

**v.4MP**

***Image-based visual music for  
improvisational performance***

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# Introduction

Musical performance, a fundamental form of human expression, is a practice that has adopted new forms throughout history as artists explore new ways of creating an impact on viewers. One such way is through the combination of music and visuals, a practice that has evolved over time, closely linked with the evolution of technology. The aim of this combination was well imagined by Gene Youngblood back in 1984 stating, “The practice... constitute(s) an organic fusion of image and sound into a single unity, created by a single artist who writes and performs the music as well as conceiving and executing the images that are inseparable from it” (Youngblood, 1984). With the shift of the audiovisual creation process to the digital realm and the steady increase in computing power, tools have now started to facilitate this vision of one artist working in both domains (Akiyama, 2007). This makes sense, as the informational signals that ultimately produce both audio and visual data are the same and interchangeable (Strick, 2005).

Despite the digital affordance of working in both realms simultaneously, artists creating works in both mediums are still comparatively rare. I believe one reason for this is that the high-level process of conceiving and producing each is unique and requires different foundational knowledge structures. For musicians interested in adapting an audiovisual performance practice, the process of learning to create visuals can be a large commitment and time-consuming process, taking away time from time to work on music. For this reason, there is a benefit in tools that bridge the gap between the music and visual creation process at a high level. Further, integrated interfaces may lead to breaking out of standardized, default styles and enable artists to shape a unique audiovisual language (Akiyama, 2007).

Ease of use by musicians is not the only benefit of closing the audio and visual production gap. This can also reduce the need for moving back and forth between mediums, changing mindsets, and breaking workflows. A tighter integration between the processes can enable rapid experimentation with audio and visual interaction and, in turn, new styles (Akiyama, 2007).

A particularly interesting and less researched form of audiovisual performance is improvisational performance, which this project specifically aims to explore. There are a few reasons why improvisational performers are an interesting group for this type of work. First, their fluid and adaptive style permits a degree of responsiveness to external factors, visual media likely being a prominent source. In this sense, there lies the potential for a feedback loop between the musician and the computational system where each influences and responds to the other. Second, improvisational recordings are data that provide an opportunity for systems to learn characteristics of performers' unique styles and, in turn, mimic, compliment, respond to, or contrast their style through a visual medium. While this second factor was out of the scope of this first iteration of v.4MP, it is continuing to be explored for future versions.

## User Group

*Independent Musicians => Solo performers/small bands => Improvisational performers*

## Problem Statements

- *For independent musicians seeking to create visuals themselves, the process of learning graphics software is time-consuming, challenging, and takes away from time for creating music.*
- *Easy-to-implement audio visualization tools lack expressivity and creative capability.*
- *Creating a visual project requires different knowledge structures and workflows than creating music.*

## Research Questions

- *How might we provide a route for musicians to enter the audiovisual art space without the need to dedicate a significant amount of time and effort to learn complex graphics software?*
- *How might we narrow the gap between metaphors for creating in the audio and the visual mediums when conceiving of audiovisual media?*
- *How do improvisational performers actually want to represent their sound visually?*
- *Could machine learning capabilities provide a route to simplified control over complex graphics systems?*

## Related Work

A review of current systems quickly reveals that this area of work and research is far from new. While many systems already exist, I believe they can broadly be categorized into one of two groups.

### Group 1: Graphics Production Suites

Graphics production suites are complex, highly capable systems. Prominent examples in this category include TouchDesigner [9], Max/MSP [7], and Resolume [20]. As mentioned, these types of tools go deep, enabling seemingly infinite output capability. However, with this ability comes a steep learning curve, which this project aims to avoid. Additionally, while these systems can certainly be used to create correlated audio and visual media, this requires thought and preparation as they are not specifically made for this goal.

## Group 2: Audio Visualizers

Group 2, broadly being called “Audio Visualizers”, are tools designed with a narrower focus and specifically aim to visualize sound in some way. This category is more comparable to the aim of this project. These come in varying levels of complexity and control and can again be divided into 2 groups. First are tools that provide pre-selectable visuals. While these are simple to get up and running, they are limited in the options they provide for artists, removing most of the creative opportunities. Some examples in this category include SYQEL [24], Audio Canvas [22], and WZRD [27].

The second group provides the artists with more control, allowing them to produce visuals through sets of parameters. Examples in this category include RokVid [21], AutoLume [2], and Geometrum [10]. Of all these examples, RokVid [21] and Geometrum [10] are the only two systems that can run natively within music performance production software, effectively making the visual creation process immediately more familiar to musicians. Further, of all examples, RokVid [21] has the highest output range and, subjectively, creative capability and is also the only one that uses media files as the base graphics.

While RokVid [21] is both effective and easy to use, it still has drawbacks. First, its ability to integrate with the music is highly limited. Rather than using real-time audio signals as an input source for automation, it is limited to using waveforms synced to the bpm (beats per minute) of the music. Additionally, its limited set of effects leads to a repetitive output style when used over time. My contribution aims to provide an audio visualization tool that is easy for musicians to learn, allows for easily integrating audio and visuals at a complex level, and provides a high output range through the use of media files. This is something that does not currently exist in available tools.



Figure 1: RokVid Interface

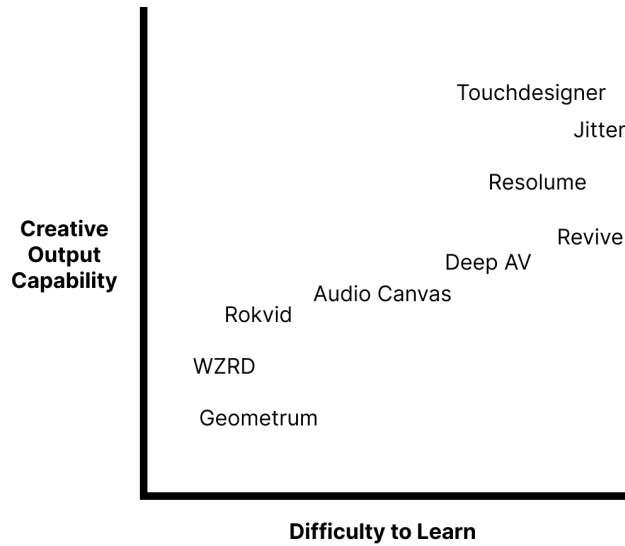


Figure 2: Existing Systems Graph

## v.4MP Version 1 Overview

My contribution, v.4MP, is a software program that can run within Ableton Live [1] or as a standalone Max patch. It can receive audio input of any kind, such as an instrument, microphone, or complete tracks. It contains an audio analysis section, separated in tabs by type, which automatically runs on the audio source. These audio analysis objects report values that can be directly mapped to control all visual parameters.

Visually, v.4MP functions as a system for blending images. Users load any number of folders that contain image files. Video files can also be used but the design is optimized to support creative use of images. The user then creates “sets” of three folders. One image is pulled from each folder at a time, creating a continuously flowing blend of three images. v.4MP includes a tab for controlling the image blend output by rate and blend mode and supplies many different effects to use. In addition to the UI effects, there is a menu for selecting an additional effect from over 100 options.

Important to v.4MP is the ability to save presets to use throughout a performance. These presets can store sets (the images used), the states of visual control and effect parameters, and the mappings between audio and visuals. More information on v.4MP’s functionality can be found in the user manual included in appendix 1.

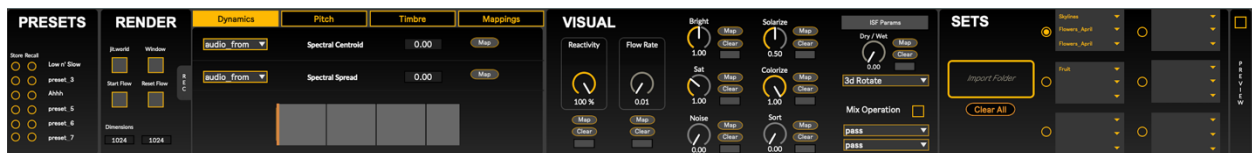


Figure 3: v.4MP Final Interface

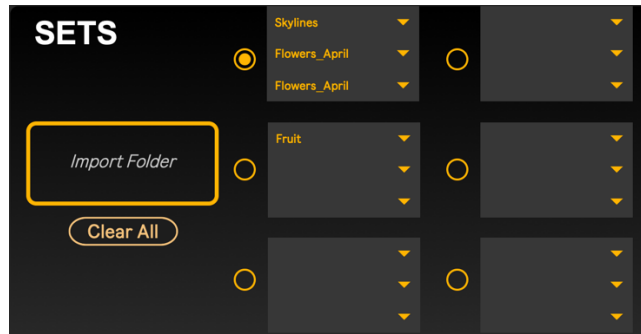


Figure 1: v.4MP Sets Tab

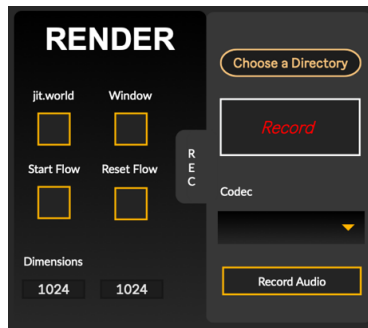


Figure 2: v.4MP Render and Record Tab



Figure 3: v.4MP Visual Tab

Dynamics		Pitch		Timbre		Mappings		
	SOURCE	VAL	TARGET	VAL	min	max	min	max
X	● Avg Amplitude	0.07	Saturation	0.60	0.00	1.00	0.50	0.95
<input type="button" value="Clear All Mappings"/>								

Figure 4: v.4MP Mapping Matrix

# Methods

## Generative Research

With an understanding of the current landscape of audiovisual performance tools, a generative research phase was begun. The goal of this research was to explore musicians' needs, workflows, and opinions first-hand. This research phase included two primary methods and two additional methods: user interviews, ethnographic inquiry, autobiographical design, and Jobs-to-be-Done. Each method offered up slightly different findings.

### User Interviews

The most prominent user research method was user interviews. This method was selected as a means of broadly exploring musicians' interests, needs, and the current landscape of audiovisual performance tools in the music community. Participants ranged from professional touring musicians, music educators, music students, and recreational music creators. Each participant can be categorized into one of the following 3 groups: advanced musician, experienced visual artist (n=2), advanced musician, novice visual artist (n=3), recreational musician, novice visual artist (n=1). Interviews took on a semi-structured format and were all conducted over Zoom. The complete interview guide is included in appendix 2. Affinity mapping was done to synthesize findings from interview data. Transcripts were broken down into small codes and organized as to reveal common sentiments and high-level findings.

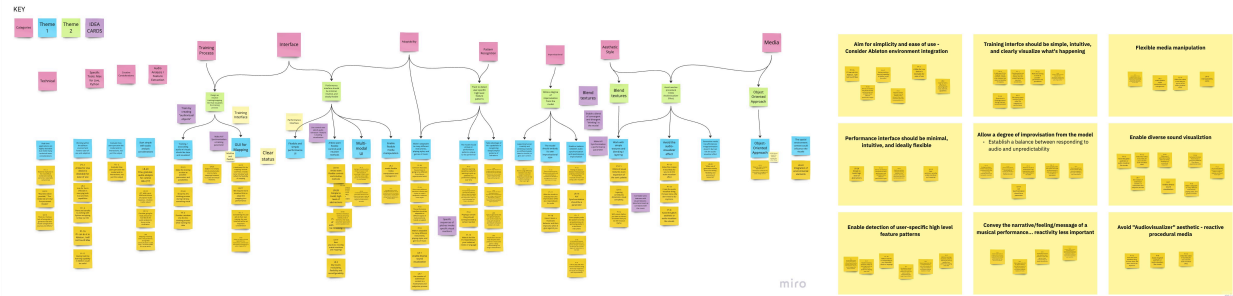


Figure 5: Affinity Map

## Findings

### 1. Support media management and manipulation features

Musicians expressed interest in a tool for managing and controlling a large body of media, such as image or video files. They believed current systems lack a creative approach to handling this type of data.

## **2. Interest in Ableton integration**

Ableton Live is a popular music production and performance software. Many musicians thought creating a “Max for Live” device, a software format that is capable of running natively within Ableton Live [1], would be immediately familiar and have a wide reach.

## **3. Avoid outdated animation styles**

Many musicians voiced that there already exist many procedural animation styles that reflect an outdated, overused aesthetic akin to early 2000’s audio visualizers. They thought a system with similar aesthetics would not provide anything new or interesting and suggested aiming to avoid that style.

## **4. Convey a theme and narrative through visuals**

Musicians were interested in going beyond audio reactivity alone as to use visuals to support an overarching theme or story in a performance.

## **5. Establish a balance between responding to audio and unpredictability**

Musicians were interested in a system that could be set up in advance and then operate semi-autonomously during a performance. They sought a tool capable of expressing “a mind of its own”, albeit within prepared constraints, rather than being perfectly structured and predictable. This concept is similar to that of creating generative systems.

## **6. Preparation interface should be simple and clearly visualize what’s happening**

Musicians were interested in a tool that aimed to simplify processes while maintaining flexibility to satisfy the needs of varying artists and styles. In terms of machine learning integration, musicians desired a system that clearly showed how and what was learned. This stemmed from general concern about the use of AI and ML in music and the arts at present.

## **Ethnography**

Ethnographic research was completed as a means of understanding how musicians and audiovisual artists are currently using or aiming to use these tools in context. This research was conducted at an audiovisual music event called “Generactive Music” held at South

River Art Studios in Atlanta, GA. Documentation methods included observation and note-taking as well as discussions with both performers and attendees, many of whom identified as musicians themselves. Analysis methods were similar to that of the affinity mapping done with user interviews, albeit with less data.

## **Findings**

### **1. Performance interface should be minimal, intuitive, and ideally flexible**

This finding resulted from the discovery that musicians are fully engaged in the music creation process during a performance. This seemed to be true regardless of the method, from playing an instrument, DJing, or even live coding. For this reason, people expressed that when adding a live visual component, it needs to be easy to control any necessary changes throughout the performance.

### **2. Visuals do not have to be parallel reactive to be effective**

This finding resulted from both observation and discussion around the style of the visuals. Parallel reactivity, visuals perceptually synchronized and mimicking the audio, can be very effective at times, but can also be overwhelming if overused. Visuals that are more subtle can add a pleasing balance over time. This finding is in support of Constantin Basica's research showing that counterpoint, a disjunction between what is heard and seen, is often desirable or even seen as the ideal in music performance (Basica, ...). This does not necessarily mean that audio data cannot be used to influence or control the visuals, but rather that the output does not need to aesthetically double the audio in real-time.

## **Auxiliary Methods**

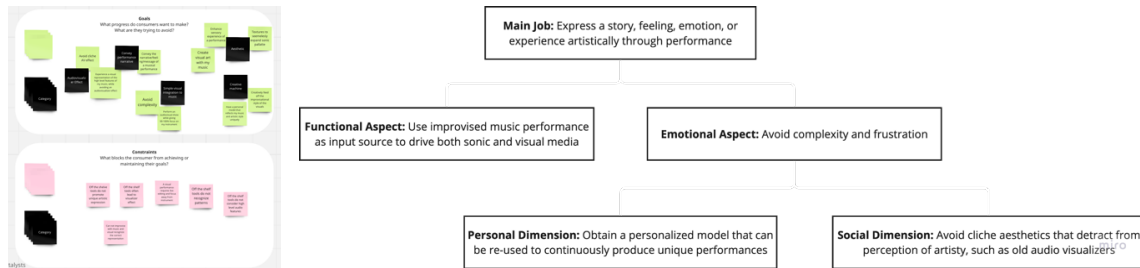
The following two methods were completed to complement the previous two primary methods and findings were only seen as being in support of the previous two.

### **Auto-Biographical Design**

Autobiographical design is a research method that involves "extensive, genuine usage by those creating or building the system" (Neustaedter & Sengers, 2012). This method entailed constructing various simple audiovisual systems to gauge potential. Having experience in both audio and visual production, this method was effective in understanding which broad directions were worth exploring further and which were less so.

### **Jobs-to-be-Done**

This method involved analyzing data obtained through interviews and ethnography against the jobs-to-be-done framework, a research method for understanding the needs of users. While using previously collected data is far less informative than gathering new data with participants, it was still helpful in drawing insights. This method ended up supporting previous findings, namely that of enabling the ability to support a theme or narrative.



## Design Requirements

Reaching a point of saturation from exploratory and user research, the following design requirements were formulated. Each pulls from the key findings discussed previously.

### Functional

1. Enable flexible media manipulation.
2. Enable a degree of unpredictability.
3. Enable diverse sound visualization.
4. Enable the ability to craft a theme or narrative.

### Non-Functional

5. Provide a minimal, intuitive, and flexible performance interface.
6. Provide a minimal, intuitive, and flexible preparation/training interface.
7. Avoid cliché aesthetics.

## Artifact Design

The conception of the v.4MP software was a highly iterative, user-involved process, which this section aims to reveal. The design phase began with various divergent ideation activities before converging on an initial concept. Then, user-feedback sessions alternated prototyping phases to produce a final design.

# Ideation

To move from a set of design requirements toward a tangible solution, the artifact design process began with various ideation activities. The goal of these activities was to engage in divergent thinking and generate as many potential solutions as possible. Most activities were completed solo with feedback from advisors throughout the process. Ideation activities completed include:

- SCAMPER
- Rapid Ideation
- Design Workbook
- Sketching
- Concept Mapping
- Mood Board
- Exploratory Prototyping

These processes resulted in a body of ideas ranging from broad concepts to small features. Concepts were evaluated against novelty, usefulness, project scope, and how well they addressed design requirements. We saw potential in various ideas and ultimately borrowed components of different ones to construct a final concept to bring forward.

# Concepts

1. Layering and blending images
2. Native classification and regression mapping
3. Self-Organizing Map for traversing image files
4. Audio pattern recognition on improvisational performance data

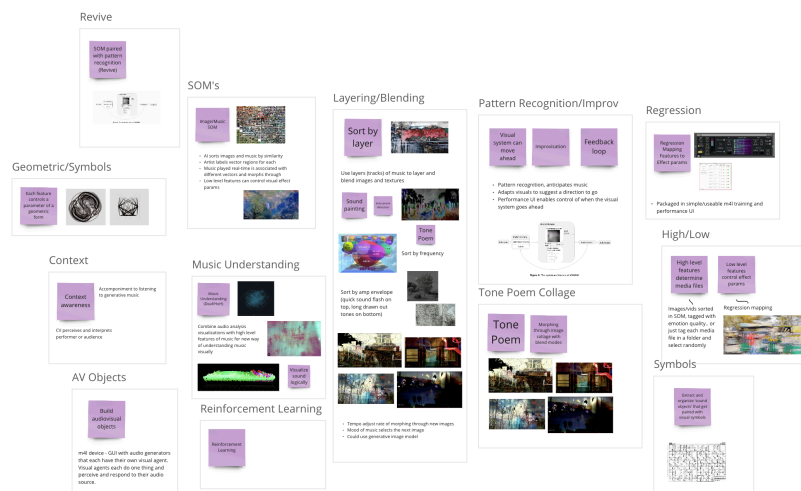


Figure 6: Concepts

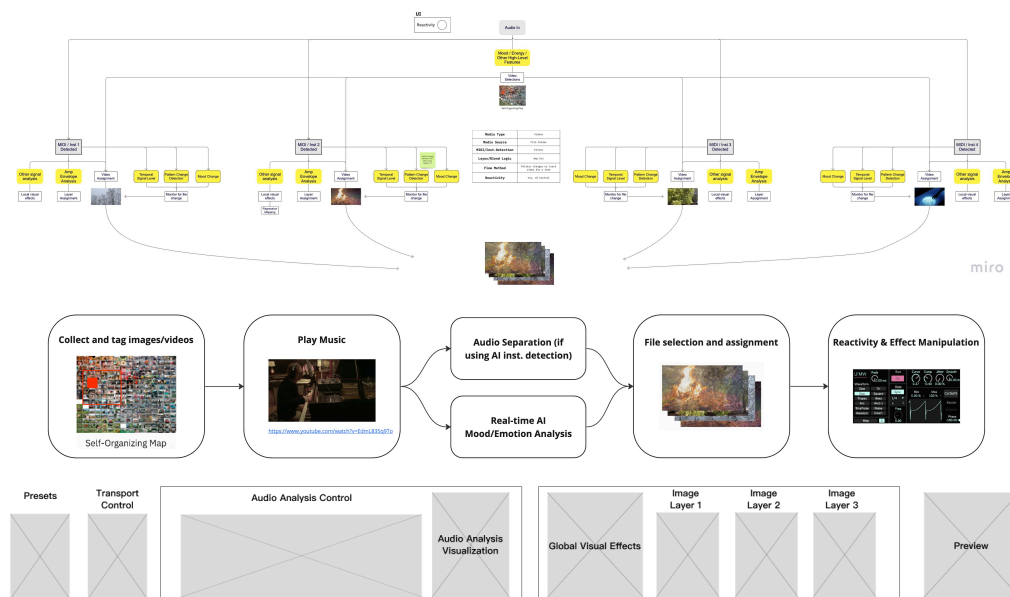
## Final Concept

The final concept brought forward can broadly be described as a system for blending image or video files. These files would ultimately be created by the artist beforehand and then imported into the tool where high-level control over blending and effecting could take place. We saw potential in this idea because it addressed many design requirements from a foundational level, such as enabling diverse sound visualization, the ability to construct and theme or narrative, and avoiding the outdated procedural animation style.

Additionally, the system would provide an interface for quickly and easily experimenting with and creating direct mappings between various audio analysis values and visual control parameters. Next, the vision for the system was to be a “Max for Live” device, as discussed previously. Lastly, we also wanted to integrate the ability to use machine learning algorithms for building complex mappings. This concept was clear enough to move forward with a vision yet remained broad enough to allow filling in and adapting to future user feedback.

## Lo-Fi Design

The initial goal of the Lo-Fi design phase was to create representations that accurately detail how the system could work, both from a theoretical and technical level, as well as to understand and convey where the different ideas may come together. This process included creating multiple flow and concept maps, some depicting the system from a high level and some detailing smaller features. Additionally, some very early wireframes were constructed, more as a means of discussing the idea than to be used for constructing the final UI.



# User Feedback Round 1

Round one of user feedback aimed at obtaining broad feedback on the concept and different potential features. Information goals included understanding what design aspects users had an interest in and what they did not care for. Further, these sessions aimed to probe for more design features of interest and explore visual styles of interest. These sessions took the form of semi-structured interviews with design probes. Design probes included UI mockups, concept and flow maps, and visual media examples. These were held with 3 participants: 2 Georgia Tech music students and 1 Georgia Tech music professor.

## Informational Goals

- Opinions on the image-blending method and visual style
- Opinions on interaction design (Set up a priori? Train while playing?)
- What benefits do musicians see in the ability of a tool to learn their unique musical “palette”?

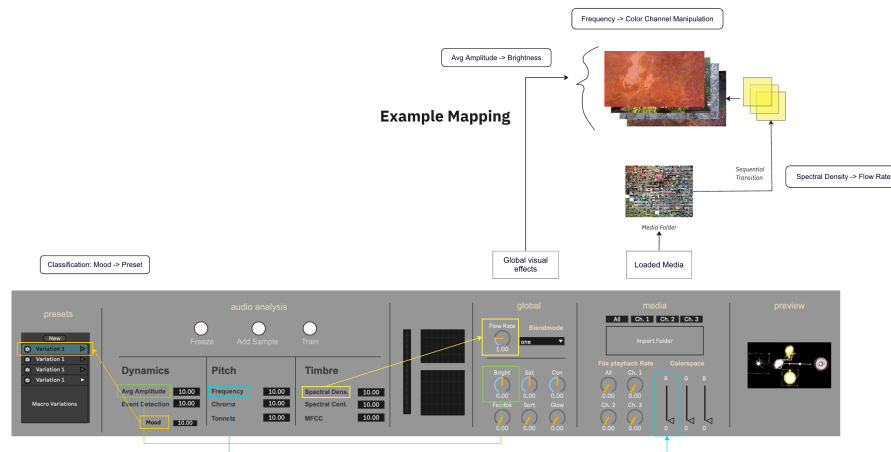


Figure 7: v.4MP Early Diagram

## Findings

Interview data was analyzed using qualitative coding and led to the following findings:

1. An image blending system is unique and has potential
2. Interest in mapping to color pallets
3. Need for visualizing the audio analysis
4. Methods for organizing audio analysis capabilities

# User Feedback Round 2

Round two aimed at obtaining feedback on the interaction design, functionality, and UI layout of the initial prototype. Additionally, these sessions aimed to explore how audio analysis needs differ across performance styles and varying visual style preferences.

Sessions included semi-structured interviews, design probes, and contextual inquiry. Design probes included the prototype and a detailed list of different audio analysis options organized by function. Contextual inquiry occurred by requesting interviewees to either briefly play their typical performance instrument or bring a sample recording of their own playing. This was done to aid in discussing performance style and how nuances can be effectively captured and represented. These were again held with 3 participants: 1 Georgia Tech music student, 1 music student in a differing program, and a recreational musician.

## Findings:

Data was again analyzed using qualitative coding and led to the following findings:

1. Preference toward fewer, highly accurate and controllable audio analysis objects than many with less control. Pitch, namely, is very important to most artists and styles
2. Interest in creating multiple image folder groupings
3. Need for controlling device size
4. A broad range of visual effects of interest

## Prototyping

Prototyping was an iterative process that took place throughout the entire design phase of this project. The process began with building out the most important design elements in their simplest form, testing, and adding to. The format of these prototypes were “Max Patches”, multimedia projects constructed in the Max [7] environment.

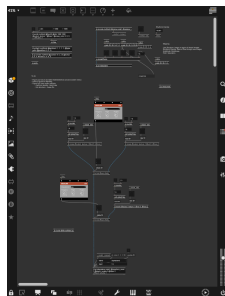


Figure 8: Early Max Patch



Figure 9: Early Max Patch

## v1 Prototype

After various iterations of work, an initial functional prototype was reached. This tool effectively implemented a system for blending. Users could load in folders of images and blend through three at a time with high-level control, such as change rate. Additionally, the system provided various visual effects, RGB channel control, and audio analysis. However, at this time, dynamic mapping between audio analysis and visual parameters was not functional.



Figure 10: v1 Prototype Interface

## v2 Prototype

A v2 prototype was constructed after receiving user feedback on the initial prototype. Updates included the ability to create dynamic mappings, the Sets feature, integration of ISF shaders, control over blend modes, a dynamic layout with tabs and pop-out menus, and a new UI design.

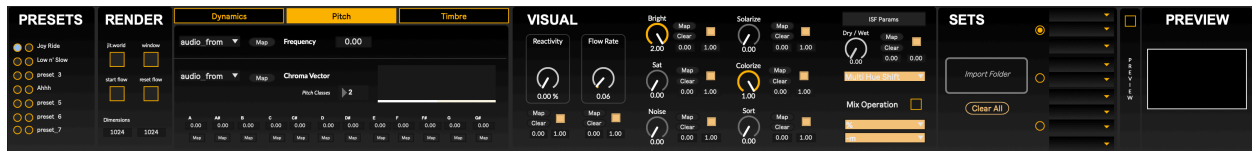


Figure 11: v2 Prototype Interface

## Evaluative Research

Evaluative research was conducted on the final prototype. The goal of this research was to gauge the functionality of the device and uncover any potential in-use problems, as well as to evaluate whether the design accomplished the initial goals. Usability testing was selected as a method for evaluating these aspects.

## Usability Testing

Usability testing was a within-subjects design that resulted in qualitative data from 5 participants: 1 Georgia Tech music professor and professional improvisational performer, 3 Georgia Tech music students, and 1 recreational amateur musician.

## **Informational Goals**

- General feelings about the device
- Features users liked or did not care for
- Uses users desired and could not achieve
- Situations where users ran into problems or confusion

## **Format**

### **Part 1: Device Overview & Documentation Review**

Sessions began with a brief verbal overview of the device, its purpose, and goal. Then, participants reviewed the documentation on their own to understand the tool's functionality and technical aspects. This was aimed at mimicking how future users are expected to come to understand the device on their own.

### **Part 2: Task-Analysis + Think Aloud**

In part 2, participants completed a task analysis with tasks including the full use process from setup through to live music interaction. Participants were encouraged to voice their thought processes out loud whilst attempting to complete each task. The full task analysis documentation can be viewed in appendix 5.

### **Part 3: Semi-Structured Interview**

Semi-structured interviews were completed after the task-analysis to gauge participants' experience. The interview guide can be viewed in appendix 6.

## **Findings**

### **Mappings**

- Lack of clarity conveying state of current mappings
- Confusion around the scalars
- Desire for more scaling control and greater resolution
- Confusion between mapping toggle and mapping button
- Desire for a "Clear All Mappings" capability

### **Sets**

- Lack of feedback confirming successful loading of files
- Lack of clarity displaying current state of set slots
- Difficulty interpreting file names
- Difficulty differentiating which slot belongs to which set

## Various

- Unfamiliarity with some audio analysis objects and their functionality
- Desire for native recording/exporting capability
- Poor menu contrast

## Design Advancements

With this feedback design updates were made to achieve the final first version of v.4MP. Specific design updates to result from usability testing included a mapping matrix for greater clarity and control over active current mappings, hover tips for clarifying audio analysis capabilities, improved feedback clarity, and various UI updates such as contrast improvement.

## Evaluation & Conclusion

User feedback suggests that v.4MP successfully accomplished many of the goals we initially sought. Musicians have expressed that its conception provides a new, unique, and useful option for audiovisual performance. While I am pleased with where v.4MP has ended up, there are still many features that were unable to be explored in this project's time frame.

Future work will continue to explore machine learning integration. Specifically, we would like to enable building complex mappings using machine learning algorithms natively in the device. Additionally, we would like to explore methods of enabling the system to learn nuances of a performer's unique style over time, which can be used as input to visuals. Lastly, we are exploring the potential of real-time image generation from prompts using diffusion models.

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