Locokit III: A versatile robotic platform to study embodied locomotion

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1 Introduction

In the past, researchers have had an interest in understanding the hidden secrets of locomotion. To a large extend, we are able to analyze animal locomotion by using high speed cameras, kinematic tracking systems, and ground reaction force measurement systems. This allows us to see what exactly goes on when an animal or human walks, runs, or climbs; thereby gaining more insights into how nature solves the task. However, with this approach several challenges rises. The first challenge is, that re-engineering the mechanical structure of muscles, bones, ligaments, etc. which nature has evolved to almost perfection is very difficult to redo in the world of engineering. Most often, we use electric motors, where animals uses muscles which are completely different ways of inducing energy into the system. In the joints, where nature uses ligaments and cartilage, the most used alternative for engineers are bearings and the transfer of energy through ligaments is also a challenging task to mimic in robots. Alternative ways of creating actuation, such as artificial muscles, pneumatic, are also becoming popular, however, they create other problems such as energy efficiency, size, weight, control, etc. Most often, electrical motors are used for actuation and is connected directly to the joint that the actuator has to control in order to make things as stable and easy to control as possible. Another point, which is just as challenging, is the control side. Though we are able to see and study how an animal or human behaves in a certain situation, the challenge of how to generalize that knowledge into something that can be used to control a robot continues to be a challenge. The problem is that two situations are never the same, so just making a copy is not possible. The controller needs to be able to adapt to both the morphology of the robot and the environment. Thought this is of cause common knowledge, and research have been working towards a general controller for years, the physical toolset for testing these systems is still limited. Thus, the majority of research employs simulation. Although simulation can be a very good and efficient tool, the reality gab remains a problems. On the other hand, working with robots can be quite time consuming, costly and annoying not to mention that it requires other competences than what control engineers and biologists might have. The use of a physical robot would always produce correct results in the sense that the results are based on the robot moving around in a physical environment and not inside a simulator. As an alternative to simulations and other toolkits such as Allbot [3], Lynxmotion [4], Vex Robotics [5] etc., LocoKit II [1] [2] allows studies in dynamic locomotion in both walking and running gaits. Though other toolkits provide abilities to do legged locomotion, to the knowledge of the authors, no other toolkit will give you the ability to study dynamic locomotion in both walking and running with multiple gaits.

This paper will, for the first time, present the newly developed LocoKit III. It holds a number of updated and improvements over its predecessor, both on the hardware and software side. These updates will make the building process of robots less time consuming compared to LocoKit II, and thereby making it more attractive to use for e.g. control engineers and biologists as part of their experiments. This together with the extension of wheels, leg-wheels, new controller options and two added programming options, it will increase the diversity of different morphologies that can be studied and thereby making it more attractive to use a robot compared to using simulations.

2 New features

The aim with LocoKit have always been to enrich and ease the creation of a legged robot. With LocoKit III, we aim at expanding the usability and easiness of using Lockit as a versatile and flexible robotic platform to study embodied locomotion using not only legs but also wheels, and their combination.

2.1 Programming with increased flexability

The basic concept of programming LocoKit through a webbrowser and have compiling done locally on the robot is maintained as it makes it easy and fast to get started using LocoKit. For programming, Blockly [6] have been implemented as a second option for programming LocoKit directly from its web-interface. For more skilled professionals, a direct editor for python is now also available, so that python code can be written directly in the browser and exe-

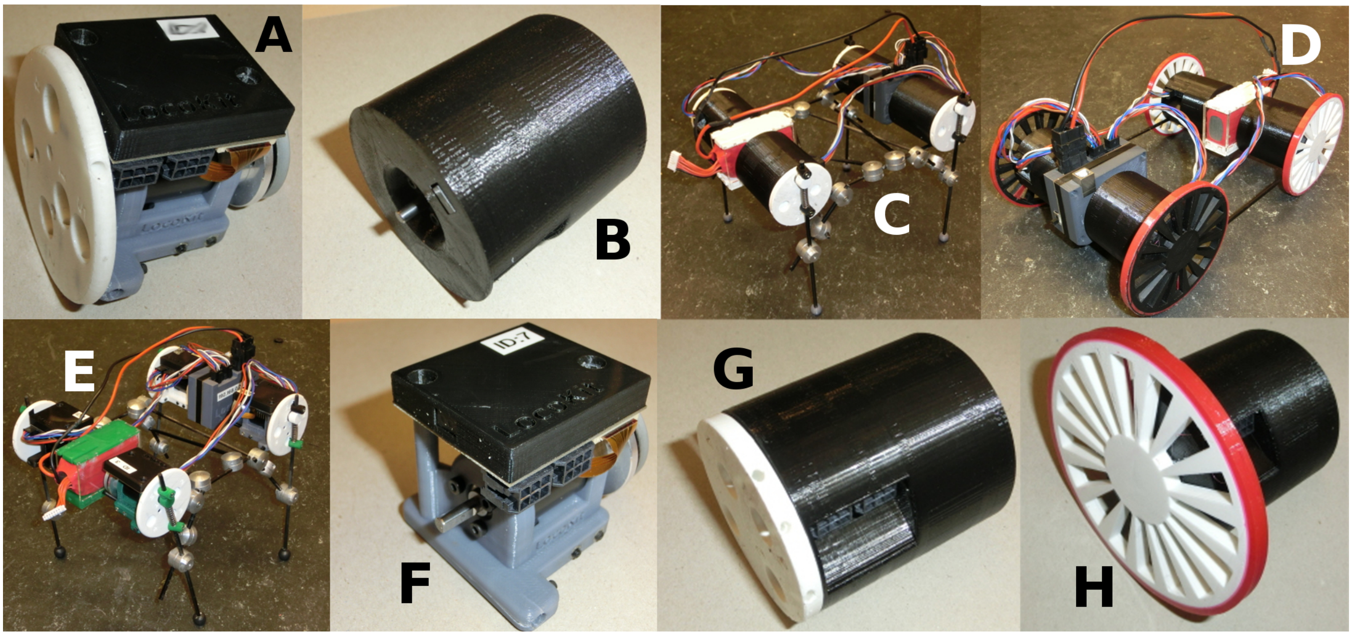

Figure 1: This figure shows pictures of new an old modules in LocoKit. A) Old motor module with connection disk. B) New motor module. C) Springybot build with new components. D) Rover build with new components. E) Springybot build with old components. F) Old motor module. G) New motor module with new connection disk. H) New motor module with new wheel module.

cuted. For those who are dedicated programmers, it is naturally still possible to connect with LocoKit through SSH and program the toolkit directly in C or python.

2.2 Updated building scheme

On the mechanical side, a number of components have been updated so that it make constructing robots easier, and makes the final structure stronger. We have reused the same basic principal of 4mm rods, and the locking mechanism so that old and new components goes together. The updates consists of the following new or updated modules:

- A newly developed motor module where the location of connection points has been optimized.
- Modules that attach to the motors-pin have been redesigned so that they become more stable.
- 3D printed wheels with light weight but strong structures and rubber tires is added to LocoKit III.
- Half-circle leg (RHex-like leg) is added to LocoKit III together with a dedicated controller.

3 The near future

In the near future we plan to look at the possibility of adding flexible components to LocoKit and thereby also target the area of soft robotics. With new composite lab facilities at the University of Southern Denmark we aim at develop new connection mechanisms for the mechanical interconnection of modules in LocoKit with a unique set of features target towards soft robotics. The use of 3D printed multi-material components will increase.

4 Conclusion

Our aim is to make it more attractive for researchers who would normally use simulations to use a robot instead. LocoKit III provide a good platform for studying locomotion, morphology, control, morphosis etc. both for teaching and research. With the new addition we believe that using the toolkit have become even simpler, while extending the application domain. Previously, it would be possible to assemble the basic four legged Springybot from LocoKit in about 1-2 hours for most people. With the new additions we believe that we can now say 0.5-1.5 hour for most people. From the programming side, improvements are the addition of Blockly, and the ability to program Python directly from the website extending the usability for non-programmers.

References

[1] Larsen, J. C., Brandt, D., & Stoy, K. (2012, August). Locokit: A robot construction kit for studying and developing functional morphologies. In International Conference on Simulation of Adaptive Behavior (pp. 12-22). Springer Berlin Heidelberg.

[2] Larsen, Jorgen, et al. ”Increased performance in a bottom-up designed robot by experimentally guided redesign.” Industrial Robot: An International Journal 40.3 (2013): 238-245.

[3] A robotic toolkit for building quadruped and biped robots. Consists of 3D printing and servo motors. URL:http://www.allbot.eu/

[4] Lynxmotion is a company that produce a number of different robotic toolkits. Both drones, quadrupeds, bipeds, hexapods, rovers and robot arms are in their program. URL:http://www.lynxmotion.com

[5] Vex Robotics produces a number of different construction kits that allow structures mostly on wheels to be created. URL:http://www.vexrobotics.com/

[6] Blockly by Google is a graphical programming interface that ease the programming experience. URL:https://developers.google.com/blockly/