Accelerated Muscle Memory: Realtime Swing Feedback

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Abstract

Muscle memory acquisition requires a significant time investment. Certain industries and activities demand accelerated acquisition of fine and course motor skills. These constraints can be mitigated by accelerated learning through constant feedback during the execution of manual techniques. Readings can be taken from an experienced user of instruments or tools as an ideal execution of motor techniques as three-dimensional coordinate readings sampled at regular intervals using accelerometer and gyroscopic modules. The objective of this project is to take readings from an adept user and use them as deviation samples when compared to samples taken from an inexperienced user. This project will employ a microcontroller that will use motors placed on a baseball bat to provide feedback proportional to the deviation of the coordinates from the experienced user.

Keywords: accelerometer, feedback, motors, gyroscope, microcontrollers, swing, muscle memory

Accelerated Muscle Memory: Realtime Swing Feedback

The purpose of this project is to provide a method of accelerating muscle memory acquisition through the comparison of samples taken from an experienced user’s swing on a baseball bat and calculating the deviation of the coordinates in 3-D space of an inexperienced user’s swing and compared to that of the standard, more adept swing. Feedback will be provided to the user through the vibration of offset motors, or more colloquially referred to as vibration motors. The vibration will be proportional to the deviation of the coordinates of the Novice user from those of the Professional user.

# Background and Motivation

Muscle memory acquisition is an involved process requiring a significant time investment. It entails the acquisition of fine and course motor skills in the execution of a hammer strike, a mallet swing, a pitch, a swing, or a Frisbee flick. The coordination of large muscle groups requires discipline and dedication on the Novice’s part to become adept at a skillset. The acquisition of these same motor skills can be exacerbated if the Novice employs improper technique. This can sometimes become apparent in local gyms whereby an athlete learned improper form when squatting. The scope of this project deals specifically within the real of swinging a baseball bat; a variety of activities can be emulated by changing the speed and directionality of the swing, be it downwards, upwards, or lateral movements. The commoditization of low-cost gyroscopic MEMS sensors and microcontrollers has lowered the feasibility of employing a real-time feedback system whereby a Novice user can remap their movements in 3-D space in relation to a Professional user of a given instrument or tool.

# General Overview

Figure 1. General System Overview



Figure 2. Lateral and Top View of Baseball Bat with Motors Attached

## Accelerometer/ Gyroscope

A MPU6050 6-Axis Accelerometer/ Gyroscope module will be used to measure samples. The module has a maximum sampling rate of 1KHz, but will be sampled at 60Hz to conserve memory. Both the Novice and Professional users’ swings will be sampled for a duration of five seconds. The 3-D coordinate readings will be encoded into a 16-bit value. The approximate memory required to store the samples will be approximately 1.2 kilobytes of memory. The microcontroller will need to have enough memory to store the readings and perform feedback calculations for each sample in memory.

## Microcontroller

The current plan is to use an ATmega328P microcontroller to serve as the central processor for both the driving circuitry and the input from the accelerometer module. The Arduino environment will be used to expedite development of the hardware and provide enough time to optimize the feedback mechanism employed on the system to provide maximum maneuverability and stability at the time of the swing from the Novice user. The ATMega328P has a maximum SRAM size of 2 kilobytes and a program size of 32 kilobytes. This leaves an excess of approximately 800 bytes as processing memory and temporary calculation space. Quaternions will be used to store the coordinates in memory, whereby the rotation of the baseball bat will be preserved and gimbal lock is avoided.

## Motor Drive Circuitry

Since each motor will require a significant current drive an external circuit will be employed that will provide a PWM signal to the motors in proportion to the deviation of the current coordinates to the coordinates of the idealized swing (the measurements taken from the Professional user). The motors employed will need to be driven at approximately 3V with a maximum current draw of 800mA. Depending on the size of the baseball bat larger motors may be necessary to provide the torque necessary to effect the swing in real-time.

## Motors

Four motors will be placed at 90-degree intervals along the main axis of the baseball bat. The motors will vibrate proportionally to the deviation of the current swing from the Novice user to the idealized swing of the Professional user. The placement of the motors will be determined by the total moment of inertia of the baseball bat and the distributed mass of the four motors. The motor placement will serve as additional poles to the total transfer function of the resulting feedback system.

Work Plan

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 3/7-3/11 | 3/14-3/18 | 3/21-3/25 | 3/28-4/1 | 4/4-4/8 | 4/11-4/15 | 4/18-4/22 | 4/25-4/29 | 5/2-5/6 | 5/9-5/11 |
| Proof of Concept of Gyroscope and motor feedback |  |  |  |  |  |  |  |  |  |  |
| Motor Drive Circuit Development |  |  |  |  |  |  |  |  |  |  |
| Derivation of System Model |  |  |  |  |  |  |  |  |  |  |
| Motor Drive Circuit Integration |  |  |  |  |  |  |  |  |  |  |
| Coordinate Space Memory Optimization |  |  |  |  |  |  |  |  |  |  |
| Testing and Improvement |  |  |  |  |  |  |  |  |  |  |
| Final Report and Miscellanea |  |  |  |  |  |  |  |  |  |  |