LocoKit - A Construction Kit for Exploration of Morphology of Legged Robots

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Abstract: Producing steady stable and energy efficient locomotion in legged robots with the ability to walk in unknown terrain is a big challenge in robotics. In addressing this challenge, it is often desirable to experiment with different morphologies and see how they influence on the way the robot walks. This is however not always easy, since robots are often built as a fixed system with a limited possibility of changing the morphology without redesign a significant part of the robot. This work is focusing on the creation of a robotic construction kit specifically aimed at easing the process of constructing legged robots. This is accomplished by giving the creator the possibility to easily do morphological changes to the robot even after it have been build, to see how it effects the robot's ability to walk in unknown terrain.

Keywords: LocoKit, Quadruped, Robot, Modular Robot, Walking

1. INTRODUCTION

For decades, scientists have tried to build legged robots with the ability to walk in unknown terrain, in order to make them more useful for real-world tasks. Often, mobile robots are using wheels for transportation, mostly because they provide a number of advantages in terms of stability, controllability, efficiency and speed. Even though wheels have been used for decades, not only on mobile robotic platforms but also on cars, trucks, farming equipment etc. they still have certain disadvantages that legs does not have, of which the biggest might be the ability to handle unknown terrain. When constructing robots, one often tends to build a robots as a whole, meaning that the robot is a fixed structure with limited possibility to change mechanical parameters on the robot after it has been build. Since the morphology of the robot is of vital importance to its performance, it is important to have a system that allows for changing the morphology of the robot in order to explore how different morphologies effects its walking abilities. This is the main reason why we feel that the conventional way of building walking robots may not be the best scientific way of exploring walking abilities in robots. In trying to come up with a solution, we have introduced the modular robotic construction kit, called LocoKit, created by Larsen et. al [3]. In this paper we demonstrate that by extending principles from modular robots, LocoKit gives the opportunity to study different morphological questions, by enabling the constructor to build legged robots from LocoKit and then afterwards start adjusting mechanical parameters on the robot, which again changes the morphology of the robot. Modular robots have been a field of research for the past 25 years and have shown us, that modular robots are able to form a number of different morphologies, all able to perform locomotion, either on legs, crawling or as a loop robots, [2][4][5].

2. MOTIVATION

When looking at animals and the morphological richness between different species, it is obvious that it is a good place to start looking when we want to get inspiration on how to create legged robots. Animals like dogs, monkeys and lizards, are all extremely good at doing legged locomotion in an elegant, efficient and lithe way. It seems like the whole body is part of their walk. When looking at the walking style of these three different classes of animals, it is obvious that their walking style is quite different from one another. They have a different morphology. While all being very good at legged locomotion, their individual morphology gives each of them certain advantages. A dog is for instance good at running fast, but a monkey is a much better climber and a lizard can move almost unseen given its flat posture. It is clear the the morphology is of vital importance to each animals ability to move. Legged robots are often created so that they look like an animal, for instance a dog. The process of modelling a dog as a robot is easily done by using a stiff frame as the body of the robot, onto which four legs are attached. The robot is also often symmetrical, which gives the robot a centre of mass placed conveniently in the centre of the robot, making it easier to make the robot stable during walk. However, building a robot by only having it look like an animal, might not always be good enough. It requires fine tuning of the morphology of the robot to get comparable walking performance to animals. I order to contribute with a new approach to designing walking robots, we are designing a robotic construction kit called LocoKit. The goal with LocoKit is to create a robotic construction kit focused on building dynamically walking robots. Since the morphology of the robots might play a big role in the walking performance, LocoKit have been created in a way that allows the constructor to adjust the morphology of the robot, even after the robot has been assembled. These adjustment could be length, width, height, centre of mass, compliance, different spines etc.

3. EXPERIMENTS

To test the construction kit, experiments have been conducted with two very different robots - *see Figure 1.*

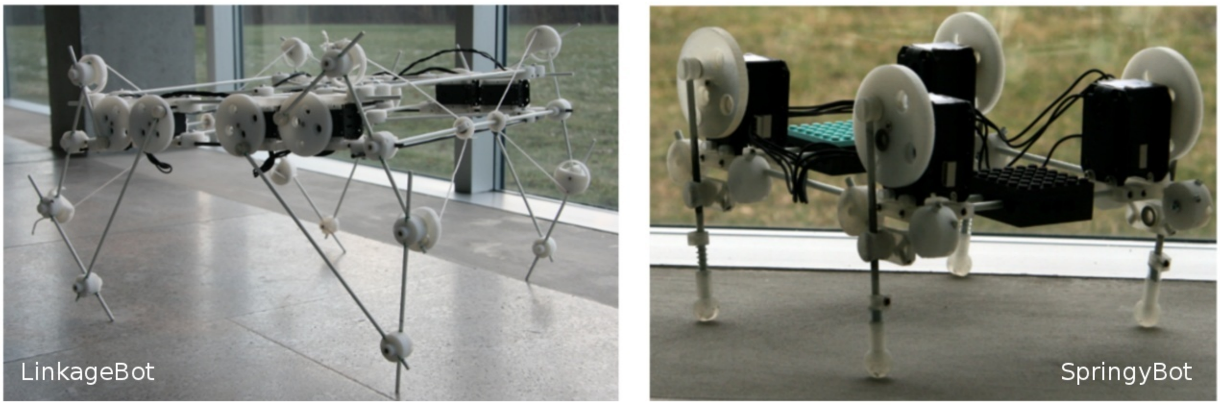

Fig. 1 Two robots build from LocoKit. On the left is the LinkageBot with a weight of 1600 g, W55 D43.5 H30 (cm) and on the right is SpringyBot with a weight of 650 g, W25 D20 H18 (cm).

The purpose of these two example experiments is to illustrate how the construction kit can be used to answer questions related to morphology.

3.1 Experiments on linkage-bar systems

The robot, LinkageBot, have been inspired by the Strandbeest robots by Jansen et. al [1]. The robot is constructed with two motors per leg, making it possible to control the trajectory of the foot from the controller - *see Figure 1*. With this robot we wanted to see if it would be possible to build a linkage-bar mechanism with LocoKit and also to see how much freedom we would have afterwards to adjust the morphology of the robot. On this robot, it was of great benefit to have the opportunity to adjust the lengths of the individual components in the legs. This made it possible in an easy way to study how different reachable spaces of the foot affected the walking abilities of the robot.

3.2 Experiments on compliance, weight and energy efficiency

The second robot, SpringyBot, with only one actuator per leg, giving the legs a fixed trajectory - *see Figure 1* have also been designed. With this robot we wanted to see how simple a robot we could build, and still gain a benefit from the adaptability of LocoKit. Firstly on this robot we started to add different levels of compliance to the legs to see how this would effect the walking ability. Secondly, we tries increasing the weight of the robot to see how this would effect the energy efficiency of the robot. These experiments show how the energy efficiency increases together with the weight. These results are similar to what is seen in animals.

4. CONCLUSIONS

The robotic construction kit, LocoKit, have been developed to make it easier to build and explore different morphologies on walking robots with the ability of doing efficient and dynamic locomotion in unknown terrain. The kit supports opportunities for changing parameters in the construction, even after the robot has been assembled. These are for now parameters like length, width, height and centre of mass. In the current state of the system, it have been used in several experiments, showing that the system is able to form legged robots with very different morphology - *see Figure 1*. The robots build from LocoKit have been tested in both flat terrain as well as in unknown terrain. Experiments show that the LocoKit system still needs some optimisation in order to perform stable legged locomotion in unknown terrain, however for walking on flat terrain the robots shows stable forward locomotion.

In future work the LocoKit system will be enhanced with better opportunities for adding compliance in the structures, as well as the possibility of doing online morphosis, that is, changing the morphology of the robot.

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