Chapter 1

Introduction

1.1 Research Background

Human perform actions in order to complete task or react to surrounding environment. We render these actions in functions form. The actions are naturally based on purposes, which commonly act as goals. Successes and failures in achieving these goals are recorded in the human mind as knowledge, for references during future attempts. This form of learning represents human intelligence for being self-sustainable that is important in improving our skills for solving surrounding problems.

Applying such intelligence in machines has been an issue surrounding many researchers. Methodologies for self-sustained autonomous machines have been well developed and various new methods and ideas are continuously being proposed in order to reduce human intervention in managing these machines. Providing actions of machines in form of functions help machines to self-evaluate their actions. Human-like functions are one of the focuses of these methods and application may provide methods for self-sustained autonomous machines that could react and adapt to surrounding environment.

1.1.1 Multi-Functionality

Human functions are not limited to individual components where each functions only reacts to a single goal. A goal may require multiple human functions to be obtainable. For example, in case of hurdle race, two human functions of jumping and running are combined to cross the finishing line which acts as a goal. Here, multiple functions are utilized, where a professional with only either jumping or running skills are not certain to be capable of achieving the finishing line perfectly. The above ability here is described as Multi –
functionality. Through Multi-Functionality, an action can be learned and decided by multiple knowledge of skill, and applied when confronting a problem that cannot be solving by a single function. Here, Multi-functionality can be described as a quality of utilizing multiple functions for performing a single goal.

A device with multi-functionality could render an action that considers multiple characteristics in surrounding environment through application of knowledge of skills from various environments. A device with conventional control method only utilizes control command that produces action based on a single function. Method of self-sustained machines could only utilize a single function to become sustainable and lack of flexibility in confronting foreign characteristics simultaneously. Multiple control option is needed in self-sustained machines in order to become autonomous. Multi-Functionality may provide a wide range of control option against any environment in self-sustainable machines.

1.1.1.1 Multi-Functionality against Non-Linearity

Most control method considers linearity in a device for deciding control option. A device with non-linearity will not able to utilize a single control method for the entire system due to parameters that would render the system unstable at a certain state. For example, a pendulum-cart device has two different states that require different control methods for operation. Multiple functions are needed to manage these multiple states. Conventional control method such as Cascade PD Control can only provide two functions for swing and stabilization control. In case of more functions required, such method could not manage to perform successfully.

![Figure 1.1: States for control of Cart Pendulum System.](image-url)
Non-linearity also exists in our common devices such as vehicles. Non-linear Control in machines is complex and hard without an expert human knowledge in the control system. Aerial hovering vehicles such as helicopters require multiple functions for managing multiple states using the Thrust and Cyclic.

Manipulation of angular orientation with thrust can provide position transition but requires skills in multi-functionality. Human multi-functionality provides expert control of machines with non-linearity. Providing multi-functionality in a non-linear control system could provide a safe and reliable control as good as an expert human.

Human multi-functionality provides expert control of machines with non-linearity due to utilization of multiple knowledge of skill when managing the machines. Through skills of angular orientation and hovering thrust manipulation, expert human pilots are able to perform radical movement of such machines in precision, for example, during position transition of the vehicles. They may react to surrounding environment while still maintaining stability of the machine that is easily affected by unstable states. Therefore, providing quality of multi-functionality as well as human-like functions in a non-linear automatic control system could provide a safe and reliable control replacing an expert human.