

CANADA WIDE SCIENCE FAIR – EXPO-SCIENCES PANCANADIENNE

Noah Bergmann won this year's Acoustic award at science fair due to his work on the "Musician's Toolbox".

Noah Bergmann has been programming in various programming languages since the age of 8, releasing his first iPhone app at the age of 15. On top of being a general computer enthusiast Noah is also passionate about music. He plays the bass, ukulele, and guitar in his spare time. Living in a small town Noah enjoys hikes out into the forest on the numerous trails surrounding his hometown.

Noah began science fair at the age of 10, with his first two projects focusing on biology. However in his third year he moved to computer science, and has been met with more success, going to national science fair in 2012, 2013 and 2014 becoming the top prize winner in BC in his most recent year.

Once graduated Noah plans to study computer science with a specialization in software engineering.



Noah Bergmann a remporté cette année le prix acoustique à l'exposition pancanadienne en raison de ses travaux sur la «Boîte à outils du Musicien».

Noah Bergmann a fait de la programmation dans divers langages depuis l'âge de 8, réalisant sa première application iPhone à l'âge de 15 ans. En plus d'être un passionné d'ordinateur, Noah est aussi passionné de musique. Il joue de la basse, du ukulélé et de la guitare dans son temps libre. Noah vit dans une petite ville où il aime faire des randonnées dans la forêt sur les nombreux sentiers à l'entour.

Noé participa pour la première fois à expo-sciences à l'âge de 10, avec ses deux premiers projets en biologie. En troisième année, il est passé à l'informatique, et a été accueilli avec plus de succès lors des expo-sciences de 2012, 2013 et 2014 en devenant le gagnant du premier prix en Colombie-Britannique ces dernières années.

Une fois diplômé, Noah prévoit d'étudier l'informatique avec une spécialisation en génie logiciel.

THE MUSICIAN'S TOOLBOX

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Résumé

La boîte à outils du musicien est une application iOS qui présente une interface accessible et pratique pour l'utilisateur pour effectuer des actions telles que le réglage, la transposition de la musique, et la création de modulations [1]. La capacité de créer facilement des modulations (transitions musicales entre deux chansons) est particulièrement utile, notamment pour les musiciens amateurs qui ne possèdent souvent pas l'expertise pour créer des transitions agréables acoustiquement. L'application est le résultat de 3 années de développement et de collaboration avec le créateur de l'invention qui a inspiré la section de modulation de l'application.

Mots clefs : iOS, musicien, boîte à outils

Abstract

The Musician's Toolbox is an iOS app that presents an accessible and convenient interface to the user for performing actions such as tuning, transposing music, and creating modulations[1]. The ability to easily create modulations (musical transitions between two songs) is especially useful, as amateur musicians often lack the expertise to create acoustically pleasing transitions themselves. The app is a result of 3 years of development and collaboration with the creator of the invention that inspired the modulation section of the app.

Keywords: iOS, musician, toolbox

1 Introduction

A modulation is a transition between any two keys in music, allowing the player to continue through multiple songs without stopping, such as in a medley. Traditionally, this is done by professional musicians, who are able to create modulations by ear. Because amateur musicians lack experience and skill, modulations are often not an option. My uncle Tim Bergmann created a tool called The Modex that allows amateur musicians to generate modulations mathematically. This would be highly beneficial to many performers, allowing them to make their shows more professional sounding and acoustically pleasing.

Even though, in theory, this invention seemed to be an amazing concept, the final product didn't meet expectations due to the fact that it was costly to produce (being in physical format), difficult to distribute and not highly intuitive. Despite the initial failure, the concept seemed worth pursuing further, and from this I began development on the Musician's Toolbox. This app would include the Modex, this time in a digital form, and would include extra functionality to improve the value of the overall package. Included in the final version of the app would be The Modex, a transposer and a guitar tuner.

2 Method

2.1 Overview

Finding the correct platform for the app was the first challenge, but eventually iOS was chosen due to the ease of development and purchase, on top of the wide market the app store reaches. Coding of the majority of the app was done in Xcode[2], with the audio playback and analysis done in Pure Data[3], an open source library and visual audio programming language.

2.2 The Modex

The basic idea behind the Modex is taking the key for two songs, and building a transition between the two. This is done by saving a codex of musical transitions in numerical format. When needed, a transition can be generated by substituting chords for the numbers and then displaying the output. If the user doesn't like a specific way to transition between songs, there are 7 different variations between any two keys to choose from. Additionally, the app allows the user to play the generated chord progression using a software keyboard, done by generating individual notes from the list of chords.

2.3 The Transposer

A transposer[4] is a tool for changing a song from one key to another. For instance, if you wanted a song to be higher, you could use a transposer to convert the chords and notes to a higher key. This is done by finding the relative distance between the two keys and then moving every note by that amount, thus keeping the notes the same relative distance away from each other.

2.4 The Tuner

The tuner can be used to tune any stringed instrument, and functions by finding the dominant frequency of the incoming sound and converting that to a note on the piano. All of this is done through pure data, and the output is then sent to Xcode where it is displayed onscreen along with a reading of how far off the frequency is from a perfect note. The dominant frequency of a sound is found by first using the Fourier transform[5] to convert the data to the frequency domain, followed by finding the frequency with the greatest amplitude. Notes are found from the dominant frequency by using the rule that A is equal to 440 hz[6], doubling to go up an octave and halving to go down. Extending this rule to create the equation for conversion $440 + 2^{(n/12)}$, with n being the note on the keyboard starting with a = 0.

3 Conclusion

The Musician's toolbox is currently on the app store with all aforementioned functionality. The interface has been improved and is quite intuitive to use when compared with the original modex. All of the functionality in the app is bug free, smooth and fast. The affordable pricing also means that it is accessible to anyone with an iOS device.

Going forward, the Musician's Toolbox will be ported to both Blackberry and Android, allowing the app to reach a wider market. Blackberry apps are written in C++, which is relatively similar to Objective-C (the language used for iOS apps), making porting to that platform a relatively simple task. Android is written in Java, which is further from Objective-C, but often times simpler.

In addition to the diversifying of supported platforms, functionality for chord and key recognition will be added to the iOS version of The Musician's Toolbox. Built within pure data, the new functionality will analyze multiple frequencies at once to get the chord being played. This will be done by analyzing the sound in an amplitude over frequency format for each point in time the analysis is being made. With my tuner, I was only analyzing the most dominant frequency, but with chord analysis, multiple frequencies need to be considered. Once enough data from the chords is generated, the device can look through a codex of keys and find the most likely key for the given group of chords. The analysis of chords is a challenging subject, and will likely be a formidable task.

Acknowledgments

I'd like to acknowledge the creator of "The Modex", my uncle Tim Bergmann, for his contribution to the musical theory of the modulations, as well as overall advice and inspiration.

References

- [1] Joutsenvirta, Aarre, and Jari Perkiömäki. "Musiikin Teoria Etusivu." Musiikin Teoria Etusivu. Web. 20 Nov. 2014. <<http://www2.siba.fi/mustel/index.php?id=93&la=en>>.
- [2] "Apple Developer." Xcode. Web. 20 Nov. 2014. <<https://developer.apple.com/xcode/>>.
- [3] "PD Community Site." Pure Data —. Web. 20 Nov. 2014. <<http://puredata.info>>.
- [4] "Music Theory: Music Theory: Transposition." Music Theory: Music Theory: Transposition. Web. 20 Nov. 2014. <<http://musictheoryblog.blogspot.ca/2008/02/music-theory-transposition.html>>.
- [5] "Fourier Transform." Wikipedia. Wikimedia Foundation, 20 Nov. 2014. Web. 21 Nov. 2014. <http://en.wikipedia.org/wiki/Fourier_transform>.
- [6] "A440 (pitch Standard)." Wikipedia. Wikimedia Foundation, 19 Nov. 2014. Web. 21 Nov. 2014. <[http://en.wikipedia.org/wiki/A440_\(pitch_standard\)](http://en.wikipedia.org/wiki/A440_(pitch_standard))>.

Project bibliography

- Brinkmann, Peter. *Making Musical Apps Real-time audio synthesis on Android and iOS*. Sebastopol: O'Reilly Media, 2012. Print.
- Kusterer, Uli. "Masters of the Void." *Masters of the Void*. N.p., 12 Feb. 2011. Web. . <<http://masters-of-the-void.com>>.
- Goldstein, Neal. *Objective-C for dummies*. Hoboken, NJ: Wiley Pub., 2009. Print.
- "PURE DATA forum~." *PURE DATA forum~*. Web. . <<http://puredata.hurlleur.com>>.
- "Stack Overflow Forum" *Stack Overflow*. Web. . <<http://stackoverflow.com>>.
- Kreidler, Johannes. "Programming Electronic Music in Pd." *Programming Electronic Music in Pd*. 27 Jan. 2009. Web. 21 Nov. 2014. <<http://www.pd-tutorial.com/english/index.html>>.

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The principle investigator is Rick Neitzel, assistant professor, U-M Department of Environmental Health Sciences.