

UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

POSITION CONTROL USING PITCH FEEDBACK

A THESIS

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

Degree of

MASTER OF SCIENCE

By

MUSTAFA A. GHAZI

Norman, Oklahoma

2013

POSITION CONTROL USING PITCH FEEDBACK

A THESIS APPROVED FOR THE  
SCHOOL OF AEROSPACE AND MECHANICAL ENGINEERING

BY

---

Dr. David Miller, Chair

---

Dr. Andrew Fagg

---

Dr. Peter Attar



## DEDICATION

To my...

# Acknowledgements

First of all, I ...

I would like to ...

Finally, I would like to ...

# Contents

|          |                                                      |          |
|----------|------------------------------------------------------|----------|
| <b>1</b> | <b>Introduction</b>                                  | <b>1</b> |
| 1.1      | Charles Chuck Yeager and Glamorous Glennis . . . . . | 1        |
| 1.2      | Tesla’s AC Induction Motor . . . . .                 | 1        |
| <b>2</b> | <b>Related Work</b>                                  | <b>2</b> |
| 2.1      | Pitch Feedback in Robots and Humans . . . . .        | 2        |
| 2.1.1    | Automated systems controlling pitch . . . . .        | 2        |
| 2.1.2    | Automated systems: summary . . . . .                 | 2        |
| 2.1.3    | Human motor control . . . . .                        | 2        |

# Abstract

An interactive robot has been developed to play a musical instrument called the theremin. The robot has 4 degrees of freedom (DOF) and uses zero crossing rate (ZCR) for pitch detection. A proportional-derivative (PD) feedback control scheme is used to control pitch and play music. A user interface converts human whistling sounds to a commanded melody for the robot. A melody extraction scheme (MES) filters and shifts the input pitch to fit in the pitch generation domain of the theremin. In contrast to other thereminist robots, this robot is a low cost platform using ‘hobby’ electronics. The interface enables non-musicians and non-programmers to command the robot to play musical pieces of their choice. Like some other thereminist robots, it can adapt to a changing environment, and can be easily re-programmed to test different control schemes. Unlike other thereminist robots which are set up to test predominantly feedforward control schemes, our robot is set up to explore feedback as well as feedforward control schemes. The development of this robot is a first step in creating tools for exploration of aspects of human aural preferences, and human motor control during musical performances. The benefits of understanding human motor control in this context can extend beyond musical robots. This understanding can impact human-robot interaction applications in general, leading to greater potential for human acceptance of robotic systems.

# Chapter 1

## Introduction

Insert long winded description here

### **1.1 Charles Chuck Yeager and Glamorous Glen- nis**

A section...blah blah blah

### **1.2 Tesla's AC Induction Motor**

Another section... Here's a [hyperlink to Section 1.1](#). And to [Chapter 2](#)

# Chapter 2

## Related Work

One of the objectives of this thesis is to...

### 2.1 Pitch Feedback in Robots and Humans

#### 2.1.1 Automated systems controlling pitch

One subsection

#### 2.1.2 Automated systems: summary

Another subsection

#### 2.1.3 Human motor control

Yet another subsection

# Bibliography