Transforming Music to Motion

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Background

The Capstone Experience is an independent project completed by all Hun Seniors and PGs. It provides opportunities for students to complete in-depth studies or explorations of things that are meaningful to them.

Peter and I decided to team up for the Capstone project. The goal is to Incorporate both of our strengths and common interest in developing this project. Therefore, based on the resources and experience we have (I built a mini car last summer with Arduino; Peter is a phenomenon saxophone player; I love music and Peter enjoys the robotics engineering class), we planned to create a mini car which is controlled by the music played by the saxophone.

Objectives

- To identify the frequency of the notes played by Peter with his soprano saxophone.
- Based on the frequency the microphone detects, the mini car would perform the corresponding actions.
- To complete/ draw a path given some music input.

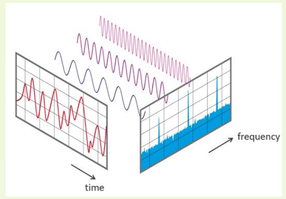
Hardware Components

- Arduino Uno board
- Electret Microphone Amplifier - MAX4466
- FA-130 Motors
- L9910 Motor Dual-Channel H-Bridge Motor Driver Module
- Plastic Chassis and wheels

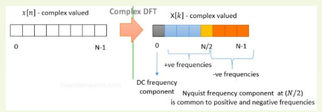
Methods

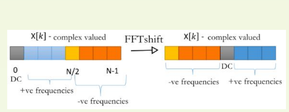
We used the open-source Arduino Software (IDE) as the main way to communicate (uploading programs) with the Arduino Uno board.

The algorithm we implemented to obtain the frequency of the input sound wave is the FFT (Fast Fourier Transform), which computes the DFT (Discrete Fourier Transform).



The FFT transforms a sound wave of time domain(kth bin) to frequency domain to find the most dominant frequency. (y axis is the magnitude)



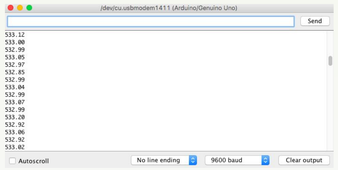


The frequency range it is able to detect is half of the sampling frequency(rate) due to the FFT shift.
Therefore, the peak frequency is calculated by:
peak = ((kth max + shift) * sampling frequency) / (number of samples)

Testing

The MAX4466 is able to receive frequency ranging from 20Hz to 20kHz, which includes the full range of the soprano saxophone (B ♭ 3 to F♯6, 233.08 Hz to 2960 Hz).

The only range we have to avoid is the frequencies produced by the spinning motors.

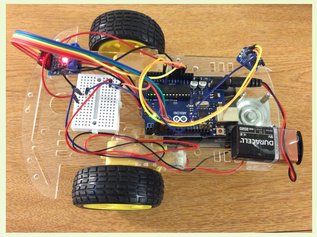


The console output of detected frequencies. (Arduino IDE)

C: 470 - 485 Stop
C#: 500 - 510 Forward
D: 535 - 545 Backward
D#: 560 - 570
E: 600 - 620 Left
F: 635 - 645 Right
F#: 670 - 680 G(1): 710 - 715
750, 800, 900(motors spinning)

We design a set of commands based on the frequencies inputs.

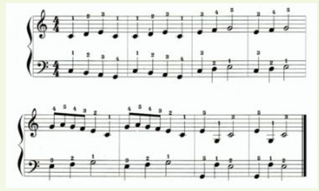
Results



Two-wheel drive mini car with a third free-rotating wheel centered at the back.

We demonstrate the mini car's ability to respond to the certain pitches of the saxophone in two ways.

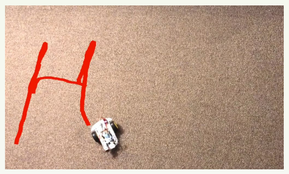
1. To follow a path predetermined by a piece of music by playing that music piece to the mini car.



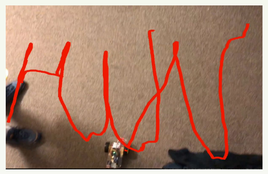
The music piece:
Frère Jacques

Following the path...

2. To draw English letters with its path.(we overlay the video to trace the path with red lines.)



It's an 'H'.



H U N !!

Conclusion

Overall, we were pretty satisfied with the result because we were not sure if this idea was entirely practical. Through days of hard work, we were able to find the suitable FFT library and design the program to accurately control the mini car by the notes of the saxophone.

However, there are some difficulties we encounter and hope to improve upon in the future. The main difficulty is to maintain the consistency of the motion of the mini car:

1. The two-wheel drive depends heavily on the floor condition because the third wheel is free-rotating, which often causes non-straight path and unexpected turning angle. Therefore, the solution might be adding two more wheels on the back to create a symmetric and solid drive-train.

2. The saxophone by nature is not a perfectly pitched instrument like the piano. But Peter still manages to control the notes to be in the range which we set for the commands.

References

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2. https://github.com/kosme/arduinoFFT
3. http://wiki.openmusiclabs.com/wiki/ArduinoFFT
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