Intelligent Robotics

Project and simulator

Thibaut Cuvelier

16 February 2017

Today's plan

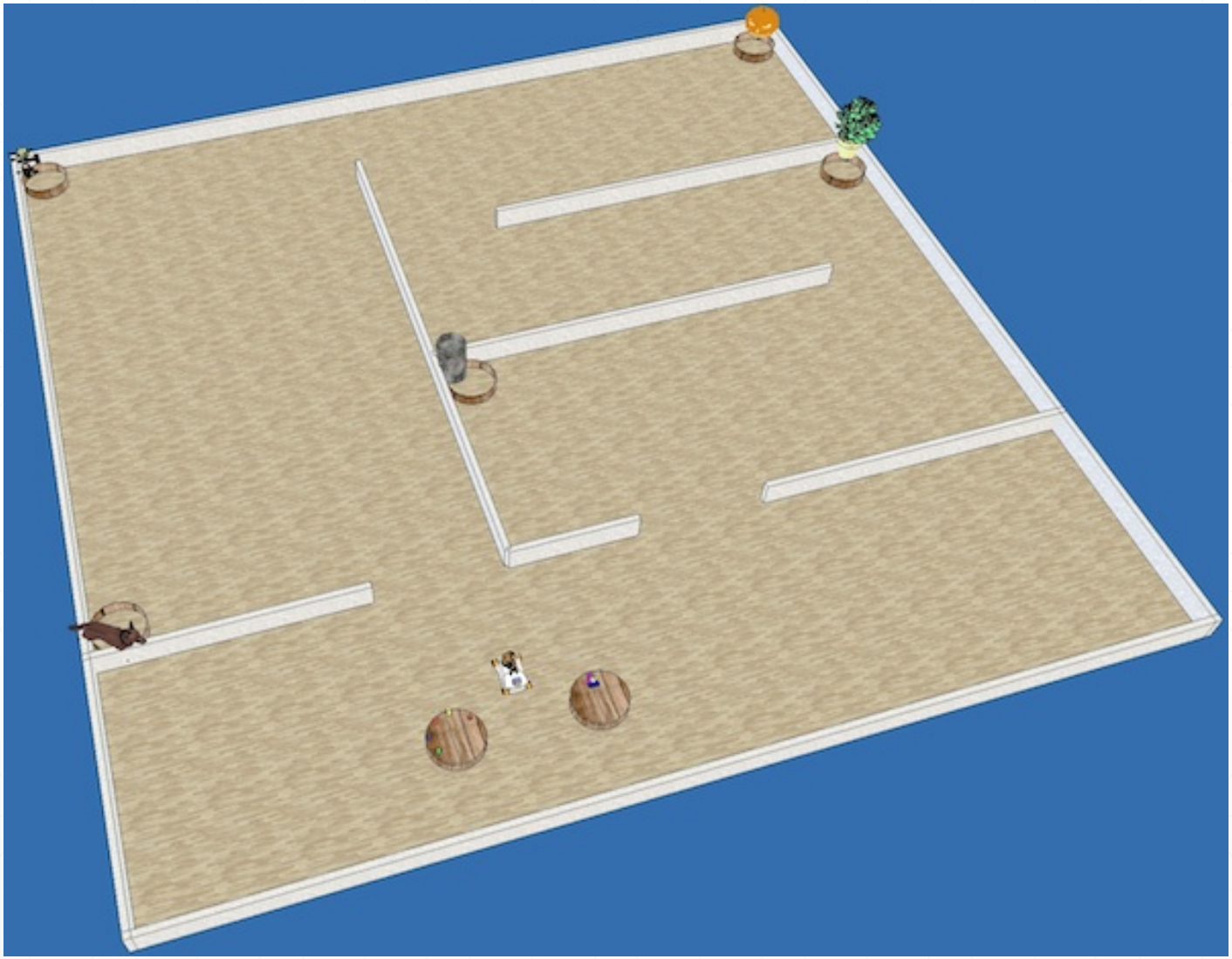
- Project details
- Introduction to the simulator
- MATLAB for the simulator

- http://www.montefiore.ulg.ac.be/~tcuvelier/ir

About the project

youBot

Your goal: deal with the groceries



Milestones

- The project is divided in a series of milestones
  - No need to do all of them!
  - Make choices based on what you prefer
- Broadly:
  - (A) Navigation
  - (B) Object manipulation
  - (C) Vision
  - (D) Manipulation with vision
  - (E) Calibration

First deadline: March 23

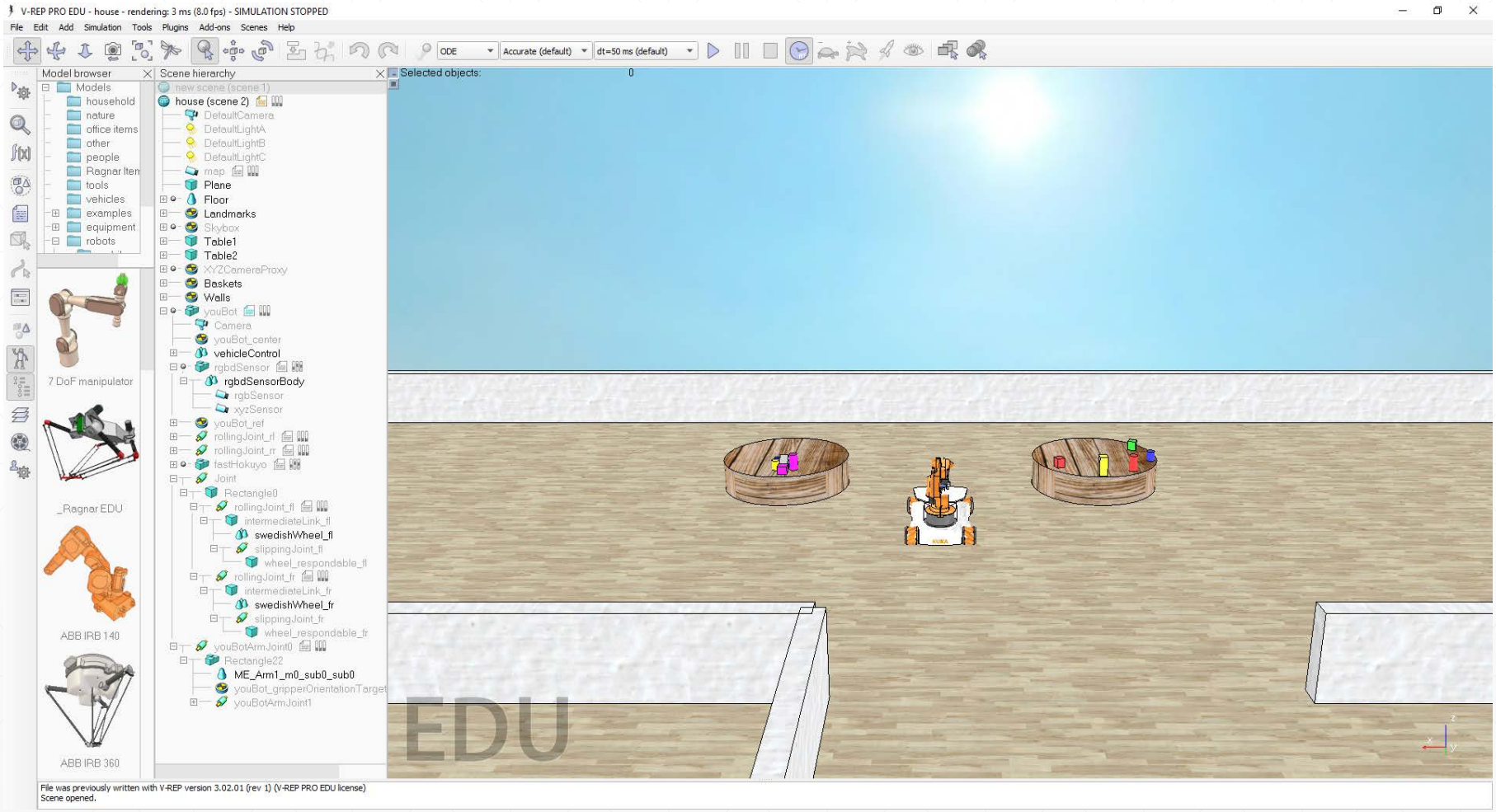
- Milestone A1: your robot moves and builds a map
  - You should prepare a small demo of your exploration
  - Roughly five minutes per group
- What we expect
  - “Basic” exploration: no need for something complicated
  - No time constraint: no need to complete exploration in 5 minutes
  - You can do more if you wish
- Schedule conflicts?
  - Contact us

Final deadline:
end of May, beginning of June

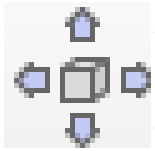
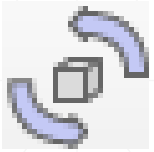
- Presentation of your whole project
  - A small report will be required
  - Oral presentation of your project
  - Think about videos if your code decides not to work
  - You may be asked to test your robot on **another** map
- More details later

Introduction to the simulator

Basic overview



Common manipulations

- Move an object: 
- Rotate an object: 
- Scaling an object: 
- **Caution**: any modification while the simulator is running is lost at the end of the simulation!

MATLAB for the simulator

Many functions available in the simulator

- You will be writing MATLAB code to interact with the robot
  - Set the speed of the wheels
  - Take a picture
  - Move the gripper
  - Get the position of the robot or one of its components
- See examples:
  - Complete example https://github.com/dourouc05/trs/blob/master/youbot/youbot.m
  - More focused and much shorter examples: https://github.com/dourouc05/trs/tree/master/youbot/focused

Many functions available, but not infinitely many

- Not all functions can be called: http://ulgrobotics.github.io/trs/project.html#api
  - For example: forbidden to move an object into the gripper
  - But you can use forbidden functions for your tests, of course

- A few functions are not allowed for given milestones Sometimes, not all arguments are allowed
  - For example, B4: you cannot use VREP IK to move the arm
  - Very natural restrictions

Many functions available outside the simulator

- When running the installer, Peter Corke's robotics and vision toolbox is automatically installed
  - Many useful functions for the project
  - Reference frame transformations, navigation, trajectories…
  - **Pay attention**: not always working as you would expect!
- If you have it: MATLAB Robotics Toolbox

Programming tips

- **Use an infinite loop**
  - Simulation goes on continuously for each iteration in this loop
  - Take actions at each iteration:
    - Set the speeds for the wheels
    - Plan your path through the room
    - Take a picture
    - Analyse a picture
    - …

```
while true
    % …
end
```

Programming tips

- **Use a state machine**, such as:

  State 1: Explore the map

  State 2: Go to the tables

  State 3: Pick an object

  State 4: Move to the corresponding basket

  State 5: Drop the object

  Back to state 2 until all objects are dealt with

- You can of course decompose further, embed state machines within some states, etc.

Debugging tips

- When you work on an image or a point cloud
  - First run a simulation and save the image/cloud to a file
  - Then develop your algorithm
  - Finally try the integrated code

  - Don’t tune a parameter, run the simulator, tune, run, etc. (Great loss of time!)

  - The samples show how to store an image and a point cloud
  - You can also use MATLAB’s `save` and `load` functions

How does the simulator work?

- The simulator uses a physics engine
  - Must be allowed to run often enough for realistic simulations

- Two impacts:
  - The simulator physics engine has an iteration every **50 ms**
    - Risk of overshooting

➢ Don’t approach waypoints at a too high speed

➢ Don’t rotate too fast

How does the simulator work?

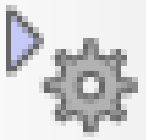
- The simulator uses a physics engine
  - Must be allowed to run often enough for realistic simulations

- Two impacts:
  - Your code **should run within 50 ms**
    - Otherwise: physics desynchronised from your measurements

➢ Use already optimised functions! (Or optimise your code)

➢ You can also precompute a few things

➢ If not enough: multiplication factor, non-real-time mode



How does the simulator work?

- The simulator uses a physics engine
  - Must be allowed to run often enough for realistic simulations

- Two impacts:
  - Sometimes, **strange robot behaviour**
    - Gripper closed, object falling
    - Robot wheels straight, but robot following a bended curve
    - Mostly due to numerical errors in the simulation

➢Dynamic steering!

Questions?

Installation

- Supposing MATLAB is installed
- Install V-REP PRO EDU: http://www.coppeliarobotics.com/downloads.html
- Install V-REP bindings for MATLAB: step 3 of http://ulgrobotics.github.io/trs/setup.html#install
- Clone or download the course's Git repository: https://github.com/dourouc05/trs
- Run the script startup_robot.m
  - Installs Peter Corke's toolbox
  - Sets MATLAB's path
  - Must be run each time you restart MATLAB!