In P. Patrinos, I. Markovsky, W. Michiels, J. Swevers, & S. Waldherr (Eds.), 38th Benelux Meeting on Systems and Control March, 2019 Lommel, Belgium

Generalized Dynamical Modeling of 2-D Modular Snake Robots

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1 Introduction

Learning from natural phenomena is widely considered to be important in developing key innovations and has been an inspiration for engineers for decades. One of the fascinating fields in research is the field of biologically inspired robotics [1]. This study will revolve around the locomotion of a snake robot [2]. Due to its small cross-section, a snake robot is ideal for locomotion in confined spaces. Snake robots can be used to inspect a pipe, a collapsed building or areas that are difficult to access by any other means. A unique characteristic of a snake is that it is very flexible. It can turn with little space and can propel itself forward using the environment whereas other robots generally avoid contact with obstacles. The goal of this study is to develop a generalized model for the 2-D locomotion of the modular robot snake depicted in Figure 1, developed at the University of Canterbury [3]. The aim is to have a single framework that can be used to model lateral undulation as well as a rectilinear locomotion.

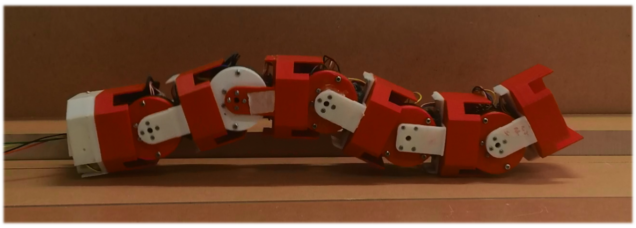

Figure 1: Rectilinear locomotion of a modular snake robot.

2 Dynamical model

Considering the large number of degrees of freedom of a robot snake and its under-actuated nature, a model is developed to simulate the locomotion of the modular snake robot. The kinematics of the modular snake robot are derived, after which the equations of motion are acquired from the Euler-Lagrange formalism and written in the canonical joint-space formulation. To control the body shape of the snake robot, partial feedback linearization is applied to linearize the actuated dynamics and PD-control is applied to indirectly control the body shape via the relative angles among the segments.

3 Contact model

To investigate the locomotion of a snake robot in space, the contact with the environment has to be modeled. In nature, snakes can propel themselves due their anisotropic skin. The effects of surface friction are incorporated as the combination of an anisotropic Coulomb and viscous type of friction. Environmental constraints such as walls are modeled with a spring-damper contact model. The interference with the environment will yield a penalizing force which can be interpreted as the exerted normal force from the environment.

4 Simulation results

In the presentation we will show the locomotion of the snake robot in different environments, such as the lateral undulation in a pipe as depicted in Figure 2.

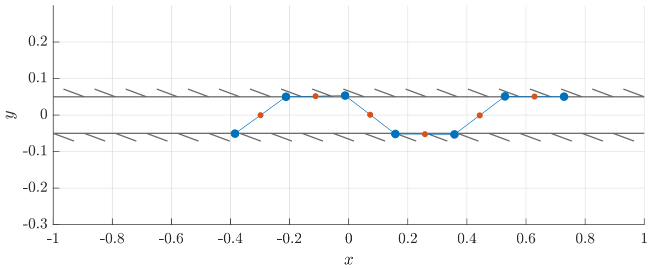

Figure 2: Simulation of lateral undulation in a pipe.

This illustrates the power of the developed model and leads to a better understanding of effective gait patterns suitable in different environmental situations [4].

References

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[4] M.A.J Koopaee, C. Pretty, K.H.J. Classens, X. Chen, "Dynamical Modelling and Control of Modular Snake Robots with Series Elastic Actuators for Pedal Wave Locomotion on Uneven Terrain," *In preparation*.