Optimizing stiffness curve to achieve high quality locomotion

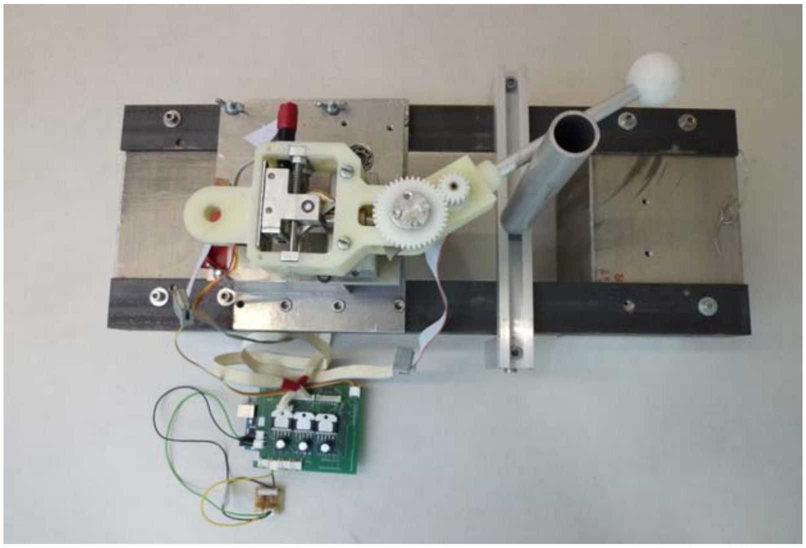
1. Motivation and target

Compliance is now attracting many efforts from robotic researches since it provides self-adaptability for robot to handle uneven terrains even with a simple controller. Moreover, the compliance helps locomotors to store energy and absorb impacts from environment [1]. However, the level of required compliance is not invariant in all environments, walking gaits, speeds, etc…. It needs to be controlled properly depending on a certain condition. Therefore, the need for variable compliance actuator is rising. In fact, there is a number of variable compliance mechanisms which have been proposed, implemented and applied in robotics fields [2,3]. Nevertheless, there are not many of those integrated in walking robots to understand how the role of variable compliance actually plays in robot locomotion. From the state of the art of terrain handling robot, we are motivated to build a quadrupedal walking robot which is targeted to achieve high quality locomotion by integrating a novel variable compliance actuator, Mestran coined at AI Lab. This actuator allows system to change its stiffness level in high speed with a small amount of energy consumption. The robot performance is expected to achieve energy efficient locomotion as well as terrain handling capability.

2. Project description

a) Improvement of rotary variable compliance actuator, Mestran

Mestran actuator now is in early development phase. Some first prototypes have been built and tested (see illustrative photo below). The preliminary results show that it is promising for further development.



Student needs to redesign and fabricate the mechanism to fit in quadrupedal robot. I have experiences on this process, we will work together.

b) Designing quadrupedal walking robot with integration of Mestran

For simplification under time constrain, robot has a traditional structure with four legs and only one active hip joint for each leg. Mestran can be placed either Hip or knee joint to control compliance level.

c) Control compliance robot to achieve high quality locomotion

The point is to optimize the stiffness curve at landing and takeoff phases in such a way that it can absorb the impact in landing phase but stiffen the leg to support it in takeoff phase. Biomechanic researchers have shown that stiffness control is a very crucial point in human and animal locomotion since the limb stiffness is changed in terms of many parameters such as attacking angle of leg to ground, speed, surface stiffness [4].... Therefore, this project aims to optimize the stiffness curve in landing and taking off phase to for robot able to achieve high quality locomotion in the perspective of energy consumption, stability (more evaluating criteria if time and working progress are allowed) by exploiting the role of stiffness.

d) Writing a paper about the project

3. Candidate

This project has been designed for one person for a period of 4-6 months. We are looking forward to students who are self-motivated and interested in bio-inspired locomotion robotics. The student should have some skills in mechanical design, machining, and programming.

4. References

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3. J.W.Hurst, Chestnutt, A.Rizzi. An Actuator with Physically Variable Stiffness for Highly Dynamic Legged Locomotion. Proceedings of the 2004 International Conference on Robotics and Automation. May, 2004.

4. A.Arampatzis, G.P.Bruggemann, V.Metzler. The effect of speed on leg stiffness and joint kinetics in human running, Journal of Biomechanics, Vol. 32, pages 1349-1, Issue 12, December 1999.

5. References

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