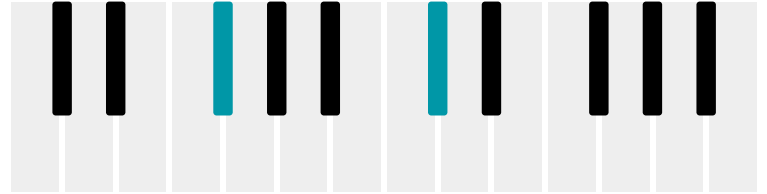


Use Case/Application

01

Problem

Music composition and arrangement requires using a piano (not portable & lacks accessibility). Online synthesizers not user-friendly & robust.



02

Solution

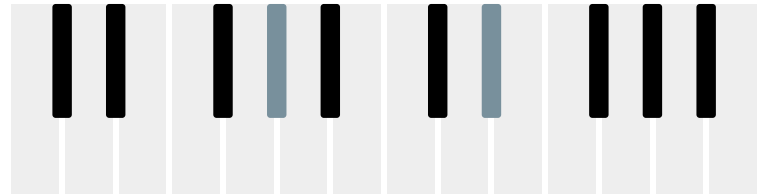
User will wear a glove of sensors, play notes on a printed piano key layout, use camera CV to detect notes, and phone for UI.



03

Areas

Software Systems, Analog Circuits, Hardware Systems, Embedded Devices, Signals & Systems



Solution Approach

1st



Gloves

Pressure sensors on fingers

Arduino BLE Nano
Microcontroller on wrist

Bluetooth connection to phone

2nd



CV

iPhone camera attached to
adjustable ring light stand

Finds which key is pressed

3rd



App-UI

Display note names

Runs CV Code

Visualize volume of notes with
range of colors

Block Diagram: Physical Components

Gloves

Left Hand:

Arduino BLE Nano
5x MD 30-60 Pressure Sensor
3x AA Batteries

Right Hand:

Arduino BLE Nano
5x MD 30-60 Pressure Sensor
3x AA Batteries

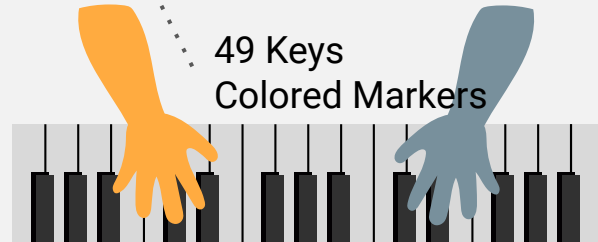
Phone + Camera

Mount to hold phone directly above user



Paper Keyboard

49 Keys
Colored Markers



Block Diagram: CV & App Interface

CV

Contour Detection

- Warp Homography
- Manual Points

10-Finger Identification

- Localization
- Media Pipe

Key Identification

- Thresholding
- Edge Detection
- Segmentation

App Interface

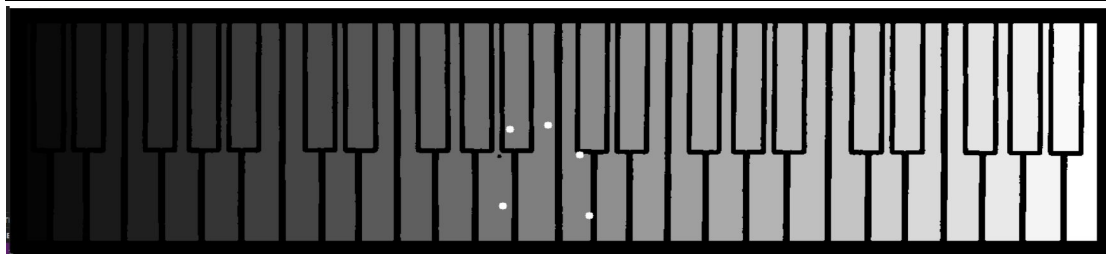
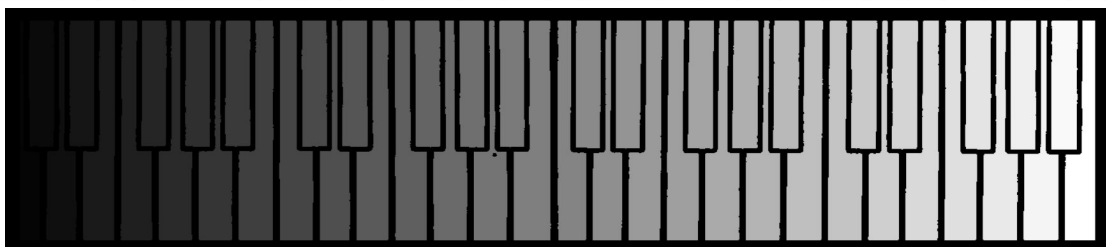
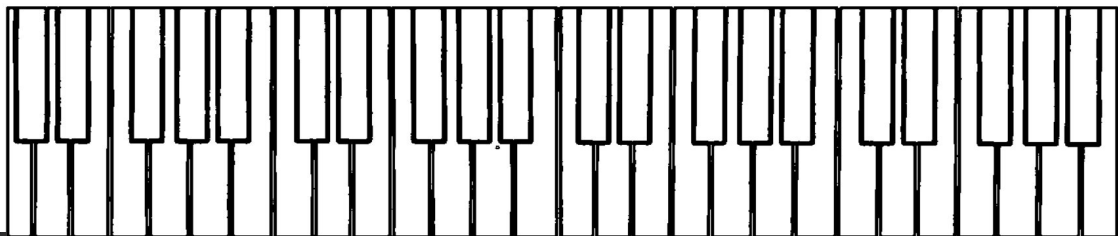
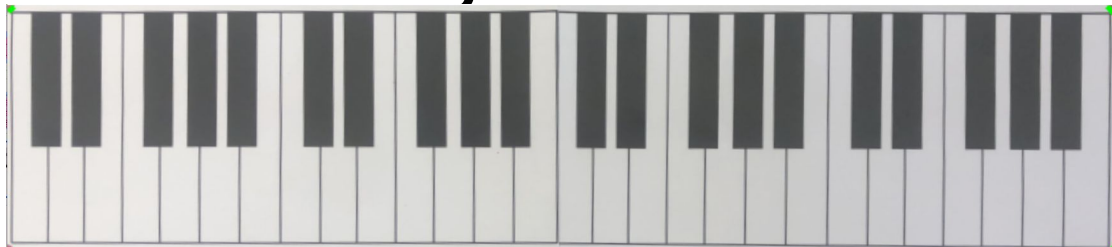
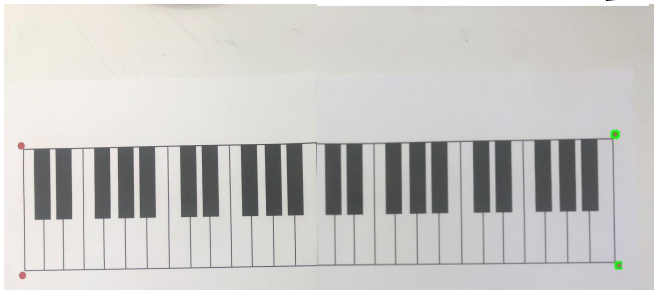
Accesses phone camera

Bluetooth information

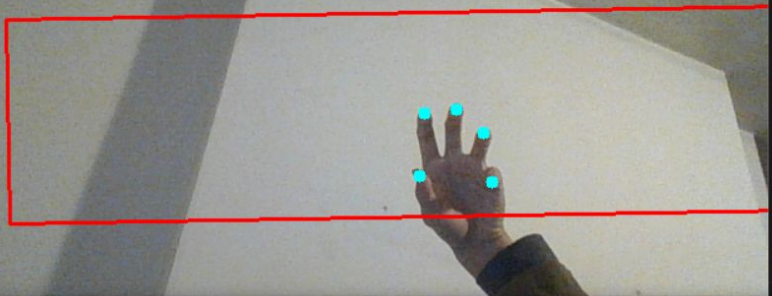
- Send and receive information

Multiple notes through speaker output

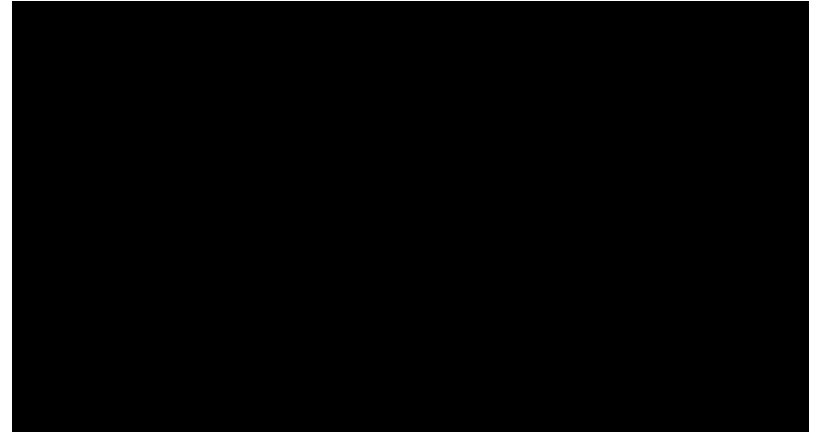
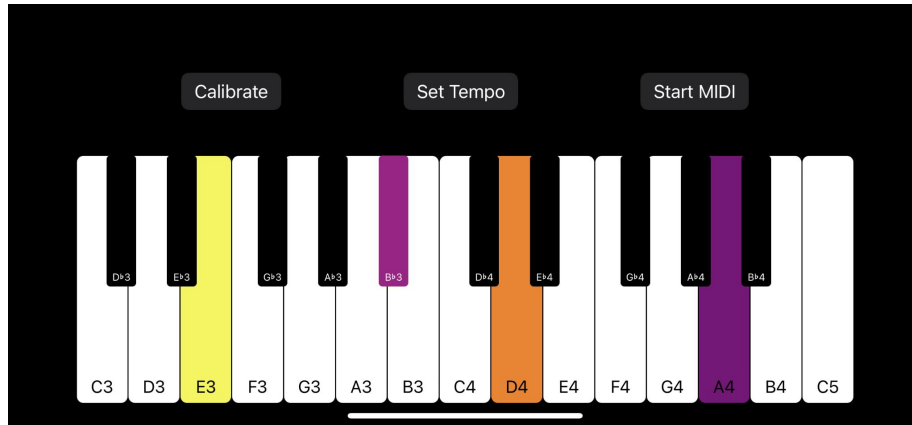
Complete Solution: CV Subsystem



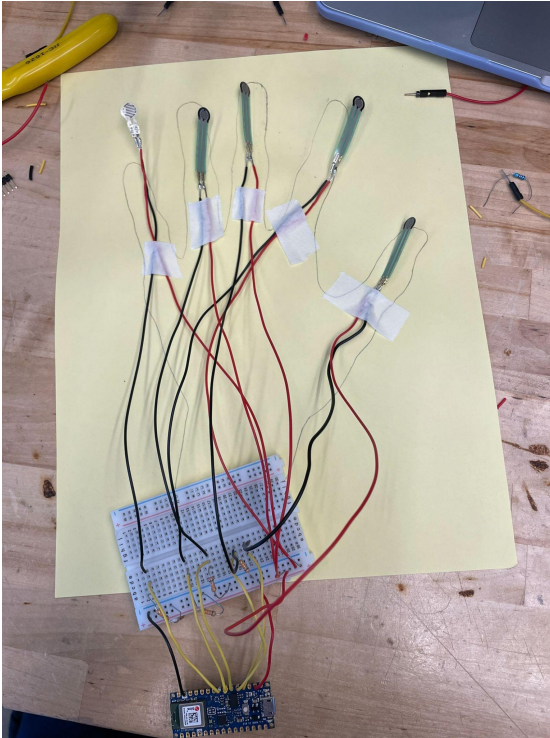
```
*****  
thumb left: (630,289), value: 116, sector: 22  
index left: (641,175), value: 122, sector: 23  
middle left: (688,167), value: 0, sector: 0  
ring left: (729,210), value: 0, sector: 0  
pinky left: (735,302), value: 0, sector: 0  
-----  
*****
```



Complete Solution: App Interface



Complete Solution: Glove



```
S1:  
0.68  
S2:  
0.63  
S3:  
1.00  
S4:  
1.34  
S5:  
0.41
```

Testing, Verification, & Validation



Key Segmentation

Mult. test images

Assign values to keys and manually check if they are correct

Color Thresholding

Camera + Paper Keyboard

Check various lighting conditions to validate RGB threshold values

Key Identification

Hands + Warped Image

Test each finger on each key simultaneously & verify for matches

Warp Consistency

Paper Keyboard at Angles

Ensure that contours work even if paper moved or tilted during use

Testing, Verification, & Validation



Playback

8 notes, 2 octaves

Time to Nano, App, Speaker

Volume

“Loud, medium, soft”

Five testers, expected vs. output

Multi-Note Volume Comparison

Play 4 notes

Unit test for successive playing

Multi-note Volume Threshold

Play multiple notes

Unit test for successive playing, at modified volume. Calculate superimposed volume.

Testing, Verification, & Validation



Note Accuracy

Play 49 keys

Compare with chromatic tuner

Note Range

2 Octaves

Play up to 2 octaves at the same time

Edge Cases

1 finger, two notes

Between b/w, b/b, w/w. Graph results to find patterns.

Time Delay

Successive vs Synchronous

Compare sound to real piano, using metronome to time duration of each note.

Trade Offs

Resistors



Use 10k ohm resistor instead of 68k ohm resistor

Arduino vs Microcontroller



Use Arduino BLE Nano instead of STM32 + HC-05 BLE

Xcode



Only using Xcode and not using Kivy anymore

Finger Identification



Chosen Media Pipe package instead of colored fiducials

