Formal Report 1
Proposal

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apollo (Xylophone-Playing Robot)

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1. Abstract

I am building a xylophone-playing robot that comes up with its own melodies. The melody will use the chords played on the connected keyboard, the color it senses, and the proximity of onlookers to the robot to change the way it plays. The system will consist of a xylophone, 12 small solenoids that will be used to play the xylophone, a Sharp IR sensor to detect the proximity of onlookers, an Arduino Due to drive the solenoids and read the IR sensor, a laptop with a wired connection to the Arduino, a webcam built in to the laptop for color detection, and a MIDI keyboard connected to the laptop through USB.

2. Introduction

Great melodies, regardless of the period in which they are written, can stand the test of time and be meaningful years after their inception. They inspire new arrangements to fit these classic melodies with current trends. However, enduring melodies are hard to write. It takes practice, talent, and often influence from other great melody-writers to produce good melodies. People also peak creatively, gradually ceasing to produce material that is as inspired as what they once wrote.

The goal of my robot is to have an autonomous system for creating and playing melodies inspired by great songwriters and influenced in real-time by the robot's surroundings. It has a useful function of creating new melodies, has sensors to react to its environment, has a special sensor to get more information from its environment, and a special algorithm. This paper discusses the integrated systems, platform, actuation, sensors, behaviors, experimental analysis and results, and conclusions in regard to the robot.

3. Integrated System

The system will consist of a MIDI keyboard, laptop with webcam, Arduino Due board, sensors and actuators, and a xylophone. Figure 1 shows an overview of the system. The keyboard will be connected to the laptop via USB and will be used to give a starting point for the melody generation algorithm. The webcam used for color detection is part of

the laptop. The Arduino Due is also connected to the laptop via USB. The IR sensor and solenoids are connected to the Arduino and the solenoids play the xylophone.

The software provides the functionality, the IR sensor and webcam observe the surroundings, and the special algorithm will also be implemented on the laptop.

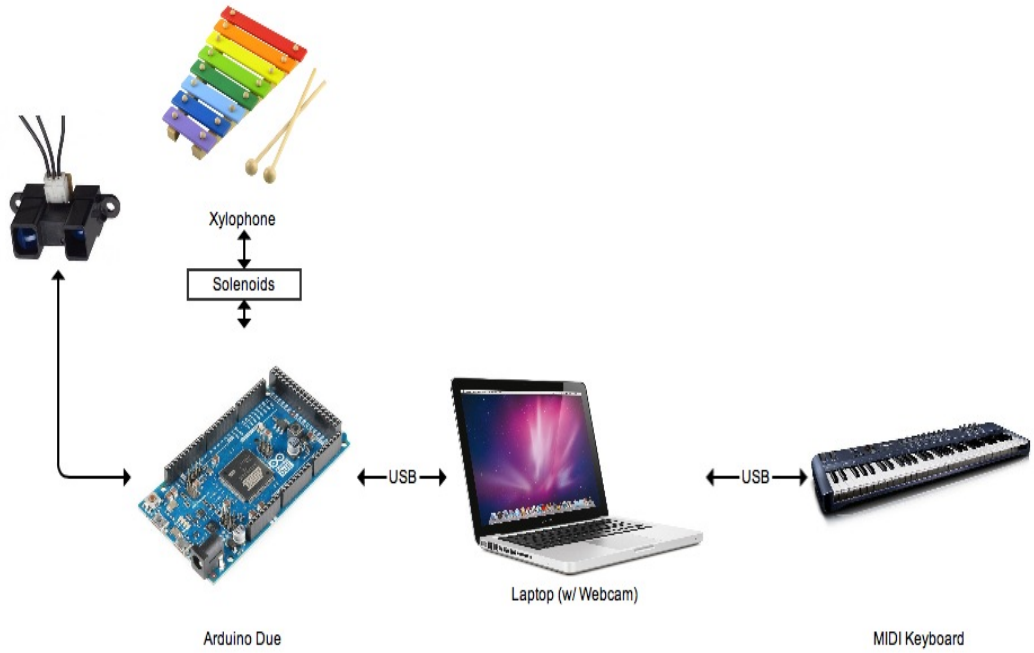

Figure 1, the system overview of the robot.

4. Platform

The robot platform will simply be a plane with the solenoids and IR sensor attached. It will have to be mounted over the xylophone and within reach of the Arduino and laptop. As the robot does not need to be mobile, all connections will be physical. The platform will first be modeled in SolidWorks and then built using wood.

5. Actuation

The actuation in this design is the solenoids striking the xylophone keys. Each of the 12 solenoids is powered with 5V. The Arduino Due runs on 3.3V, but is able to send 5V out if powered by USB. This 5V can be used with MOSFETs to power the solenoids. Each solenoid will be positioned to hit one key when powered. Figure 2 shows the circuit diagram for each solenoid.

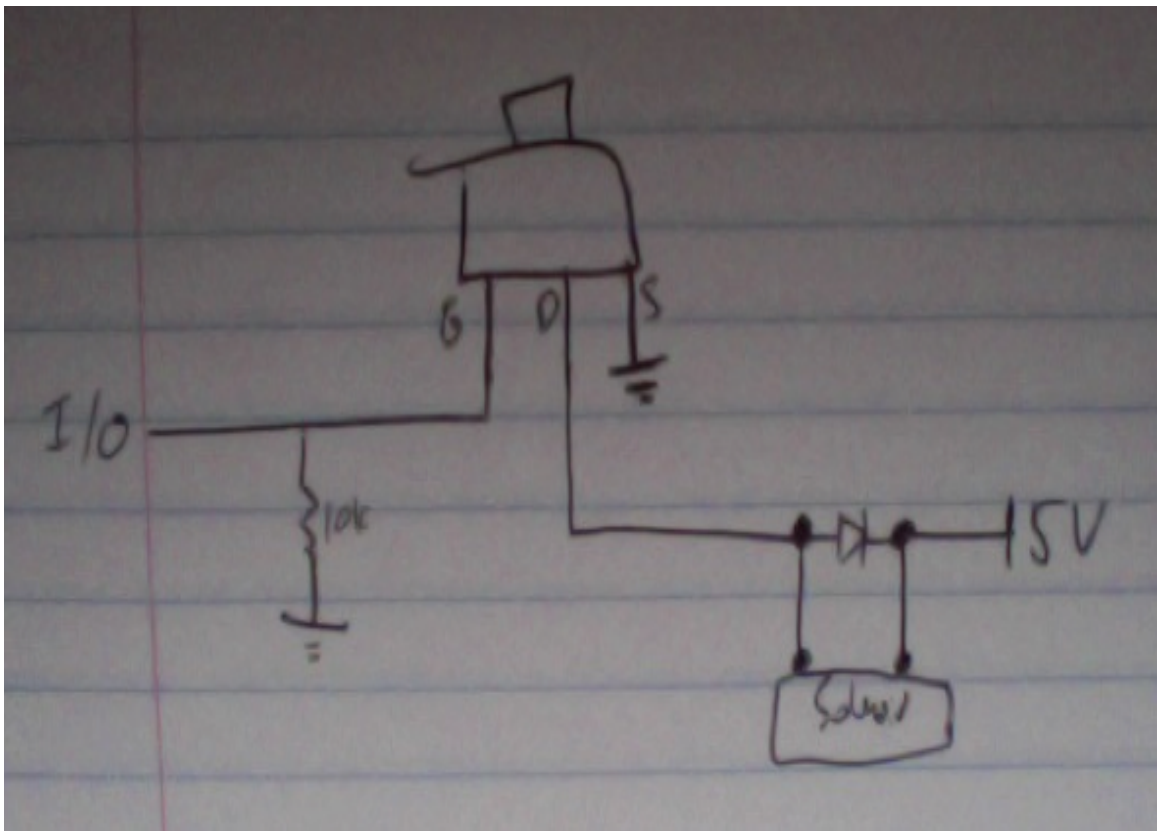

Figure 2, the circuit diagram for a solenoid.

6. Sensors

The sensors used for this robot are a Sharp long-range IR sensor and a webcam built into the laptop. The IR sensor will be used to detect how close spectators are to the robot. The closer spectators get, the "faster" the robot will play. The datasheet for the sensor is given in [2]. The webcam will be used for color detection. The range is 20 to 150cm, which is ideal for detecting how close onlookers get to the robot.

The webcam is the standard iSight webcam built into the mid-2009 MacBook Pro. This will be used to find the average color in the direction the robot is looking in. The average color of the robot's environment will influence a factor like the kind of artist the melody generation algorithm favors.

7. Behaviors

My initial plan for generating the melodies is to use Markov chains. Markov chains take an input state and compare it to its chain that gives a set of potential next states in the chain, each with a different probability based on the learning set. Figure 3 shows an example of a very simple Markov chain from [1]. For the chain given in Figure 3, given state A the probability that the next state will be state E is 0.4 while the probability that the next state will be state A again is 0.6. While this is a very simple example, one can see how this kind of model could be applied to

generate probabilities for which notes will follow specific notes given a good set of initial data.

The learning set will be developed from the works of great melody-writers. This system would form the basis for the melody generation. The keyboard input will tell the robot what key to play in and the time signature. The proximity sensor will cause the robot to play more or less notes in a measure (play "faster" or "slower"), while color detection may influence something like which artists to place an emphasis on (Blue for McCartney-esque, green for Brian Wilson, etc.).

However, if this approach does not work satisfactorily there are a variety of other artificial intelligence techniques I could try.

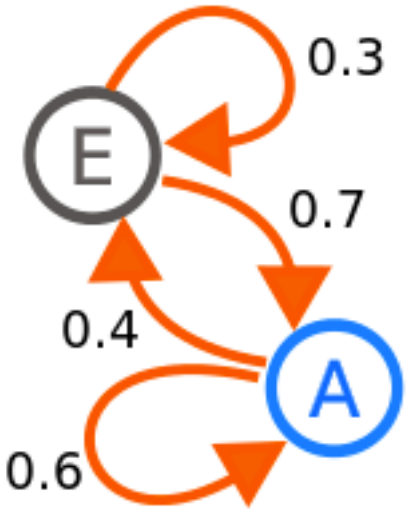

Figure 3, a simple Markov chain from [1].

8. Experimental Layout and Results

My experiments so far have included testing the IR sensor, solenoids, and serial communications. For the IR sensor I simply connected it to the Arduino and read the analog value in. The solenoid was able to operate without generating too much heat and is able to strike the xylophone with enough force to produce good sound. I was also able to control the Arduino through a C++ program via serial communication. I tested this by blinking an LED through the C++ software.

9. Conclusion

So far I have ordered all my parts, done most of the requisite research, and have started preliminary testing. I plan to get the platform, electrical, and communications work done as soon as possible, preferably by the second week of February, so that I can dedicate most of my time to the challenging artificial intelligence work. In addition to the work detailed in the previous section I have started on color detection with an OpenCV

variant. The next steps will be to read input from the MIDI keyboard and to make a SolidWorks model to begin building the platform.

10. References

[1] http://en.wikipedia.org/wiki/File:Markovkate_01.svg
[2] https://www.sparkfun.com/datasheets/Sensors/Infrared/gp2y0a02yk_e.pdf