Luminotes

ENSC 405W Capstone A
Team 14, Simple Instruments
PoC Presentation/Demonstration

Presentation Outline

1. Introduction
   - Meet the Team, Background, Motivation
2. Business Case
   - Ideal Customer, Market, Financing, Cost, Competition
3. Technical Case
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4. Risk Analysis and Management
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4. Adherence to Standards
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5. Self-reflection
6. ENSC 440 Capstone B Plan
7. Conclusion
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8. Demonstration
9. Questions

Introduction

Meet the Team

- Shahira A. Azhar (COO)
  - Firmware
- Caitlin Finnigan (CTO)
  - Firmware
- Hsiao Chen Eldon Lin (CIO)
  - Hardware
- Dayton Pukanich (CEO)
  - Structural and planning
- Adnan Syed (CFO)
  - Software & Jack of All Trades
- (Mike) Wei Hao Xu (CCO)
  - Hardware

Introduces team members and key roles.

Background

- Learning the piano requires focus and discipline
- Instructors teach music theory, history, and harmony
- Practice requires constant repetition of songs and scales

Our Product

Luminotes projector and app

- Teaches user to play songs on acoustic piano
- User inputs a MIDI file of any song onto phone app
- App communicates with projector device
- Device projects light onto the keys
- User can play along in real time
- Eliminates the need to read sheet music

And in future versions…

- Records audio and scores user

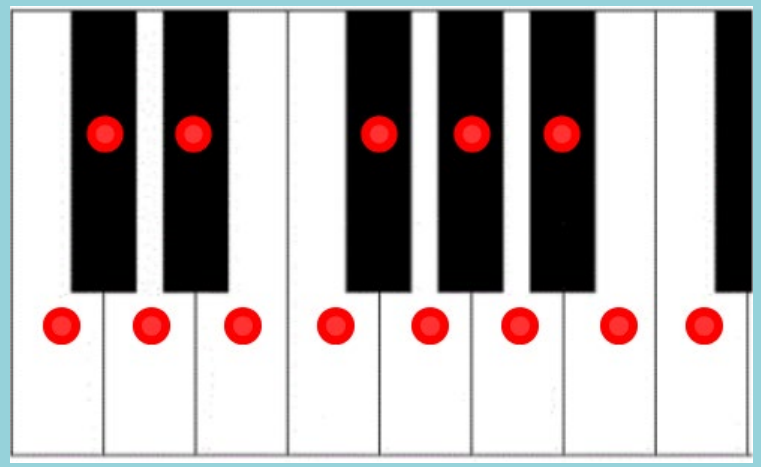


Figure 1: Piano laser projection

Motivation

- Personal experience with playing the piano
- Satisfaction of making something that friends and family can understand
- Research fields of interest that we did not have the time to do as part of our degree
- We wanted to make a really expensive cat toy

Business Case

Market

Anyone with an interest in playing piano

- Beginners, casual hobbyists, children, and students

Market size

- More than 12 million households own an acoustic piano based on data from China and the U.S. [2] [6]

Ideal Customer

- Wealthy or well-educated middle class family [1]
- A customer with an acoustic piano
- Motivated to learn songs on their own
- Doesn't want to pay for lessons

Considerations

- Doesn’t interfere with normal playing
- Feels natural to use

Price

Proof of Concept
- Galvanometer scanner cost the most at $130
- Total cost of $230

Final Prototype
- 3D printing will cost upwards of $100 due to trial and error
- Total cost of $450

Mass Production
- 20% off on $30 per unit gooseneck arms
- Creation of a custom chip to minimize product cost and size
- Replacement of 3D printing with moulds
- Expected cost of $80-110

Financing

Engineering Science Student Endowment Fund
- Can receive initial funding for parts during ENSC 440

Family Funding
- Friends and family may buy our product

Personal Funding
- We have access to money

“Angel” Investing
- After Capstone, we could pursue mass production with overhauled documentation and mass production product

Competition

Electronic Keyboards - physical keys light up in response to MIDI

Synthesia - software that indicates what notes to play [5]

Other piano teaching apps - indicate where to play along with sheet music [4]

Figure 2: keyboard
https://i.pinimg.com/736x/51/6f/60/516f60e46d64c1db939ba115725207f1--sound-speaker-the-piano.jpg

Figure 3: Synthesia
https://i.ytimg.com/vi/m5RmYEd1N9I/maxresdefault.jpg

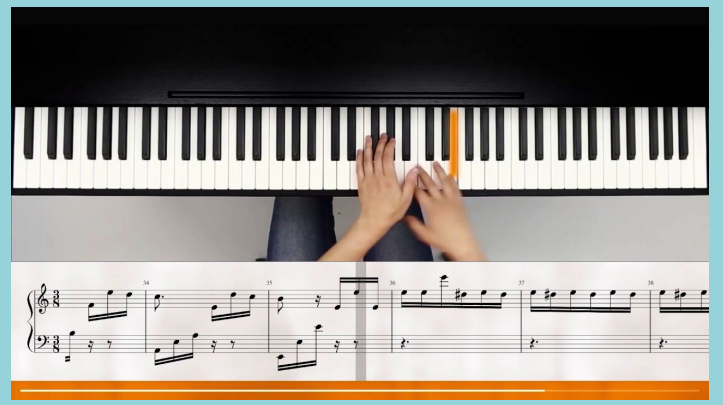


Figure 4: Flow Key
https://imag.malavida.com/mvimgbig/download-fs/flowkey-19607-10.jpg

	Luminotes	Flowkey	Synthesia
Track progress	✗	✓	✓
Displays sheet music	✗	✓	✗
Select speed	✓	✗	✓
Display finger numbers	✓	✗	✓
Projects onto acoustic piano	✓	✗	✗
Plays any MIDI file	✓	✗	✓
Can practice hands separately	✗	✗	✓
Note name displayed	✓	✗	✓
Processes audio feedback	✓	✓	✗
Gives feedback to user	✓	✓	✓
Can use without screen	✓	✗	✗
One time cost	✓	✗	✓

Table 1: Competitor comparisons

Technical Case

High-level Description of PoC

- Application provides interface to select song and use the projector
- Firmware receives song and controls the projector accordingly
- Galvanometer scanner allows laser to shine on correct keys

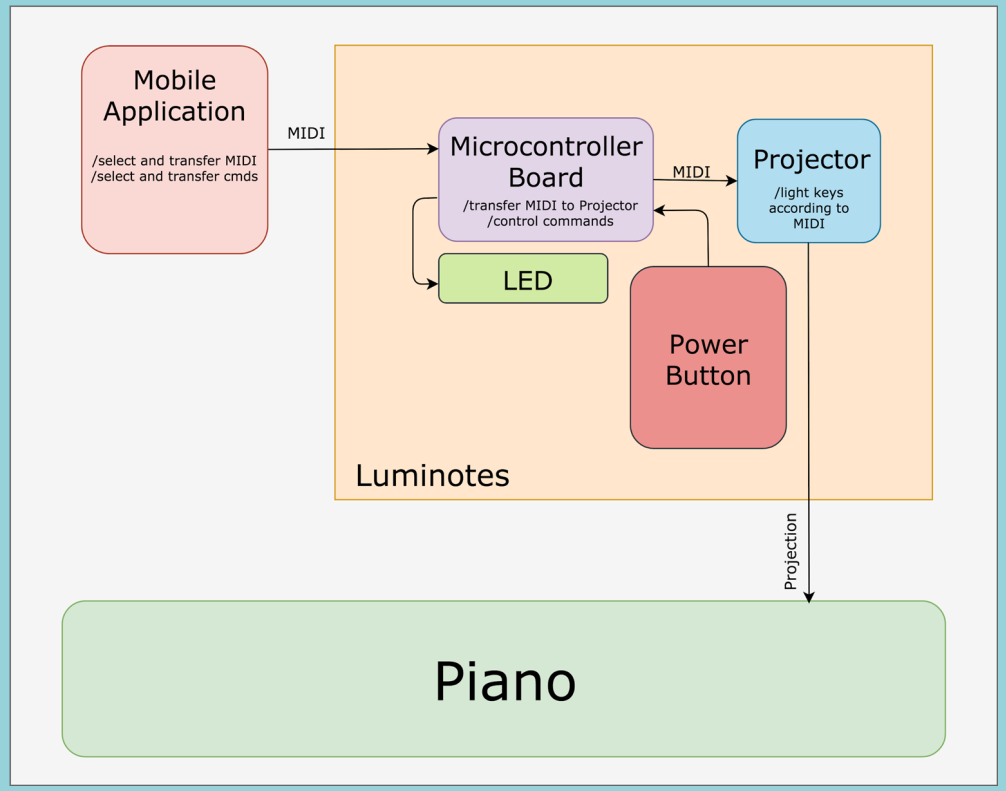


Figure 5: High level POC

Materials

- Galvanometer
- Galvo driver board
- Wood
- Laser
- Arduino
- Power supply
- Wires

Cradle-to-Cradle Design

Hardware
- Electronic scraps can be recycled

Structure
- PLA is eco-friendly and biodegradable, but not strong enough for our needs *[https://www.aidic.it/cet/15/45/279.pdf]*
- 3D filament labeled as Class 7 and cannot be recycled by municipal garbage collection *[https://all3dp.com/2/3d-printer-recycled-plastic-tips-for-your-waste-plastic/]*
- The gooseneck is made from spring steel and can be recycled *[http://www.ever-roll.com/how-environmentally-friendly-and-recyclable-is-steel/]*

Schedule Changes

- Initially we wanted to have the mobile application and digital signal processing in this version
  - Has been moved ahead to 440

Major Changes

- Structural changes
- We are only able to achieve 4 notes
- We used an Arduino instead of a Raspberry Pi
  - MIDI processing was done externally in Python
- Laser cannot be turned off

Product Safety

Concerns

- Laser hazards
- Falling-object hazards
- Tripping hazards

Solutions

- Low-powered red less than class 3A laser with a protective shield
- Lightweight product with a weighted base
- Thin and aptly sized cord

Business Risks

Concerns

- Niche audience
- Disinterest from target audience
- Expensive product

Solutions

- Coordinating with piano teachers, communities
- Additional cost-effective features
- Improve software and feedback

Adherence to Standards

Engineering Standards

ISO 11553-2:2007
- Safety of machinery -- Laser processing machines -- Part 2: Safety requirements for hand-held laser processing devices [1]

ISO 11252:2013
- Lasers and laser-related equipment -- Laser device -- Minimum requirements for documentation [2]

CAN/CSA-C22.2 NO. 61508-1:17
- Functional safety of electrical/electronic/programmable electronic safety-related systems — Part 1: General requirements [3]

CAN/CSA-C22.2 NO. 0-10
- General Requirements - Canadian Electrical Code, Part II

UL 60950-1
- Information Technology Equipment - Safety - Part 1: General Requirements

IEEE 1003.13-2003
- IEEE Standard for Information Technology - Standardized Application Environment Profile (AEP) - POSIX(R) Realtime and Embedded Application Support

IEEE 802.15.1-2002
- IEEE Standard for Telecommunications and Information Exchange Between Systems - LAN/MAN - Specific Requirements - Part 15: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Wireless Personal Area Networks (WPANs)

CAN/CSA-ISO 14040-06 (R2016)
- Environmental Management - Life Cycle Assessment - Principles and Framework

Requirements

[Req10.1.1 - a] The lasers will be recyclable.

[Req10.1.2 - b] Scanner recognize if it has been idle for more than five minutes. If so scanner will turn of the laser and turn itself off.

[Req10.2.1 - a] The app will not share the user's information with third-party.

[Req10.2.2 - a] The laser will be the color RED [3].

[Req10.2.3 - a] The lasers used must be less than class 3A [3].

[Req10.2.4 - a] The chassey must be made sturdy and robust to prevent the scanner from falling on the user.

Reflection

- Integration requires a lot of time
  - Allocate more time in 440
- Physically working together is more effective than individually
- Don’t have meetings too frequently, and stick to the agenda
- Allocate more time for testing

Self-reflection

- It takes time to choose and integrate a functional component
  - Ordering for time, cost, convenience
  - Understanding how everything works without a manual

- Working together is time-efficient for productivity, provided we don’t encounter bottlenecking
  - We can’t all work with our hardware at the same time, but we can with software and firmware through GitHub

- Ask for help earlier on rather later on

ENSC 440 Capstone B Plan

- Nicer, more compact structure
- Ability to change height of projector
- Ability for projector to reach multiple octaves
- Phone application to control the board
- Raspberry Pi
- More precise DAC
- Ability for device to process sound, and score the user's playing through the app

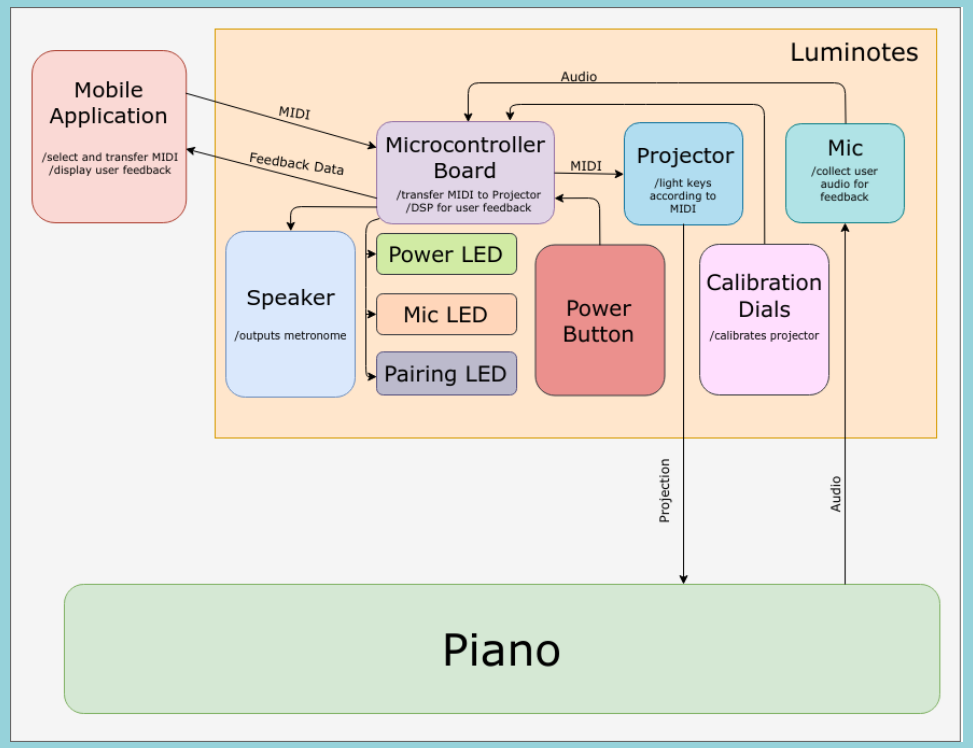
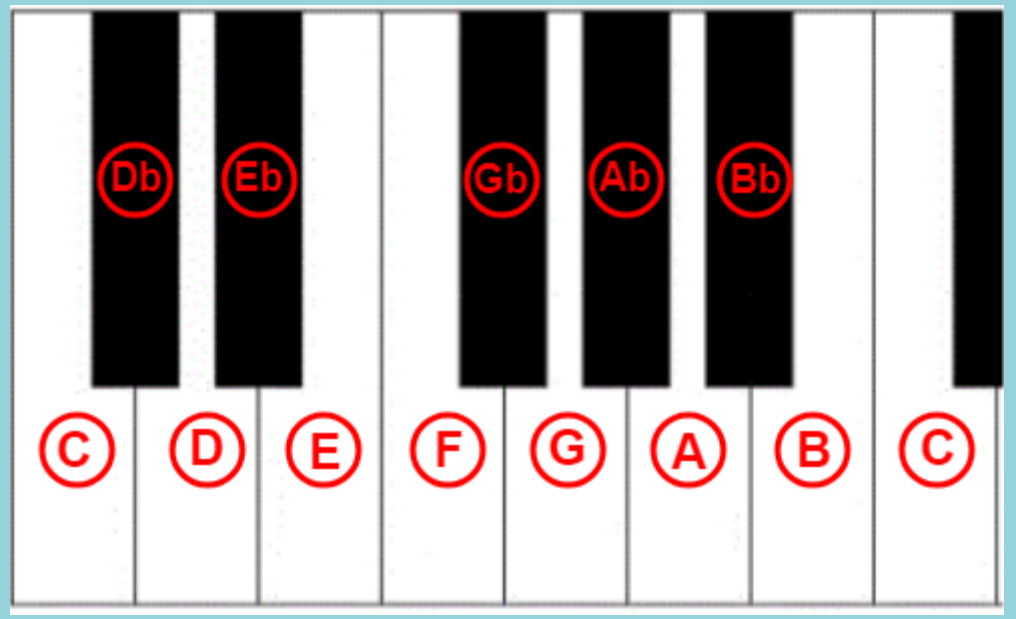


Figure 6: High level ENSC 440

UI for 440 Prototype

- Covers 4 octaves
- Display key names, finger numbers



Conclusion

Conclusion

Luminotes Projector and App

- Teaches user to play a song on the piano, by shining a light onto keys
- No need for sheet music
- Good for user prefers acoustic piano over electric keyboard

What We Learned

- Mike: How to work with a power supply (safety and wiring)
- Caitlin: Integration is the most difficult part of the design process
- Syed: Don’t order parts if they have no documentation
- Dayton: It is very difficult to design and build a functional structure
- Eldon: Learning and getting everyone to use gitlab to manage deadlines
- Shahira: Debugging is a lot easier when you read the open source code comments

References

[1] “Social history of the piano,” *Wikipedia*, 25-Mar-2019. [Online]. Available: https://en.wikipedia.org/wiki/Social_history_of_the_piano. [Accessed: 28-Mar-2019]

[2] Al Jazeera, “China's piano craze fuels production boom,” *News | Al Jazeera*, 08-Apr-2015. [Online]. Available: https://www.aljazeera.com/news/2015/04/china-piano-craze-fuels-production-boom-150408053222031.html. [Accessed: 28-Mar-2019]

[3] G. Chapman, Class Lecture, Topic: "Laser Safety.” ENSC470/894, Faculty of Applied Science, Simon Fraser University, Burnaby, Jun., 14, 2018.

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[6] “Piano U.S. unit sales 2017 | Statistic,” Statista. [Online]. Available: https://www.statista.com/statistics/452772/number-of-pianos-sold-in-the-us/. [Accessed: 28-Mar-2019]

[7] ESSEF. [Online]. Available: http://www.esss.ca/essef. [Accessed: 28-Mar-2019]

[8] [Online] Available: https://github.com/mido/mido [Accessed: 30-Mar-2019]

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Demonstration and Questions