CHAPTER 1 - INTRODUCTION

1.1. Background

A Cheetah-cub robot is a small legged, trotting, quadruped robot which achieves high-speed locomotion on flat terrain. The robot was developed based on feline morphology by scientists at the École Polytechnique Fédérale de Lausanne in Switzerland.

The main focus of the Cheetah-cub robot is its locomotion speed and stability. The locomotion gait of the Cheetah-cub robot was generated by means of implementing a Central Pattern Generator (CPG), with the purpose of producing rhythmic-patterned outputs. The resulting joint angle profile of the Cheetah-cub robot resembles a sinusoidal wave with different frequencies between its swing and stance phase. [1]

As a sinusoidal wave, the analysis, implementation and tuning of the joint angle profile were expected to be more straightforward. The parameters defining the gait were reduced to be the amplitude, frequency and offset value of the sinusoidal wave. The gait still had natural gradual rate of change as characterized by the sinusoidal wave. Thus, simplification into sinusoidal gait control was meant to compromise between imitating natural animal gait and emphasizing ease of control. The evaluation on the implementation ability of the sinusoidal gait control was also made.

This thesis will discuss about the development of the sinusoidal gait control for the Cheetah-cub robot instead of implementing CPG, taking special care on the joint angle profile modeling. An explanation regarding considerations and justification in reconstructing both the quadruped simulation model and actual platform will also be included. Finally, the implementation result of the sinusoidal gait on both the simulation model and actual platform will be evaluated and analyzed.

1.2. Research Problems

The research problems to be solved are as follows:

1. Determining the parameters defining the sinusoidal gait model.
2. Investigating the capability of sinusoidal gait in generating periodic, rhythmic leg motion.
3. Making necessary adjustment on the sinusoidal gait, so that the gait can be implemented on actual robot.

1.3. Research Objectives

The objectives of this research are as follows:

1. To design the mechanical model of the newly-developed robot generally based on the Cheetah-cub mechanical structure with necessary adaptations.
2. To construct the actual platform of the robot.
3. To design the sinusoidal gait model.
4. To develop the implementation method of the sinusoidal gait control on the actual quadruped robot.
5. To test the implementation of the sinusoidal gait on the actual quadruped robot.

1.4. Significance of Study

The significance of this research was investigating the possibility of the sinusoidal gait control as a compromise between a trajectory-based method and biologically-inspired method.

The sinusoidal wave is relatively easy to be mathematically defined but also capable in providing a natural rate of change. The wave is commonly describable only by its magnitude, frequency and offset, so the tuning process for designing the controller is possibly more intuitive and effortless. As the controller relies on a smooth magnitude variation of the sinusoidal wave, exact knowledge of the robot model was not required on generating the gait.

Although the gait model also adopts the drawback of having unguaranteed movement stability as commonly encountered on biologically-inspired controllers, its straightforwardness of parameters—similarly found on controllers designed with

trajectory-based method—gained the advantage of reasonable tuning process instead of trial-and-error tuning on typical biologically-inspired controllers, which are usually described by numerous and complicated parameters.

1.5. Research Questions

Question #1: What are the roles of each part of the mechanical model of the Cheetah-cub robot, by means of gait locomotion?

Question #2: How are the walking, trotting, and step-climbing gaits for the newly-developed Cheetah-cub robot defined?

Question #3: What are the parameters controlling the gait and what are their each significance?

Question #4: Which stability criteria will be chosen as the basis of determining the capability of the sinusoidal in maintaining stability of the robot?

Question #6: Is it possible to re-implement the gait tuned for one quadruped platform onto another similar quadruped platform?

1.6. Hypothesis

Hypothesis #1: Implementing the leg parameters and joint angle profile of the robot based on stride cycle of an actual cat may tend to result on valid gait locomotion.

Hypothesis #2: As the parameters defining the gait are straightforward, the effect of each of them on the resulting gait would be significant enough to be observed through a study on parameter sensitivity, thus the gait tuning process should have some basic rules concluded from the study result.