

IOWA STATE UNIVERSITY

EE/CPRE/SE 491 Spring 2019, Team sddec19-13

Sheet Vision

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Project plan

Problem Statement

Problem Statement

The image displays a musical score for piano, consisting of two systems of music. Each system is written for a grand piano, with a treble clef and a bass clef. The time signature is common time (C). The first system is labeled "Piano" on the left. The melody in the treble clef is written in quarter notes, with the notes E, E, F, G, G, F, E, D, C, C, D, E, E, D, D. The bass clef accompaniment consists of whole notes: C, G, C, G. The second system begins with a measure rest (5) in the treble clef. The melody in the treble clef is written in quarter notes, with the notes E, E, F, G, G, F, E, D, C, C, D, E, D, C, C. The bass clef accompaniment consists of whole notes: C, G, C, G, C.

Problem Statement

Sheet music is helpful, but it's:

- Hard to read
- Hard to “hear the music”
- Hard to learn from

The image displays two systems of piano sheet music. Each system consists of a treble clef staff and a bass clef staff. The first system is labeled 'Piano' on the left. Above the treble staff, the notes E, E, F, G, G, F, E, D, C, C, D, E, E, D, D are written above the staff lines. Below the bass staff, the notes C, G, C, G are written below the staff lines. The second system is labeled '5' on the left. Above the treble staff, the notes E, E, F, G, G, F, E, D, C, C, D, E, D, C, C are written above the staff lines. Below the bass staff, the notes C, G, C, G, C are written below the staff lines. The music is presented in a way that emphasizes the visual complexity of reading individual notes on a staff.

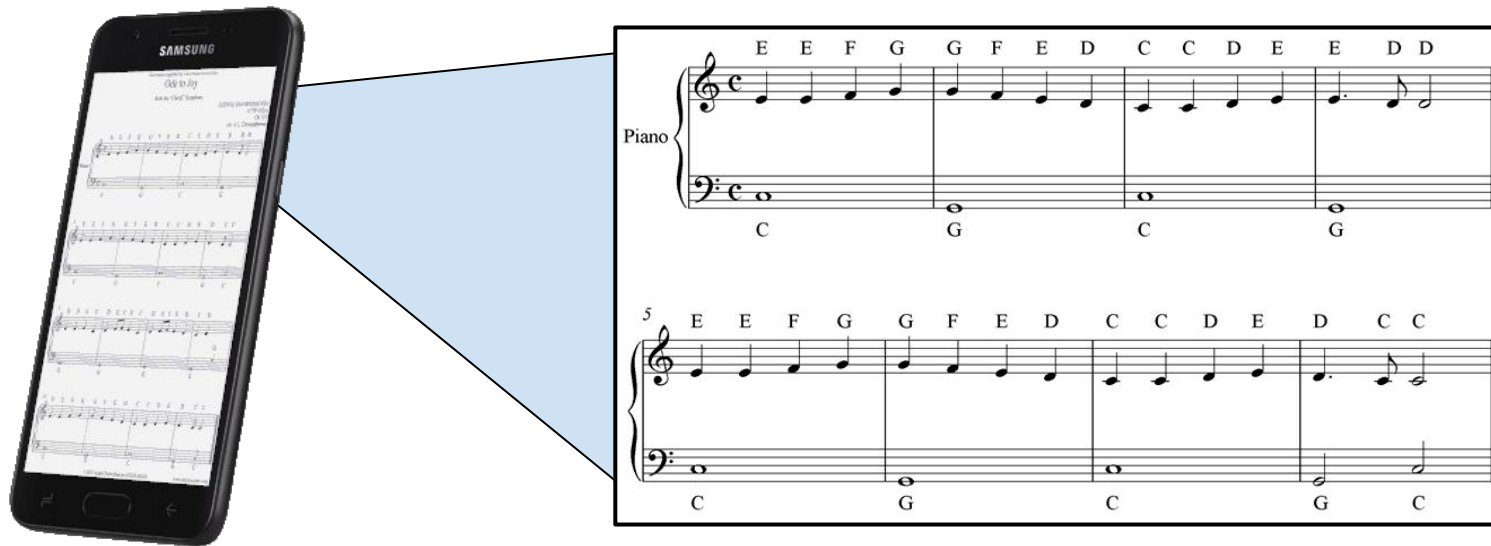
Problem Statement



Piano

The image shows two systems of musical notation for piano. Each system consists of a treble clef staff and a bass clef staff. The first system has notes E, E, F, G in the treble and a single note C in the bass. The second system has notes G, F, E, D in the treble and a single note G in the bass. The third system has notes C, C, D, E in the treble and a single note C in the bass. The fourth system has notes E, D, D in the treble and a single note G in the bass. The fifth system has notes D, C, C in the treble and a single note C in the bass. Chord labels C and G are placed below the bass staff notes.

Problem Statement



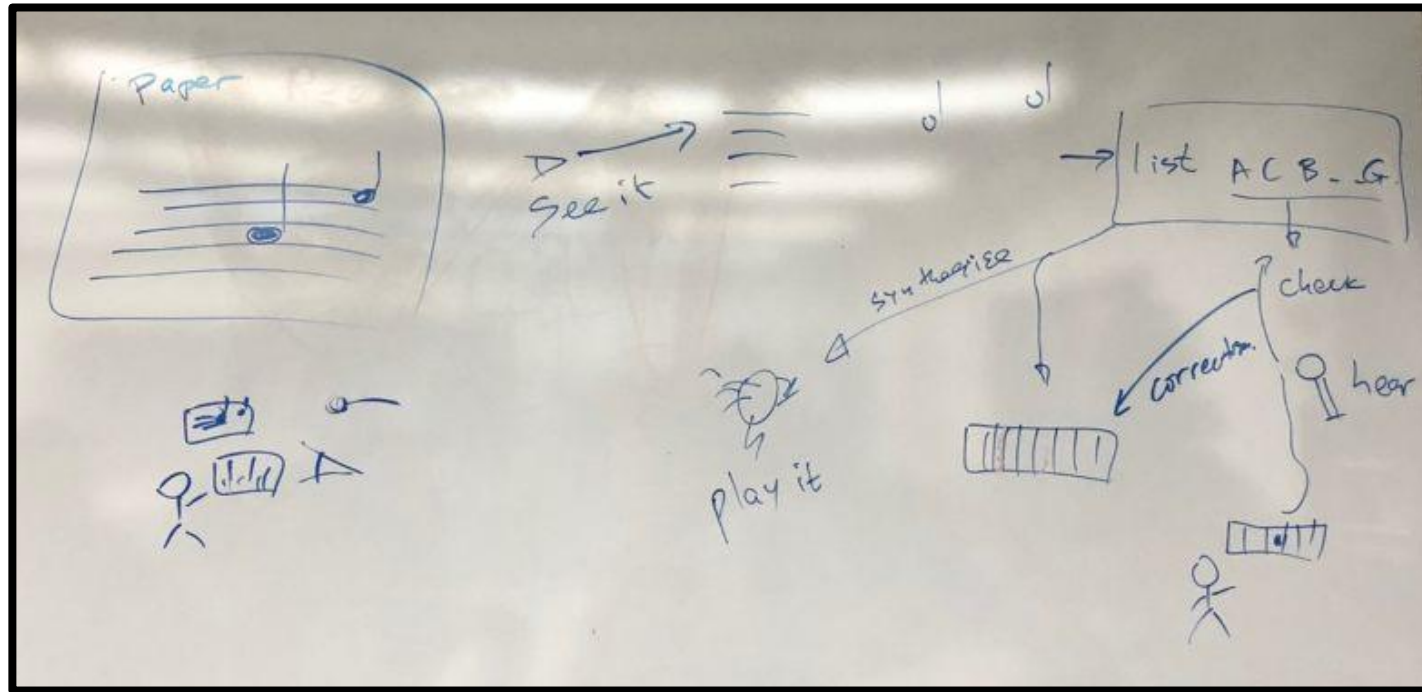
Problem Statement



Piano

The image shows a musical score for piano accompaniment, consisting of two systems. Each system has a treble clef staff and a bass clef staff. The treble clef staff contains a melody of quarter notes with chord letters E, E, F, G, G, F, E, D, C, C, D, E, E, D, D above the notes. The bass clef staff contains a bass line of whole notes with chord letters C, G, C, G below the notes. The second system starts with a measure number '5' above the treble clef staff and ends with a final chord letter 'C' below the bass clef staff.

Conceptual Sketch



Functional Requirements

Platforms: iPhone, Android

- Sheet Music Reader
 - Access to images in memory or from camera
 - Generate MIDI files from scanned sheet music
 - Playback MIDI files from scanned sheet music

Functional Requirements

Platforms: iPhone, Android, Desktop

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 - Generate MIDI files from scanned sheet music
 - Playback MIDI files from scanned sheet music

Functional Requirements

Platforms: iPhone, Android, Desktop

- Sheet Music Reader
 - Access to images in memory or from camera
 - Generate MIDI files from scanned sheet music
 - Playback MIDI files from scanned sheet music
- Music Trainer
 - Displays keyboard, plays along with the music

Functional Requirements

Platforms: iPhone, Android, Desktop

- Sheet Music Reader
 - Access to images in memory or from camera
 - Generate MIDI files from scanned sheet music
 - Playback MIDI files from scanned sheet music
- Music Trainer
 - Displays keyboard, plays along with the music
 - Access to audio from microphone
 - Process audio, check for correctness

Non-Functional Requirements

- Performance:
 - Run image processing on AWS in less than 5 seconds.
 - Music trainer should run in real time.
- Scalability:
 - Large and real-time data.
- Extensibility:
 - Test that the algorithm runs on AWS/APP.

Potential Risks

- Unfinished work
- Untested camera/lighting combinations
- Untested sheet music types

Constraints and Considerations

- Multi platform application
- Computer vision is computationally expensive
- Different styles of sheet music

Market survey

- Few competitors
- Competitors suffer from:
 - Poor UI
 - Low accuracy
 - No note visualization
 - No playback correction

Resource/Cost Estimate

- Rolling Stone Easy Piano Sheet Music Classics
 - (~\$20)
 - Optional
- eLoam Mini Document Camera Scanner S300P
 - ~\$130
 - Optional
- Audio-Technica AT2020 Cardioid Condenser Studio XLR Microphone
 - ~\$100
 - Optional

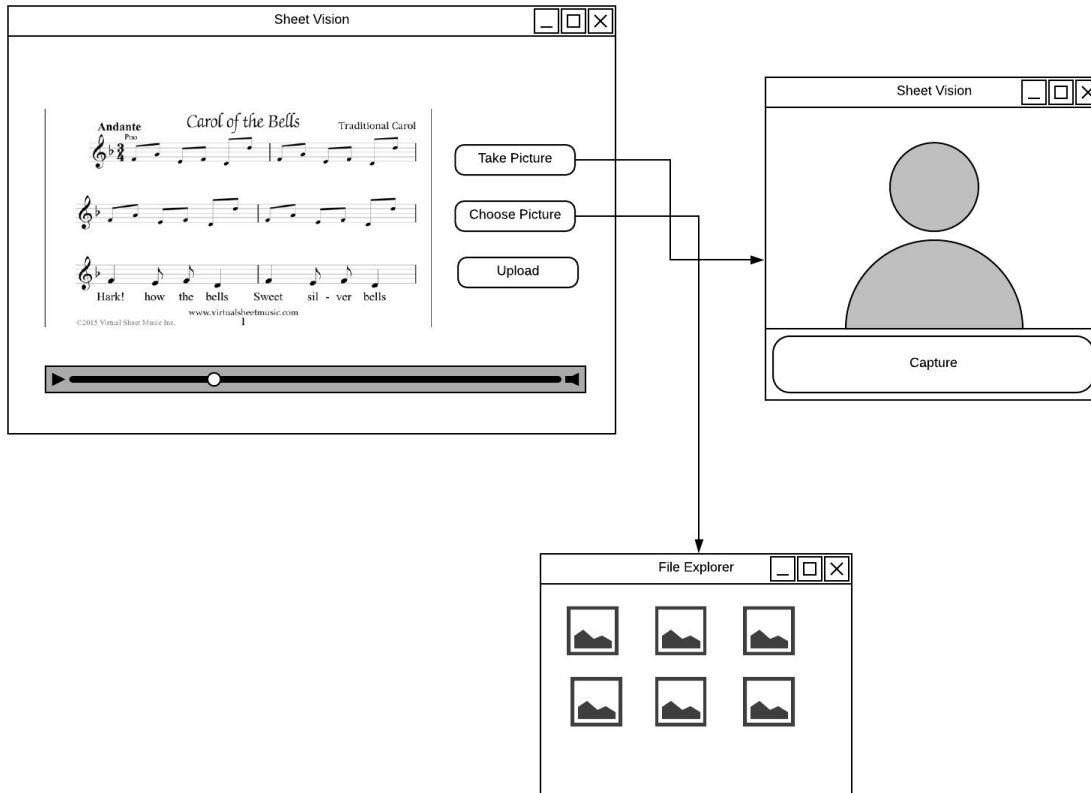
Milestones

Feb. 2019	Feb. 2019	April 2019	Sep. 2019	Oct. 2019	Dec. 2019	Dec. 2019
ReactJS Desktop application for windows	Application can read images from camera/file directory	Algorithm can recognize music notes in sheet music	Application can play correct notes from processed sheet music	Application can listen to user audio using the microphone.	Application can listen to user audio using the microphone.	Algorithm can recognize music notes based on audio input.

System Design

Functional Decomposition

- User scans and sends sheet music
- User watches a preview of how to play in accordance to the sheet music
- User plays their instrument into recording device
- User uses the comparison of notes played and sees more accurately what they did wrong



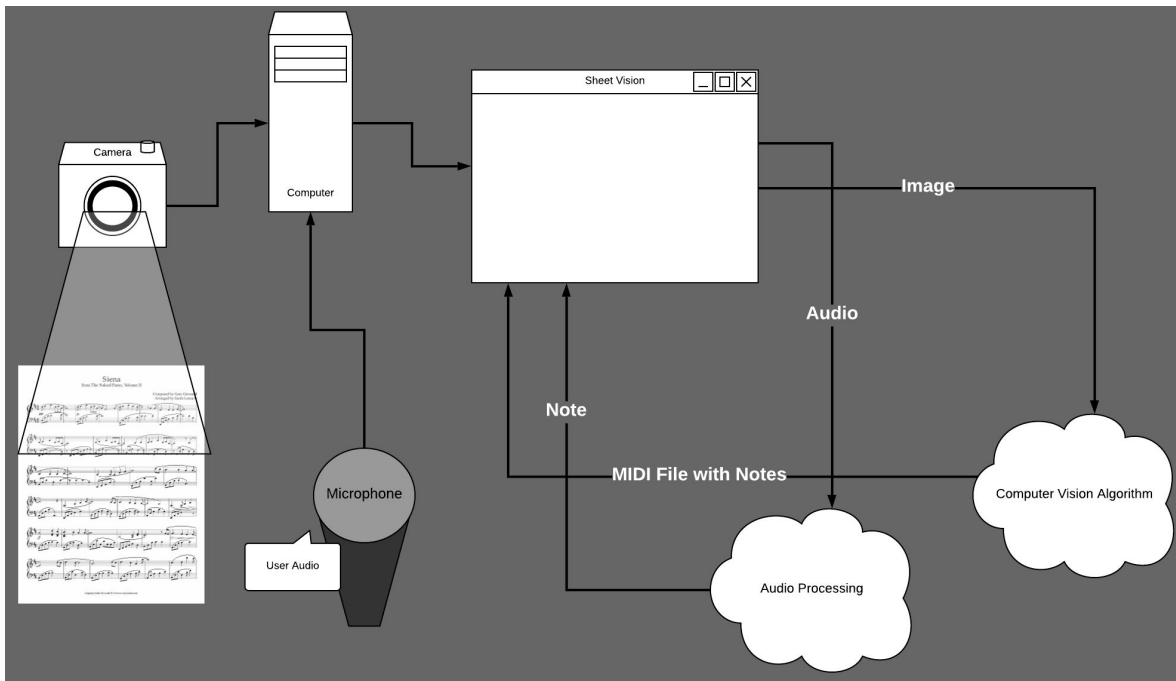
Detailed Design

HW/SW/Technology Platform(s)

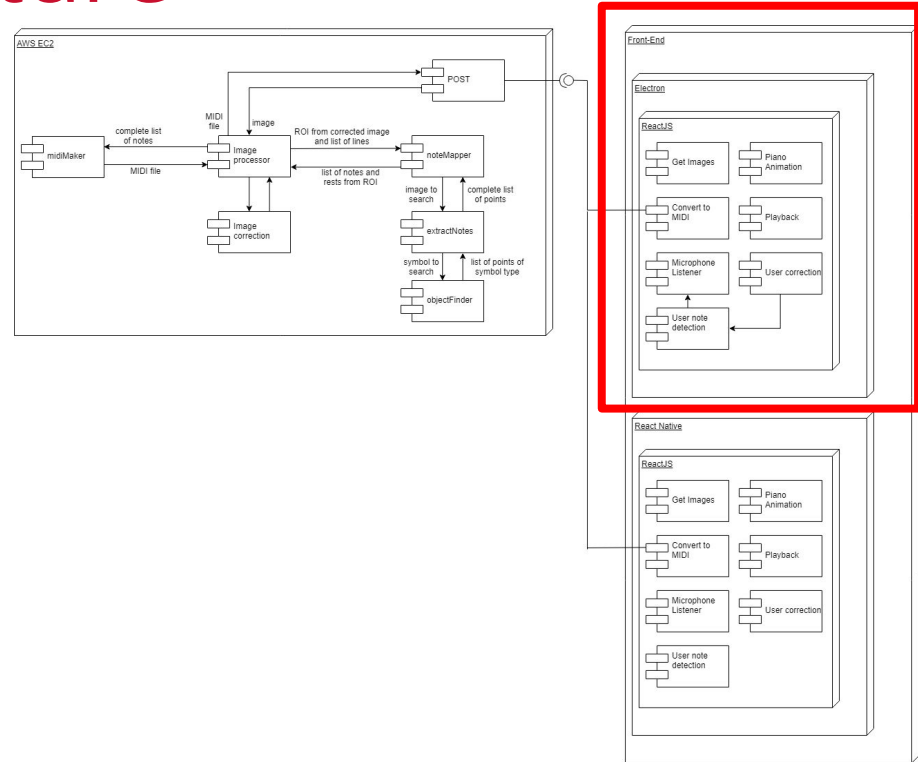
- Amazon Web Services
- React/React Native
- ElectronJS
- Apache
- OpenCV
- MIDIUtil

General Architecture

- Front-end
 - React Native
 - Electron
 - ReactJS
- Computer Vision
 - AWS
 - OpenCV

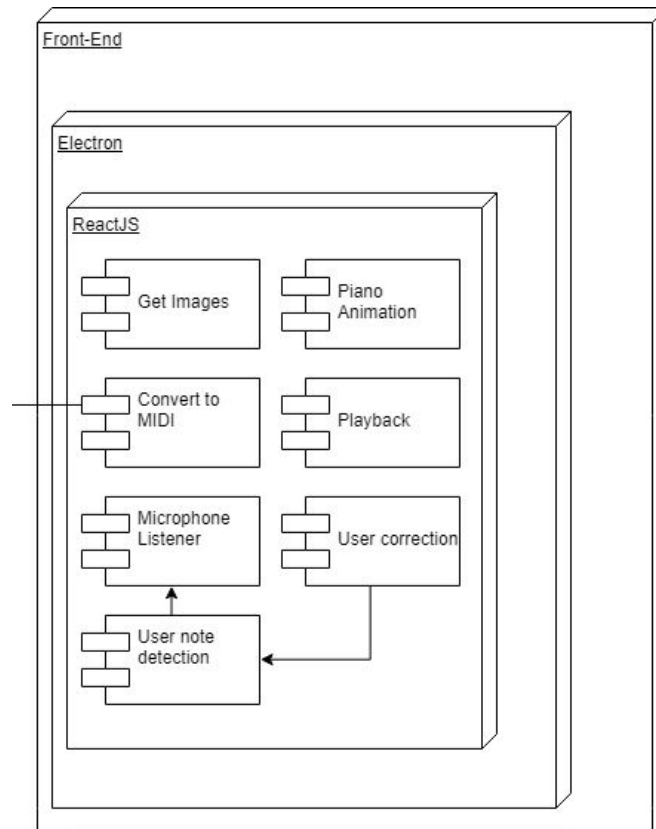


General Architecture

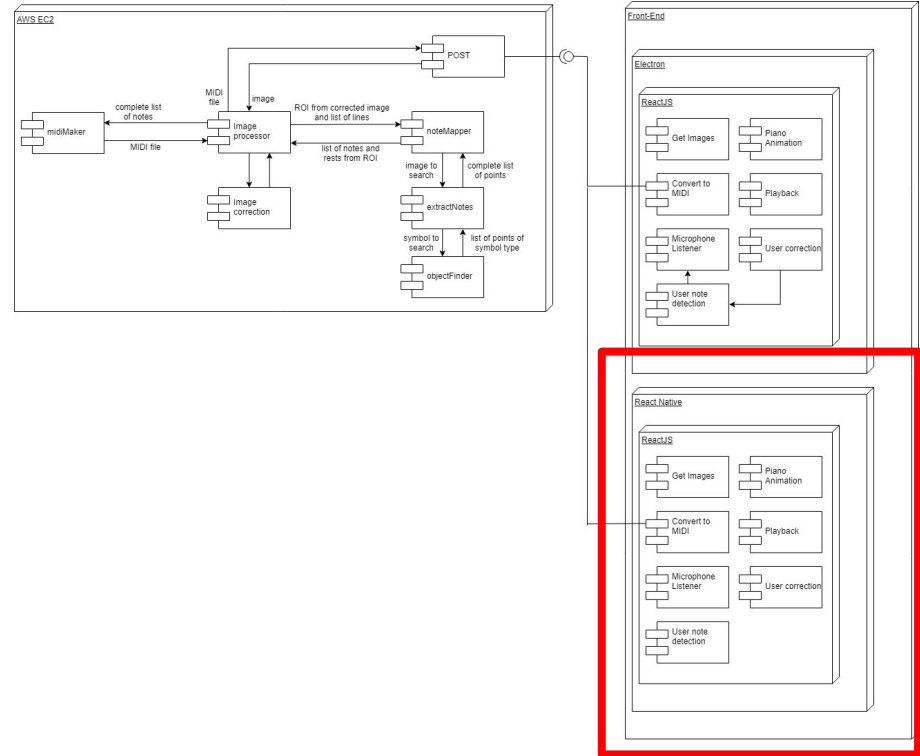


Desktop Architecture

- Stack of:
 - Electron
 - ReactJS
- Why?
 - Multiplatform
 - Modular Components
 - Portability to Web

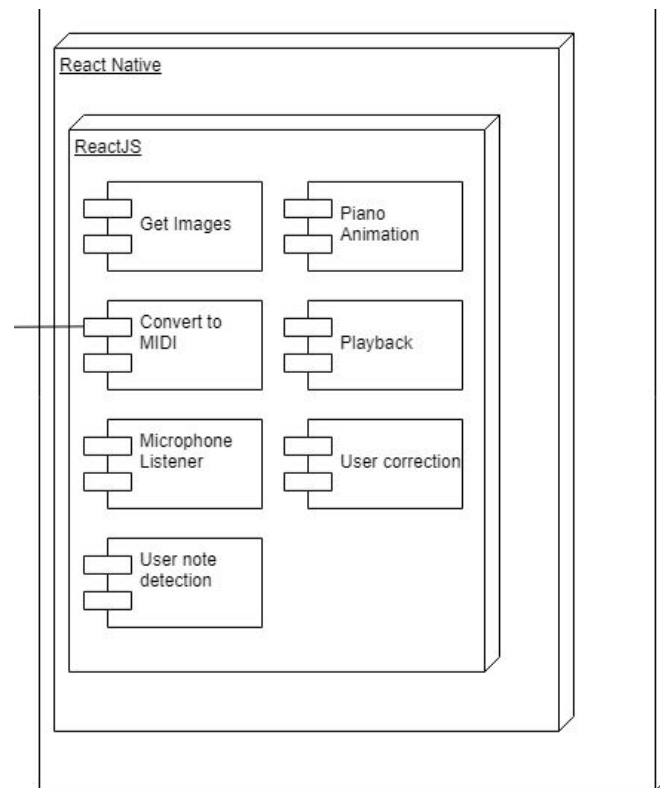


General Architecture



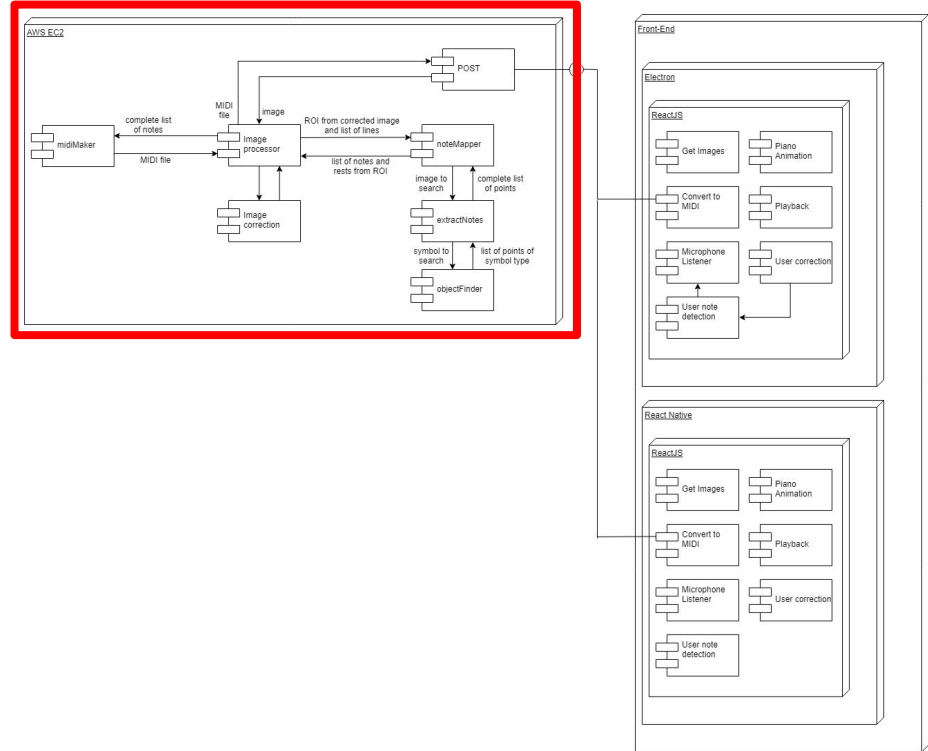
Mobile Architecture

- React Native
- Why?
 - Multiplatform
 - Modular Components

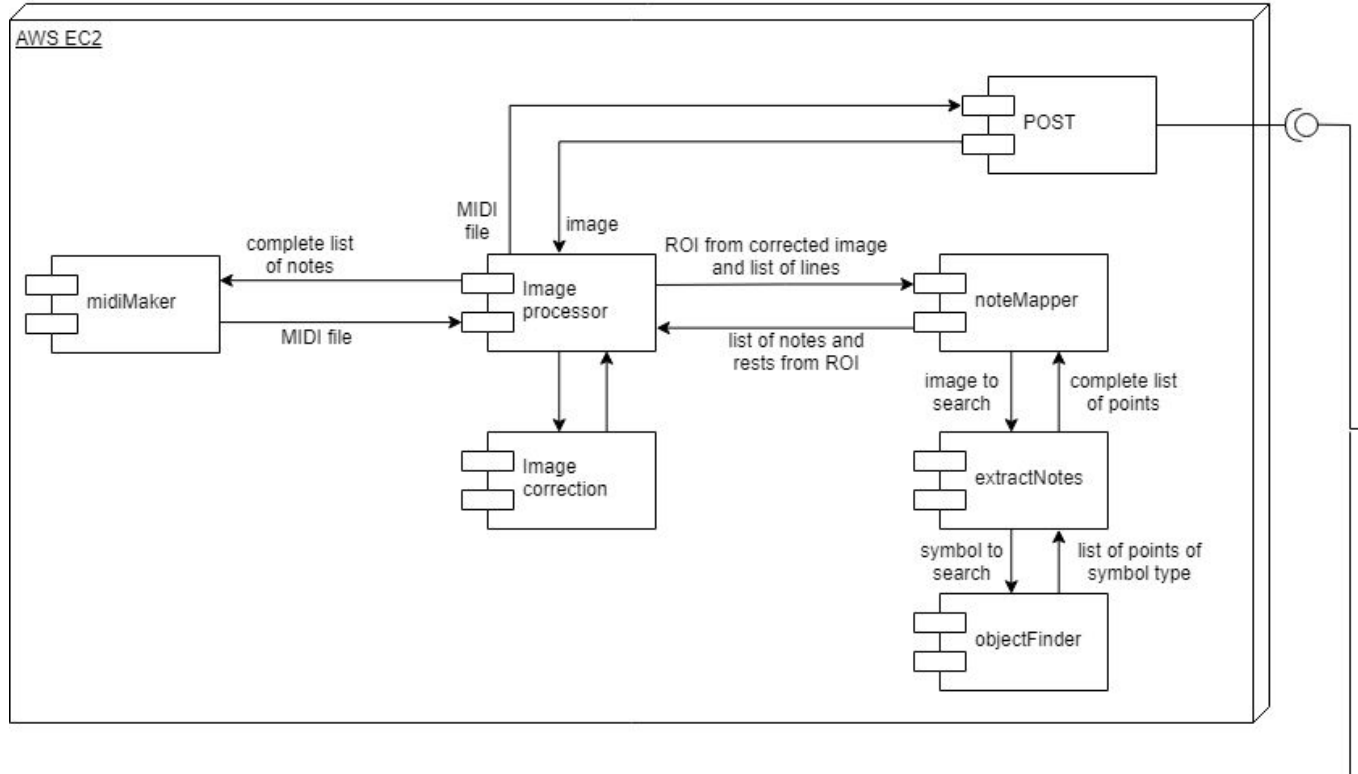


General Architecture

- Front-end
 - React Native
 - Electron
 - ReactJS
- Computer Vision
 - AWS
 - OpenCV



Computer Vision Architecture



Computer Vision Algorithm

Works in three stages

- Image correction and preprocessing
- Note extraction
- Note mapping and MIDI construction

Remove Noise, Balance Colors

Panel Off

Mary's Lamb Had the Blues
Arranged by Jerold M. Simon

Slow and easy - Like you've really got the Blues ♩ = 70

Ma-ry had a lit-tle lamb, lit-tle lamb.

lit-tle lamb, Ma-ry had a lit-tle lamb, and

they can sing the blues.

Teacher's Tip
The main purpose of this lesson is to teach students a left hand blues pattern. The best way to describe the left hand blues pattern is by teaching intervals. The left hand plays a perfect 5th (i.e. C & G), then a major 6th (i.e. C & A), a minor 7th (i.e. C & Bb), back to the major 6th, and ending with the perfect 5th. It repeats this pattern following the primary cadences 1, 4, and 5.

© 2008 by Music Mathworks™

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Split into ROIs

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Test for Sheet Music Traits

Musical score for 'Mary Had a Little Lamb' in 4/4 time. The right hand (treble clef) has fingerings 3, 1, 2, 1 and dynamics >. The left hand (bass clef) has fingerings 2(1), 5 and dynamics >. The lyrics are: Ma - ry had a lit - tle lamb, lit - tle lamb,

The same musical score as above, but with red arrows pointing to various sheet music traits: a red arrow at the beginning of the right hand staff, red arrows pointing to the first and second measures of the right hand staff, red arrows pointing to the first and second measures of the left hand staff, and red arrows at the end of the right hand staff.

 **Teacher's Tip**

The main purpose of this lesson is to teach students a left hand blues pattern. The best way to describe the left hand blues pattern is by teaching intervals. The left hand plays a perfect 5th (i.e. C & G), then a major 6th (i.e. C & A), a minor 7th (i.e. C & B ♭), back to the major 6th, and ending with the perfect 5th. It repeats this pattern following the primary cadences 1, 4, and 5.



Filter Out Non-Sheet Music ROIs

Mary's Lamb Had the Blues

Arranged by Jerald M. Simon

Musical score for measures 1-3. The right hand plays a melody with lyrics: "Ma - ry had a lit - tle lamb, lit - tle lamb,". The left hand plays a blues pattern with intervals 3, 2(1), and 5. Fingerings 1, 2, and 5 are indicated.

Musical score for measures 4-6. The right hand continues the melody with lyrics: "lit - tle lamb, Ma - ry had a lit - tle lamb, and". The left hand continues the blues pattern. Fingerings 3, 5, and 3 are indicated.

Musical score for measures 7-8. The right hand continues the melody with lyrics: "they can sing the blues.". The left hand continues the blues pattern. A double bar line is at the end of measure 8.

Teacher's Tip
The main purpose of this lesson is to teach students a left hand blues pattern. The best way to describe the left hand blues pattern is by teaching intervals. The left hand plays a perfect 5th (i.e. C & G), then a major 6th (i.e. C & A), a minor 7th (i.e. C & B), back to the major 6th, and ending with the perfect 5th. It repeats this pattern following the primary cadences 1, 4, and 5.



Musical score for measures 1-3. The right hand plays a melody with lyrics: "Ma - ry had a lit - tle lamb, lit - tle lamb,". The left hand plays a blues pattern with intervals 3, 2(1), and 5. Fingerings 1, 2, and 5 are indicated.

Musical score for measures 4-6. The right hand continues the melody with lyrics: "lit - tle lamb, Ma - ry had a lit - tle lamb, and". The left hand continues the blues pattern. Fingerings 3, 5, and 3 are indicated.

Musical score for measures 7-8. The right hand continues the melody with lyrics: "they can sing the blues.". The left hand continues the blues pattern. A double bar line is at the end of measure 8.

Note Extraction



A musical score consisting of two staves. The top staff contains a melodic line with a dynamic marking of *p* (piano) at the beginning. The bottom staff contains a bass line. The music is divided into four measures by vertical bar lines. The notes in the top staff are: Measure 1: G4, A4, B4, C5, B4, A4, G4; Measure 2: G4, A4, B4, C5, B4, A4, G4; Measure 3: G#4, A4, B4, C5, B4, A4, G4; Measure 4: G#4, A4, B4, C5, B4, A4, G4. The notes in the bottom staff are: Measure 1: G3, A3, B3, C4; Measure 2: G3, A3, B3, C4; Measure 3: G#3, A3, B3, C4; Measure 4: G#3, A3, B3, C4.

Find symbols and erase them

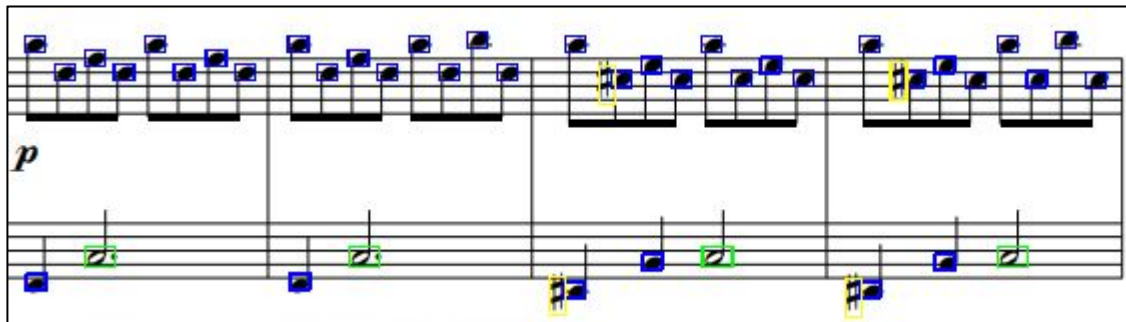


A musical score consisting of two staves. The upper staff contains a melodic line with eighth notes and rests, marked with a piano (*p*) dynamic. The lower staff contains a bass line with quarter notes and rests. Four notes in the bass line are highlighted with green rectangular boxes: the first note in the first measure, the first note in the second measure, the second note in the third measure, and the first note in the fourth measure.

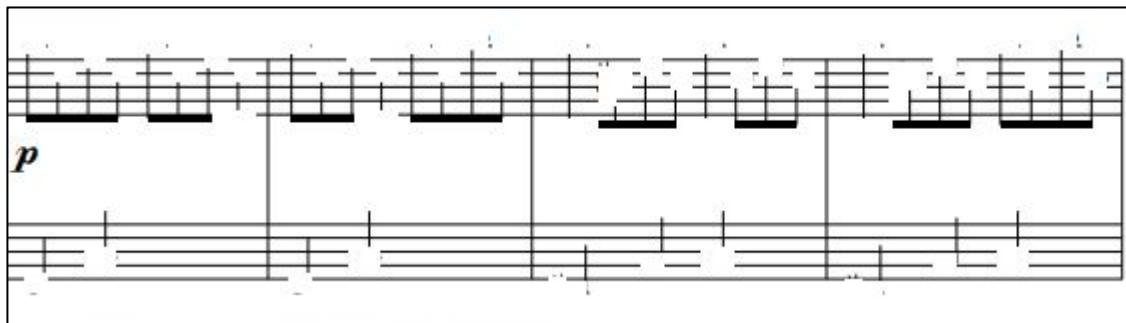


The same musical score as above, but with the green boxes removed from the bass line. The notes are now plain, and the task is to identify and erase any symbols that were present in the original image.

Repeat For All Symbol Types



A musical score for two staves. The top staff contains a sequence of notes, with several notes highlighted in blue. The bottom staff contains a sequence of notes, with several notes highlighted in green. The score is marked with a dynamic of *p* (piano). The notes are arranged in a way that suggests a specific pattern or sequence.

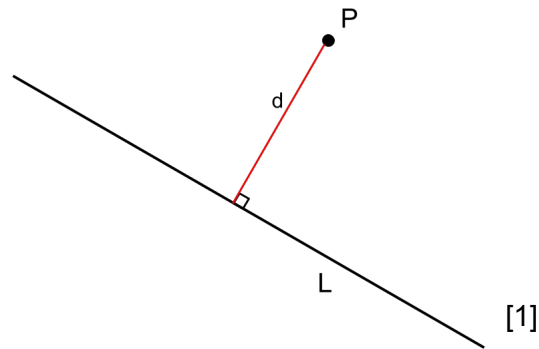


A musical score for two staves, identical to the one above. In this version, all notes in both staves are highlighted in blue. The score is marked with a dynamic of *p* (piano).

Note Mapping and MIDI Construction

Use point to line segment distance

Use point to point distance



[1]Distance between Point and Line. *Brilliant.org*. Retrieved 15:33, April 26, 2019, from <https://brilliant.org/wiki/distance-between-point-and-line/>.

Test Plan

Functional Testing

- Application usability
- Algorithm correctness

Non-functional Testing

- Performance
- Scalability
- Extensibility

Prototype Implementations

Currently our prototypes can:

- Take pictures and upload images on our desktop app.
- Have the images make a round trip to the AWS machine, be processed by opencv, and return back to the app.
- Detect music notes on OpenCV algorithms.

Conclusion

Current Project Status

- Machine vision model complete
- Exploring React/React Native to improve UI
- Amazon Web Server is up and running
- Communication between server and test applications are finalized

Task Responsibility/Contributions

Name	Responsibility	Contributions
Bryan Fung	Frontend/Backend, Meeting Facilitator, Report Manager	Implemented a piano
Garrett Greenfield	Front end, Team Scribe	Implemented piano animations
Ricardo Faure	Frontend/Backend, Architectural Engineer	Implemented communication between the device and AWS
Trevin Nance	Machine vision, Chief Engineer Power System	Created note detection/mapping and MIDI file generation algorithms
Walter Svenddal	Machine vision, Report Manager	Sheet music preprocessing and measure line extraction

Plan for next semester

- Finish UI
- Improve machine vision algorithm
- Begin development on audio processing model

Acknowledgement

- Our sincere thanks to ISU Engineering Department and Dr. Daniels for providing us with this opportunity.
- We would like to thank our faculty advisor Dr. Stoytchev for his support and great feedback.

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Questions?