Multi-link Mechanical Locomotors in Natural Gaits - Controller Design and Experiments

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Declaration

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I hereby certify that the work embodied in this thesis is the result of original research, completed subsequent to admission to candidature for the degree.

Md Nurul Islam

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“Excellence is the result of caring more than others think is wise, risking more than others think is safe, dreaming more than others think is practical, and expecting more than others think is possible.”

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Abstract

A multi-link mechanical system designed for locomotion, can be regarded as a mechanical rectifier as periodic oscillations of the links are rectified to induce locomotion of the system. The essential mechanism underlying the limbless locomotion of many animals can be viewed as rectification that converts periodic body movements to thrust force through interaction with the environment. It inspires the mechanical design of multi-link locomotors. To uncover the fundamental engineering mechanism underlying the rectifier model, we developed a prototype mechanical rectifier (PMR) comprising of two-link system and a disk at the first stage. A biologically-inspired central pattern generator (CPG) controller was developed to achieve the locomotion of the disk with a certain sense of natural oscillation of the links. This PMR system is simply enough to reveal the animal locomotion mechanism. However it is too simple to understand the complicated locomotion gaits. Later on, we designed and manufactured a multi-link fully-actuated system to examine the ray fish-like flapping-wing gait and a multi-link under-actuated system to analyze the snake-like serpentine gait. These two systems were developed to realize the complex natural locomotion gait and at the same time to validate the effectiveness of the CPG controller to achieve the stable autonomous locomotion gaits with the undulation of the body links at natural oscillation.