COMP1730/COMP6730

Programming for Scientists

Functional abstraction, with robots

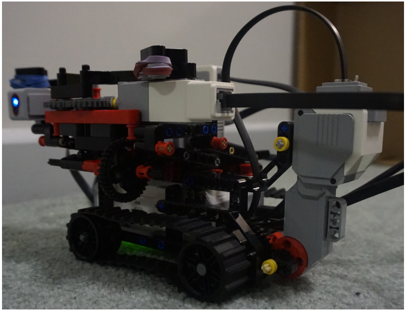
Reminders

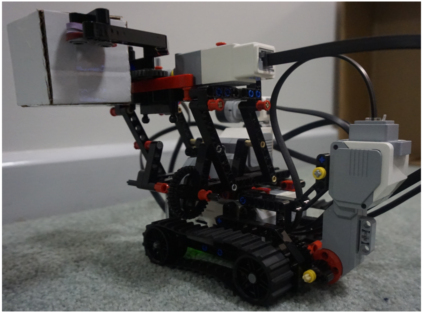
- Three important TODOs:
  - Fill in the Demographic Information Questionaire on wattle.
  - Sign up to a lab group (if not already allocated).
  - If you are on campus, log in to STREAMS before your first lab.
- Student course representative wanted.
- Read the news forum on wattle.

Lecture outline

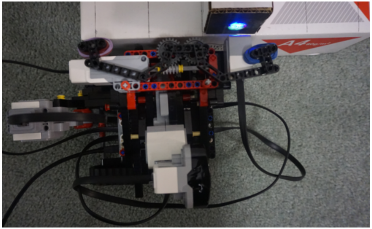
- **The warehouse robot**
- Importing modules
- Functional abstraction
- The python language: First steps

The robot





- Drive left/right along the shelf:



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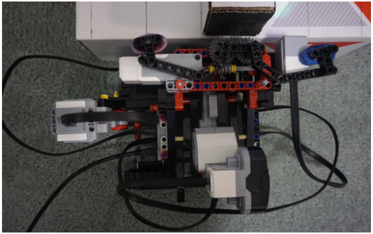
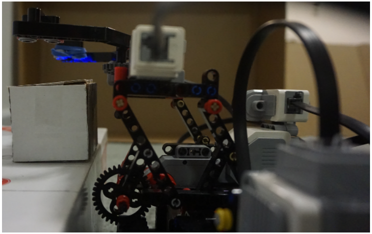


- Move lift up/down:



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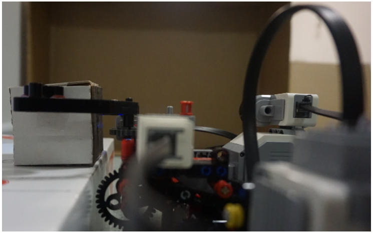
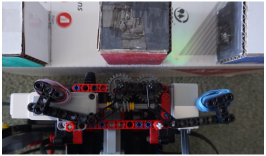
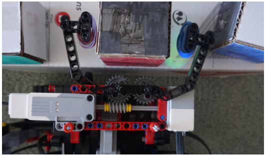


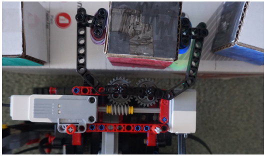
- Change position of the gripper:



folded



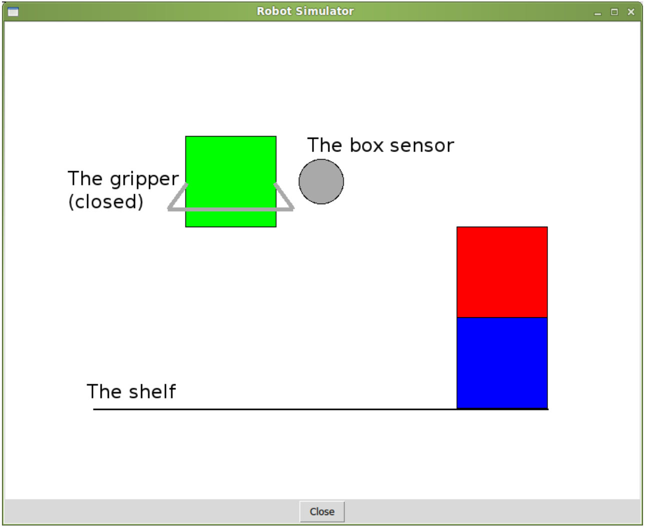
open



closed

- Moving sideways or down, the gripper may hit boxes if it is not folded.
- Folding/unfolding the gripper may hit boxes in adjacent stacks.

The robot simulator



```
>>> import robot
```

Start new simulation:

```
>>> robot.init()
```

Start simulation with larger area:

```
>>> robot.init(width = 11, height = 6)
```

Start simulation with random boxes:

```
>>> robot.init(width = 11, height = 6,
               boxes = "random")
```

Drive right/left one step:

```
>>> robot.drive_right()
>>> robot.drive_left()
```

Move the lift up one step:

```
>>> robot.lift_up()
```

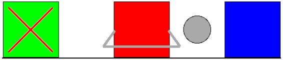
Move the lift down one step:

```
>>> robot.lift_down()
```

Change gripper position:

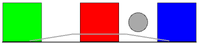
```
>>> robot.gripper_to_open()
>>> robot.gripper_to_closed()
>>> robot.gripper_to_folded()
```

- If the robot hits a box, no command works until a new simulation is started.



Programming problem

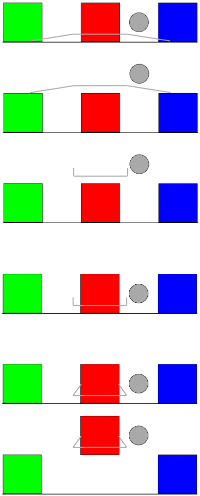
- How to pick up a box without hitting the box(es) next to it?



- How to pick up a box without hitting the box(es) next to it?

```
robot.lift_up()
robot.gripper_to_open()
robot.lift_down()
robot.gripper_to_closed()
robot.lift_up()
```

- A *program* is a sequence of instructions.



Lecture outline

- The warehouse robot
- **Importing modules**
- Functional abstraction
- The python language: First steps

Libraries, modules, namespaces

- *Library* is a generic term for a collection of (useful) functions, data structures, etc.
- In python, libraries are called *modules*.
- *Importing* a module,

```
import math
import robot
```

makes its content available to use.

- Imported names are prefixed with the module name, as in `math.pi`, `robot.lift_up`, etc.
  - They are placed in a separate *namespace* (more about namespaces later in the course).

- How does python find modules?
  - Standard modules (e.g., `math`) are installed in a specific location on the file system.
  - Non-standard modules (e.g., `robot`) must be in the *current working directory* (cwd).

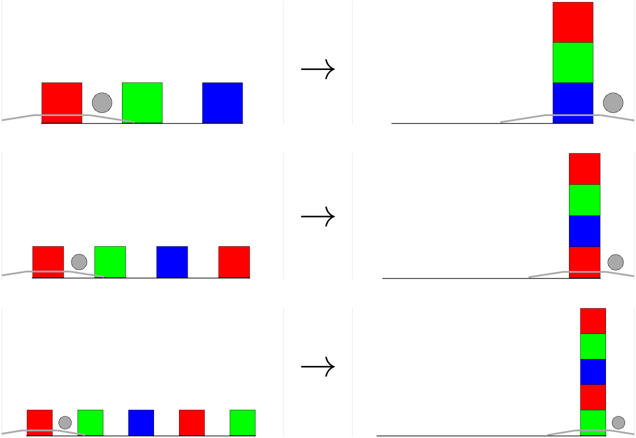
```
>>> import os
>>> os.getcwd()
’/home/patrik/teaching/python’
```

- When running a program, the cwd is (normally) the directory where the file is.

Lecture outline

- The warehouse robot
- Importing modules
- **Functional abstraction**
- The python language: First steps

Problem: Building a tower

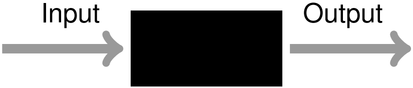


```
robot.init(width = 7, boxes = "flat")
robot.drive_right()
robot.lift_up()
robot.gripper_to_open()
robot.lift_down()
robot.gripper_to_closed()
robot.lift_up()
robot.drive_right()
robot.drive_right()
robot.gripper_to_open()
robot.lift_down()
robot.gripper_to_closed()
robot.lift_up()
robot.drive_right()
robot.drive_right()
robot.gripper_to_open()
robot.lift_down()
⋮
```

Functional abstraction

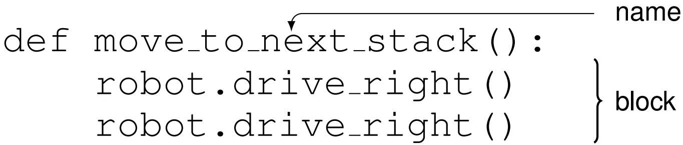
- In programming, a *function* (also known as “procedure” or “subroutine”) is a piece of the program that is given a name.
  - The function is *called* by its name.
  - A function is defined once, but can be called any number of times.

- Why use functions?
  - **Abstraction**: To use a function, we only need to know *what* it does, *not how*.
  - Break a complex problem into smaller parts.



“*Engineering succeeds and fails because of the black box*”
Kuprenas & Frederick, “101 Things I Learned in Engineering School”

Function definition in python



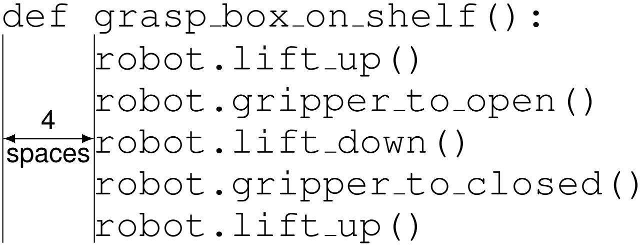
```
def move_to_next_stack():
    robot.drive_right()
    robot.drive_right()
```

name

block

- `def` is a python keyword (“reserved word”).
- The *function’s name* is followed by a pair of parentheses and a colon.
  - Inside the parentheses are the function’s parameters (more on this in coming lectures).
- The *function body* is the sequence of statements that will be executed when the function is called.

Function definition in python



```
def grasp_box_on_shelf():
    robot.lift_up()
    robot.gripper_to_open()
    robot.lift_down()
    robot.gripper_to_closed()
    robot.lift_up()
```

- In python, a suite is delimited by *indentation*.
  - All statements in the suite **must be preceded by the same number of spaces/tabs** (standard is 4 spaces).

Function definition in python

```
def release_and_pickup_next():
    robot.gripper_to_open()
    robot.lift_down()
    robot.gripper_to_closed()
    robot.lift_up()
```

- The `def` statement only *defines* the function – it does not execute the suite.
- The whole definition is itself a statement.

Building a tower of 5 boxes

```
robot.init(width = 9, boxes = "flat")
robot.drive_right()
grasp_box_on_shelf()
move_to_next_stack()
release_and_pickup_next()
move_to_next_stack()
release_and_pickup_next()
move_to_next_stack()
release_and_pickup_next()
move_to_next_stack()
robot.gripper_to_folded()
robot.lift_down()
```

Lecture outline

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Syntax

- The *syntax* of a (programming) language is the rules that define what is a valid program.
- A python program is a sequence of *statements*:
  - defining a function:

    ```
    def move_twice():
        robot.drive_right()
        robot.drive_right()
    ```

  - calling a function:

    ```
    move_twice()
    robot.lift_up()
    ```

  - importing a module: `import robot`
  - ...and a few more.

Whitespace

- Spaces, tabs and end-of-line are known as *whitespace*.
- The whitespace before a statement is called *indentation*.
- In python, whitespace has two special roles:
  - end-of-line marks the end of a statement (some exceptions, more later in the course);
  - indentation defines the extent of a *suite* of statements.
- Other than this, whitespace is ignored.

Permitted names in python

- A function name in python may contain letters, numbers and underscores (_), but must begin with a letter or undescore.

Allowed	Not allowed
moverighttwice	move right twice
move_right_2	2_steps_right
is_box_red	is_box_red?
imPort	import

- Reserved words cannot be used as names.
- Names are *case sensitive*: upper and lower case letters are not the same.

Comments

- A hash sign (#) marks the beginning of a *comment*; it continues to end-of-line.

```
robot.init(width = 7) # use a wider shelf
# grasp the first box:
robot.lift_up()
...
```

- Comments are ignored by the interpreter.
  - Comments are for *people*.
  - Use comments to state what is not obvious.
- If it was hard to write, it's probably hard to read. Add a comment. (Punch & Enbody, Rule 6)

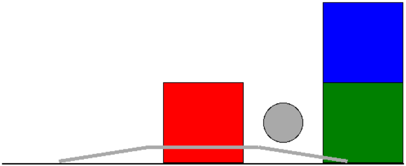
- Write comments to describe *what* a function does, and *when* it should be expected to work.

```
# Pick up a box from the shelf, without
# hitting adjacent boxes.
# Assumptions: The robot (gripper) is in
# front of the box; the gripper is folded
# and the lift is down.
def grasp_box_on_shelf():
    ...
```

Testing and debugging

Test, test, test

- How do we know our program works?
  - Specify the assumptions under which the program (or function) is meant to work.
  - Test it with a variety of cases that fall under those assumptions.
  - Particularly, “edge cases”.



Errors

```
Traceback (most recent call last):
  File "stack-3-v1.py", line 35, in <module>
    robot.lift_up()
  File "/.../robot.py", line 40, in lift_up
    _robot.lift_up()
  File "/.../robot.py", line 600, in lift_up
    + " and can't go any higher!")
robot.RobotError: Robot Error: The lift is at
level 1 and can't go any higher!
```

- Errors will happen.
- Read the error message!

- Some common errors:
  - `SyntaxError`:
    You have broken the rules of python syntax.
  - `NameError` or `AttributeError`:
    You have used a (function) name that doesn’t exist. Check for typos.
  - `IndentationError`:
    Too much or too little indentation.
    - All statements in a function suite must have the same indentation.
    - All statements outside function definitions must have no indentation.