Embedded Programming Education with Lego Mindstorms NXT using Java (leJOS), Eclipse (XPairtise), and Python (PyMite)

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Tutorial 4

Sunday, October 11, 2009, 14:00 to 18:30 (coffee break from 16:00 to 16:30)

Inside the Open Source Lego Mindstorms NXT

Speakers:
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Abstract: The tutorial attendees will be presented with a technical introduction to the Lego Mindstorms NXT. Alternative approaches to firmware and user-level programming will be introduced while continuously relating to the underlying hardware. Attendees will afterwards be able to choose between alternative approaches where to go and do their future research, teaching, or community building with NXT.

Slides of the tutorial:

Outline

1. Aim of Tutorial
2. Introduction
3. Open Source
4. Sensors
5. Inside NXT C 101
6. Firmware Programming
7. ARM7
8. NXT Software
9. Debugging NXT
History + helicopter view

• Source code + GCC
• CBS:
  – High school
  – 1 sem programming.
  – 3 sem OOA&D (wind meter)
  – Master thesis (Ultra Sensor w. custom firmware)
Motivation

• Embedded systems are expensive (for non-EE/CS schools)
• Sharing one means looking at the guy next to you programming
• Many schools already teach Java for application
• We have found a way to make embedded systems programming with Java easier and more affordable (CDIO?)
Problem & Solution

• The school have 10 workable (20) NXT sets for a class of many more students
• We have 40-80 students sharing them
• We decided to use NXT because it is open source
Component 1: Eclipse plugin

- We also use Eclipse which is an open source platform composed of plugins.
- One plugin is called Xpairtese, and it is an Eclipse plugin that allows for distributed team programming.
- The students change roles and one programs at a time.
Component 2: Lejos

• Lejos is probably one of the best firmware replacements for LEGO MINDSTORMS NXT
• It is a programming environment for Java
• Students can get a quick start with Java
• The embedded systems students can program the ARM7 processor directly
Lejos is used with Eclipse
Students can share the programming environment
Team Setup
Team: Functionality

- The setup is somewhat complex/fragile
- It requires someone with good understanding of hands-on programming
- Not limited to Java... (Python...)(...)

Diagram:

- Participant 1
  - Bluetooth radio/USB
  - Serial
- Participant 2
  - XPair protocol
  - TCP/IP
- Xpairise server
  - XPair protocol
  - TCP/IP
- PC
  - Embedded
PYMITE: A PYTHON ON-A-CHIP PROJECT

- Some students are better than others, and perform so-called firmware replacements
- We demonstrate the relative easiness (1 day) of starting up a new embedded operating system on NXT
Method: HW->GCC->Target OS

- LEGO MINDSTORMS NXT has open hardware specifications
- It is a question of creating a toolchain for ARM7 (use the one from NXTGCC) and go from there
Discussion: Teaching Advantage

- Em. Sys. team programming: just a teacher dream?
- Students have a system where they can use an easy language (Java or whatever) or create a new operating system
- Focus on HPL-HAL-HIL interdependencies
- They can create new sensors (PCBs)
- NXT mixes well on an educational continuum:

EE  CS  Nat. Sci.  BS
Conclusion

• We have shown a method to include team programming which is good for many students

• The NXT can also be used for more advanced programming with C and assembler programming: Pymite

• From here: Working on a minimalistic introductionary EECS “mechanics book” with ARM/gcc/bootloader/assembler/C...

http://nxtgcc.sourceforge.com