Tampere University of Applied Sciences

Setting Up an Interactive Audio-visual Installation

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ABSTRACT

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In recent years, projection mapping has become more popular as part of art installations, theatrical and music events. In times where VR, AR and immersive audio are becoming especially popular, many of these installations on the contrary do not offer the possibility to interact with them.

The purpose of this thesis was to show how to build an interactive mapping installation from the technical point of view that allowed video and audio to be processed separately and synced in real-time. This setup was conceived for small budget productions where only two computers would be considered.

Some theoretical background behind the idea, history of the projection mapping and further applications are discussed with the goal of encouraging creators of all fields to develop their own setups and ideas to collaborate.

The use of Millumin, Ableton Live and Microsoft Kinect among other resources is researched with the idea of providing an optimal setup for professional results to be achieved.

Key words: interactive, mapping, motion capture, Millumin, Ableton Live, Kinect

CONTENTS

GLOSSARY

ADAT	Alesis Digital Audio Tape. Digital format for transferring audio signals
AR	Augmented Reality
CC	Continuous Controller. MIDI message. Varies from 0 to 127.
DAW	Digital Audio Workstation. Software used for producing audio.
GPU	Graphics Processing Unit
MIDI	Musical Instrument Digital Interface. Digital protocol for connection between devices
LiDAR	Light Detection Ranging
Projection mapping	Image or video projected over a flat or three-dimensional display surface
SDK	Software Development Kit
Thunderbolt	Protocol for high speed digital data transfer
USB	Universal Serial Bus. Digital protocol for communications
VR	Virtual Reality
Wi-Fi	Technology for wireless connection between devices

1 INTRODUCTION

In past years projection mapping has become an essential part of audio-visual installations. Technology has evolved in a way that greater results can now be achieved on a smaller budget.

The objective of this thesis is to show how to design a setup for an interactive installation. The purpose of this is to build a system where using only two computers visuals and audio could be processed separately in real-time, allowing not only for better performance but for the visual artist and sound designer to be able to work separately if needed.

Microsoft Kinect was the camera of choice to study the motion capture for its affordability and native integration with Millumin and macOS. Other depth technologies as Intel RealSense are studied. Millumin and Touchdesigner are discussed as mapping software being Millumin the chosen for the research due to its friendly user interface and interoperability. Various methods for the synchronization are shown to suit the need of the production. A final demo project is presented.

This thesis focuses on how to achieve professional results on a small budget using creativity and technical knowledge.

2 THEORETICAL BACKGROUND

The topic for this thesis came from previous projects in collaboration with other students from TAMK. Konsta Fedorov, from Interactive Media who is a graphic designer and visual artist, developed an interest in motion design and projection mapping from one of the courses during his studies. His first installation was presented in IWeek 2018 where a locker was mapped (Fedorov 2018; Appendix 4).

Since 2018 I have collaborated with him in different installations in Tampere as a sound designer (Appendix 1; Appendix 2). It was soon clear enough that to take the installations a step further and make them interactive, we needed to think about a way to maximize our resources (laptops) and come up with a setup that allowed us not only to deliver more complex installations but to work on or own. In other words, we could not afford a dedicated high-end computer to handle all the tasks so building a setup where our computers had a sole purpose would offer all the flexibility we needed.

PICTURE 1. Poster for STRUKTUR during Tampere Film Festival 2020 (Fedorov 2020)

3 PROJECTION MAPPING

3.1 History

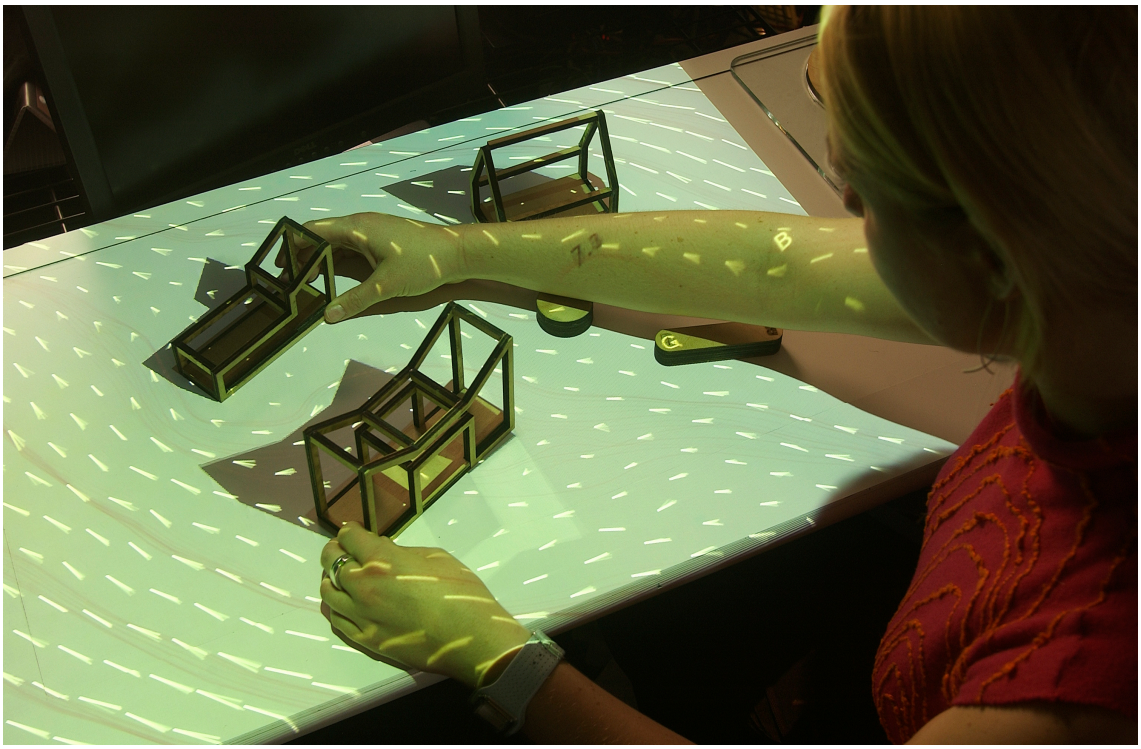
Projection mapping or “spaced augmented reality” as it was called originally started back in 1969 when the Haunted Mansion in Disneyland was opened. The installation consisted in a video projection over a mannequin head which was used to welcome the visitors. (Ascend Studios n.d.; Jones n.d.)

The next registered recorded mapping took place in 1980. Michael Naimark, for his “Displacements” installation recorded a living room using a rotating 16mm motion picture camera. Then he played back the movie using a rotating projector over the same room spray painted in white. (Naimark n.d.)

PICTURE 2. Displacements (I like this art 2010)

But it was not until 1998 when the first attempt of an interactive projection happened. John Underkoffler used his I/O Bulb and Luminous Room ideas on two projects where the concept was using every surface as a possible display for the projection. I/O Bulb consisted in a camera and a projector working together collecting and displaying information at the same time whereas Luminous Room was

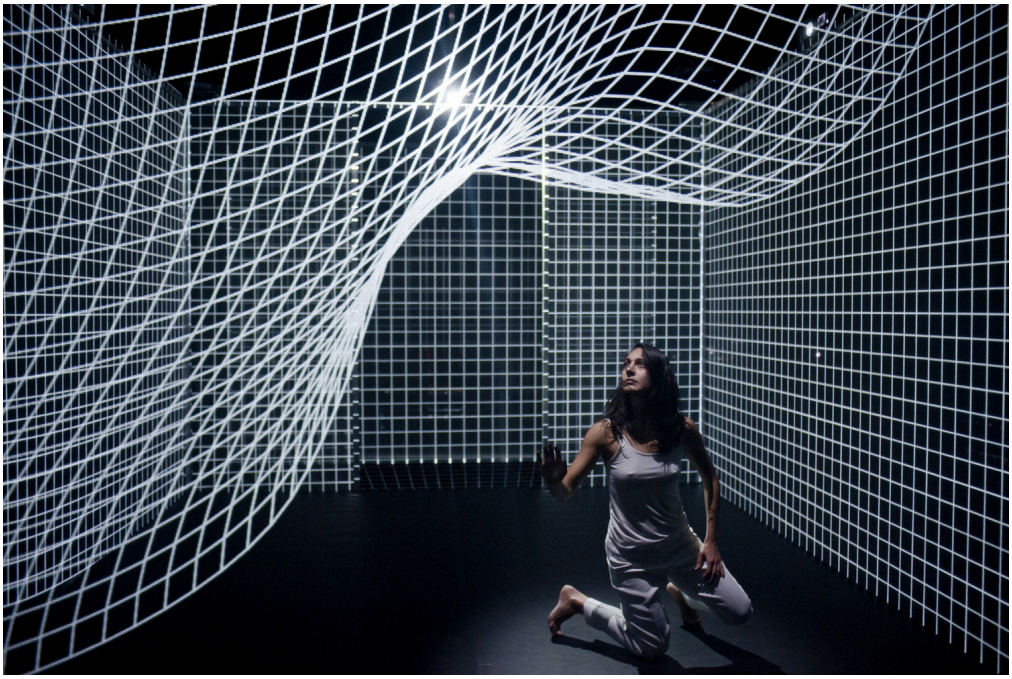
an enclosed space where various I/O Bulbs worked together projecting on different locations of the room. (Tangible Media Group n.d.)



PICTURE 3. Luminous Room (Tangible Media Group n.d)

3.2 Present

The company Adrien M & Claire B is specialised in digital arts since 2004. Impressive performances and art exhibitions involving choreography and projection mapping have made them a reference in contemporary art. With special focus on the human being and body movements, they use the technology to create a unique story for every performance. Pixel is one their best know projects. (Adrien M & Claire B n.d.)



PICTURE 4. Hakanaï. Projection mapping by Adrien M & Claire B (Vesnin 2016)

Kuflex is another company based in Russia that creates interactive digital art using human tracking, lights, point cloud processing and video effects. Their installations feature powerful and highly engaging visuals. (Kuflex n.d)

PICTURE 5. Quantum Space installation by Kuflex (Behance n.d)

4 SETUP

4.1 Visuals

This is the first part of the setup. Motion capture and video are handled on this first step on one computer. The data collected from the user interaction is used to process the video and sent via MIDI at the same time to the second computer to work on the audio.

In order to make the user an active part of the installation it is key to make it feel involved. It is crucial that the projection follows the user interaction smoothly. That involves being able to track specific movements and process them in real-time. Two solutions are shown: Microsoft Kinect and Intel RealSense depth cameras.

4.1.1 Microsoft Kinect

Microsoft Kinect is a controller released in 2010 for the Xbox 360 that allowed users to interact with the console without any physical contact. Using infrared sensors and a camera, Kinect is able to track motions and recognize faces and voices. (Ein Press Wire 2010.; Xataka Windows 2013.) A second version was released in 2013 that came along with the Xbox One and a final PC version on 2014 (Machkovech 2014). It was discontinued on 2017 but due to its integration with third party software like Millumin or Touchdesigner it is still nowadays a useful tool for interactive installations (Wilson 2017). It’s affordability on the second-hand markets made it a good option for research purposes.

PICTURE 6. Microsoft Kinect 2 (Montaño 2020)

4.1.2 Intel RealSense

RealSense is a 3D depth tracking technology developed by Intel, used to enable devices to interact with their environment (Intel RealSense n.d).

Named originally “perceptual computing” in 2013 it was meant to be a standard feature of every Intel powered computer and tablet from brands like Acer, Asus, Dell, Fujitsu, Lenovo or NEC. After the strategy did not work as expected, in 2014 the concept was renamed as RealSense. Intel opted for a change of direction and change of partners. With Razer they developed a webcam more oriented to the game streamers and they included their depth cameras on the Yuneec Typhoon H drone which helps the device calculate the distance between obstacles. (Carey 2016.; Freedman 2017.; Yuneec n.d.)

PICTURE 7. Intel RealSense depth camera D435i (Intel RealSense n.d)

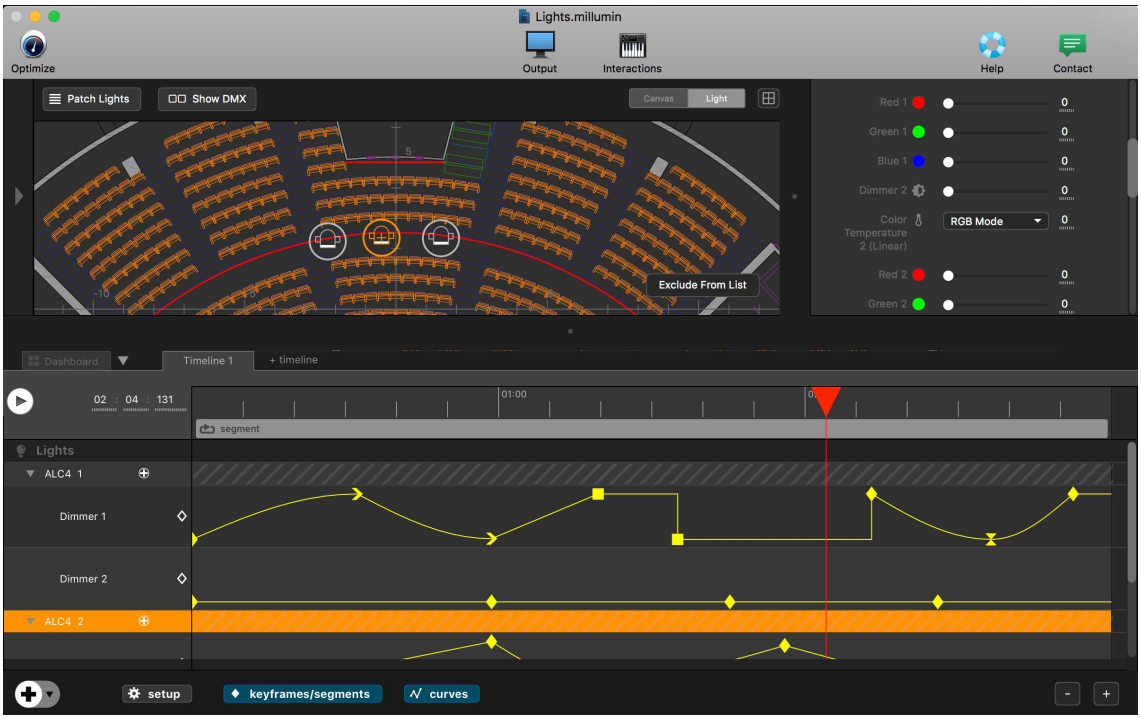
In 2020 the focus is in research and further develop of the technology. New cameras as the L515 using LiDAR (Light Detection Ranging) designed for logistic applications and 3D scanning, hand gesture recognition for AR or self-calibration cameras. (Intel RealSense 2020.; Scimeca 2020.; Wasser n.d.)

RealSense is not supported on Millumin. Touchdesigner offers integration with depth cameras on both Window and macOS systems. The SDK though has been discontinued (Phillips 2015).

4.1.3 Millumin

Created by Philippe Charaund and officially released in in 2012 Millumin offers a complete solution to create audio-visuals and manage video and lights live (Millumin n.d; Poole 2014). It was the software chosen for the research due to its friendly user interface, integration with Kinect, MIDI capabilities and the possibility of using a fully functional copy (only watermarks added) after the 30-day trial period.

It performs at its best in situations when video needs to be synced to theatrical cues or sequence of events during music shows. Also works as a mapping software, being able to blend two or more projectors. (Poole 2014.; Help Millumin n.d)

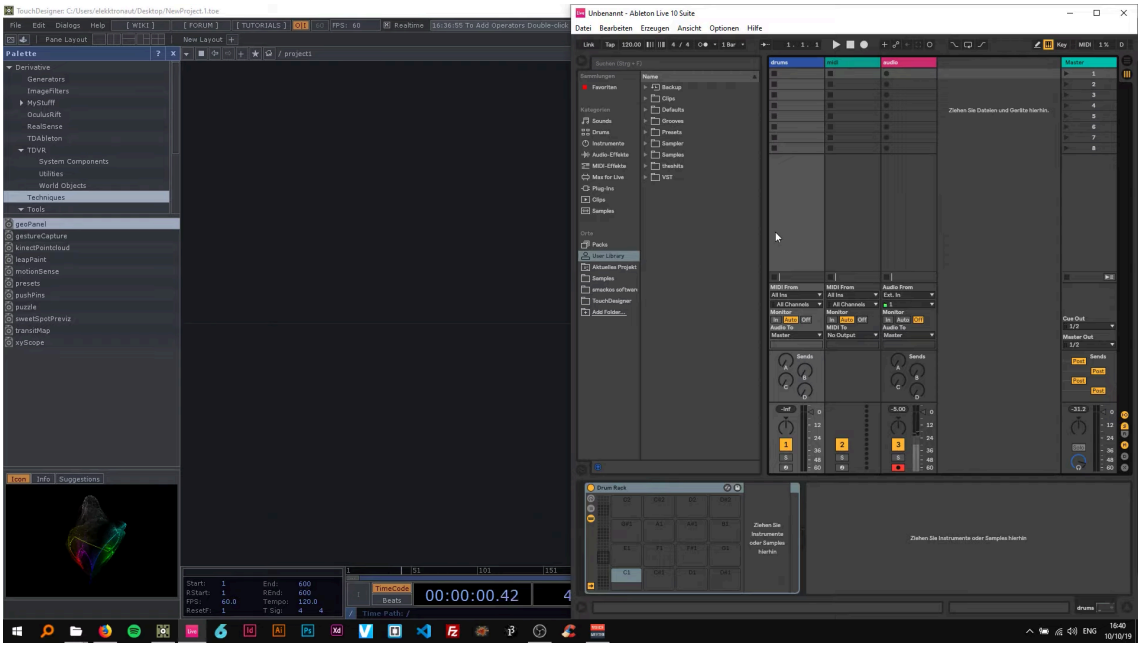


PICTURE 8. Millumin interface (Millumin n.d)

4.1.4 Touchdesigner

Touchdesigner is a node based virtual programming language able to create interactive multimedia content (Sharma 2014). Among its main features are interoperability with external hardware and third-party software, real-time 3D rendering, projection mapping, lighting design, VR support, customizable. It is also compatible with depth cameras using RealSense technology, as opposed to Millumin. (Derivative n.d.)

It is more complex than Millumin and considered for high end productions. Its use requires also more dedication and developing skills. It is recommended to use on Windows systems due to its high graphic demand though nowadays it is possible to use with an external GPU if needed also on macOS environments. (Pallas 2018.)

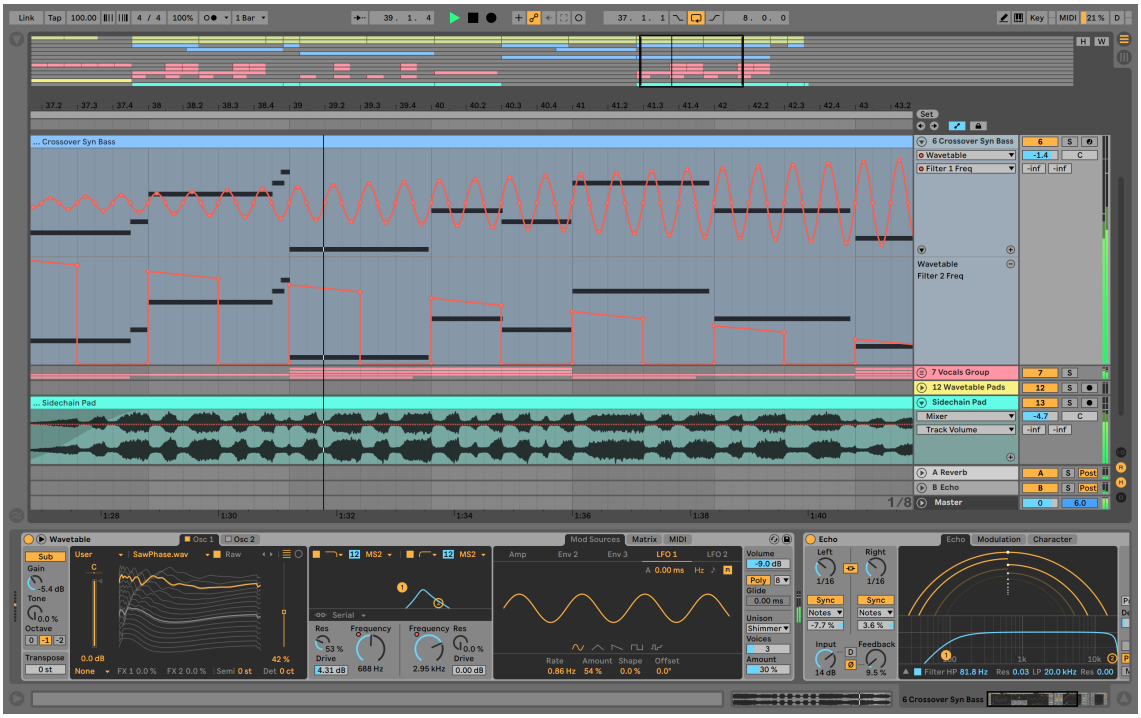


PICTURE 9. Touchdesigner and Ableton Live (YouTube 2019)

4.2 Audio

This is the second part of the setup. MIDI control data comes from the first computer running the video. This data is used to control different functions and parameters on the DAW.

Ableton Live was the software of choice for the live sound design part. Its flexibility to work with audio clips, MIDI and sync with external devices made it the perfect choice for this setup. It provides a friendly user interface and straight forward workflow for live situations. (Ableton n.d.)



PICTURE 10. Ableton Live 10.1 (Hispasonic 2019)

4.3 Connecting devices

This part covers the connection between all the devices involved in the setup for a correct workflow and later synchronization.

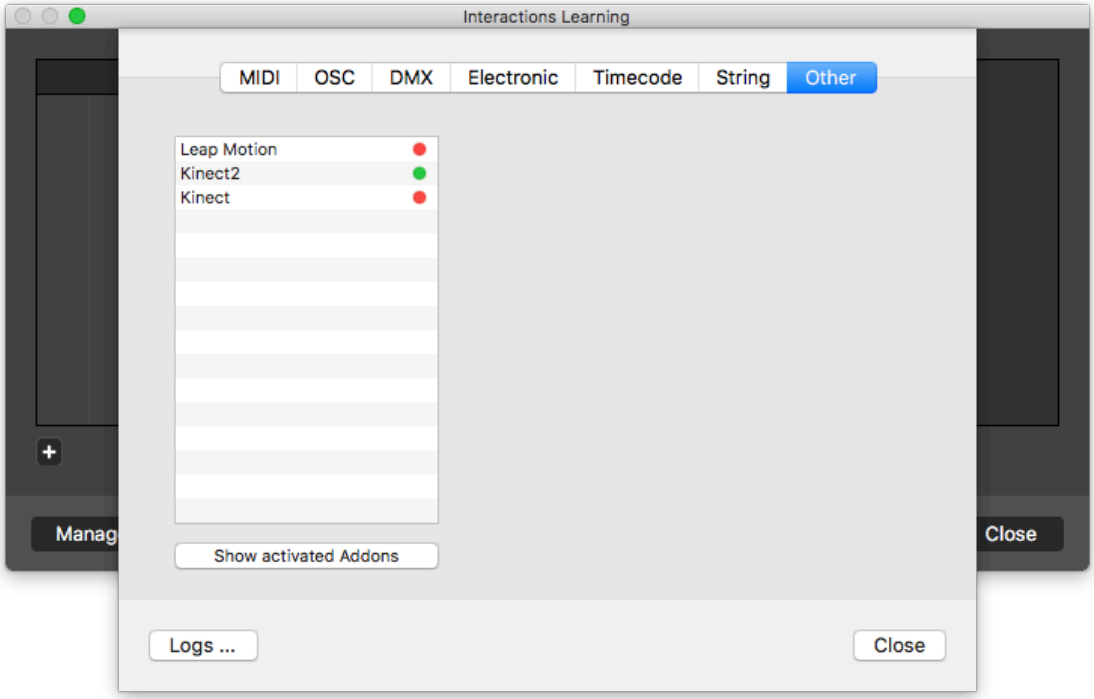
4.3.1 Computers

This setup was built using two Apple MacBook connected via MIDI. Two methods were researched: using an external interface and creating a network between the two computers. Both methods explained in detail in the Synchronization section.

4.3.2 Microsoft Kinect

The Kinect model used for the research was the one included with Xbox One, second version (Anthony 2013). The camera works with an external power supply and connected straight into the computer with an USB 3.0 cable. The camera

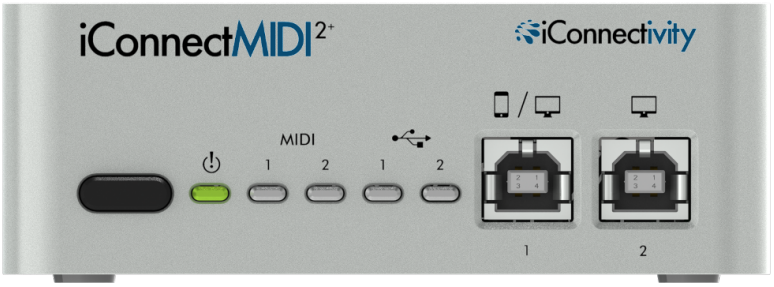
does not accept connection via USB hub. It is important to do this connection before starting Millumin. Otherwise reboot is necessary.



PICTURE 11. Kinect connected to Millumin (Montaño 2020)

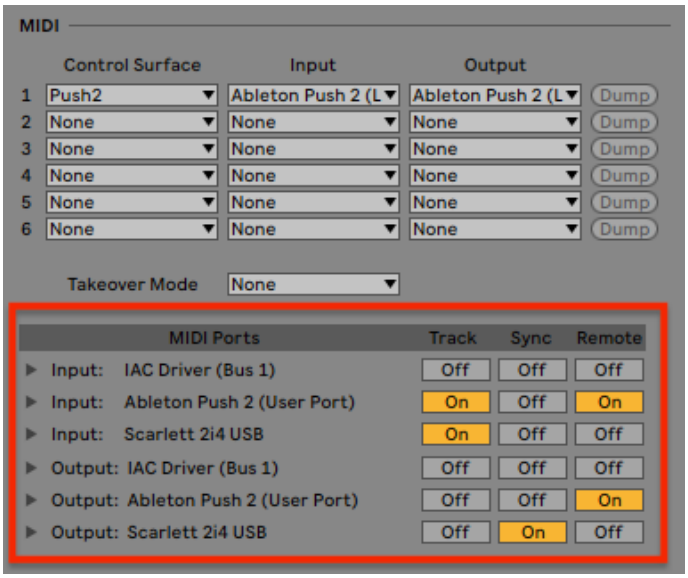
4.3.3 iConnectMidi2+

iConnectMidi2+ is a small interface that allows MIDI and audio signals to pass digitally between two computers or a computer and an iOS device (iConnectivity n.d).



PICTURE 12. iConnectMIDI2+ (iConnectivity n.d)

The device is USB powered. Both computers would connect via USB to it. If this method of connection is used, on Ableton Live preferences the sync option must be activated at the input of the iConnectMIDI2+.



PICTURE 13. Ableton MIDI preferences. Sync is active for the output of a Scarlett 2i4 audio interface (Help Ableton n.d)

4.3.4 Universal Audio Apollo

The audio interface chosen for the research was a Universal Audio Apollo x8. Its high-quality converters, zero latency processing and number of outputs make it an optimal device for small or bigger events. The connection is done via thunderbolt to the second computer. (Walker 2018.)

PICTURE 14. Universal Audio Apollo x8 front (Universal Audio n.d)

PICTURE 15. Universal Audio Apollo x8 back (Universal Audio n.d)

4.4 Synchronization

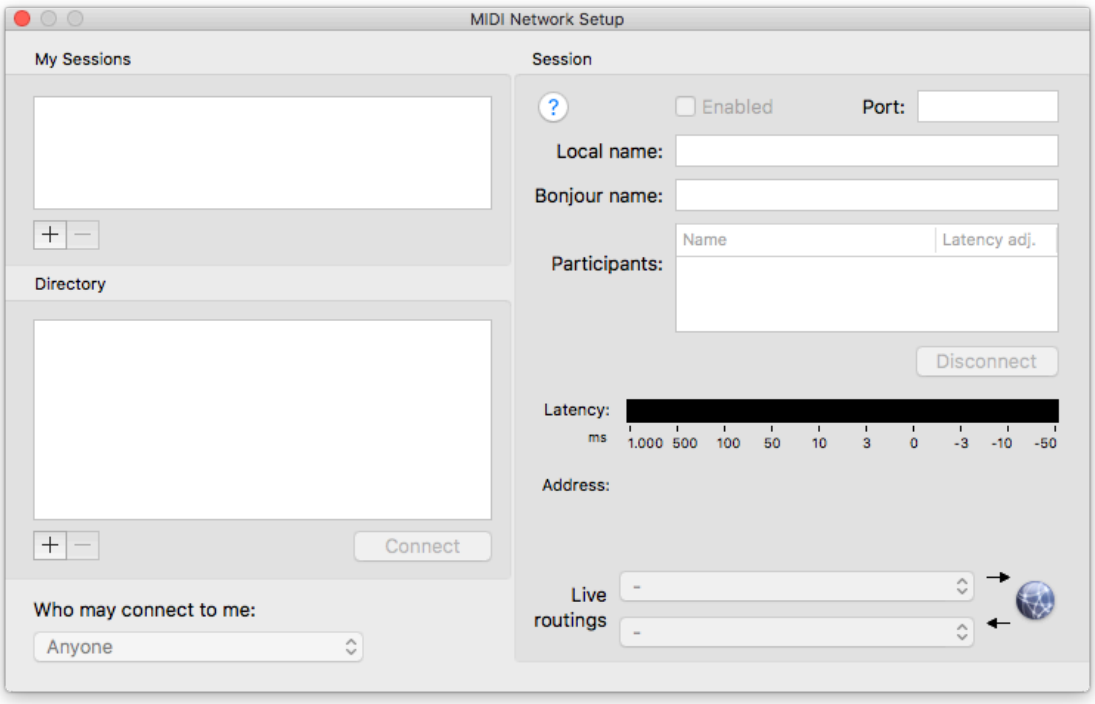
This section explains two methods of synchronization for the devices to guarantee the proper workflow of the installation.

4.4.1 Audio MIDI Setup

macOS provides a network MIDI driver that allows to send and receive MIDI information between computers on the same network (Apple support n.d). No external interfaces required. The way to do this for two machines is the following:

1. Both computers must be connected to the same network via Ethernet or Wi-Fi (Apple support n.d).

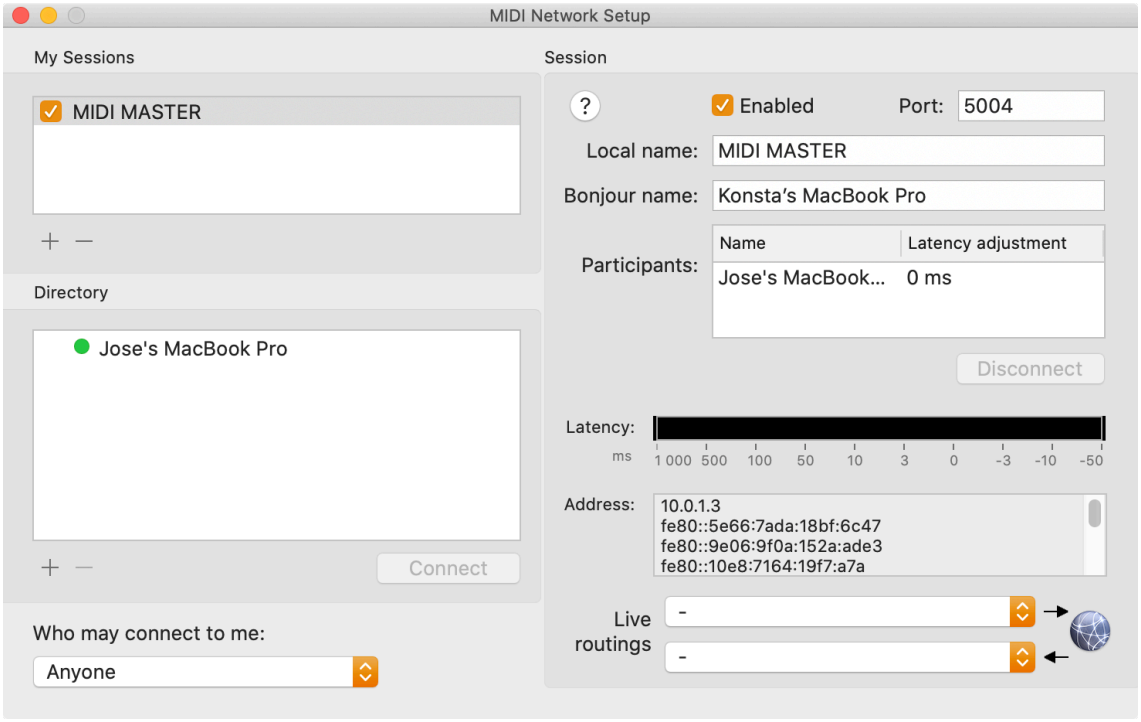
2. In Audio MIDI Setup, press “command+2” to show the MIDI studio (Apple support n.d).



PICTURE 16. Audio MIDI Setup by default (Montaño 2020)

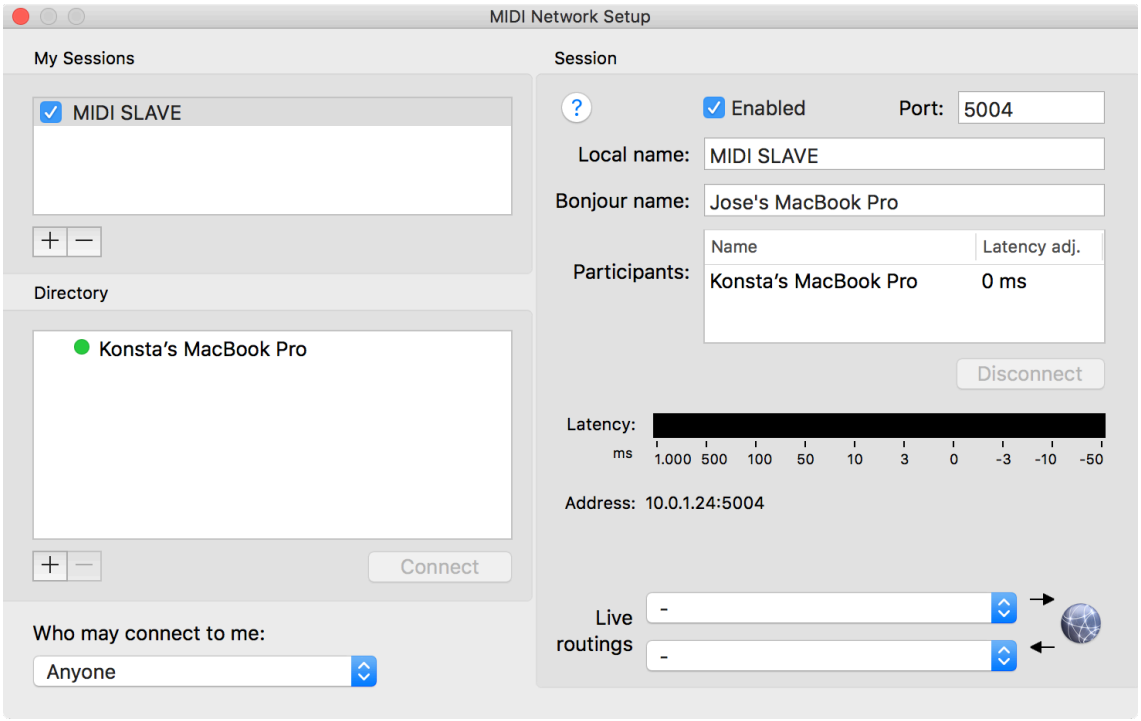
3. Under My Sessions press “+” to create a new session. On the right side create a Bonjour name that will be the network name for that machine (Mitchell 2020; Apple n.d.).

4. Under Directory all the computers available on the network will be displayed. Press on the computer desired and “Connect” to add it to the network. (Apple support n.d.)



PICTURE 17. Audio MIDI Setup on the master (Montaño 2020)

5. This must be done on every computer on the network (Apple support n.d).

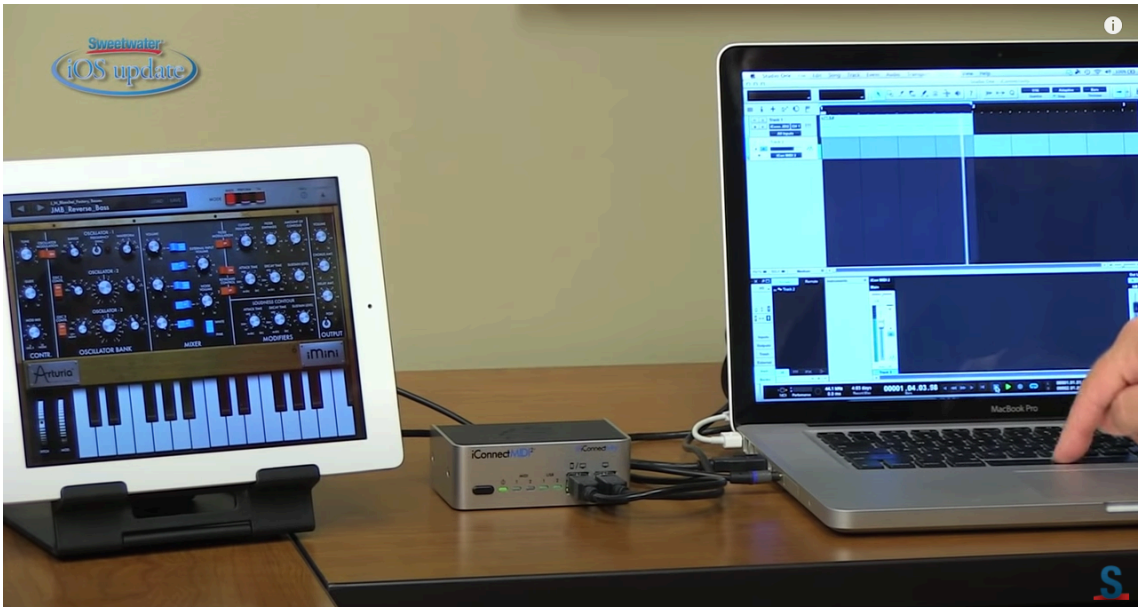


PICTURE 18. Audio MIDI Setup on the slave computer (Montaño 2020)

4.4.2 MIDI interface

Working on macOS as explained on the previous section eliminates the need for external interfaces to transfer MIDI information between computers. On this particular setup all the audio will be handled on the second computer using the MIDI information provided from the first one.

But in case that audio needs to be transferred between computers also, then the interface is needed. In this situation all the MIDI and audio information would be transferred digitally through the iConnectMIDI2+ avoiding any latency, conversion or possible network problems (iConnectivity n.d).



PICTURE 19. iConnectMIDI2+ connecting MacBook and iPad (YouTube 2014)

4.5 Output

The final section of the setup covers the output of the installation. Video and audio projected and played in sync.

4.5.1 Visuals

If the number of projectors is lesser than three there is no need for a switch. Each projector can be fed straight from a thunderbolt output of the MacBook (Apple support n.d). The computers used for this research had two Thunderbolt ports each.

When using three or more projectors it is usually necessary to use expansion modules like the TripleHead2Go from Matrox that also allows to create one single big display by combining three screens/outputs (Matrox n.d).

PICTURE 20. Matrox TripleHead2Go (Matrox n.d)

In this case an external GPU is also required to handle all the extra graphic processing from real-time rendering and displaying on three screens. Some like the Razer Core X (Faulkner 2019).

PICTURE 21. Razer Core X eGPU (Razer n.d)

4.5.2 Audio

Audio output would go straight from the monitor outputs or line outputs from the Apollo interface to the PA or audio system of choice. In case of needing more analogue outputs another external module could be connected via ADAT according to the following (Apollo x8 n.d, 28-29; Sweetwater 2001):

ADAT PORT CHANNEL ROUTING				
Sample Rate (kHz)	**Input Port 1**	**Input Port 2**	**Output Port 1**	**Output Port 2**
44.1 & 48	1 – 8	Disabled	1 – 8	1 – 8 (mirror of port 1)
88.2 & 96	1 – 4	5 – 8	1 – 4	5 – 8
176.2 & 192	1 – 2	3 – 4	1 – 2	3 – 4

PICTURE 22. Universal Audio Apollo x8 ADAT specifications (Apollo x8 n.d, 25)

5 DEMO PROJECT

Because of the Covid-19 situation on 2020, the complexity on this demo installation had to be reduced to its basics. Nonetheless a practical example is provided where the setup and capabilities of the system are shown (Appendix 3).

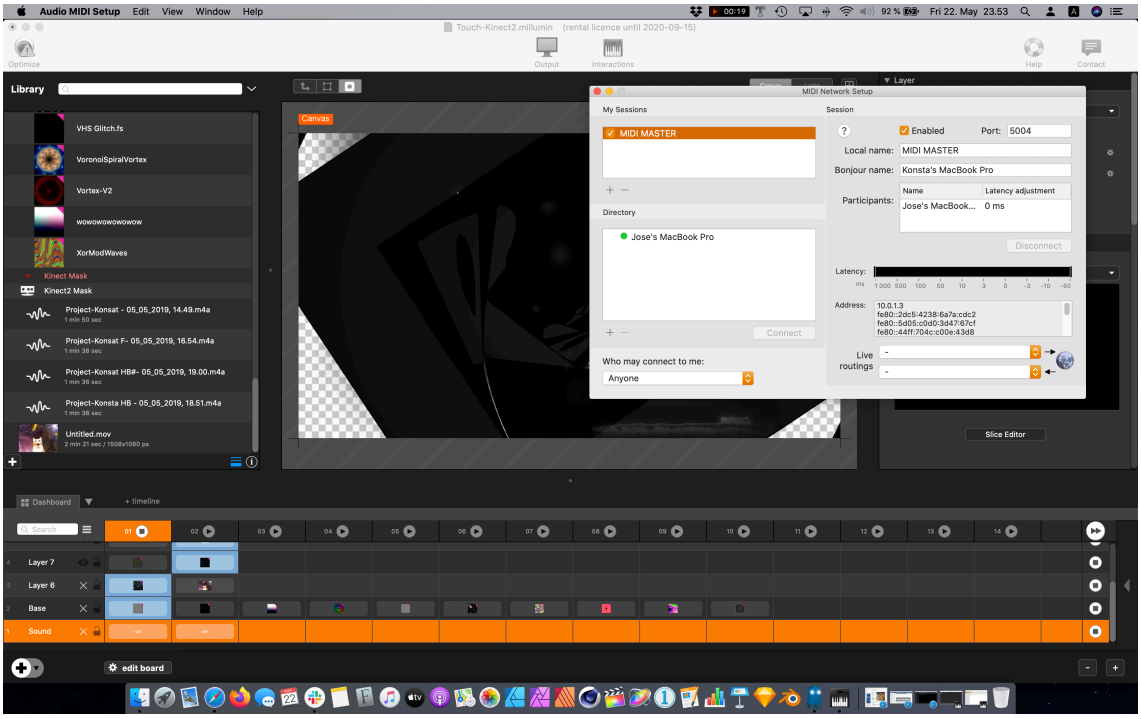
The demo was built over a previous installation, Electric Heart (Fedorov 2019; Appendix 4), where motion capture and real-time rendering was used. I started from a simplified version of it to build a canvas where I could define some interactions that would affect the sound in different ways.

PICTURE 23. Electric Heart installation (Fedorov 2019)

I set two laptops, Kinect and one projector in the living room. A Focusrite 2i4 audio interface and a pair of speakers for monitoring purposes. The whole performance was video recorded with an Iphone Xs and the sound straight into Ableton using the resampling function (PQ 2016) and synced afterwards.

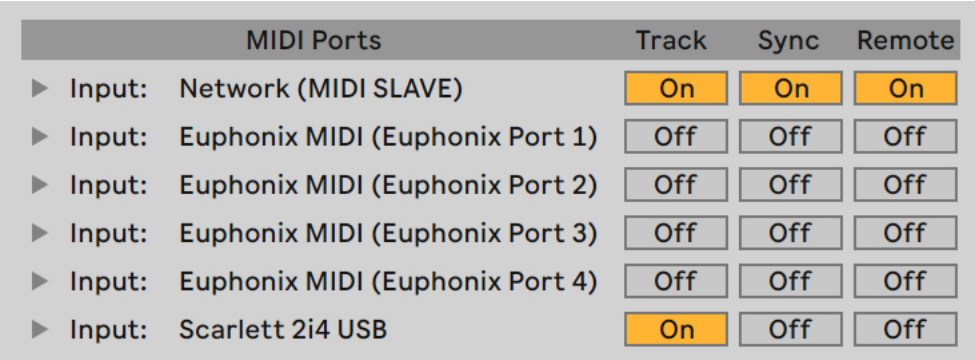
PICTURE 24. Demo setup (Montaño 2020)

Both computers were connected to the same Wi-Fi network and linked using the native macOS network MIDI driver.



PICTURE 25. Screenshot of Millumin and Audio MIDI Setup (Montaño 2020)

In order for Ableton Live to receive this MIDI information I enabled the Track, Sync and Remote options at the MIDI network input.

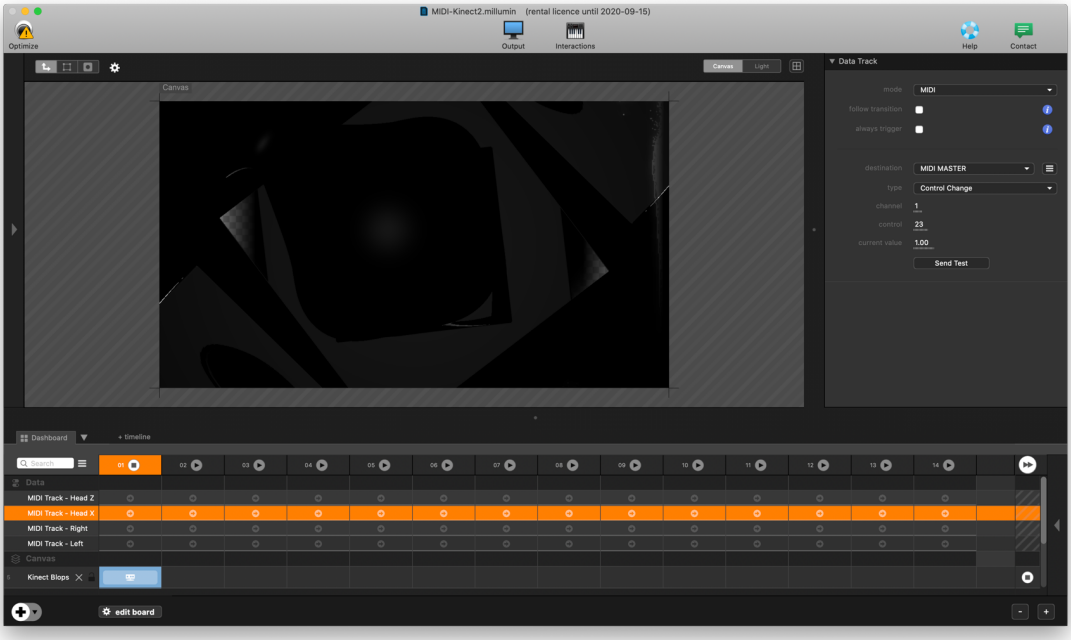


PICTURE 26. Ableton Live MIDI preferences (Montaño 2020)

I created four interactions in Millumin and assigned them to different effects in Ableton Live:

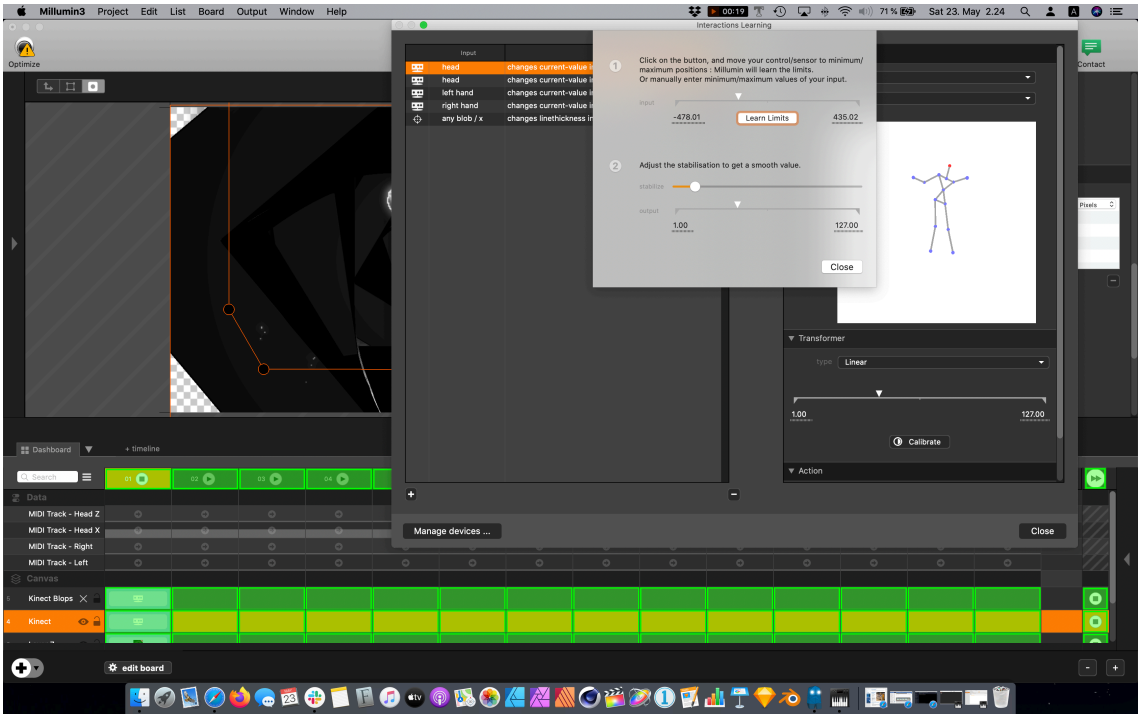
- Head X: Tracks the head on the X axis (left / right) and controls the dry/wet of the tremolo.
- Head Z: Tracks the head on the Z axis (forward / backwards) and controls the dry/wet and frequency rate of the flanger.
- Left hand: Tracks the left hand and controls the cuttoff filter.
- Right hand: Tracks the right hand and controls the dry/wet of the stutter.

Every interaction was assigned to the MIDI network and to a certain CC value from 0 to 127.



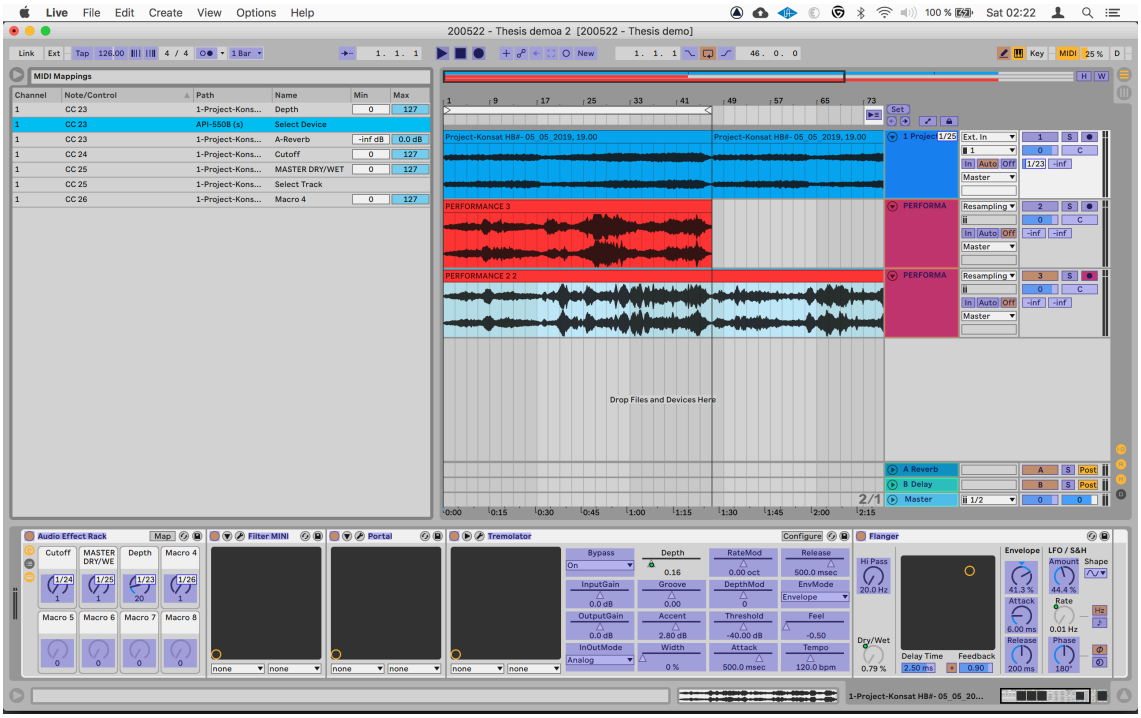
PICTURE 27. Assigning CC values to interactions (Montaño 2020).

Every interaction must be calibrated also to define the range of the motion and tracking area.



PICTURE 28. Calibrating the different interactions Montaño (2020)

Once the interactions were defined, I MIDI mapped the desired macro controls in Ableton Live according to the CC values in Millumin. The way to do this was activating first the MIDI mapping option in Live, clicking on the control we wanted to map and then from Millumin pressing “Send test” on every interaction.



PICTURE 29. MIDI mapping Ableton Live. Bottom left corner shows the CC values from Millumin (Montaño 2020)

Once this was set, Live macro controls immediately responded to the movements tracked by Kinect. From that point I was able to interact in real-time with the installation that was also being rendered live.

On the demo videos (Appendix 3) I show a small performance with the installation. Kinect seemed to respond fine in tracking my hands and position without problems though a little lag was noticed sometimes. Another issue was that Kinect when working with Millumin was only able to track one person at a time. If someone else would be near the camera while someone else is performing, then Kinect would usually lose its focus in favour of the other person. The two computers worked together fluently without any noticeable latency even though they were synced wirelessly. For real life situations where projects and the amount of processing is heavier, I would probably connect them with an ethernet cable or

MIDI interface to reduce latency to its minimum and avoid any external interference.

6 CONCLUSIONS

Projection mapping and interactive installations of all kinds have become more and more present in our daily life also thanks to AR and VR that have helped us to be familiar with them. As consumers we tend to adopt all new technologies that somehow behave as an extension of us. Therefore, is our duty as creators to push the boundaries and provide new content that breaks the barriers of what is already established.

I think figuring out new ways to collaborate and create is a must considering how affordable and accessible technology is nowadays. Working remotely, sharing content or just the ability to program some code within the software to expand its functionality shows clearly that limits are not that big anymore.

I hope the idea from this thesis can encourage other people to work together and discover new ways of collaborating and discovering new things. This setup can be applied to different scenarios from art installations, music events, projection mapping, educational purposes etc.

The setup could be taken also to a further level using several projectors, immersive sound configurations and light design, all at the same time. It could be used with recreational purposes or make it a tool that will help us in our day by day interactions.

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APPENDICES

Appendix 1. Idea and Duckl

Idea. Project description:
https://www.konstafed.com/projects/project-1/hirvitalo.html

Duckl. Project description:
https://www.konstafed.com/projects/project-2/duckl.html

Appendix 2. STRUKTUR

STRUKTUR. Project description:

https://www.konstafed.com/projects/project-21/struktur.html

Appendix 3. Demo project

Millumin & Ableton Live – Demo 01 Video:
https://www.youtube.com/watch?v=Q4HqBACasBk

Millumin & Ableton Live – Demo 02 Video:
https://www.youtube.com/watch?v=txuY6SACB4Y

Appendix 4. Konsta Fedorov interview

Interviewer: José Montaño
Interviewee: Konsta Fedorov
Tampere, 10.05.2020

José: Could you tell me a little bit about yourself and how did you get interested in projection mapping?

Konsta: I've been a graphic designer for more than 10 years now, before I moved to Tampere (I'm originally from St. Petersburg). I became interested about two years ago in motion design and projection mapping through the studies at TAMK. I was in a video installation course and for the final assignment we didn't want to do just a flat projection on the wall. There was a locker in the room, and we decided to project on it and learn something new for ourselves as a team (Fedorov 2018). Then our work was selected for the IWeek 2018. From there I started experimenting with the mapping and sometime after we had the chane to create the Duckl and Idea installations in collaboration with VideoKanava.

After that, for IWeek 2019 I came up with an interactive installation, Electric Heart that was also presented in Hiedanrannan Kartano during the SWÄG Festival that same year.

José: Which software / tools do you use?

Konsta: Touchdesigner, Isadora, Millumin. Millumin is not that powerful but has an easy user interface and you can get really nice results if you don't want to dig into the programming. And of course, a MacBook Pro. It's still the only processing power I use, no external GPU's.

José: What was your last project?

Konsta: Since 2018 I started collaborating with Carlos Portilla on the technical support and José Montaño with the sound design. We started approaching the Tampere Film Festival around autumn 2019 to check the possibility of doing

something with them on 2020 for their 50th anniversary. We came up with STRUKTUR, a projection mapping series on different buildings in Tampere during the Festival.

José: Do you consider immersive experiences nowadays something of a mayor interest for the daily life?

Konsta: It's not implanted on platforms like Netflix or Spotify for example, which are things that most people consume nowadays, but if you go to a museum people are expecting to interact with the installation. We went to Amos Rex in Helsinki to see the TeamLab installation and you could clearly see that people was missing something, touching the walls and kids playing in front of the projections when there wasn't anything interactive there at all.

José: How relevant do you think immersive experiences will be on the next years?

Konsta: There has been a boost on VR sales during the Corona situation. Nowadays AR and VR are mostly used for industrial purposes like employee trainings or showrooms for instance. AR is probably the most immediate thing. There are very useful apps like the one from IKEA that lets you see how the furniture would fit your room and also some art exhibitions have been done already just with AR using your phone. No paintings or pieces of art at all.