Project no. 231688

LOCOMORPH

**Robust Robotic Locomotion and Movements Through
Morphology and Morphosis**

Small or Medium-Scale Focused Research Project

Seventh Framework Programme, Theme: ICT-2007.8.5

Future and Emerging Technologies (FET), Embodied Intelligence

Start date: 1 February 2009 – Duration: 50 months

D2.5 – Educational robotic toolkit, comprising of the heterogeneous robotic modules developed throughout the project (M50)

Due date: 9th of May 2013

Actual submission date: 9th of May 2013

Number of pages: 25

Project Consortium

Beneficiary no.	Beneficiary name	Short name
1 (Coordinator)	Universitaet Zurich	UZH
2	Friedrich-Schiller-Universitaet Jena	UJEN
3	Ecole Polytechnique Federale de Lausanne	EPFL
4	Syddansk Universitet	USD
5	Universiteit Antwerpen	UANT
6	Ryerson University	RU

Dissemination Level

Project co-funded by the European Commission within the Seventh Framework Programme Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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Abstract

In this deliverable we describe an *educational robotic toolkit, comprising of the heterogeneous robotic modules developed throughout the project.* This deliverable is unconventional since we submit it in the form of a website dedicated to the educational robotic toolkit LocoKit (locokit.sdu.dk). Hence, we combine the effort of disseminating and selling LocoKit to the public with this deliverable (which is also public). The deliverable is accessed by going to locokit.sdu.dk, but a printout of the top-level pages of the website are included within this document to serve as proof of completion of the deliverable. However, the website is the primary source since formatting is lost in the translation to pdf.

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Apr 23, 2013

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It is now possible to order one or more LocoKits from the "Order" form.

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New LocoKit Website

The development of a new web site for the LocoKit have just started. We are working hard to get it running as soon as possible. This site will have information on the current system with introduction how to get started, idears for further structures and software updates. Also we have forum on this site that can be used ot exchange experiences and idears.

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LocoKit is a robot construction kit optimized for building light-weight, dynamic robots. LocoKit provides a complete package for building your robot including mechanics, electronics, and software.

You can easily built a robot from the LocoKit mechanical components using a screw driver and a hex key (both included). You can also take them apart again and reuse the components for another project. If you are lucky to have a rapid prototyping machine available, e.g. a 3D printer, you can easily extend the system with your own parts to build even more advanced robots.
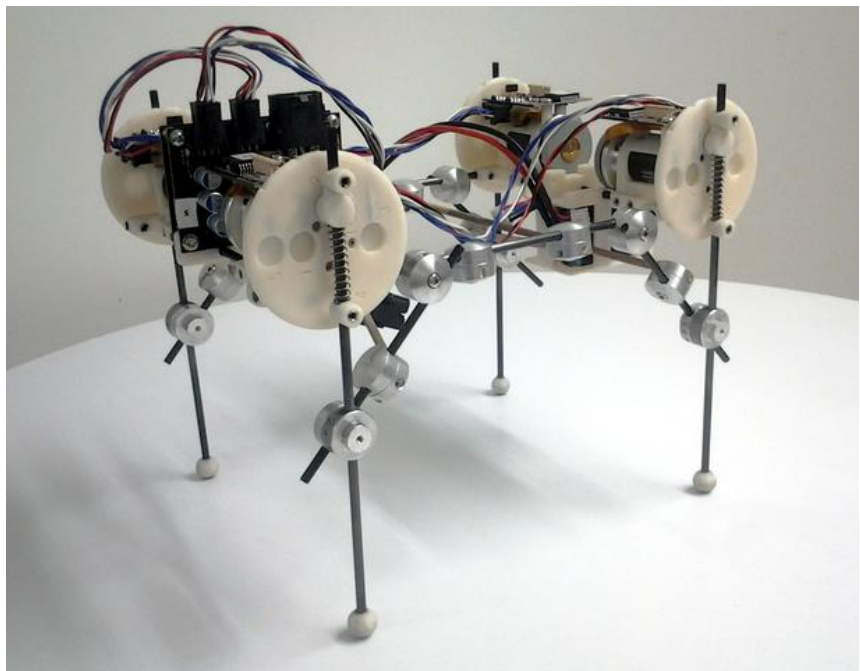
A quadruped robot build with LocoKit®

LocoKit electronics is ready to go. Once you have attached the cables connecting the battery to the main board and the cables attaching the main board to the motors you are done. If you remember to turn it on. For those with electronics skills there is a wealth of available pins for attaching your own sensors.

The robot can, once turned on, be controlled using a standard web-browser running on any WiFi enabled device (computer, tablet, smartphone, etc.). No software installation required. Again for those of you with programming skills, you can program the robot either in C or Python. A full development suite is available on-board, but you can also develop on your own platform and copy source files using Secure Shell (ssh - free for all major operating systems) to the robot for compilation and execution.

LocoKit is built to get you the robot you need for your research or educational project as fast as possible without compromising on quality.

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LocoKit is open-source and all source and design files can be obtained from us. In fact, we encourage you to produce your own LocoKit parts, make news ones or improve on the existing ones. We also encourage you to produce parts (even ours) and make them available to the community at a suitable price. Note, however that to be included in the LocoKit eco-system all your design and source files have to be made open-source as well allowing other people to produce or modify your designs.

We are currently developing functionality on this website to support this exchange, but for now please e-mail Jørgen Larsen (jcla@mmmi.sdu.dk) to obtain or submit any source file.

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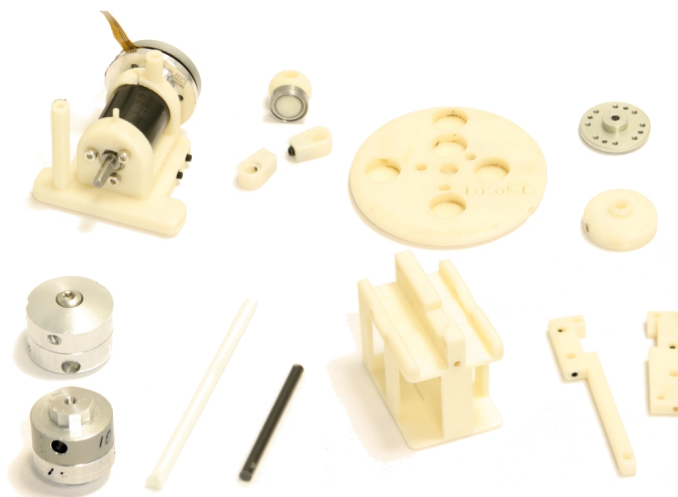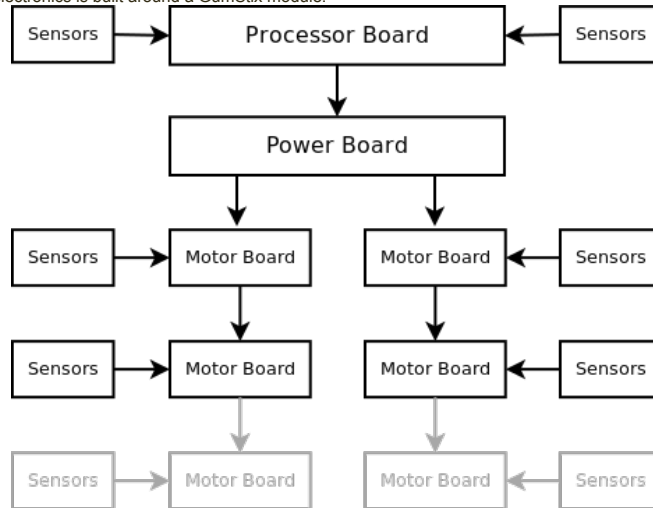
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Mechanics

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The mechanical components of LocoKit are kept simple to make it easy to construct light-weight, dynamical robots. LocoKit consists of the following components:

- Rods forming the skeleton of the robot
  - The rods have a standard dimension of 4mm and are made of carbon-fiber. 4mm rods are typically available from your local supplier also in other materials such as aluminum, wood, fiberglass-enforced, etc.. (note: as the only LocoKit component, the rods are not always reusable because they are penetrated by set screws as part of the construction process).
- Fixed joints
  - The fixed joints make it possible to connect two rods to each other at fixed, arbitrary angles.
  - The fixed joints have tactile feedback that makes it easy to assemble regular geometries (e.g. squares).
- Rotary joints
  - Built-in ball bearing allows for low-friction, continuous rotation.
  - The fixed and rotary joints are produced in aluminum to ensure long life.

In addition, to these general components there are some with specific functions:

- Compliance integration components
  - These allow springs to be integrated with rods to allow them to be compliant.
- Motor mounts
  - Bioplastic (PLA) components for mounting the LocoKit motors onto the rods.
- Gears and connector components
  - These components transfer the power from the motor to the mechanical structure

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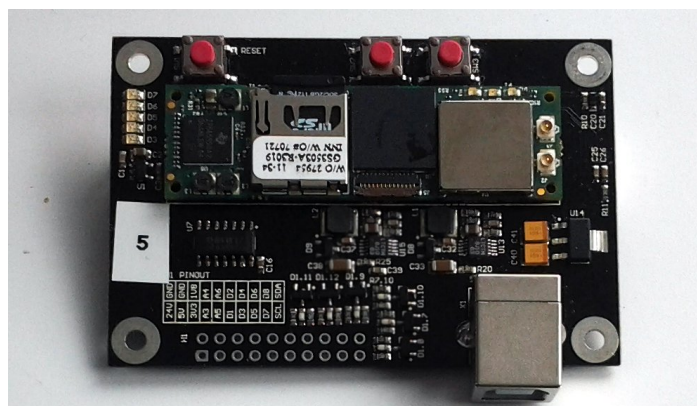
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Electronics

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The LocoKit electronics is built around a GumStix module.

The architecture of the LocoKit electronics platform is shown in the figure above. The two top boards, the "Processor Board" and the "Power Board", are mounted on top of each other. A robot only contains one of these sandwich-boards. Communication to the peripheral motor boards goes through a wired connection (six wires to be exact). There is no dedicated board for integrating external sensors because they can be connected directly to the Processor Board or any of the Motor Boards in the system using the available pins

Processor board

The main component is the "Processor Board", which as mentioned is an interface board for the GumStix module. Besides interfacing to the GumStix, it provides onboard sensors as well as available port for external sensor inputs. The GumStix board has the following specifications:

- Interfaces to a Gumstix Overo Air standard processor board, 600MHz OMAP3, 512MB RAM
- Runs Angstrom Linux, but other distributions are possible
- Onboard accelerometer and gyroscope
- General sensor interface
- SDCard reader (used as harddrive)
- 8 general purpose I/O ports
- 4 analog inputs
- 1 I^2C interface
- 2 Buttons and 5 LEDs

Power board

To support LocoKit with a stable power supply, a custom-design Power Board is provided. The Power Board has the following specifications:

- A 6S LiPo battery provides the power
- Fuse for short-circuit protection
- Battery undervoltage protection is implemented in hardware
- Voltage is regulated to a stable 24V
- Maximum cont. current 10A
- Efficiency of 90-95%
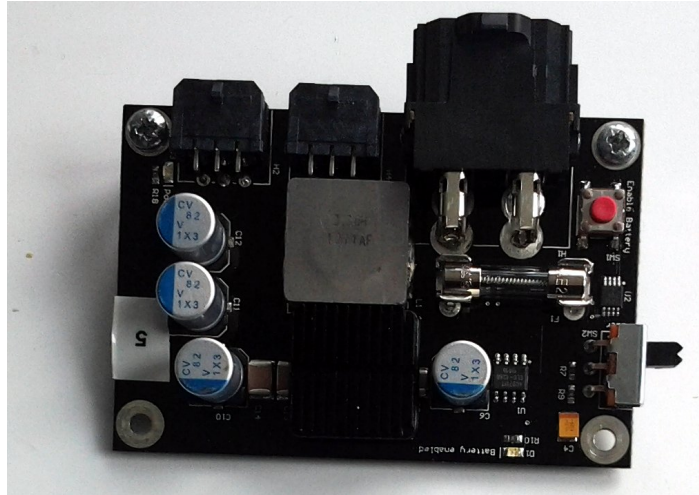
Motor board

We have chosen to use Maxon motors despite their high cost because they provide great stability, efficiency and power density. On top of this they are designed in a way that makes it possible to overdrive them without damaging them. For this reason we have made the Motor Board compatible with many of the connectors from Maxons Brushless motor series.

The Motor Board have the following specifications:

- Controls 1 brushless DC motor
- Interfaces to most Maxon BLDC motors
- Designed for 24V, 48W
- 48MHz ARM7 processor for time critical control and motor commutation
- 4 general purpose I/O inputs multiplexed with analog inputs for local sensor interface

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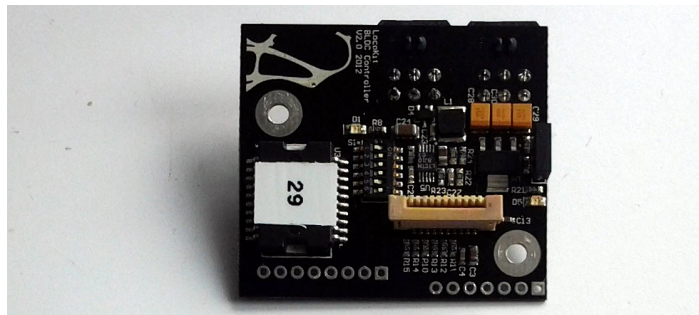
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Software

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Linux

On our GumStick platform we are using Debian Linux which gives us many benefits because of it being a modern operating system. In particular, software package management and development environments comes as standard. This allow the user and us to spend more time on robot specific software.
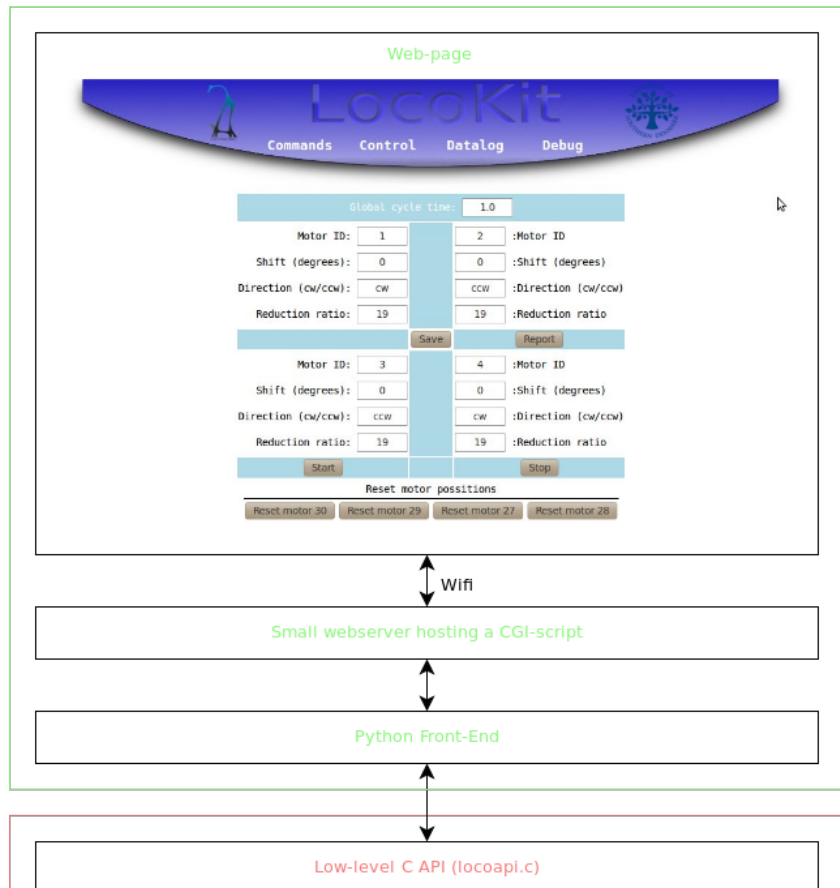
Programming Interface Supporting C and Python

The interaction with the LocoKit system is done through a standard c library called LocoAPI for which a Python implementation also exists. This makes programming the robots easy because standard C or Python development tools can be used for editing, debugging, compiling, and documenting. The API include rich possibilities for control of the motors, but also has a powerful logger interface.

Web-interface

LocoKit can also be access through a web page hosted on the robot. This web page makes it possible to control for instance a quadruped robot. Data from sensors of the robot is also visualized on the web page live making it possible to see the impact of parameter changes in real-time. The webpages also allows the user to generate a report of the setting of the robot to make it easier to reproduce the data obtained.

Overview of the software structure

The overall architecture of the LocoKit software is illustrated below: The web interface runs on a remote PC, which interacts with a lightweight web-server running on the GumStix board. The web-server interacts with a generic server implemented in Python, which mediates remote access to the control API. The control API provides access to the ARM7-based motor boards as well as any on-board sensors.
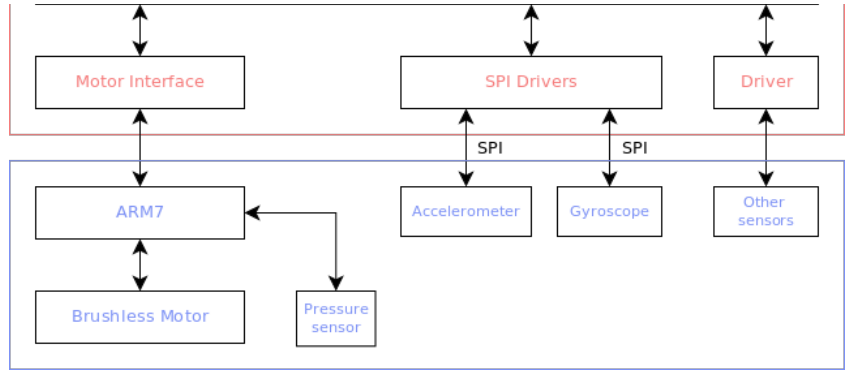
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Motor Interface

SPI Drivers

Driver

SPI

SPI

ARM7

Accelerometer

Gyroscope

Other sensors

Brushless Motor

Pressure sensor

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Getting started

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Using the LocoKit Hardware

Important information!

- The last motor in a chain should have a terminator (shown in the middle of the photo below) connected to the unused connector.
- Be carefull not to drop the motors on the floor. They may break.
- Do not disconnect or connect motors on the system while the power is on. Always power off the system before.
- Do not try to connect two LocoKit boards together as it may damage both.
- When programming yourself, copy the examples folder to your own folder which you can create under the "users" folder. The examples folder is overwritten when LocoKit software is updated.

Motors and the LocoKit Board

The motors can be connected to the LocoKit board using one of the two connectors located next to the battery connector (as shown in the figure below).

It does not make any different which connector on the LocoKit Board is used and you may also use both if you want. Additional motors can be attached to other motors in a chain passing a cable from one motor to the next. At least twelve motors can be connected.

When connecting cables to the motors, make sure that you support the PCB by holding on to it, while pressing the connector into place. If not done so, the material holding the PCB may break. The cable will need a firm push to make the connector go into place.
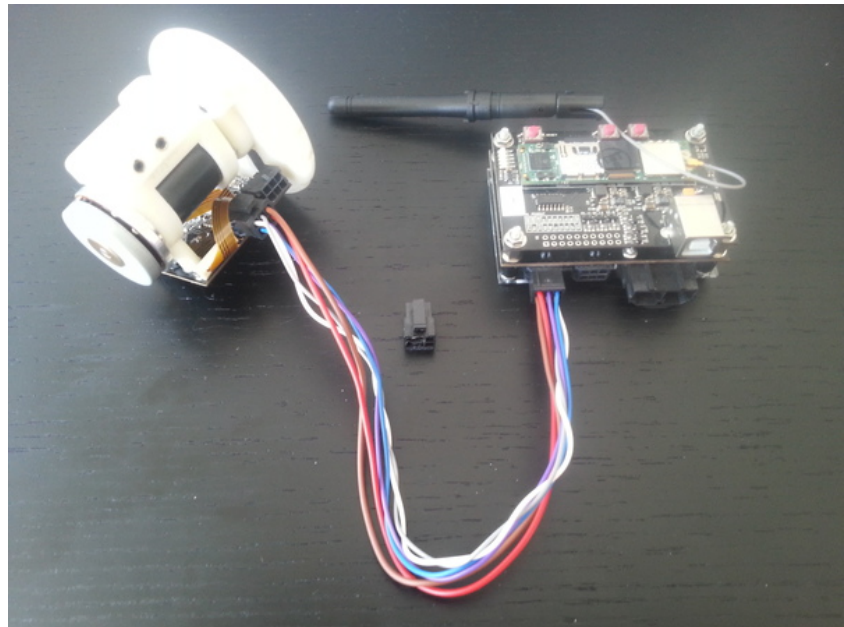
Battery and LocoKit Board

The battery is attached to the LocoKit Powerboard as shown in the photo below.

Battery and charger

The LocoKit battery is a six cell lithium polymer battery. The default charger for the battery is the Hyperion EOS0606i. The recommended setting for the charger is shown below as they appear on the display of the charger.

LiPo Charge, 0.8A

C= 850mAh, 6S

The battery is connected to the charger using two cables as shown below. Both cables need to be connected.
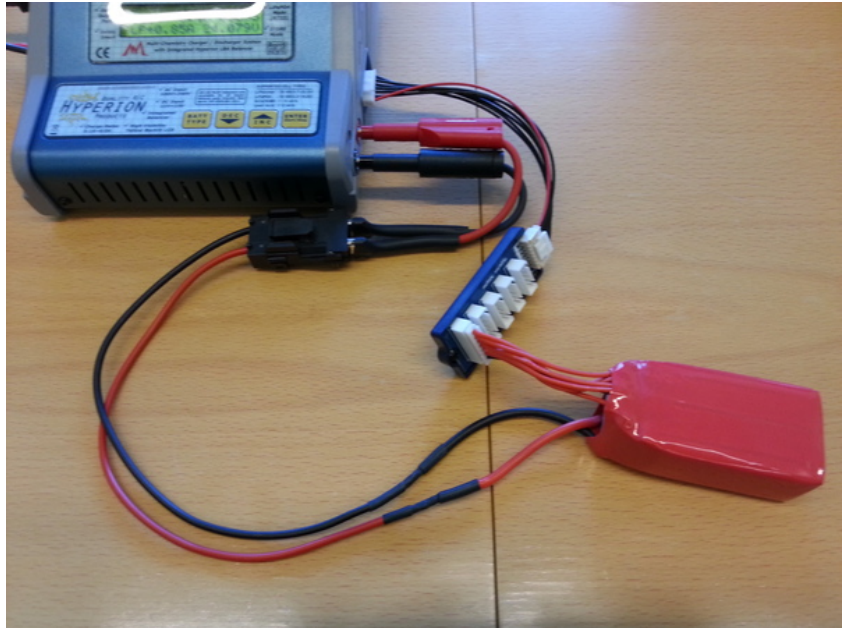
Using the LocoKit Software

Connecting to LocoKit using WiFi

After LocoKit powers up, which takes about a minute, it connects to a predefined Wi-Fi network. You should connect your computer to the same network.

Opening the LocoKit Web Interface

After succesfully completing the steps above your computer and LocoKit are on the same network and you can now start to interact with LocoKit.

The first step should be to open the LocoKit web interface. Open your favorit web brower and enter the IP address of your LocoKit robot into the address line and press return (e.g. loco-donotuse.mmmi.sdu.dk). This should immediately open up the LocoKit web interface.

Connecting to LocoKit using SSH

When LocoKit and your computer are on the same network you can use ssh to login to Linux running on Locokit. From a command shell you type "ssh root@loco-donotuse.mmmi.sdu.dk". When asked for password just press return - no password. You are now given a standard Linux command prompt.

Example source files, editing, and running

It is important to notice, that all compilers and editors you may require to program and compile software for the LocoKit are installed on the system. You will therefore not need any compilers, editors on your computer to start working. Only a SSh client is required. So just go ahead and log in to the system via SSH as described above.

Once you are logged into LocoKit, you can navigate to the /examples/source ("cd /examples/source") directory to see some code examples of how to program LocoKit in C. Several editors are installed e.g. mec readSensors.c (exit: ESC-z). The examples can be compiled by using Make ("make all"). The executables are put in /examples/bin where you can find and execute them (./readSensors).

Read more about programming LocoKit in the API section.

Important: read the important messages at the top of this page!

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Programming API

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The LocoKit web interface provides a high-level interface that facilitates quick experimentation with standard gaits. Advanced users may however want to program their own specific gaits, this is current supported through APIs implemented in C and Python. As described under Software, the LocoKit main board runs Linux and comes with both a C compiler, an editor, and Python installed (in addition remote acess using e.g. ssh facilitates remote access from an IDE). Moreover, complete documentation and exampels are included with the system. For reference, an overview of the respective APIs can be found here:

- C API documentation
- Python API documentation

We are continuously expanding the capabilities of these two APIs based on feedback from students and researchers using the system.

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Locokit General

Here general questions regarding LocoKit should be kept

1 Posts
1 Topics

Last post by (guest) in This is just a simple test
Apr 22 2013, 10:49

Software

Here questions regarding software issues should be discussed

0 Posts
0 Topics

Mechanics

Questions regarding the mechanical parts of LocoKit should be kept here

0 Posts
0 Topics

Morphology

Here questions regarding morphology should be discussed

0 Posts
0 Topics

Electronics

Discussions on electronics goes here

0 Posts
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LocoKit

In this gallery there will be uploaded pictures from events where LocoKit have been used. We will constantly be adding more pictures.

Any questions regarding this gallery can be sent to Jørgen Christian Larsen on jcla@mmmi.sdu.dk

The Locomorph Summer School 2012

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- **"ECHO - Darmstadt"**, *"Wissenschaftler bringen Robotern das Laufen bei"*, URL: http://www.echo-online.de/region/darmstadt/Wissenschaftler-bringen-Robotern-das-Laufen-bei;art1231,3751122, (Get a pdf version here)

- **"Ostthüringer Zeitung"**, *"Wie Roboter das Laufen lernen"*, *URL: http://www.otz.de/web/zgt/suche/detail/-/specific/Wie-Roboter-das-Laufen-lernen-778945419 (Get a pdf version here)*

Press videos:

- **"Ostthüringer Zeitung"**, URL: http://www.otz.de/web/zgt/suche/detail/-/specific/Laufroboter-Konferenz-in-Jena-1052456543

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Order

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This is the order form for ordering LocoKits and in the near future also extra spare parts for the LocoKit system. For now the order will be send to us in a email. After submitting your order, we will contact you to get payment details and delivery address.

LocoKit Construction Kit

A complete LocoKit construction kit consists of the following parts:
- A set of LocoKit from which a quadruped robot can be build
  - 4 Motors
  - 2 Batteries
  - Controller and power board
  - Mechanic LocoKit components for a quadruped robot
- Charger

The price of one LocoKit is 2500 eur.
Numbers of LocoKits to order [Amount ⇕]
If you are interested in buying more than 10 sets of LocoKit please contact us directly through email: jcla@mmmi.sdu.dk

[Continue...]

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