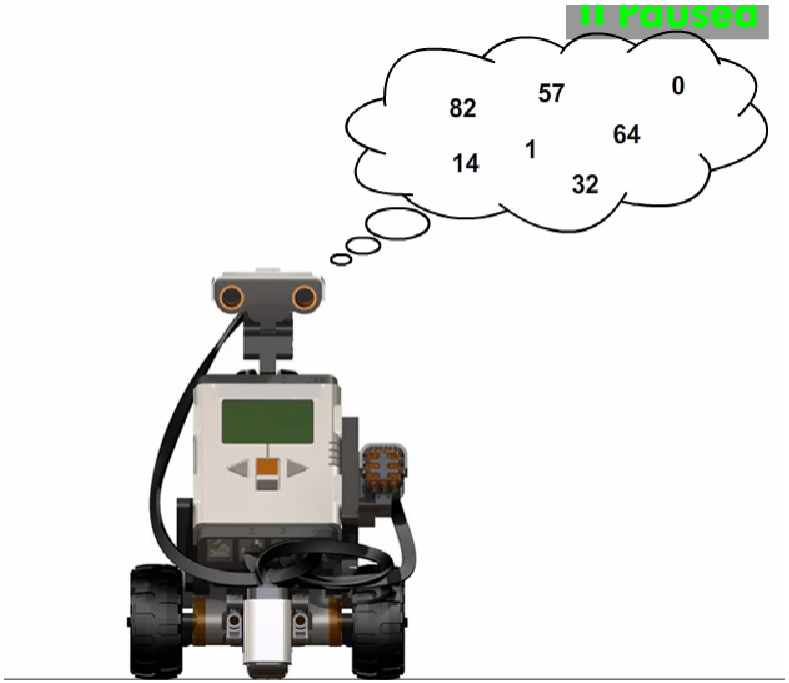
CISC 1003 - EXPLORING ROBOTICS

ROBOT DECISION MAKING

CISC1003

How a Robot Thinks

- Robot can ‘learn’ the world using their sensors
- Sensors return data in number format



http://cmra.rec.ri.cmu.edu/previews/nxt_products/nxt_video_trainer2/

How a Robot Thinks

- The robot can answer ‘yes’ or ‘no’ questions
- Example:
  - Is the touch sensor bumped?
  - Is the audio level in the room above 50%?
- This ability is based on a special logic
  - Called ‘***Boolean logic***’

How a Robot Thinks

- Programmers can give the robot its decision-making capability
  - By combining the numbers provided by the sensor with robot ability to answer questions
- This requires the following:
  - Robot is programmed to ask questions
  - Act one way if the answer is ‘yes’
    - and another if the answer is ‘no’

How a Robot Thinks

- Boolean operators are used when asking the questions, such as:
  - < ‘less then’ ,
  - > ‘more than’,
  - == “equal to’
  - etc.

How a Robot Thinks

- Example: We want the robot to stop moving before it runs into a wall
  - Use the feedback from an ultrasonic sensor
  - Use ‘less than’ operator
    - with a certain distance threshold
      - E.g., 10 inch
- This will result in a program that moves the robot until it detects an obstacle
  - Within the distance specified (10 inch)

How a Robot Thinks

- How does the program work?
- The robot moves forward
- It repeatedly asks the questions:
  - “Am I 10 inch away from anything?”
- If the answer is no, the robot continues moving forward
  - If the answer is ‘yes’, it stops

Conditional Statements

- The parts of the program where the robot choose an action
  - Depending on a certain condition

Summary

- We can create conditional statements
  - by combining sensor output and Boolean operators
- This allows the robot to make decisions

How a robot thinks

- What kinds of questions can a robot ask?
  - “yes” or “no” questions
  - Questions that have only two possible answers
- What can a robot do with the answer to the question?
  - Use the answers to choose between two different actions
    - E.g., move forward or stop


QUESTIONS

RSVP: ROBOT SCENARIO VISUAL PLANNING

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Exploring Robotics

RSVP: ROBOT SCENARIO VISUAL PLANNING

- Making a picture or a “visual representation” of the scenario and instructions you want the robot to perform
  - can be great way to ensure your robot performs the tasks properly
- A picture of the instructions the robot will perform allows you to think through the steps before translating them to the code

RSVP: ROBOT SCENARIO VISUAL PLANNING

- The RSVP is composed of three types of visuals:
  - A floorplan of the physical environment of the scenario
  - A statechart of the robot and object's states
  - Flowcharts of the instructions for the tasks

Mapping the Scenario

- The first part of the RSVP is a map of the scenario
- A map is a symbolic representation of the environment
  - where the tasks and situations will take place
  - The environment for the scenario is the world in which the robots operate

Mapping Example

A robot world for NXT Mindstorms Test Pad

*Robot Programming: A Guide to Controlling Autonomous Robots, C. Hughes and T. Hughes

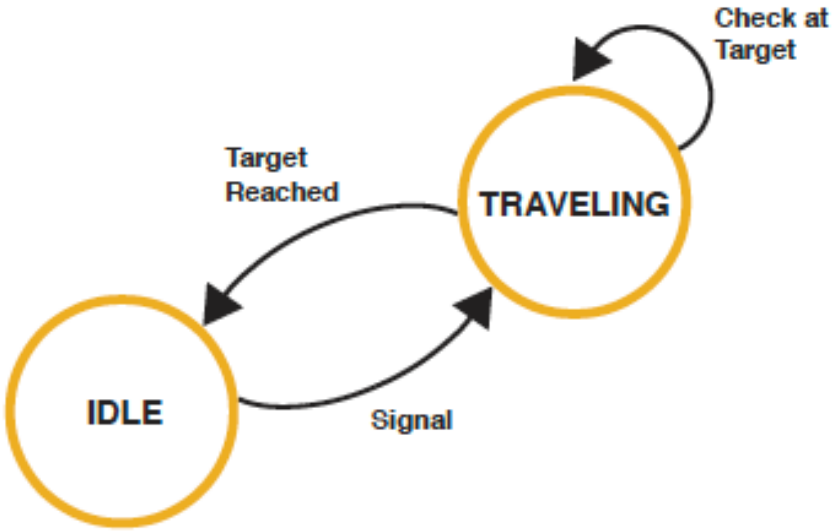
State Chart

- A statechart is one way to visualize a state machine.
- For example , a “change of state” can be as simple as a change of location.
  - When the robot travels from its initial location to the location next to the table, this is a change of the robot’s state.
  - Another example is that the birthday candles change from an unlit state to a lit state.

State Chart

- The state machine captures the events, transformations, and responses.
- A statechart is a diagram of these activities.
- The statechart is used to capture the possible situations for that object in that scenario

Example – State Machine



* Robot Programming: A Guide to Controlling Autonomous Robots, C. Hughes and T. Hughes

Pseudocode and Flowcharting

- Flowcharts are a type of statechart
  - they contain states that are converted to actions and activities
    - Things like decisions and repetitions are easily represented
      - what happens as the result of a branch can be simply depicted.
  - Some suggest flowcharting before writing pseudocode

Pseudocode and Flowcharting

- Pseudocode has the advantage of being easily converted to a programming language or utilized for documenting a program
  - It can also be easily changed.
- A flowchart requires a bit more work to change when using flowcharting software.

PseudoCode

- What is the problem we are trying to solve?
  - Identify the behavior you need
  - Write down the sequence of behaviors that is needed
    - To achieve your goals
  - Identify the sub-tasks needed to achieve your goals

Pseudocode

- As we increase the level of details, we will reach commands we can express directly in programming language
- This is the plan the robot needs to follow
- The steps are written in English
  - So can be understood by the human programmer
- This is called *Pseudocode*

Pseudocode Example

```
task main()
{
 while ( touch sensor is not pressed )
  {
    Robot runs forward

    if (sonar detects object < 20 cm away)
    {
      Robot stops

      Robot turns right
    }
  }
}
```

Pseudocode and Flowcharting

RSVP Type	Advantages	Disadvantages
Pseudocode: A method of describing computer instructions using a combination of natural language or programming language.	Easily created and modified in any word processor. Implementation is useful in any design. Written and understood easily. Easily converted to a programming language.	Is not visual. No standardized style or format. More difficult to follow the logic.
Flowcharting: Flow from the top to the bottom of a page. Each command is placed in a box of the appropriate shape, and arrows are used to direct program flow.	Is visual, easier to communicate to others. Problems can be analyzed more effectively.	Can become complex and clumsy for complicated logic. Alterations may require redrawing completely.

Flowcharting

- The four common symbols used in flowcharting are:
  - Start and Stop
  - Input and output
  - Decisions
  - Process

Flowcharting

- Start and stop:
  - The start symbol represents the beginning of the flowchart with the label “start” appearing inside the symbol.
  - The stop symbol represents the end of the flowchart with the label “stop” appearing inside the symbol. These are the only symbols with keyword labels.
- Input and output:
  - The input and output symbol contains data that is used for input (e.g., provided by the user)
    - and data that is the result of processing (output)

Flowcharting

- Start and stop:

  - The start symbol represents the beginning of the flowchart
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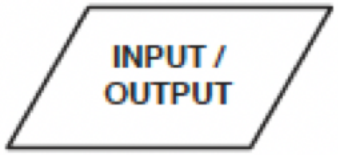
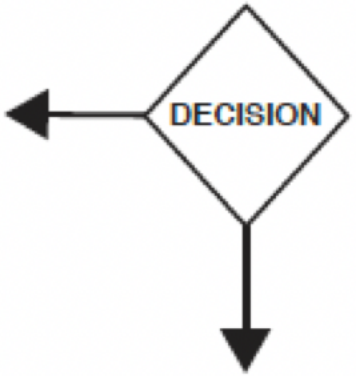
Flowcharting

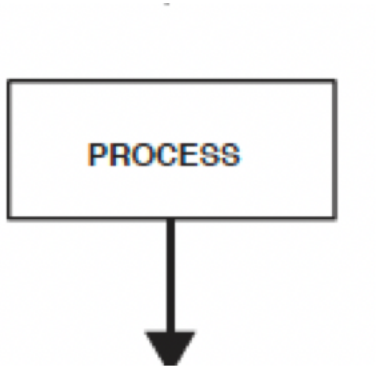


- Input and output:
  - The input and output symbol contains data that is used for input (e.g., provided by the user)
    - and data that is the result of processing (output)
- Decisions:
  - The decision symbol contains a question or a decision that has to be made.

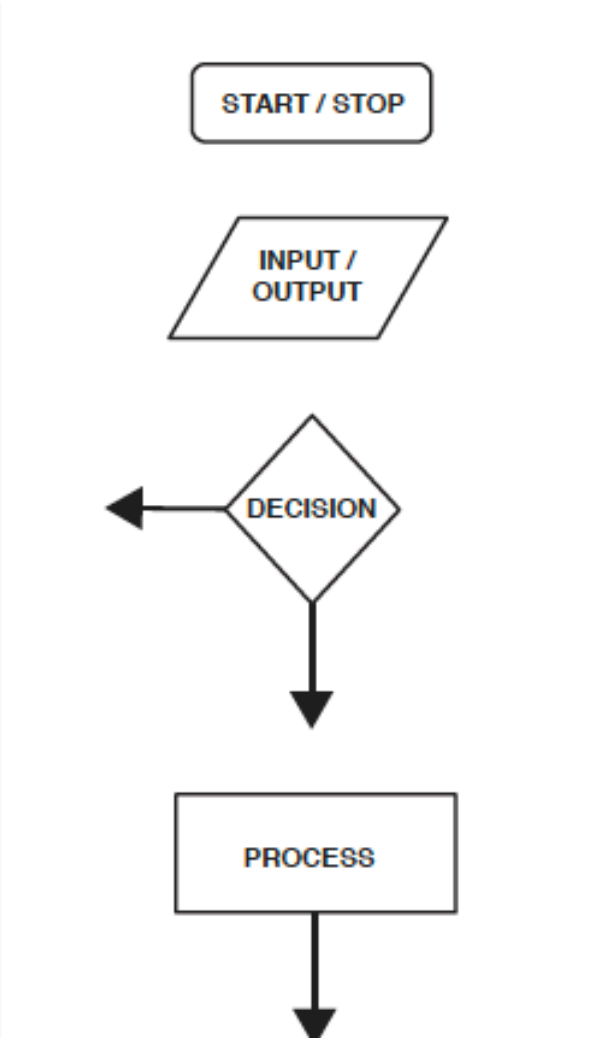


Flowcharting

- Process:
  - The process symbol contains brief descriptions (a few words) of a rule or some action taking place .



Common Flowchart Symbols



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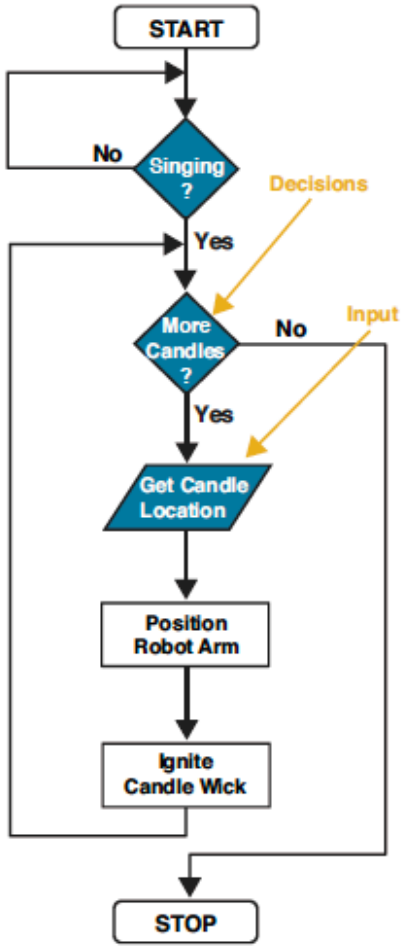
Example - Candlelighting Flowchart



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Flowcharting

- The task a robot executes can be a series of steps performed one after another
  - a sequential flow of control.
- ***Flow of control*** details the direction the process takes
  - which way program control “flows
- Flow of control determines how a computer responds
  - when given certain conditions and parameters

Example: Sequential Flowchart

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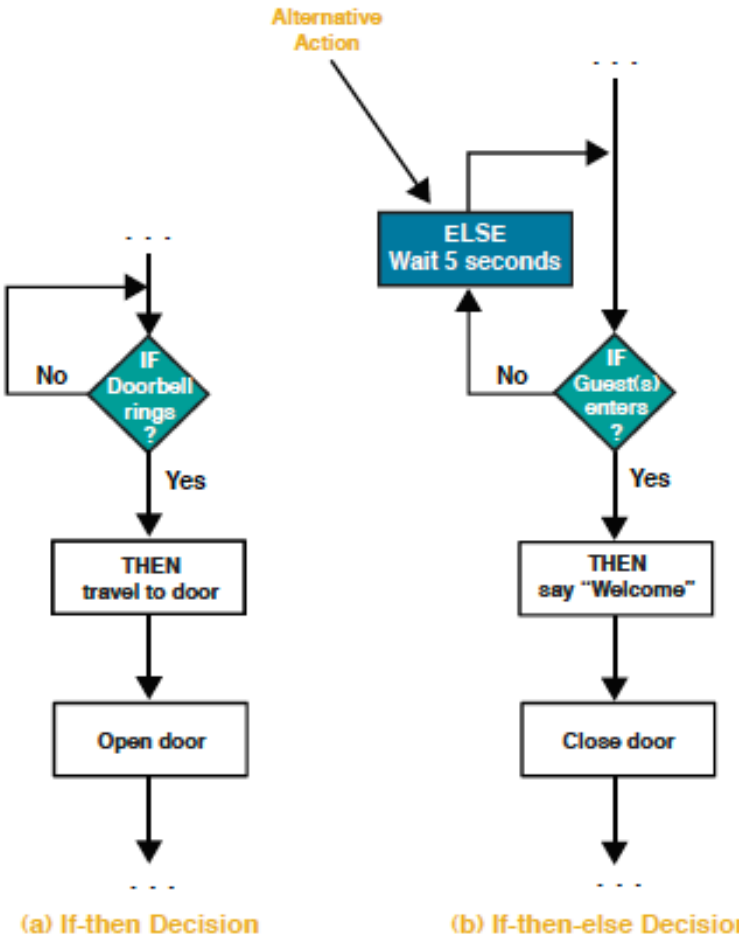
Flowcharting

- A decision symbol is used to construct branching for alternative flow controls.
- Decision symbols can be used to express decision, repetition, and case statements
- A simple decision is structured as an if-then or if-then-else statement

Example – Guest Welcoming Flowchart



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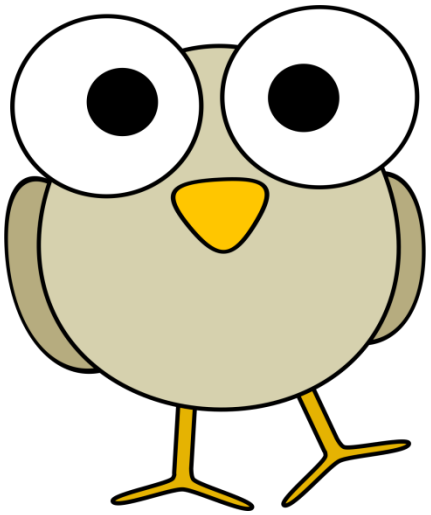
Summary

- The RSVP is composed of three types of visuals:
  - A floorplan of the physical environment of the scenario
  - A statechart of the robot and object's states
  - Flowcharts of the instructions for the tasks
- These visuals ensure that you have a "clear picture" of what has to be done
  - to program a robot to save the world
    - or light the candles on a cake

- Questions?



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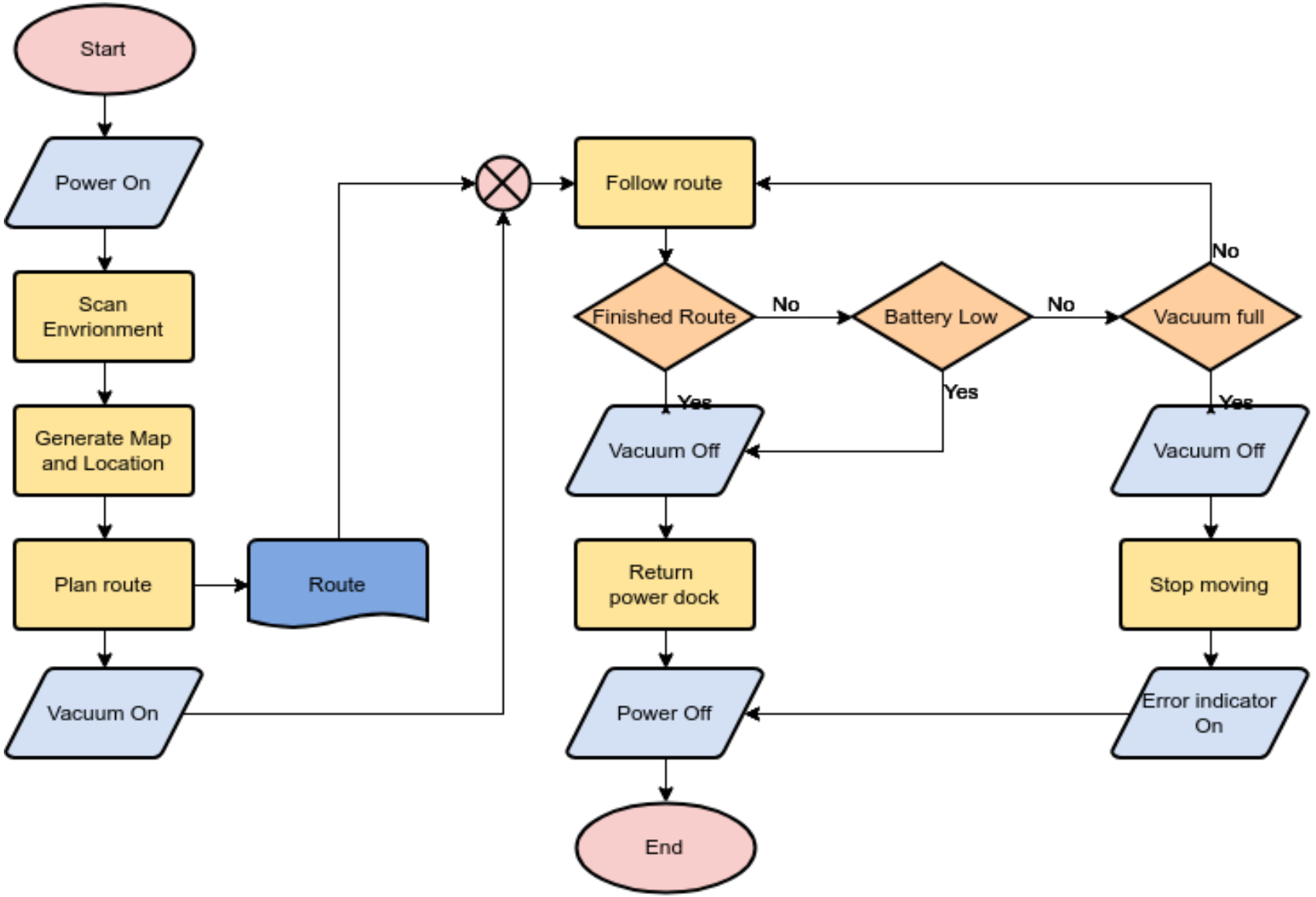
Flowcharts

- https://www.youtube.com/watch?v=kxZJv56BxU8

Flowcharts

- The friendship algorithm

Vacuum Robot Flowchart Example



Sample Program

- Robot moves as long as a touch sensor is not pressed
  - But stops and turns to the right if its sonar detects an object less than 20cm away

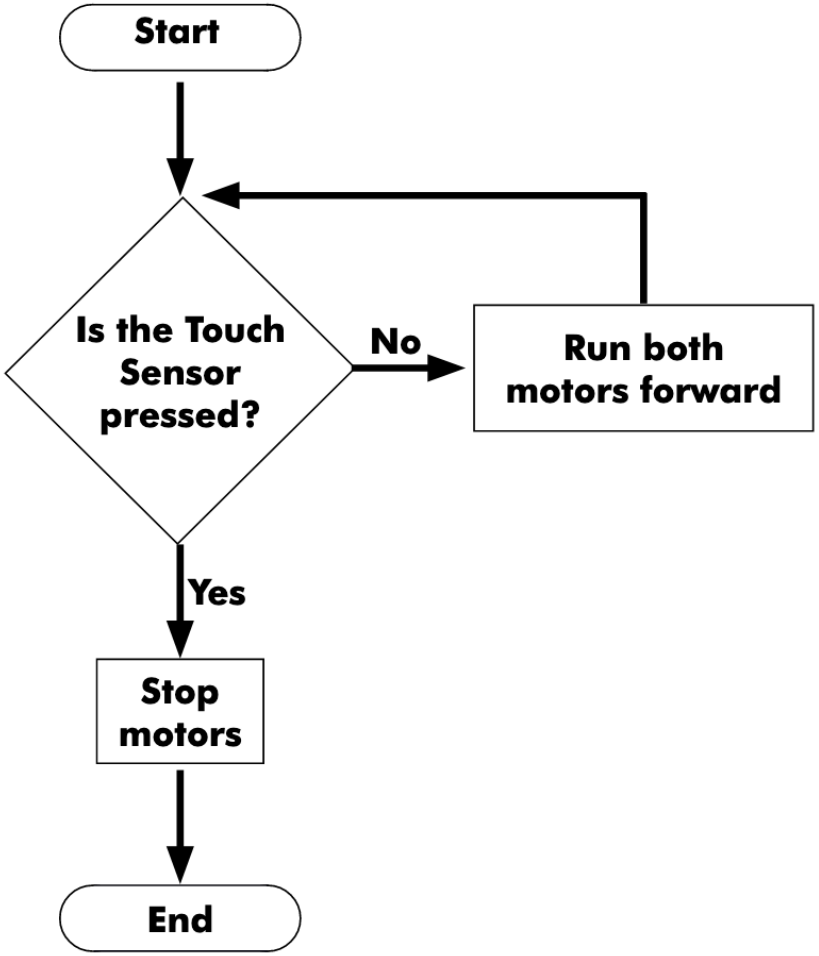
Pseudocode Example

```
task main()
{
 while ( touch sensor is not pressed )
  {
    Robot runs forward

    if (sonar detects object < 20 cm away)
    {
      Robot stops

      Robot turns right
    }
  }
}
```

Flowchart Example

- Robot moves forward as long as its touch sensor is not pressed
  - When the touch sensor is pressed the motors stop and the program ends
- How would you create a flowchart for this program?

Flowchart

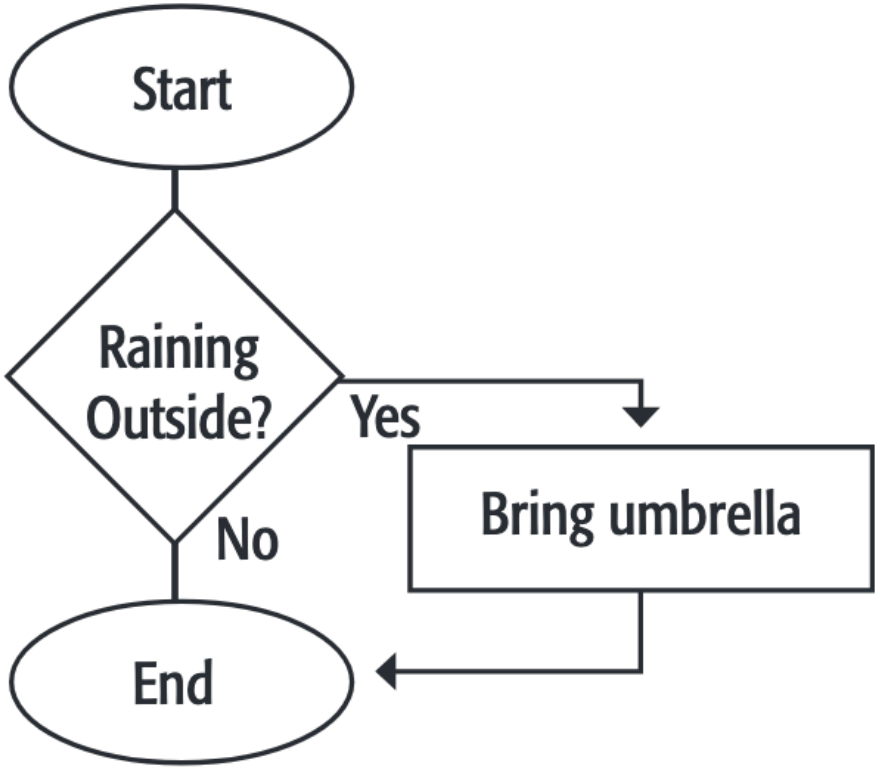


http://cdn.robotc.net/pdfs/nxt/reference/hp_pseudo_flow.pdf

Flowchart Example 2

- If it’s raining, bring an umbrella

Flowchart Example 2

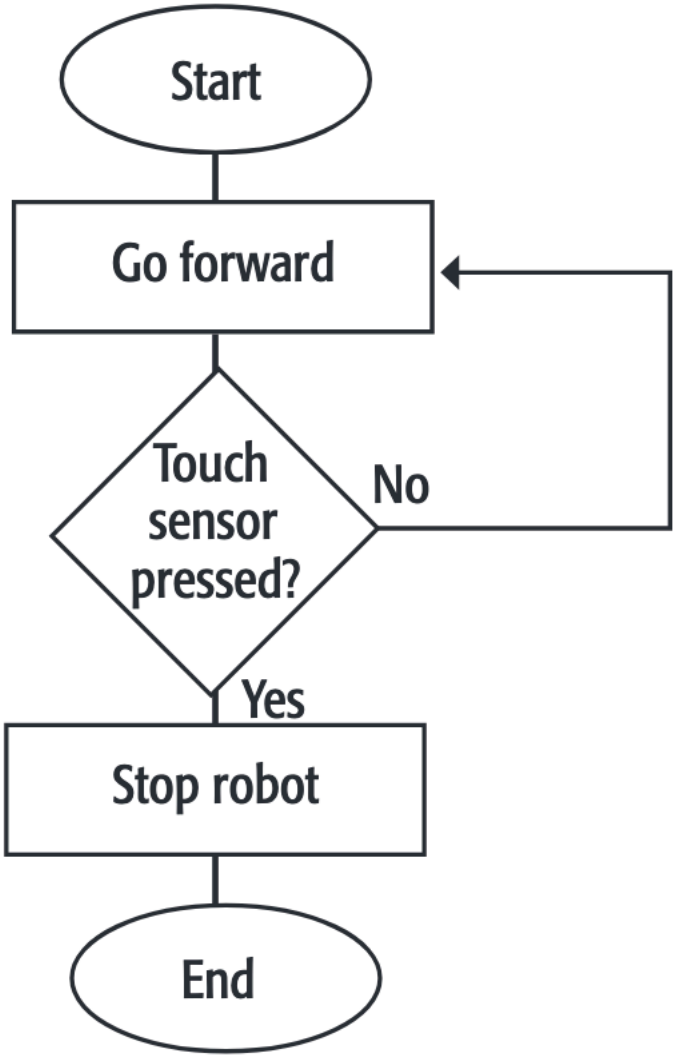


http://cmra.rec.ri.cmu.edu/products/vex_easy_c/programming/logic/Flow_Charts.pdf

Flowchart Example 3

- Go forward until the Touch Sensor (on port 1) is pressed in, then stop

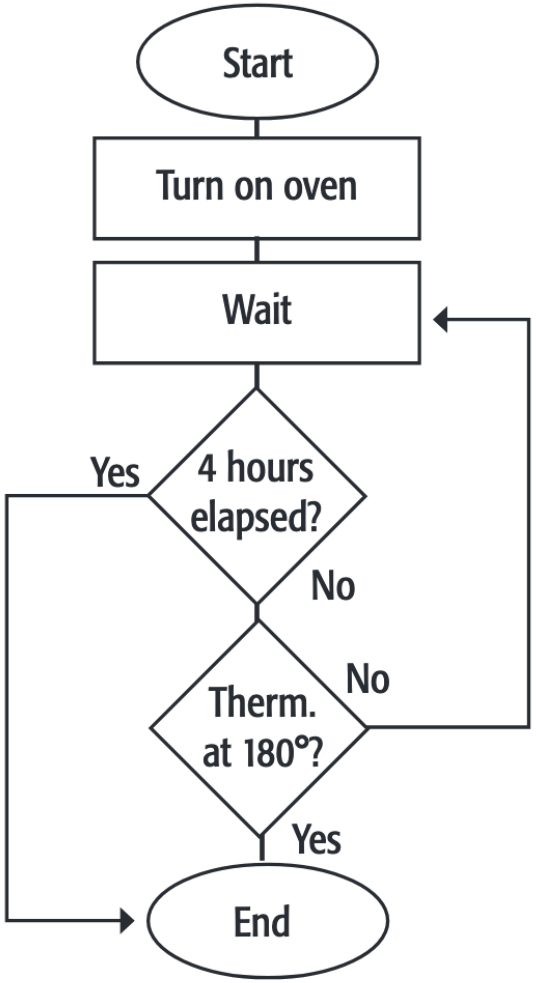
Flowchart Example 3



Flowchart Example 4

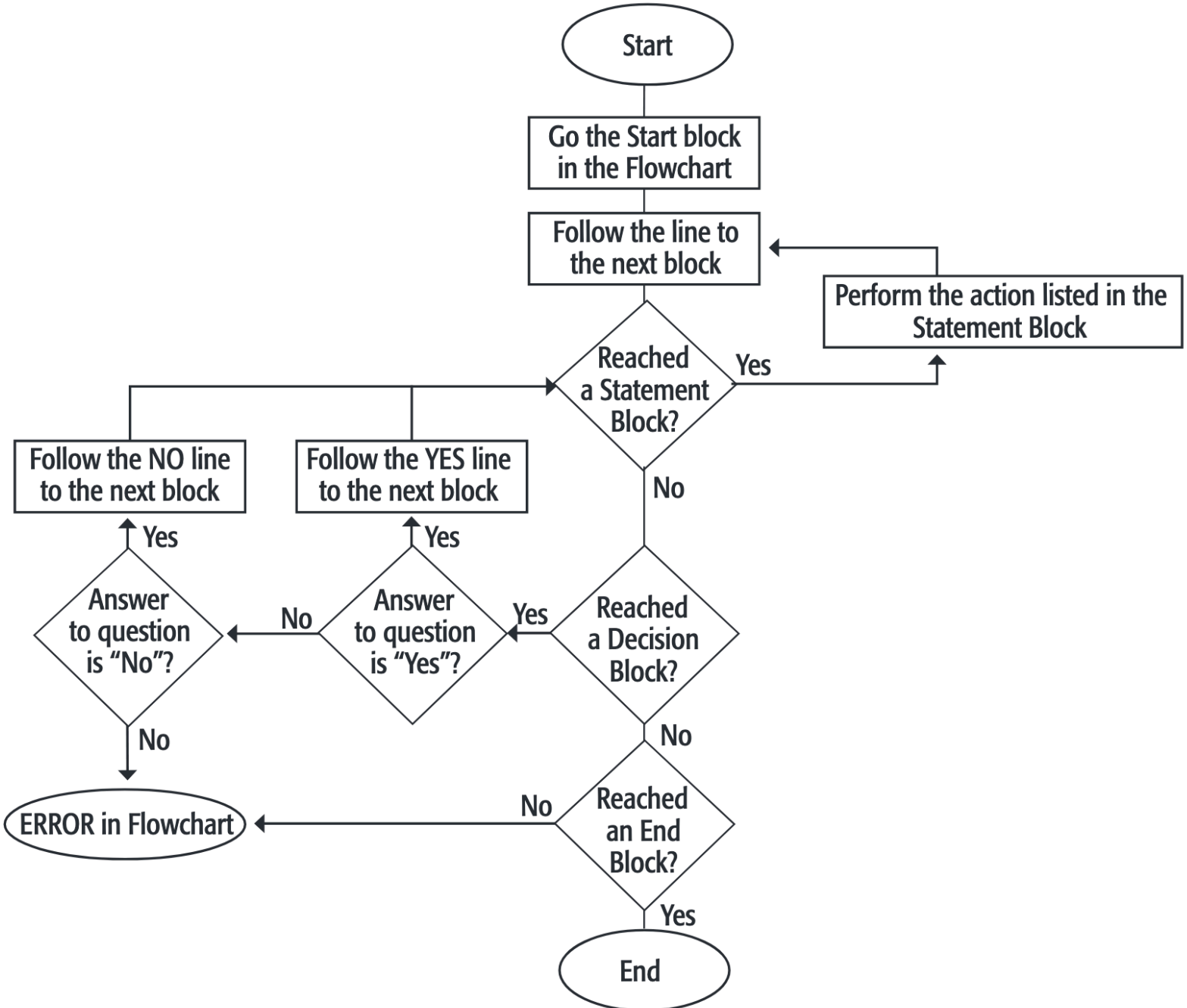
- Turn on oven. Cook turkey for 4 hours or until meat thermometer reaches 180 degrees

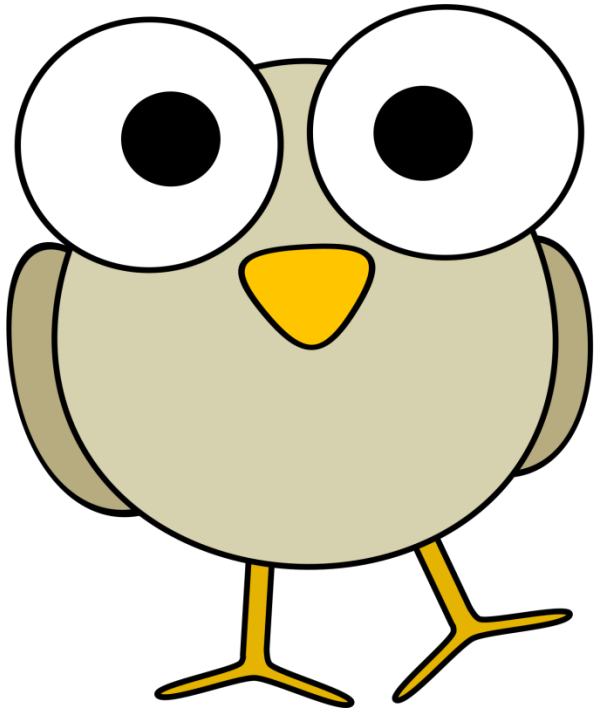
Flowchart Example 4



Flowchart Example 5

- How to read flow charts


Start
Go the Start block in the Flowchart
Follow the line to the next block
Perform the action listed in the Statement Block
Reached a Statement Block?
Yes
No
Follow the NO line to the next block
Follow the YES line to the next block
Yes
Yes
Answer to question is "No"?
Answer to question is "Yes"?
Reached a Decision Block?
No
Yes
No
No
ERROR in Flowchart
Reached an End Block?
No
Yes
End



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