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m-shaper: A Sketch Drawing System for Musical Shape Generation

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m-shaper: 음악적 형태 생성을 위한 스케치 드로잉 시스템

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Abstract This paper proposes a sketch drawing system called m-shaper for musical shape generation. Through simple sketch drawing, users can generate musical shape configuration which can be played by a computer. One key ingredient of the process is a unique concept for the interactive musical shape generation that combines shape and sound based on the designers' manual inputs. m-shaper captures the numerical values of drawing characteristics and determines how the musical notes and shapes can be generated. Using a tablet, four sketch movements are captured such as pressure, tilt, rotation and speed. Each point of a shape corresponds to a certain musical note that represents a type of instrument, duration, pitch, and octave. The current m-shaper has been developed as a computational tool for supporting the schematic design process. Designers in m-shaper draw geometric sketches with a musical inspiration and explore possible conceptual forms. They also can control the parameters for results and transform their sketch drawing.

요 약 본 논문은 음악적 형태 생성을 위한 스케치 드로잉 시스템, 엠쉐이퍼 (이하 m-shaper)를 제안한다. 간단한 스케치 드로잉을 통해 사용자들은 컴퓨터로 바로 연주가 가능한 음악적 형태를 구성할 수 있다. m-shaper는 드로잉 특징을 규정하는 변수를 획득하고 이를 이용하여 음표와 형태를 제작한다. 타블렛을 이용하여 4가지 스케치 움직임 정보, 압력, 회전각도, 기울기 각도, 속도 정보를 감지한다. 형태를 구성하는 각각의 점은 악기 종류, 음길이, 음높낮이, 옥타브를 표현하는 특정 음표에 매핑된다. 현재 m-shaper 시스템은 디자인 초기단계를 지원하는 컴퓨터 연산도구로 개발되었다. 디자이너는 음악적 영감을 받으며 기하학적인 스케치를 그리고 개념 형태를 탐색할 수 있다. 디자이너들은 관련 제어값을 조절하면서 결과물을 조절하고 스케치 드로잉을 변형할 수 있다.

Key Words : m-shaper, shape generation, sketch drawing, musical shape, conceptual drawing

1. Introduction

Designers often draw shapes to investigate forms in the schematic design process. Herbert argues that “study drawings” is a medium for designers to find formal design ideas unlike final drawings [1]. The ambiguity of drawing may be obtained with irregular overlays of various colors, in shapes, spaces, lines, or in images with any specified degree of irregularity. Fraser and Henmi also argue the importance of ambiguity and irregularity in drawings [2]. Designers draw shapes from their minds’ eye or preconceived images and develop further by combining additional shapes. This process is repeated until the drawing becomes closer to the designer’s preconceived images.

Computers can play an important role as a creative

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partner in design practice by generating multiple formal ideas or possible solutions. Various research efforts such as shape grammars and algorithmic shape generation have explored this approach [3]. These generative systems are based on the basic concept of computation: input information is transformed or operated to produce outputs following a series of algorithms. Using this computational design process, various generative drawing machines have been developed with shape manipulation algorithms. The common goal of these systems is to generate drawings using computer algorithms. In other words, a designer uses this system to investigate formal design idea and explain the generated form with the computer algorithms.

For a long time, music has played a tremendously important role in the stylistic development of visual art. It has created impetus and inspiration for those artists wishing to produce a pure and transcendental art form. Music has also been used as an analogy or metaphor in artistic expression. By listening to music and emulating it in their work, artists have discovered unconventional techniques in their art-making approach. For instance, Kandinsky was fascinated by music's emotional power [4]. Kandinsky could get a freedom of imagination, interpretation, and emotional response from music which expresses through sound and time.

This paper proposes a generative drawing system called m-shaper for shape and sound generation. Through the variation of pen movements, users of m-shaper perform music and develop their sketch drawing as well. The shapes consist of a set of points that contains the graphical music annotation. By developing this system, this paper investigates two major research issues: generative algorithms for shape and sound generation with sketch drawing, and easy control of the generation process. Shape and sound generation algorithms can be modified to create more complicate shape patterns. Moreover the algorithms can be embedded with a visual and musical knowledge that controls the shape generation and manipulation.

The rest of this paper is divided into four parts. Chapter 2 describes related work, including example applications of generative drawing system and graphical notation systems for music. Chapter 3 gives an overview of the m-shaper system and the overall use. Chapter 4 explains how sketch movements are sensed, and Chapter 5 describes the musical note generation. In Chapter 6, the shape generation is explained with a set of rules with possible drawing examples. Finally, Chapter 7 concludes with a discussion and identifies topics for future work

2. Related Work

2.1 Shape Generative System

There have been several approaches to use a set of rules to analyze and describe a certain design style and generate new designs. For example, Stiny developed an ice-ray grammar to describe Chinese lattice design variations and explained how a computer could generate different lattice design patterns [5].

Some generative software systems help designers to explore formal design ideas by defining or controlling the rules that manipulate shapes or forms. Shape grammar applications showed how a set of shapes and spatial relations could generate 2D shape configurations. GEdit allows a designer to draw and manipulate shapes to define a spatial relation and a set of rules [6].

2.2 Graphical Music Notation

There have been various research approaches for the alternative representation of the musical notation [7]. John Cage's Fontana Mix is an example of instant musical performance by generating and converting shapes [8]. Independent transparent layers are used each on which has points, lines, curves, and surfaces are positioned. They re-arranged the layers for each performance for variation. Hans-Christoph Steiner

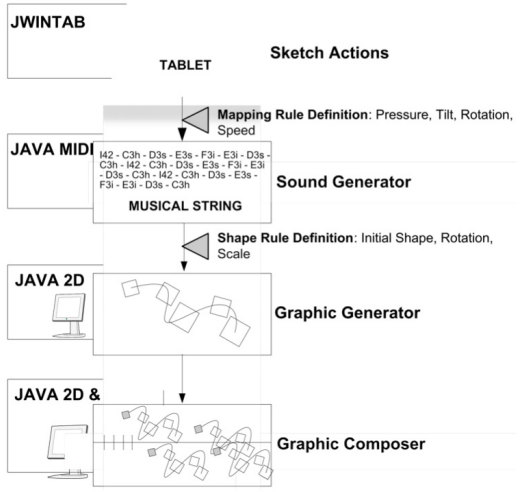
created graphical score called Solitude using Pure Data's data structures. Solitude notation may be, like music on traditional staves, a time-pitch graph system which is still represented by reading left-to-right [9]. It provides for seamless intermixing of melody and timbre and the interplay between the two. Notation is a modern compendium and anthology of graphical scores inspired by John Cage's Notations [4].

There are various approaches to develop new instruments investigating the relationship between technological developments and music visualization. A.W. Rimington developed color organs that display modulated colored light in some kind of fluid fashion comparable to music [10]. To create a visual music comparable to auditory music, artists such as Oskar Fischinger, Len Lye and Norman McLaren found its fulfillment in animated abstract films. The rapid advances of computer technologies encourage the development of a system to visualize the sounds.

3. Overview

3.1 System Overview

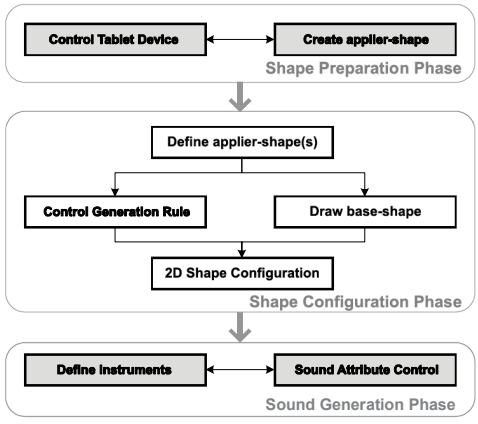
m-shaper consists of four main modules: sketch actions, sound generator, graphic generator, and graphic composer as illustrated in Fig. 1. When a user draws a sketch, the pen movement is digitalized with four types of information (orientation, tilt angle, pressure, and speed) with numerical parameters and labeled with musical notes. In this step, users can change the mapping rule between the type of pen movement and the musical notes. The musical notes are played through the Java MIDI library. The graphic generator creates shapes following a set of shape transformation rules (rotation, scale, move, shape) generated from each of the corresponding musical notes. In the graphics composer, users can manipulate the generated shapes for final drawings.



[Fig. 1] System overview with the four main modules: sketch actions, sound generator, graphic generator, graphic composer

3.2 m-shape in Action

During the sketch, users in m-shape follow three phases: the shape preparation phase, the shape configuration phase, and the sound generation phase as shown in Fig. 2.



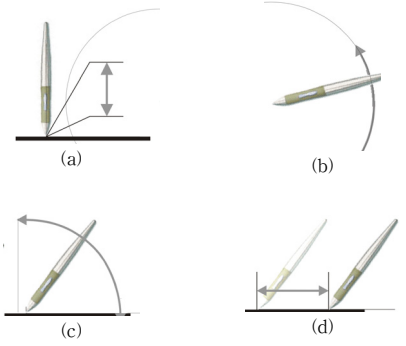
[Fig. 2] Three phases drawing process in the m-shaper: the shape preparation phase, the shape configuration phase, the sound generation phase

In the shape preparation phase, a designer creates the shapes which will be used as an applier shape. Then the designer draws base-shapes which are

attached with the applier-shapes. He can control the applying process by changing the shape generation rules. In the sound generation phase, the designer defines an instrument and controls the sound attributes such as duration, pitch, and octave in detail to play the music.

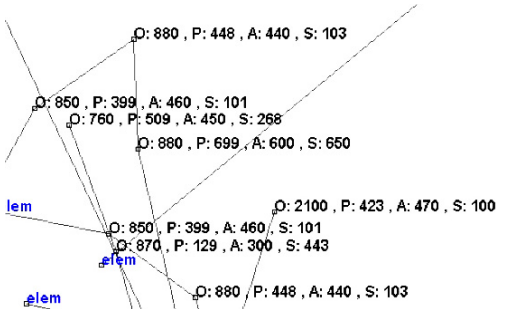
4. Sketch Motion Sensing

A tablet device is used for sensing the sketch motion information. Currently, the Wacom tablet provides four types of pen movement information such as pressure, tilt angle, rotation angle and the vertical and horizontal position as illustrated in Fig. 3.



[Fig. 3] Four sketch drawing movements (a) pressure (b) rotation (c) tilt (d) position

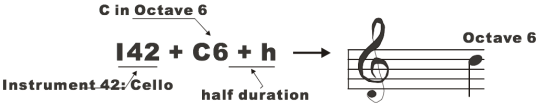
When users move the pen on the tablet, the system generates a series of points which contain X and Y coordinates and four sketch information (pressure, tilt, rotation, and speed). New point is added whenever there is any change in the six parameters. For example, one point will be created when the tilt angle of the pen is changed even without any change in the x and y coordinates. Fig. 4 shows the sketch drawing points with four types of movements parameterized into numerical numbers.



[Fig. 4] Example of the parameterized sketch information with each sketch point (O: orientation, P: pressure, A: tilt angle, and S: speed)

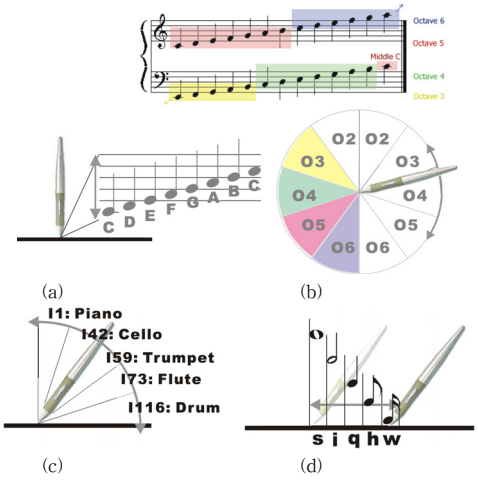
5. Musical Note Generation

The captured sketch information is used to create musical notes with four types of musical information (instrument, note, octave, and duration). Each point of the shapes corresponds to a certain sound that is based upon the four musical elements. As illustrated in the Fig. 5, the musical note consists of four parts: instrument number (I1 ~ I143) musical note (A, B, C, D, E, F, G), an octave number (1 ~ 10) and duration code (w: whole duration, h: half duration, q: quarter duration, i: eighth duration, and s: sixteenth duration). This musical note is used not only to play music but also to generate shapes for the shape generative rules.



[Fig. 5] Musical note to represent instrument, octave, duration, and note.

Fig. 6 shows how sketch movements can be mapped to the components of the music note. For example, pressure is mapped to a music pitch and the octave is used for rotation. The tilt selects the types of instruments. The speed is for the duration of a sound. After setting the movements with musical elements, users can define the number of range and the value of each zone related to the elements of musical note.



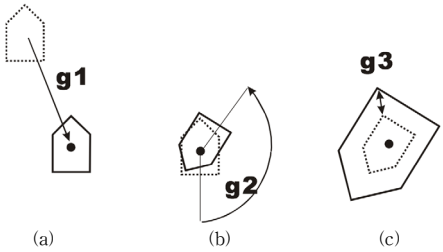
[Fig. 6] Sketch movement-mapping examples with musical note information: (a) pressure to pitch, (b) orientation to octave, (c) tilt angle to instrument (d) speed to duration.

The music notes are played following the order of the points. There are two different modes to perform a sound relative to the sketch action: a line mode and a point mode. Line mode makes a series of sound when one stroke that consists of several points is finished. In the point mode, users can listen to each sound whenever the sketch point is generated.

6. Shape Generation

6.1 Shape Generation Rule

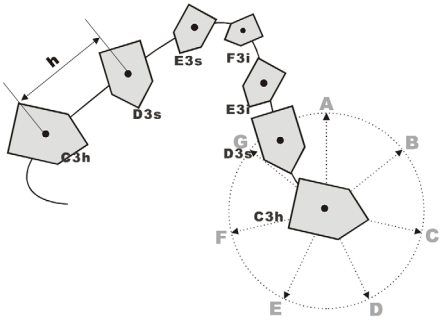
m-shaper records a series of points from the sketch movements, and generates shape configurations based on the musical information as described in the previous session. m-shaper is developed based on the shape generative system ArchiDNA developed by the author [11]. The sketch line by the user becomes the base-shape and the attached shapes are called as an applier-shape. The shape configuration is a collection of applier-shapes positioned on each point of the base-line. To generate shapes, there is a set of rules of the shape generation and transformation with five elements {S, L, G, B, A}. B is the base shape to which the rule and source shapes apply to start a computation. A is an applier shape to act as a source for replication and as the base shape for orientation. S is a set of shape rules of the form [A → B] that specifies how an applier-shape (A) can be transformed to the base shape (B). S is a set of three parametric rules: Rule 1 (move), Rule 2 (rotate) and Rule 3 (scale) [Fig. 7]. G is a set of parameters that assign values to transformation rules - the width and angle of each shape. L labels the location from which shapes are drawn by changing the way in which parameters (G) given to the rule (S) are interpreted. Fig. 7 shows one pentagon shape is moved, rotated and scaled on a single point.



[Fig. 7] Shape transformation rules: (a) move, (b) rotate, and (c) scale

6.2 Shape Derivation

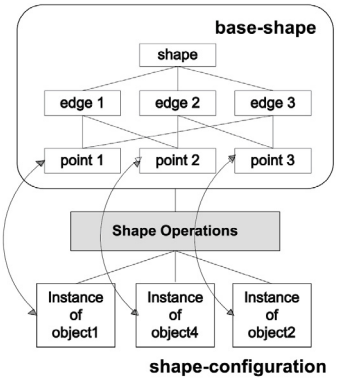
To generate the drawings by using the rules, a designer starts with an applier-shape source and draw using a tablet pen indicating the sequence of reproduction. The parameters of the rules are set by the musical note generated by sketch points. Fig. 8 shows the derivation of the shapes following the rule set of the musical note. As the designer draws a line, m-shaper makes a copy of the shape for every point of the base shape, rotate, and scale it so that the shapes represent the sketch gestural characteristics and musical properties. For instance, the shape type can be mapped to the instrument type, the shape size to the musical pitch, the distance between the shapes to the musical duration.



[Fig. 8] Example of shape derivation with a series of musical notes

6.3 Shape Data Model

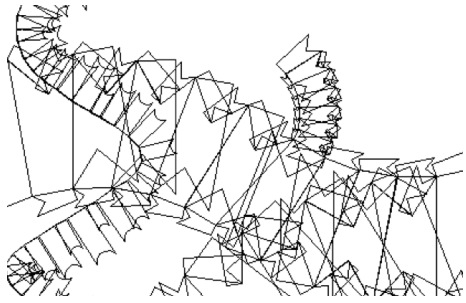
m-shaper has a simple data structure to represent the 2D shapes with musical notes. Fig. 9 shows how the system generates shape configurations by referencing shapes. Instances of shape objects are linked to the points of the base-shape. The system transforms the instances to match and attach to the points. For this, m-shaper sets a location for translation and calculates an angle for rotation and a scale-factor for scaling, using the points of the base-shape.



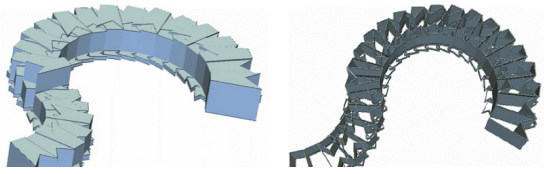
[Fig. 9] Shape data model for shape generation and configuration

6.4 Drawing Examples

The current m-shaper is a 2D drawing system. Similar to other drawing systems, It supports a set of basic drawing functionalities for creating and editing the shapes. One of important parts in developing drawing systems is to demonstrate how to use m-shaper to meet the particular design goals. The m-shaper drawings can be saved as an Adobe illustrator file format, and used in other 2D and 3D software. One of the possible scenarios is to use it as a schematic plan drawing for the architectural design. The m-shaper drawing [Fig. 10] is developed further to 3D form [Fig. 11] using the 3D solid modeling program called formZ [12].



[Fig. 10] Example of 2D sketch drawing in the m-shaper



[Fig. 11] Example of 3D form design by extruding 2D drawing the generated from the m-shaper.

7. Conclusion

This paper described an interactive sketch drawing system called m-shaper for creating 2D conceptual drawings. One key ingredient is a unique concept for the interactive musical shape generation that combines shape and sound based on the designers' manual inputs. m-shaper is a working system. It efficiently manages generation of shape configurations and sounds. However, there are more features one could add. For instance, the current m-shaper does not support composing an entire music by arranging the musical shapes. To do this, m-shaper can support a

horizontal bar that acts as a musical timeline to play music from left to right. This bar represents the tempo of music and specifies the order of musical shapes. Moving the shapes into the right position of the bar, we can compose music.

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