Actuator Design for a Passive Haptic Display

A Thesis
Presented to
The Academic Faculty

By

Lawrence Joseph Tognetti

In Partial Fulfillment
of the Requirement for the Degree
Masters of Science in Mechanical Engineering

Georgia Institute of Technology
June, 1999

Actuator Design for a Passive Haptic Display

Approved:

_____
Dr. Wayne J. Book, ME, Chairman

_____
Dr. Aldo Ferri, ME

_____
Dr. William Singhose, ME

Date Approved _____

Dedication

Dedicated to my four grandparents Laura Tognetti, Emio Tognetti, Irene Faoro, and Julius Faoro. They have provided the foundation so that their family may have a better life. In their actions they demonstrate the importance of strong family support.

Acknowledgments

I give my thanks to Dr. Wayne Book for his support and assistance. His support is acknowledged not only in the research arena, but also in professional development of graduate students. I am gracious for the National Science Foundation's support of Intelligent Machine and Dynamics Laboratory's investigation of passive haptic displays (grant IIS-9700528). I also send thanks to Dr. Hakan Gurocak who encouraged my ambitions to proceed with my education.

Most importantly I thank my parents, Dr. Rod Tognetti and Mrs. Laurette Tognetti, for their support and patience with an occasionally less then cheerful son. Without their assistance and motivation I would not be at this stage of my career. Lastly, I express appreciation to all my friends and colleagues who showed support throughout my experiences at the University of the Pacific and the Georgia Institute of Technology.

Table of Contents

List of Tables

List of Figures

Chapter 1

Chapter 2

Chapter 3

Chapter 4

Chapter 5

Summary

Haptic interfaces have various applications ranging from training devices to super joysticks for remotely operated robots. Existing marketed haptic interfaces rely on powered actuators to resist motion or apply force to the user, simulating desired virtual boundaries and other haptic features. Due to the size or nature of certain applications, it may not be desirable to use a haptic interface with capabilities of overpowering the human's input. This has opened the area of passive haptic interfaces. Passive haptic interfaces do not use actuators capable of adding energy to the system, but rather utilize actuators that dissipate or redirect user supplied energy. PTER (Passive Trajectory Enhancing Robot) is a two-degree of freedom passive haptic robot test bed, utilizing clutches to dissipate or redirect user supplied energy in order to simulate virtual boundaries. Deficiencies in PTER's actuators have been identified in past research.

This research initially surveys industrial available clutch / brakes, but none are found to suit the project's requirements. Efforts are then turned to redesigning the existing Dynacorp electromagnetic friction clutches. The new clutches incorporate provisions to measure actual applied torque for use with feedback control and rely on a new spring back mechanism to ensure repeatable engagement and disengagement. Careful attention is given to torque measuring sensitivity and endurance strength of the new components. One prototype clutch is built, tested, and modeled. Benefits of closed loop proportional torque control are demonstrated with experiments and advantages of various digital controllers are simulated.