Project from Real-Time Systems –
Lego Mindstorms NXT

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Lego Mindstorms

- manufactured by LEGO, http://mindstorms.lego.com
- history:
  - RCX, 1998
  - NXT, 2006; NXT 2.0, 2009
  - EV3, 2003
- use in education:
  - out-of-the-box, easy to use
  - widely adopted,
  - faithfully illustrates the features of embedded real-time systems and their programming.

NXT Brick

- 32-bit ARM7 microcontroller, 256 KB FLASH memory, 64 KB RAM
- timer doing 1000 ticks per second
- 4 input ports, 3 output ports, peripherals connected via modified RJ12 cables
- USB port, Bluetooth interface
- loudspeaker (conversion tools from MIDI, WAW, etc. available)
- buttons, display
- power source: 6 AA batteries

Motors & Sensors

Motors

- 3 electric motors, built-in gear
- synchronization, built-in rotation sensor (accuracy +- 1 deg)
- typical use:
    - set power (0-100), direction (fwd, rev), set on/off, or
    - turn the shaft by a given angle at a given power.

Sensors

- touch sensor (binary: pressed/not pressed)
- sound sensor - measures acoustic pressure, up to 90 dB, works with a percentage of max value.
- light sensor - measures intensity of ambient/reflected light
- ultrasound sensor - measures distance to objects (0 – 255 cm, +- 3cm), accuracy depends on size, shape and composition of objects

Programming Environments

Visual:

- NXT-G (bundled)
- Robolab

"Code-based":

- NXC (Not eXactly C)
  - C-like syntax, IDE for Win (BricxCC), compiler (NBC) source available for Mac and Linux
- leJOS NXJ
  - firmware replacement allowing to run Java on NXT Brick
  - comes with rich Java API
  - plug-ins for Eclipse
- ... and many others (see, e.g., Wikipedia, or `http://www.teamhassenplug.org/NXT/NXTSoftware.html`).

All reasonable languages support multitasking.

Project: Organization

- work in teams
- each team chooses a leader
- submit short project abstract (up to 1/2 page) by April 8
- work :)
- submit a project report (up to 5 pages) and program source by May 11
- presentation of results (probably) during a lecture on May 14

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Project: Requirements

- the robot performs a non-trivial, meaningful and a well-defined task.
- the robot uses at least 2 motors and 2 sensors
- the robot uses display or speaker
- the implementation uses concurrency in a meaningful way (at least 2 threads running in parallel)
- the resulting system is a hard real-time system (i.e., a successful completion of the defined task depends on a correct timing)
- implementation in NXC or leJOS is preferred, choice of a different language should be consulted in advance

Project: Evaluation

Project report:

- up to 5 pages
- describes the task performed by the robot and the implementation, substantiates changes from the project abstract, describes difficulties encountered during implementation, points out the use of concurrency
- specify the contribution of individual members (does not have to be equal, but team members may "kick out" work-avoiding colleagues)

Source code:

- non-visual language
- well-documented source code

Presentation:

- with slides and demo, not necessarily by the team leader

Project: Topic

- it is a part of the project to choose an interesting yet doable goal
- search the internet for inspiration (e.g., YouTube: Lego Mindstorms)
- all-time classics: finding, picking up and transporting a ball; following a black line; navigation through a maze

Quick Start Guide

- if possible, install Lego Mindstorms, BricxCC, or leJOS
- play around for a while, test the sensors etc.
- read manuals and tutorials on the web
- build a simple robot and try to compile a simple program
- discuss the project