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MusicFlow: An interactive music composition system

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ABSTRACT

Music notation has evolved to the point in which music scores can be digitalized to give composers a different dimension of music composition. Traditional method of music notation using pen and paper requires much time and effort especially during reviewing and editing of hand written music scores. On the other hand of the spectrum, computerizing the entire music composition process can potentially reduce the workload; however, previous approaches in digitizing music notation suffer from the overwhelming functions and the lack of human touch. In this paper, we designed, implemented, and evaluated a multi-touch application called Musicflow, which allows for automatic transcription of composers' music into digital music scores through one's fingertips. To facilitate natural, efficient interaction, MusicFlow supports many multi-touch gestures such as music notation, editing and playing back for reviewing. In addition, Musicflow includes a collaborative teaching tool which further enhances music education by engaging both the teacher and students actively on a multi-touch table. Our initial evaluation indicates that MusicFlow is intuitive to use and effective for music composition.

Keywords: music composition, music notation, automatic transcription, multi-touch, collaborative teaching, human computer interaction

1. INTRODUCTION

Computerizing music composition has produced much benefit such as ease of use in revising and editing of music scores as well as the ability to save and reprint music scores. Composers now spend lesser time than they would have as compared to manual composition of scores which involves time consuming mandatory tasks such as key transposition, extraction and layout. However, precise music transcription is still an active research field due to its extremely challenging computational requirements. Furthermore, most current music notation software uses keyboard and mouse which is not intuitive and the array of functions in these software applications are too overwhelming for novice users. Thus, we aim to provide more human touch to music notation software by capitalizing on efficient computational resources in our project.

We developed a multi-touch application, MusicFlow, which effectively combines a multi-touch platform with music composition. Some of our main features of MusicFlow are:

1. **Real time transcription of musical scores:** Musical scores are automatically generated real time when users play on the virtual piano.
2. **Intuitive multi-touch gestures used for editing:** The multi-touch gestures are designed to make the editing process efficient and easy.
3. **Integrated music composition system:** All the composing work is done in a single workspace, without the need to shift between spatial mediums such as synthesizers and computer.
4. **Collaborative learning tool:** Creates an enriching music learning environment by capitalizing on the collaborative design of a multi-touch table.

2. RELATED WORK

Previous research can be categorized into three main aspects which exemplifies on user needs & requirements, affordances for flexibility and creativity of system, transcription & editing processes, with each having a significant impact on the way we design MusicFlow. These three aspects are:

1. **The mental model of composers**
 - Finding the right type of interaction to suit the way composers compose and edit music.
2. **Medium, flexibility and creativity of system**
 - Finding an appropriate medium and interface to incorporate suitable interactions for notating and editing, while supporting creativity in composers
3. **Transcribing and editing**
 - Finding efficient and economical methods to notate and edit musical notes on the music sheet with appropriate level of accuracy

2.1 The Mental Model of Composers

Three different types of human computer interactions are commonly used in music notation: 1) Music Notepad's 2D gestural input using pen-based interaction¹⁰; 2) Personal Composer's MIDI music transcriptions using WIMP user interfaces¹¹; 3) Real-time transcription of music directly from instruments^{4, 5}. Each of these interactions specifically targets certain group(s) of users. Music Notepad targets novice composers such as children who are learning how to notate music notes from simple songs. Personal Composer on the other hand targets less novice users by providing greater flexibility in notating and editing of scores using WIMP. For direct instrumental transcription, it outweighs the other two interactions in terms of its efficiency and overall user experiences in that music scores can be instantaneously generated from the playing instrument.

2.2 Medium, flexibility and creativity of system

The "*Paperoles Project*"¹² considers tangible objects such as paper, best at aiding the compositional process. This is because the real world affordance of having to compose using paper during composing is still very attached to the mental model of composers today.

In areas of flexibility and creativity, Automatic Notation Generators² discusses different theoretical and statistical approaches which allow multiple realizations of algorithmic compositions, direct transcriptions etc. A few other papers presented innovative ideas to enhance the overall user experience and usability in composing music. Some of these include Music Gesture Recognition⁸, Speech Interface (Voice Music)⁹ and Tangible-Probability based music composition⁷. For a more relevant reach to our MusicFlow system in terms of music notation and editing, Music Gesture Recognition was analysed in greater detail. This system has three main components: (Staves-Preprinted Anoto Paper, Digital Pen and a Recognizer). Firstly, the digital pen is used to make gestures on a pre-printed paper. Once the pen is lifted off the paper, the gesture is tracked and sent to the recognizer to retrieve the shape. Finally, the specific location of the shape as well as its spatial relationship with the other gestures on the music sheet will be noted. The shape will be approximated into a music notation and stored.

2.3 Transcription and editing

"*The Justification of Printed Music*"⁶ addresses one of the most common problems in music notation - the appropriate spacing between music notes on music scores. "*The Design of Pen-based Input System*"³ provides an overview of current techniques for music notation: Direct Keyboard Entry makes use of ASCII music representation languages such as DARMS and MusicTex; Direct Manipulation Music Input combines a keyboard and pointing device with a bit-mapped display to allow direct manipulation of musical symbols; these two techniques allow users to enter music by playing a

music keyboard connected to the computer, and Optical Music Recognition is a computer system that attempts to parse the bitmap image of a scanned music score. These techniques have helped us gain a better understanding on the overall progress of music notation systems.

MusicFlow is thus designed in accordance to an analysis of the literature review. It follows the design of real-time transcription onto digital scores as stated in the section on “Mental model of composers”. For the choice of interaction medium, MusicFlow is built upon a multi-touch table system. The advantages of such a design can be seen in the areas of transcription and editing. Based on the understanding from Blostein’s paper⁶, MusicFlow’s transcription process is designed to compute both fixed tempo (as set by the user) and the duration of the “touched” key on the virtual piano to measure the correct duration of the played note. For editing, pen-based interaction was originally our initial choice. However, we decided to keep all interactions to multi-touch. Our justifications expound on the fact that our hands provide greater intuitiveness for editing and manipulating digital data, and also significantly reduce the number of interactions users need to learn.

3. DESIGN PROCESS

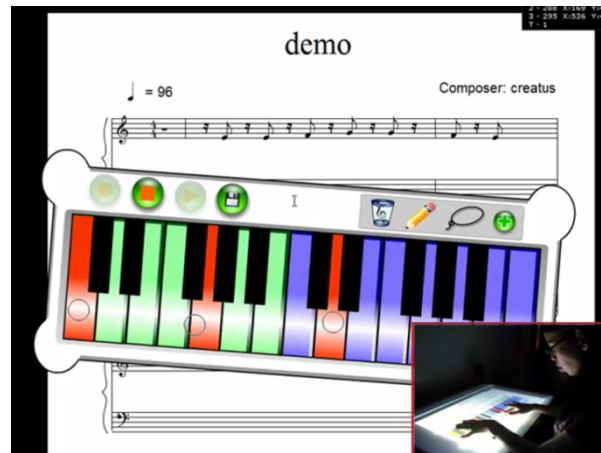
3.1 Prototyping tools

Paper prototypes were used in the initial design process as they are simple to create. They are also easy to manipulate during usability testing and efficient for gathering user feedbacks on system navigation and screen layout. However, for certain actions that cannot be easily replicated on paper, such as hand gestures, we will guide users in the process.

3.2 1st Iteration

We first came up with a rough sketch of the user interface, which basically includes a music score and a piano keyboard. This interface design was intended to be minimalistic (for simplicity and intuitiveness), exemplified by eliminating the cluttering of features that can complicate the music composition process. The piano keys are designed to be highlighted when pressed for providing visual feedback. Subsequently, we designed the algorithm to translate the piano keys pressed into music notes on the score. In the initial programming development phase, we used mouse clicks to simulate movements. This allowed us to first test out the algorithm and concentrate on making it as accurate as possible.

3.3 2nd Iteration



Video 1. Automatically transcribes music score when user plays on the virtual piano. <http://www.youtube.com/watch?v=6x2c2CUHF-c>

We continue to implement the multi-touch detections after a thorough evaluation of the algorithm. The application was evaluated again to identify the potential bugs. Next, the algorithm was refined again to account for other music attributes such as adding of rest intervals between notes, note ties etc. In addition, the piano keyboard was redesigned to include dragging, scaling and rotating functions. Users are also allowed to save their scores as an image for the ease of printing; this has proved to be an extremely useful feature for music composers. The end result is thus a more aesthetically pleasing and user-friendly interface.

3.4 3rd Iteration

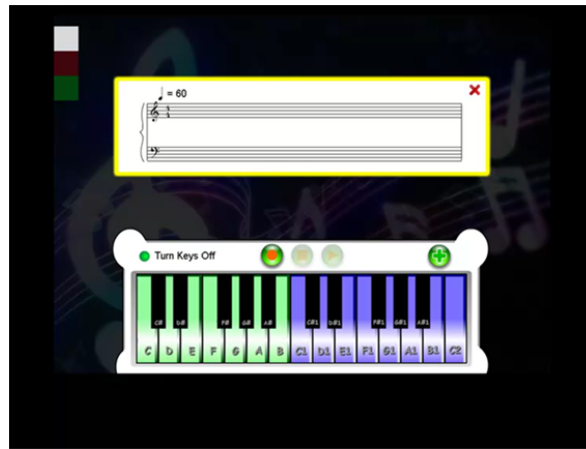
Since users commented that the music notes are too small, a magnification correction was done and we implemented a scrolling gesture for easy navigation of the score. A vertical scrolling mechanism is used as opposed to a horizontal one to ensure a more continuous navigational flow and for a better view of the last few bars of the previous score. We have also added a 'playback' function since users prefer to listen to what they have played previously. In this way, they could improve on their previous music creations or continue their composition from the position where the play back has stopped. Our virtual piano keys have been enhanced with contrasting colours for the left and right hand for better visibility of the music playing process. Furthermore, users are allowed to delete individual music notes by first selecting a particular note and then tapping on the trash icon, or by 'pinching' the note with the thumb and index finger. Lastly, a 'lasso' tool (which incorporates circling hand gestures) is included to group notes, which will then be deleted using the trash icon.

3.5 4th Iteration

While the deletion of notes is useful, we felt that there was room for improvement in terms of visibility and user experiences. Thus, an animation simulating a 'puff of smoke' is used to indicate to the user that the note is deleted. Furthermore, graphical music visualizations (which change dynamically according to the volume and frequency of the music) are added as an option while the user plays back.

3.6 5th Iteration

In our initial evaluations, one user suggested a collaboration system for multiple users. Given that the multi-touch table supports collaboration, we are able to scale the productivity and potential of MusicFlow by integrating more users. In view of this, MusicFlow is now extended to integrate collaborative learning and teaching features. Firstly, we redesigned the keyboard to make it more suitable for teaching; Key indicators are now prominently displayed on the keyboard to aid the learning process of the individual keys. Moreover, users have the option to turn them on or off. As for the music sheet, small sections of the full score are displayed. At any one time, more than one score can also be added or deleted. Overall, the enhanced interface first allows the teacher to play a small set of notes, and playback them for the students to listen. Following on, students will learn those sounds that correspond with the notes, and proceed to create a new score by playing the same set. These scores can be then saved or deleted.



Video 2. Shows how collaborative teaching tool allows student and teacher to learn and teach together on the multi-touch table. <http://www.youtube.com/watch?v=p6-RgDdVFKY>

4. EVALUATION

4.1 Participants

All participants were either pianists or composers experienced with using graphical user interfaces. Three male and seven female, between ages of 23 to 38, volunteered to participate and consent to the use of audio recording. One of the participants was a professional piano teacher.

4.2 Method

Participants were briefed on the objectives of the evaluation process. A 5-minute demonstration was then carried out by the experimenter on the basic use of MusicFlow's features. Following which, participants were requested to perform a series of tasks listed below. An interview is further used to conclude the evaluation process.

1. **Notating music sheet:** Users were asked to play a song on the virtual piano on the multi-touch table.
2. **Editing music sheet:** Perform deletion, adding of dynamic expressions.

3. **Reviewing and saving music sheet:** Play back song to review the song just composed. Execute Task 2 if editing of the score is necessary. Finally, save the music sheet to a desired graphical format.
4. **Learning a new song:** A teacher (experimenter) will first compose a new song to generate the music sheet. The student (participant) will then observe the music score as it is being played back and attempt to replay the song after that.

4.3 Interview

The interview first enquires about the participants' experiences in playing piano and composing music. Following this, they were asked about usability and aesthetic issues (i.e. the layout and functionalities) of MusicFlow. Lastly, questions were targeted at users on their suggestions to add or improve features for MusicFlow.

4.4 Results

8 out of 10 participants enjoyed the multi-touch functions as they were intuitive and easy to use. One participant specifically mentioned that using hands to notate music is much less troublesome than using keyboard and mouse as the transcription is instantaneous and efficient. 6 out of 10 participants gave feedbacks that the highlighted piano keys provided good visual feedbacks but could not completely replace the tactile affordances of a real piano. However, one participant commented on the inability to rest one's hands for concern of an unintentional trigger of touch events. As for the musical range, a piano teacher felt that it is not sufficient to accommodate more complex songs. And with respect to the collaborative teaching tool of MusicFlow, the piano teacher commented that it was interesting to incorporate touch and music technology into learning which could be adjusted for each individual learner. Her main concern was that the techniques of playing a piano could not be learnt from our teaching tool due to the lack of touch from a real piano.

5. CONCLUSION

Our evaluations showed that users enjoyed using MusicFlow to compose music due to the ease of 'learn-ability', usage of the features and the intuitiveness of the multi-touch gestures used in editing. However, most users felt more comfortable using a real piano for composing. Overall, the design of MusicFlow to enhance music compositional experience is promising.

The main major limitation of MusicFlow is the lack of tactile feedback. Replicating the exact tactile feedback from a piano onto our multi-touch application is nearly impossible with today's technology. However, we have tried to compensate tactile loss by providing visual feedback in the form of highlighted keys but it was not sufficient. Moreover, the range of piano keys was limited by the size of the multi-touch table as increasing the range of piano keys would make the keys too small to be accurately played on.

SLAP Widgets¹ is a possible solution for providing tactile feedback absent from our current system. By replacing our virtual piano with a piano SLAP Widget, MusicFlow would be able to provide tactile feedback in addition to visual feedback. Such piano SLAP Widgets can be built from a custom piano keys mould in order to mimic a more accurate and similar feel provided by real pianos. MusicFlow can also be enhanced by incorporating more musical instruments such as guitar or drums and our further research will focus on the collaborative aspects in order to make MusicFlow a much more interactive music composition system.

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