Graph Composer: music composition from graph design

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Abstract. *The Graph Composer is an app that allows the user to compose music through the design of a graph. You can create or modify an existing graph, listen and modify the composition in real time. Insert new nodes and connect them, change the corresponding note by clicking over the node and selecting a new one from the scale, define it's duration over time and select a decoration to change the sound sequence.*

1 Background and motivation

A graph [1, 2] is a mathematical object consisting of a set vertices and edges that connect them. Each vertex can have several attributes or values depending on what is being modeled. The edges can have direction, in which case we talk about a directed graph.

In the Graph Composer, each vertex represents a note and it's duration over time. The edges connecting the vertices define a path over which the graph will be traversed, playing the notes on the sequence of connected vertices. The sound produced by each vertex has different forms according its decoration: a single note, chord or arpeggios.

For example, taking the following score, from Figure 1, it can be represented as a directed graph (Figure 2). Paths are the possible sequences of vertices that can be traversed in a graph. In this example, the graph has a unique possible path, but when there is more than one edge leaving a vertex, multiple paths are possible.

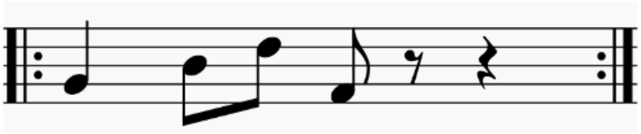

Figure 1: An example score

The app proposes to the public the possibility to compose music through a priori mathematical modeling, so they can both understand how a graph is represented and built as well as how the model is applied to musical compositions.

The app encourages the user to try and discover new graph constructs and forms that may sound pleasing or even unexpected.

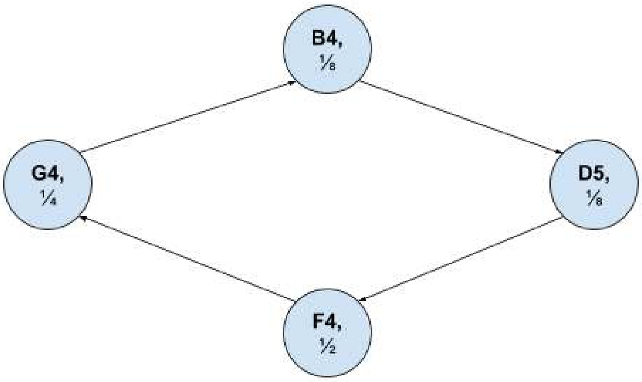

Figure 2: Directed graph representing the score from Figure 1

2 Model of the Graph Composer

The model used for the Graph Composer is actually applied in Computational Musicology research, an area where mathematics and computer science are applied to music. In research, the model is used to represent and analyze musical compositions. In the research, compositions are modeled as graphs to compare and extract different mathematical features. For example: the number of times that a transitions from one note to another is repeated, or the number of times that three (or more) different notes appear in the same sequence, among others.

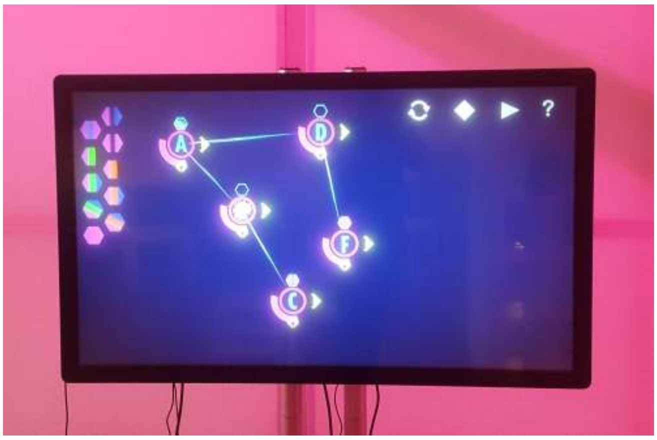

Figure 3: Setup of the app in a touch screen monitor

The app offers the possibility to compose music through the mathematical model of paths over graphs. The program walks paths along the graph from the root vertex through the directed edges until it finds a vertex with no outwards edges, when it returns to the root vertex. How it

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looks can be seen in the setup of Figure 3, and an example of the app in use can be seen Figure 4.

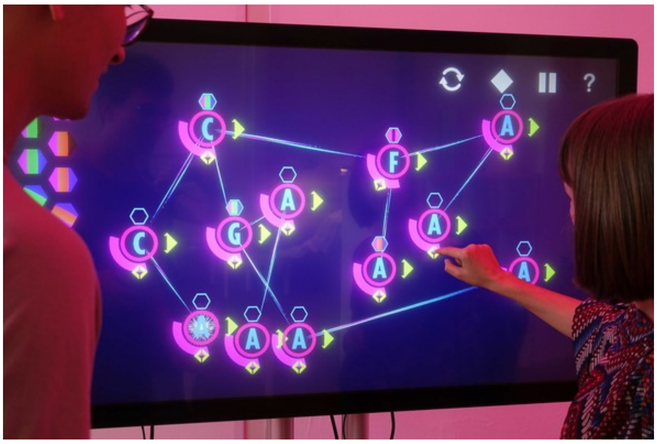

Figure 4: Usage of the app

In an empty setting, the user will find only the root vertex (one with no incoming edges), which he can grow adding new vertices and edges. The attribute of the vertex are: a note, a decoration and a time duration. The user can modify the note by clicking the vertex, the time duration using the slider in the side of the vertex and the decoration by dragging the available ones from the palette located in the left of the screen. The user can delete vertices dragging then out of the screen, and also delete edges by swiping their finger over it.

In the case that there exists more than one possible path in the graph, the program will choose one randomly. This means that when the program reaches a vertex with more than one outward edge it will choose one randomly. This creates what we call random walks through the graph. Since the music produced by each path could have different durations, the user may perceive this as some kind of arrhythmia

The app uses a minimalist design, with highly visual choices and options, but the user can still produce complex outcomes.

The app should lead the user to:

- Grasp the mathematical abstraction of a graph and its independence of its drawing. This is achieved by showing how the music played depends merely on the attributes of the vertices and the edges drawn, since the position of the vertices in the screen has no effect on the resulting music.
- Think the music as sequences of both simple and compound sounds. This is achieved by showing how several sounds can be represented by a unique symbol (chords and arpeggios) or that, conversely, simple musical representations can be enriched with this kind of musical structures. This resources are widely used by musicians to enrich interpretations of known music compositions as well as in improvisation.

3 Infrastructure and target audience

The infrastructure required for this application is very short: a touch screen monitor, a computer to run the app and speakers or a headphone. The setup should not take much space and it is intended to be located in a place where people can pass by and play with it for a few minutes.

Graph Composer was developed to be simple and encourage the user to try music in a game like way. The app is intended to reach a good range of people, besides being a very funny platform to learn some basic concepts of music and math, it can be seen in use on Figure 4.

References

[1] Reinhard Diestel. *Graph theory*. 5 edition, 2016.

[2] John Adrian Bondy, Uppaluri Siva Ramachandra Murty, et al. *Graph theory with applications*. Citeseer, 1 edition, 1976.