Introduction

Objective

One to two paragraphs detailing the problem statement and proposed solution.Learning the piano can be a difficult thing because in order to do it yourself you are required to know something about how the notes you are playing sound. Without this knowledge, and without someone there to correct finger placement, it can be hard to determine conveniently if you are playing the right chord. The internet has many resources that make any individual capable of teaching themselves the piano or looking up chord structures. Websites are available that allow you to put in the different notes you are playing, or even click the keys you are pressing on a piano keyboard graphic, and will return the chord that it makes. However, this is inconvenient to work with as several steps are required in the process and can provide a roadblock to a beginner who gets frustrated.

Our proposed solution is to bring these resources that are available on a separate technology directly to the instrument. Heads Up Display technology is being used to bring access to information away from separate technologies and into the way we interact with the physical world. Using the information from the MIDI (Musical Instrument Digital Interface) keyboard, we will be able to determine, as the user is playing the keyboard, each chord that they play and then use the HUD technology to place the chord being played onto a music stand so the user can see the data on their preferred place on their sheet music while they are playing.

Background

There are many MIDI interface software products currently on the market. These include simple recording programs, pitch bending, sustain pedals, and various sound effects. Additionally, there are web services designed to translate key presses, guitar fret positions, or note names, into chord names. These web services, along with many forum posts looking for ways to determine chord names while playing them, are right at the top of any web search for “how to tell what chord I’m playing.” Until now, these products have been largely separate. That is, MIDI interface devices and largely limited to purely storing or manipulating MIDI data, rather than analyzing it, and music analysis software, even when given a MIDI interface, tends to assume the user is displaying the information on a computer (see https://www.kvraudio.com/product/midichordanalyzer-by-insert-piz-here). Our product is thus unique in offering a hardware tool to view the chords played on a MIDI instrument in real time.

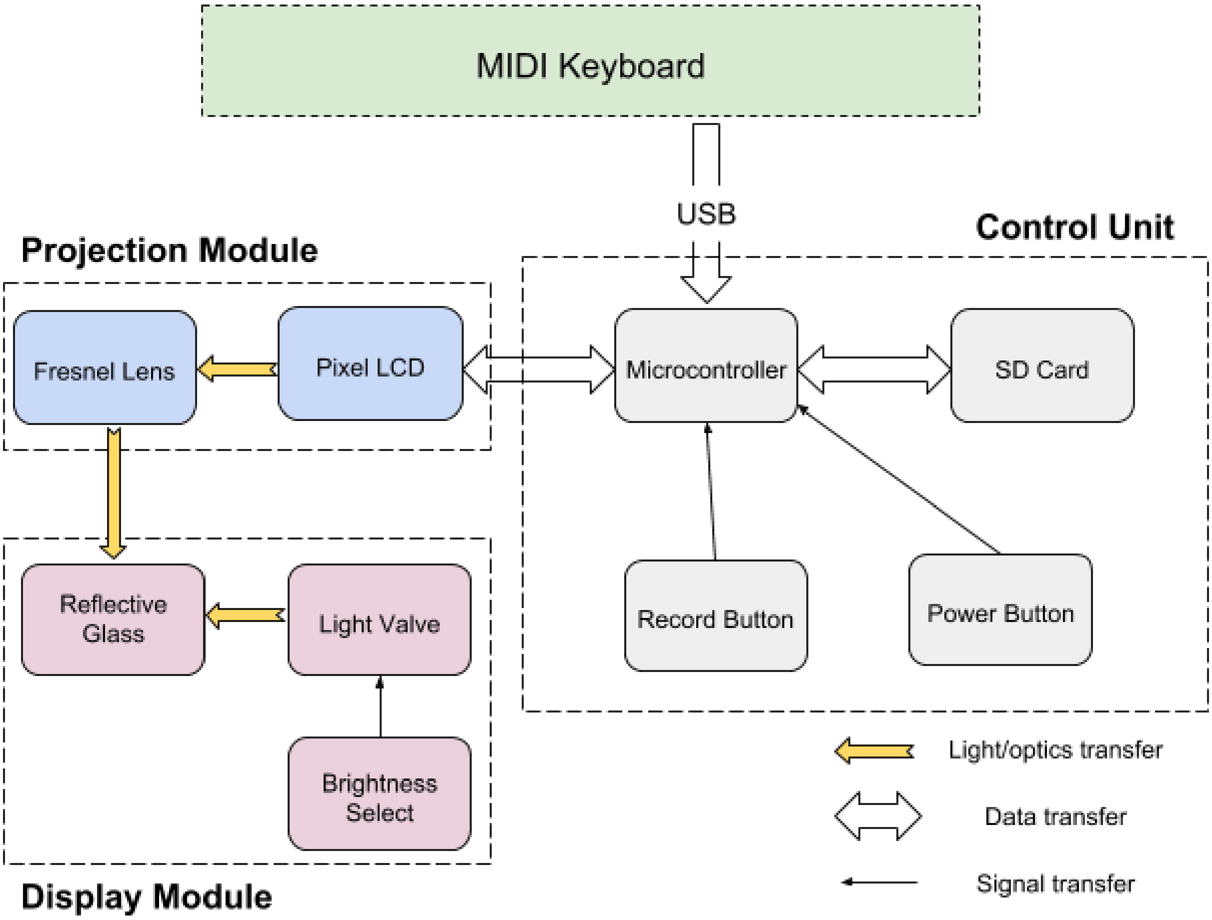
High-level requirements list

- Projector must be able to display the pixelated images in the correct orientation and with clarity onto the reflective, transparent glass.
- MIDI input must be interpreted accurately and in real-time
- Data capture must be easily turned on and off by the user and stored in the SD card in an accessible format.

Design

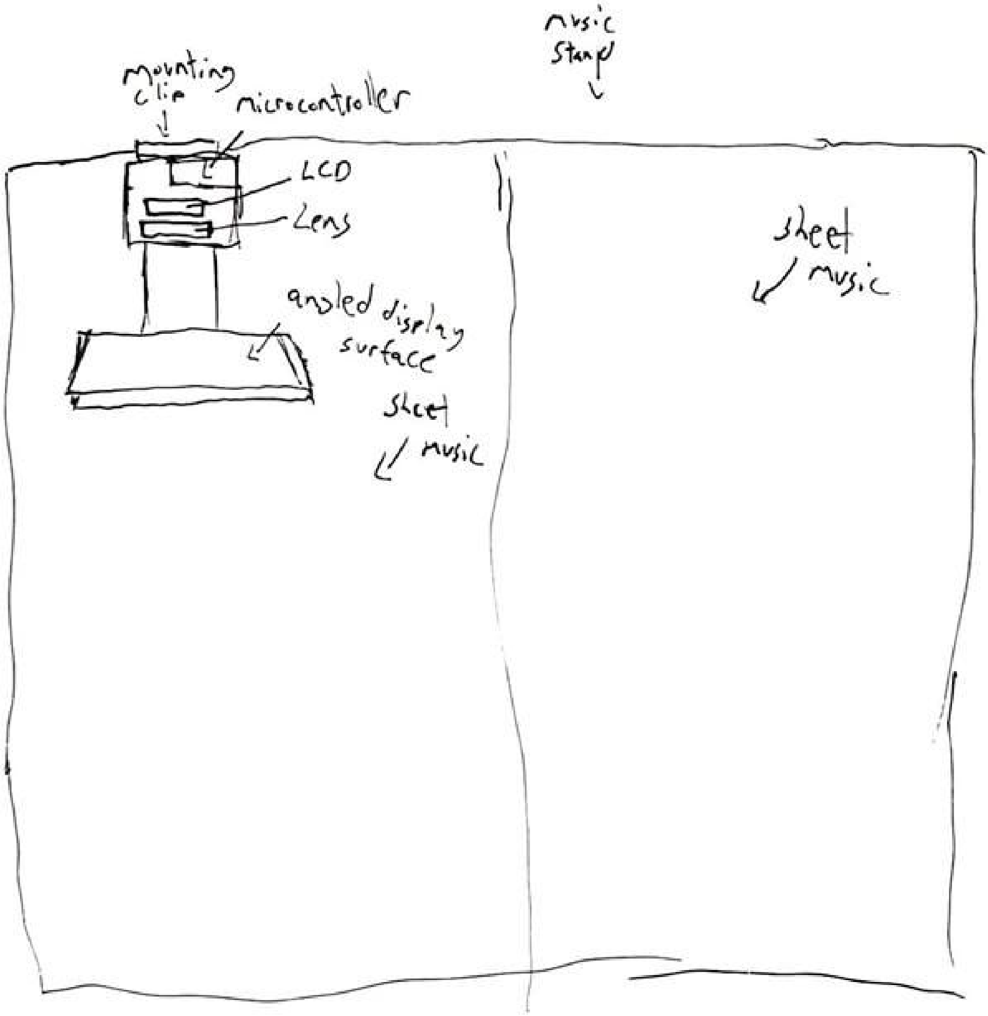
Block Diagram

This MIDI interpretation and data display device can be separated into: a control unit, a projection module, and a display module. The control unit will be responsible for interfacing the the MIDI input from the keyboard via the USB cable with the data interpretation, user input, and data storage with the SD card. The projection module will be the first step of data display of the control unit’s chord name output. This consists of the pixel LCD which will show the chord names as a mirrored image, and the fresnel lens which will be placed as to bring this image to the desired dimensions. The display module, a combination of an adjustable light valve and the reflective glass, is the Heads Up Display itself which will be placed on the user’s music stand over sheet music. The reflective glass will be placed in front of the light valve with respect to the light coming from the projection module, and the light valve will be immediately behind it so as to adjust the brightness of the display without causing an additional reflected image.



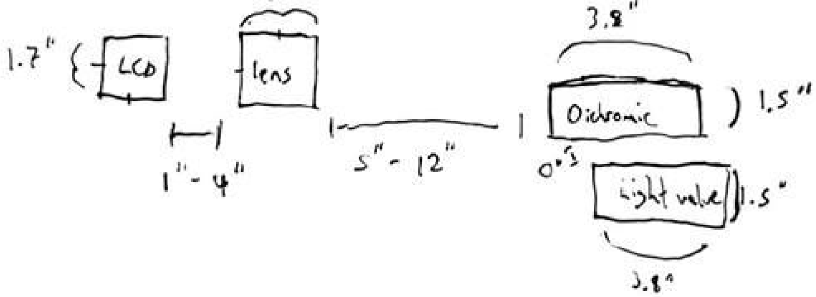
MIDI Keyboard
USB
Control Unit
Projection Module
Fresnel Lens
Pixel LCD
Microcontroller
SD Card
Record Button
Power Button
Reflective Glass
Light Valve
Brightness Select
Display Module
Light/optics transfer
Data transfer
Signal transfer

Physical Design



Device in use

Projection components & spacing



Functional Overview

A brief description of the function of each block in the block diagram and explain how each block contributes to the overall design and feature list above. Include a discussion of the interface with other blocks. Every block in the block diagram must have its own description and each description should be 1-2 paragraphs in length. A brief description of the function of each block in the block diagram and explain how each block contributes to the overall design and feature list above. Include a discussion of the interface with other blocks. Every block in the block diagram must have its own description and each description should be 1-2 paragraphs in length.

Control unit

Microcontroller

We have chosen to use an ATMEGA328 microcontroller. This will receive the communication via the USB from the keyboard, send data to the SD card, receive inputs from the Record and Power buttons, and send information to the pixel display in the Projection Module.

Requirement: The microcontroller must be able to send determined chord values to the pixel display while sending MIDI data to the SD card if in the record mode at less than a minute after the user ends the recording.

SD Card

An SD card will be placed in the main body of the device for saving MIDI data while in record mode. It will not be needed to write data to the device, only read.

Requirement: The SD card must be capable of storing MIDI data as fast as it is sent through the USB connection from the keyboard.

Record Button

This button will be placed on the main body of the device for enabling recording mode. When this button is “on”, MIDI data from the keyboard will be stored in the SD device. In “off” this function will be turned off.

Requirement: When record button is “on”, there needs to be an indication on the display informing the user that the device is in record mode.

Requirement: The record button needs to be clearly labeled as the record function compared to other user inputs.

Power Button

This button will be placed on the main body of the device to power it on and off.

Requirement: The power button needs to be clearly labeled as the power button.

Projection Module

Pixel LCD

We have chosen to use the Adafruit 1.54" 240x240 Wide Angle TFT LCD Display for the pixel LCD display. This will receive output from the microcontroller and will display a mirrored image of chord names that have been determined by the device’s MIDI interpreter.

Requirement: The LCD display must display mirrored chord names, as the user of this device will be the chords reflected off another surface and not reading from this display.

Requirement: The chord name images on this display must be detailed so that when the image is expanded in projection the quality of image is high.

Fresnel Lens

A fresnel lens from a magnifying glass will be used to project the small image of the pixel screen into a larger display on the reflective glass a small distance away. This will be placed between the pixel LCD and the reflective glass.

Requirement: This lens must be of high enough quality to only magnify and not distort the pixel image.

Display Module

Reflective Glass

The reflective glass that will act as the display for the user will be a dielectric beam splitter mirror. This is used in teleprompters, and has a reflective side with tint-free mirror coating and a backside with anti-reflective coating to prevent a double image. The image of the live-updating chord name projected from the projection module will be shown here.

Requirement: The reflective glass must be large enough that an easily readable size of lettering can be displayed from the projector module.

Requirement: The reflective glass must be able to clearly show the images being output by the projector module.

Light Valve

We have chosen to use a controllable shutter glass liquid crystal light valve to control the transparency of the display. This will be attached to the beam splitter mirror so that the mirror is in between it and the projection from the fresnel lens. The brightness of the valve will be connected to the “Brightness Select” user input potentiometer and has an input range of 0-5v (in which 5v input will cause complete opacity and 0v will cause complete transparency).

Requirement: The light valve must only receive an input between 0 and 5v.

Requirement: The light valve must be attached to the back of the beam splitter mirror in a compact and secure manner.

Brightness Select

The Brightness Select is a potentiometer that will be adjusted by the user in order to control the transparency of the heads up display and change the display quality. This will be connected directly to the light valve and will not go through the microcontroller.

Requirement: The Brightness Select must be limited to controlling an input to the light valve between 0 and 5v.

Requirement: This must be easily accessible and clearly labeled so the user knows it is for adjusting the heads up display quality.

Risk Analysis

There are two main risks here. Firstly is the greatest risk in terms of probability, which is that the projection system fails in some way. Our system is designed to be very simple to combat this, but this simple design could lead to poor image quality. Additionally, we have only a few other examples of people using a setup similar to our own. This isn't necessarily bad, but if we run into difficulties, we won't have many resources for troubleshooting this exact configuration, and perhaps there are good technical reasons others don't use it. Most importantly, if our product doesn't display chords, then it has failed its main mission. However, there are scaling degrees of failure possible in the optical system. A poor display is still a display. Our biggest risk in terms of threat to the usability of the product is the microcontroller itself, as if something goes wrong in there, nothing works at all. There is no condition in which a partial failure of the microcontroller leads to anything less than a complete failure of the device.

Ethics and Safety

MIDI is a freely available data protocol, and we were unable to find any other examples of our product on the market, so from an intellectual property perspective there are no issues. It is technically possible for someone to plug the device into someone else's instrument and use it to record their performances without their knowledge or permission, but given the size and shape, that seems unfeasible. As for safety, the biggest risk to the end user comes from the fact that we plan on using teleprompter glass for part of the display, which could break and produce sharp edges. If testing shows this to be too great of a risk, we do have plans for an alternative display using a plastic reflective surface instead. Our own safety risks are no greater than any other computing electronics projects; we aren't working with any high voltage equipment, so the most dangerous thing we might encounter is a soldering iron.