FROM MUSICAL SCORE TO GRAPHIC PLAN: THE DEVELOPMENT OF SUM AS A DESIGN TOOL

Mika Kuuskankare
Sibelius Academy – DocMus
mkuuskan@siba.fi

Sara Adhitya
EHESS / IUAV / IRCAM
sara.adhitya@eheess.fr

ABSTRACT
This paper presents the latest developments of the SUM tool, aimed at the integration of image and sound. A user library within the PWGL visual programming environment, it allows both image sonification and graphical computer-aided composition. Initially developed for the sonification of graphic urban maps, in which MIDI data is generated from graphics, the SUM process can now be reversed, with MIDI being the generator of the graphics themselves. We present three new developments which allow this: the ability to import MIDI into SUM to generate spatio-temporal vector time-paths; the ability to access the temporal structure of these paths through its points; and the ability to draw vector objects and develop a custom-made object library. These functions will allow us to generate graphics from music, which may form the basis of future works of ‘visual music’ as well as the musical-generation of graphical designs.

1. INTRODUCTION
The SUM tool [1] is a user library with a graphical user interface within the computer-aided composition environment of PWGL [2]. Initially designed for the sonification of images, through a user-defined mapping process, it also allows a graphical approach to computer-aided composition. [3]

The field of graphic-based computer-aided composition spans from Xenakis’ pioneering UPIC, to CAC software such as OpenSampling, and image sonification toolkits such as SonART [4]. However, the former was limited to piano-roll lecture, the second allows the description of object-based notation [5], and the third permits the scanning and exploration of imported raster images.

SUM combines all three approaches to allow both the pixel-by-pixel exploration of a score as an image, its temporal reading from any number of angles, and the ability to generate images internally. It also supports the use of multiple time paths, allowing the lecture of the image from different perspectives.

Previously, we have explored the use of this multi-dimensional spatio-temporal structure in the computer-aided composition of graphic scores. In this paper, we explore how SUM can be used as a graphic composition tool in the design field.

After first presenting an overview of the existing structure of the SUM tool, we introduce its three latest developments in light of this structure: the ability to import MIDI files as vector paths; the ability to access the temporal structure via the individual points on a path; and the ability to draw objects ‘frehand’ and create a library of custom-designed shapes.

In order to demonstrate how these new functions allow the ‘musical’ generation of a graphic composition, we apply it to an urban design project. By importing a MIDI file of interest, we use SUM to visualize the temporal structure of the music, allowing its direct application in design, or as a basis for design development.

Thus in this paper, we explore the SUM tool as a temporal approach to graphical design.

2. EXISTING STRUCTURE
In this section we outline the existing spatio-temporal structure of SUM, consisting of multiple image layers and vector time paths.

2.1. Timing in SUM
When translating information between the visual and auditory domains, the structuring of time needs to be addressed. Most sonification tools are limited to a single horizontal time axis, in the style of a piano-roll. However, SUM allows us to access the images from any direction and at any speed through the drawing of a vector polyline over the image(s). Through its subsequent application in the mapping process, the path samples the image(s) according to Bresenham’s line algorithm [6].

2.2. Images in SUM
SUM allows the co-existence of both raster and vector images. It also supports the layering of multiple images, allowing them to be played simultaneously, even when covering one another. Thus we can compose multi-layered graphic compositions, from both existing images and new vector objects.

In SUM, images are used as musical ‘data-sources’. Raster images can be imported, and the spatial scale depends on the resolution of the image in dpi. Vector objects can also be created within the tool. SUM supports the superimposition of multiple images, which can be seen to form a 3D matrix. This layered structure of image data-sources can be seen as the equivalent of simultaneous parts. Images can either be read independently or in combination with each other.

2.3. A multi-dimensional structure
Through the combination of multiple image layers and vector time paths, SUM can be seen to support the composition of multi-dimensional spatio-temporal structures. Previously used to compose graphical musical scores, it is equally adapted to the composition of temporal graphical designs. Based on this structure, in the following section we will explain the implementation of SUM’s latest developments.

3. IMPLEMENTATION
The new developments to SUM allow greater flexibility to manipulate this spatio-temporal structure through the ability to: 1) import a MIDI file as a time path; 2) access the temporal structure of a path through its individual points; and 3) create custom vector shapes by ‘frehand’ drawing using an Object Illustrator.

3.1. MIDI Importation
A standard MIDI file can be imported as a path layer. The MIDI tracks are converted into paths and each event in the track is converted into a point. The points have default spatial positions that are calculated according to the start times of the associated MIDI events. The time resolution, i.e. pixels per second, can be defined by the user. By default, the events are arranged along a straight horizontal line to ensure synchronization between the tracks.

Figure 2 demonstrates four new point functions. In Figure 2 (a) the speed of the second line segment is set to 128 units. The definite speed of the line segment depends on the speed unit of the enclosing path. The points not showing speed values use the default speed set by the path.

Figure 2 (b) shows the ability of points to be silenced. The line segment following a silenced point consumes the same amount of time as a normal line segment but produces no sound. A silenced line segment is represented as faded.

The points can also be made ‘discrete’, which means that the following line segment is not rasterized at all. A discrete point skips the subsequent line segment and playback is resumed from the next non-discrete point onwards. These skipped line-segments are shown in Figure 2 (c) as dashed lines.

Finally, each point can be assigned an individual shape, as shown in Figure 2 (d). The shapes are displayed instead of the standard point. Custom shapes can be created using the SUM vector object Illustrator.

3.3. Object Illustrator
SUM has a built-in Illustrator, which allows for the user-definition of vector objects. The SUM Object Illustrator is a drawing tool that can be used to create open or closed polygons. Open polygons are generally used as...
FROM MUSICAL SCORE TO GRAPHIC PLAN: THE DEVELOPMENT OF SUM AS A DESIGN TOOL

Mika Kuuskankare
Sibelius Academy – DocMus
mkuuskanka@siiba.fi

Sara Adhitya
EHES/ IUAV/ IRCAM
sara.adhitya@ehess.fr

ABSTRACT
This paper presents the latest developments of the SUM tool, aimed at the integration of image and sound. A user library within the PWGL visual programming environment, it allows both image sonification and graphic computation. Initially developed for the sonification of graphic urban maps, in which MIDI data is generated from graphics, the SUM process can now be reversed, with MIDI being the generator of the graphics themselves. We present three new developments which allow this: the ability to import MIDI into SUM to generate spatio-temporal vector paths; the ability to access the temporal structure of these paths through its points; and the ability to draw vector objects and develop a custom-made object library. These functions will allow us to generate graphics from music, which may form the basis of future works of ‘visual music’ as well as the musical generation of graphical designs.

1. INTRODUCTION
The SUM tool [1] is a user library with a graphical user interface within the computer-aided composition environment of PWGL [2]. Initially designed for the sonification of images, through a user-defined mapping process, it also allows a graphical approach to computer-aided composition. [3]

The field of graphic-based computer-aided composition spans from Xenakis’ pioneering UPIC, to CAC software such as OpenVGL [3], and image sonification toolkits such as SonART [4]. However, the former was limited to piano-roll lecture, the second allows the description of object-based notation [5], and the third permits the scanning and exploration of imported raster images.

SUM combines all three approaches to allow both the pixel-by-pixel exploration of a score as an image, its temporal reading from any number of angles, and the ability to generate images internally. It also supports the use of multiple time paths, allowing the lecture of the image from different perspectives.

Previously, we have explored the use of this multi-dimensional spatio-temporal structure in the computer-aided composition of graphic scores. In this paper, we explore how SUM can be used as a graphic composition tool in the design field.

After first presenting an overview of the existing structure of the SUM tool, we introduce its three latest developments in light of this structure: the ability to import MIDI files as vector paths; the ability to access the temporal structure via the individual points on a path; and the ability to draw objects ‘frehand’ and create a library of custom-designed shapes.

In order to demonstrate how these new functions allow the ‘musical’ generation of a graphic composition, we apply it to an urban design project. By importing a MIDI file of interest, we use SUM to visualize the temporal structure of the music, allowing its direct application in design, or as a basis for design development.

Thus in this paper, we explore the SUM tool as a temporal approach to graphic design.

2. EXISTING STRUCTURE
In this section we outline the existing spatio-temporal structure of SUM, consisting of multiple image layers and vector time paths.

2.1. Timing in SUM
When translating information between the visual and auditory domains, the structuring of time needs to be addressed. Most sonification tools are limited to a single horizontal time axis, in the style of a piano-roll. However, SUM allows us to access the images from any direction and at any speed through the drawing of a vector polyline over the image(s). Through its subsequent application in the mapping process, the path samples the image(s) according to Bresenham’s line algorithm [6].

2.2. Images in SUM
SUM allows the co-existence of both raster and vector images. It also supports the layering of multiple images, allowing them to be played simultaneously, even when covering one another. Thus we can compose multi-layered graphic compositions, from both existing images and new vector objects.

In SUM, images are used as musical ‘data-sources’. Raster images can be imported, and the spatial scale depends on the resolution of the image in dpi. Vector objects can also be created within the tool. SUM supports the superimposition of multiple images, which can be seen to form a 3D matrix. This layered structure of image data-sources can be seen as the equivalent of simultaneous parts. Images can either be read independently or in combination with each other.

2.3. A multi-dimensional structure
Through the combination of multiple image layers and vector time paths, SUM can be seen to support the composition of multi-dimensional spatio-temporal structures. Previously used to compose graphical musical scores, it is equally adapted to the composition of temporal graphical designs. Based on this structure, in the following section we will explain the implementation of SUM’s latest developments.

3. IMPLEMENTATION
The new developments to SUM allow greater flexibility to manipulate this spatio-temporal structure through the ability to: 1) import a MIDI file as a time path; 2) access the temporal structure of a path through its individual points; and 3) create custom vector shapes by ‘frehand’ drawing using an Object Illustrator.

3.1. MIDI Importation
A standard MIDI file can be imported as a path layer. The MIDI tracks are converted into paths and each event in the track is converted into a point. The points have default spatial positions that are calculated according to the start times of the associated MIDI events. The time resolution, i.e. pixels per second, can be defined by the user. By default, the events are arranged along a straight horizontal line to ensure synchronization between the tracks.

3.2. Temporal Points
Previously, the paths were traversed by SUM in their entirety and at a constant speed. The speed could be assigned to each path, either defined spatially - in metres or kilometres per second – or temporally, such as the beats per second used in music. However, the temporal structure of a path could not be altered within itself.

Now, SUM supports additional point types that can be used to control the rasterization process. Every point can now be assigned an individual speed, which determines the speed of the line segment immediately following. Thus individual line segments of the same path can now be assigned different speeds.

Figure 2 demonstrates four new point functions.

Figure 2 (a) shows the speed of the second line segment is set to 128 units. The definite speed of the line segment depends on the speed unit of the enclosing path. The points not showing speed values use the default speed set by the path.

Figure 2 (b) shows the ability of points to be silenced. The line segment following a silenced point consumes the same amount of time as a normal line segment but produces no sound. A silenced line segment is represented as faded.

The points can also be made ‘discrete’, which means that the following line segment is not rasterized at all. A discrete point skips the subsequent line segment and playback is resumed from the next non-discrete point onwards. These skipped line-segments are shown in Figure 2 (c) as dashed lines.

Finally, each point can be assigned an individual shape, as shown in Figure 2 (d). The shapes are displayed instead of the standard point. Custom shapes can be created using the SUM vector object Illustrator.

3.3. Object Illustrator
SUM has a built-in Illustrator, which allows for the user-definition of vector objects. The SUM Object Illustrator is a drawing tool that can be used to create open or closed polygons. Open polygons are generally used as...
paths. The shapes can be drawn using either a freehand mode or by inputting discrete points, as well as using a combination of both. A finished shape can be modified through the point selection mode, which allows the point handles to be manipulated by dragging. If more precise manipulation is needed, a single control point handle can be selected and repositioned by entering the exact coordinate values.

The vector objects created within the SUM Object Illustrator can be individually moved, resized, and modified. They can also be copied or pasted. The line thickness, color and position of each object are defined when applied to a SUM vector layer.

Furthermore, the vector objects can also be defined algorithmically. This allows for the definition of shapes that are difficult to draw by hand, such as, circles or bezier curves. Every aspect of the points in the shape, in addition to the coordinates, can be controlled algorithmically.

The vector objects can then be saved with the active project or they can be saved as global shapes making them accessible from any SUM project. Thus a SUM Object Library can be developed by the user.

4. APPLICATION TO DESIGN

In order to demonstrate the use of SUM as a design tool, here we apply it to an urban design project. We use the MIDI file of a piece of music to compose urban design elements along selected paths of interest, and thus inform the urban experience along them.

4.1. Raster image and Vector path

First, a raster image of the site was imported, and the path of interest drawn as vector paths. One path is drawn along the road, shown in dark green, while the other is to be generated within the park (light green).

4.2. MIDI-to-Path Mapping

The chosen music can then be mapped to the selected vector path using SUM’s MIDI import function. We have chosen to map Steve Reich’s Piano Phase [7], consisting of a two identical lines of music (a 12-tone melody) which are played at slightly different speeds so that they phase in and out. The MIDI file consists of two tracks, one for each piano part, shown in two different colors in the piano-roll below.

4.3. Graphical manipulation of MIDI path

After importation, we chose to maintain one MIDI path at the original speed to structure elements along the road, and manipulate the other path to generate a more flexible design for the park.

4.4. Point-to-shape mapping

Finally, we apply the tree object created earlier using our Object Illustrator and saved in our SUM Object Library (see Figure 3). We map this object to the points of the park path, and use it to generate a tree layout for the park, shown in Figure 7 below.

Figure 3. A tree object created in the Object Illustrator and saved to its Object Library for later usage (see Figure 7).

Using the Object Illustrator option panel (Figure 3), several options can be selected.

a) A mirror symmetry mode can be used to define vector objects that are symmetrical on either the x or y axes.

b) A background grid can be displayed to aid with both scaling and drawing. The size of the grid can be user-defined. By selecting the ‘snap-to-grid’ option, the points can be automatically aligned to the nearest grid intersection. Grid alignment can also be applied afterwards to the whole shape or to a selection of points.

A line simplification algorithm can also be applied to the object. Currently, we use two simplification methods. The simpler of the two just reduces the number of points in the shape by half, i.e., every second point is removed. The second algorithm is implemented using the Ramer-Douglas-Peucker line simplification algorithm. [6]

The resulting piano roll shows the modified ‘rhythm’ of the modified park path, compared to the original rhythm of the linear road path.

Figure 4. Imported raster image of site and drawn vector paths and areas of interest.

Figure 5. The MIDI file of Reich’s Piano Phase represented as a piano-roll with two tracks (blue and black).

Figure 6. Piano roll showing the contrasting rhythms of the original path (blue) and the modified path (green).

Figure 7. Resulting tree layout for the park.

5. CONCLUSIONS

In this paper, we have explored the use of SUM as a design tool. Through the development of three new functions – MIDI import, temporal-manipulation of points, and the Object Illustrator – we have been able to map music as MIDI to user-defined vector graphics and subsequently modify them both spatially and temporally.

As an example, we applied these tools to an urban design project. We generated a tree layout for a park design based on Reich’s Piano Phase. Thus this paper is also the beginning of an exploration of how music can be used to inform the composition of urban experience.

These developments have allowed us to develop the SUM tool, from an image-sonification tool and a music composition tool, to a graphical design tool. In the future, this approach could be used to generate a new graphical language for music representation.

6. ACKNOWLEDGEMENTS

The authors would like to thank IRCAM and CCRMA for hosting the research. The work of Sara Adhitya has been supported by the Academy of Finland (SA137619).

7. REFERENCES


[6] [Accessed February 2013]

paths. The shapes can be drawn using either a freehand mode or by inputting discrete points, as well as using a combination of both. A finished shape can be modified through the point selection mode, which allows the point handles to be manipulated by dragging. If more precise manipulation is needed, a single control point handle can be selected and repositioned by entering the exact coordinate values.

The vector objects created within the SUM Object Illustrator can be individually moved, resized, and modified. They can also be copied or pasted. The line thickness, color and position of each object are defined when applied to a SUM vector layer.

Furthermore, the vector objects can also be defined algorithmically. This allows for the definition of shapes that are difficult to draw by hand, such as, circles or bezier curves. Every aspect of the points in the shape, in addition to the coordinates, can be controlled algorithmically.

The vector objects can then be saved with the active project or they can be saved as global shapes making them accessible from any SUM project. Thus a SUM Object Library can be developed by the user.

4. APPLICATION TO DESIGN

In order to demonstrate the use of SUM as a design tool, here we apply it to an urban design project. We use the MIDI file of a piece of music to compose urban design elements along selected paths of interest, and thus inform the urban experience along them.

4.1. Raster image and Vector path

First, a raster image of the site was imported, and the path of interest drawn as vector paths. One path is drawn along the road, shown in dark green, while the other is to be generated within the park (light green).

4.2. MIDI-to-Path Mapping

The chosen music can then be mapped to the selected vector path using SUM’s MIDI import function. We have chosen to map Steve Reich’s “Piano Phase” [7], consisting of a two identical lines of music (a 12-tone melody) which are played at slightly different speeds so that they phase in and out. The MIDI file consists of two tracks, one for each piano part, shown in two different colors in the piano-roll below.

4.3. Graphical manipulation of MIDI path

After importation, we chose to maintain one MIDI path at the original speed to structure elements along the road, and manipulate the other path to generate a more flexible design for the park.

4.4. Point-to-shape mapping

Finally, we apply the tree object created earlier using our Object Illustrator and saved in our SUM Object Library (see Figure 3). We map this object to the points of the park path, and use it to generate a tree layout for the park, shown in Figure 7 below.

The resulting piano roll shows the modified ‘rhythm’ of the modified park path, compared to the original rhythm of the linear road path.

ACKNOWLEDGEMENTS

The authors would like to thank IRCAM and CCRMA for hosting the research. The work of Sara Adhitya has been supported by the John Crampton Scholarship Trustees of Australia. The work of Mika Kuuskankare has been supported by the Academy of Finland (SA137619).

REFERENCES