Autonomous agents
Lecture 13, 20160307

Course summary

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Course summary: Autonomous robots

- In general, check the learning goals presented in the slides for each lecture!
- Also, review the quizzes. The quiz questions are rather simple (i.e. simpler than exam questions), but still important!

Course summary: Autonomous robots

- Robot types
  - **Wheeled**
  - Walking
    - Humanoid
      - Android
  - Flying

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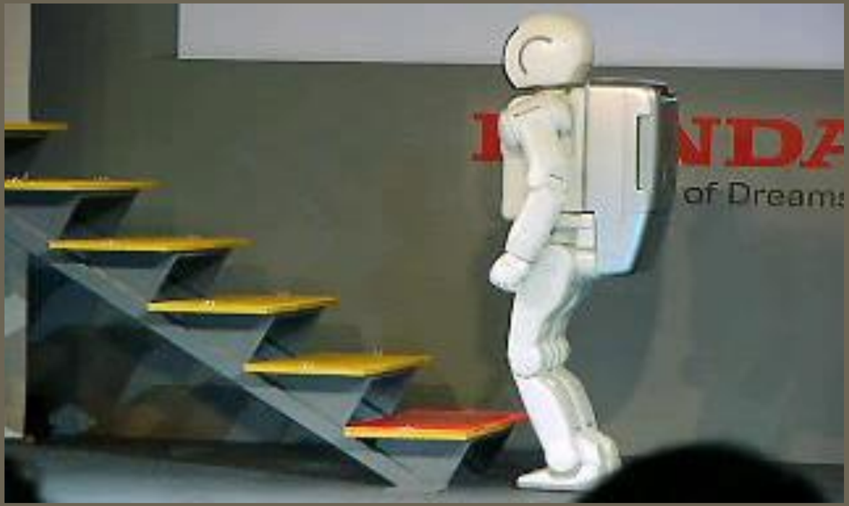

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Course summary: Autonomous robots

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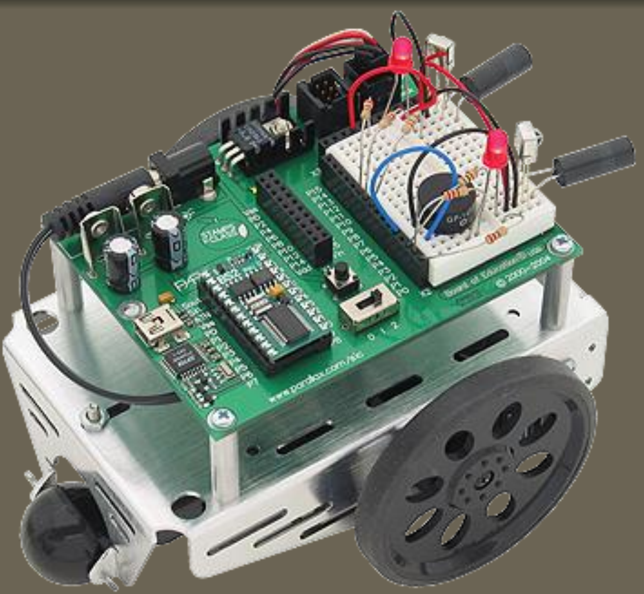
Course summary: Autonomous robots

- Important special cases: Two-wheeled, differentially steered robots



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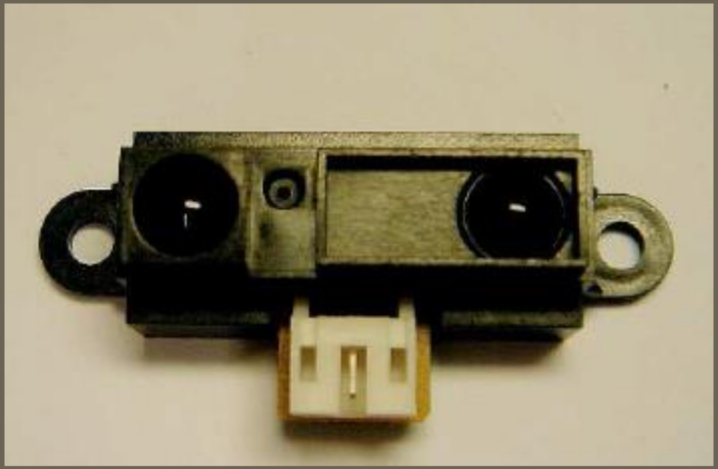
Course summary: Autonomous robots

- Sensors
  - **IR Sensors**
  - Wheel encoders
  - Sonars
  - Laser range finders



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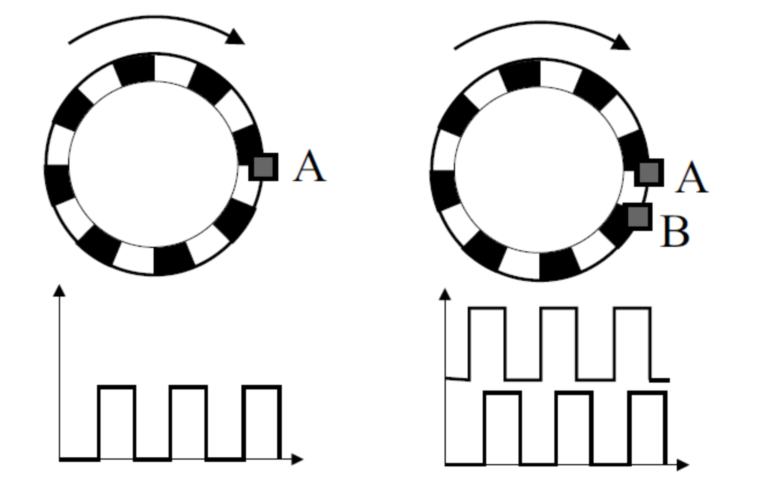

Course summary: Autonomous robots

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Course summary: Autonomous robots

- Sensors
  - IR Sensors
  - Wheel encoders
  - Sonars
  - **Laser range finders**

Course summary: Autonomous robots

- Sensors: Important aspects
  - What is measured?
  - How are the readings obtained?
  - Range?
  - Accuracy?
  - Updating frequency?

Course summary: Autonomous robots

- Actuators: DC motors
  - Underlying principles
  - Basic equations
  - Gear boxes

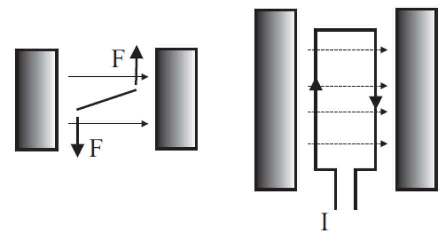

Figure 1.12: *A conducting loop of wire placed in a magnetic field. Due to the forces acting on the loop, it will begin to turn. The loop is shown from above in the right panel, and from the side in the left panel.*

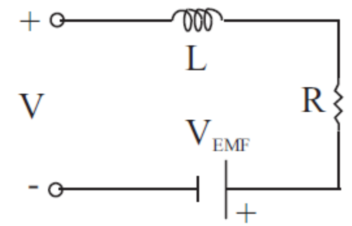

Figure 1.13: *The equivalent electrical circuit for a DC motor.*

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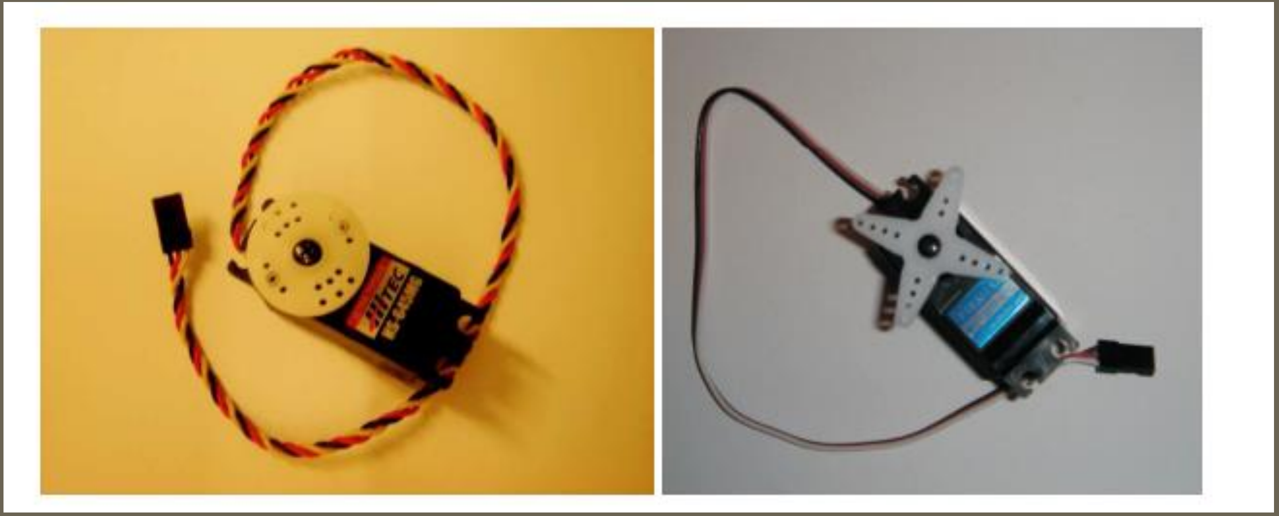
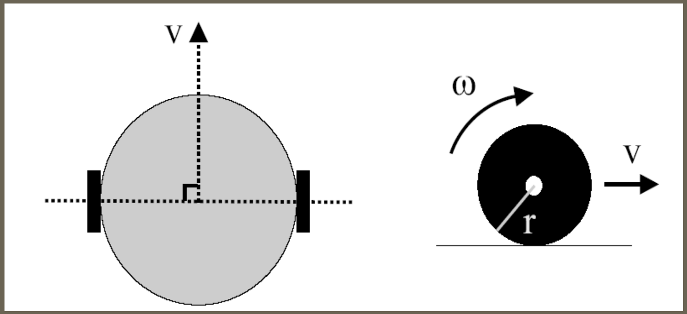
Course summary: Autonomous robots

- Important special case: Servo motors
  - Pulse-width modulation



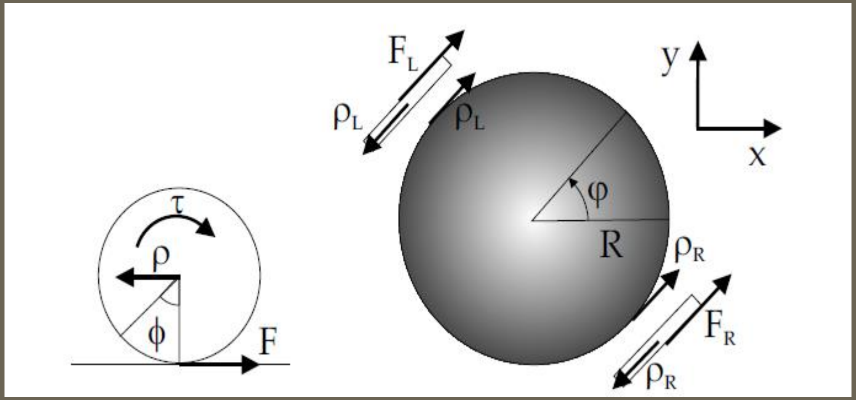
Course summary: Kinematics

- Studying the possible motions of a robot (taking into account constraints, but not forces)
  - Equations for the special case of differentially steered, two-wheeled robots.
  - Odometry (and odometric drift).



Course summary: Dynamics

- The motion of a robot in response to forces and torques
  - Derivation of the equations of motion (linear and angular) for the special case of a differentially steered, two-wheeled robot.



Course summary: Simulations

- General aspects
  - The flow of a time-step based simulation
  - Event timing
  - Collision-checking (grids etc.)

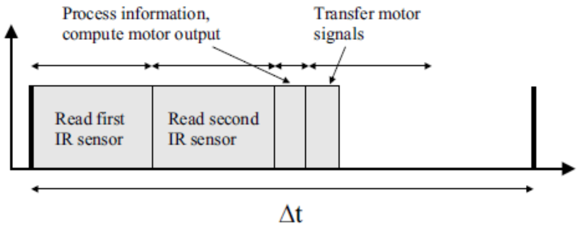
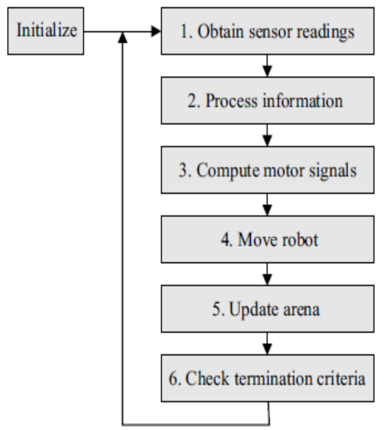


Figure 3.2: *A timing diagram. The boxes indicate the time required to complete the corresponding event in hardware, i.e. a real robot. In order for the simulation to be realistic, the time step Δt used in the simulation must be longer than the total duration (in hardware) of all events taking place within a time step.*



Course summary: Simulations

- Simulating sensors
  - Important special case: Ray-based sensors
    - The use of ray readings
    - Equations for ray readings for different sensor types
    - Line-line intersections!
  - Sensor noise

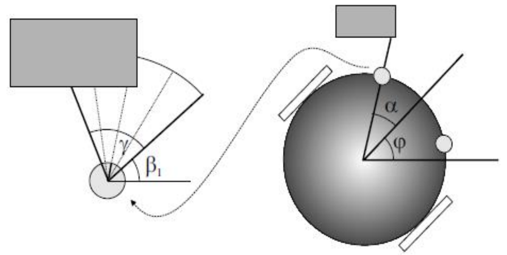


Figure 3.4: *The right panel shows a robot equipped with two IR sensors, and the left panel shows a blow-up of the left sensor. In this case, the number of rays (N) was equal to 5. The leftmost and rightmost rays, which also indicate the opening angle γ of the IR sensor are shown as solid lines, whereas the three intermediate rays are shown as dotted lines.*

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Course summary: Simulations

- Equations of motion
  - Discretization
  - Integration (simple Euler sufficient)

Course summary: Animal behavior

- Motivation
- Bottom-up vs. top-down approaches
- Ethology
  - Reflexes
  - Kineses and taxes
  - Fixed action patterns
  - Complex (adaptive) behaviors

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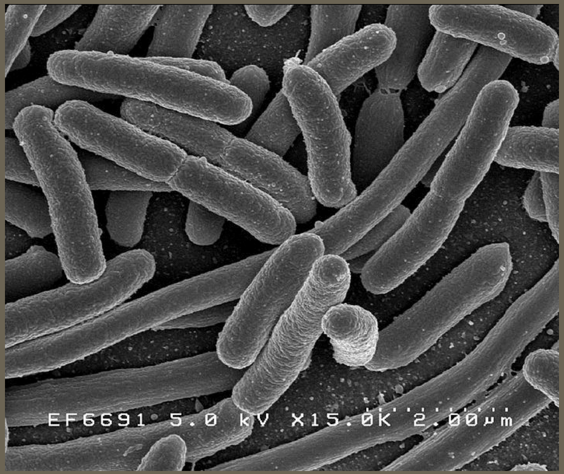
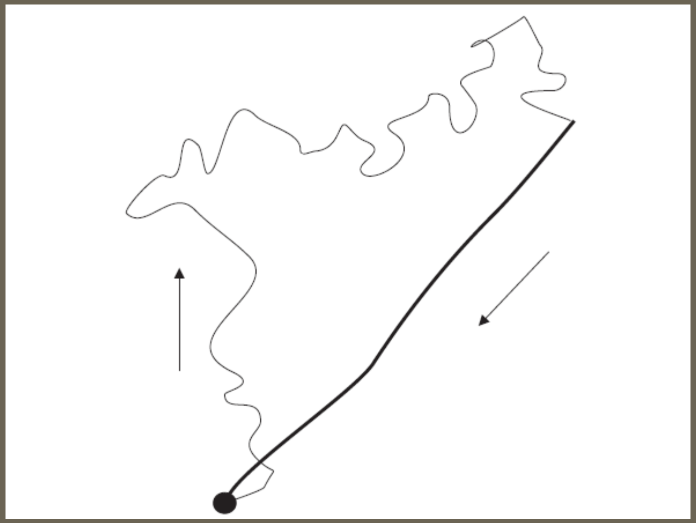
Course summary: Animal behavior

- Case studies:
  1. Behavior selection in E. Coli bacteria
  2. Navigation (and decision-making) in Cataglyphis ants





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Course summary: Robot intelligence

- Approaches to machine intelligence
  - Classical AI
  - Behavior-based robotics
- Behavioral architectures:
  - Finite-state machines

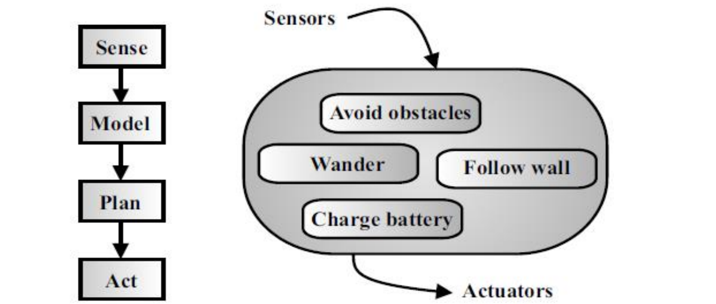
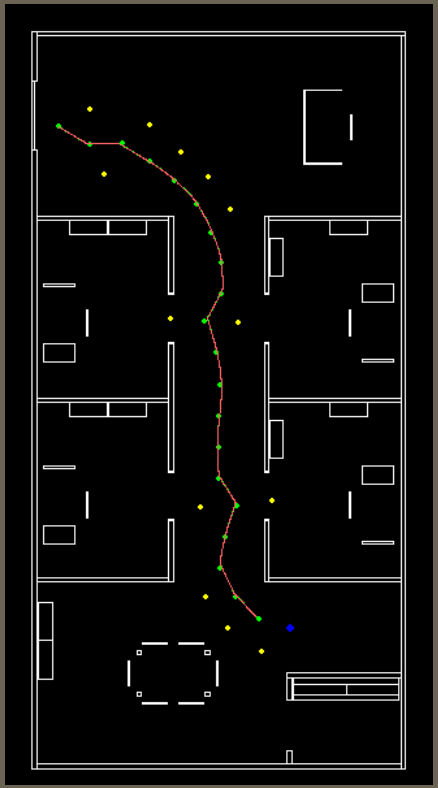


Figure 5.1: *A comparison of the information flow in classical AI (left panel) and in BBR (right panel). For BBR, any number of behaviors may be involved, and the figure only shows an example involving four behaviors.*

Course summary: Robot behaviors

- Exploration
  - Sensory area coverage
  - Algorithm
    - Node placement
    - Node selection
    - Minimum node spacing
    - Etc.



Course summary: Robot behaviors

- Grid-based navigation
  - General description of grids
  - Best-first search (BFS)
  - Dijkstra's algorithm

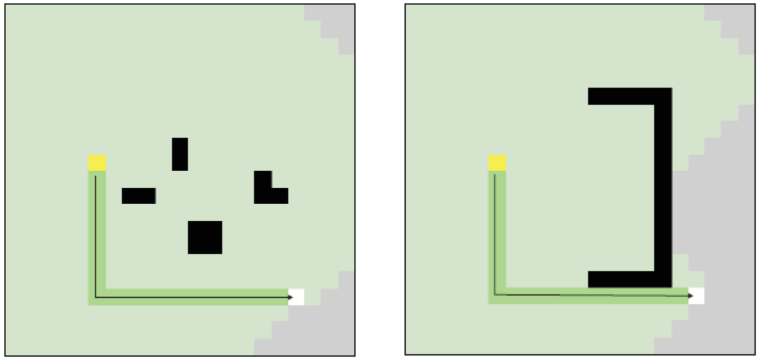
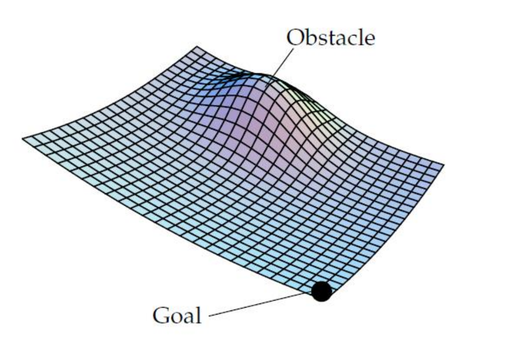


Figure 6.9: *Two examples of paths generated using Dijkstra's algorithm. The cells (nodes) that were checked during path generation are shown in light green, whereas the actual path is shown in dark green and with a solid line. The yellow cell is the start node and the white cell is the target node.*

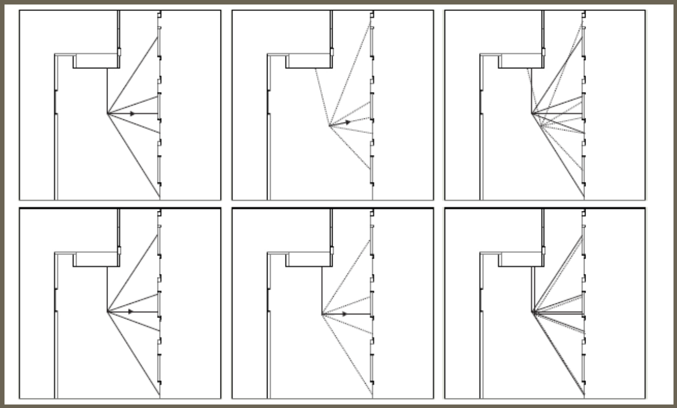
Course summary: Robot behaviors

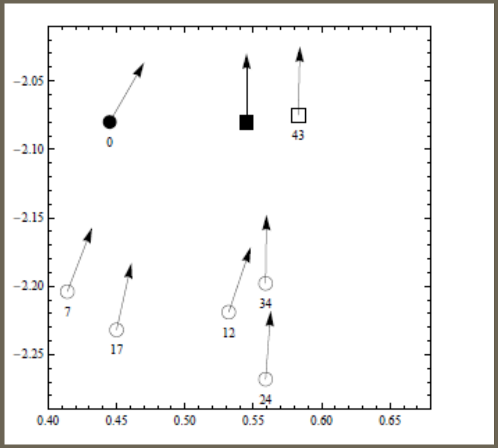
- Potential field navigation
  - Setting up a potential field
  - Obtaining the desired *direction*
  - Locking phenomenon
  - Using the method
    - Obtaining wheel speeds given the direction suggested by the potential field.



Course summary: Robot behaviors

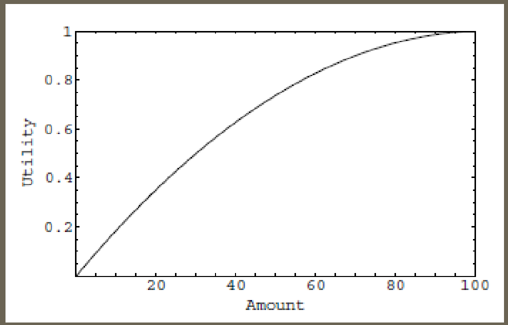
- Localization
  - Laser scan matching
  - Search method





Course summary: Utility

- The utility concept
- Properties of utility (functions, axioms)
- Computing utility values
- Rational decision-making – utility maximization
- Risk aversion
- You do not need to memorize the example regarding Stentor.



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Course summary: Decision-making

- Taxonomy
  - Arbitration methods
  - Cooperative methods
- The utility function method
  - Sensory preprocessing
  - State variables
  - Utility functions
  - Noise tolerance
  - Decision-making (utility maximization for motor behaviors)

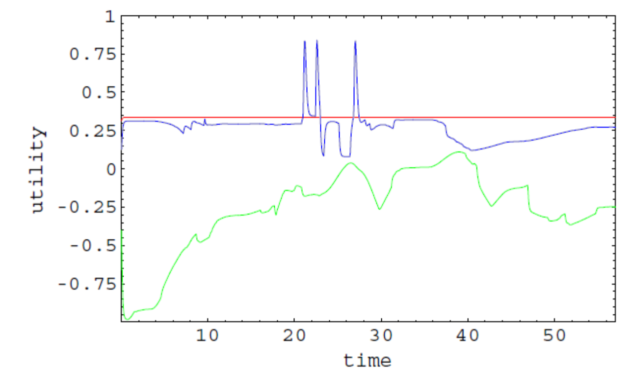

Figure 8.3: *An example of utility function dynamics, showing the variation (with time) of three utility functions u_1 (red), u_2 (green) and u_3 (blue).*

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Exam information

- A practice exam has been posted on the course web page.
- Please download and go through the problems in the practice exam.
- The actual exam will take place on **March 15, 14.00-18.00, M.**

About the exam

- Study Chapters 1-8 + slides + the literature references (links on the web page and in handouts)
- There will be *no programming problemts* (Matlab) in the exam.
- Types of problems
  - Definition and description of various concepts
  - Derivations
  - Computational problems
- The problems (of which there will be four or five) are not necessarily in increasing order of difficulty.

About the exam

- You are allowed to use a calculator, as long as it cannot store any text.
- You may ***not*** use lecture notes, slides, electronic forms of communication, papers from the course etc.

Fourth quarter preparations

- **<u>NOTE (Important!):</u>** It is mandatory to attend the lecture on Thursday (10th). At this lecture, groups will be formed for the work in the 4th quarter.
- *Those who do not attend will simply be placed in a group, without the possibility to choose group members*.
- See the course web page for a link to the page that will be used in the fourth quarter!
- Do not forget to return the robot after the fourth quarter!