



**The
Sound of
Sight**

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Use Case

- Problem:
 - Playing piano requires dexterity & coordination of hands/arms, which not everyone has
- Previous Capstone Project: Spring 23, D7 - accompanyBot¹
 - Solenoid case that played piano processed from sheet music
- Our Solution:
 - User can compose sheet music with eye tracking
 - The music can be sent to a piano to be played hands-free
- ECE Areas: Circuits & Software

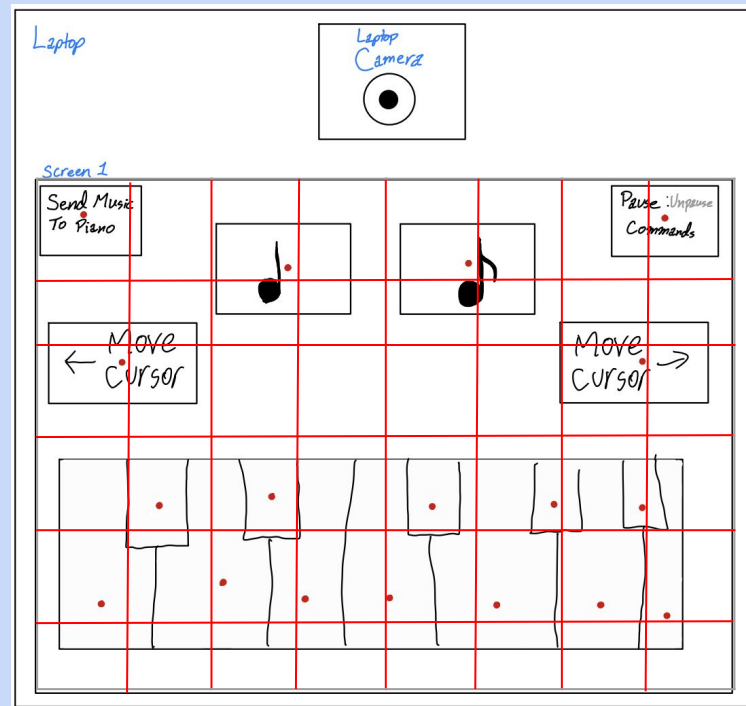
[1] Fiol, A., Khandelwal, R., & Wan, N. (2023, May 05). accompanyBot. [Capstone project, Carnegie Mellon University].

https://course.ece.cmu.edu/~ece500/projects/s23-teamd7/wp-content/uploads/sites/252/2023/05/Team_D7_Fiol_Khandelwal_Wan_final_report.pdf

Use Case Requirements

- Accuracy
 - 75% accuracy at identifying each individual eye-command
 - 95% accuracy at identifying the section (of 48) the user is looking at
 - 100% on solenoid movements

UI concept:



Red dots: Target for user to look at for commands
Red lines: Separate sections for commands

Use Case Requirements

- Response Time/Latency
 - Eye commands are processed within 500 ms
 - Physical key presses within 10% of the BPM when $\text{BPM} < 120$
- Coverage
 - One octave (13 notes)
 - At least two note lengths
- Power Consumption
 - Under 60 watts^{1,2}

[1] Fiol, A., Khandelwal, R., & Wan, N. (2023, May 05). accompanyBot. [Capstone project, Carnegie Mellon University].

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[2] Fiol, A., Khandelwal, R., & Wan, N. (2023) *accompanyBot*. [PDF] . Carnegie Mellon University, ECE Design Experience.

<https://course.ece.cmu.edu/~ece500/projects/s23-teamd7/wp-content/uploads/sites/252/2023/02/Proposal-Presentation-1.pdf>

Use Case Requirements

- **Accessibility**
 - Product is completely accessible for people without the use of limbs
 - With the exception of installation
- **Installation**
 - Non-destructive installation and ability to reinstall

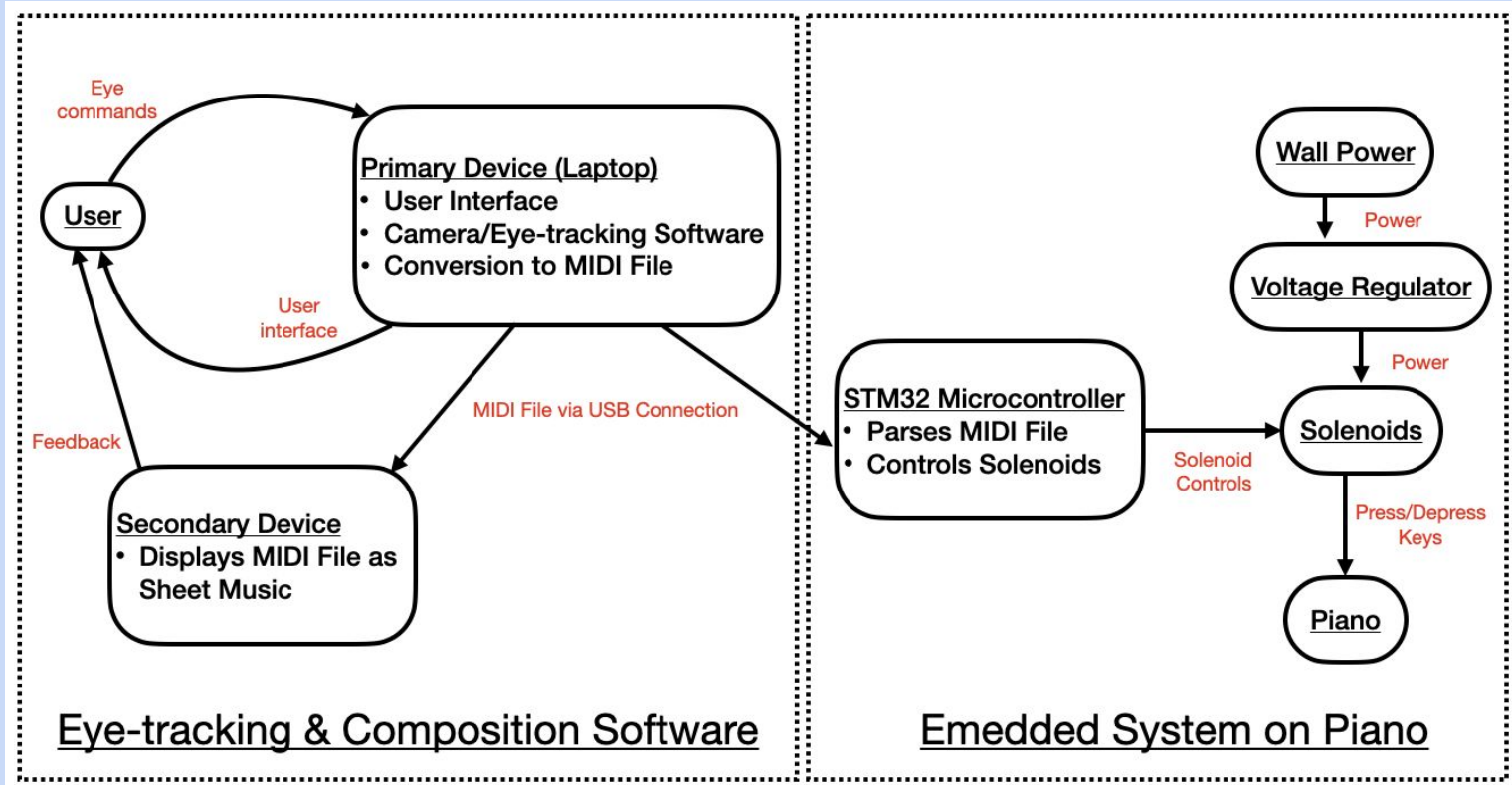
Technical Challenges

- Software
 - User interface can't be too simple, but also can't be too complex
 - Unintended eye movements
 - Angle of the computer screen/position of user
 - No prior experience with OpenCV/eye-tracking

Technical Challenges

- Hardware
 - Solenoids may be too slow to press & depress
 - Power consumption

Solution Approach



Solution Approach

- Asynchronous!
- Hardware
 - STM32 microcontroller
 - Wall power, 12V/1A for solenoids ¹
 - SPI or I2C communication, depending on speed vs power needs
- Software
 - MIDI files to store data
 - OpenCV for eye-tracking
 - Wait-time to confirm command
 - Allow for more complex commands like chords and note-editing

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Testing, Verification, and Metrics

Testing	Verification	Metrics
Accuracy	<ul style="list-style-type: none">- Give multiple users a series of eye-commands/songs to perform- Measure accuracy of detected vs expected eye-movements & solenoid presses	<ul style="list-style-type: none">- > 75%/95% eye-tracking- 100% solenoid movements
Latency of eye-tracking	<ul style="list-style-type: none">- Perform each eye-command from different starting points & record video- Evaluate avg time for eye-tracking system to register	<ul style="list-style-type: none">- Eye commands processed in < 500 ms
Latency of physical output	<ul style="list-style-type: none">- Evaluate delays between solenoid presses for the songs the user have performed	<ul style="list-style-type: none">- Each note <10% of expected BPM (songs < 120 BPM)
Power consumption	<ul style="list-style-type: none">- “Measure voltage and current over time with oscilloscopes to calculate average power”²	<ul style="list-style-type: none">- Average power < 60 Watts²

Tasks and Division of Labor

Fiona	Shravya	Peter
Application/UI Implementation	Power Management	Solenoids
	Firmware/Hardware	
Eye-tracking Software		

