Noteworks Report: Comparative Evaluation

Team 622: Becky Chu, Andy Hickner, Avalon Hu
February 23, 2010

Word count: 3162

Executive Summary

This report outlines the methods, findings, and recommendations of a comparative evaluation analysis for the music creation application called Noteworks. Noteworks is a program that uses a network approach to model and create music compositions.

Methods: Our team used data compiled from our Interviews, Personas, and Scenarios report in order to determine who Noteworks' competitors were, in addition to Internet searches; we collected our data by filling out a matrix for easy comparison. After completing and analyzing our preliminary data, we determined which music creating programs to use as Noteworks' direct, analogous, indirect, and partial competitors; Max MSP, ChordGeometries, Nodal, Ableton Live, GarageBand, and Prezi are systems that are comparable to Noteworks.

Findings & Recommendations: Based on the data we collected, we had five key findings:

1) Noteworks has only one direct competitor, Nodal. Noteworks is not directly comparable to current music education software; consequently, Noteworks' development team should decide whether or not they want to compete in the music education software market.

2) External audio inputs, soundboard interfaces, and frequency visualizations are common amongst music creating software. If Noteworks decides to commercialize their product, more functions or exploring social media avenues are recommended.

3) The product market for music creating software is small and composed mainly of avid users. Noteworks should define what niche they fill in the market, either by further developing the software's current capabilities or by creating new ones.

4) Interactive zoom-in and zoom-out capabilities are possible in web-based applications. Currently, Noteworks does not have zooming functions but Prezi is one example of how those functions can be incorporated. Also, reaching out to researchers is one method of gaining valuable feedback and developing a market niche.

5) Music composing programs generally have steep learning curves as a result of their advanced functions, features, and targeting of professional users. Due to its low learning curve and comparatively smaller functionality, Noteworks should target casual users.

Discussion: We encountered several limitations in our study. They include having a small sample of competitors, comparing first-generation beta software to complete versions of multi-generation software, and ambiguity in Noteworks target market. Avenues of research we were unable to explore, due to time limitations, include investigating generative music software and algorithm-based music composition programs as types of competitors.

Introduction

Noteworks is a Java-based computer application that produces music through the use of temporal networks. The temporal networks are represented by arrows linking MIDI notes (Musical Instrument Digital Interface) to one another; the arrows denote sequence and relationships between the different notes. The end result: Noteworks is a music composition program that enables users to craft both visual and auditory works of art, eschewing traditional music notation for a more modern approach to sound.

Noteworks is a system that originated out of a GROCS (Granted Opportunities [Collaborative Spaces]) project proposal submitted in 2008. Since 2008, the brainchild of Rob Alexander, Patrick Turley, and John Umbaugh has developed into a full-fledged computer application that is targeted for an early February 2010 beta-release. The original idea came out of a neuroscience class that one of the creators was taking, and after learning about how different sections of the brain could be connected via pathways to create thoughts, retrieve memories, and produce emotions, the question became, "what else could be modeled after the neuron paradigm?"

During its two years of development, Noteworks has shifted from a word-based poetry visualization program to a music composition application that is attracting considerable interest amongst electronic music enthusiasts and music educators.

We intend the following comparative evaluation which follows to answer a number of questions:
- What features, functionalities, and qualities are expected among non-traditional music composition software?
- Who are Noteworks' chief direct, indirect, and analogous competitors?
- What information does trade literature provide that is relevant to our evaluation?

Addressing these questions will help us finalize the next phase of our evaluation, surveying potential users. In identifying and describing key competitors, we hope to provide Noteworks' developers with a better sense of the market they are entering, and how they can best position Noteworks to potential users. We can also hone in on where Noteworks surpasses its competition, and where it may be necessary to refine or adjust the product in order for it to compete more effectively.

Methods

We began our study by compiling a list of music creation software used by our interviewees and client, as stated in the previous report, Interviews, Personas, and Scenarios. We supplemented this list by scouring the Internet using Google for what types of music creation software existed. We then searched the journal literature for product reviews in trade journals. See Figure 1 for an outline of our search strategy.

Figure 1: Search strategy process for University of Michigan subscription library databases
1. "Subject=(music software) And Subject=(review)" in "General Interest" subset of MLibrary SearchTools 2. Identified database with most results (ArticleFirst) 3. Searched ArticleFirst with the following strategy: (keyword: music* and keyword: software) and keyword: review. 36 results retrieved. 4. Repeated steps #1-3 with the names of specific competitor products substituted as keywords.

The instrument we used for data collection was a matrix describing the following attributes for each product: product name, manufacturer, type of competitor, website URL, key user characteristics, representation method, price, and market share. (See Appendix B: Overview of competitors.) We were unable to identify the market shares of these products through trade journals, and instead contacted their creators to obtain this information. However, due to the sensitivity of the data and the time constraints of our study, we were only able to gather this information for a select few programs.

As part of the process of analyzing our data, we assigned each product to one of four categories of competition (see Figure 2).

Figure 2	
Type of Competitor	**Characteristics**
Direct	Offering the same functions in the same way (e.g., Food.tv vs. Epicurious)
Analogous	Offering the same functions in a different way (e.g., Google News vs. NYTimes print edition)
Indirect	A competitor that covers some but not all functions (e.g., Gmail vs. Outlook)
Partial overlap	A non-competitor that might give ideas about how to provide functions better (e.g., Wolverine Access Backpack vs. Amazon Shopping Cart)

Adapted from Newman, 2010

After reviewing a variety of different products, through a combination of trade reviews, consumer reviews, and first-hand application testing, we narrowed our list

to six competitors that we felt best exemplified the commercial potential of music creation software and computer applications that were closest to Noteworks in idea, theme, or capability.

The six products we selected, each of which highlighted a particular category of competition and covered the types of users Noteworks were targeting, are outlined in Figure 3. (See Appendix B for the complete comparison matrix.)

Figure 3		
Name of Competitor	**Type of Competitor**	**Main Audience**
Ableton Live	Indirect	Music arrangers, editors, musicians, and DJs
ChordGeometries	Partial	Music theorists, composers, and mathematicians
GarageBand	Indirect	Music composers, editors, musicians, and beginners
Max MSP	Indirect	Electronic musicians, composers, and application developers
Nodal	Direct	Electronic musicians, composers, and music theorists
Prezi	Analagous	

After determining the competitors we wished to evaluate, we converted the matrix data and our individual notes into brief narrative descriptions of each product. We also gathered screen captures of each application to help illustrate their interfaces. (Evaluations of these five competitors are available in Appendix A.)

Key Findings

1. Noteworks is unique compared to most music composition and educational software.

Among the competitors we studied, Nodal is Noteworks' only direct competitor. Nodal's user-defined graph is similar to the temporal network metaphor used by Noteworks; however, whereas Noteworks considers itself sequencing software, Nodal calls itself generative music software. Generative music can be defined as music that is created under a set of rules but is out of control, unrepeatable, and unfinished [1]. The user learning curve is relatively low, but in order to create compositions, knowledge of Western music notation is helpful. For instance, Nodal uses traditional octaves and note names to connote the pitches of their nodes. Noteworks is similar to Nodal in this regard as it also builds on concepts of Western notation.

At our first meeting with Noteworks, our client contact indicated that its developers have yet to determine Noteworks' target user base for Noteworks. One potential market for the software that we discussed is music education, i.e. marketing Noteworks as a tool to help music students learn notation and composition. In the course of our competitive evaluation, we found that music composing software with an educational purpose is very different from those for regular or professional use whether its design style or functionality.

GarageBand was the educational software that we explored but it relied more heavily on traditional instrumentation and forms of Western notation than Noteworks does. GarageBand, which is pre-installed and free with the purchase of a new Mac, allows users to gradually learn and transfer their knowledge of music to normal, non-electronic instruments.

Recommendation:
The Noteworks' team must identify ways to build its uniqueness into a market niche. In particular, if they decide to play up its affordances for learning and polish its existing interface and interaction design, there is great potential to capture the market for casual users. Through subsequent iterations of the product, they should strive to preserve existing strengths such as its comparatively gentle learning curve and simple user interface.

2. Certain functionalities are common among music composing software products.

Major music composing software such as Ableton Live and Max MSP are equipped with instrumental input, sound board interface and frequency visualization or other visuals that can facilitate users' editing experience. Ableton Live, for example, is a complete audio workstation that can be used at any stage of the audio recording, editing, or composing process, including live performance, while Max MSP is a popular tool for electronic musicians and DJs due to the complexity and flexibility built into its framework. At retail prices of $449 (download only) and $495, respectively, these programs are expensive to purchase and, therefore, both Ableton Live and Max MSP cater to professional users and high-end amateurs.

Recommendation:
Currently, Noteworks lacks the robust and complex capabilities of software like Ableton Live and Max MSP. To compete with these products, the Noteworks team should invest substantially in new features and a potentially radical overhaul of the interface. The Noteworks team should identify features of competitors that complement the product, without detracting from its core simplicity. Some functionalities, such as analog instrumental input, may complement and enhance Noteworks' existing key features (although incorporating them into the product may pose a technical challenge). Rather than trying to compete in the crowded e-soundboard market, the Noteworks team could use its strong, simple visual character to facilitate web-based sharing of compositions. Noteworks could explore other market such as web-based music editing and using the advantages of social media to allow users to share their work across social networks.

3. The product market is made of small, mainly hardcore users and not casual users

Based on the research we conducted, the product market for music composition software similar to Noteworks is relatively small. When researching Noteworks' only direct competitor, Nodal, we found that after launching its Google Group page on February 11, 2009 [2], they have since only compiled 92 members and 146 discussion messages, as of February 22, 2010. Although member numbers and discussion messages will not equate directly with the size of a program's user base, it demonstrates a relatively small number of active and vocal users. Furthermore, "Electronic Musician", the self-described "[number one] magazine in the U.S for musicians who record and produce music in a home or personal studio environment", had a total circulation of 61,102 as of June 2005 [3]. Even well-known music composition software such as Max MSP only have an estimated 30,000 users, while ChordGeometries possesses 10,000 users [4, 5] . That many of these products have significant learning curves and or require advanced theoretical or technical knowledge may help to explain these fairly small user bases.

Recommendation:
Since even well-established products in the market have modest numbers of users, Noteworks would be considered a respectable success with its adoption by a few thousand users. With its comparatively friendly user interface, however, Noteworks has the potential to capture many casual users who are intimidated by the complexity of other music composition products. We reiterate its social media potential if the files and compositions are easily sharable and user collaboration is emphasized.

4. Noteworks' analogous competitors include web-based application, Prezi

Prezi is an alternative web-based slideshow presentation program that was developed and written in Java but implemented using Adobe Flash. It features zoom-in and zoom-out capabilities and a linear presentation style by allowing users to place their materials on a big canvas without boundaries. Users are able to sequence their slides using a "path" tool and can specify how to zoom-in and out of different areas throughout their presentation. Prezi uses a tiered pricing model where users can create presentations for free, or they can purchase a membership package, which includes additional features for $59 or $159 per year. The web application grew out of a research project, similar to both ChordGeometries and Noteworks' direct competitor, Nodal (see Appendix A for more information). Prezi was able to draw from different fields of professionals in order to develop its innovative and user-friendly interface and program [6].

Recommendation:
Noteworks should consider replicating some of the features of its analogous competitor, Prezi, such as their zooming techniques. Noteworks can also simulate Prezi's approach to research by soliciting and cultivating niche opportunities for research applications with music theorists, network theorists, and neuroscientists.

Depending on the feedback that Noteworks' development team receives, such applications could conceivably serve to enhance users' editing experience as well.

5. Steep learning curves

Compared to Noteworks, the learning curves of most music creation software is relatively steep. These programs tend to target professional users, and their higher functionality usually requires more time, effort, and previous knowledge in order to master their interfaces and functions. For example, Max MSP demands a comfort level with visual programming – a visual version of traditional computer programming – and the ability to interpret the intimidating visuals of a "patch." Likewise, one of the primary uses of ChordGeometries is to illustrate voice leadings – the arrangement of voices or parts within a composition – an exercise that would confuse anyone without past training in music theory. Yet while these sophisticated products are demanding to novice users, users who have invested the time to learn them and to use them proficiently are probably not going to find Noteworks a viable substitute for the work they perform.

Recommendation:

As noted previously, Noteworks lowers the learning curve by eliminating some complicated functions that intimidate unskilled users and makes it less time consuming to learn the software. We posit that Noteworks may be more suitable for beginning or casual composers. However, advanced users may want to stick with the tools they already know and complex, higher level music composing and editing products gives them more control over their work. If the Noteworks team wants to target advanced digital composers, it will need to grow its functionalities and features, specifically the ability to add external instrument inputs.

Discussion

During the course of our study, we encountered several limitations. First, Noteworks has only one direct competitor, which may or may not have affected our findings and recommendations. The fact that the application has only one direct competitor limits our ability to properly extrapolate and interpret the data correctly. Consequently, our recommendations may be biased or may include incorrect assumptions about the underlying industry.

Second, because Noteworks is still in the beta-testing phase, there are many uncertainties as to the program's functions, features, overall interaction design, and how long the development process will take. Depending on the time lag, our recommendations may become less useful. Furthermore, comparing an in-testing, startup program to such industry stalwarts as Ableton Live, is generally unflattering to the startup. Noteworks may yet undergo drastic overhauls to its interface and functionality due to circumstances unrelated to the research conducted.

Third, we had difficulty classifying and identifying Noteworks' competitors due to the ambiguity of its target user. During our initial client meeting, we were told there were several potential uses and users being targeted, including electronic musicians, music educators, and the idea of making Noteworks a web-based application. While researching for competitors, we discovered that music education programs, like GarageBand, were drastically different in comparison to programs designed for electronic musicians, such as Max MSP; music education programs steep themselves heavily in traditional instrumentation in order to build key concepts for further learning, whereas programs for electronic musicians are professional in nature and feature advanced uses that require considerable amounts of time to learn. Comparing them both to Noteworks means that our recommendations may appear contradictory due to the disparate needs of different types of users. Ultimately, which recommendations should be adopted depends on the resources available to the development team and which user market they decide to target.

An area of research we were unable to fully examine due to time constraints were generative music software and algorithm or fractal-based music software, like Noatiki or Koan. Generative music programs and algorithm-based programs feature music visualizations that are vastly different from the popular commercial properties that we explored. Also, based on the brief searches we conducted, there are an abundance of these niche programs, but because they cater to an even smaller market than the competitors we examined and were not listed by any of our interviewers or by the client, we decided against further research. Subsequently, for our study, we focused on the more commercially successful music composition programs. Time allowing, we will explore these other music applications for future research.

Conclusion

The key findings of our investigation are that most music creation software is complex, caters to a small number of skilled, professional users, and carries a steep learning curve. We also found that Nodal is the only music composing application that has features, functions, and designs that are directly comparable to Noteworks current framework. Additionally, having advanced zoom in and out capabilities are possible in a web environment, and presumably, in non-web environments as well. Our recommendations for Noteworks is to better define their target user and cater to that market directly through a combination of additional features and polishing existing functions.

Despite our best efforts, limitations of our study include having a small sample of competitors, comparing a beta version of a product against fully functioning systems, and difficulty classifying competitors due to target user ambiguity. Moreover, a domain for additional research would be more analysis and comparison

between Noteworks, generative music software, and algorithm or fractal-based music software.

Our next study will be designing and conducting surveys. We hope to probe fifty potential Noteworks users for information regarding their current music software habits and what they look for in software in general, in order to guide Noteworks on what to do and what to avoid.

References

[1] Eno, B. (1996). Generative Music Talk. Delivered in San Francisco, June 8 1996. *In Motion Magazine.* Retrieved from http://www.inmotionmagazine.com/eno1.html on February 20, 2010.

[2] (2010). Introduction to Nodal. *Google Groups.* Retrieved from http://groups.google.com/group/nodal/web/introduction-to-nodal on February 20, 2010.

[3]Penton Media. (2010). About us. *Electronic Musician.* Retrieved from http://emusician.com/about/ on February 22, 2010.

[4] Herrera, J. Personal email correspondence. February 17, 2010.

[5] Tymeczko, D. Personal email correspondence. February 17, 2010.

[6] (2010). Prezi Review. *AppAppeal.* Retrieved from http://www.appappeal.com/app/prezi/ on February 22, 2010.

Appendix A: Detailed Evaluation of 6 Competitors

Ableton Live (Indirect Competitor)
Ableton Live is an indirect competitor to Noteworks. The digital audio workstation is manufactured by German company Ableton and allows for multichannel recording, live DJ mixing, and music arrangement and editing. Ableton Live uses a combination of session and arrangement views to display music. Session views allow non-linear music representation, and soundboard metaphors are used throughout the program to control audio effects. Due to the large assortment of uses, digital effects, and music capabilities, the learning curve is extremely high but is mitigated by their numerous tutorials. Moreover, certification programs are available in Ableton Live's major user territories [1].

Common user characteristics include digital and traditional musicians, composers, song-writers, producers, arrangers, and DJs. The product is available for download for $449, but box versions are also available for the higher price of $549 [2]. There are also different versions of the product, Ableton Suite, that includes more tools and sounds, and Ableton Live Intro, which is a lighter and cheaper version of Ableton Live [3]. The program is available in both Mac and PC versions.

The number of users and market share is unknown.

Session View

Live is the only music production software with the "Session View": a unique grid for recording and playing musical ideas and phrases. The Session View is non-linear, so you can record and play back your ideas in any order you want. When you're working on a new track, this is a smart, flexible way to write and record. If you're performing music live, it gives you complete flexibility and freedom to improvise.

Arrangement View

Live also has a second view: the "Arrangement View," a complete music production environment. This is the linear counterpart to the Session View and is well-suited to "traditional" recording, arranging and mixing. These two views interact with one another, each with its own strengths and intricacies. Both views are based on the single principle of creative, intuitive music-making.
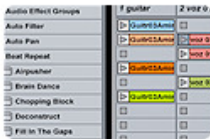
Uninterrupted creative flow

In Live, you never have to stop the music. Record audio and MIDI on the fly, drop in loops and samples, add effects and swap sounds without ever hitting the stop button: everything happens in real time. You're free to improvise and the computer actually becomes a musical instrument—an expressive and creative tool, perfectly at home on stage or in the studio.

Beats made easy

Live's unique Drum Rack combines drag-and-drop simplicity in a familiar pad-style interface. Each of the 128 drum pads can have its own instrument or sample plus effects. Slice beats, loops or REX files to MIDI for additional control options and use the new groove feature (which includes grooves from the legendary MPC and SP1200 machines) to add swing to your beats.

Creative expression for DJs

Mix and match tracks and loops automatically, remix on the fly, capture audio loops in real time from decks and other external sources, incorporate your own productions into the mix, and much more. Whether it's the centerpiece of the DJ rig or just a creative sidearm, Live gives DJs entirely new worlds of creative expression.

Share: effortless remote collaboration

Share your Live Sets with others via the web. Live 8's simple and intelligent solution for online musical collaboration streamlines the sharing process with one-click sharing and loading, a simple system of setting access permission, speedy transfers and no issues with external plug-ins and instruments.

Looping with Live

Not only for guitarists, the Ableton Looper gives you classic sound-on-sound looping without the limitations of a hardware device. Looper is set up for remote operation, so you can record, overdub, undo and more without touching the computer.

Totally compatible

Live works seamlessly with controller hardware and assigning custom MIDI controls is simple. Live supports AIFF, WAV, MP3, Ogg Vorbis and FLAC files, VST and AU effects and instruments. Live can handle REX files and runs as a ReWire Master or Slave, so it works nicely alongside other DAWs like Pro Tools, Logic, Cubase or Reason. And if you have a multicore or multiprocessor system, Live supports that, too.

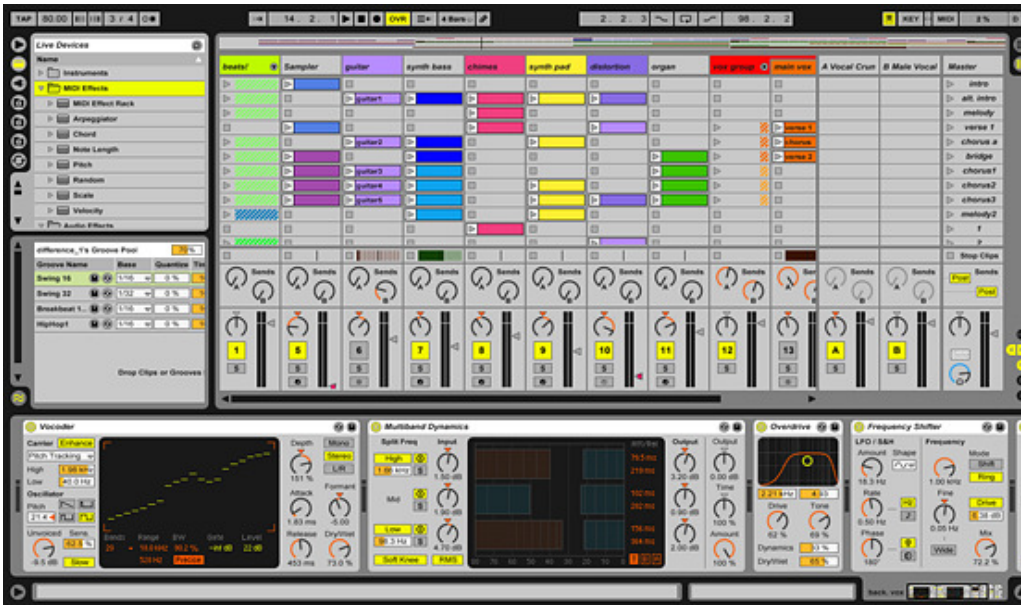**Figure 1: Ableton Live's advertised features and capabilities. Images taken from http://www.ableton.com/live-8**

Figure 2: Ableton Live's session view. Image taken from
http://www.ableton.com/live-session-view
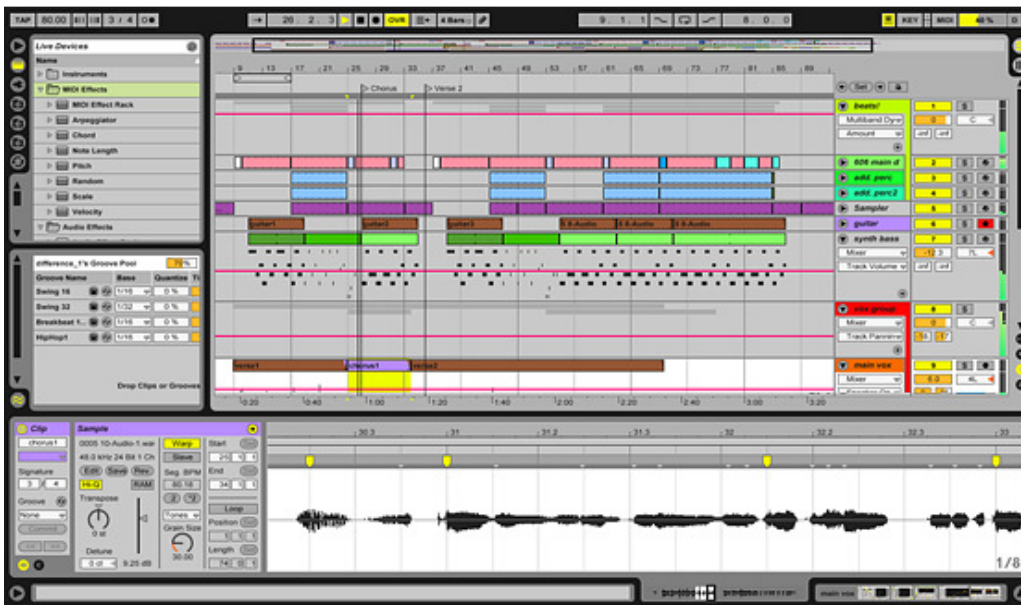
Figure 3: Ableton Live's arrangement view. Image taken from
http://www.ableton.com/live-arrangement-view

Figure 4: A close-up of Ableton Live's drag-and-drop audio effects.

ChordGeometries (Partial Competitor)

Max MSP actually provided the environment for development of another competitor we consider, ChordGeometries. We classified ChordGeometries as a partial overlap with Noteworks. Like Noteworks, ChordGeometries using networks to assemble a visual representation of music; however, as its creator, Dmitri Tymeczko observes, "I don't really conceive of the program as a notation program. It is a way of representing music, that is true -- but only some aspects" [4]. The Chord Geometries download page describes the program's representation method: "represents chords and voice leadings in a variety of 3D geometrical spaces. You can enter chords on a MIDI keyboard or using the Keyboard window. Voice leadings between successive chords are represented by continuous paths in the spaces" [4].

Dr. Tymeczko estimates that ChordGeometries "has been downloaded more than 10,000 times -- say 15,000 or so" [5]. The primary audience and user base of ChordGeometries include music theorists, composers, and mathematicians. The program requires Quicktime and, generally, users must have both an understanding of Western music theory and chord structures, and an adventurousness and patience with software. In contrast with the steeply priced Max MSP, users can download ChordGeometries for free from Dr. Tymeczko's personal homepage on the Princeton University website. Downloads in both Mac and Windows are available.
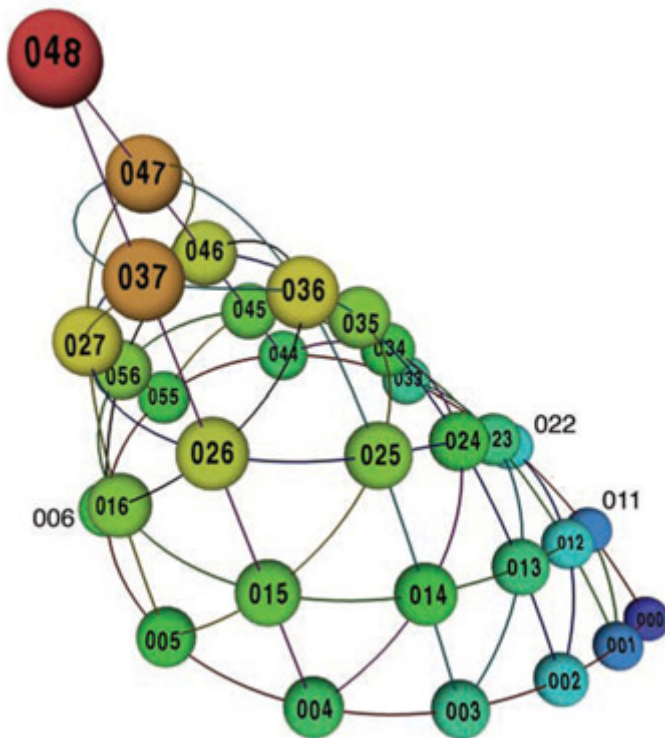
Figure 5: An illustration from ChordGeometries of three-note chord types as a cone. Image taken from http://www.fsu.edu/news/2008/04/20/geometry.music/
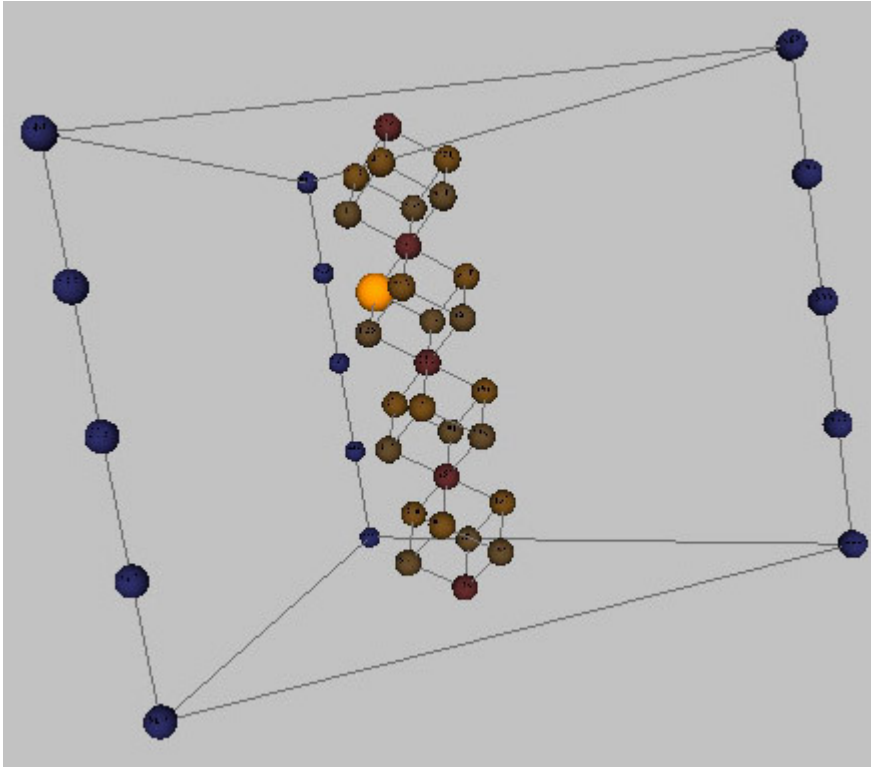
Figure 6: Another representation of MIDI chordes and voice leading in ChordGeometries. Image taken from http://music.princeton.edu/~dmitri/ChordGeometries.html

Max MSP (Indirect Competitor)
The company that has taken the lead in developing and commercializing MAX MSP, San Francisco-based Cycling74, describes the product as "An interactive graphical programming environment for music, audio, and media. *Max* is the graphical programming environment that provides user interface, timing, communications, and MIDI support. *MSP* adds on real-time audio synthesis and DSP" [6].

We classified Max MSP as an indirect competitor, since it is a programming environment rather than a ready-to-use composition software, with a significantly higher learning curve and set of capabilities than Noteworks. Based on a sampling of the projects shared on its website, Max MSP users include electronic musicians or composers and application developers [7]. It is priced at $495.00, and Cycling74 estimates its current user base at around 30,000 customers [8].

Figure 7: Image taken from http://cycling74.com/products/maxmspjitter/

Max Features

Time

Working with time is easier in Max than traditional programming because you use objects to create visual "timing machines" whose behavior you can see, hear, and modify as they operate. **Learn More**

Interactivity

Working with interactivity is easier in Max because you can design interfaces visually, and the interfaces are then part of the program itself. For example, controls the timing and transport of the timing example above. **Learn More**
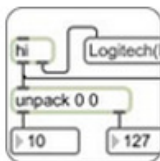
Control

In Max everything can be connected to everything, because everything speaks numbers. Another way to say this is that modularity is a core design principle of everything in the software. **Learn More**

Extensibility

Max users extend the environment in every possible direction. As a by-product of their work with the software, passionate Max users have contributed thousands of objects written in C, Java, or Javascript back to the user community.
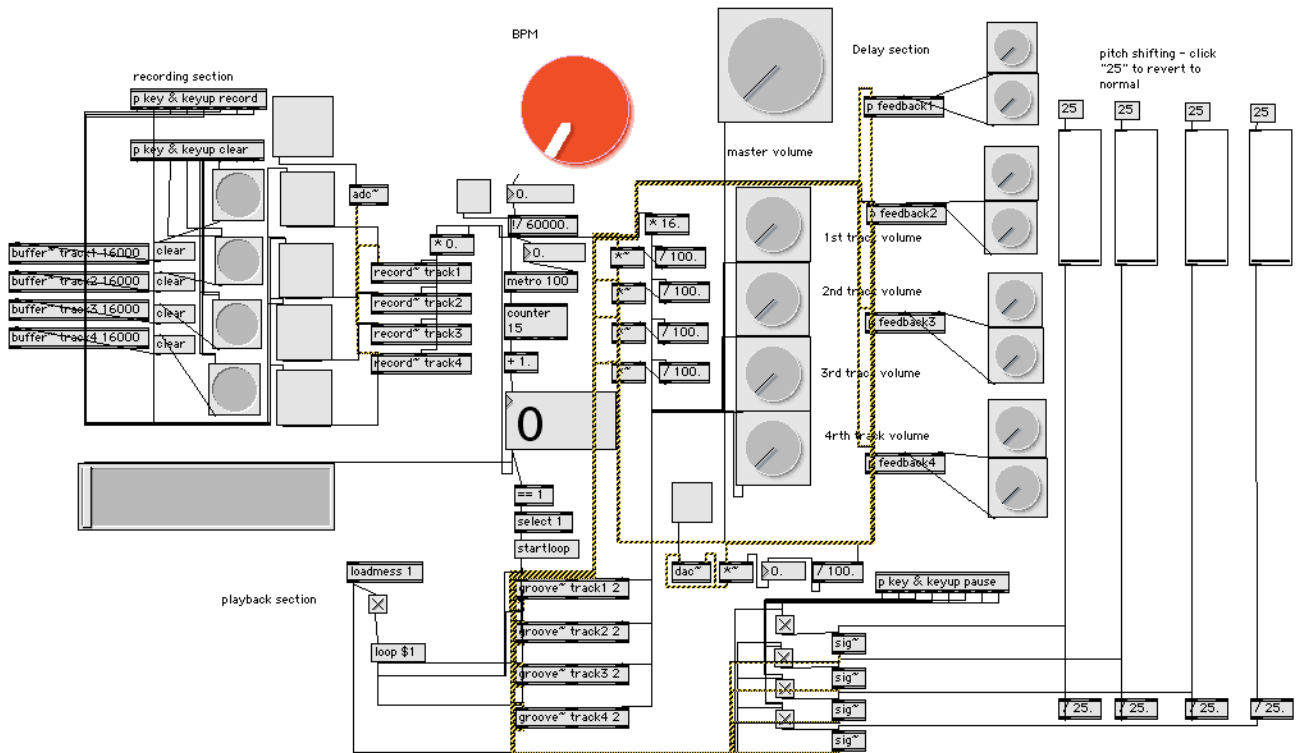
Figure 8: Image taken from http://cycling74.com/products/maxmspjitter/

Figure 9: An example of an MSP patch. Image taken from
http://interactive.usc.edu/members/mtuters/2007/02/maxmsp_canon_patch.html

Nodal (Direct Competitor)
Nodal is a generative music computer application that competes directly with Noteworks. The system represents music through the metaphor of a user-defined graph that consists of nodes (musical events) and edges (connections between events). The timing of the nodes is determined by the length of the edges separating the nodes, with all of its music being MIDI based[9]. Nodal's manufacturer is the Centre for Electronic Media Art (CEMA) at Monash University, Australia, as the computer application originated as a research project [10].

The user learning curve is quite low but relatively higher when compared with Noteworks. Additionally, traditional knowledge of Western music notation is useful for learning the program, which is the similar to Noteworks. The user characteristics are electronic music composers, musicians, and music theorists. Several research papers have already examined Nodal's composition methods, especially as written for the Australasian Computer Music Conference [10].

The software is available in both Mac and PC versions and full versions have a retail price of $25. The exact market share is unknown but the product's Google Group contains 92 members [11].
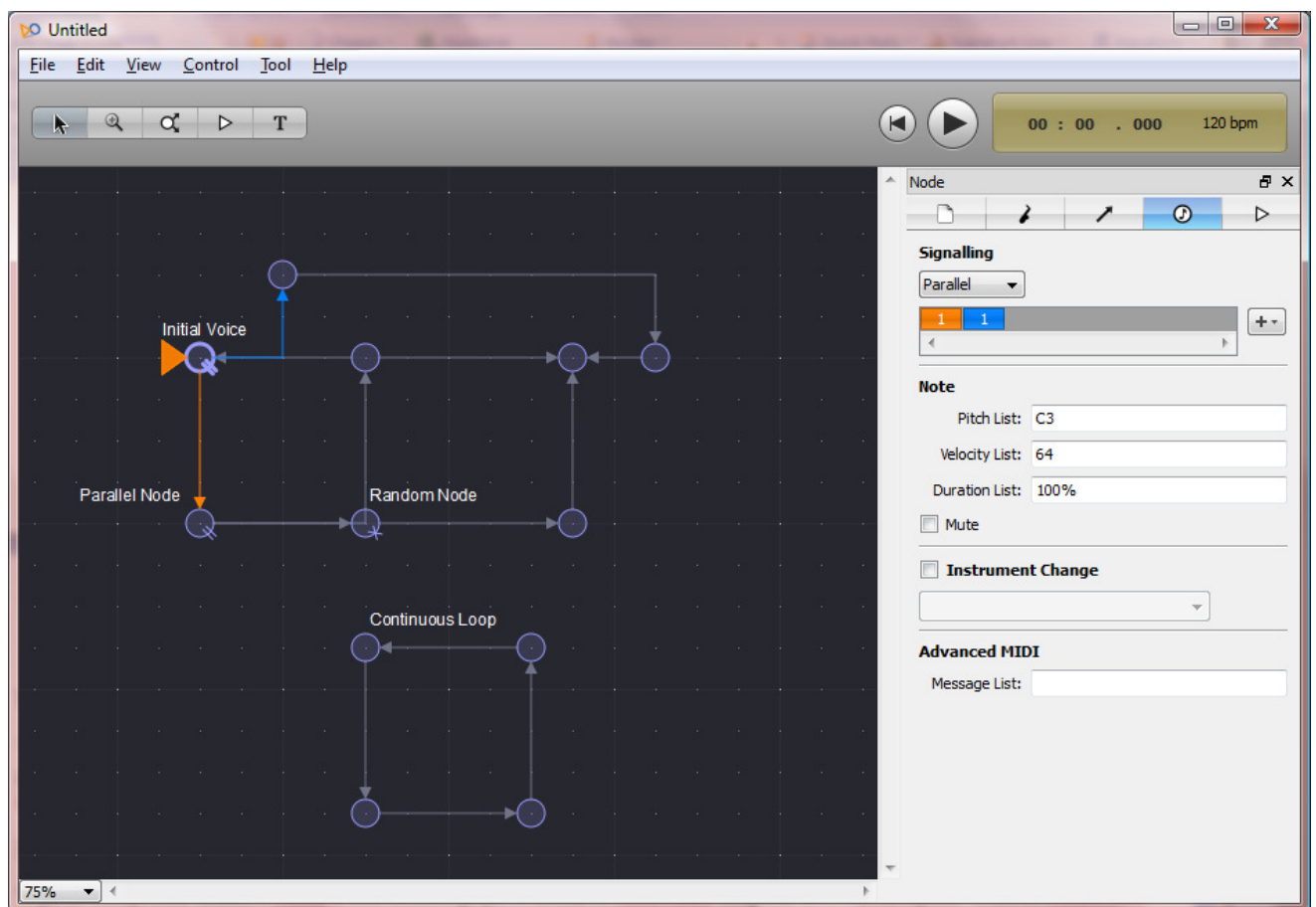

Figure 10: A screen capture of Nodal's interface.

GarageBand (Indirect Competitor)

GarageBand is a music application bundled with Apple's <u>iLife</u> suite and comes pre-installed on every new Mac. It allows users to create music or podcast. In GarageBand 09, it features audio recording, visual software instruments, MIDI editing, and music lessons.

Prezi

Prezi is a web-based presentation tool featuring mapping and zooming and use the concept of linear presentation to offset the shortcomings of regular slide show.
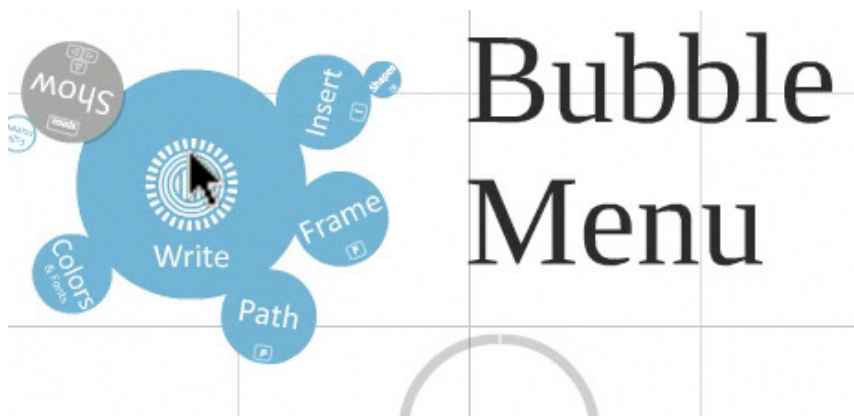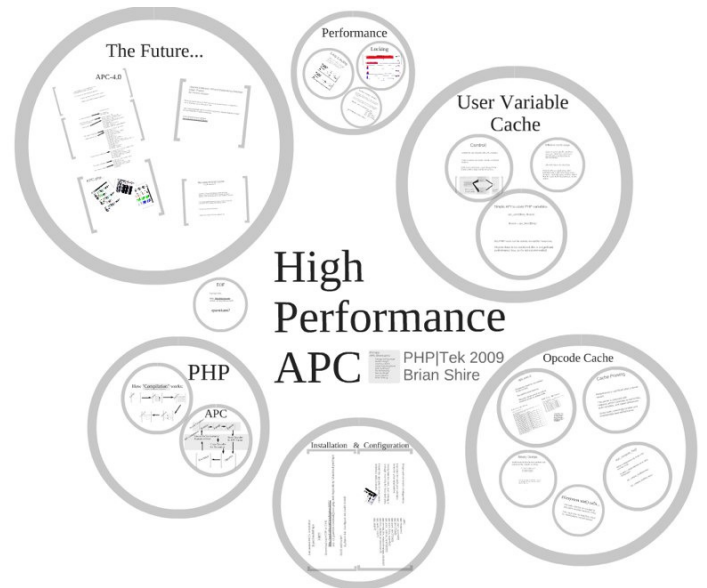

Figure 13-15: (from left to right, top to bottom) Images taken from cdspd.wikispaces.com, tekrat.com, and prezi.com

Appendix B

Name	Manufacturer	Type of Competitor	Website	User Characteristics	Representation Method	Price	Market share
ChordGeometries	Dmitri Tymeczko	Partial overlap	http://music.princeton.edu/~dmitri/ChordGeometries.html	Mathematicians, composers, music theorists, researchers	Geometrical spaces and paths to represent chords and voice leadings	Free	~10k
Max MSP	Cycling74	Indirect	http://cycling74.com/products/maxmspjitter/	Electronic musicians or composers, application developers	Visual programming, visual patches	$495	~30k
GarageBand	Apple	Indirect	http://www.apple.com/ilife/garageband/	Mac users, casual users, students, beginners, educators	Soundboard, frequency, visual instruments	Free, $79	All Mac users
Prezi	Prezi	Analogous	http://www.prezi.com	Visual designers, casual users, creative industry people, students	Zoom in/out, linear presentation	Free, $59, $159	Unknown
Nodal	CEMA, Monash University	Direct	http://www.csse.monash.edu.au/~cema/nodal/	Electronic music composers, music theorists.	User-based graphs	$25	Unknown
Ableton Live	Ableton	Indirect	http://www.ableton.com/live-8	Musicians, music composers, song-writers, music producers, arrangers, DJs	Soundboard, frequency, and direct manipulation	$449	Unknown

Appendix References

[1] Ableton. (2010). Education. *Ableton Live.* Retrieved from
    http://www.ableton.com/education on February 22, 2010.

[2] Ableton. (2010). "Products – Ableton Live 8." *Ableton Live.* Retrieved from
    http://www.ableton.com/live-8 on February 22, 2010.

[2] Ableton. (2010). "Products – Ableton Live." *Ableton Live.* Retrieved from
    http://www.ableton.com/products on February 22, 2010.

[4] Tymeczko, D. (2010). Chord Geometries Download Page. *ChordGeometries 1.1.*
    Retrieved from http://music.princeton.edu/~dmitri/ChordGeometries.html on
    February 18, 2010.

[5] Tymeczko, D. Personal email correspondence. February 17, 2010.

[6] Cycling74. (2010). Max-Cycling74. *Max.* Retrieved from
    http://cycling74.com/products/maxmspjitter/ on February 18, 2010.

[7] Cycling74. (2010). Community - Cycling74. *Max.* Retrieved from
    http://cycling74.com/products/maxmspjitter/ on February 18, 2010.

[8] Herrera, J. Personal email correspondence. February 17, 2010.

[9] Centre for Electronic Media Art. (2010). What is Nodal? *Nodal – Generative Music.*
    Retrieved from http://www.csse.monash.edu.au/~cema/nodal/# on February
    22, 2010.

[10] Centre for Electronic Media Art. (2010). Nodal Research & Development. *Nodal
    – Generative Music.* Retrieved from
    http://www.csse.monash.edu.au/~cema/nodal/research.html on February 22,
    2010.

[11] (2010). nodal – generative music software. *Google Groups.*
 Retrieved from http://groups.google.com/group/nodal on February 22, 2010.