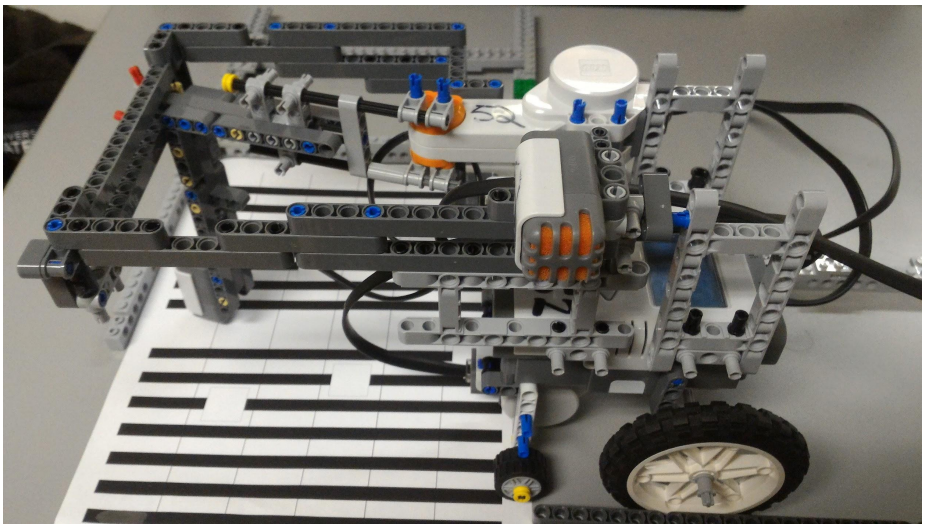
University of Waterloo

Faculty of Engineering

iScore

Lego NXT Musical Score Reader



By:

Team Chop'In Notes**:** Justin Hsuanting Wang, Heerak Bae, Sung An Jung, Hsuan Ling Chen

1A Mechatronics Engineering

November 13, 2015

Table of Contents

List of Figures

1.0 Introduction / Background

When learning music for the first time, many people experience difficulties if they can not properly reflect on their progress; without the aid of a teacher or professional, their ability to learn is hindered by their lack of knowledge and inability to distinguish correct and incorrect steps. This primarily stems from the principal's unfamiliarity with the concepts of "pitch" and "rhythm," and how it applies to the music being played. To properly hear what the music should should like, often times the only solution is to input the music onto expensive softwares which provide few personalized options and interaction.

It is our goal to provide a more interactive and exciting solution to beginners in music through iScore. iScore will read sheet music created by the user and play back the tune at a chosen tempo. By hearing what specific pitches and rhythms involved, the user can understand how to approach the music.

2.0 Design Specification Summary

The current design of iScore is shown in Figure 1 and Figure 2 below.

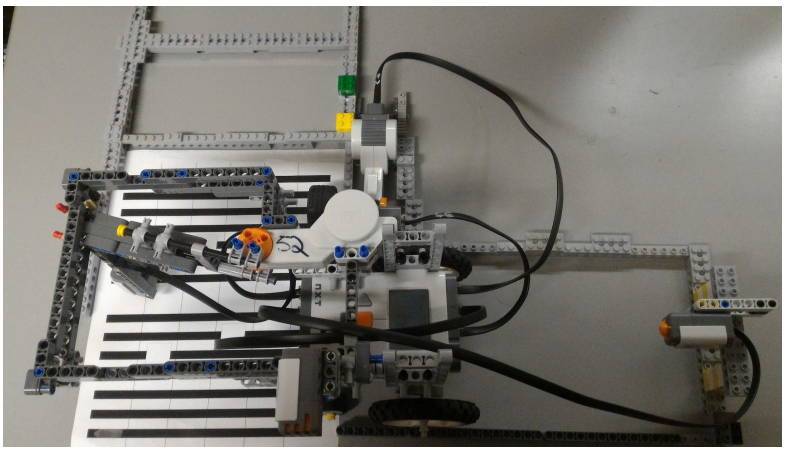


Figure 1: Top view

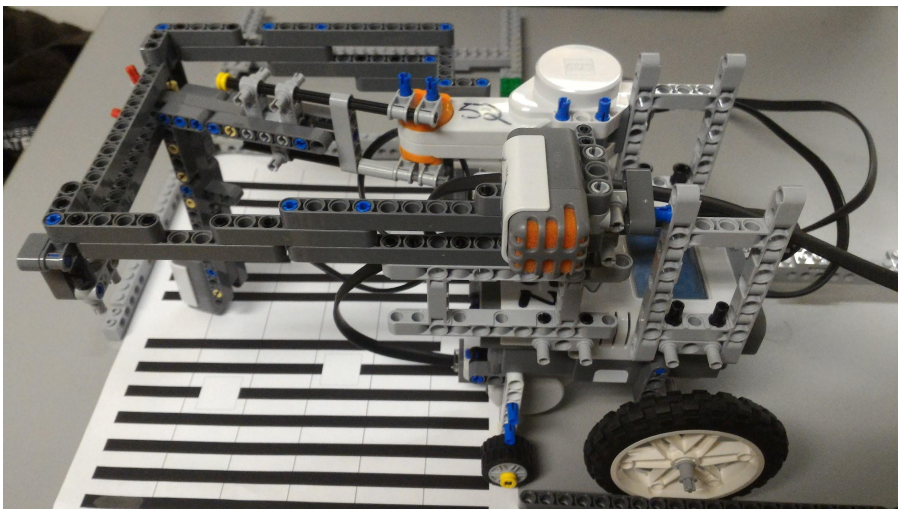


Figure 2: Side view

In our design of iScore, we have set several constraints that we must meet, and criterias that are desired. Several alternative designs were also considered. These are detailed below.

2.1 Constraints and Criterias

In our design of iScore, several constraints must be met. Firstly, the robot must be able to playback music at a pitch range of at least two octaves, specifically pitches on the treble clef. Any less than two octaves may result in the playback of most pieces to be impossible. Secondly, the robot will be able to play from a tempo range of 60 - 240 beats per minute to allow for sufficient flexibility for the user. In addition, the robot needs to be able to play at least three different note values. It must also read the score at a speed of at least ten notes/minute. The speed of the reader directly translate to its usefulness; the less time needed to wait, the quicker the user can benefit from the robot. Lastly, the robot needs to be able to distinguish all 12 key signatures and play the music accordingly, in order to avoid forcing the user to transpose the music directly.

Several criterias are desired that would help the robot's ability to aid in music. Firstly, to be able to play multiple notes simultaneously spanning multiple clefs, the robot can playback chords on pianos and double stops on strings. The robot should be able to play all different rhythms (i.e. grace notes, triplets, and dotted rhythms) and be able to distinguish accidentals to allow for a broader spectrum of pieces. It should also read as it plays back sound, and be able to read from hand-drawn sheet music.

2.2 Alternative designs:

There are several alternate design ideas that have different methods of reading the sheet music and changing the paper.

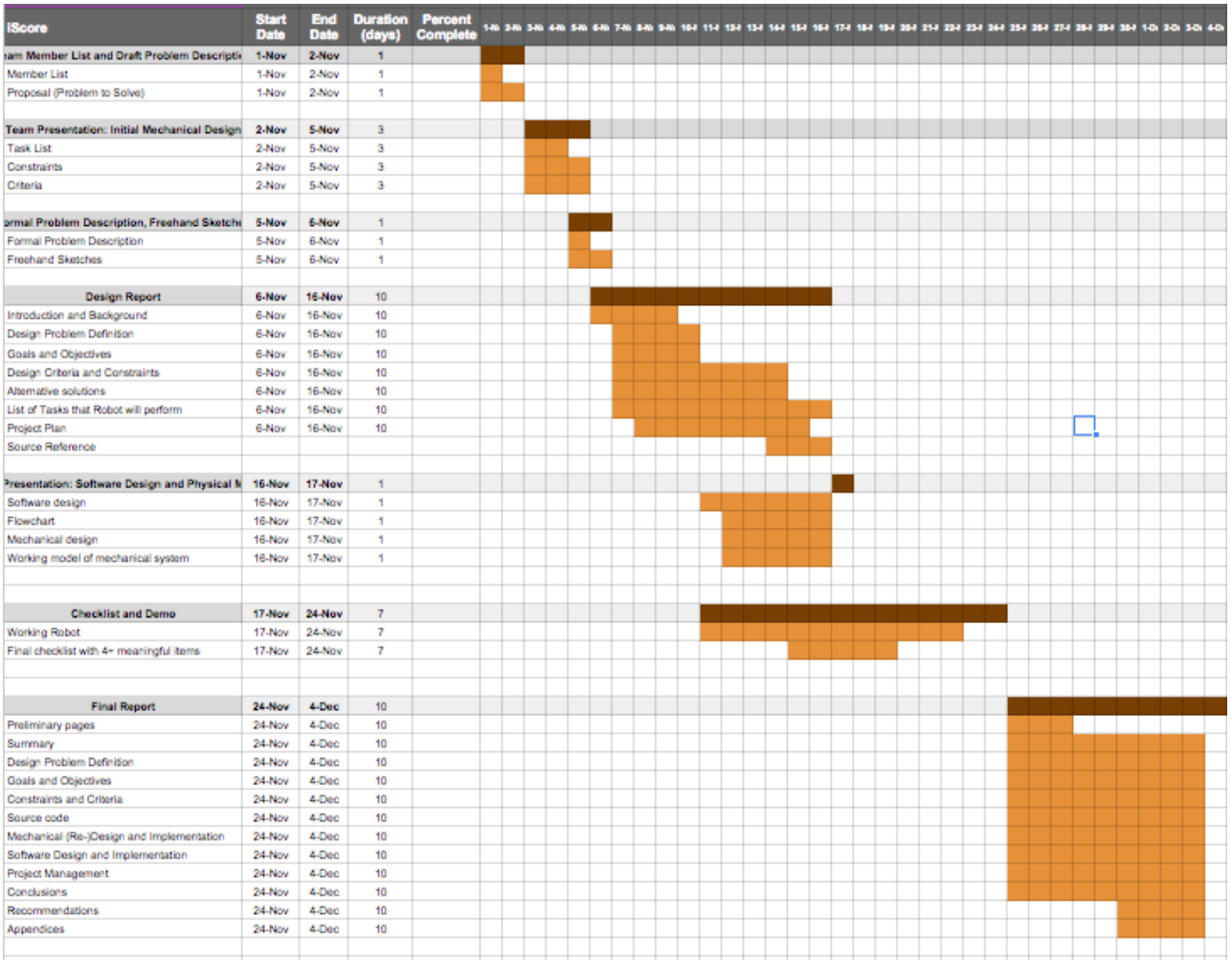
1. Two motors to move the colour sensor across the length and width of the musical staff. For detailed drawings, please refer to Appendix A.
    - This is an accurate method for scanning notes, because the colour scanner would move directly atop of the notes. However, this option requires racks and pinions or belts and wheels, which are not readily available and difficult to manufacture. Thus, the option of radial movement of the colour sensor was chosen instead.
2. The musical staff will be written on across a stack of paper, with the motor rolling the top sheet off after reading. For detailed drawings, please refer to Appendix B
    - This method is practical, as it does not require any preprocessing of multiple sheets of paper. However, it is less reliable (i.e. it may roll multiple sheets off), and requires more complex parts, such as multiple wheels and gears, to properly function. To tape each sheet together and feed the whole sheet in is a much safer option.

3.0 Tasks Performed:

1. The robot must first reads color-coded time signature and key signatures.
2. The robot must scan the sheet using the color sensor, and two motors that provide radial and horizontal motions.
3. At the end of the line of notes, the robot must hit the touch sensor and stop reading. The sensor will also reset the motor encoders for more precision.
4. The third motor must roll in a new line of music, and the color sensor will move back to its original position.
5. The tasks are repeated until paper is rolled to an end.
6. The sound sensor must take in the tempo.
7. The robot concludes the program by playing back the music at the given tempo.

4.0 Project Plan:

Our project planning will be done using the Gantt Chart, which is one of the most popular and useful ways of showing tasks or events displayed against time [1]. The left of the chart shows the list tasks and the top displays time in suitable scale. We have created our project plan as shown in Figure 3.



iScore	Start Date	End Date	Duration (days)	Percent Complete
ıam Member List and Draft Problem Descriptı	1-Nov	2-Nov	1	
Member List	1-Nov	2-Nov	1	
Proposal (Problem to Solve)	1-Nov	2-Nov	1	
Team Presentation: Initial Mechanical Design	2-Nov	5-Nov	3	
Task List	2-Nov	5-Nov	3	
Constraints	2-Nov	5-Nov	3	
Criteria	2-Nov	5-Nov	3	
ormal Problem Description, Freehand Sketchı	5-Nov	6-Nov	1	
Formal Problem Description	5-Nov	6-Nov	1	
Freehand Sketches	5-Nov	6-Nov	1	
Design Report	6-Nov	16-Nov	10	
Introduction and Background	6-Nov	16-Nov	10	
Design Problem Definition	6-Nov	16-Nov	10	
Goals and Objectives	6-Nov	16-Nov	10	
Design Criteria and Constraints	6-Nov	16-Nov	10	
Alternative solutions	6-Nov	16-Nov	10	
List of Tasks that Robot will perform	6-Nov	16-Nov	10	
Project Plan	6-Nov	16-Nov	10	
Source Reference				
Presentation: Software Design and Physical M	16-Nov	17-Nov	1	
Software design	16-Nov	17-Nov	1	
Flowchart	16-Nov	17-Nov	1	
Mechanical design	16-Nov	17-Nov	1	
Working model of mechanical system	16-Nov	17-Nov	1	
Checklist and Demo	17-Nov	24-Nov	7	
Working Robot	17-Nov	24-Nov	7	
Final checklist with 4+ meaningful items	17-Nov	24-Nov	7	
Final Report	24-Nov	4-Dec	10	
Preliminary pages	24-Nov	4-Dec	10	
Summary	24-Nov	4-Dec	10	
Design Problem Definition	24-Nov	4-Dec	10	
Goals and Objectives	24-Nov	4-Dec	10	
Constraints and Criteria	24-Nov	4-Dec	10	
Source code	24-Nov	4-Dec	10	
Mechanical (Re-)Design and Implementation	24-Nov	4-Dec	10	
Software Design and Implementation	24-Nov	4-Dec	10	
Project Management	24-Nov	4-Dec	10	
Conclusions	24-Nov	4-Dec	10	
Recommendations	24-Nov	4-Dec	10	
Appendices	24-Nov	4-Dec	10	

Figure 3: Chop'In Notes' Current Project Plan

5.0 References

[1] “What is a Gantt chart?,” *What is a Gantt Chart? Gantt Chart Information, history and Software*, 2012. [Online]. Available at: http://www.gantt.com/index.htm. [Accessed: Dec-2015].

Note: Appendix A has already been submitted.

Note: Appendix B has already been submitted.