Use of Frequency Domain Analysis with Microcontrollers for a Beat Detection Device

Analysis of Electronic Music in the Space of Both Natural and Public Perception

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction:

One of the strangest parts of studying electrical engineering is seeing music being used as a signal itself for circuit based applications. Music is both ingrained as a product of thousands of different frequency signals all colliding in frequency space, as well as one of humanity's greatest cultural exports, being able to express our deepest thoughts and feelings often better than any basic language can. Music software has not only broadened this aspect to so many people, but has forever changed the way that music is made and consumed as a whole. This technical project aims to further the ability for starting musicians to better connect online music into real life results through the use of a beat-detection device that infers tempo through the use of digital signal processing and plays the drums to it. The audio of a song will be played real-time through a microcontroller to process output audio and signals to play the drums. The STS project will involve researching the impact that technology has on the fundamental process of music creation, both the physical process itself and the perception of music from both creators and the greater public.

Technical Topic:

Music, as something inherently not taught with a form of spoken language, can be very difficult to pick up for a beginner. From its arcane-looking symbols to its form and structure dating back centuries to Western Europe, approaching music as an individual is extremely difficult, especially as an adult. Music education is often very expensive for private lessons, and as such, is a luxury only a select few can afford. Even music programs offered through primary schools only approach the material in a group context, with individuals failing to understand the material and easily being able to drown themselves out with others. This is a looping cycle, with the lack of play significantly contributing to one's misunderstanding of music, and only encouraging the individual to drop their music career as a whole (Dowling, 1999).

Encouraging practicing, as well as general music engagement, greatly helps form the mental ties to dedication to a task over a long period of time, as well as general guidelines to

work ethic. Both skills are easily extrapolated to other hobbies and academic endeavors (Bamberger, 1995). Not only are these skills improved, but technical ones as well, with both motor control and hand-eye coordination receiving increased attention during practice sessions. More abstract qualities, such as creativity and ingenuity, are also greatly promoted when practicing, playing, or composing a musical piece (Welch, 1998). The tangible benefits from these activities need to be available to children of all socioeconomic backgrounds.

The technical project serves to help solve this issue by allowing greater ability for any individual to practice music in a solo environment with any genre of music they choose. This works by playing a drum pad to a given song by analyzing the song using Digital Signal Processing (DSP) techniques such as Discrete Fast Fourier Transforms (DFFT) and controlling the motor servos which move the drumsticks using these derived signals from a microcontroller. These DFFTs perform computations on the frequency of the song itself, in addition to how it changes over time, to extract both the tempo and beat markings in any given song. A microcontroller, a smaller processing unit, is great for this type of application, with microcontrollers being separate from a normal computer allowing them to be used in embedded products such as this. The microcontroller to be used is the Texas Instruments MSP432, an advanced version of the MSP430 with much greater ability for floating point precision and a greater RAM for song analysis. The fast nature of this process allows the microcontroller to have a greater practical application than a simple metronome, as the user is easily able to connect their computer to the microcontroller, with both fast tempo markings and an actual physical output both being present.

STS Topic:

Music is often the backbone of cultural expression, regardless of the other central components of that culture itself. Music forms a basic foundation of emotion that members of a culture can share together without a spoken word (Knight, 2012). This emotion often comes from the instruments themselves, made of materials often plentiful to the area or of great

cultural significance. These are all reasons why it is so important to analyze why the advent of technological music, and the software that produced it. The genesis of this new form of music production was a slow one, but for many individuals, the convenience of being able to listen to music at home easily was too easy to pass up on (Taylor, 2001). It only makes sense that the tools to make music in the same, easily playbackable manner would flow in the same vain. As previously mentioned, music almost always either gains part of its character from the instruments the music is played on, or the public's perception of the instruments themselves (Barton, 2018). For music produced from these instruments, it is an extreme case of both (Toiviainen, 2007). Genres range from light tech influence, such as hip hop, to heavier ones such as metal, with some genres such as the aptly named electronic music being produced in a purely digital form.

Electronic music is the product of signals and systems they were constructed from. Electronic music is often a loud, uncaring environment, with the analog signals of traditional music being crushed into a digital landscape (Emmerson, 2017). The public's perception of electronic music pushes it even further, with most people looking at the alien-like apparatuses being used to make such pieces with a strange eye, perceiving electronic music as a unique subgenre not suitable for most individuals (Cannon & Greasley, 2021). Part of the paper will focus on the themes behind the relationship that electronic music and its greater scene have with the public. Additionally, it will focus on if humans are as naturally attracted to the more discrete, perfect signals coming from a computer, and what the arguments are for how exactly electronic music may or may not be considered music in a traditional sense.

The sound of the music itself is not the only important aspect of technology's impact on a soundscape. The tools that digital music production provides are applicable to all genres of music, from beginners to expert musicians. As the tools that are required are already part of your daily life, such as a computer or even a phone, it allows those of a lower socioeconomic background to approach music in a much easier way. Digital production tools also greatly

simplify the learning process, as while older music making software was an archaic process of endless command line scripts, newer music production software is often a great combination of more understandable user interfaces. These tools also offer lengthy tutorials explaining the software's often limitless features, and an explanation of the music terms and symbols used (Liu, 2021).

I will research this topic using Actor-Network Theory to establish and analyze the relationships between the greater public and the music industry, focusing on professional musicians, music students, music teachers, the music these groups produce, and the technology these groups use to make it. Both humans, music, and music technology are important actors in this network, with them constantly developing different relationships through the continued advancement of both parties due to the other. This relationship continues to change, with both new artists entering the field and the public's perception of music changing, as well as technology for music becoming more powerful and impactful day by day.

For my timeline, I hope to finish my full bibliography by the middle of November, with the final draft being made a few days after that. The presentation will be finished at the end of the 2022 semester. For next semester, I will be working on both this paper and another, and hope to have both them and their respective abstracts and bibliographies done by their respective dates.

Conclusion:

My technical project aims to solve the problems faced by many individuals looking to start a music hobby or career, but often cannot due to the barrier of entry, either through budgetary reasons or the inability to properly comprehend the material. By using the device produced through this project, users will both get feedback from the machine and a way to understand the songs they want to listen to, practice, and play to a greater degree. At the same time, the STS project will dive deeper into why those looking to study music have to do these things, and how the technology we create helps to establish a better relationship with the public and a greater understanding of music.

Key Texts:

Barton, G. (2018). The Relationship Between Music, Culture, and Society: Meaning in Music. In Music Learning and Teaching in Culturally and Socially Diverse Contexts (pp. 23–41). Springer International Publishing. https://doi.org/10.1007/978-3-319-95408-0_2
This article explores how music and culture reflect on each other. With culture and the current attitudes of that culture reflect on what type of music is produced, large parts of culture become defined by what music is produced during that time. At the same time, the music that is produced by this culture becomes a strong cultural backbone of understanding between members of this culture to further create an identity. My project uses these ideas to express how culture impacts musical understanding.

Emmerson, S. (2017). Living Electronic Music. Routledge.
https://doi.org/10.4324/9781351217866
This article explores two different themes from music theory. The first is exploring how "live" performances with electronic music may be different from classical music purely in the scope of cultural understanding. The second is exploring how traditional ideas of musical theory are not as applicable in the scope of electronic music. This is especially noticeable in the studies the author has presented where specifically "simple" instrument-wise music leads to heavier dancing from a general populace. My project uses these ideas to express how, on a fundamental level, the concepts present in classical and electronic music differ.

Taylor, T.D. (2001). Strange Sounds: Music, Technology and Culture (1st ed.). Routledge.
https://doi.org/10.4324/9780203700235
In electronic music, the idea of "artificial-ness" can be present among those trained from a more classical background. This piece explores how music technology emerged over the last century and explores why making music with it can cause some musicians to feel that way. My project uses these ideas to express how music technology emerged onto the scene as something so desirable for a large number of artists.

Toiviainen, P. (2007). The psychology of electronic music. In The Cambridge Companion to Electronic Music (pp. 218–231). Cambridge University Press.
https://doi.org/10.1017/ccol9780521868617.014
In this article, the author explores how traditional understandings of score and concrete musical expressions aren't as applicable in the scope of electronic music. As such, it is necessary to explore more abstract elements of music such as timbre to analyze this music psychology, both on a cultural perspective and on an individual level. The author then proceeds to explore these topics on a scientific level with low-level audio analysis. My project uses these ideas to express how electronic music affects the psychology of individuals different from both classical music and simply music that uses actual instruments.

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