Project no. 231688

LOCOMORPH

Robust Robotic Locomotion and Movements Through Morphology and Morphosis

Small or Medium-Scale Focused Research Project

Seventh Framework Program, Theme: ICT-2007.8.5

Future and Emerging Technologies (FET), Embodied Intelligence

Start date: 1 February 2009 – Duration: 50 months

D7.2 – Robotic undergraduate project leading to participation in an international robotic competition

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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
7	Technische Universitaet Darmstadt	TUD

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)	

Abstract

The contribution to the deliverable was three fold. First, we conducted a class for undergraduate students to build robots. Unfortunately, it was not possible to follow up on this first step. Therefore, we extended the approach and included the use of the LocoKit. Our approach was to combine efforts and establish a synergy between this deliverable and the dissemination of the LocoKit. Hence, as second and third contribution for this deliverable we used the LocoKit in the context of competitions at the Locomorph summer school and the 6th international Symposium on Adaptive Motion of Animals and Machines.

Contents

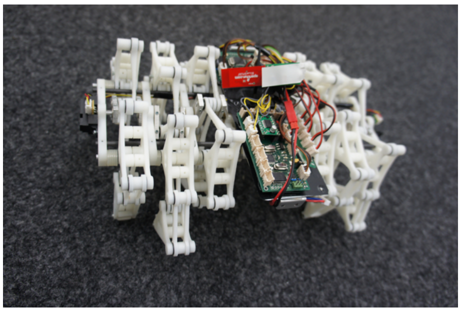
1 Introduction

The idea of the deliverable was to use robots developed in the context of the project and to let undergraduates participate in an international robotic competition with them. A first step towards this goal has been made by Dr. Lijin Aryananda, the previous Project Manager, by initializing a class for student to build robots. The results were presented during the review of year 2. More details can be found in Section 2.

In the second year, Dr. Aryananda left the project and her robotic building classes were terminated. Hence, we had to reorientate our approach. At this point in time the educational LocoKit had finished another successful round of improvements and it had significantly matured. We were able to see the potential for a number of applications for our robot construction kit. However, we also realized the opportunity to use it as a tool to be employed for organizing our planned international competitions. Our approach was to combine efforts and establish a synergy between this deliverable and the dissemination of the LocoKit. We expected to get valuable feedback to improve it further and to spread the word about it. In this context, we organized two competitions with the LocoKit. One was conducted during the Locomorph summer school (see Deliverable 7.1 for more details). We asked the international and multidisciplinary participants to use the LocoKit to build different robots. In Section 3, we present the outcome. Finally, we also took the opportunity to involve participants of the 6th international Symposium on Adaptive Motion of Animals and Machines in using the LocoKit. The international audience consisted of scientists at different educational levels, as well with different backgrounds. More information on the outcome can be found in Section 4.

2 Robot building class for undergraduate students

In Spring 2010, Lijin Aryananda (UZH) organized a Master-level class on bio-inspired robotics, which involved a hands-on robotic project throughout the course. A group of 10 students participated. They teamed up in two and worked on a legged-robot platform, which they had to use for a competition at the end of class. Each team had to choose a design concept for their robot's morphology and then built it in collaboration with the teaching team. Each team's robot was equipped with a number of sensors, including one for detecting the presence of another robot. The competition consisted of a prey predator game carried out in an area consisting of various terrain. Each robot had to assume the role of the predator in one round, and the role of the prey in the next round. The competition essentially evaluated each robot's skills in finding or avoiding the other robot, avoiding obstacles, and traversing different terrain. The students really enjoyed the hands-on robotic project opportunities, specifically the opportunity of creating their own morphology design.



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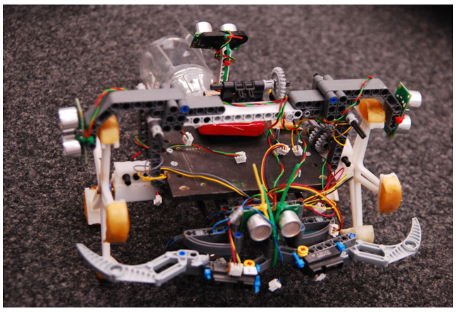

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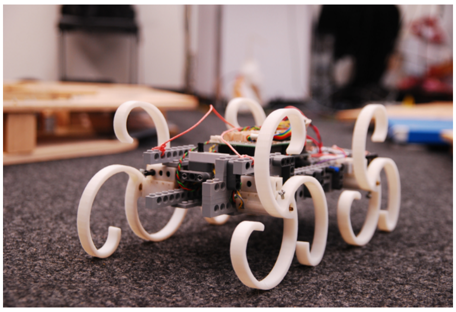


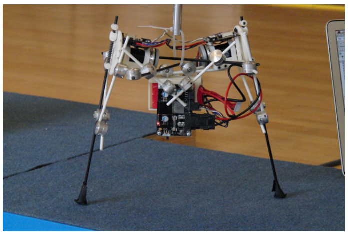
(c)

Figure 2.1: Some of the robots built by the students at UZH.

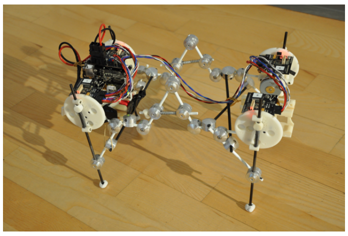
3 Competition at the Locomorph Summer School

In the context of the Locomorph Summer School on Morphology and Morphosis in Animals and Robots we organized a competition in a more general way. The total number of participants was 27 from 17 different countries. The majority of the students were Ph.D. students, however, there were also a few MSc students and a Postdoc. We asked them to build robots they would like to use for their investigation. Based on their interests, they formed 8 groups. One of these group did not build a robot, but conducted experiments with humans on force plates. The rest of the groups built a range of different robots. Figure 3.2 shows the results of the students. One can see the impressive versatility of the LocoKit. Some of the robots were bipedal, meant to be used on a boom. Other robots were quadrupedal. All of them with different morphologies motivated by different research interests. For example, the students built robots to study the role of a (compliant) spine (e.g., CheetahBot in Figure 3.2b or the SpinyBot in Figure 3.2d). Another example is a robot built as a physical realization of the M-SLIP model (BipedalBoomBot in Figure 3.2a). There was even a robot with 14 legs (the caterpillar robot in Figure 3.2g. While the results of the student point to the versatility and potential of the LocoKit, clearly it was difficult to let them compete against each other, e.g., with respect to velocity. Nevertheless, this test case was very helpful and provided us with valuable feedback.

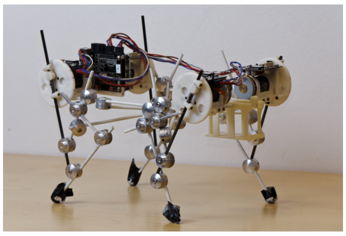
Figure 3.1: Group photo with participants and robots from the Locomorph summer school



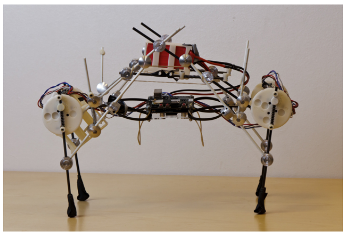
(a) BipedalBoomBot - to investigate the M-SLIP model.



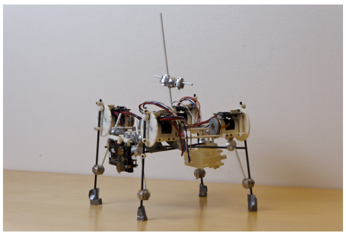
(b) CheetahBot - with a flexible spine



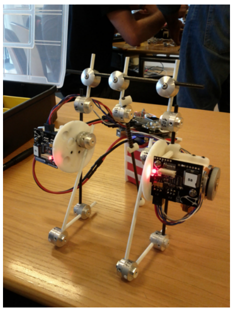
(c) ConnectBot - using a linkage-bar structure



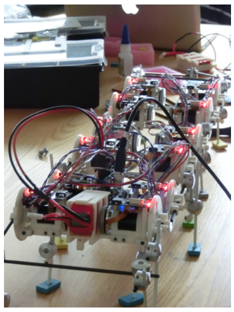
(d) SpinyBot - investigation of different spine designs



(e) Head Banger - exploring the effect of changing the center of mass.



(f) CrutchSLIPwalker - inspired by passive walkers



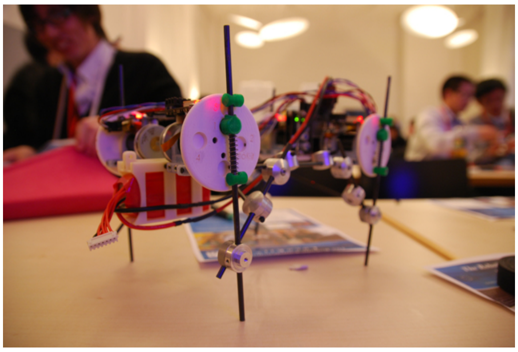
(g) Caterpillar with 14 legs

Figure 3.2: Seven different robots constructed by the participants of the summer school.

4 Competition at AMAM 2013

The 6th international Symposium on Adaptive Motion of Animals and Machines has been organized by the project Locomorph and was hosted by partner TUD. Besides the special single track session on Locomorph we also presented the LocoKit in form of a tutorial (presenter: Jørgen Larson from partner USD), followed by a hands-on including a competition.

We prepared 6 robots in the same configuration as the SpringyBot. During a fast assembly of a SpringyBot, typically, arbitrary geometrical morphological parameters are slightly different from the original SpringyBot. For example, the leg length will not be the exact same length or some body asymmetries might have been introduced. In order to assure the same behavior, one would have to adjust theses parameters my measuring them and adjust them accordingly. This last step has been intentionally omitted this time. As a result, all individual robots were slightly different in their behavior.



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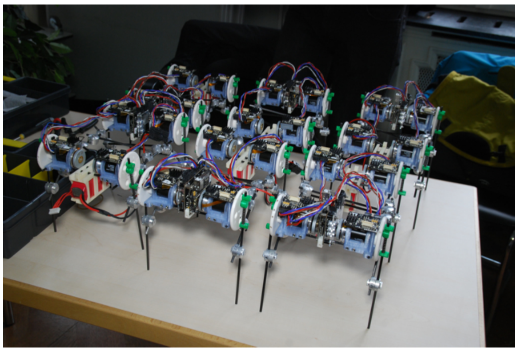


(b)

Figure 4.1: For the competition we prepared 6 robots in the same configuration as the SpringyBot. They have been assembled slightly different in their morphological parameter, and, hence, exhibited slightly different locomotion behaviors.

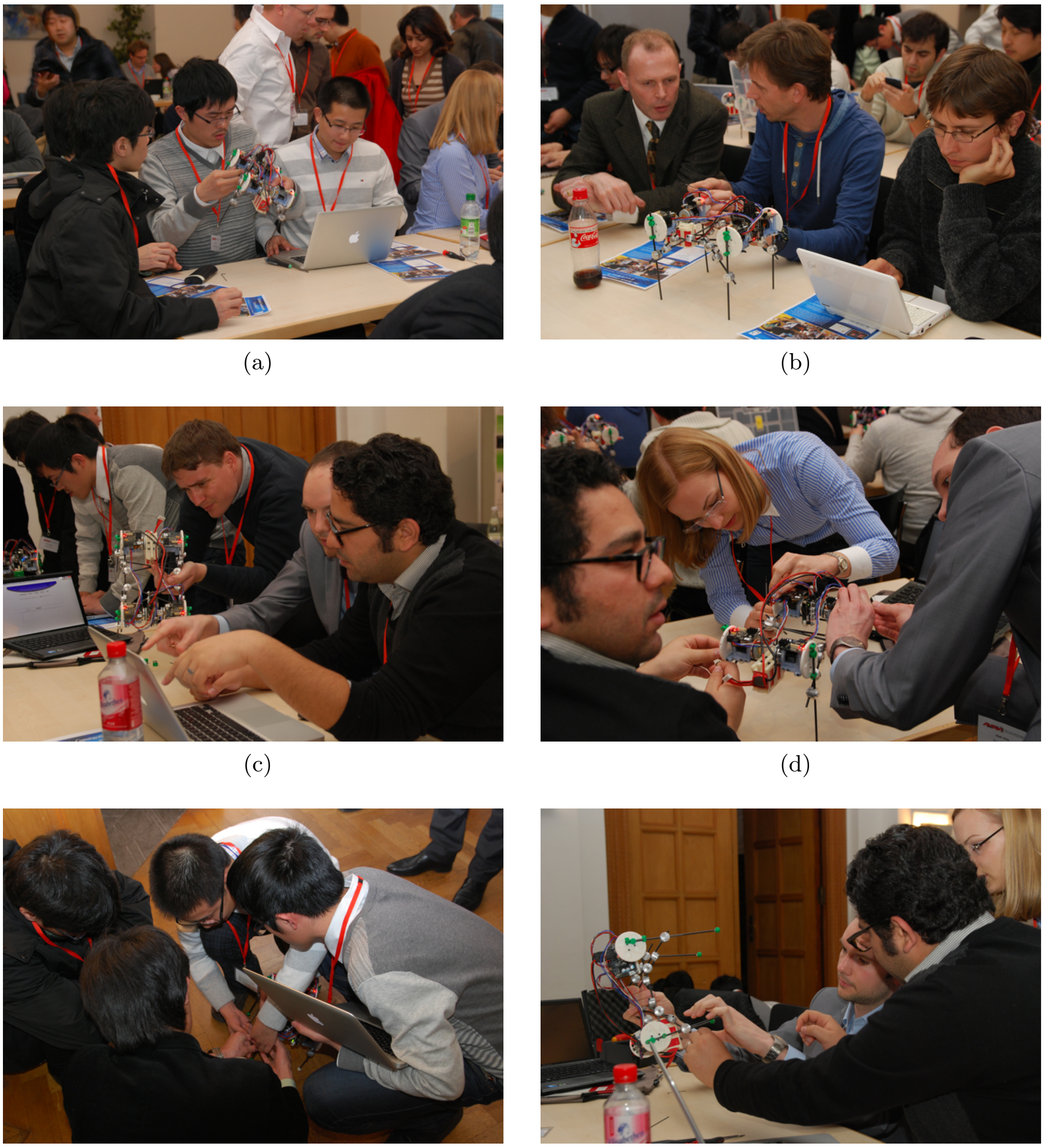
The task for the participants was to adapt the morphology to improve the locomotion with respect to speed. The participants formed six groups, one robot per group. They had 30 minutes to improve their robots. This included the time to get familiar with the LocoKit parts and the web interface to control the motors. For more details on the interface we refer to Deliverables D7.4 and D2.5. Figure 4.2 shows some picture of the groups working with their robots. Finally, the robots competed against each other two times. There was no clear winner, as none of the robot was able to walk completely straight. Nevertheless, it was impressive what the participants were able to achieve in such short time - even more remarkable, as there were also participants with no robotic or mechatronic background whatsoever. The robots exhibited different gaits, facilitated by the web interface. People were using their iPads and even their smart phones to control the robots. While we were able to demonstrate that in rather short time one can use such robots, one would need more the 30 minutes to establish a fully productive robot, as, for example, in a workshop, a seminar, or done during the summer school (see Section 3).

The feedback from the participants was very positive. Most of them were surprised what they were able to do in such a short period of time. They also liked the flexibility of the tool kit and the possibilities of the hardware. Prof. Roy E. Ritzmann[1] and Prof. Barry Trimmer[2], both leading and renowned researchers, expressed that they think it was a wonderful tool. Furthermore, they told us that such a toolkit is what they had been looking for, especially, because they were not able to get their engineers to produce something that was useful for them. This points clearly to the potential use of LocoKit in the context of none engineering researchers.

The competition was a success and contributed to disseminate further the LocoKit.

[1]Professor of Neurosciences; http://www.case.edu/artsci/biol/ritzmann/ritzmann.htm

[2]Henry Bromfield Pearson Professor of Natural Sciences Director, Neuromechanics and Biomimetic Devices Laboratory; http://ase.tufts.edu/biology/faculty/trimmer/

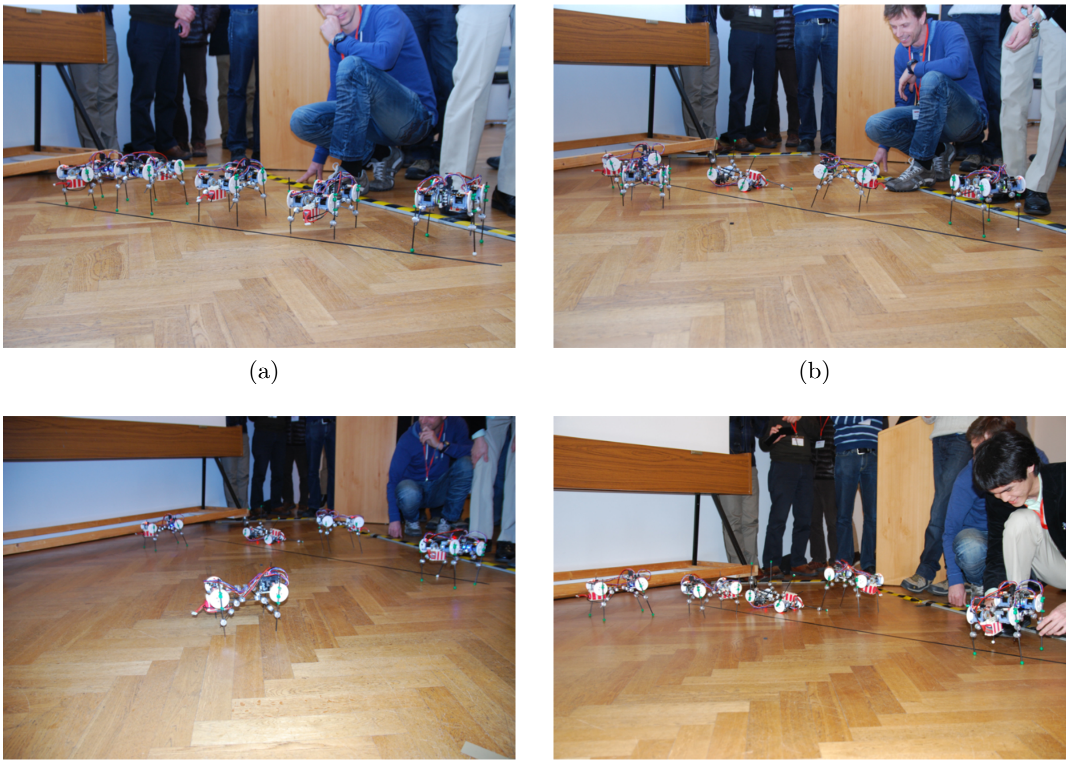


(a) (b)

(c) (d)

(e) (f)

Figure 4.2: Impressions of the teams working with the LocoKit robots.



(a) (b) (c) (d)

Figure 4.3: The LocoKit competition.