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COMP1007
Imperative Programming
Part I

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Imperative...

imperative — expressing command; commanding, peremptory; urgent; obligatory.

- An imperative program is a sequence of commands.
- Let's explore this.

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Some commands

- Assume a simple robot can obey the following commands:
  - *forward()* - move 50 cm forward.
  - *left()* - turn left.
  - *right()* - turn right.
- The robot is instructed to move using a program statement like:

```
robot.forward();
```


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More robot commands

- The robot can also be asked questions:
  - *atDoor()* – answer true if the robot is next to a door (in front, left or right), false otherwise.
    - (The robot has a detector triggered when close-by a small transmitter attached to the door.)
  - *canMoveForward()* – answer true if the robot can move forwards, false otherwise.
    - (The robot has a sensor switch on its front bumper.)

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A very simple program

```
robot.forward();
robot.right();
robot.forward();
robot.right();
robot.forward();
robot.right();
robot.forward();
```

Note the punctuation. Each statement is terminated by a semi-colon.

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How do we know what the robot does?

- Each statement has a well defined meaning.
- Each statement is carried out in the order given by the written sequence.

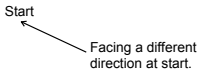
Of course, we assume there are no unexpected problems, like a hole in the floor!

Same statements, different sequence

```
robot.forward();
robot.forward();
robot.right();
robot.forward();
robot.right();
robot.right();
robot.forward();
```


Same program, different starting state

```
robot.forward();
robot.forward();
robot.right();
robot.forward();
robot.right();
robot.right();
robot.forward();
```



Going to the door

```
robot.forward();
robot.forward();
robot.forward();
robot.right();
robot.forward();
robot.forward();
robot.left();
robot.forward();
```

Start

Easy - Problem solved??

What if ?

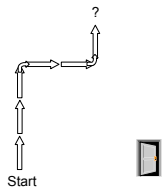
… the robot starts off facing in a different direction?

… the robot is put in a different starting position or a different room?

… the door moves?

The program context

- The program only solves the problem (getting to the door) in very specific circumstances.
- Change the circumstances, rewrite the program…



Too much hard work!

- In fact, you have to do all the work of solving the problem.
- The robot just does exactly what you command it to.
- No way! Let's get the robot to do some of the hard work.

What we would really like

- A program that can guide the robot to the door in any room, starting in any position.
- A program that doesn't have to be changed for every specific context.

Help!! That's hard to do...

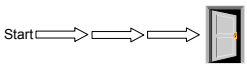
Too hard – simplify

- Let's try to solve a simpler problem first.
- If we can solve that, hopefully we can learn more about solving the harder problem.

- Strategy: Look for a sub-problem and solve it first.

First go

- Assume the robot is always facing in the direction of the door.
- Assume there are no obstacles between the robot and the door.



Easy?

- Program is just: robot.forward(); robot.forward(); robot.forward()…
- But how many forwards?
- Depends on how far away door is.
- Snag: we still have to change the program for every start position.

Solution

- We need to able to say: "Keep moving forward while you have not reached the door".
- But we need additional commands to do this.

A While Loop

```
while (!robot.atDoor())
{
    robot.forward();
}
```

Loop Body

- Called a "loop" as it loops around!
- Keep looping while a condition is true.

Details

- while is a sequencing command providing iteration or repetition.
- atDoor performs a test that has a boolean value.
- ! meaning not, is a logical operator that is applied to a boolean value.

A Result!

- We now have a program that will move the robot to the door, regardless of the starting position.
- Providing it is facing the door.
- Providing there are no obstacles.

A Harder Problem

- We've solved our simple problem, so let's make it a bit harder and see what happens.
- Assume robot can start facing any direction.
- Assume robot is in a room with four walls, one door and no obstacles.

Brainstorming!!

An idea!!

Try another program

```
while (robot.canMoveForward())
{
  robot.forward();
}
robot.right();
while (robot.canMoveForward())
{
      … Hmmm, what happens here?
}
```

Rethink…

Find an example that fails

Examine evidence…

Try again

How about?

Wow!

- Iteration allows a more general purpose program to be written.
- We have a program that will work in any empty room.
- (Providing all our assumptions remain true.)
- What about testing the code – does it *really* work…

Obstacles

- An unexpected pile of bricks…

- Need to divert round the bricks.
- Any need to change the program?
  - Suggestions…

Questions?

Selection

- Suppose the floor is covered in tiles of different colours.
- If robot is on a red tile its red light turns on.
- If robot is on a blue tile its blue light turns on.
- If robot is on white tile no lights are on.

If...

- We want to say:
  - "If the tile is red, then show red"
  - "If the tile is blue, then show blue"
  - "If the tile is white, then show no light"
- A selection command is needed.
  - And commands to check tile colour.

Let's Try...

```
while (!robot.atDoor() && robot.canMoveForward())
  {
     robot.forward();
     if (robot.onRed())
     {
       robot.turnOnRed();
       robot.turnOffBlue();
     }
     etc.
     …
```

An if statement

New Commands

- The robot needs:
  - onRed, onBlue and onWhite to check tile colours.
  - turnOnRed, turnOffRed, turnOnBlue, turnOffBlue to control lights.

Results

- We can now write a program to get the robot to find the door of a room.
- And flash its lights as it moves around.
- We've discovered iteration and selection as being fundamentally necessary to get things working.
- And discovered a set of commands the robot needs to understand.

Language v. Robot

- While loops and if statements are part of the programming language.
  - They are basic language features.
- Moving, testing for door, controlling lights are part of the robots behaviour.
  - Not part of the programming language.

Questions?

Remember – Java and Objects

- Java is object-oriented, so you will encounter many software objects and soon be creating your own.
- You have already seen out
  - System.out.println("hello");
- And g
  - g.drawLine(…);

Objects

- Our robot is really a software object.
- It has an external interface.
  - The actions you ask it to perform.
- And an internal implementation.
  - The code that does the work, but which you don't see.

Objects and Methods

```
robot.forward();
```

- robot is the name of the object.
- forward() is a method call.
  - We use the name method rather than command or action.
- The robot is instructed what to do but actually performs the actions itself.

Methods

- Each method is a sequence of program statements.
- A robot has a collection of methods, each of which is a different statement sequence.
- Hence, statements are grouped into units rather than being one big long list.

Responsibilities and Collaborations

- We can also take the point of view that the robot has responsibilities:
  - To move, to test, to control lights.
- And collaborations:
  - To ask other objects about the floor colour and location of walls and doors.

Questions?

Core Language Statements

- The statements (if, while, etc.) we use need to be at the right level of detail.
- Too low level – too awkward to work with.
- Too high level – can't express the amount of detail needed.

Abstraction

- abstraction:
  - A representation or model that includes the important, essential or distinguishing aspects of something while suppressing or ignoring less important, immaterial or diversionary details.
  - Removing distinctions to emphasise commonality.

Choosing the right abstractions

- Our basic commands, selection and iteration are all abstractions of behaviour.
- They represent the lowest level of abstraction that we generally want to work with.
- (We can go lower – assembly language programming or even direct binary coding…)

Creating new abstractions

- Programming relies heavily on using and creating abstractions.
- As programs get larger we have to create new abstractions to manage the huge amount of detail involved.
- The robot object is a higher-level abstraction constructed from programming language abstractions.

Further thoughts...

- We have seen programs with the basic structure of:
  Start -> Do the work -> Stop
- Where we explicitly expect the program to run to a pre-determined conclusion.
- Are all programs like that?

Programs that stop?

- The robot “find the door” program may never stop...
  - but that would be a flaw that requires the program to be fixed.
- What about the drawing programs? How do they stop?
- What about a word processor?
- Or the control system in a car?

Run for ever...

- In fact, many kinds of programs are designed to run continuously until the user explicitly stops them.
- If the program stops any other way something has gone wrong...

The main loop

- Consider this overall program structure:

```
while (true)
{
   doWork();
   if (userQuits())
   {
      stop();
   }
}
```


Event driven

- Loop forever, responding to events.
- Events are mouse clicks, key presses, timer and so on.

```
while (true)
{
   waitForEvent();
   handleEvent();
   if (userQuits())
   {
      stop();
   }
}
```

And the drawing programs?

- Your drawing programs are actually event driven, with a main loop.
- You don't see that explicitly – it comes for free as part of the infrastructure of the Java code libraries.

The Graphical User Interface (GUI)

- All programs that use windows, the mouse and so on, have a GUI.
- These programs are all event driven, with a main loop.
- They are designed to keep running for ever until you tell them to stop.

Event loop means GUI?

- No. An event driven program doesn't need a GUI.
- Consider control systems (in a car, plane, lift, ATM machine).
- They run continuously, responding to events, until explicitly stopped.
  - Or the power is cut off.

Summary

- Sequence, iteration, selection.
- Problem solving by decomposing a large problem into simpler smaller problems.
- Starting to think about abstraction.
- The main loop and event driven programming.