W.A.R.P.

Wirelessly Accessible Record Player

Group 15

Martin Do

Jose Medina

Daniel Weinberg

Micaiah Reid

Mentor/Criticizer In Chief

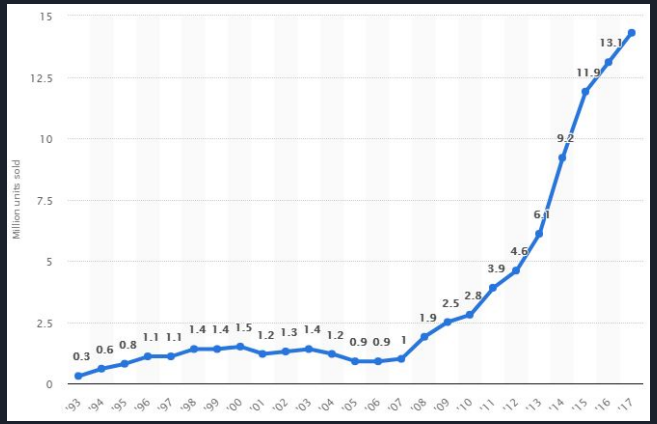
Chung Yong Chan

Company Sponsor

SoarTech 

Background

- Device for reproducing sound from an analog storage medium
- Existing since 1940s with earlier versions being invented in 1870s



Millions of records sold per year

- Market up 9% from 2016
- 14% of all physical album sales

Motivations

- Recent resurgence of vinyl record players
- Difficult setup and use
- People are used to immediate control over their music
  - this isn’t currently possible with analog records

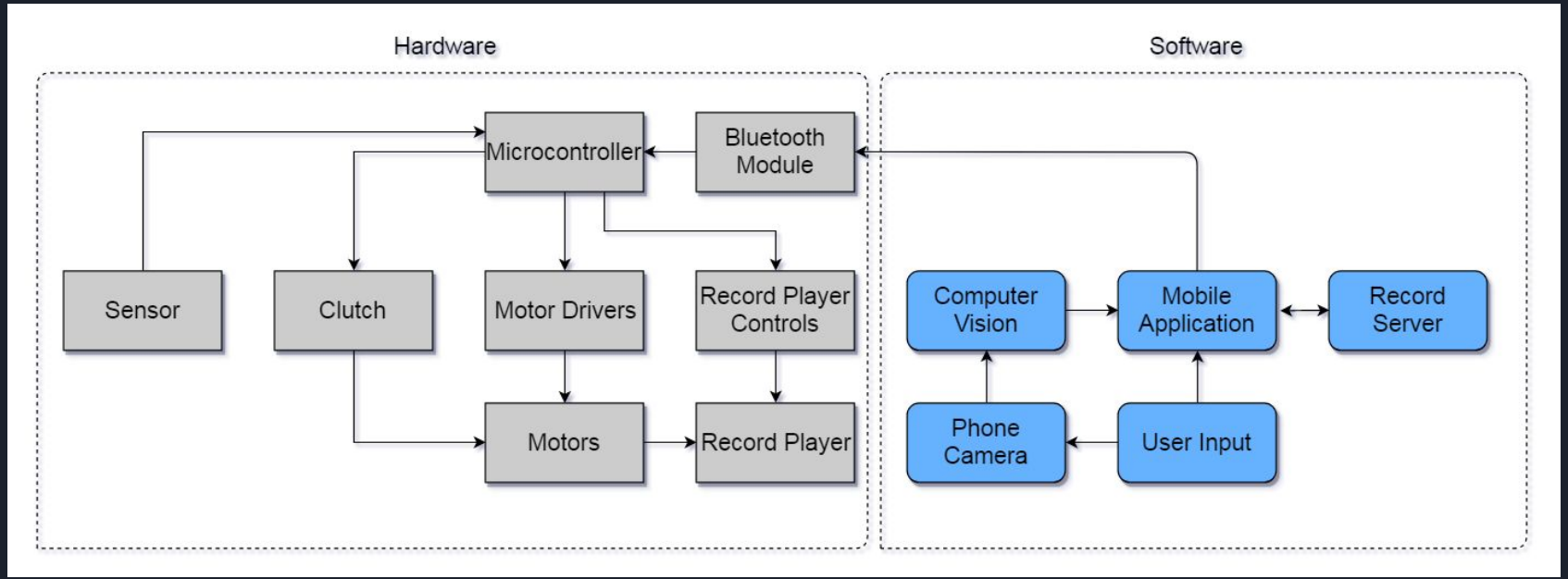
Goals & Objectives

- Create a record player that allows for full control over the currently placed record.
  - This includes power, rotation speed, and the current song that is playing.
- Maintain all normal, manual functionality of the record player.
- Create an intuitive app to catalog the user's record collection and to control the record player.

Specifications

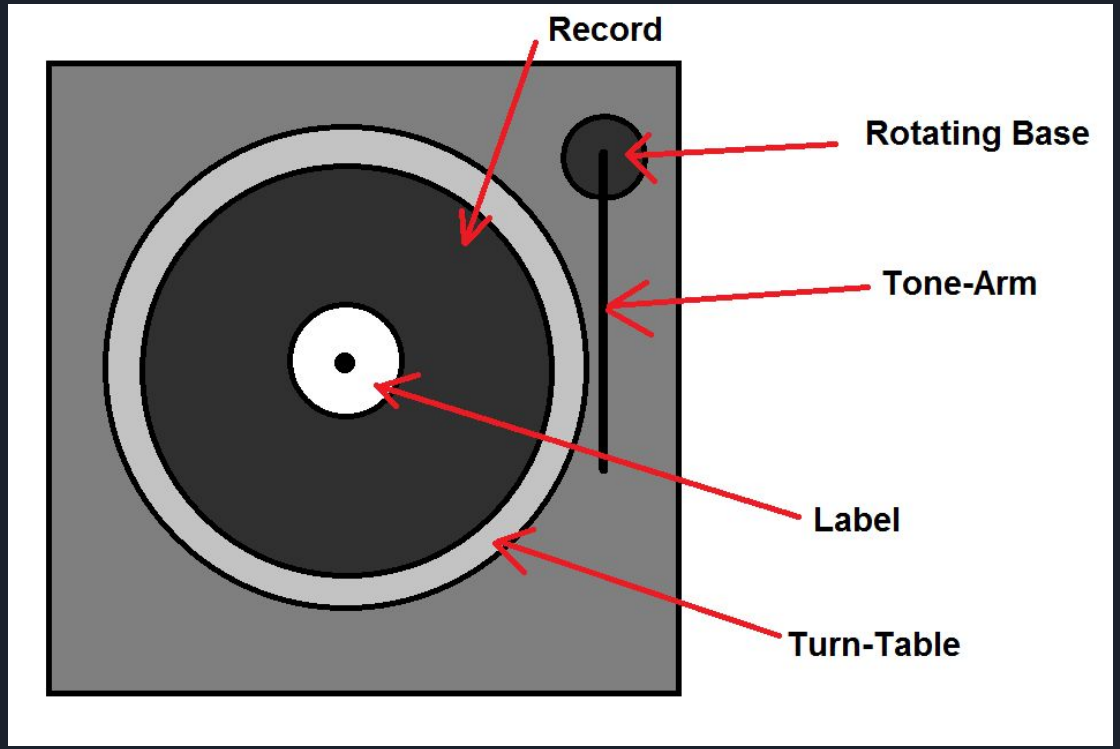
- Allow user to search for records by taking a picture of the label.
- 80% accuracy for optical character recognition.
- The tonearm should be placed within 5 seconds of playtime from the selected time of the song.
- The tonearm should be raised, calibrated, and replaced within 5 seconds of a song being selected.

System Block Diagram



How W.A.R.P Will Work

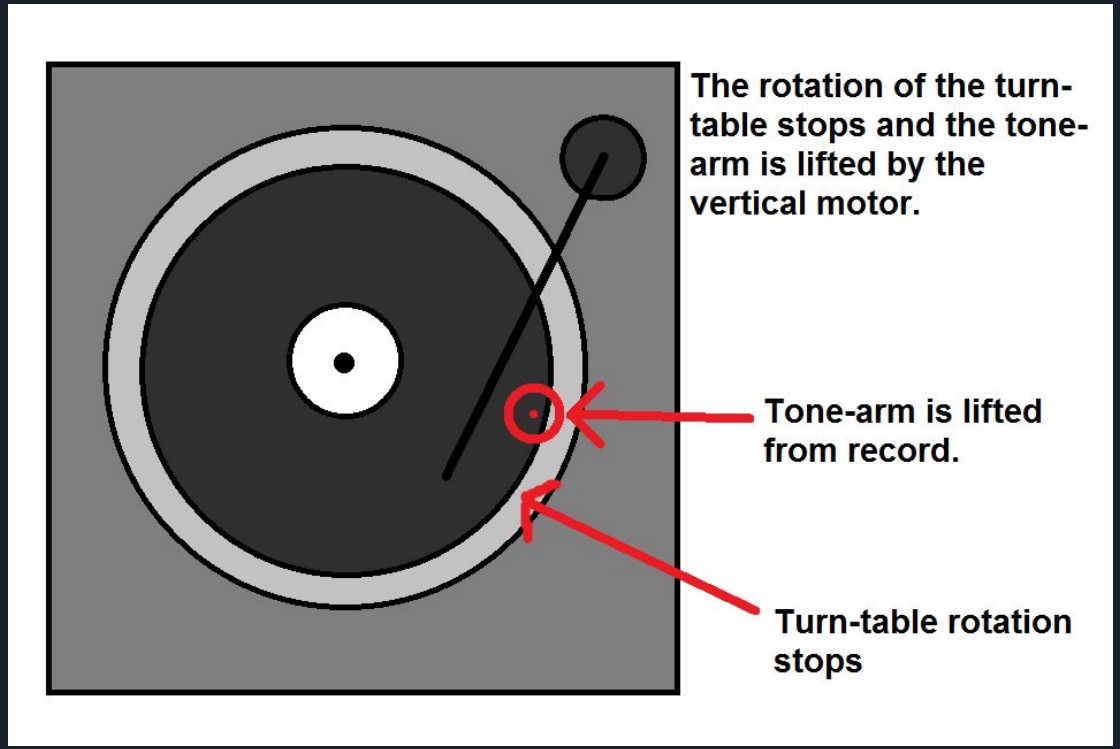
How W.A.R.P Will Work



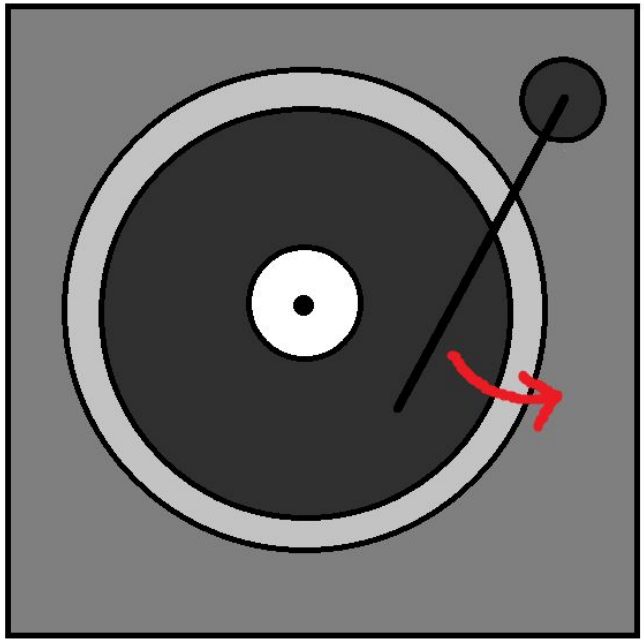
How W.A.R.P Will Work

Tone-arm begins at some unknown position. The clutch is disengaged and the sensor interupt flag is clear.

How W.A.R.P Will Work

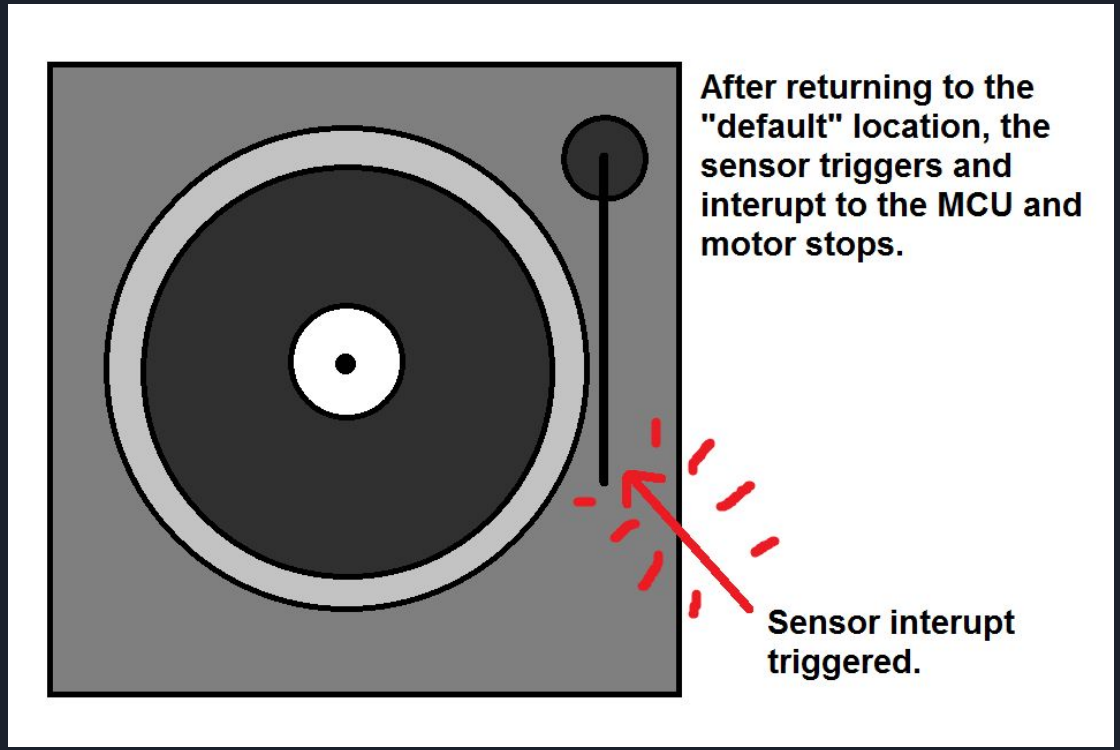


How W.A.R.P Will Work

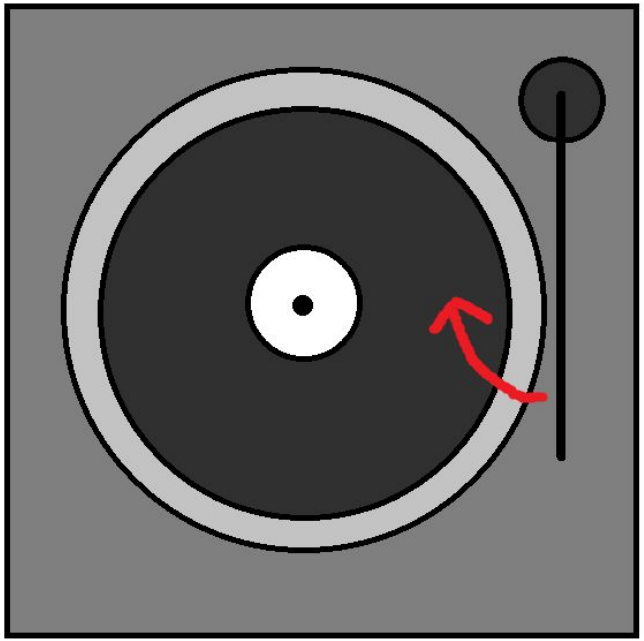


The clutch is engaged and then the horizontal motor moves the tone-arm away from the record.

How W.A.R.P Will Work

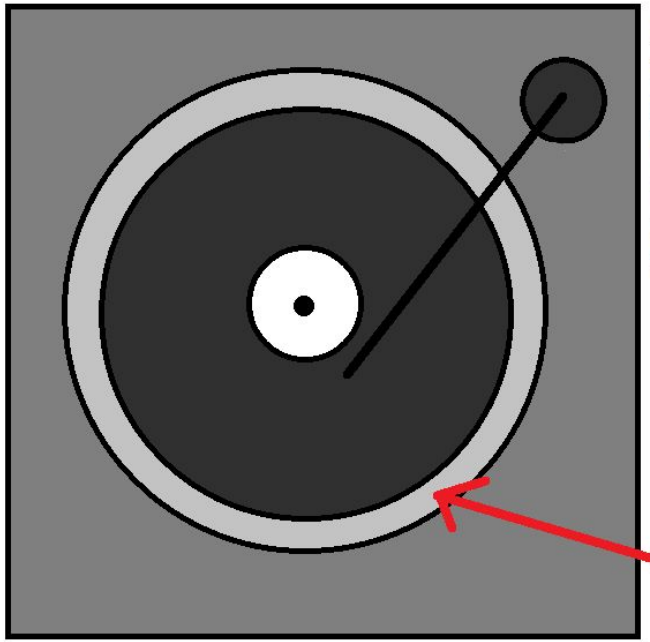


How W.A.R.P Will Work



After reaching the "default" location, the horizontal motor rotates the tone-arm towards the record player the number of step recieved from the phone app.

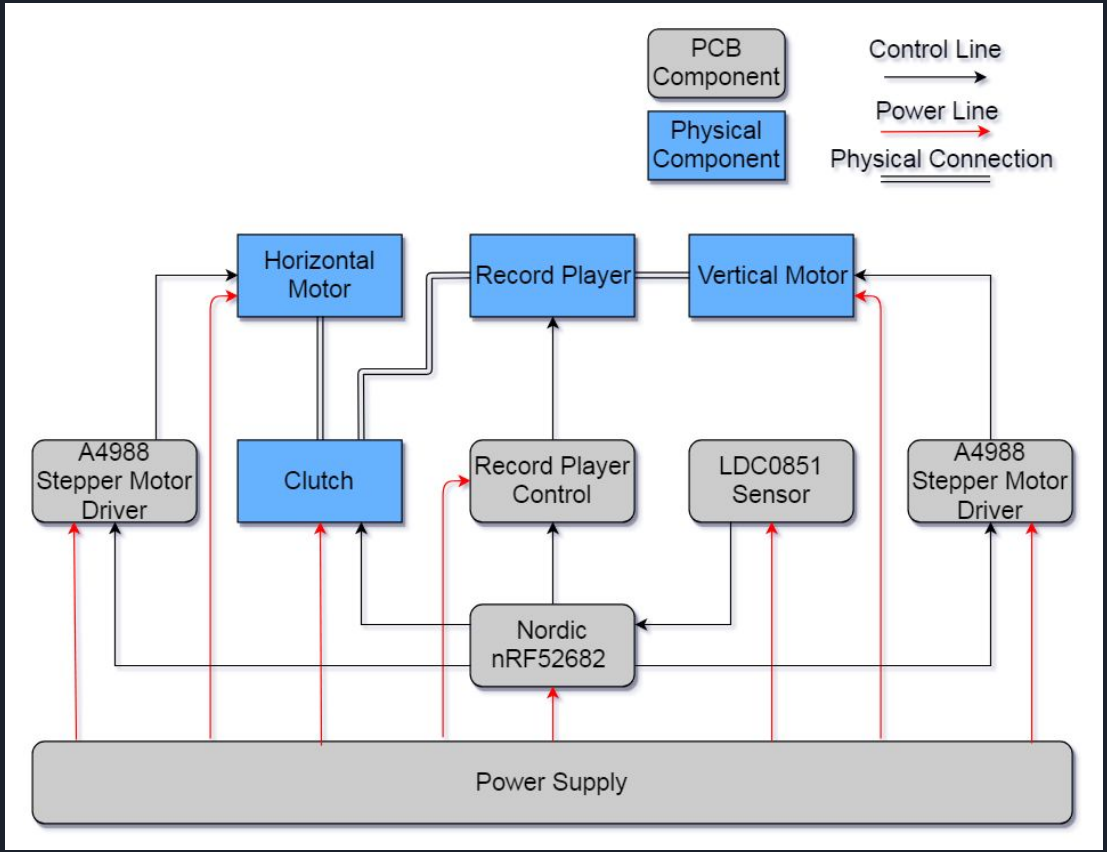
How W.A.R.P Will Work



At the specified step angle, the motor rotation stops. The arm is lowered, the clutch disengages, the interupt flag is cleared, and turn-table begins spinning.

Turn-table begins rotating.

Hardware Block Diagram



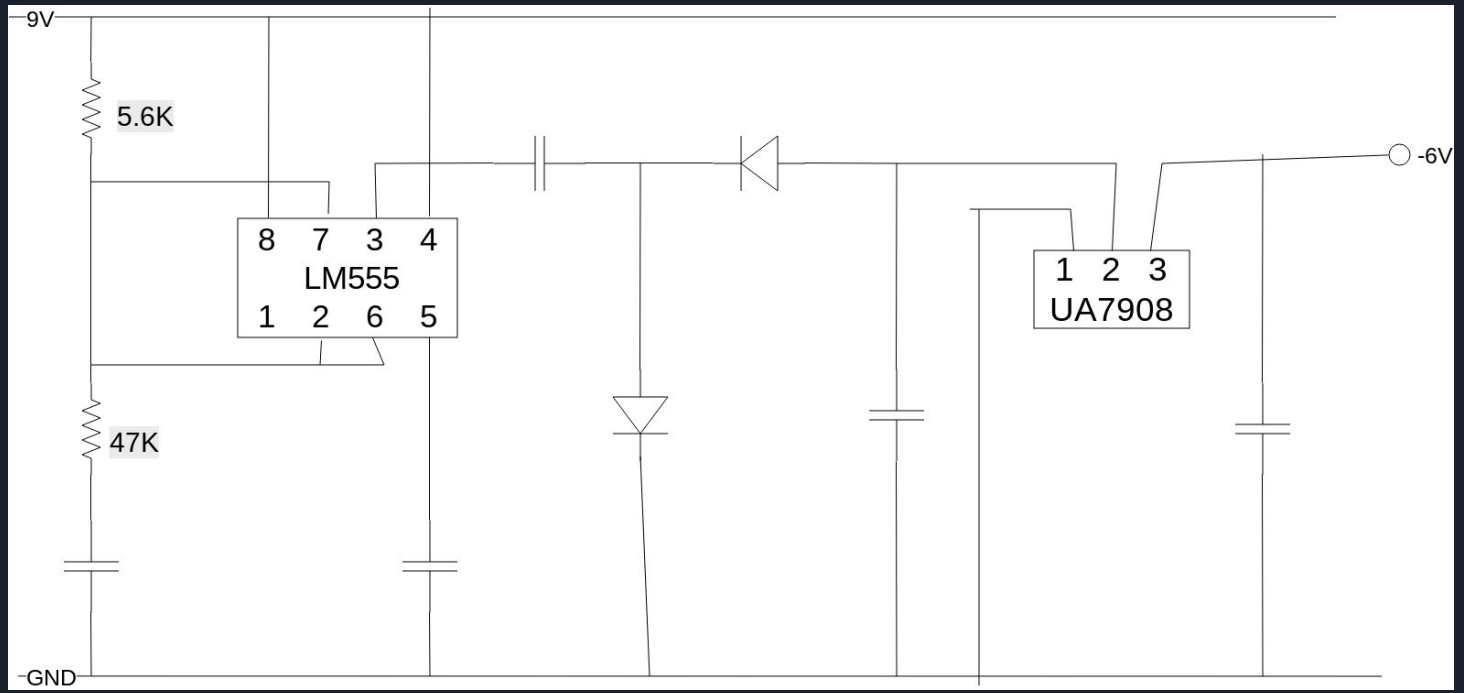
Power Supply

12V Power Supply Adapter

12V Step Down to 9V Power Supply

12V Step Down to 3.3V Power Supply

Power Supply



Motors

- Stepper motors chosen due to accuracy and reliability.
- Control the movement of the tonearm to allow microcontroller to select record playtime.
- Two different types of motors will be used to select time and raise and lower arm.
  - Vertical motor to raise/lower tonearm.
  - Horizontal motor to move tonearm to specific grooves along record.

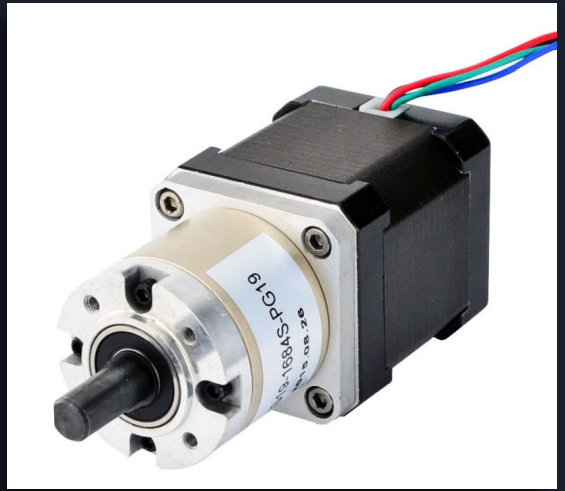
Nema 17 Stepper Motor w/ Planetary Gearbox

Purpose

- Controls the radial distance of tone-arm.
- Rotate the tone-arm across the record.
- Must have very small step angle.
- Must be accurate and reliable.

Features

- Standard NEMA 17 dimensions. (1.7 x 1.7 inch)
- 19.2:1 Planetary Gearbox.
- 1.8 degree step-angle
- ~.006 degree step-angle after gearbox and microstepping adjustments.



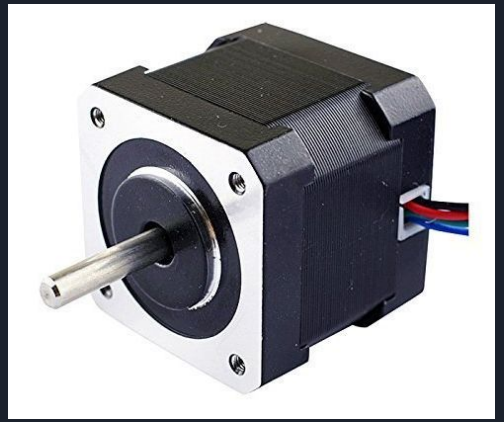
Nema 17 Stepper Motor

Purpose

- Controls vertical movement of tone-arm
- Lift and lower the tone-arm to the record.
- Does not need to have as small of a step-angle as the horizontal motor.
- Must be accurate and reliable.

Features

- Standard NEMA 17 dimensions.
- 1.8 degree step-angle.
- Cheaper than the horizontal motor.



Clutch

Purpose and Requirements

- Needed to allow for movement of the tonearm when motors are running and to move freely when not being controlled.
- Must be able to hold tonearm and motor secure without slipping.

Ongura FMC 10-27 Electromagnetic Clutch

- Has enough torque to hold the tonearm and motor.
- Easy to control. Only requires a 12 volt supply to engage.
- Ogura graciously supplied two sample clutches.

Sensor

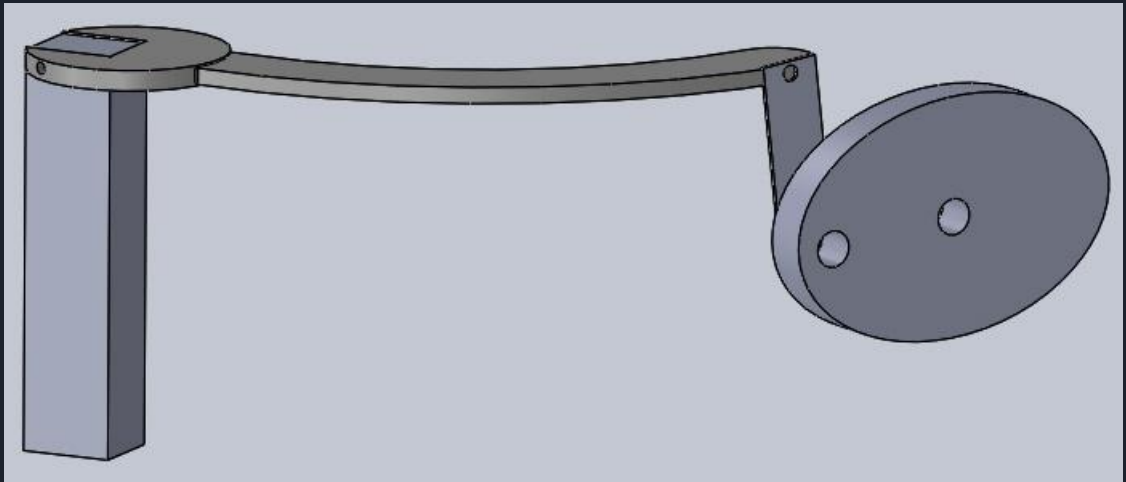
Purpose and Requirements

- Needed to lower tonearm calibration time.
- Must reliably trigger at same position.

Texas Instruments LDC0851

- Gives active low output when conductive material approaches inductive coil.
- Reliable and accurate.
- LCD0851EVM board available for easy testing.
- Free samples given from TI.

Vertical Arm Movement



- Used for controlling vertical motion of tonearm & needle
- Oval-shaped component interfaces with stepper motor
- Rotation will translate to raising and dropping curved arm

Record Player Requirements

- Heavy turntable
- Direct drive rather than belt drive to allow for turntable direction control
- Straight tonearm
- Cost effective

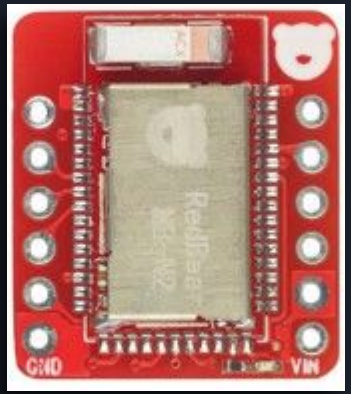
	AT-LP60	AT-LP3BK	AT-LP120BK-USB	TT250USB	T.62 M2
Cost	$99	$249	$299	$190	$160
Direct Drive	No	No	Yes	Yes	Yes
Tonarm	Straight	Straight	Curved	Curved	Straight

Stanton T.62 M2

RedBear BLE Nano 2

Features

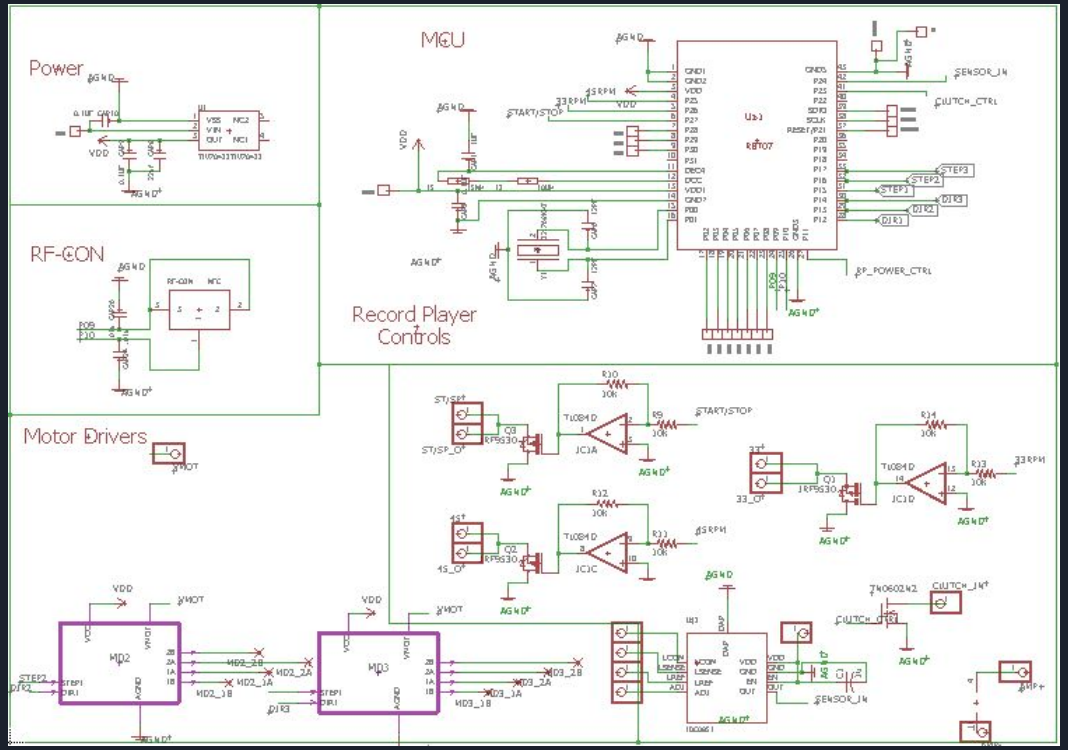
- Built-in Bluetooth module
- 1.8-3.6V operating voltage
- 32 IO pins
- Uses the Nordic nRF52862 SoC



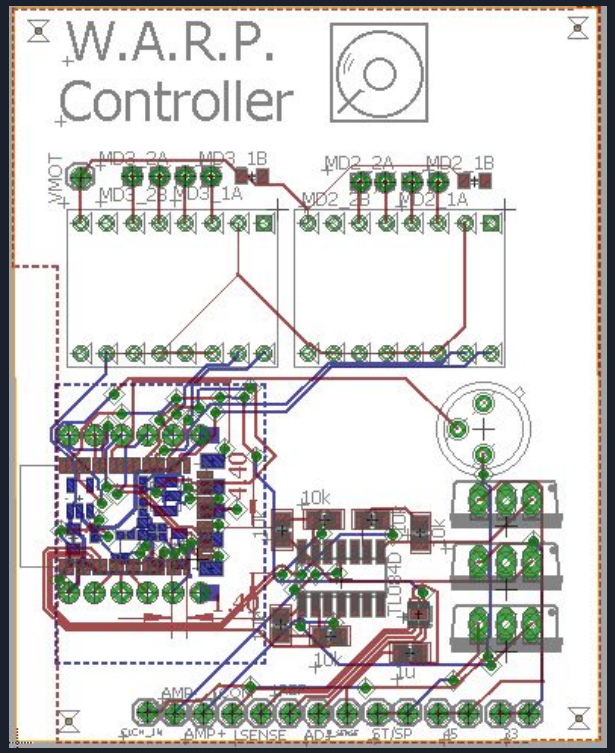
Purpose

- Use Bluetooth to communicate with the app
- Control all motor drivers to move the tonearm
- Control the clutch to engage and disengage the motors
- Receive inputs from sensors to recalibrate the tonearm

Main PCB Schematic

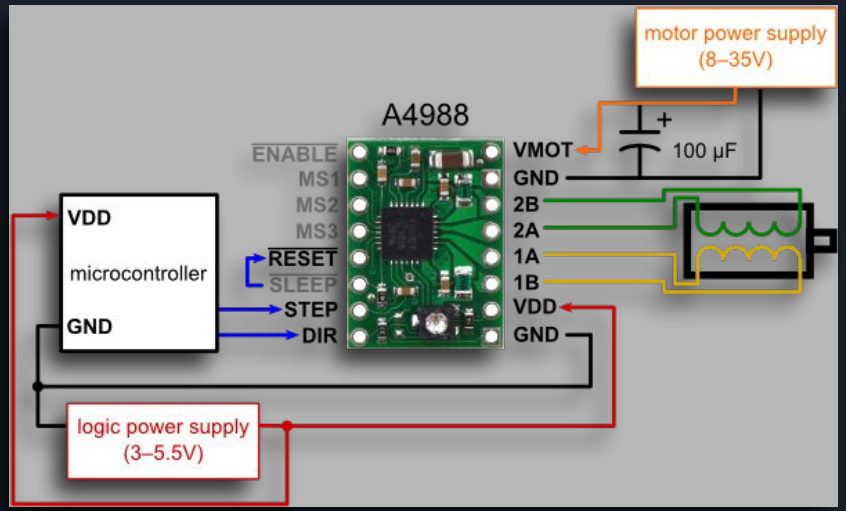


Main PCB Layout

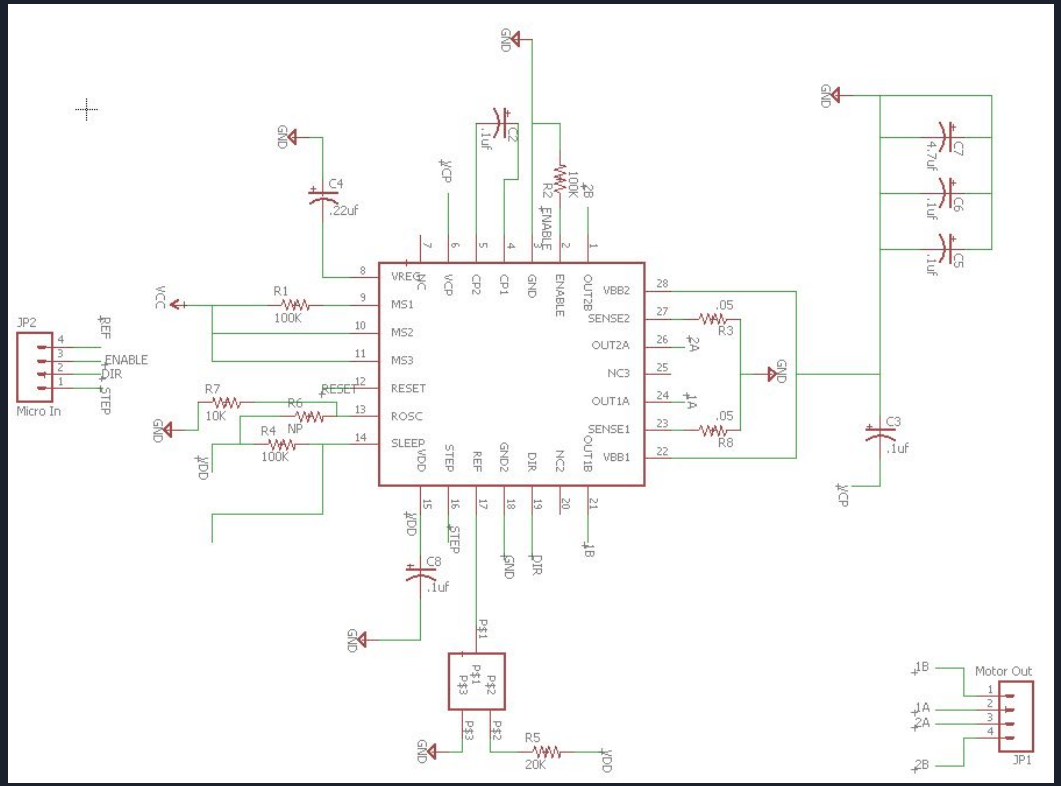


A4988 Motor Driver

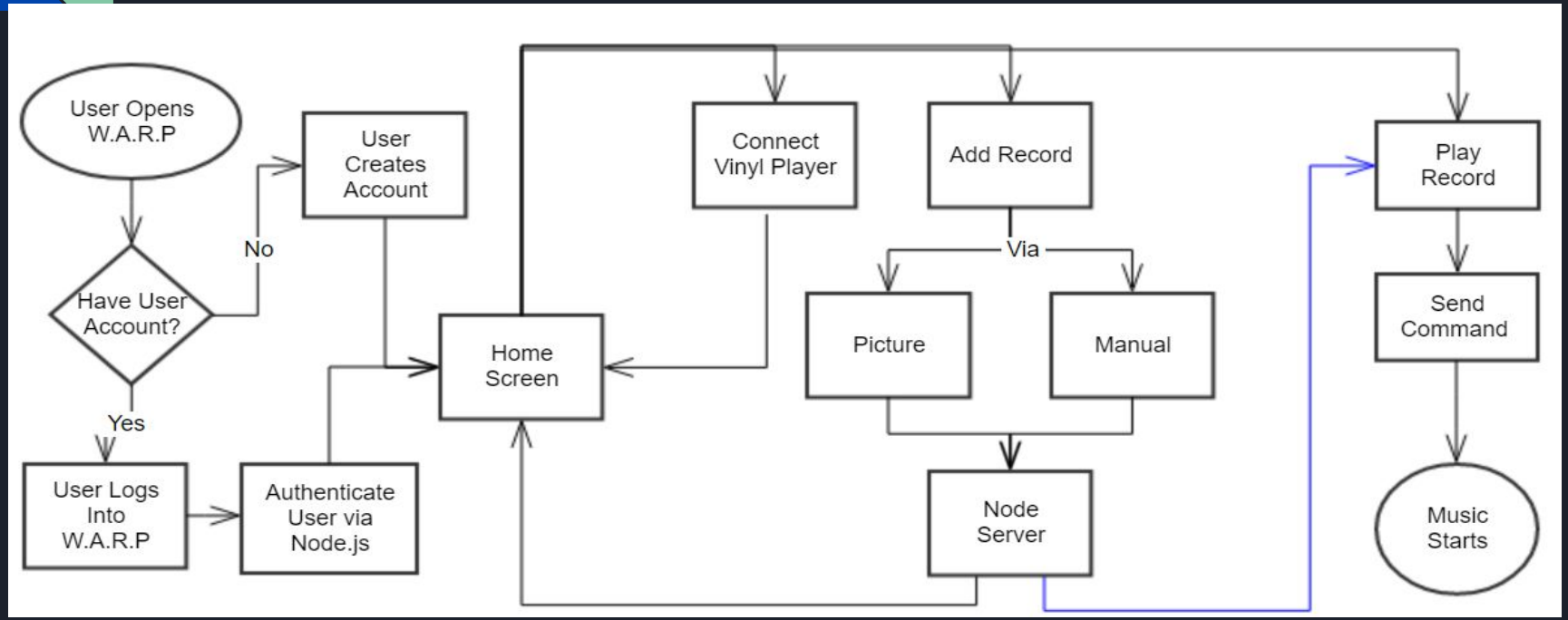
- 8-35 V operating voltage
- Five step resolutions (up to 16th-step)
- Built in over-temperature thermal shutdown, under-voltage lockout and crossover current protection.



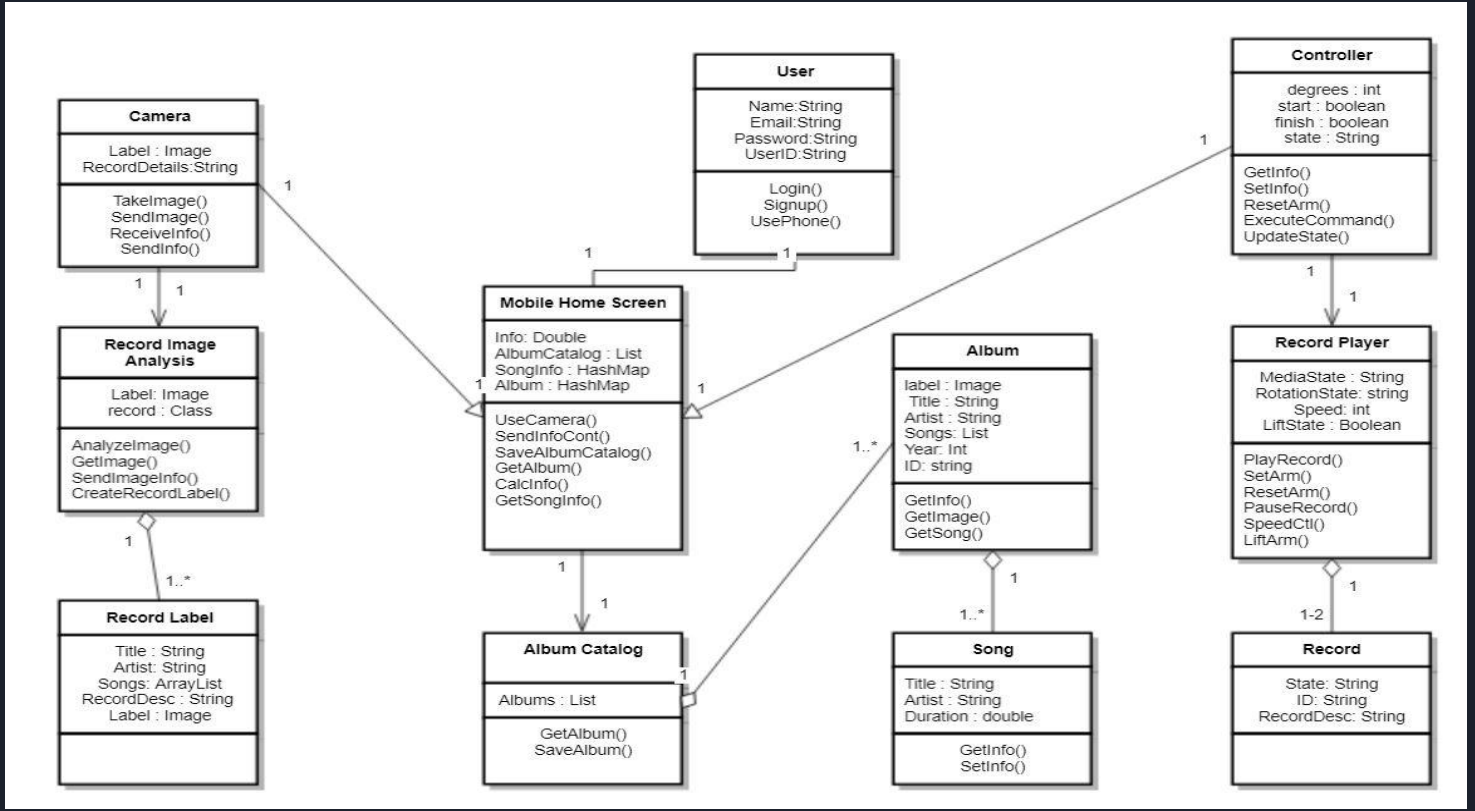
A4988 Motor Driver



Software Flow Chart



Software Class Diagram



Mobile Application

Catalog your Vinyl Collection

- Save your vinyl records into your phone

Modern Interface

- Providing media controls

Selective

- Play any song you want anytime

Informational

- Information about the album, artist, songs, etc.

Relaxed Experience

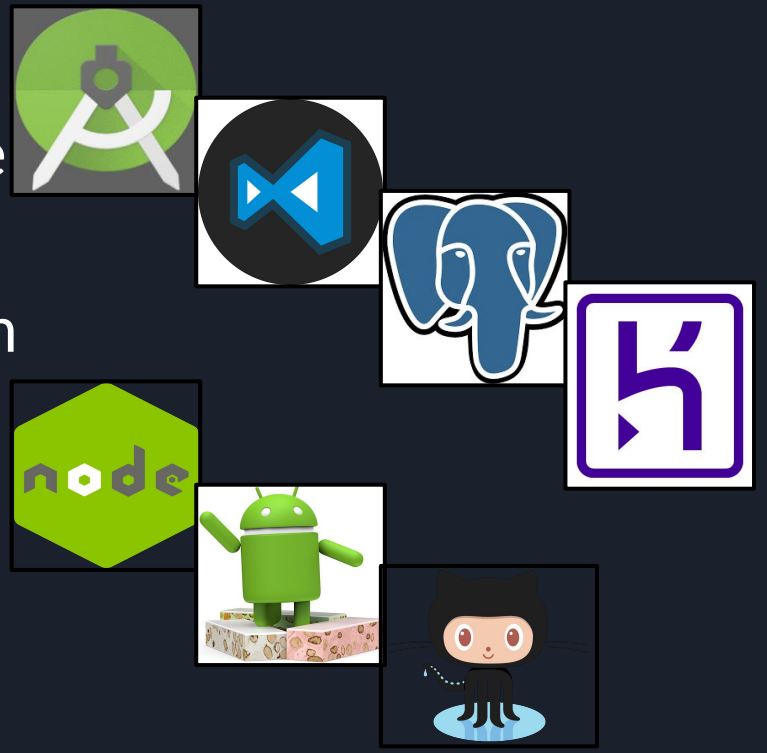
- Controlling your vinyl player remotely

Droids Vs. Apples

Language: Java	Language: Swift
Open Sourced	Closed Source
Android Studio IDE	Xcode IDE
Available on PC/Linux/Mac	Available on Mac
Minimal Setup	Substantial Setup
$25 registration for lifetime	$100 registration per year

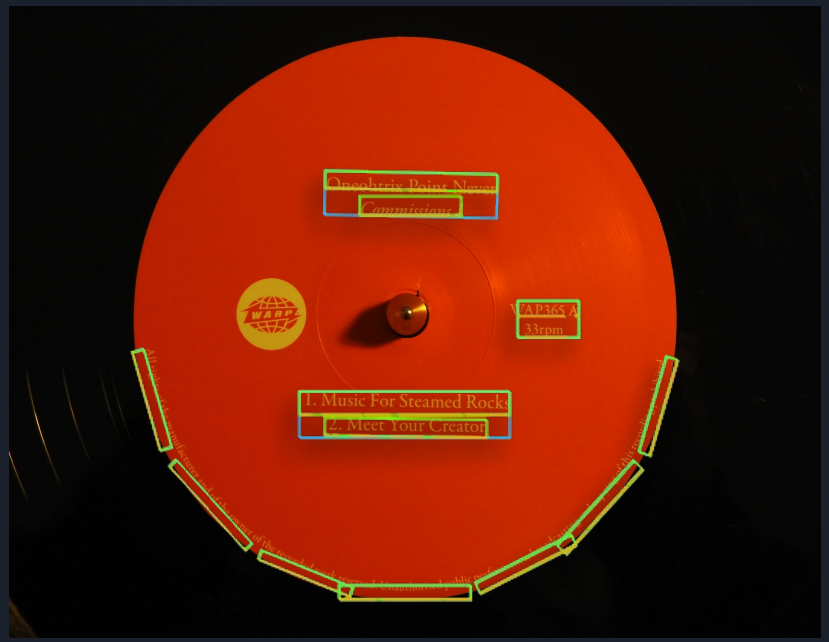
Mobile Tools & API

- IDE : Android Studio
- Code Editor : Visual Code
- Database: PostgreSQL
  - Managed by PGAdmin
- Cloud Hosting: Heroku
- Authentication: Node.js
- Android OS: Nougat
- Version Control: Github



Optical Character Recognition

- Useful for determining which record to play
- Convolutional neural network implementation



Tools & Libraries

- General computer vision library
- Used mainly for preprocessing

- De Facto programming language for machine learning
- Supported by most libraries needed for application

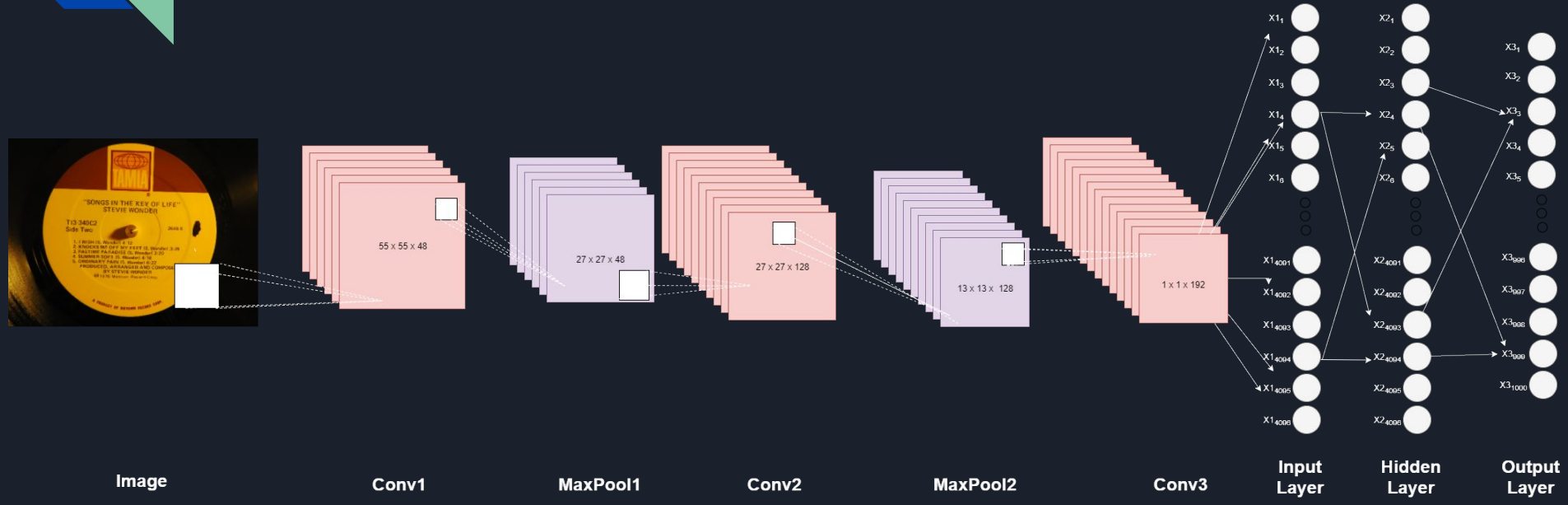
- Open-source web application for live coding
- Used for fast prototyping of OCR system

Tools & Libraries

Machine Learning Library Comparison

Library	Language	Actively Development	CNN Support	Developed By
TensorFlow 	Python, C++	Yes	Yes	Google
Theano theano	Python	No	Yes	University of Montreal
Torch 	Lua	Yes	Yes	Facebook
Keras 	Python	Yes	Not directly	François Chollet

Convolutional Neural Network Architecture



- Variation of artificial neural network that is popular in analyzing imagery

Image Representation

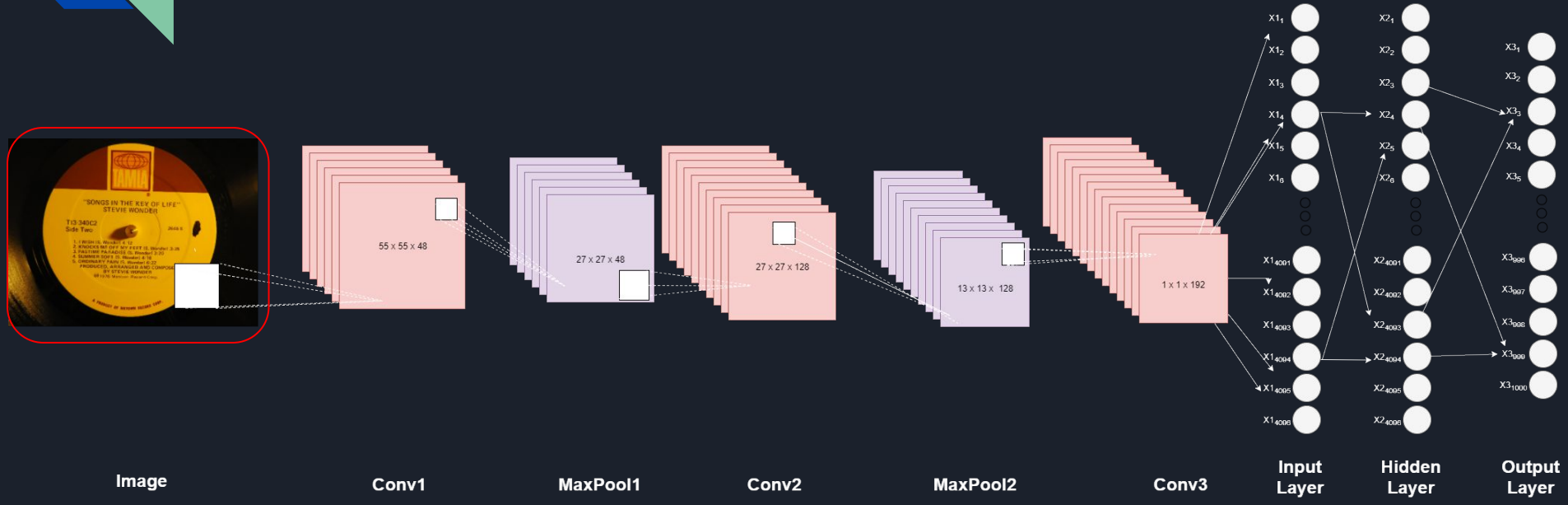
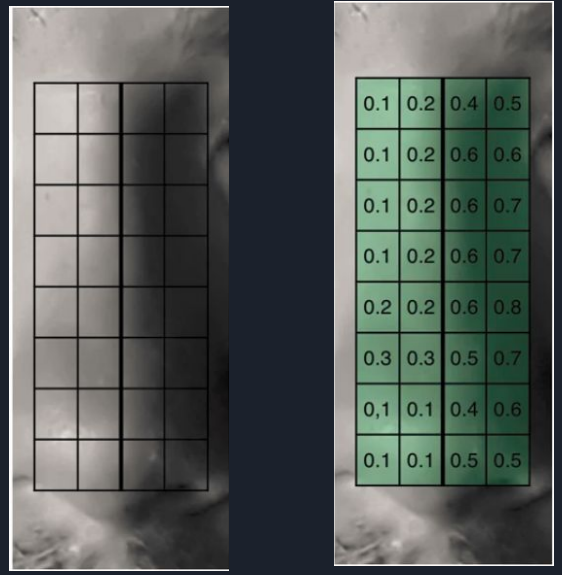


Image Representation



Example of pixel density matrix

- Grayscale images represented as a 2D array of values ranging from 0 to 256, which can be normalized
- Tensor representation is used instead of 2D array
- Preprocessing operations such as scaling image and eliminating color channels are done to

Feature Extraction

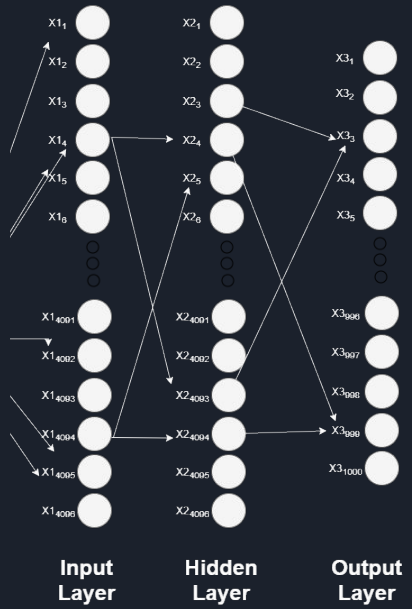
Convolutional Layer

- Applies a convolution operation do the image
  $(f*g)(t) = \int[f(\tau)*g(t-\tau)]d\tau$
- multiple filters used image to create feature maps

Max Pooling

- Reduces dimensionality of image while maintaining features
- Helps to reduce overfitting

Neural Network

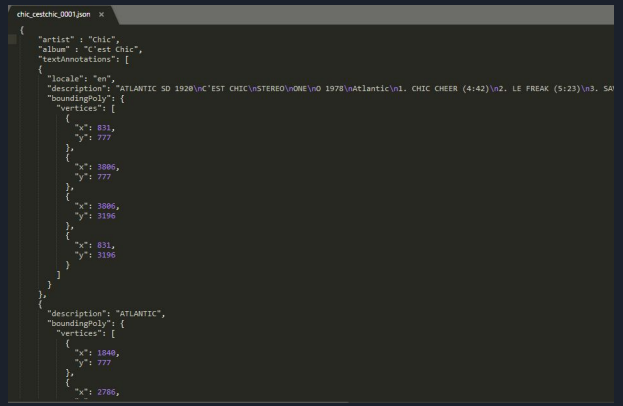


- Network is densely connected and uses a softmax output activation function
- Weighted nodes are used to analyze the high-level features of the image
- Gradient descent is used to update weights

Dataset

- Data is broken into three sets: training, validation & test
- Each dataset is composed of input images and labels that correspond to each image

Raw Image



Labels

Record Server

- Handles all user authentication
- Interfaces with the Discogs API to find records and song times
- Stores user catalogs
- Runs all image processing to reduce load on user device

Work Distribution

Task	Task Lead	Task Secondary
Mobile Application	Martin	Jose
Computer Vision	Jose	Martin
Record Server/Database	Micaiah	Jose
Arm Control	Daniel	Micaiah
PCB Design	Micaiah	Daniel
Embedded Programming	Micaiah	Daniel
Encasement	Daniel	Everybody
Solidworks/Laser Cutting	Jose	Daniel

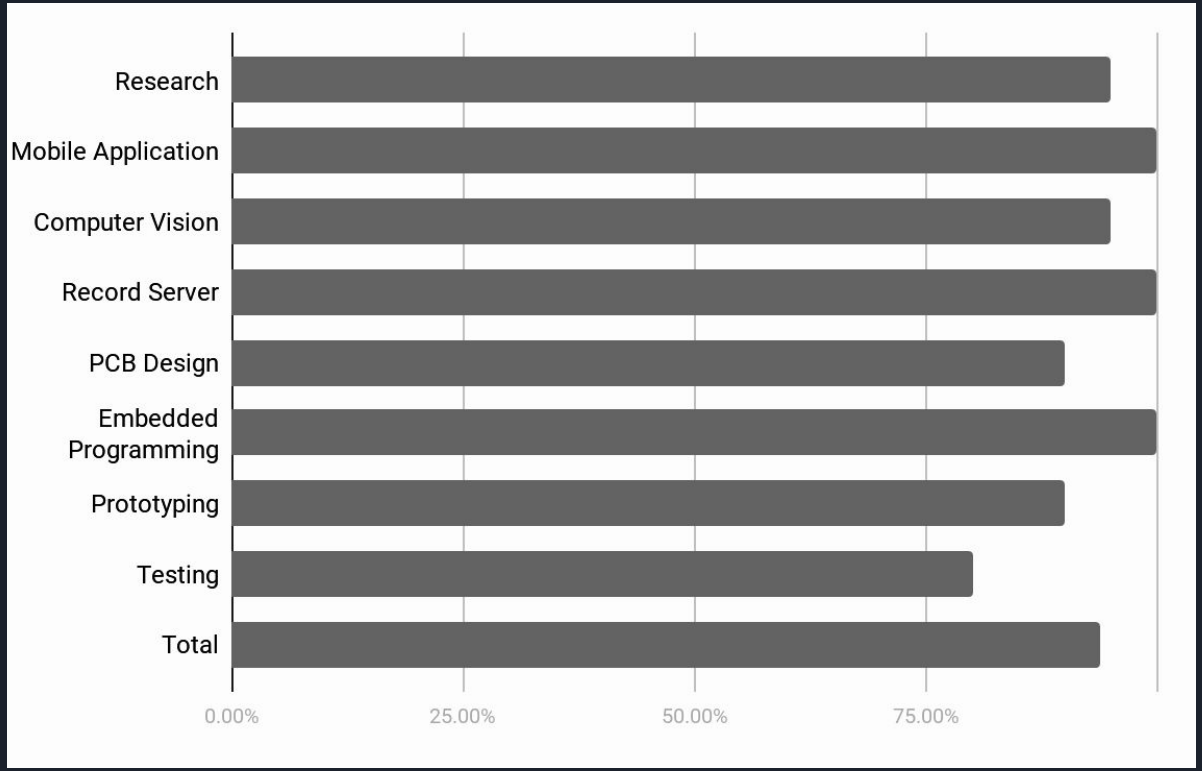
Budget

Item	Cost Per Item	Quantity	Subtotal	Development Cost Only
Record Player	$116.41	1	$116.41	No
Development Boards	$25.57	3	$76.71	Yes
Motor Driver	$5.95	3	$17.85	No
Motor Driver (Header pins soldered)	$7.45	1	$7.45	Yes
Stepper Motor (vertical)	$12.99	2	$25.98	No
Stepper Motor (horizontal)	$47.00	1	$47.00	No
Signal PCB	$98.56	1	$98.56	No
Sensor for testing	$20.00	1	$20.00	No
Motor Mounts	$8.99	1	$8.99	No
Breadboards & Wires	$10.99	1	$10.99	Yes
Shipping	$123.94	1	$123.94	Yes
USB Port Hub - Targus	$15.99	1	$15.99	Yes
PCB Parts	$69.05	1	$69.05	No
Printing Report	$30.00	1	$30.00	Yes
Drill Bit and Tap Set	$4.97	1	$4.97	Yes
Standoffs	$18.43	1	$18.43	No
Loctite	$4.19	1	$4.19	Yes
Screws/Nuts	$6.55	1	$6.55	No
Bluetooth module	$17.90	1	$17.90	No
Fabric	$6.99	1	$6.99	No
Velcro stickers	$7.98	1	$7.98	No
Power Converters	$30.26	1	$30.26	No
Soldering Equipment	$9.00	1	$9.00	Yes
Multimeter	$18.19	1	$18.19	Yes
Development Total	$793.38		Product Total	491.95

Financing

- $1,000 sponsorship from SoarTech
- Artificial intelligence company geared toward modeling human reasoning

Progress



Completed! (hopefully)

Issues

- Different records have different spacing
- Burned MCU suspected to be caused by power supply
- Burned sensor

Questions?


stanton