Pocket Media Studio

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Background

With today's technological advancements, most media production is accomplished with computer software and audio sampling, requiring a multitude of instruments and software. Our device is a medium between the user and the computer software where musical instruments will be projected onto any flat surface and used in real time. **Why does this matter?** This device will create an inexpensive and streamlined approach to producing music anytime, anywhere.

Hardware Components

Microcontroller
ESP32 - ultra-low-power consumption microcontroller that is used to control communication between the machine vision, audio, and projection modules via I²C and UART. This module provides Wi-Fi and Bluetooth functionality which can allow our proposed device to be amplified with external speakers.¹

Audio
DFPlayerMini – this module uses a microSD card reader integrated with an 8002 IC. The 8002 chip is an audio power amplifier that uses a Class AB differential amplifier (Figure 4). The IC allows the delivery of 2W of continuous average power to a 4Ω load with less than 10 distortion using a 5V dc power supply. The 8002 is unity-gain stable which allows for higher gain by modifying the gain setting resistors.

Machine Vision
CMUcam5 (aka "Pixy2") – a small camera designed for object recognition with a framerate of 60 frames/sec. The piano keys are detected and arranged based on their location using a relative cartesian coordinate system. (Figure 1)

Projection
DLP2000 – a digital micromirror device (DMD) which uses small mirrors placed on a silicon wafer and controls the visual output by adjusting the mirrors ±10 degrees (Figure 5). This micro-opto-electromechanical system (MOEMS) allows light to be reflected out through the lens and places RGB filters in front of the light source where it's intensity is adjusted using pulse width modulation.
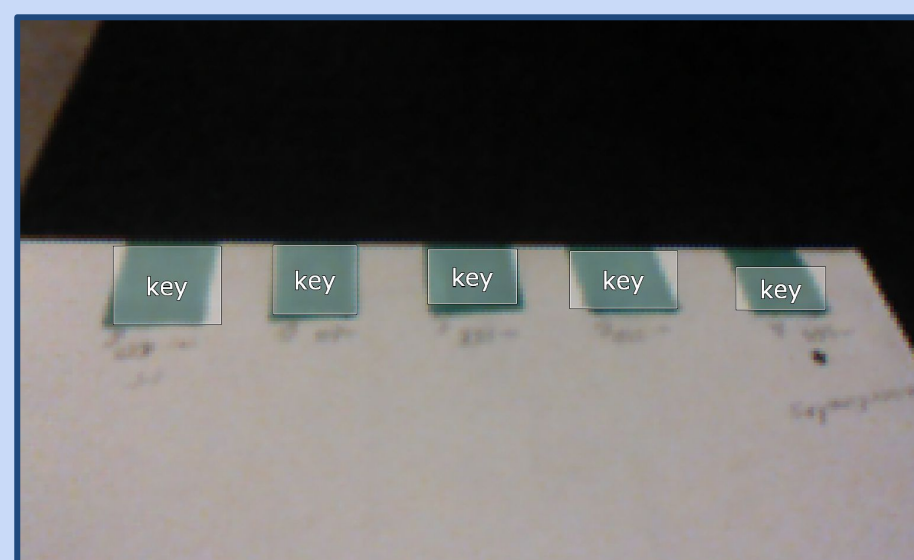

Figure 1 - Machine vision camera display of defined keys which will be assigned a piano key (eg. A#, B♭)
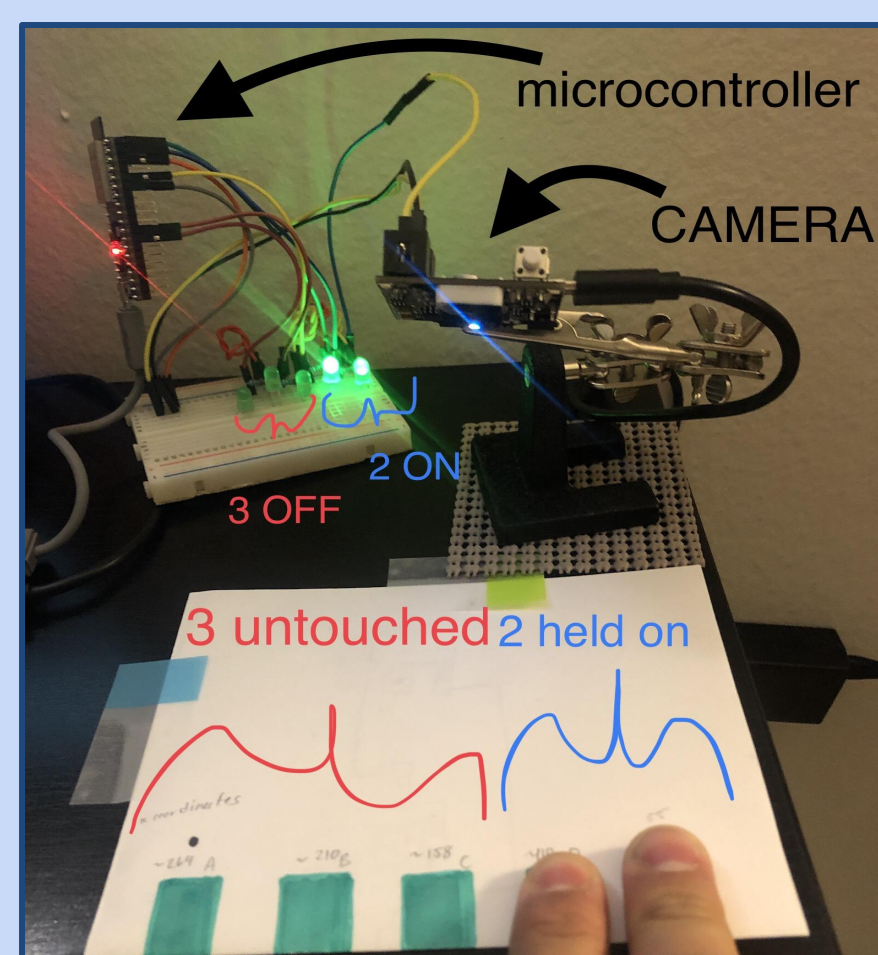

Figure 2 - Visual piano representation of machine vision. (e.g when 2 keys pressed, the LED turns on, which also produces audio.)
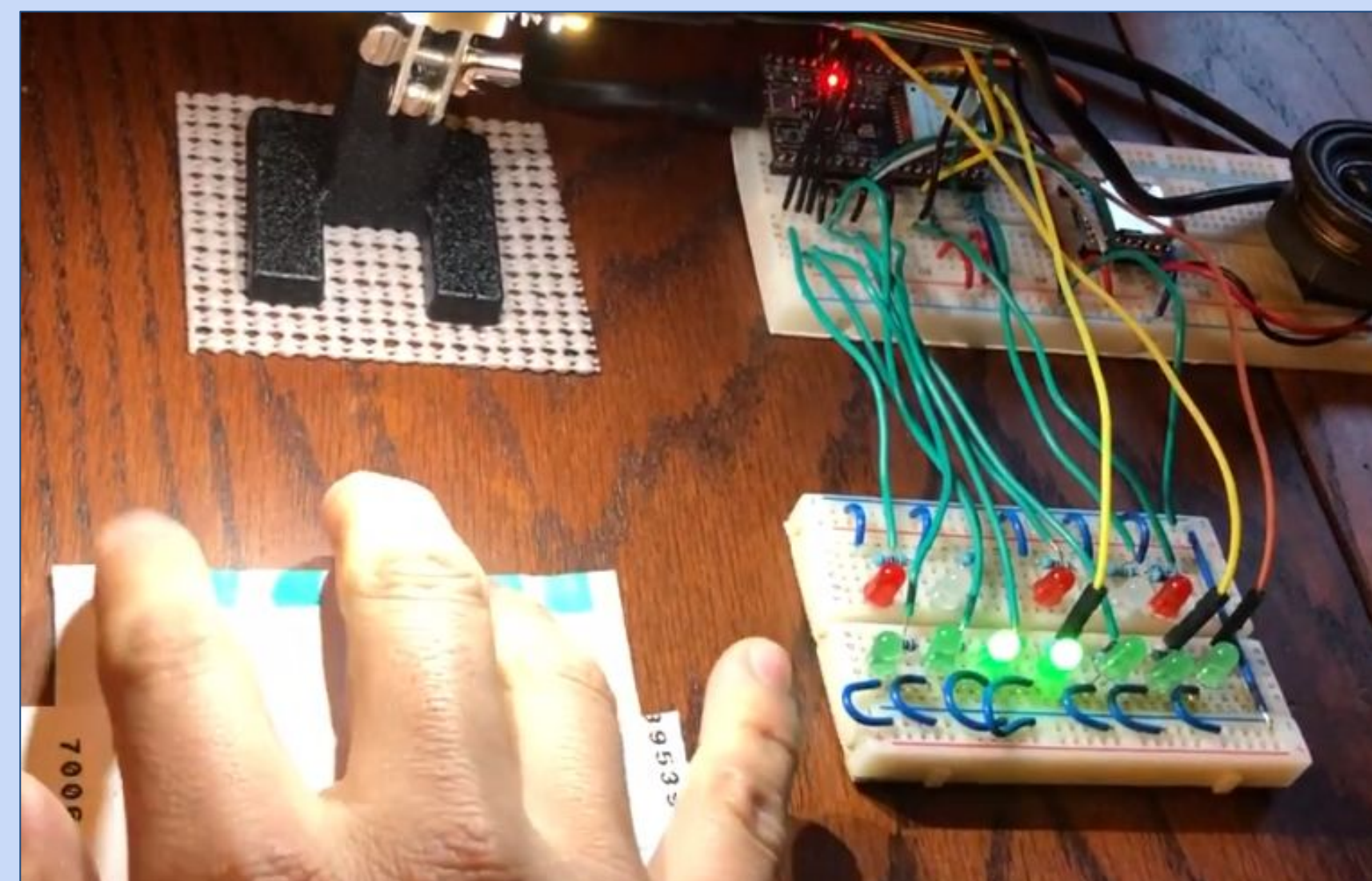

Figure 3 - Implementation of machine vision and audio
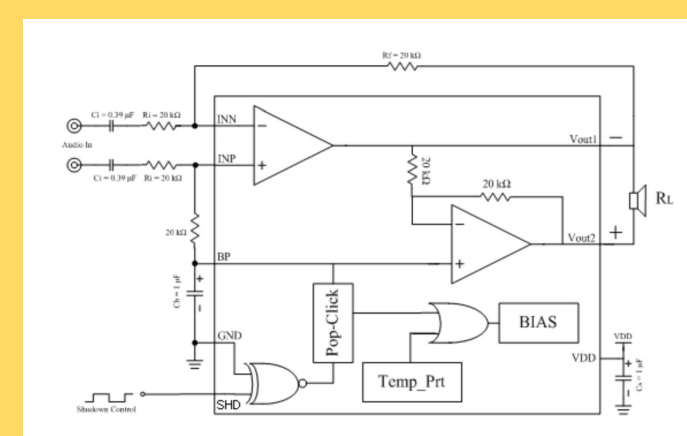
Overview / Design Process

Figure 4 - Class AB differential amplifier used in the DFPlayer mini module. This configuration uses a 4Ω speaker load to amplify high-quality audio.
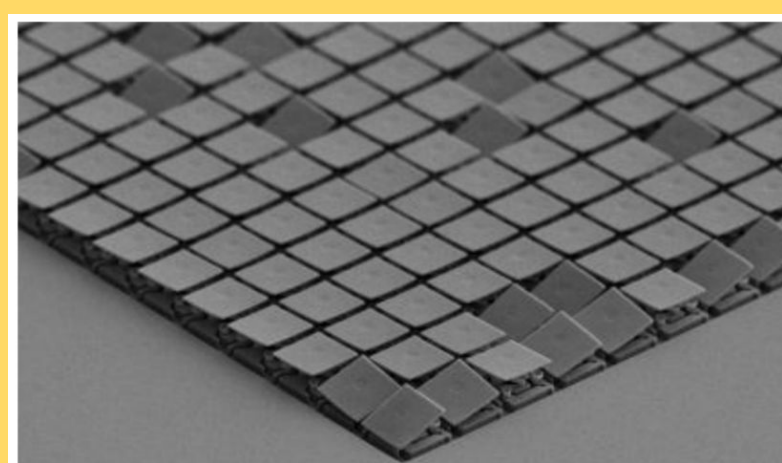

Figure 5 - A digital micromirror device (DMD) which uses micro-electro-mechanical system (MEMS) to modulate light and create a grid for image projection, Image provided by Texas Instruments.

The media studio is composed of an object detecting camera, a microSD reader, audio power amplifier, and a projection module.

The object recognition is composed of a designated processor and an image sensor at a framerate of 60Hz. With a color-based filtering algorithm, the processor sends location information to the microcontroller via I²C. The coordinates of the objects(keys) are then used to assign a piano key.

The microSD is used to store pre-recorded piano keys and its harmonics.

The audio power amplifier is connected to a speaker load to produce the sound.

This is then projected with a digital micromirror device based projection system which used pulse width modulation to display the designed piano.

Current Progress

- Developed piano key assigning algorithm based on recognition of projected image
- Formatted the piano audio files for each octave of the piano
- Drafted and machined an aluminum stand for camera stability and angle calibration as well as projection module height and calibration
- Created design schematics of a control board to interface with individual modules
- Interfaced machine vision with audio and projection modules via I²C

Broader Impact

Currently, our team's focus is to develop a projected piano to demo the concept. Our intentions are to allow the user to project and use multiple instruments saved on the device. For example, the user will be able to project a drum kit or beatpad. With the WiFi/Bluetooth capability of the ESP32, the user will be able to upload recorded files to music production software and connect external sources to amplify sound.

Future Development

- Transfer all modules onto schematics and then fabricate PCB's based on schematic design
- Create enclosed case to house all boards and components used
- Add additional instruments for user to select from
- Include functionality that will allow user to save and transfer created files to a computer for use with existing music production software

Citations

1 - DroneBot Workshop. (2018, October 23). Pixy2 Camera – Simple Object Recognition. Retrieved February 11, 2019, from https://dronebotworkshop.com/pixy2-camera/
2 - Nanda, U., & Pattnaik, S. K. (2016, January). Universal asynchronous receiver and transmitter (uart). In 2016 3rd International Conference on Advanced Computing and Communication Systems (ICACCS) (Vol. 1, pp. 1-5). IEEE.
3 - Paret, D., & Fenger, C. (1997). The I2C bus: from theory to practice. John Wiley & Sons, Inc..

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