Computing BEng

Individual Project

Rubato: A Musicality Tutor using Adaptive Learning Techniques

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1 Introduction

As usage of the world wide web has become ubiquitous among citizens of the developed world, web based teaching has grown rapidly to try and modernize learning methods to fit into the 21st century lifestyle. Increasing numbers of companies like Coursera, Codeacademy, Duolingo are providing easily accessible education for anyone with an internet connection and a desire to learn. Codeacademy and Duolingo in particular are notable for their use of rich, highly interactive learning tools which - through requiring the user to have an input into the educational process - establish a feedback system with powerful results.[?] These companies offer a variety of different programmes the user can study, and each of these is taught through a series of exercises, the results of which are used to track the users progress through the course, and provide statistics on how much they have learned. Duolingo, a website that teaches foreign languages, takes it a step further by introducing adaptive learning methods to recognise the user's proficiency in various areas, information it can then use to tailor-make lessons to fit the user's needs.
The web is a great place to teach music theory, and train the musical ear, a pair of skills we shall refer to under the umbrella term of "musicality" from hereon in. The rich media options possible on modern day web browsers mean that the input and output of music to a web browser is easily doable, as well as being user friendly. However, while there are many "music theory tutors" and "ear trainers" there are no existing adaptive learning solutions. Such a solution would be invaluable to potential students as the current solutions are static, and uninteresting.

In this paper I propose an application to harness the power of the modern web browser to deliver engaging musicality tutoring based on adaptive learning principles. The application will comprise of various exercises designed to challenge and improve a user's musicality, and keep track of their progress as well as their strengths and weaknesses in different areas.

In order to teach adaptively we must analyse information about a user's performance, and then change how we teach accordingly. There are various ways of measuring musicality, and in the real world a common way of gauging a musician's ability is simply by giving them a musical phrase to sing, and comparing the resulting singing to what we expect to hear. This critical appraisal of musicality is well understood, and affected by a number of factors. Obvious factors that affect percieved musicality are the intonation of the singer i.e. how well they produce the correct relative pitches, as well as their sense of rhythm i.e. how accurately they can keep time[1]. If we supply the user of our application with a suitable piece of music, and then process their performance of it using pitch detection techniques, we can recognise the weaknesses in their performance, and adapt our teaching methodologies accordingly.

To successfully adapt different exercises to the users needs requires some form of stochastic music generation. This

[1]More subtle factors such as the phrasing of the music and general use of dynamics, but they aren't as indicative of musicality as they are of how well trained a singer they are.

2 Background

2.1 Adaptive learning

Web based learning has existed in one form or another for a long time, and the introduction of the HTML5 standard has opened up even more opportunities for computers to play a role in the education process.[?] 3 notable examples of web based learning systems are Coursera

2.1.1 Adaptive learning in music

There are many ways that adaptive learning techniques can be applied in a musical context. As an example, imagine a simple exercise.

- The user is played a rhythmical phrase.
- They must then replicate the phrase by tapping it in on the space bar.
- The application then calculates how accurate the user's approximation of the rhythm is, and feeds this information back to the user

After repeating this exercise multiple times the application notices something: The user is always getting examples featuring multiple consecutive dotted quavers wrong [2], and determines that this particular rhythmical device is something the user is struggling with. It can then subtly adapt future exercises to incorporate this device prominently, in order to expose the user to it as much as possible, and hopefully cause them to improve their understanding of that specific rhythm, and rhythm in general.

2.2 Real-Time Client-Side Pitch Detection

One thing I'd like to explore is seeing if it's possible using a run of the mill inbuilt microphone on a laptop to do pitch detection accurately enough to be able to provide feedback to the user about their intonation, and stuff like that. This could be powerful because we already know the expected pitch the user should be singing, so we can use this to only attempt to match the sung pitch to pitches within a given frequency of the expected note. the highest note anyone could reasonably be expected to sing in a melody test such as this could be assumed to be a soprano C6 with a corresponding frequency of 1046.5 hz. This would mean that according to the shannon-nyquist sampling theorem, the sampling rate would need to be 2.1Khz in order to measure this. This should be fine as audio is usually sampled at 44Khz.

2.3 Stochastic melody generation

So my app should be able to generate melodies for people to sing?? and then it should analyse their singing of it. This could be done by asking the user to sing at a fixed tempo, or by detecting the tempo of the melody sung through some sort of clever analysis. After this, the clip of their singing could be broken down into chunks corresponding to each note of the phrase, then each time period where the note was expected to be could be analysed.

[2] This is a type of rhythm that could prove difficult for the user as it can sound like the rhythm is going in and out of time due to it's naturally syncopated nature against a four four baseline

References