LEGO mindstorm robots

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2008/11/11
Lego Mindstorm® components

3 output ports (A, B, C)

1 USB port for software upload

4 input ports (1, 2, 3, 4) for connecting sensors

motor

collision sensor

light sensor

Ultra sonic Sensor

Lego NXT control unit
Basic robot for lab

- 1 ultra sonic sensor
- 2 independently controlled wheels

The basic robot will be extended by additional sensors and actuators during the labs.
Data flow programming using LabVIEW

- LabVIEW programs = graphs
- Specification of operations and dependences
- can be executed in arbitrary sequence as long as data dependences are met
- we don’t care about the precise sequential code needed for each of the nodes.

Example:
Virtual instruments

VI = virtual instrument
VIs represented in 2 windows:
- Front panel: user interface
- Block diagram: functionality of the system
LabVIEW NXT tool kit

Front panel irrelevant, since robots have no “user interface”

Mindstorm programming:
- functions menu contains all required features as addons
- Use **only** these addons! The other features are not available for the mindstorms

Introduction of most relevant NXT features
**Input (1)**

**Menu:** NXTToolkit => NXT Library =>
Input => Touch Sensor / Sound Sensor

**Touch sensor**
- reads in sensor from designated input port
- Mode: pressed/released
- Output: yes/no

**Sound sensor**
- reads in sensor from designated input port
- Output: volume
**Input (2)**

**Menu:** NXTToolkit => NXT Library => Input => Light Sensor / Ultrasonic Sensor

**Light sensor**
- reads in sensor from designated input port
- sensor must be switched on (Generate Light => True )
- Output: intensity

**Ultra sonic sensor:**
- reads sensor from designated input port
- Output: distance
Comparison

Menu: NXTToolkit => Comparison

- Essentially self-explaining
- Result: Boolean
- Exception: Select

\[ \approx 2 \rightarrow 1 \text{ Mux} \]
Case-dependent data flow
(some control elements present in LabView)

Menu: NXTToolkit => Structures => Case Structure
Move from Functions-Palette into editing area using drag & drop

- Consists of several sub diagrams, only one of which can be active
- Click on the arrows next to the case label to display a particular sub diagram.
- The case selector serves as the input to the case structure; Possible data types: Bool, String, Integer.
- Action to be performed designated by additional elements within the case structure
- Right click opens context menu
Data flow loops

Menu: NXTToolkit => Structures => While Loop

- Sub diagram will be repeated until Boolean condition is true
- Condition is represented by conditional terminal
- Right allows selecting whether iterations will stop or continue if condition is true
- The iteration terminal includes the number of the actually executed iteration
Output (1)

Menu: NXTToolkit => NXT Library =>
Output => Motor Unlimited / Sync Unlimited

Motor control (unlimited)
- controlling one motor
  - Designate output port
  - Direction (true = forward)
  - Velocity
- controlling both motors
  - Designate output ports
  - Direction
  - Velocity
  - Relative speed (steering):
    -100 (left) … 100 (right)
Output (2)

**Menu:** NXTToolkit => NXT Library => Output => Motor Distance / Motor Time

**Motor control (distance)**
- controlling one motor
  - Designate output port
  - Direction
  - Velocity
  - Distance in degrees
  - Follow-up action (braking, free running)

**Motor control (time)**
- controlling one motor
  - Distance indicated via time
  - Otherwise, same as above
Output (3)

**Menu:** NXTToolkit => NXT Library => Output => Stop Motor / Legacy Lamp

**Motor control (stop)**
- controlling one motor
  - Designate port
  - Stop motor thrust
- there is a variant controlling both motors

**Lamp**
- Designate output port
- indicate intensity
- switch on explicitly
Display

**Menu:** NXTToolkit => NXT Library => Display => Display Text

Display
- display line of text on robot‘s display
- displays only strings
- numbers must be converted into strings:
  NXTToolkit => String => String/Number Conversion => Number to Decimal
Downloading software

**Menu:** Tools => NXT Module => NXT Terminal

- Download either via USB or Bluetooth
- Terminal window
  - Find robot
  - compile + download
  - upper window: files on PC
  - lower window: files on robot
Small example

Goal: robot moves forward until collision sensor detects a collision

Terminate loop if sensor returns true
Summary

Mindstorm Programming