e-puck

the EPFL educational robot

The e-puck platform has been developed with the goal to have a miniature mobile robot for educational purposes at university level. The robot has the following main features:

- **Good structure.** The robot has a clean mechanical structure, simple to understand. The electronics, processor structure and software are a good example of a clean modern system.
- **Flexibility.** Because of the number of sensors and actuators, the embedded processing power and the extension possibilities, the robot covers a large spectrum of educational activities. Potential educational fields are mobile robotics, real-time programming, embedded systems, signal processing, image or sound feature extraction, human-machine interaction or collective systems.
- **User friendly.** The robot is small and easy to exploit on a table next to a computer, ensuring an optimal working confort. It needs no wiring in its basic operation (using Bluetooth), can run on batteries for several hours and batteries are easily replaced.
- **Good robustness and simple maintenance.** The robot resists to student use and is simple and cheap to repair.
- **Cheap.** The e-puck is about 10 times cheaper than available commercial robots with similar performances.
- **Open hardware.** All related documents and files (mechanical drawings, schematics, production files, source code) are distributed under an open hardware license.

A first set of prototypes has been tested during one year in two courses and some student projects. After this phase the robot has been redesigned to consider the problems met and the final design looks as shown below:

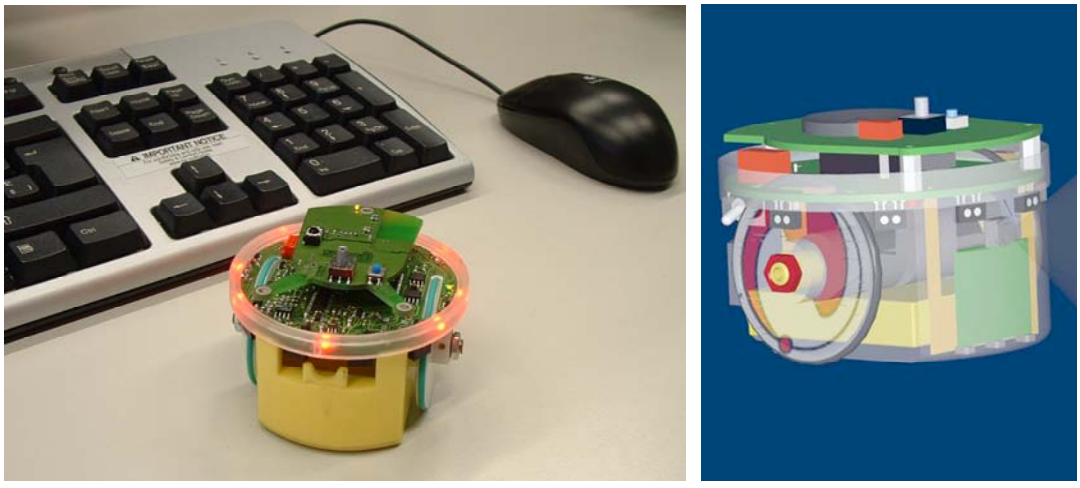
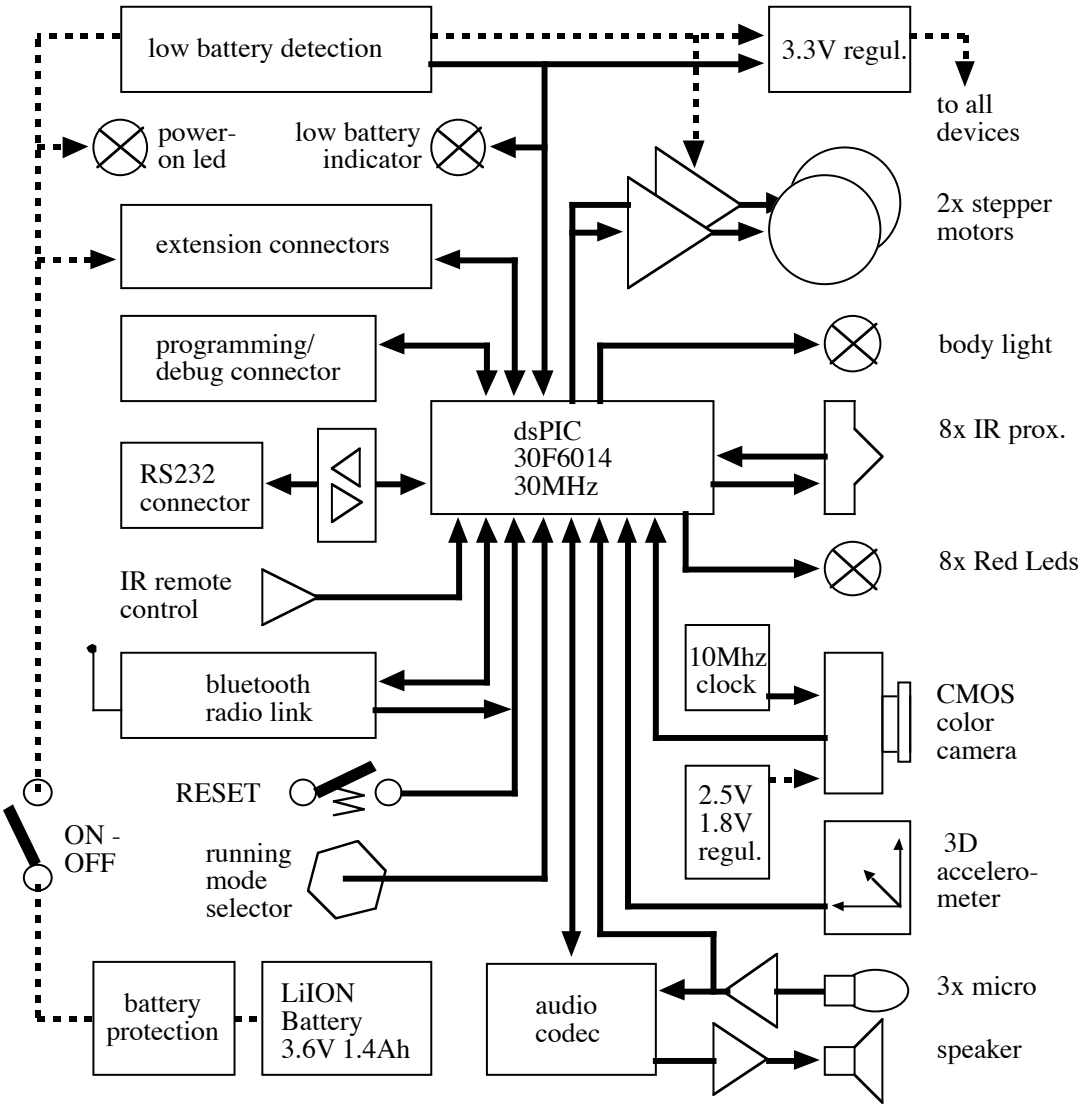


Figure 1: left, the last prototype before production, right the CAD model.

Structure of the system:



Comments on the structure:

The e-puck is based on a plastic body supporting the motors, the battery and the electronics. This plastic body, yellow on figure 1, will be fully transparent allowing to see all elements of the robot. On the back the body will have the EPFL and e-puck logos. The wheels will not be fully transparent and will have the e-puck logo on them, as illustrated in figure 1 right.

The battery is placed on the bottom and can be easily extracted and recharged separately. A battery protection is implemented to avoid battery damage. *Power on* and *low battery* indicators help in understanding the status of the battery. The processor can read the battery level.

The two wheels are actuated by stepper motors with 20 steps/revolution through a reduction gear with a ratio of 50:1. The third contact point with the ground is made by the plastic body. The robot is designed to run on flat surfaces such as a table. Being

well protected against dust, the robot should be able to run on a standard room ground.

The processor onboard is a dsPIC 30F6014 running at 60 Mhz (internal, corresponding to 15 MIPS). This processor has both a standard microcontroller structure and a DSP (digital signal processing) computation unit. Its 16 bits core is much more advanced than a PIC core (dsPIC has 16 registers and many DSP and C oriented instructions) and is designed to support C programming. The DSP core brings very high performances in signal processing applications.

The e-puck is equipped with 8 infrared (IR) proximity sensors with a detection distance of some centimeters (3-4). Others sensors are a 3D accelerometer, 3 omni-directional microphones and a color camera with a resolution of 640x480 pixels. The processor is very well suited for the processing of the IR sensors, of the accelerometer data and the sound. The camera provides a much larger amount of data the processor can even not store in its memory. The camera can therefore only be used if small portions of the image or a lower quality are acquired.

As output, in addition to the wheels, the e-puck is equipped with a speaker, 8 red leds around the body and a green led inside the transparent body. On the speaker one can play any kind of sound. The 8 red leds and the green body led can be controlled in intensity.

The communication links supported by e-puck are a standard RS232, an infrared remote control and Bluetooth. On Bluetooth there is a serial line emulation supported by any PC, making the communication and the development of PC software very simple.

The e-puck is equipped with several extension connectors allowing to expand the system in several ways, with intelligent extensions or very simple interfaces.

At the software level a BIOS will be available, including bootloader (through Bluetooth or RS232) and a communication protocol.

The compiler to generate code for the dsPIC is a ported version of GNU GCC.

e-puck technical specifications:

Diameter	70 mm
Weight	150 g
Battery	LiION removable 5Wh
Autonomy	2-3 hours
Motors	two stepper motors 20 steps/rev
Gear type	included in motor block
Gear reduction	50:1
Resolution on wheels displ.	0.1 mm
Mechanical structure	plastic body supporting PCBs, battery and motors
Surface of work	very flat
Processor	dsPIC 30F6014 @ 60MHz
processor type	16 bit microcontroller with DSP core
RAM	8 k
FLASH	144 k
Sensors	8 IR proximity and light sensors
	3D accelerometer
	3 microphones
	640 x 480 color camera
	battery voltage
Actuators	2 stepper motors
	8 leds around the body, controlled indipendently in intensity
	one speaker
	one body light
Communication	RS232
	Bluetooth
	InfraRed remote control
Pogramming env.	GCC integrated in Mplab

e-Puck Robot
Open Source Hardware License

Version 1.0
August 2005

Preamble

This Open Source Hardware License aims at the dissemination of the specifications necessary to build the e-Puck robot, a mobile robot developed by the Ecole Polytechnique Fédérale de Lausanne ("EPFL"), Switzerland.

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"License" shall mean this Open Source Hardware License.

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