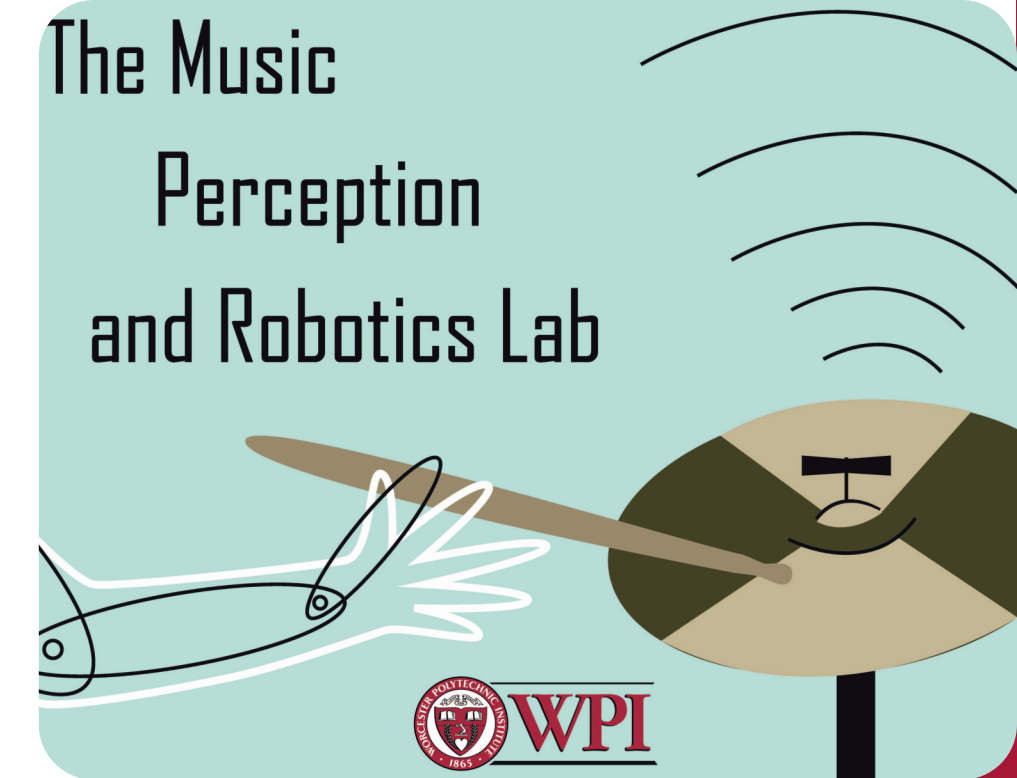


Robotic Plectrum System for Stringed Instrument Characterization

PJ Aubin (RBE), Theodore Barnes-Cole (RBE)
 Advisor: Professor Scott Barton (RBE & Humanities and Arts)

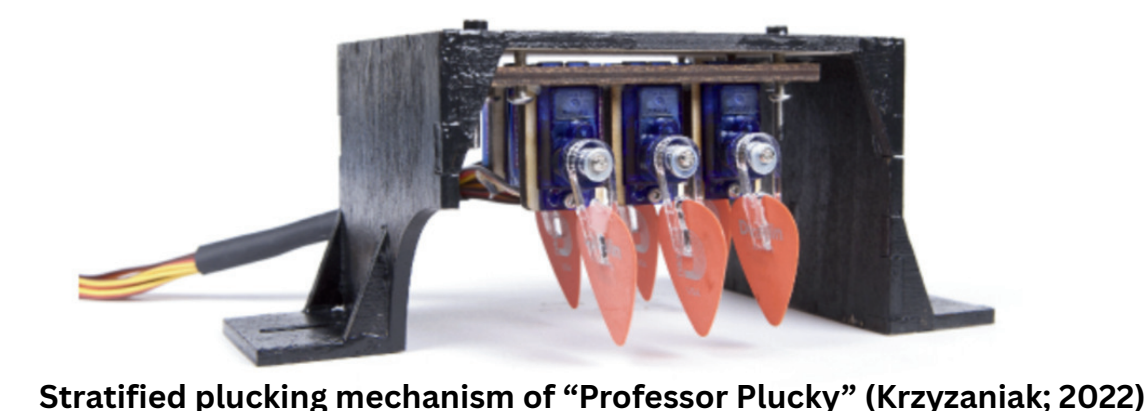


Abstract

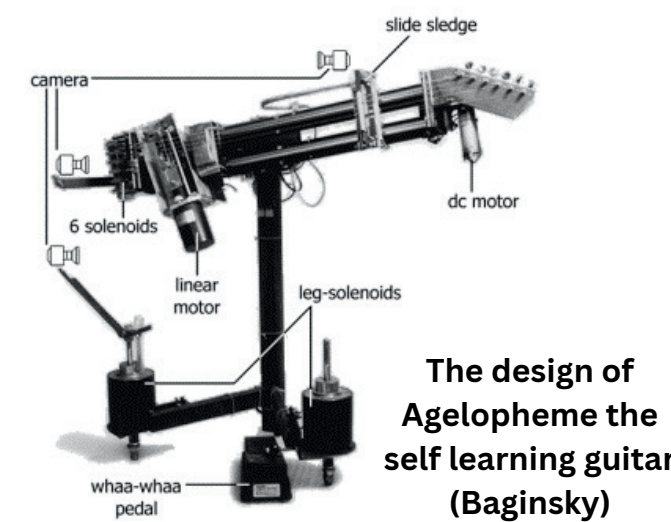
This project aimed to create a robotic system that emulates human playing techniques while controlling variables such as string position and picking speed. The developed system accurately locates the strings of any guitar placed on it and uses that information to play individual strings with high repeatability. Evaluation involved comparing human and robotic playing across various guitars and analyzing the spectral response of the notes played.

Background

Musical robots can be divided into two categories: integrated mechatronic instruments and robots capable of playing existing instruments. Guitar-playing robots can be divided into both strumming and picking robots. Despite the varying existing playing methods, many of these mechanisms focus on controlling only a few picking variables, with complex robotic arm applications being the only designs that have both nuanced plectrum control and the ability to pick and strum.



Stratified plucking mechanism of "Professor Plucky" (Krzyzaniak; 2022)



The design of Agelopheme the self learning guitar (Baginsky)

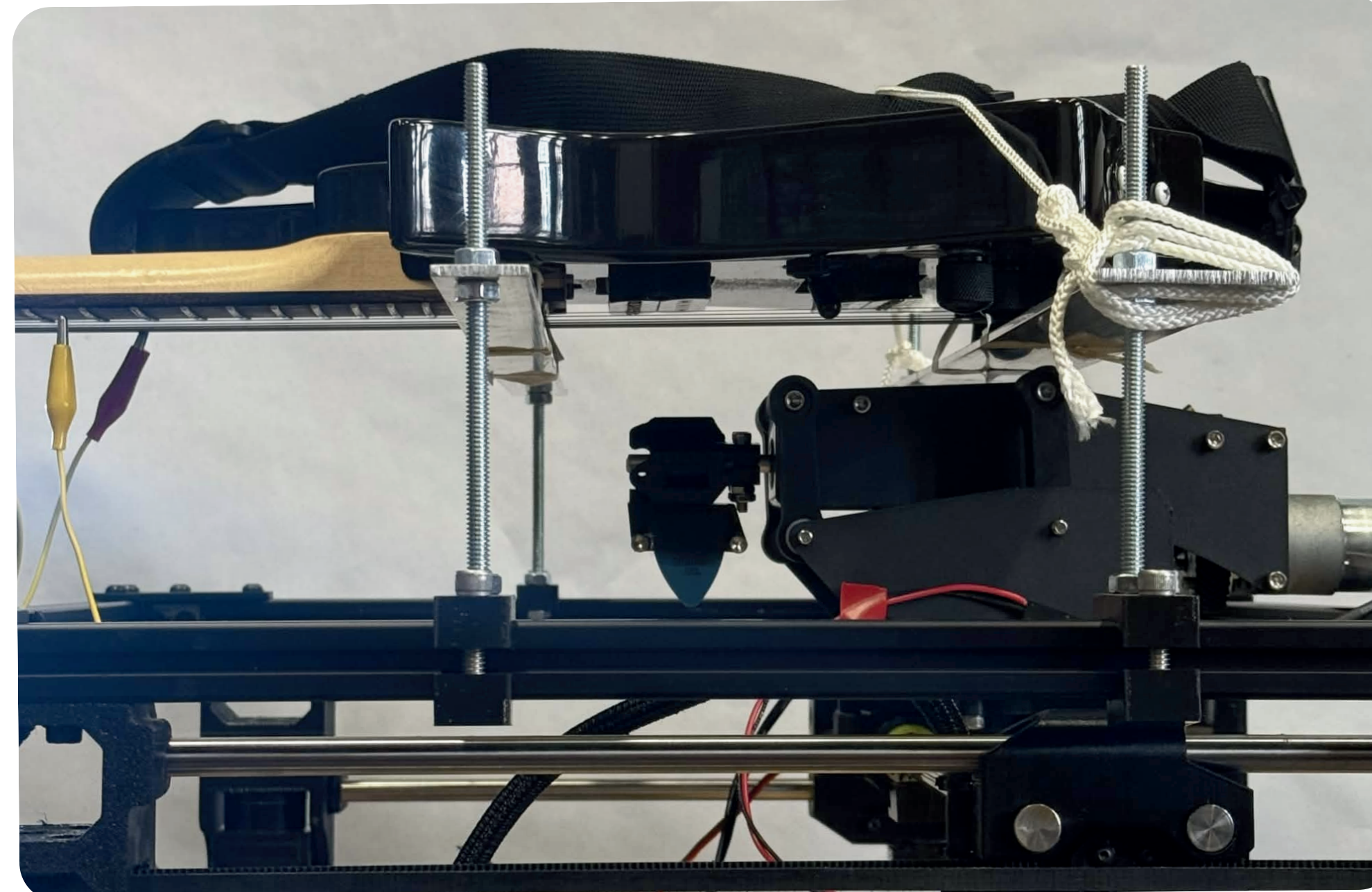
Purpose

Our implementation of these capabilities aims to create a tool that could be used by research labs or guitar manufacturers to isolate playing variables in guitar and stringed instrument testing.

Objectives

- 1 Automatically locate guitars regardless of position/orientation
- 2 Derive string positions in 3D space and move to these positions
- 3 Control picking dynamics and timbre through plectrum speed and height

Final Design



Mechanical

- Taz Workhorse structure (X & Y motion)
- Custom 3D printed picker assembly:
 - Modular pick holder
 - Z-axis height adjustment/probe
 - Helical gears for power transmission
- Fabricated guitar stand

Electrical

- Arduino Due
- Adafruit Motorshields:
 - Y-axis steppers, Z-axis servo, picker motor
- ST microstep driver
 - X-axis stepper
- AMT-232 absolute encoder

Testing Methodology

Test 1

Dynamic consistency

- Standard height
- Standard speed
- Flat picking
- 8 plucks

Test 2

Effect of pick height variation

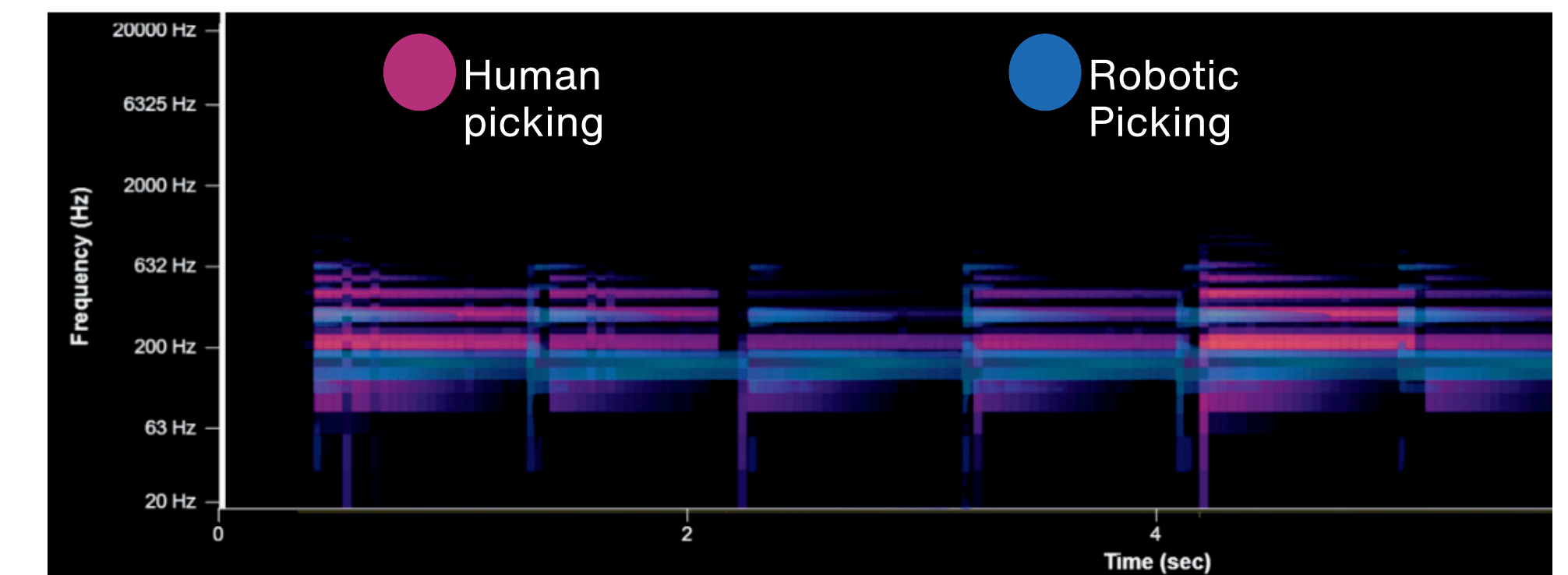
- Standard speed
- Flat picking
- Sample incrementing height by .05 inches until motor stalls
- 8 plucks per height

Test 3

Effect of picking speed variation

- Standard height
- Flat picking
- Sample at 60, 100, and 120 bpm
- 8 plucks per speed

Results



Dynamic and frequency testing: Spectral analysis contrasting response of human and robotic picking performance on "A" string at 60 BPM

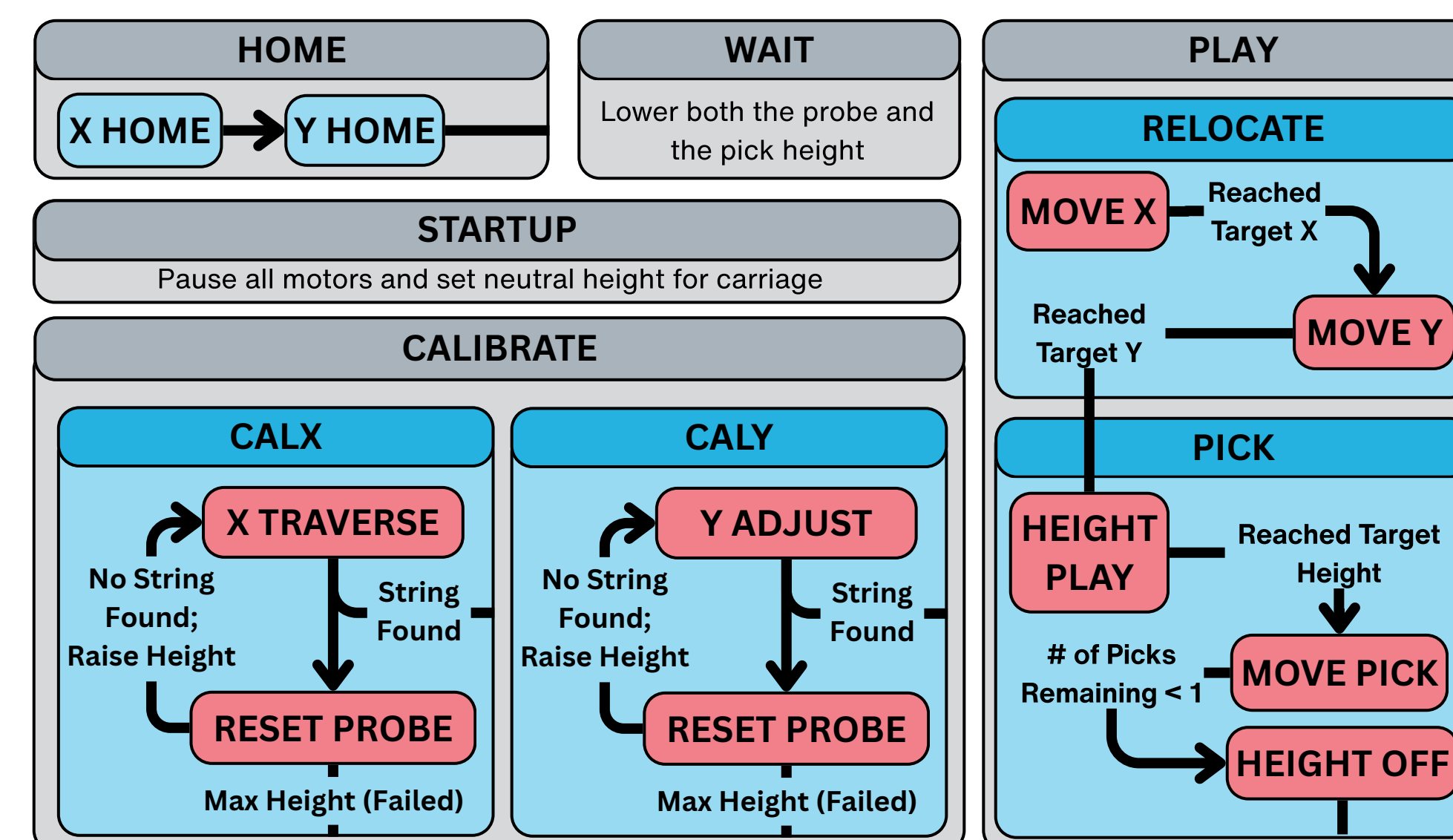
Frequency Response:

- Fewer partials compared to human playing
- Substantially reduced "noise" beyond intended note
- Background noise around 400 Hz

Dynamic response:

- Highly consistent output
- Dynamic control limited to less granular adjustments due to hardware
- Improved timing consistency introduced by motor

State Diagram



Future Research

Machine improvements:

- Faster motor drivers would allow for faster positioning and the inclusion of strumming functionality
- Further development of modular picker would allow for testing of multiple picks without change in guitar setup

Further tests:

- Using modular picker to test pick angle would give useful data on its effect on timbre
- Testing on a large number of guitars could be used isolate specific tonal characteristics of each instrument