Ada Mathea Hoel

Adapt!

Producing a cyclic web album using adaptive processing

Master's thesis in Music technology
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June 2020

Master's thesis

NTNU
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Science and Technology

Acknowledgements

Summary

In this thesis I present the process of producing an hour long cyclic album using adaptive processing techniques. For this purpose I developed an analyzer and mapping plugin in Max for Live called *Adalyce*. A cyclic album is in this context an album that is streaming in a loop on my website www.adahoel.com. The music expresses a personal experience using seasons as metaphors for phases of a real life process.

Preface

0.1 This thesis

For this thesis I wanted to create an hour long cyclic album exploring adaptive processing techniques as a production tool. A cyclic album is in this context an hour long album that plays in a loop on my website. To do the adaptive processing I developed a plugin, *Adalyze*, in Max for Live. The aesthetic aspect of the processing was more important to me than the technical, as I wanted to find out what the adaptive processing would add to the music. This can be regarded as a continuation of the work I did for my bachelor's thesis, *Adaptiv liveprosessering - En utforskning av adaptive og kryssadaptive liveprosesseringsteknikker* (2016), where I explored auto-adaptive and cross-adaptive live processing techniques. Going from a live setting to production has its own set of possibilities and challenges. I went from being a performer and real-life technician to being able to create layers and experiment with multiple options as a producer, as well as being able to postpone decision making. As a producer, my artistic expression - the album format using seasons as metaphors of process stages, loops and processes - had a bigger place than the technical aspects, although they also played an important part of this thesis. The work I am about to present describes both the technical process of developing and utilizing my plugin, the music production process and how I have drawn parallels between processing and processes. I wanted to create something that would sound alive, and also in some ways reflect life.

Table of Contents

List of Figures

Chapter 1

Introduction

Adaptive audio processes are commonly used in most genres today, from the cross modulation found in ring modulation[1] and the use of vocoders[2], to the audio adaptive processing done in sidechain compression[3], which is widely used in EDM[4] and other popular music genres(Reiss, J. D. and Brandtsegg, Ø.). Adaptive processing lets the user use an audio signal as a modulator signal that informs the way a different or the same audio signal is processed. Recently there has been new and interesting research in the field, both here in Trondheim with Øyvind Brandtsegg's Cross adaptive processing as musical intervention(Brandtsegg, 2018), the research done by Verfaille on Adaptive digital audio effects(Verfaille et al., 2006) and the research done on intelligent audio at the Queen Mary University of London.

The way we consume music is also evolving, with more focus on singles, clips and music videos than on full length albums. Using adaptive processing techniques I want to explore a different album format. I want to create a work that conveys repeating emotional processes from real life using the calendar year and the seasons as metaphors. I also want to find ways to use adaptive processing to reflect how life events can modulate our experience and reality. Adaptive processing will also be used as a tool to make the instruments "talk" to each other in an effort to make the music sound more organic and alive.

With this in mind I hope to create a new and different musical expression in the name

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[1]Ring modulation is an audio effect where two signals are multiplied, creating two new frequencies

[2]A vocoder is an audio processor that captures the characteristic elements of an an audio signal and then uses this characteristic signal to affect other audio signals, often synthesizing instruments to sound like human speech

[3]In sidechain compression the amount of compression on one sound is controlled by the amplitude level of another sound

[4]Electronic dance music

of my solo project *Ada Hoel* which will be continuously broadcast as a one hour cyclic album on http://www.adahoel.com. The playback start time of the loop will correspond to the real time minutes and seconds in the hour. One of the ways the album is divided is by seasons and the 12 months. Each month of the year has been given 1/12 of an hour (5 minutes) and you will for example start listening from "January" if you enter on the hour (xx:00) or from the middle of "August" if you enter on the hour (xx:37).

You can also find the work on https://soundcloud.com/adahoel/adapt-producing-a-cyclic-web-album-using-adaptive-processing/s-bxVL1X2XVFt for analytical listening purposes.

Chapter 2

Adaptiveness

2.1 The conversation as actions and reactions

In an ideal conversation with your friend you listen to their words in silent engagement as they finish their statement. They signal to you they are awaiting your response by falling silent, and you start talking. As they digest your reply they may either listen or shoot in small remarks which lead you to briefly pause your word flow in order to give room to their new insights.

These communication "rules" are common, and we have learned them through social coding. They are there to ensure the best flow in our communication and to avert chaos. They are one of many learned social behaviors we execute every day, like crossing the street on green lights, waiting in line at the supermarket and not picking your nose in public. In different societies there will be different rules and codes, but to be well-adapted in our society we need to abide by them. If we miss or disrespect any of these social cues we may get repercussions like ugly stares or social alienation.

In these examples we can see an effect and a cause, an action and a reaction. There are similar "rules" to playing music together too: like the fact that we're usually playing in the same tempo, or that when someone has a solo the other musicians lower their volume to give them space in the music. As in different societies there are also different norms in different genres. The same way musicians adapt their tempo and expression to the conductor, producers and mixers will adapt their audio processing of the different elements in the mix to the others. In the traditional scenario all the decisions have been made by the technician based on what they hear in the music - little has been left to coincidence.

Let's draw the parallels between the conversation, the interplay and mixing even further. If we look at the conversation again we can see similarities between the conversation partners speaking in turn and jazz musicians trading solos. In the audio mixing world it is a common technique to keep the element you want the listener to focus on in the foreground of the mix, by relatively lowering the level of the other elements. Multiple elements sounding in the same frequency range is traditionally also seen as not ideal. This is often solved by using an EQ[1] to filter out colliding frequencies between the instruments. When, if we go back to the conversation, one of the speakers interrupts the other and the interrupted person quickly goes from speaking to listening again, it has similarities with another common mixing technique, the side-chain compression mentioned in chapter 1.

I want to create effects similar to these real life actions and reactions in my music. By using already existing cross-adaptive concepts I want the sounds to adapt to each other within a set framework. This would not necessarily be to replace the technician but to create other results than they previously would have been able to make. This could be a way to create life in the mix, almost like the processing can give "opinions" based off of what I feed it. Where the effect itself is listening and adapting.

2.2   In interplay

Communications rules as those described above are in play when improvising together in ensembles, where each of the performers can take on one or multiple "functions" in the interplay. While the accompanying musicians play softer, the soloist takes the spotlight with higher volume in comparison to the others. If the soloist chooses to pick up the intensity the accompanying musicians follow and help build up the energy. Maybe one of the horns will initiate a riff, or the drummer will switch to double time quickly joined by the bass player.

In these examples the musicians are either amplifying or contrasting each others' ways of playing. When amplifying another player, you choose to join in on their initiative, like playing in the same dynamic range or joining in on chaotic rhythms. When contrasting you experiment with multiple layers in the real time composition, making a more complex soundscape. In this way, the musicians together creates either a homogeneous or heterogeneous sound image, or a mixture of these approaches. I have used this idea as a concept for adaptive processes in mixing and timbral modulation. In chapter 5 I will come back to how I have used this concept in the production part of this thesis.

You can see some ways to create contrast in Figure 2.1. As you can see the contrasting functions are opposite to each other in the circle.

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[1]Equalization or EQ is an audio effect for boosting or reducing the levels of different frequencies in a signal
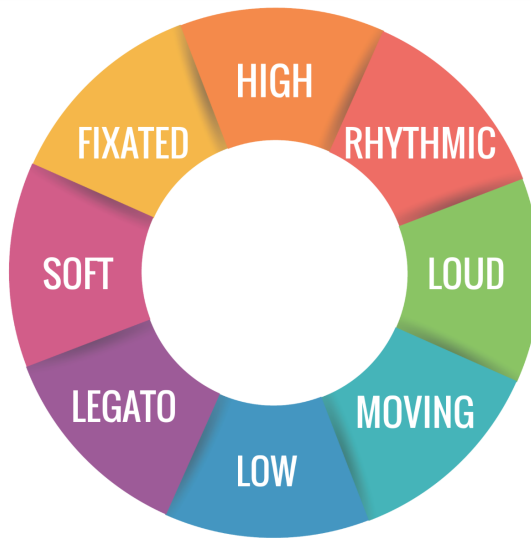
Figure 2.1: Contrasting functions in an ensemble.

2.3 Giving the processing "ears"

I wanted the prerecorded sounds in my production to behave as if they could communicate with each other like they were musicians in an interplay situation. I wanted the processing to make it possible to have that same action and reaction between them, as if they could "listen" and "react" to each other through analysis and mapping. The adaptive tool could almost be thought of as a conductor, or an ensemble hive mind.

In the same way that improvisational musicians listen to each other, and adapt their playing to their band mates, the plugin would make the DAW[2] able to change the parameter settings on different plugins based on multiple analyses. As musicians may choose different "parameters" to adapt to, like "if they play soft, I'll go loud", or "If I play in the low register they'll have more space in the highs", the plugin could make the synth reverb decay shorter when the vocalist sings high notes or the vocals have more distortion when the synth plays louder in the mix.

By using adaptive tools the technician is able to create a more homogeneous or heterogeneous sound image, depending on if the effect amplifies or contrasts the analysis, if for instance the vocals would get louder when the synth would play louder, or if a reverb would duck from the high notes of the vocals.

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[2]Digital Audio Workstation. Software for audio recording, editing and production

2.4 Adaptive processing

In adaptive processing one uses extracted audio features as modulators for the effect processing. Having control parameters depend on an audio signal is what defines an adaptive audio effect (Verfaille et al., 2006). Like the examples above adaptive processing should answer to the circumstances around it without the technician having to automate the process.

2.4.1 The compressor and side-chain compression as adaptive effects

If we again look at the well known effect compression, it uses an analysis of how much of the input signal's amplitude surpasses a threshold set by the user, and then reduces the output signal according to parameters set by the user. Usually, we set a threshold for where the gain reduction should be activated, and a compression ratio for the gain reduction above that point. So if the input signal is 6 dB higher than the threshold and the user has set the ratio to 2:1, the output dB will be cut by 2 for every 1 dB. In this example the amplitude over the set threshold will be reduced from 6 dB to 3 dB. This is an example of auto-adaptive processing. Auto here is referring to the "self," and is not an abbreviation of "automatic," in contrast to auto-tuning or auto-mixing. (Reiss, J. D. and Brandtsegg, Ø.)

With side-chain compression on the other hand, which is used in most EDM tracks to create a pumping effect, in addition to the more subtle use to give space to the vocals or the kick in the mix, an external signal is used to duck the signal whenever the modulating signal's amplitude exceeds a set threshold. This is an example of cross-adaptive processing, implying that certain features "cross over" from one sound to the other. (Reiss, J. D. and Brandtsegg, Ø.) According to Brandtsegg and Reiss' research there is a distinction between cross-adaptive (where the modulating signal can be heard) and external-adaptive (where the modulating signal is not audible in the output mix). In many current pop productions this effect can be artificially constructed by compressing the sound to an inaudible LFO[3] (See Figure 2.2). Although the sound in this example would be modulated by a signal not audible in the output mix the fact that the modulator signal is generated would make it not authentically external-adaptive. Real external-adaptive processing is still not common in the mainstream music industry.

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[3]A LFO or a low frequency oscillator is an electronic frequency which is usually below 20 Hz and creates a rhythmic pulse or sweep

Figure 2.2: LFO used for side-chain compression in FL Studio

2.4.2 Cross-adaptive research at NTNU 2016-2018

One of the leading research projects on adaptive and cross-adaptive processing was run by project leader professor Øyvind Brandtsegg at the Norwegian University of Technology and Science(NTNU).

"The project ran from 2016 to 2018 and explored cross-adaptive processing as a drastic intervention in the modes of communication between performing musicians. Digital audio analysis and processing techniques were used to enable features of one sound to inform the processing of another. These techniques allows the actions of one performer to directly influence another performer's sound, and doing so only by means of the acoustic signal produced by normal musical expression on the instrument." (Brandtsegg, 2018)

To realize the adaptive processing Brandtsegg developed a massive plugin where the user can map practically any audio feature as a control signal. This approach allows the technician and performers a lot of freedom, and basically anything is possible. The project was strongly based on practical experimentation, and one can find a lot of resources and documentation on their blog.[4]

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[4]http://crossadaptive.hf.ntnu.no/index.html

2.4.3 Adalyze, my Max for Live device

Inspired by the possibilities of adaptive processing I decided to develop my own plugin. It has less functionality than Brandtsegg's, but is in my opinion easier to use. I personally felt a little overwhelmed the first time I opened Brandtsegg's multiple VST devices, and can imagine other performers also would, especially those with a less technical background.

I wanted my device to be easy to use and have a relatively intuitive user design, with as few different instances as possible. I developed it in Max for Live, a visual programming language where one can build one's own instruments and effects for Ableton Live. Many improvisational performers and producers use it, which was one of the reasons I chose to use this platform, even though it as a result will not be accessible to users of other DAWs. I also find it highly practical the way that native Ableton Live devices (and Max for Live devices) are shown with their GUI in the Device bar as opposed to in a separate floating window. When the user can see and control all the parameters directly in the device bar it gives a better overview in my opinion. This limits the space you can deploy for parameters, but I find it easier to create mappings and switch between instruments in the DAW this way.

2.5 From stage to studio

The current implementation of the plugin is a continuation of the work I did for my bachelor's project *Adaptiv liveprosessering - En utforskning av adaptive og kryssadaptive liveprosesseringsteknikker* (2016). In that project I experimented with adaptive and cross-adaptive techniques in a live setting. The tools I used at the time were also developed by me, but much more simple.

In that project I used two different approaches. One was to split the incoming sound signal into three frequency bands in Ableton Live using filters, getting a low, a medium and a high band signal on three separate return tracks. I would then use Envelope Followers on these tracks to map parameters on other effect plugins, using them as modulators. I called this "band pass amplitude analysis".

The other approach I employed was a Max/MSP patch where I transformed pitch tracking data to MIDI data which I then sent to Ableton Live. In this approach I also split the data into four bands; lows, mids, highs and very high register. I called this "pitch analysis".

I found that the band pass amplitude analysis approach worked the best for polyphonic instruments like the guitar and the drums, and the frequency analysis approach worked best for monophonic instruments like my voice and the viola. The result of the bachelor was a concert with performers Håkon Brunborg Kjenstad on the guitar and viola and Ola Djupvik on percussion where I would utilize my tools to do live auto-adaptive and cross-

adaptive processing.

In my bachelor project I discovered how challenging it could be for the musicians to do a live performance using the auto-adaptive and cross-adaptive tools. This was due to the fact that they in addition to improvising to express their own personal expression also had the function of a modulator signal for the other performers or their own processing. To be able to make their output sound work as both was challenging, and probably led to different musical choices than if they were performing in their habitual way. These are also the performer constraints actively explored by Brandtsegg and his team in the Cross adaptive interventions project (Brandtsegg, 2018).

In a production setting this will be different, but I was curious if I would meet the same problems. Would I face the same challenges when using a sound both for its timbral characteristics and as a modulation signal? How would the adaptive intention shape my choice of sounds in the production?

In post production, contrary to in live settings, the producer makes all the decisions after the fact with more overview than what's possible to have for the musicians in the moment of action. Using adaptive processing techniques I can make the parts "listen" to each other in ways I have predefined, and react to each other in real time, and in that way give them "a second chance" to adapt to each other.

Chapter 3

Cycles and processes

3.1 The world modulated

If we draw the idea of adaptiveness into the real world we can see a myriad of ways adaption takes place. When we look at adaptiveness as a modulator affecting or provoking a reaction it is a big factor in most processes around us, from the way hormones in the human body make us act in different ways, to how rain and light stimulate plants to grow. In a way all life on earth is modulated by the sun. The sun's distance and angle in relation to our planet determines the temperature and the amount of light reaching us. In turn these factors modulate our sleep cycles, digestion and mood during the day, but also which season of the year we are in. Another earth modulator from outer space is the moon, causing high tides and low tides with its gravitational pull, causing the earth and the water to bulge out on the sides closest and farthest away from the moon.[1]

These processes are circular, evolving in a never ending loop. They have different stages they go through on each iteration and have a big impact on life on earth.

3.2 The process/the year

My album is a one hour loop that represent multiple processes at once. The frame of the cyclic album is the year. I split the length of the album in to 12 parts, the 12 months. These months form metaphoric seasons: winter, spring, summer and fall. It is also a metaphor

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[1]https://scijinks.gov/tides/

for multiple stages in a process.

The seasons that bring the most change, spring and fall, lead up to the more stable and stagnant seasons summer and winter. In a way spring can be seen as an awakening and fall as falling asleep. It's easy to find contrasts in the different seasons, with the warm and light summer being opposite to the cold and dark winter and the spring with its creating force as a contrast to the death of the flora in the fall. Things alive go into hiding from the harsh hardships to come, and stay in hibernation through winter, waiting for the spring to bring new life and nourishment.

Change, both for the better and worse, can be perceived as painful and chaotic. Humans find patterns and systems to survive in this world, and any change can feel threatening.

The importance of cycles as an inspiration for artists can be traced back a long time. One composer that created music based on the seasons was Antonio Vivaldi with his work Four Seasons. He evoked strong sensory associations of the seasons composing different narratives. Four Seasons is a good example of classical program music, where instrumental music is intended to evoke something extra-musical in the listener. Similarly to my album Vivaldi's four seasons is also split into 12 parts.

To me the seasons represent stages in a painful process I had to go through over multiple years. Using the seasons as metaphors for the different stages has been a tool for me to see the bigger picture and present my story. I started by figuring out what the seasons represented for me personally in order to recreate them in the loop.

3.3   Pain as a modulator for change

In addition to the body receiving hormonal "rewards" for actions like eating, exercise and sexual activity to promote repetition of such activities to the benefit of the person's health and reproduction, the sensation of pain is used to communicate danger or harmful actions. It may be a painful bleeding scrape telling you to be more careful the next time you go for a walk, chewing your tongue by accident or a shock of pain urging you to quickly remove your hand from the oven to prevent further damage. From these pain triggers it's obvious and intuitive what action to take to stop the pain and avert harm. In other situations it can be less obvious. If you have been inside all day you might be building up a headache from the lack of fresh air and movement. Even though you might be aware that this probably is the cause of your pain it may be a less intuitive solution to go for a walk. In other cases the way to get out of the pain can even be counter intuitive.

I'll share an anecdotal story from my own experience with chronic pain as an example. When I felt the first signs of my would-be chronic lower back pain I, in what would seem

logical due to my prior experiences with pain, avoided all actions that would inflict sensations of pain. From bending down to picking up heavy objects, dancing with my friends to exercising, I would avoid it all not to feel the sensation of pain. In my head it was the logical thing to do, just like pulling away from the hot stove to avoid a blister. The thing is, from avoiding all activities that was causing pain, I was becoming over-anxious and stressed. By running away from my pain instead of meeting it I was actually making it worse! At the same time I was working hard to keep my grades up and fulfill my obligations. I was so afraid of failing, and my pain was just getting worse. I cut out meeting friends, going to concerts and dancing at my dance club. But I kept stressing every day to try and finish my work, which was just piling up.

It turns out the pain was my body's way of telling me I was doing too much and needed to pull back. I had been misinterpreting the signal. This realization I gained at the absolute bottom of my process. Because I hadn't listened to my body, it started shouting. When I continued to ignore it, it was screaming at me. It had no choice, it was the only way to make me listen! Gaining this insight was extremely painful, an absolute breakdown, but the only thing that led me to healing. This process of mine is represented in the music work as fall (the beginning of pain), winter (going into hibernation and pulling away from the outside world) and spring (the painful realisations that finally led to healing through a new beginning). This process took me 5 years, but finally I had the tool to stop the pain. To listen!

3.4   The website as an album platform

Today the popular mainstream music business has a big focus on hard hitting music singles. This tendency favors the single over the album and the EP, therefore creating fewer possibilities for the artist and producer to explore more complex concepts and extended narratives. Instead of listening to the songs as pieces of a bigger puzzle the listener gets used to the instant gratification of a hit song without the sometimes needed build up of an album to create context. When the song only exists in a vacuum without world building from surrounding songs it can loose out on impact building contrasts. The piercing sound of a hammer hitting stone will feel much louder coming from silence, and the pain of the main character in a movie will feel much more real if we know their back story. Beyoncé's 65 minute long audiovisual album *Lemonade* is a great example of using the album form to convey a narrative.

What inspired me to make this experimental hour long cyclic album was actually Pharrell William's 24 hour music video to his major pop hit single 'Happy' that was broadcast on the website *http://24hoursofhappy.com*. Here you would continually see multiple music videos of dancers and actors performing to the song in a 24 hour loop. The different

videos had surroundings corresponding to what time of the day you would enter the page, representing the day and night cycle.

I just loved the concept of real life factors like the time of day influencing the users experience of the music. Digital technology allows for new and exciting ways to present and share music, and the web is the most obvious choice. Another artist that have utilized the online album form in an inspiring way is the Icelandic singer, songwriter and producer Björk. [2]

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[2] https://bjork.com

Chapter 4

Developing the *Adalyze* plugin

4.1 Requirements for the plugin

As a background to guide my choices in developing Adalyze, I set down some requirements. These were based on my specific needs for this production, and my general needs as a music producer. I also reviewed some other existing tools to see what I wanted to re-use from them, and what I wanted to do differently.

These were my requirements for the plugin:

- It needed to be able to analyze perceptual features from a sound

- Have an intuitive mapping design to make it easy to modulate any parameter in a DAW.

- To be contained in the Device View bar in Ableton Live without the need to open up an additional window.

- Have enough different analyses to get variety in the modulations without overwhelming the user.

I wanted the plugin to be very intuitive to use without the need to read a lot of documentation first, although it would rely on the user having a basic understanding of cross-adaptive concepts. However its similarity to the widely used sidechain-compression technique will probably make it easier to grasp at first sight.

4.2 Already existing adaptive tools

4.2.1 Featexmod / Brandtsegg

In the context of the cross-adaptive project (Brandtsegg, 2018), Brandtsegg developed some comprehensive tools for this kind of signal analysis and modulation. It has two VST plugins for analyzing and mapping, both developed in Csound and Cabbage.

Figure 4.1: Brandtsegg's analyzer VST offers a lot of control over the input signal.
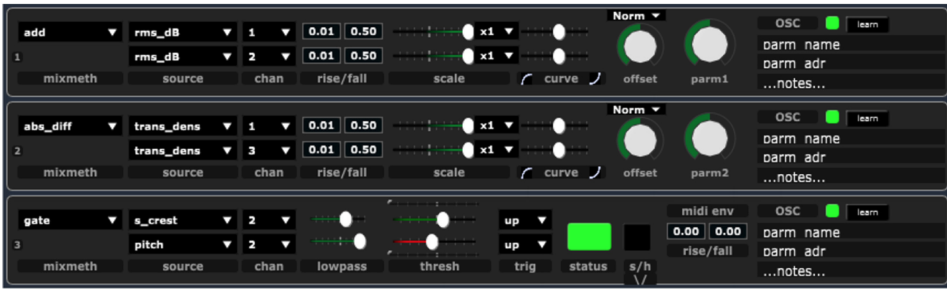
Figure 4.2: Brandtsegg's mapping VST. Different modules for the mapping of analysis signals from several sources.

4.2.2 The Envelope Follower in Ableton Live

The Max for Live device *Envelope Follower* that is a part of the Max for Live Essentials package that's included in the Suite version of Ableton Live has some adaptive functionality. Using this device the amplitude of an audio signal can be mapped to modulate any parameter in Ableton Live. One can also calibrate the modulating output signal by setting the *Gain*, *Rise*, *Fall* and *Delay* values according to one's needs. It is a simple yet versatile plugin.

Figure 4.3: The Envelope Follower device in Ableton Live.

4.2.3 iZotope Neuron

iZotope Neuron is an assistive mixing technology used to speed up and simplify the mixing process. In iZotope Neuron the user can for instance link a dynamic EQ between tracks to adaptively adjust the bass guitar EQ in relation to the frequency of a kick drum. The tools in Neuron are mainly for mixing purposes in order to solve problems. With creative cross-adaptive applications we're not trying to solve problems, but rather challenge the links between different sound sources and use that for creative causes.

4.2.4 Adaptive functionality in REAPER

The DAW REAPER also has a functionality for mapping an Envelope Follower to any parameter on the same track. This will make it possible to do auto-adaptive processing.

4.2.5 Adaptive video tool in Ableton Live

I was also inspired by the RokVid Max for Live device by Adam Rokhsar[1] that allows the user to employ different waveforms and audio analyses to map different parameters controlling the visual processing.

Figure 4.4: The RokVid device by Adam Rokhsar in action

4.3 Motivations for developing my own plugin

Even though Øyvind Brandtsegg has already developed an impressive and very complex plugin for this exact purpose I still wanted to develop my own. Brandtsegg's plugin has a lot of advanced features, like being able to utilize multiple audio signals as modulators at once and very detailed control over the analyzed signal. This leads to a lot of control for the user, but also a lot of choices to consider. For my purpose I wanted a tool that was less complex and therefore easier to use. In my project it was more important that it was easy to analyze the sound and map it right in one device (rather than two) than to have such extensive functionality. This would allow me to focus more on the composition in the production process rather than tweaking the plugin too much.

4.4 Development process

Early in the development process I decided to base *Adalyze* on the earlier mentioned Envelope Follower. It has some of the same functionality that I needed in my own plugin,

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[1] RokVid Max for Live device by Adam Rokhsar https://www.ableton.com/en/packs/rokvid/

and was therefore a good starting point. It was especially its mapping function that suited my needs. The first thing I had to do was to add more ways to analyze the incoming signal than the already existing amplitude analysis. To keep a good overview I also knew I wanted to visualize all the audio signal analyses side by side, which would be a challenge due to the limited space of the Device Bar in Ableton Live.

All Max for Live devices can be edited directly from Ableton Live, opening its framework Max/MSP in a new window. This makes it possible to reuse blocks of code or make adaptions to already existing devices, and enabled me to reuse some of the code from the Envelope Follower in my own plugin. I already had an Audio Analysis Max/MSP patch developed by Andreas Bergsland that could analyze pitch, onset, RMS, four band split amplitude and a centroid that I chose to merge with the Envelope Follower. This would give me the Ableton Live friendly mapping functionality from the Envelope Follower in addition to more ways to analyze the incoming signal, which was exactly what I needed!
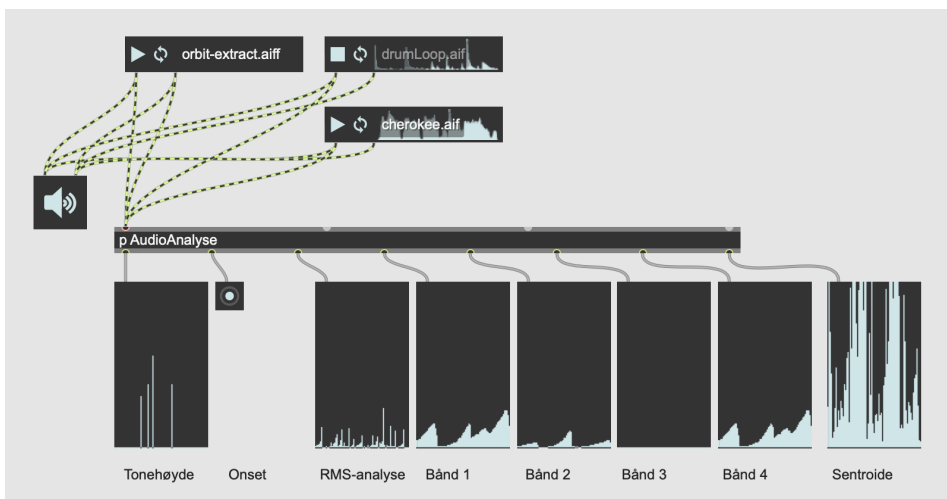
Figure 4.5: Bergsland's Audio Analyzer

After combining and modifying the codes I got errors from my new device that I had to fix to make it function. To reduce possible error sources I first removed the redundant features from the Envelope Follower such as the *Fall*, *Rise* and *Delay* parameters. Even though these are useful to control the output signal, I aimed for simplicity, and also wanted all the parameters to fit in the Device Bar. After a lot of experimentation I instead gave them a fixed set of values that worked in most situations.

To save space I used only one master input gain dial to control all the amplitude based analyses. This choice was based on my experiences with my bachelor project, where I could "cheat" by adjusting the gain on the individual bands to get the modulation signal I

wanted. By having them linked I wouldn't be able to do this. What was important to me was their value relative to each other, so this would also avoid problems by having to set their gain individually to correspond to each other.
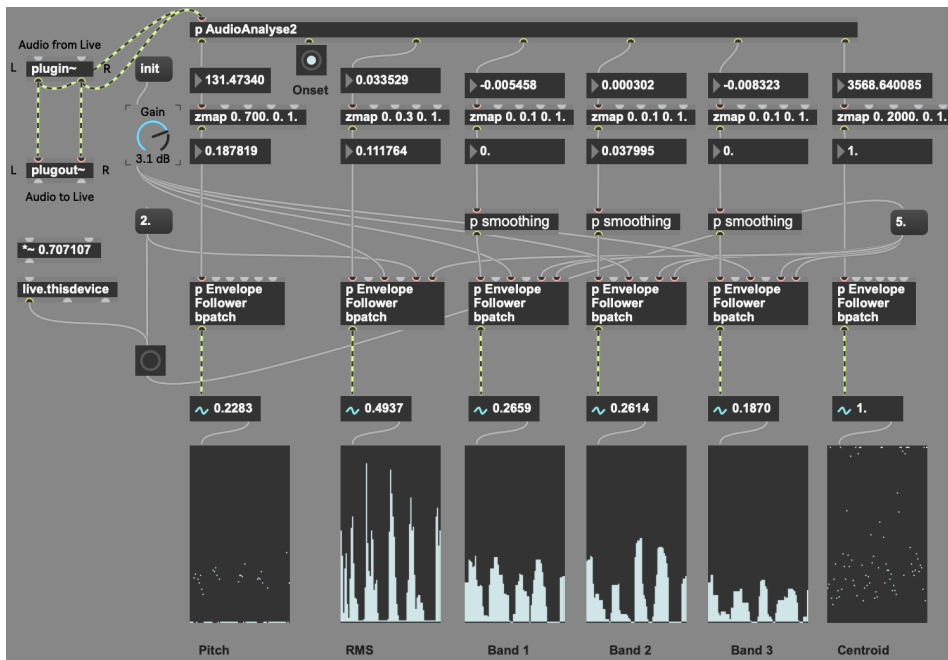
Figure 4.6: Here is the full view of the finished Max for Live patch.

There were a lot of initial errors with the Vizzie Audiosplittr in the original patch including no output from several bands, and the CPU overloaded due to the graphical elements in the patch. As this part of the patch wouldn't even be visible for the user I chose to replace it with filters to split the bands instead. As can be seen in figure 4.8. I used multiple filters in order to create more steep filtering to get better separation between the bands. I also reduced the amount of bands from four to three, because it would not be a big enough difference between the output values to justify using four different bands.

Applying a trial and error approach over an extended period of time using my voice and different instruments as input sources, I found the best configurations for the filter values. This means that my idea of low, mid and high sounds as a performer would result in that band getting a higher value without bleeding to much into the other bands. These values may not fit every instrument but suited my preferences as a producer.

I found the already existing graphical representations of Bergsland's Audio Analyzer adequate for my needs, so I decided to integrate them into my plugin with some modifications. This was because they give the user all the needed information in both the value and in the
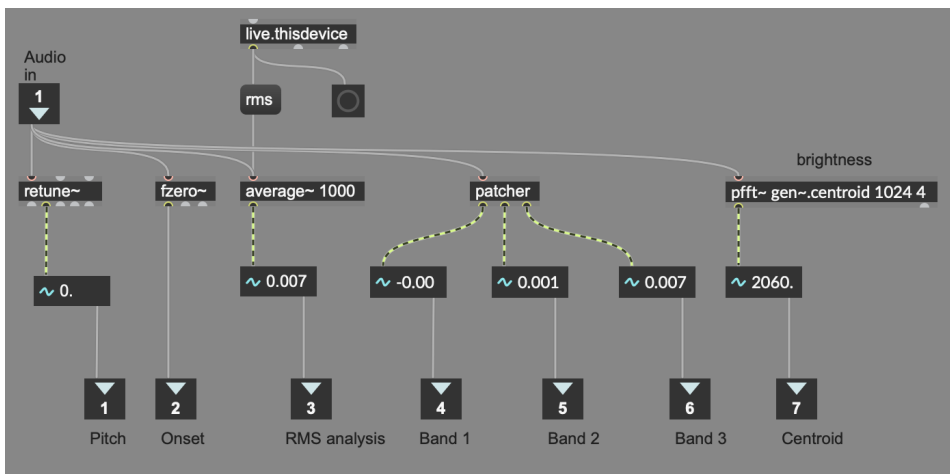
Figure 4.7: Here you can see the audio analyzing objects inside the subpatch named "p AudioAnalyse2" in Figure 4.6
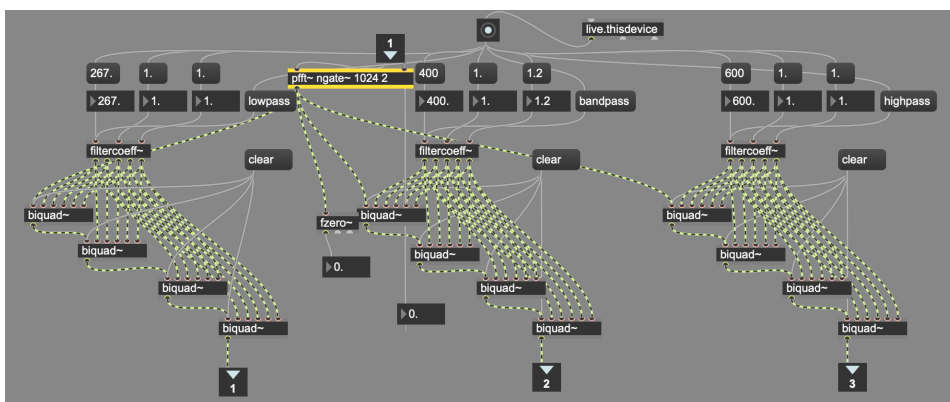
Figure 4.8: Here you can see how I used filters to split the audio signal into three bands. This is the "patcher" subpatch in Figure 4.7 that replaced the Vizzie Audiosplittr.

time domain without taking up too much space.

4.5 The Adalyze plugin

Here is the final version of the plugin. As you can see it had a lot of similarities with both Bergsland's MaxMSP device and the Envelope Follower.

Adalyze lets the user map six sources of modulation to any parameter in Ableton Live. The
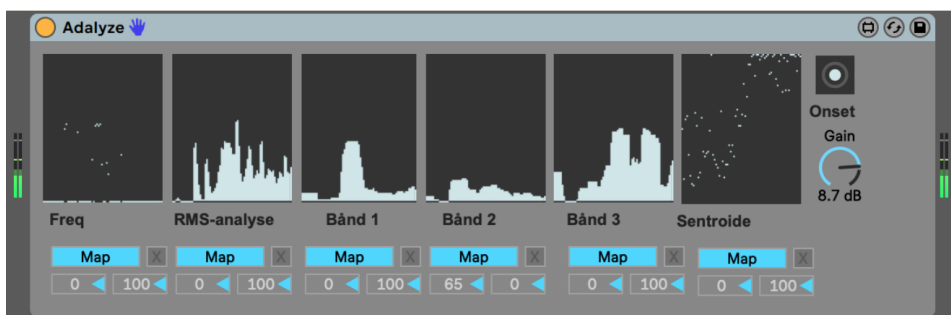
Figure 4.9: The Adalyze plugin

six trackers - *Pitch*, *RMS*, *Lows*, *Mids*, *Highs* and *Centroid* - should give the user enough variety to get different modulation signals without feeling overwhelmed. It is simple yet effective, and shows the user visually how the different modulation signals behave in the time domain. After clicking the *Map* button and then clicking the wanted parameter in Ableton Live the user can further calibrate the signal by adjusting the minimum and maximum values including inverting them if needed. To delete a mapping the user can either overwrite it with a new mapping or press the *X* button.

5

The music production process

5.1   Testing adaptive processing in a production setting

The first phase of the project consisted of multiple experiments to figure out what the possibilities would be with the *Adalyze* plugin in an audio production context, and what musical impact it would add to the productions. After the experience I obtained using the cross-adaptive and auto-adaptive techniques live in my Bachelor's thesis I already knew about the possibilities they offer in real time use. I wanted to find ways to really benefit from the controlled situation of a production setting, meaning the possibility to try out different options in post production rather than on the stage.

I started by conducting some simple experiments using the cross-adaptive band split amplitude technique I had already developed for my bachelor's project (see section 2.5). This was to test how cross-adaptiveness in a production setting would differ from real time processing, and to give me an idea about what functionality I needed in my plugin.

The cross-adaptive processing was applied on the synth and the vocals, modulating the synth processing with the vocal signal. Because I was only doing band split amplitude tracking I made a vocal line with big variation in the vocal range. The low band from the vocal Envelope Follower would send more of the synth's signal to an effect chain with a lot of deep sounding processing. Looking back at the interplay functions from chapter 2.2 – where the performers would either act as an amplifying or contrasting function – that entails that the processing had an amplifying function, because the synth would "follow" the deepness of the vocal. The mid band from the vocal analysis caused the Decay time of the reverb placed directly on the synth track to increase, causing it to "blur" out in the

vocal's mid range, creating a dreamlike effect. The high band from the vocal sent more of the synth signal to an upwards gliding ring modulator I developed in Max for Live. This effect also "extends" the high range of the vocal, again having an amplifying function.

During this experiment I found that the fact that these effects were triggered by the vocal made a big difference from them being automated by the producer. These findings motivated me to develop the plugin, knowing that adaptive processing certainly was an effective tool also as a producer. The resulting song created with this approach is titled "You" and can be heard from 47:46 in the album.

5.2 Using Adalyze

In the next sub sections I will present specific examples from the production process using the Adalyze plugin.

5.2.1 The first tests with Adalyze

Part of the music production process was done simultaneously with developing the plugin. This allowed me to go back and forth to tailor the plugin to my needs as a producer. I started by conducting experiments where I would use recordings of my voice and different percussive and melodic instruments like a cymbal, a drum and a glockenspiel. These recordings are not included in the album, but were an important part of the development process of the plugin.

5.2.2 Under / Time

"Under / Time" was the first full track produced using the Adalyze plugin. In the production I used various nature samples and field recordings including ocean and rain sounds, my own vocals, a bass guitar processed with analogue pedals, an upright bass and various synths. I categorized the water and ocean samples into three mixing groups in Ableton Live: lows, mediums and highs, based on their perceived main frequency area. I would then use Adalyze to make the groups duck in dB when the vocal would trigger that amplitude band, almost creating a multi band side-chain compressor. Contrary to the previous example in section 5.1 the cross-adaptive processing here functions as a contrast to the modulating signal.

I would also use the tool in an auto-adaptive way by processing the vocal with more distortion in lower frequencies with the low band in an amplifying adaptive function. The RMS

of the vocal would make the bass sound more resonant in a way that made more space for the vocal in the mix. The vocal RMS also controlled the speed of the arpeggio of the synth making them sound synchronized.

5.2.3 Listen to the Fiddle

In "Listen to the Fiddle" I used an external-adaptive approach to make the fiddle sound as if it was speaking using only the modulation of a resonator effect. In an external-adaptive audio effect, the modulating signal derives from features extracted from a sound source other than the one to which it is applied. Even though this definition would also apply to cross-adaptive processing, the term is according to Reiss, J. D. and Brandtsegg, Ø. used exclusively for cases where the external signal itself is not heard.

The first time I tried an external-adaptive approach with vocal speech modulating the resonator processing the Hardanger fiddle my heart started pounding, because it sounded just like I could hear the voice speak through the fiddle! It was as if I could only hear the shadow of the sound. This proved to me that interesting compositional effects can be created when only the modulated signal, and not the modulator itself, is audible.

The effect was created by modulating the Dry/Wet parameter on a resonator that was processing the fiddle with the RMS analysis of the talking vocal, while the pitch of one of the resonator voices was controlled by the low band analysis of that same speaking voice. This effect could easily have been exaggerated by modulating the pitch too obviously or having a too wide frequency gap the pitch would sweep between. That is why I limited the modulation of the fiddle by setting the max-value on the pitch modulation to 81 instead of 100. With this setting it could almost have been the fiddle player herself that imitated the speech with her playing. During the piece the effect gets more and more audible by automating the volume of the external modulator louder towards the end. The effect can be heard in "Listen to the Fiddle" from 03:50.

5.2.4 Sand, Not Paper

Here I based the beat on noises found in some field recordings. I layered the beat by dubbing the rhythm with MIDI-triggered samples, first percussion and then the bass line. I wanted the beat to be uneven, so I chose not to try and "fix" the rhythm. It is also in a different time signature than the vocal riffs, creating layers of poly rhythm that flow against each other in a dreamlike way. Sand, Not Paper" plays from 32:45 in the album.

5.3 Nonlinear recording in the composition process

With DAWs there is less need to get one perfect take compared to earlier analog processes using tools like the tape recorder. Being able to juxtapose different clips together with ease to structure something completely new allows for interesting possibilities for experimentation. This has of course also been possible with earlier methods.

A limitation, but also an advantage is the fact that decisions can be made at a later stage in the production process, which can also postpone it too long and make it hard to make decisions.

Composing with the raw material from different recordings, or putting together already processed material in different ways, can create new and interesting juxtapositions that will probably be very different from a precomposed version. As a producer I often like to let the material lead, and being able to go back and forth in the studio process.

5.4 Letting the adaptation lead the decision making

Using adaptive technologies is in a way letting go of control, but at the same time setting certain conditions to get the result you think you want. It is also a way to make you have to change one sound to change the other. This is a device of creative tension, where the imposing of rules forces the creative process into new modes of exploration. This can sometimes help us step out of habitual patterns and thus allow us to discover new ones.

5.5 The one hour loop

Putting together the finished result where I had both older pieces and newer that had to fit within the overall concept in the right time was a challenge, but is was also an interesting workflow that helped me make some difficult choices. I for instance had a part in April and May I wasn't entirely satisfied with and also a lot of material from an impro session with jazz guitar player Jonas Ehnroth and myself with material that I felt could suit either spring or summer. Summer was pretty finished at this stage of the process, so then this would be my new spring track. Since I wanted spring to feel turbulent and be full of changes I had to edit it that way, and took a lot of harsh production measures. I also mixed in a lot of the parts I originally had planned for spring to make it even more chaotic.

5.6   Creating video using an adaptive video tool

My two videos "Under / Time" and "Ice" are examples where I used the RokVid tool mentioned in chapter 4.2.5. In the videos you can see the audio clearly affecting the image in different ways. The way I used the tool was to let multiple layers of video be processed one by one with different settings, and then later layer them on top of each other with different opacity settings in Adobe Premiere Pro.

Chapter 6

Results

The result of these efforts is a Max for Live device and an hour long cyclic album that's continuously streaming on my website http://www.adahoel.com. It is on the border between an album and an installation.

Figure 6.1: The music is streaming on adahoel.com

6.1   The cyclic album form

The music has a cyclic form, and it is composed with the intention that the listener does not have to start playing from the beginning. The way I use the term *cyclic form* in this context is different from the classical *cyclic form* or *cyclic technique* in which a later movement reintroduces thematic material of an earlier movement (Macdonald, 2001). This in fact happens in my loop too, but when using the term *cyclic* I'm referring to the fact that the piece plays in an endless cycle without a set beginning or end. The experience will be different depending on where you start, but since the form loops back on itself it should appear as a contiguous one-hour piece regardless of the starting point. Each month of the year has been given 1/12 of an hour (5 minutes) but the individual musical components are of various lengths. If you start listening at spring, it may feel chaotic and confusing. If you join at winter it will feel more stagnant, or like loss and grief. In this way you will have different experiences of the album every time you revisit, depending on your starting point. Your initial listening experience may affect the way you perceive the work on later relistens.

The album is composed from individual tracks, juxtaposed clips and soundscapes that are meant to flow together as one expression. The nature of the work, being inspired by life, also implies that it will be multifaceted, it is patched together by multiple expressions and impressions. The oldest audio clips included in the album are from five years ago, when I first started experimenting with cross adaptive and adaptive processing.

It's a personal work to me, and it reflects a difficult process I've been through, but I hope it can also resonate with others. This way of viewing a process - as a cycle with multiple stages, with degradation and worsening, but also growth and healing, and drawing parallels to the seasons that are changing in a never ending loop, may also be meaningful for the listener. We all know that after a cold and harsh winter we will feel the warm sun on our skin again, even if it's hard to imagine in the moment of harsh darkness. This process is OK. Change is necessary for renewal.

I will now present some of the tracks in the order of the album timeline. The day does not begin at midnight, so I will start with the summer part of the album. Summer is in the cycle is a "neutral" starting point, before the destroying forces of fall occurs.

6.2   Summer

The summer of the album represents a peaceful, calm place in the process, although you can still hear echoes of traumas from earlier iterations. The fact that all the music was composed after the real life summer period had passed resonates in the music. In contrast

to the spring and the fall summer has more stability, like a meditation of reflection. This can be heard through the use of drones and static tones in addition to the lyrics.

6.2.1 Blått i Grønt

"Blått i Grønt" (starting 27:02) is my adaptation of the jazz standard "Blue in Green" by Miles Davis and Bill Evans. The tune is presented in two different forms: a MIDI-generated and pitch-and-time varying piece, and the real version, recorded with jazz guitarist Jonas Ehnroth and myself, singing new self written lyrics in New Norwegian. The MIDI version (starting 15:17) that can be heard in the spring section works as a foreshadowing to the "real" summer version(27:00). The spring version is meant to be confusing and unclear to listen to. Still it is a sign that there are better times ahead, even though the that there are better times ahead, even thought the listener will have to go through more hardships, manifested in the collage section. Change for the better is often not linear, but has ups and downs within itself.

The intro to the real "Blått i Grønt" is constructed from small samples and grains from the guitar recording, also to foreshadowingly lead in to the actual song.

The lyrics are about finding peace in nature, giving you back the ability to breathe. Nature is also a symbol for a peaceful place within yourself, distancing yourself from pressure from the outside. The "milestone" in the text can be both a stone set up beside a road to mark the distance to a place(nature), and a significant stage or event in someones life (within the self). The fact that you have crossed *over* the milestone signifies that you made it through from the difficult change represented by spring.

Blått i Grønt lyrics

Over blåner blå
Finn du fred
Du når ditt eige grøne sted
Pust ut, trekk inn
Ein bit av blå

Og smått om senn
Blir du ein ny ein
Over bortgøymd milestein
Av knudra grå
Blant grøn og blå

Og smått om senn
Blir du ein ny ein
Over bortgjømt milestein
Av knudra grå med mose på
Og spegelpytt av blå

Loosely translated it means:

Over blue mountains
You'll find peace
You'll find your own green spot
Breathe out, breathe in
a piece of blue

And little by little
you'll become a new one
Over hidden milestone
of textured/knobbly grey
in between green and blue

And little by little
you'll become a new one
Over hidden milestone
of rough grey
with moss on top
And mirror puddle of blue

6.2.2   Sand, Not Paper

The next song of summer is "Sand, Not Paper" (starting 32:45). The piece starts off with layers of vocals. The vocals are not perfectly tuned, but striving to be. Even though you made it through to summer there will still be imperfections in this state. There is also a dreamlike drone that's there through the whole piece creating stability. This too has a few touches of imperfection. In the production I used field recordings from a journey I made on my own through Europe last summer, being a symbol of finding calm in unfamiliar

environments.

The lyrics are reflective on life and the human existence. "The longest walk" signifies the difficult fall, winter and spring, and that even though they made a big impact they are sometimes best forgotten, so that you are able to face a new reality.

In the second part of the lyrics I reflect on all the time I wasted on my chronic pain and the fear of having missed out on life and life progress after being stagnant for so long.

Sand, Not Paper lyrics

Some say you'll never see the dawn again
Some say you're just part of the endless chain

Some say the longest walk, is written in the sand, not paper
Millions of particles, are moving and I'm just another

Human. Just another

I wasted so much time
I'm scared I'm left behind
I'm scared

6.2.3   Late Summer Thunder

This composition produced from recordings of studio improvisations by Jonas Ehnroth and I (starting 38:40) is that late summer night when you lay in the grass and the rain start dripping from the quickly graying sky. It leads in to fall with an increasingly more disturbed soundscape.

6.3   Fall

With fall comes a worsening change from the calm and peaceful summer. It gets colder, darker, and nature start dying. In the music pain begins to appear, first as a warning. Then as a chaotic soundscape. Then as loneliness and hopelessness.

6.3.1 Pain collage/Lonely Island

Starting from 44:18, sounds from the spring section make a return, this time reversed. It is supposed to feel overwhelming and uncomfortable to listen to. "Lonely Island" fades in, a composition with only the sound of thumping bells. This piece expresses the loneliness one can feel when dealing with chronic pain. By pulling away from social interactions to avoid pain the pain is also reinforced, as there are no distractions.

6.3.2 You

"You" (48:07)has a seemingly less mournful sound design, but a lot of grief in the lyrics. It was a composition I wrote five years ago when someone wanted to help me, but wasn't able to. I felt a lot of guilt because of people worrying about my chronic pain, and that I was hurting others too by not getting better. In a way the musical expression of "You" is very different from the pieces surrounding it, but it was an important stage of fall so I chose the chronology over the flow of the album in this case.

You lyrics

It's my body you can't fix it
It's my body you can't fix it
It's my battle you can't fix it
It's my wreck and love can't fix it

6.3.3 Heavy Bones

"Heavy Bones" is full of self-pity, starting to acknowledge the changing situation without accepting it, leading in to winter. It's composed with recordings from an improvisation where I imagined standing on a cliff looking at the water underneath, thinking about jumping (51:26). After standing there for a long time, taking the leap (53:42) to land in the dark, cold water at 55:55.

Heavy Bones lyrics

No one cares

And that sets me free

6.4   Winter

The winter section is a harsh and stagnant place. It is the "bottom" of the process, the darkest and coldest part. It exists without faith of betterment, and with a belief that the state is ever lasting.

6.4.1   Silence

In Silence (00:00) I wanted to create something that felt like the color blue. I did field recordings out in the snow and vocal improvisations over a drone made with a spectral freeze plugin I developed a while back. In the editing process I tried to be very intuitive and go with whatever idea I got from the material. There is something there trying to break free, without being able to. To create this feeling I used a lot of reversed samples. The reversedness is a symbol of steps you think is progress or leading the right direction but in reality is not. It is also a song of grief caused by a group of people who caused pain, with no one stepping in to stop it. When "Silence is contagious" is sung the sub bass kicks in, the harsh reality hits that no one will be the first to speak up. After the last "silence" there is a real silence from the voice, except for an in breath, as if someone wanted to say something but didn't.

Silence lyrics

Silence
Silence is contagious
Kindness is outrageous
Silence, silence is contagious
Silence

Listen to the Fiddle

This slow winter piece starts with long Hardanger fiddle notes stacked in a dronelike way(03:50). It also expresses grief, but is a turning point of winter. Using external-adapting techniques a voice is speaking through the fiddle. The words are unclear still, but this new knowledge will in turn lead to spring. The words are also very painful to hear, expressed through the music by fragmented dissonant sound pieces building up to a climax.

Forgive me myself (babe, it's ok)

This composition (07:26) expresses the realisation that pain is OK. That I wasted many years, but I had to forgive myself. This was the only way to getting better, to reach spring.

Ice

After the realisations made in "Forgive me myself (babe, it's ok)" the ice finally starts melting(09:05), and even though it is still cold the sun is slowly returning.

6.5   Spring

The spring section marks a change for the better, but it's a painful process. It is a season of confusion, with glimpses of the brighter future, but also with many relapses back to the darkness and pain of winter in a non-linear process.

6.5.1   Collages sequence

This collage (10:40-20:50) consists of juxtaposed samples from multiple sources. Many of the clips in this sequence are productions composed in the winter part of my real life process. Presenting them in this rapid fashion is a metaphor for working through previous issues to get insight and find healing, like they are too many thoughts flying through the mind. It may be difficult to see connections in the moment, and it is supposed to feel chaotic and disorienting. As a part of this collage we can also hear the foreshadowing version of "Blått i Grønt" (see Section 6.2.1) There are also silent parts in this sequence, with only the ambience of spring nature. This is a symbol of the discomfort of change, even for the better, and how it can feel like a blanket is being pulled from underneath you.

6.5.2   Under / Time

In the beginning of "Under / Time"(20:55), "Under" is more stable than the earlier spring pieces. It still expresses the pain of change, but leads in to summer in a last shredding of the old skin. "Time" is the first piece of summer, and is a mournful song of all the time lost in fall and winter. It also urges us to use the limited time we have better, realizing how lucky we are to have it

Under / Time lyrics

Time is slipping through my hands
I'm overtime, half time
My mind is morphing through states
till I'm out of time in no time

For a while I've wondered if wandering's
waste of time or worth my while
Oh time, a limit for living
but take your time
Yes take your time

6.6   Adaptive video

I have also made two adaptive video pieces supporting the music of "Under / Time" and "Ice". The video work for "Under / Time" is created from self taped footage and under water films. The videos are adaptively processed by different elements in the music. There is a big visible shift from the two states, "Under" and "Time". "Under" can be seen as a metaphor for being under the surface of water, breaking the surface when entering summer. "Time" is where the viewer can finally find some rest and meditation, through use of looping in the video footage.

Chapter 7

Evaluation and Conclusion

7.1 Evaluation

To evaluate my process and productions in this thesis I will have to look at my initial goals
for the project:

- To produce an hour long cyclic album using the seasons as metaphors for real life
  processes.

- To explore how I could use adaptive processing techniques to reflect real life modu-
  lators.

- To create an easy to use plugin for this purpose.

- To make a strong artistic expression.

7.2 The Cyclic album

There were a lot of artistic and technical challenges producing the album, and some of
them was a result of the grandness of the task. Because the work was so personal to
me, it was very important to get it right, and to properly reflect my experience. The
compositions were created over a five year period, and not all of them made having the
year in mind. Sometimes the theme of the lyrics was best suited for one season, but the
sound design fitted better somewhere else in the composition. Setting a frame for the

overall composition inspired me to create a certain expression, but also limited which of my compositions I could use in the piece. I noticed I produce mostly songs full of grief and sadness, best suited for the fall and winter part of the project. This was probably because I personally was in that mindset during the majority of the composition process. This lead to some tough choices picking which parts would be included as the winter was only so long in the album. I do feel that the real life processes, like going through a traumatic event, the life and death of a plant or a year, are reflected in the composition.

7.3 Adaptive processing

Through adaptive processing I managed to create musical effects that I otherwise would not have been able to. As I didn't implement a good rhythmic analysis in the plugin I wasn't able to create all the forms of contrasting functions that are in Figure 2.1. The field of audio analysis and feature extraction is seeing a lot of progress, and I'm excited to implement more features in *Adalyze* in the future, without compromising with its simplicity for the user.

Using it as a post production tool in this way made me able to predict some of the results from the processing, but it also led to some surprises, like in "Listen to the Fiddle" with the auto-adaptive processing. As I knew exactly when the different elements in the production would appear I was able to manipulate the modulator signals to my processing needs. This gives room to a lot of possibilities and experimentation not available in a live situation.

To make the sounds behave like in real life processes is of course not possible due to the complexity of real life. But by using some features of sound to modulate the expression of others I was able to mimic some of the actions and reactions from human interactions and from nature.

7.4 The Adalyze plugin

In the development process I was able to create an easy to use analysis and mapping plugin for Max for Live. I was able to create a limited but effective toolkit to apply adaptive techniques in Ableton Live that allowed me to focus on both the artistic and the technical part of the production by not having to readjust multiple parameters during the process. The plugin has some room for improvement, for instant implementing a different pitch tracking object in Max/MSP. I got a lot of new errors when updating Ableton Live from version 9 to 10, causing me to have to rework several features that suddenly stopped working. This includes having the mapping button display where the signal is mapped and a better work-

ing pitch tracking. The plugin did however work well for my production intention, and I have had multiple co-producers being intrigued by it and wanting to use it in their own productions. This implies that there was a need for this plugin to exist, and I will continue to to use it even more in the future.

7.5   The artistic expression

Using the plugin in the compositions was sometimes a challenge because I often just wanted to make music, and put the adaptive processing in almost as an after thought. I should probably have used the cross adaptive tools earlier in the composition process so they could become a more integral part of the piece. It often added more to the music than I had anticipated and proved to be a valuable addition to my music. Sometimes it's probably hard to hear the effects for the listener and other times they are more obvious. To me it wasn't important that the listener could understand and follow the processing, as it to me was just a tool to create a dynamic and interesting expression. I feel that I was able to convey my personal artistic expression through this project, and am very proud of the result. The album consists of multiple aspects of my artistic expression, with soundscapes, vocal and instrumental improvisations, jazz and even pop. I like the way the year and the loop works as a frame for all these compositions.

7.6   Conclusion

To conclude, I have achieved most of the things I set out to do. I had high ambitions, and although I didn't succeed in realising all of my plans I'm very satisfied with the final product. The essence of my idea was to create something that could convey in a way the process I've been through. It has in many ways been a very personal project of mine, and at times painful to work with since it's so personal. I still felt it was important work, and maybe also for others who have also struggled with chronic pain or other difficult situations. I wanted to convey the cycle of pain in this way, that you have a bottom point, a point from which it can only change to the better. And that this cycle repeats itself through life. The adaptiveness in it represents unforeseen and foreseen circumstances that will shape the contents of the loop. The plugin I developed offers a lot of possibilities for other producers as well, and not only in experimental genres.

My original idea was using weather data to live process the audiovisual media, which would have conveyed this message even clearer, and is something that I aim to realize in the future. In addition I had also planned to produce an hour long music video to go with the music, which will also have to wait. I do feel that the music is strong enough on its

own. In some ways it's even clearer without the distractions and hand holding a video can represent.

The album is now streaming on my website. It in one way lasts for one hour, but can also be seen as an on-going installation that will last as long as I can afford to pay my web hosting expenses.

I also plan to release individual tracks from the album on commercial platforms like Bandcamp, Spotify and iTunes. This will remove them from their context, but can be a way to make people listen to the whole thing on my website.

I am at the beginning of summer writing this, but I expect many falls, winters and springs to come. What I do know is that after the harsh winter full of darkness I will always feel the sun on my face again.

Bibliography

Brandtsegg, Ø., 2018. Cross adaptive processing as musical intevention: About the project. `http://crossadaptive.hf.ntnu.no/index.php/about-the-project/index.html`.

Macdonald, H., 2001. Cyclic form. URL: `https://www.oxfordmusiconline.com/grovemusic/view/10.1093/gmo/9781561592630.001.0001/omo-9781561592630-e-0000007001`.

Reiss, J. D., Brandtsegg, Ø., TITLE=Applications of Cross-Adaptive Audio Effects: Automatic Mixing, Live Performance and Everything in Between, J.V.Y.U.D.I., .

Verfaille, V., Zolzer, U., Arfib, D., 2006. Adaptive digital audio effects (a-dafx): a new class of sound transformations. IEEE Transactions on Audio, Speech, and Language Processing 14, 1817–1831.

Appendix

My website:
http://adahoel.com/

The full cyclic album (for analytical listening purposes):
https://soundcloud.com/adahoel/adapt-producing-a-cyclic-web-album-using-adaptive-processing/s-bxVL1X2XVFt

Under / Time music video:
https://youtu.be/IGWvbBqAlX8

Ice music video:
https://youtu.be/C8Xjt8IZw4g