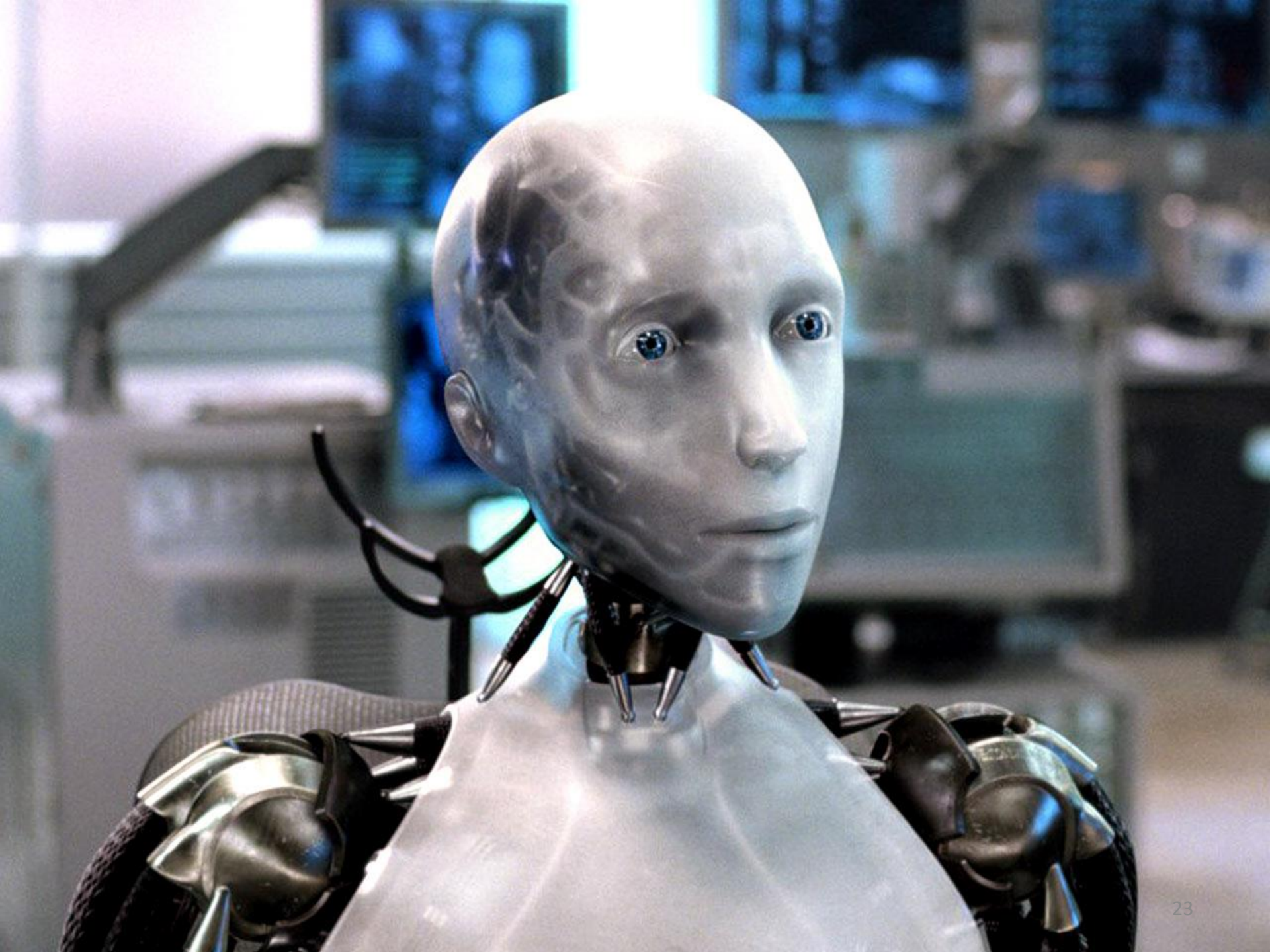
In the library



In the library
http://www.probabilistic-robotics.org



Free online
http://planning.cs.uiuc.edu




nature
THE INTERNATIONAL WEEKLY JOURNAL OF SCIENCE
At last — a computer program that can beat a champion Go player PAGE 484
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POPULAR SCIENCE
WHEN GENES GOT 'SELFISH'
Dawkins's calling card 40 years on
PAGE 462
NATUREASIA.COM
28 January 2016
Vol. 529 No. 7587

AlphaGo


Google DeepMind
Challenge Match
8 - 15 March 2016


IBM
GARRY
KASPAROV
DEEP
BLUE


Google DeepMind
Challenge Match
8 - 15 March 2016

2016


IBM
GARRY
KASPAROV
DEEP
BLUE

1997

MORAVEC'S PARADOX


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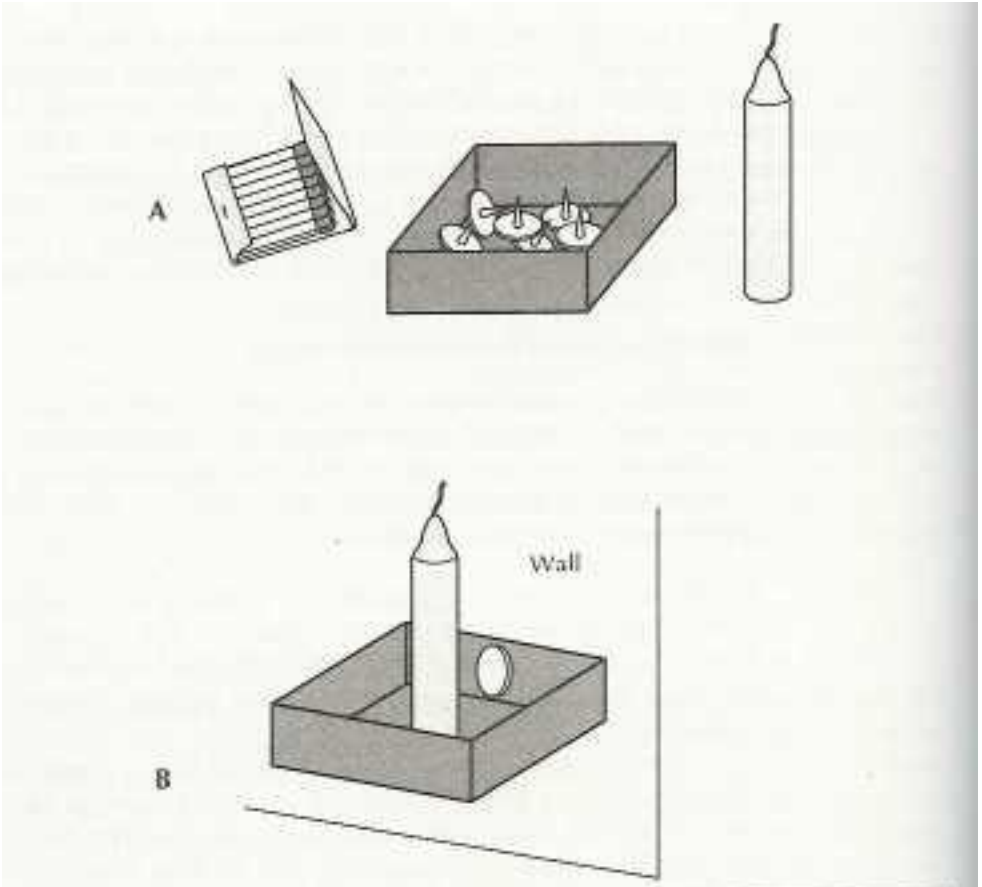
Left versus Right

Attach the candle to a vertical wall and light it.
No wax is allowed to drip on the floor
at any point during the process!

Now the other half…

Attach the candle to a vertical wall and light it.
No wax is allowed to drip on the floor
at any point during the process!



Duncker's (1945) Candle Problem The subjects are asked to attach a candle to the wall and are given a box of tacks, candles, and matches, as shown in panel A. The solution is shown in panel B.

~25%

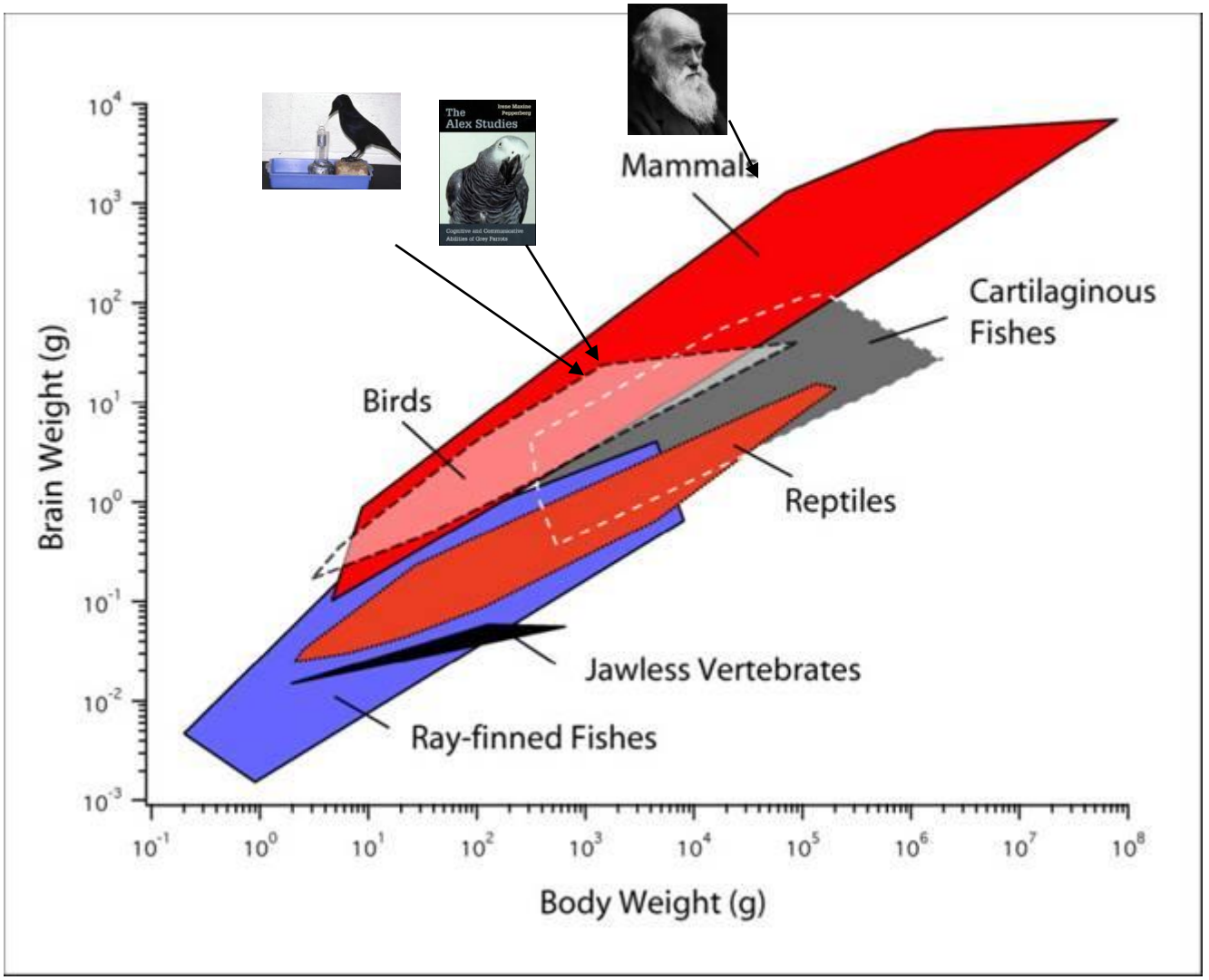
>80%

What Do We Know about Intelligence?


The Lockbox
Innovative solving of a multi-step mechanical problem in Goffin's cockatoos
Auersperg, Kacelnik & von Bayern
Universities of Oxford & Vienna

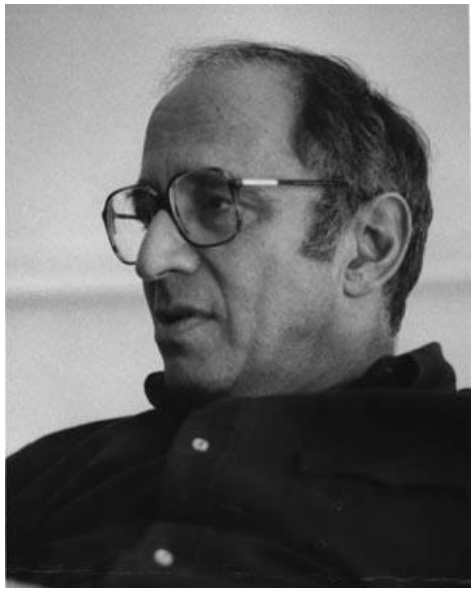
Brain and Body Size Variation

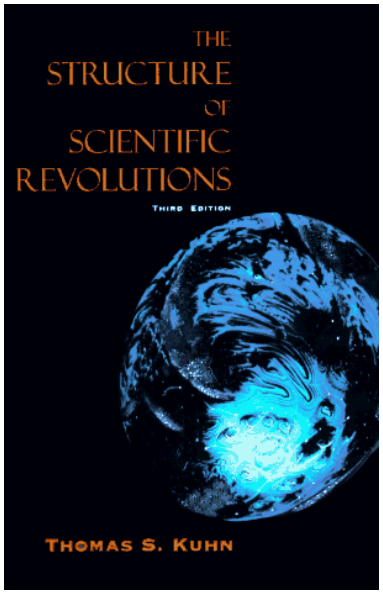
(with thanks to George Striedter and Alex Kacelnik)



Phlogiston

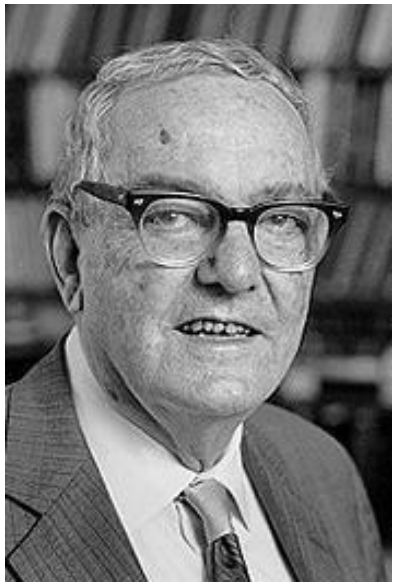
Johannes Joachim Becher, 1667

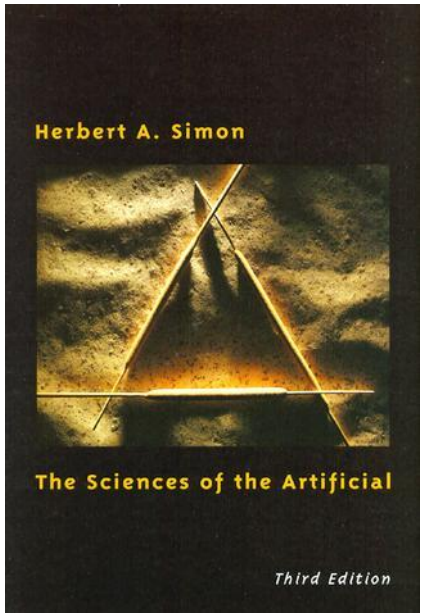




"...the successive transition from one paradigm to another via revolution is the usual developmental pattern of mature science."

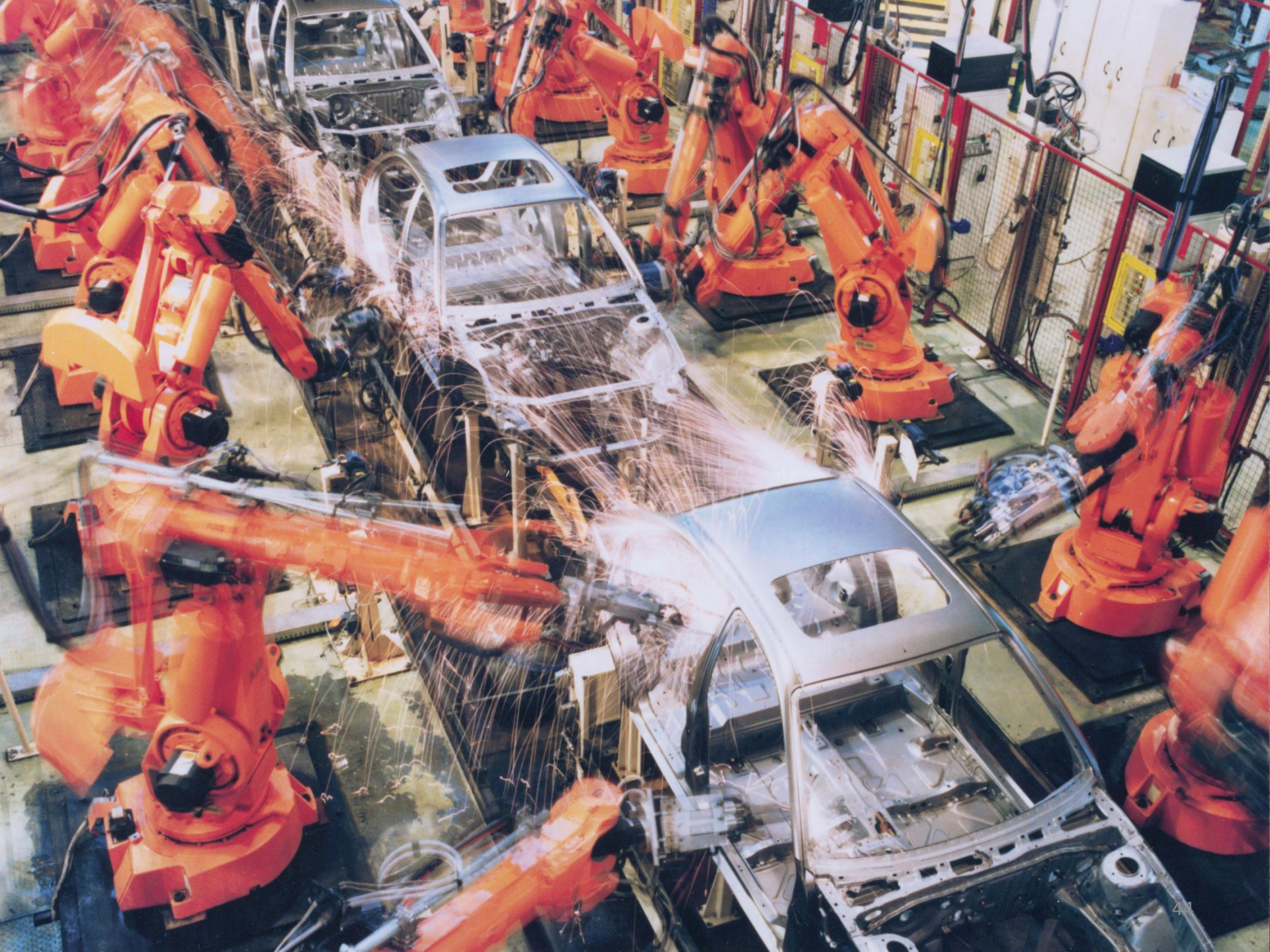
Thomas S. Kuhn in "The Structure of Scientific Revolutions"

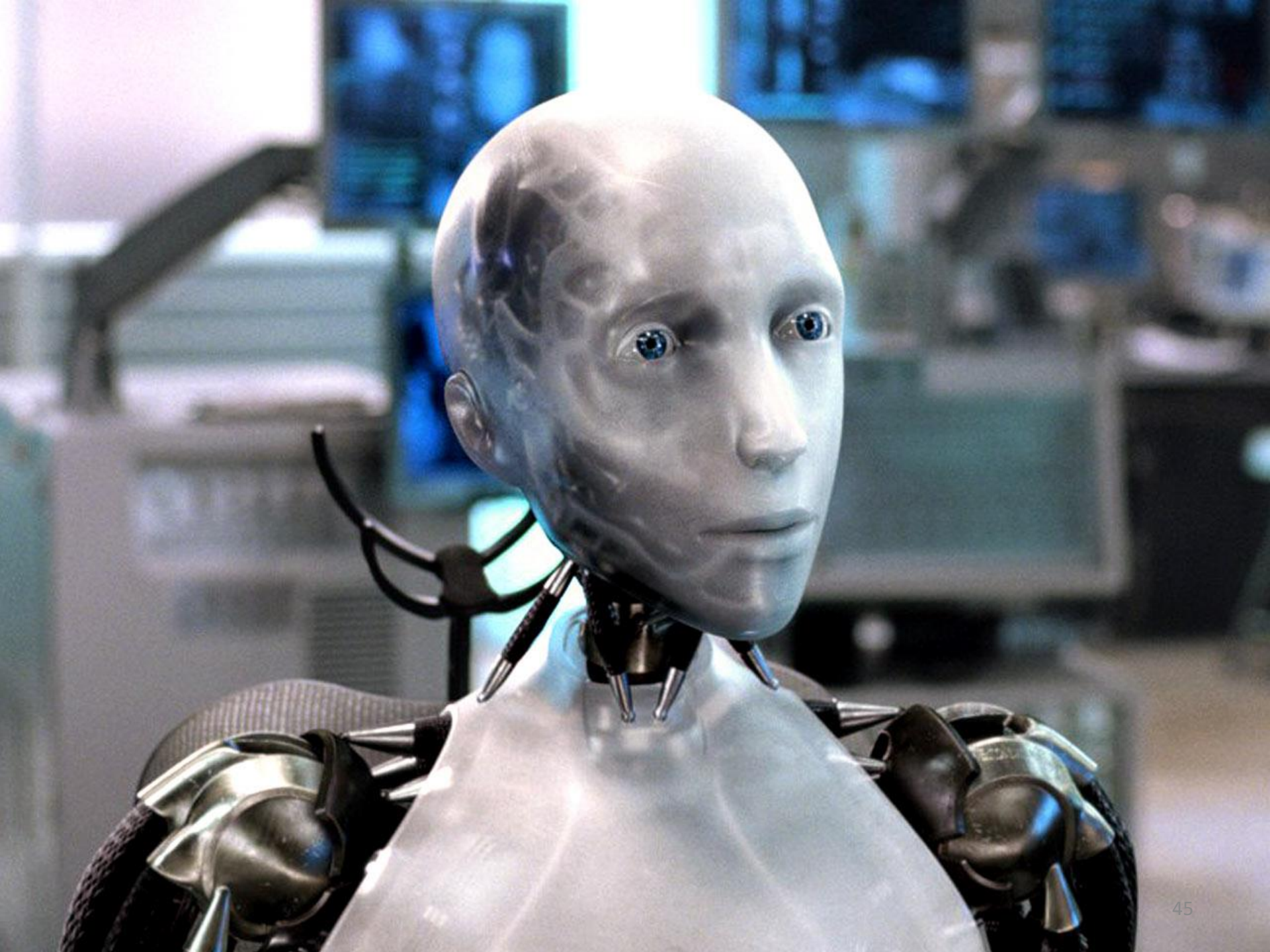




"The central task of a natural science is to make the wonderful commonplace: to show that complexity, correctly viewed, is only a mask for simplicity; to find pattern hiding in apparent chaos."

Herbert Alexander Simon in "The Sciences of the Artificial"



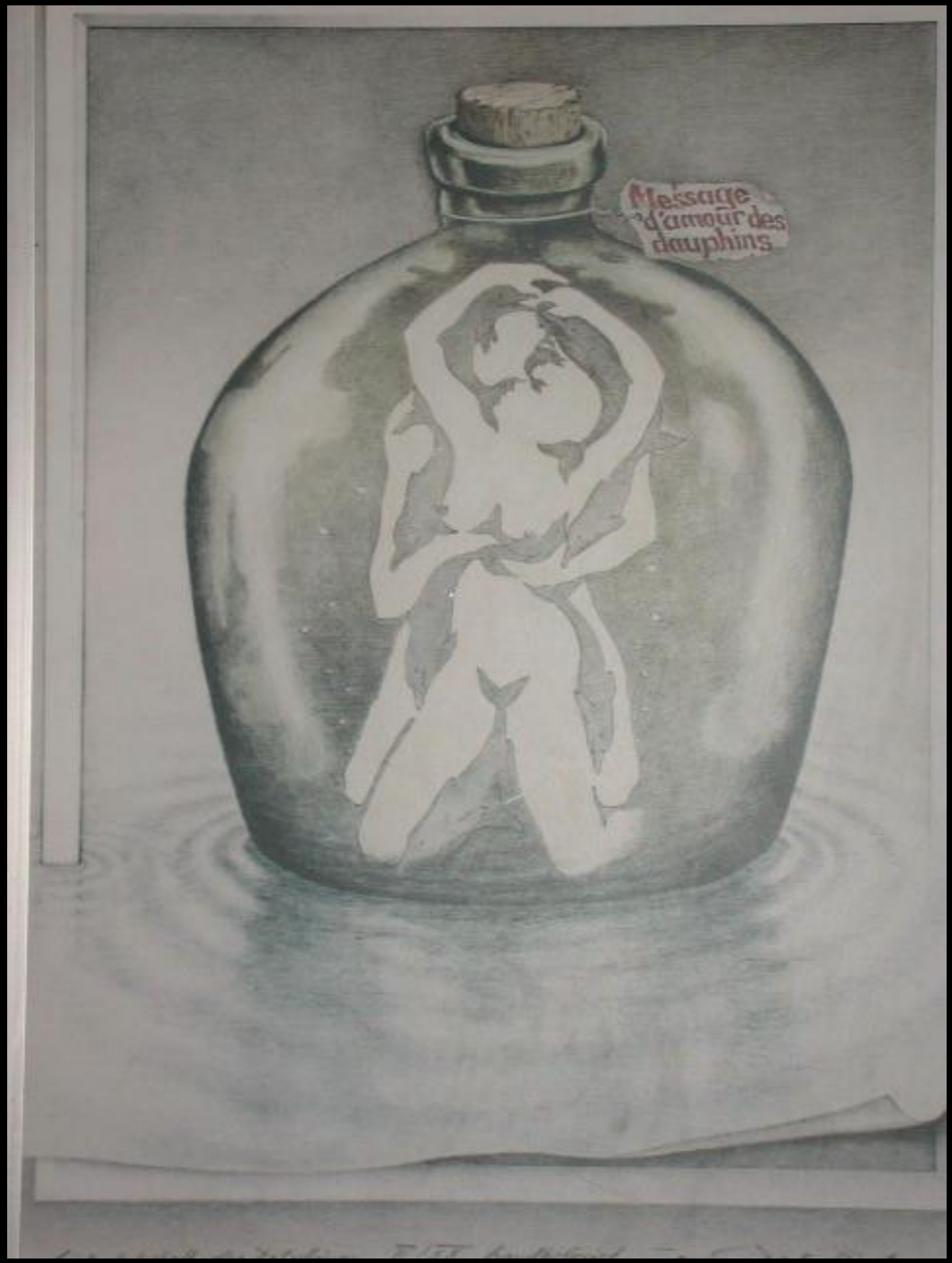


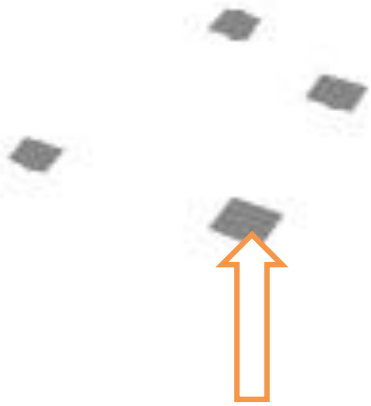
Robotics and Automation

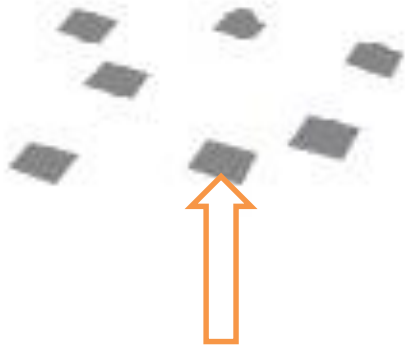
“Robotics focuses on systems incorporating sensors and actuators that operate autonomously or semi-autonomously in cooperation with humans. Robotics research emphasizes intelligence and adaptability to cope with unstructured environments. Automation research emphasizes efficiency, productivity, quality, and reliability, focusing on systems that operate autonomously, often in structured environments over extended periods, and on the explicit structuring of such environments.“

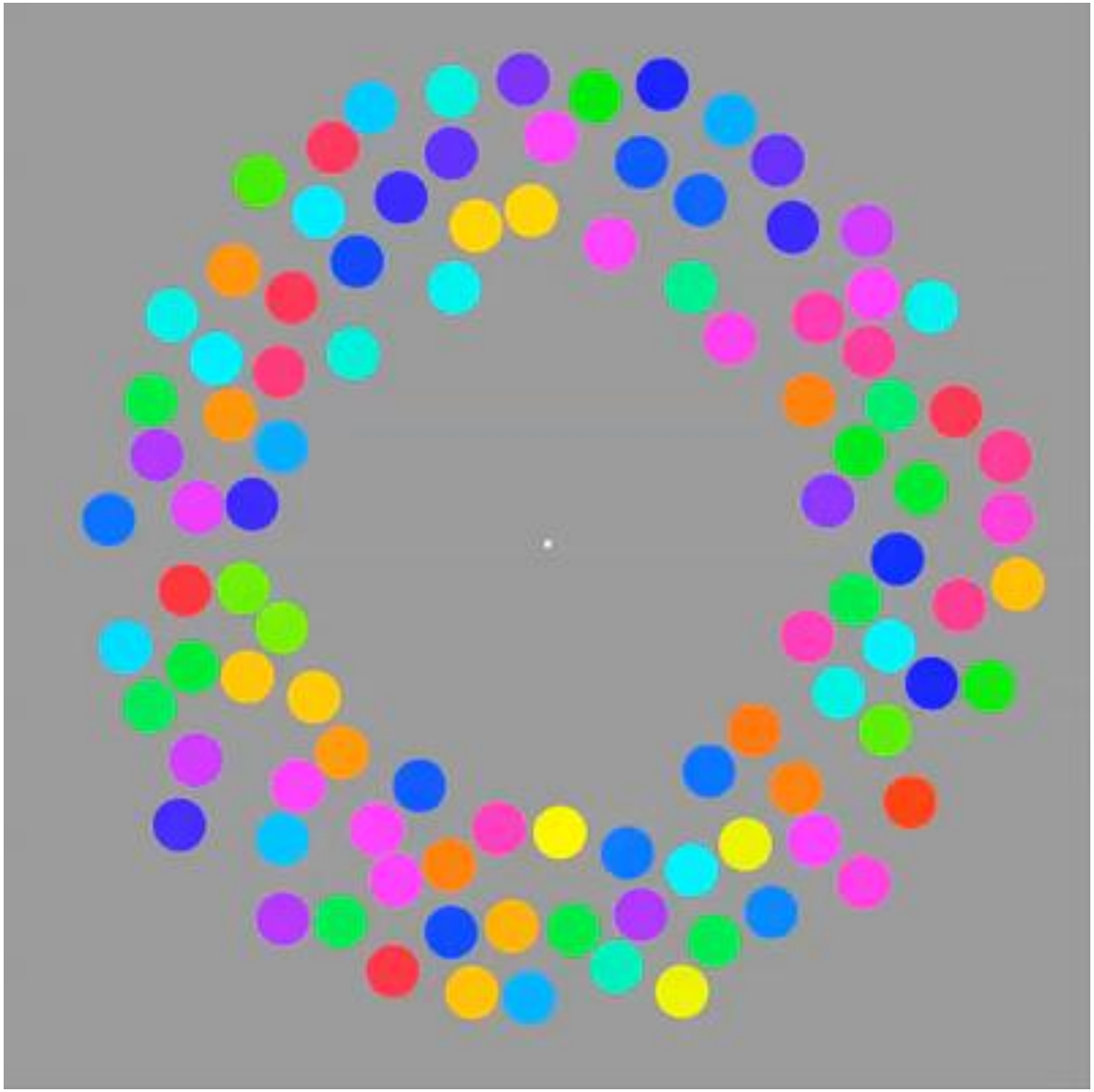
Robotics and Automation Society, Institute of Electronics and Electrical Engineers (IEEE)


ge provided courtesy of 3D SCIENCE.COM


Message
d'amour des
dauphins

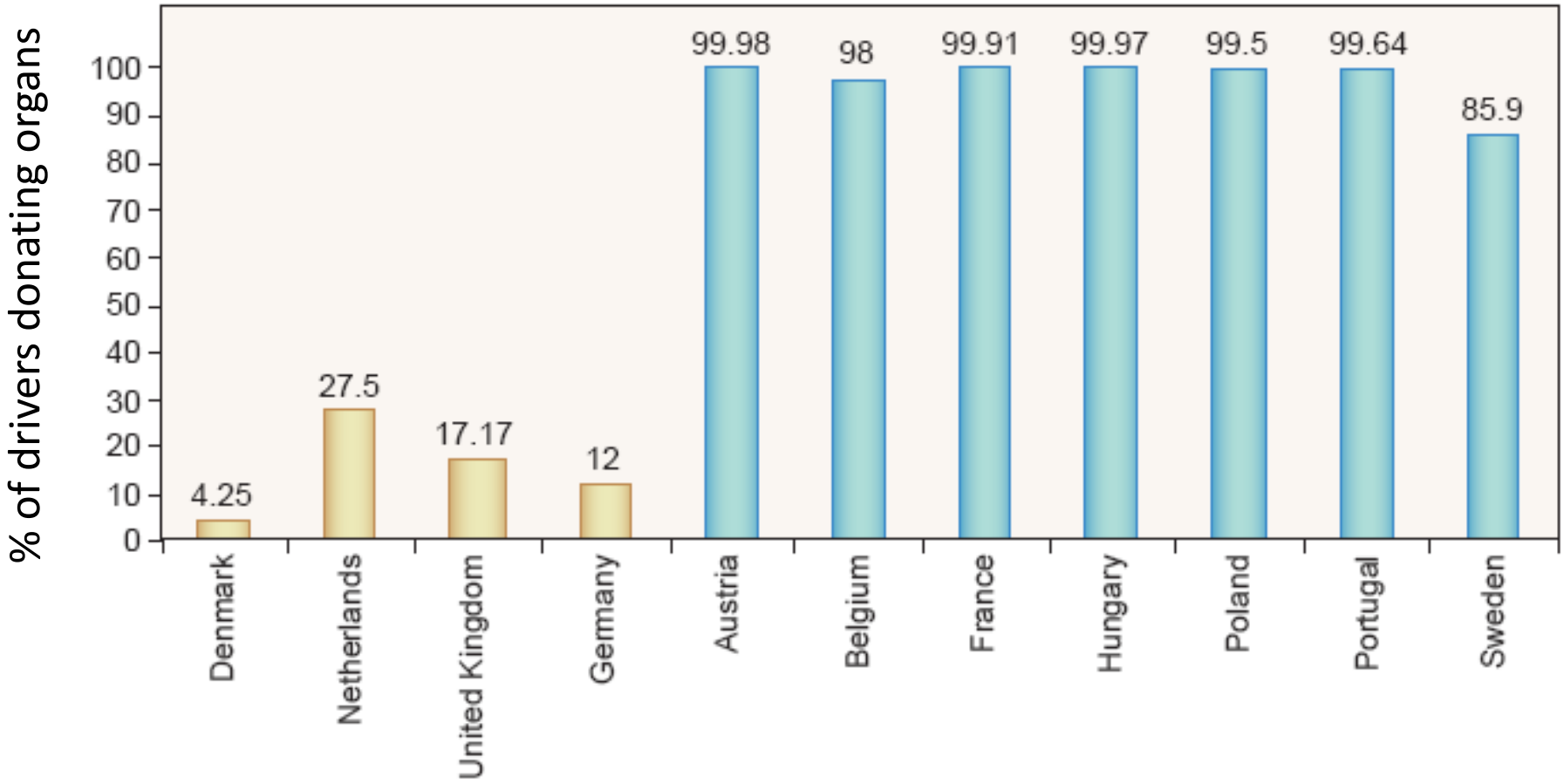







BBC TWO

Organ Donations

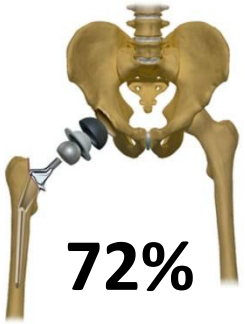


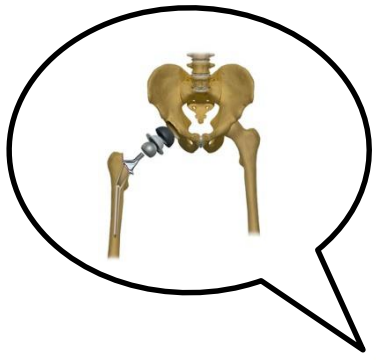
Johnson & Goldstein (2003)

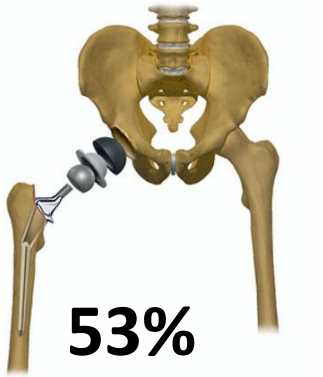
Johnson & Goldstein (2003)

Opt-in

Opt-out







Redelmeier & Shafir (1995)