

1 Introduction

1.1 Introduction

1.2 Summary of work completed

1.3 Motivation

1.4 Thesis structure

2 Background to study

2.1 Introduction

- Introduce what will be discussed in this section
- A brief historical perspective

2.2 The idea generation stage of music production

Introduction Give an overview of different stages of music production as outlined in [duignan_computer_2008] and end with focus on the initial idea generation

- Using an instrument
- Scoring software
- Quirky music tools such as “Loopy”
- Most commonly in electronic music, DAWS

2.3 Discussion of DAW Metaphors

1. Introduction
2. Piano roll
3. Mixing console
4. Plugins

2.4 Discussion of more open systems

1. Introduction
2. Textual programming systems
 - Supercollider
 - Csound

- Commonmusic
 - Nyquist
 - Chuck
3. Graphical programming systems
 - Max MSP
 - Pure data
 - Ircam Open music
 - Plogue Bidule
 - Jeskola Buzz

2.5 Music in the browser: a new frontier

Discuss drum machines, etc available on the web. Note the accessibility that they provide. Perhaps introduce tone.js here.

2.6 Conclusion

While the dominant metaphors used in DAWs have their uses they can lead to limitations in the creative process particularly at the early stage of ideas creation. More open system give too much power and impede the creative process.

3 Similar work

3.1 Introduction

3.2 Sonic sketching from a historical perspective

1. Visual music
 - (a) Oskar Fischinger
 - (b) Fantasia
2. Legacy synth systems
 - (a) Oramics
 - (b) UPIC
 - (c) ANS synth

3.3 Sonic sketching in the twenty first century

1. Golan Levin [@levin_painterly_2000]
2. Music animation machine [@malinowski_music_2017]
3. SonicPainter by William Coleman [@coleman_sonicpainter:_2015]
4. Fischinger google doodle

3.4 Alternative music systems on the web

1. Pink trombone - <https://dood.al/pinktrombone/>
2. Tonehack
3. Auraglyph (although not web based)
4. <http://arthurcarabott.com/mui-envelope/>

3.5 Summary of currently available music creation systems

(Note that UPIC style sketch synths are not available online)

3.6 Conclusion

Both the twentieth and twenty first century have seen a great deal of experimentation with ideas of visualizing music and sketching. The audio processing capabilities available in modern browsers offers an opportunity to explore and refine less mainstream music creation metaphors.

4 My approach

4.1 Introduction

4.2 Appraisal of options

4.3 Approach - theory

4.3.1 HCI considerations

4.3.2 The Musical Interface Technology Design Space (MITDS)

4.3.3 Cross modal perception

4.4 Approach - practice

4.4.1 Delivery on Web Browser

4.4.1.1 Modern Web Browser as a delivery platform

4.4.1.2 Benefits of using Tone.js cite:mann_interactive_2015

4.4.1.3 Paper.js for the graphics system

4.4.1.4 FM synthesis :: Give a brief overview of FM synthesis and why it was a

good choice for the application

4.4.1.5 Live coding workflow

4.4.1.5.1 Introduction

4.4.1.5.2 React.js framework

React is a web framework built by Facebook that aids the developer in updating the DOM (Document Object Model), a process that is required when the state of the application changes. This was a role traditionally carried out on the server and served to users as a static page. This all changed however with the rise of Single Page Applications (SPA) around the 2000s. The value proposition of the SPA is increased interactivity and responsiveness to user input allowing the look and contents of the page to update dynamically as the user interacts with the system. To aid the construction of these SPA's a number of frameworks to help the process were introduced by the community. Some popular early examples include backbone.js and angular.js. An increasingly popular option was a system called two way binding which created two way link between the current state in the model to the visual appearance of the view. This however has a number of issues including some serious performance issues, in addition to some conceptual problems. React offers a simpler one way binding system using what is termed the Virtual DOM. In the model a special virtual version of the DOM is constructed and when the model changes is updated. The parts of the DOM that require changing can thusly be pinpointed and the real DOM can be updated or reconciled in the parlance of React. This system has proven to be particularly beneficial when paired with functional programming techniques, a style of programming that emphasizes the use of pure functions as the primary building block of programs. In the case of working with the DOM, it can lead to an increase in efficiency in the rendering of the applications as well as a simplification of the programming model. A number of projects have emerged that attempt to benefit from this simplified model including writing console programs, writing web audio applications and even Arduino projects.

4.4.1.5.3 Clojurescript

4.4.1.5.4 Managing state with Re-frame

4.5 Conclusion

5 Execution

5.1 Introduction

The following chapter gives an outline of the process that was undertaken to build out the final application. A description of early prototype work is given to give context to the construction of the final working prototype version. This is followed by a description of the technical architecture of the system as well as an outline of the sometimes tricky setup process of getting the live reload system working (as described in the previous chapter). Some detailed discussion of the the core functionality of the system is then given. The core of the system primarily consists of timeline events, which visually manifest themselves as strokes on the canvas and aurally as fm synthesized frequency modulated sounds. As will be discussed an important aspect of any well constructed software system is a good degree of separation of concerns, a characteristic espoused to and evident in the resulting code. To this end, the code that brings the central functionality to life can conceptually divided into a data or entity layer, a business logic or use case layer and an output layer which in this case consists of the visual output into a html canvas element and the audio output through the web audio api. In this sense the architecture conforms to the principles of the Clean Architecture as presented by Bob Martin (??).

5.2 Early prototype work

5.2.1 Melodypainter

Melodypainter is an early prototype built out in Max MSP that allows users to draw freehand lines, which are converted into break point function data and used to generate a melodic profiles using Bach for Max MSP. Bach is a suite of composition tools that allow for a number of computer aided composition techniques (CAC) and provides similar functionality to IRCAM's Open Music system. These melodic profiles are then filtered to only includes notes from a pentatonic scale, to give reasonably pleasing aural results. Some notable flaws in the system include the following. It is limited to strictly western tonal music styles. It has no allowance for rhythm and plays only eight notes giving results a noticeably bland and predictable quality. The freeform nature of sketched input however was quite a pleasing means of inputting the control information.

5.2.2 Sonicshaper [0/1]

A separate application was created in Processing which allowed users to draw shapes, using either mouse or ideally, pen input and have a sound that is associated with each shape played back. As the sound of each shape plays back, it is lit up using animation, creating a strong connection between the shape and it's resulting sound. The application uses the “gesture variation follower” system [caramiaux_adaptive_2015], which while promising in principle, didn't have a high rate of accuracy in recognizing the shapes.

5.2.3 TODO Web version of William Coleman's SonicPainter [0/1]

A potential starting point that was considered was using the code from William's SonicPainter and porting it to the web platform. This process proved to be quite straightforward. The processing code could more or less be embedded in a webpage as is using “processing.js”, a web version of the Processing library that enables users to run processing sketches in the Web Browser. Some notable changes that had to be made were removing the OSC functionality as this is not technically possible to use in a browser. In addition, some other pieces of code had to be commented out and tweaked. As it's not possible to run Max MSP patches in the browser, the audio system was re-implemented using Tone.js. As SonicPainter uses simple FM synthesis, a very close approximation to the original version could be created. In the end, it was decided not to build on this codebase however as there were some issues with functionality and useability that would be difficult to resolve in an inherited codebase. A fundamental issue was that transitions between certain states would cause crashes or unpredictable behaviour. An example of this is when a user attempts to use the vibrato tool while in the process of creating a note. Instead of either finishing the note and starting the vibrato tool or disallowing the behaviour, the program would crash. This is a common problem in software development and is evidence even in commercial products. To alleviate such issues in the new codebase a more disciplined approach would be taken to managing transitions between states. The process of porting the code did however give a more in depth incite into Coleman's implementation including the pitfalls mentioned above. In addition, the basic visual look and conceptual functionality would form the basis of the workings of SonicSketch.

5.3 Actual implementation

5.3.1 Setting up the architecture

5.3.1.1 Clojurescript and javascript npm modules

Despite the fact that clojurescript has existed for six years(??), some areas of

the development process are still difficult, particularly when building out a more complex real world application. It should be noted that a good deal of work is being carried out to make this a smoother experience and thusly these pains are likely to become less of an issue in the near future (???ref). It should also be noted that building applications using plain javascript is not a trivial process and in all likelihood will include a build process using a system like webpack or browserify. A primary issue that had to be resolved to allow the application to be built out was the incorporation of javascript npm modules. NPM is the module system used by node.js originally for more server oriented technologies but increasingly for rich clientside applications. For a purely javascript application, it would be a matter of simply adding the desired libraries as dependencies. However, with the use of clojurescript some extra steps needed to be carried out. In addition to adding the dependencies, a javascript file was created that imported these into a “deps” object. This deps object could then be referred to in clojurescript using the standard interop syntax ‘js/deps.myDependency’. At the time of development an alpha feature that allowed npm dependencies to be declared as part of the project.clj file was experimented with but was not used in due to difficulties getting it to work. While the project setup was not as elegant or succinct as might be wished, it did provide a stable base to build on and a means to harness the rich resource that is the NPM ecosystem and use such tools as Paper.js and React.js.

5.3.1.2 Paper.js and react.js (paper.js bindings)

As has been outlined in the previous chapter, a declarative coding style would be employed to enable a live coding workflow and to avoid a building a codebase that is increasingly difficult to understand. In other words the code should as much as possible describe the “what” of the functionality rather than the “how”. These qualities emerge quite naturally when using the *React.js* architecture. Paper.js however runs in the context of a canvas element and thusly it is not possible to directly use *React.js* with it. This shortcoming has been addressed in projects such as *three.js react bindings* and *pixi.js react bindings* which allow the use of react’s declarative programming style for 3d and 2d scenegraph oriented systems that run in the html canvas element. These solutions both work by creating dummy empty dom elements and hook into the *React.js* lifecycle events to the real work of updating the scenegraph. In many ways the scene graph structure of projects like these and indeed Paper.js exhibit a high resemblance to DOM structures and APIs making React a good fit for them. A similar approach to the above mentioned libraries approach was taken to integrate paper.js for use in SonicSketch and worked reasonably well but required quite a bit of setup. During the development of the project, a more suitable solution emerged from the open source community at an opportune time. This used the next version of *React.js* which has better support for render targets that are not the DOM and has the distinct advantage of not requiring the creation of redundant DOM nodes. The library was far from comprehensive and thusly a custom version

of the library was used that included some custom functionality required for SonicSketch.

5.3.1.3 Tone.js and react.js

In some ways audio output can be thought of in a similar way to the visual output of the app and thusly can be treated in similar way by *React.js*. It can use the declarative data oriented system of react to configure the particular settings and connections in the audio graph and hook in to its lifecycle events to instantiate the various audio generating and processing web audio nodes. This addresses a notable (by design) omission in Tone.js which does not allow the code to query the state of the audio graph once it has been setup. It is down to the userland code to keep track of this and manage it accordingly. The value proposal offered by introducing react.js into this part of the system is that it maintains the simple relationship between state and generated output. Conceptually the flow of change is:

1. The state updates
2. The react wrapper objects update their properties accordingly
3. The lifecycle events are triggered which takes care of altering, adding and removing web audio nodes (thus altering the audio being output)

The design of this part of the application is influenced by *react music*, a system that uses *React.js* with *tuna.js*, a web audio library similar to *tone.js* (???ref).

5.3.1.4 Reagent and react.js paper.js bindings

The final piece of the jigsaw in the underlying technology stack is the integration of react with clojurescript via the *Reagent* library. The core syntax of this system is simple clojurescript vectors similar to the following:

```
[[:div
  "Hello " [:span {:style {:font-weight bold}}
world]]
```

This would result in the following html output:

```
<div>Hello <span style="font-weight: bold">world</span></div>
```

As can be seen the vectors begin with a keyword that corresponds to the tagname of the html. Additionally, instead of using html tag keywords, function calls can be made to generate html to allow for code reuse and logic. It was unclear how the paper.js bindings would work within this system due to the fact that it required a different version of react and uses non standard tag names for elements that can be drawn on screen such as “circle” and “rectangle”. This however turned out to be much more straightforward than expected and the provided paper.js primitives could be simply using the relevant paper.js keywords. Complex

scenegraphs could be constructed by using the following succinct clojurescript syntax to describe the playback indicator:

```
[[:Group {:position [position 0]
          :pivot [0 0]
          :opacity 0.75}
  [:Rectangle {:pivot [0 0]
               :size [1 height]
               :fill-color "#ffffff"}]
  [:Path {:segments [[-5 0] [5 0] [0 7] [-5 0]]
          :fill-color "#ffffff"}]]]
```

As can probably be inferred from the code the ‘position’ and ‘height’ are properties that are passed into the hiccup and trigger updates to the visual display when they change: in the case of position, when the playback position changes and in the case of the height, when the user resizes the browser window. The path element describes the triangle that is places at the top of the screen.

The current state of the art in live code reloading in the browser is still not as comprehensive or as easy to setup as might be wished. Once it has been configured it is difficult to return to the compile and run workflow, and is in most cases a worthwhile investment of time. With these underlying elements in place the process of creating the core functionality application could begin and will now be described.

5.3.2 Core functionality - timeline events (or notes)

At the core of the application is the creation of timeline events which unfold in a looped fashion. These events are created based on the input of the user with a mouse or mouse like input device. On the production of a valid input gesture, the screen is updated immediately with a visual display of this content. The details of this gesture is stored in memory and the event that will eventually create the sound is registered with tone.js.

5.3.2.1 Add timeline event

5.3.2.2 Add vibrato

5.3.2.3 Remove note

5.3.2.4 Move note

5.3.2.5 Change sound (preset system)

5.3.2.6 Probability tool

5.3.3 Secondary functionality

1. Introduction
2. Transport controls
3. Animation (current play position & notes)
4. Undo and redo
5. Fullscreen
6. Outer UI
7. Save and load file

5.3.4 Performance issues

5.4 Conclusion

- Summarise the resulting artifact

6 Evaluation

6.1 Introduction

6.2 Initial pilot test

6.3 Exhibition

6.4 Conclusion

7 Conclusion and further work

7.1 Summary of work completed

7.2 Broader implications of development

7.3 Future work

7.3.1 Performance improvements

7.3.2 Broaden visual language

7.3.3 Allow for larger structures

7.3.4 3D spaces, VR, spatial audio