Robotics
JACOBS
UNIVERSITY

Artificial Intelligence

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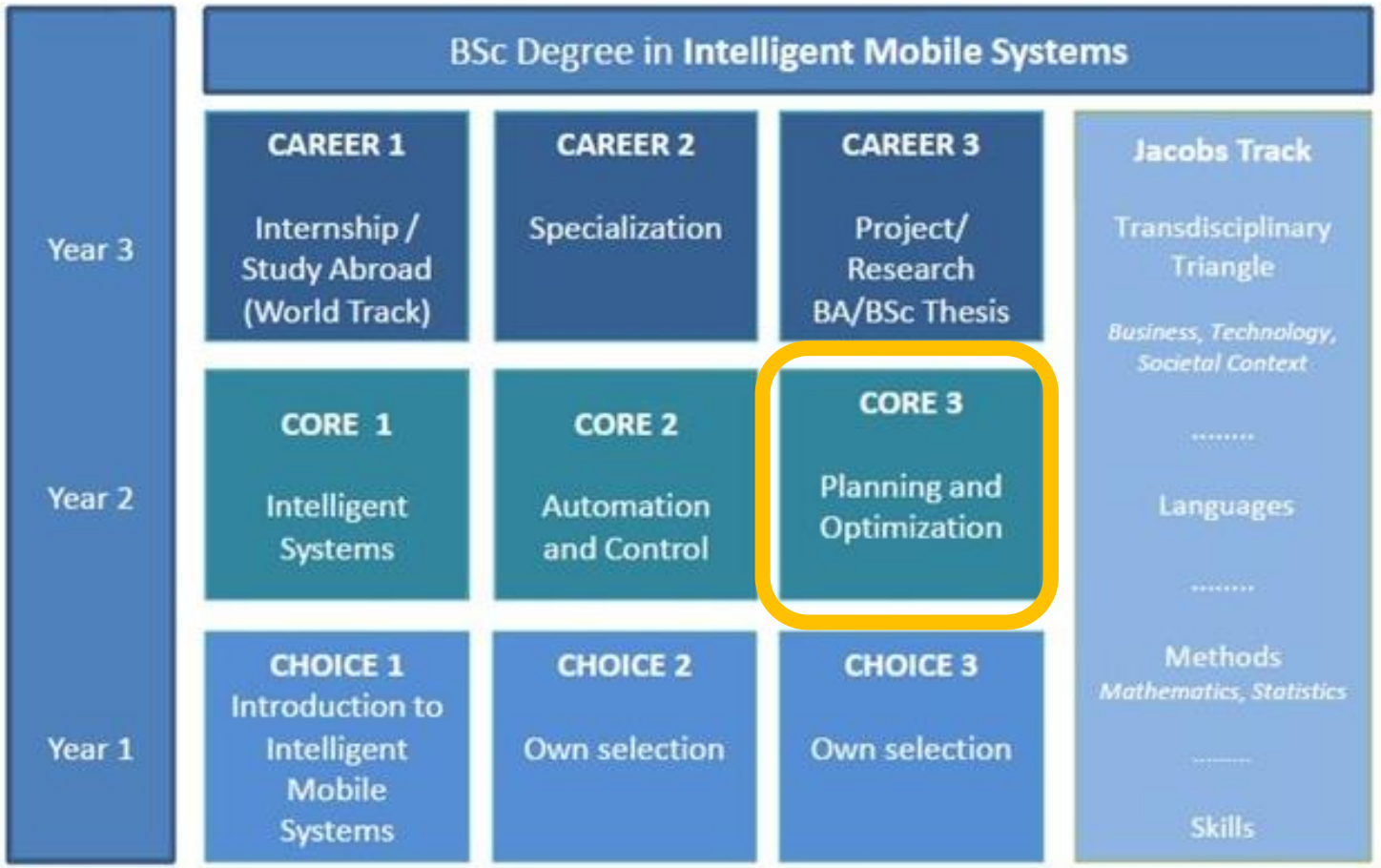
AI @ Jacobs



part of **Intelligent Mobile Systems (IMS)**

AI @ Jacobs

Year 2 - CORE					**45**
Take all three modules or replace one with a CORE module from a different study program. [2]					
CO22-IntelSys	**Module: Intelligent Systems**		**me**		**15**
CO22-320671	Computer Vision	Lecture	m	3	5
CO22-320311	Robotics	Lecture	m	4	5
CO22-320372	Machine Learning	Lecture	m	4	5
CO23-AutoCo trol	**Module: Automation and Control**		**me**		**15**
CO23-320301	Control Systems	Lecture	m	3	5
CO26-300312	Embedded Systems Lab	Lab	m	3	5
CO23-320203	Automation	Lecture	m	4	5
CO24-PlanOpt	**Module: Planning and Optimization**		**me**		**15**
CO29-080202	Operations Research	Lecture	m	3	5
CO24-300491	Optimization	Lecture	m	4	5
CO24-320521	Artificial Intelligence	Lecture	m	3	5

note:

Machine Learning (a.o. Artificial Neural Networks, ANN) is covered in an other lecture (Intelligent Systems module)

Scope of the Lecture

a bit of an ***autonomous systems*** perspective
(often also denoted as *intelligent autonomous systems*)

- autonomy
  - data-structures & algorithms
  - for acting in “intelligent” ways
- system
  - system integration
  - software architectures

What is „intelligence"?
Or „autonomy"?

Background

- meaning of “**intelligence**” has severely changed in the course of history
  - The Roman politician **Marcus Tullius Cicero** (106 - 43 B.C.) forming the noun “intelligentia”
  - from a divine property to a marketing label
- the same applies to “**autonomy**”
  - from powercord-free to human property
  - less awareness of the wide range of meanings

Notions of Autonomy

- a philosophical approach
  - auto = self + nomos = law, rule (Greek)
  - self + decisions => alive + cognition ?!?!
- a technical approach
  - not directly defining/explaining autonomy, but **autonomous systems**
  - computerized systems capable of “intelligent" /"adaptive" performance in "complex" environments/tasks

Related Terms

- Cognitive Systems
  - was a large EU funding scheme
  - typically more related to Neuro/Cognitive Science
- Cyber Physical Systems
  - started as US funding “brand”
  - more related to Internet of Things (IoT) & Industry 4.0

note:

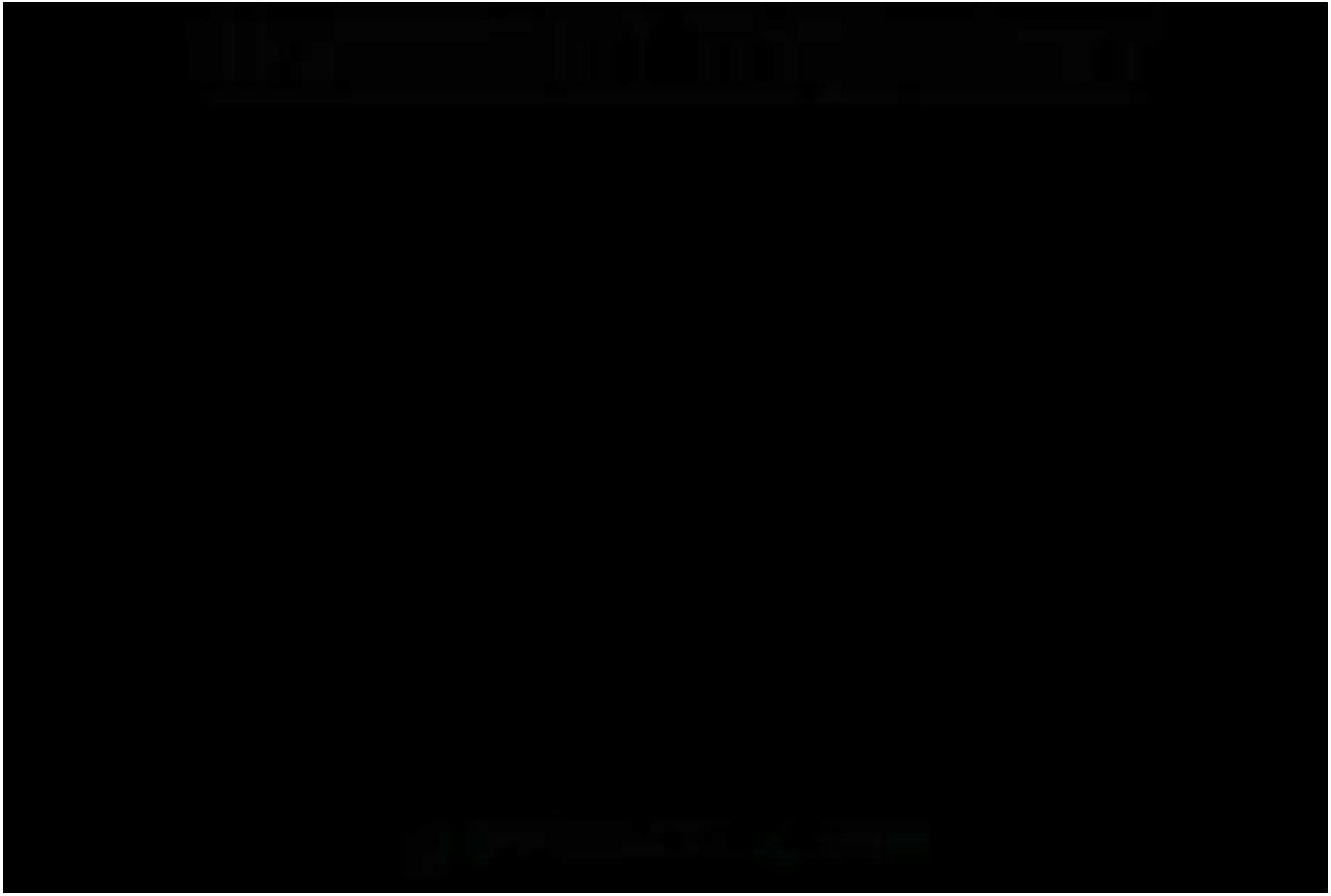
buzzwords with fuzzy boundaries

and not “scientific” terms

Machine Intelligence

Deep Blue (1997)

machine beats human at chess



DARPA Urban challenge (2007)
autonomous driving in urban scenario

Machine Intelligence

DARPA Robotic Challenge (2015)
(semi)autonomous search and rescue scenario

Machine Intelligence

“intelligence”: we are subjective observers

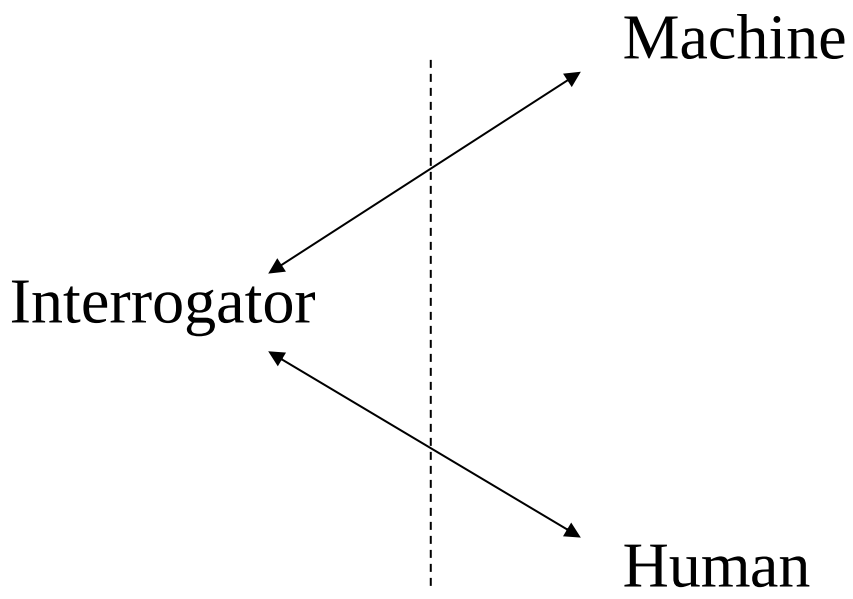
- as how hard do we perceive the problem?
- are adaptive/creative solutions needed?
- how human like is the performance?
- how fast and robust is the system?

Turing Test (Alan Turing, 1950)

I propose to consider the question, "Can machines think?" This should begin with definitions of the meaning of the terms "machine" and "think." … [But] [i]nstead of attempting such a definition I shall replace the question by another, which is closely related to it and is expressed in relatively unambiguous words.

The new form of the problem can be described in terms of a game which we call the 'imitation game."

The Imitation Game



conversation via written text

"I believe that in about fifty years' time it will be possible to program computers, with a storage capacity of about 10^9, to make them play the imitation game so well that an average interrogator will not have more than 70 per cent chance of making the right identification after 5 minutes of questioning"

-Alan Turing (1950)

Cheap Trick(s) Solution: Eliza

psychotherapist Joseph Weizenbaum
programmed in 1966

- keywords and pre-canned responses
  - “Perhaps I could learn to get along with my mother”
  - “Can you tell me more about your family?”
- Parroting
  - “My boyfriend made me come here”
  - “Your boyfriend made you come here?”
- Highly general questions
  - “In what way?”
  - “Can you give a specific example?”

e.g.: http://www.masswerk.at/elizabot/

Machine Intelligence

some persistent topics for “intelligence”

- perceiving and representing “the world”
- reasoning about “the world”
- acting in “the world”
- in some “optimal” way

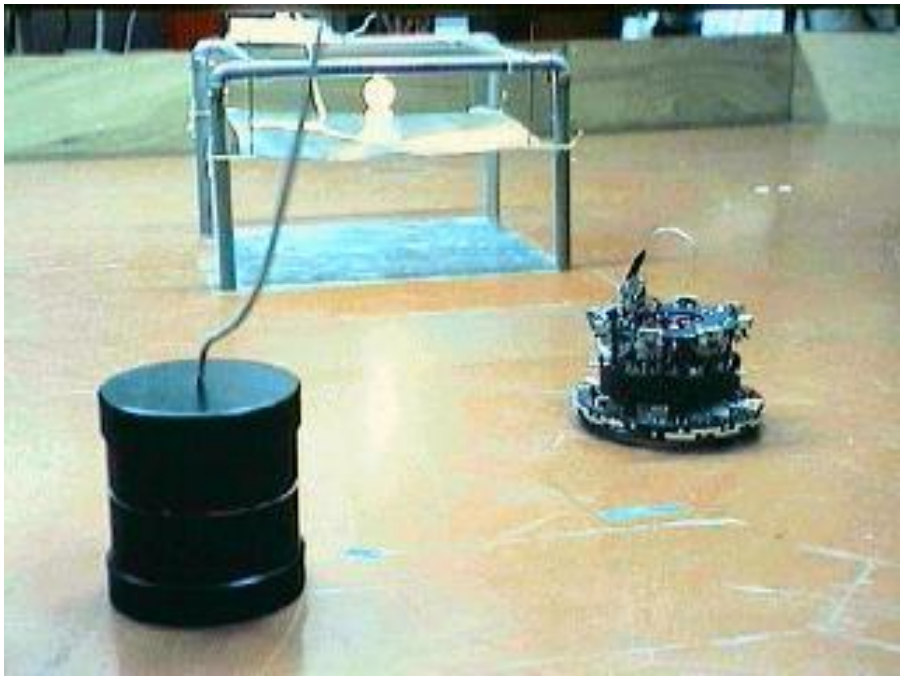
with “the world” e.g. being

- an abstract game like chess
- a physical environment

Intelligence as "Optimal" Performance in "the World"

- the role of choice
  - caring about resources [Ross Ashby 52]
  - energy and basic cycles [David McFarland 97]
- systems perspective
  - manipulation and mobility
  - "thinking" (perceive, model, reason)
  - to get and manage resources

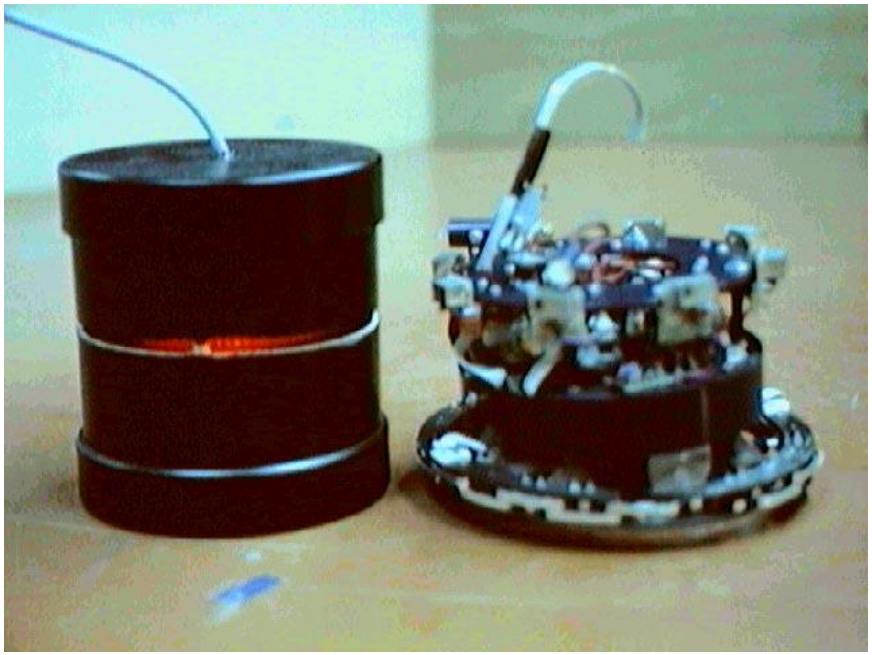
E.g., Robot "Ecosystem"



basic set-up

[Steels, McFarland 1994]

- "simple" mobile robots
- charging-station
- competitors
  - boxes housing lamps
  - working task



AI: Two Worlds in One

bad cliche:

- science = understanding things
- engineering = making things work

but it pays to

understand while/by making things work

Two Worlds in One

basic research

- constructive understanding of intelligence
- inseparable aspects of
  - body
  - mind
  - society

application-oriented R&D

technical devices

- with elaborate I/O (incl. sensor/motor interfaces)
- freed from explicit and permanent human supervision
- being networked

Scientific roots & relations

Artificial Intelligence

- changes in emphasis over time
  - symbolic (reasoning) / sub-symbolic (neural nets)
  - “nouvelle” AI: situated, embodied, reactive behavior

(more about this soon)

- always strong ties to robotics
  - Stanford AI Lab (SAIL), robot-arm in ‘68
  - Stanford Research Institute (SRI), mobile robot **Shakey** from ‘66 on
    - cameras, optical range sensors, bumpers
    - radio-linked to a DEC PDP-11, vision & planning
    - over-ambitious goal to get an industrial device

Robotics

two roots: **science fiction** & **technical reality**

SF

- Karel Capek (Czech) 1921: “robota”
  - satirical play “Rossum’s Universal Robots(RUR)”
  - robots as superhuman slave workers
- Isaac Asimov, 50s SF-novels: robotics
  - the **three laws of robotics** require high cognitive capabilities of the robots

Robotics (2)

technological reality:

- Robotics Industries Association (RIA)
  - re-programmable multi-functional manipulator
- Robot-arms
  - Unimation (Universal Automation) founded in ‘58
  - by Joseph Engelberger; technology George Devol
  - first five axis, hydraulic manipulator
- used in production
  - repetitious tasks
  - precision and strength

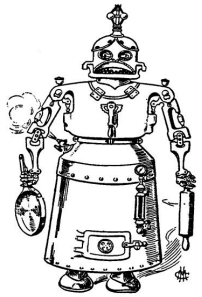
Robotics (3)

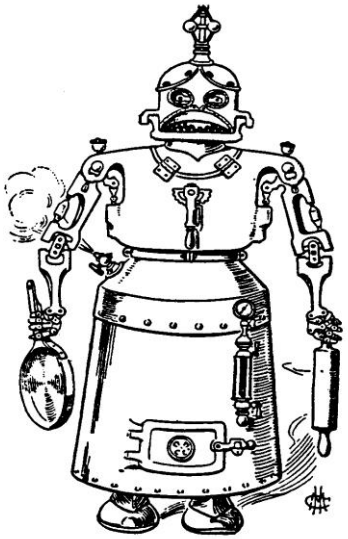
two notions of a robot

- SF: highly intelligent superhuman
- industry: dumb, inelegant robot-arm

are breaking apart and coming closer

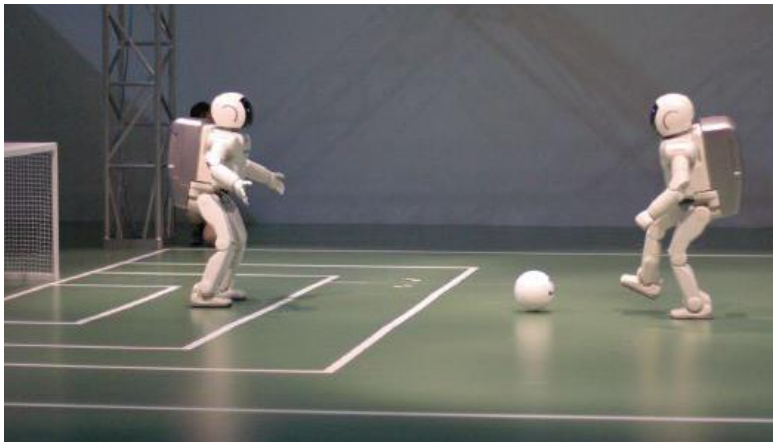
(a.o., due to progresses in AI)





AI & Robots

science fiction
and
reality
are getting closer



can you list some AI capabilities needed here?

Organizational Matters

course page:

http://robotics.jacobs-university.de/TMP/AI19/

pre-requisites

- CS choice module (strongly recommended)
- IMS choice module (or being CS 3rd year)

grading

- final (55%) 04. Dec. 2019
- midterm (45%) 04. Nov. 2019 (tentative)
- **homework** (**not graded**) exam prep, **discussed in class**

Organizational Matters

There is

- **a strong correlation**
- **between class attendance**
- **and the course grade!!!**

Past experience showed:

You need to attend all classes of this course to pass it!!!

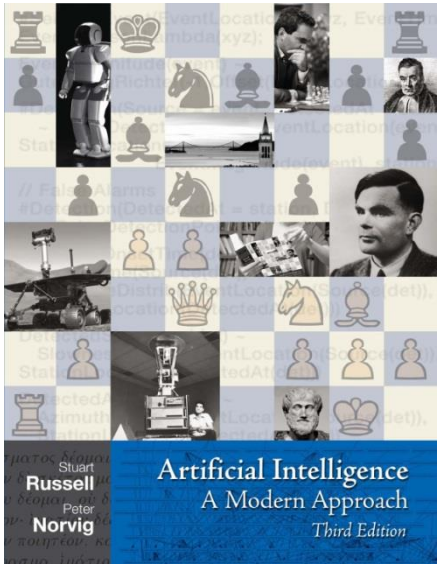
Content

- “flavors” of AI
  - Goofai vs Nouvelle AI, agent architectures
- behavior-oriented AI
  - behavior programming, scheduling, hierarchies
- problem solving as search
  - simple search, informed search
- domain specific application: path-planning
  - representation, algorithms
- logic
  - propositional logic, first order logic, planning
- imprecision and uncertainty
  - fuzzy logic

Textbook(s)

Stuart Russell and Peter Norvig

Artificial Intelligence:
A Modern Approach



Jean-Claude Latombe

Robot Motion Planning