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Context & Methodology

Creating a virtual instrument is the use of customisable software used to provide simulations of musical instruments including synthesizers, samplers, pianos, drum-machines and various types of guitars etc. A digital audio workstation (DAW) acted as an enabler for me to create my virtual instrument.

This essay aims to explain the research, workflow and feedback conducted to create my virtual instrument. For this essay I have decided to create a stringed instrument, with the foundation of sound being created by a nylon stringed guitar. To create my virtual instrument, I have used the FL Studio DAW.

Approach & Principles

The first important step for me in my approach was choosing the right microphone (mic) to record my instrument. Choosing the right mic can be a pain because there are many different types and prices. Fundamentally microphones come in 3 options: dynamic mic, condenser mic and a ribbon mic [See fig.1A]. I narrowed my options to the ribbon mic and condenser mic as a dynamic mic is generally not suitable for recording instruments with higher frequencies and harmonics (Teach Me Audio, 2020), which a nylon guitar has a lot of. If I was recording a kick drum or a bass guitar (in most instances) this mic option could be more suitable. I considered a condenser mic as they are light compared to dynamic microphones, hence more efficient at capturing a range of high frequencies and it is easy to obtain a flat frequency response (Teach Me Audio, 2020). Ribbon mics are good at capturing highly dynamic, warm, and natural sounds. Very few microphones can capture accurate details, incredibly clear highs and accurate lows like a ribbon mic can (Pro Audio Land, 2016). This means that they are very good at capturing stringed instruments. However, they are quite expensive & can be seen as a luxury more than a necessity for a student producer. Fortunately, I own both a condenser mic and ribbon mic and decided to record with the ribbon mic as it was very important for me to capture the vibrant, natural feel and spatial sound of the nylon guitar. As I was recording from one audio source I decided to record in mono.

Once I picked my mic, the placement of the microphone and where I decided to record was very important for me to consider. Mic placement has a very big effect on your recordings. It was important to ensure that the recording was as clean as possible so it would be easier for me to mix. To enable this, I maintained a distance of 1-2ft. At times it can be tempting to get really close to the mic to cut back on the room sound or aid separation, however, this can create a proximity effect. It can quickly make for a muddy recording as low frequencies increase as the distance to the mic is reduced.

Unfortunately, due to the COVID-19 pandemic I was not able to access a recording studio, so this left me with a dilemma in which to record. The space you record in can leave subtle sonic imprints in your recordings which can make or break it (Izotope, 2018). I initially recorded my instrument in my bedroom as this is where I have recorded vocals of many of my collaborators. However, as my bedroom is small it enhanced the low end, which I wanted to avoid as I wanted my recordings to sound as clean as possible. Also, a lot of the music I make incorporate heavy basslines so I would not want my instrument to clash with this frequency. I am aware you can EQ frequencies you may not want, but as stated above, capturing a clean take was my priority. I then decided to use my living room, as its bigger than my bedroom, but not too big where it could cause an echo. It also has items that help absorb background sounds such as couches and pillows.

The next thing I considered when recording my instrument was the recording articulations. I had to decide if I wanted my recorded notes to be sustained or played in staccato. The intention of my virtual instrument was for me to be able to play legato and tremolo notes with ease on my midi keyboard. I therefore opted for staccato and I also felt this would give me more flexibility when it came to the mix. Additionally, playing sustained notes on my instrument could be achieved through adding reverb on my mix. I also had to consider the velocities I played my instrument. To make the virtual instrument sound as realistic as possible I played the instrument in different velocities on the chromatic scale. This was done as an aid for when I programmed the velocities on my sampler. When each note was played, I asked someone to perform a loud clap before moving onto the next note. This helped me easily spot each note in the cutting and editing process as there were peaks in the wav form.

The next part of my approach was editing and cutting the instrument. My first priority was to clean out any background noise in my recordings. This was done through edison, a stock plug-in on FL-Studio. I normalised the audio so I could hear the parts of the background noise easier and then removed these frequencies. This gave me a clean-cut recording for my virtual instrument. For notes that may have been slightly out of key I used another stock plug-in on FL-Studio to pitch shift my recordings to the right key.

Once I finished recording all the notes of the chromatic scale and inserted into my sampler, I then moved onto mix. This was the part that really enabled me to make a unique sound and drift away from conventional nylon guitar sound. One of the most important principles for me when mixing an instrument is to never solo mix. I think of it as cooking a meal, ingredients on their own might not taste that special. But when combined in just the right way, they enhance each other's flavours. The same goes with mixing majority of instruments in the context of a song. A lot of my beats are heavy in the low-end due to booming basslines so my first point of order was to perform a light corrective EQ to remove any low-end frequencies that could potentially clash with my beats [See fig.4A]. The next step in the mix was to put my virtual instrument through a virtual amp [See fig.3A], specifically choosing the acoustic shimmer pre-set. This was done to achieve a distinctive sound from the typical sounding commercial nylon guitar. It instantly inspired me, and it was at this point I started to develop a vision for its use in my music. When heard, I wanted my instrument to sound intimate, in the sense of you could imagine an instrumentalist playing this instrument in front of you. This was achieved through adding a room reverb [See fig.3B], as stated by The Pro Audio Files, room reverbs give a natural colour and liveliness to a sound. I then added a delay to enhance the euphoric feeling of my instrument [See fig.3C].

The final step in the process was to put my virtual instrument through a granular synthesiser. Granular Synthesis is a method by which sounds are broken into tiny grains which are then redistributed and reorganised to form other sounds [See fig.2A]. According to Curtis Roads in his book *Microsounds*, a grain of sound is a brief micro-acoustic event, with a duration near the threshold of human auditory perception, typically between one thousandth of a second and one tenth of a second (from 1 to 100 ms). I put my instrument through a granular synthesiser because it enabled me to have more control over my instrument as a sound designer. Each grain can be individually manipulated, as can the overall arrangement of the grains (Izotope, 2019). This enabled me to make my instrument bespoke and create unique and interesting melodies/samples. The possibilities are truly endless with granular synthesis.

Issues, Reflections & Improvements

One of the key principles when recording a stringed instrument is taking time to consider how the instrument behaves, even if you are familiar with the instrument. Each performer, each room and each design of instrument will bring a set of unique variables to consider (Music Tech, 2012). With this in mind, upon reflection, I should have taken more time to listen to my instrument, and move around my house to have a better understanding of the relationship between my environment and my instrument. In particular, one of the biggest misconceptions I originally made was the input of the sound hole in the guitar. All instruments emit sound in several directions rather than it radiating from a single point-source. An acoustic guitar, for example, resonates across its entire body, with the sound hole actually working as a form of bass. The initial mistake I made was to place the mic in this area as that is where I assumed the sound was coming from. This gave me undesirable results as the recordings were heavy in the low-end. If I were to do this process again, I would trust my ear more, and try to find the spot where I felt the instrument sounded its best.

As mentioned previously, I was torn between a condenser mic and a ribbon mic and I ended up opting for the ribbon mic. However, after some thought, if I were to do this process again, I would do the same takes with a condenser mic as they also have their benefits. They have a wide frequency response, uncoloured sounds and more specifically, small-diaphragm condenser mics tend to deliver a more natural and flat response (Neumann, 2016) which was a priority for me. Ultimately, you put yourself in a better position when you have options. Being able to compare & contrast recordings from a condenser mic and a ribbon mic would have enabled me to make less of a biased choice and use/trust my ear more.

One thing I did well was recording multiple takes from multiple distances to provide me multiple references to choose from. My main priority was not being too close to the mic to reduce the amount of low-end frequencies it recorded. However, I found myself raising the gain applied to the microphone for my first few takes as the instrument was too far from the microphone. This gave me issues with room noise, floor rumble and even at times noisy housemates. As stated on Music Tech, as you move the mic away from the instrument, you'll also change the relationship between direct sound coming from the instrument in question and reflected sound bouncing off surfaces and walls. As my room was not the best treated room for recording, the reflections were not positive. It therefore took a few takes from differing distances to get the sound I was looking for. Staying on the topic of microphones, upon reflection, I should have considered more than just the distance between the microphone. Two other variables I did not consider were the height and axis of the microphone. From my experience of recording vocals, the lower the microphone (closer to your chest) the more low-end of the voice you record. The opposite is true as well – when you raise the microphone, the more high-end you record. In regard to the axis of the microphone, a blog post on landr stated that when you rotate the mic, you're reducing the bass and plosives from the output. These are things I wish I experimented with as it could have delivered interesting results.

In regard to the mix of my instrument, if I were to do this process again, I would experiment more with granulation. More specifically around warping time and pitch. I would look to use Native Instruments' Intakt. This is a playback and manipulation tool. As well as the basic principles of granular synthesis stated previously (beat slicing – handing each rhythmic event in a loop as a separate sample), Intakt has a granular time machine mode [See fig.2B]. To the left of the waveform display you get two knobs, both marked tempo. The smaller one on the right gives you manual control over the speed of playback of the sample and is great for experimenting with how granular time-stretching works and sounds. Turning this knob anticlockwise would

enable me to slow down the playback of the instrument slowly, all while maintaining the original pitch. As mentioned by Sound on Sound, if you go to extremes, you should be able to hear what is happening to the sample – at about 5% of the original speed you can clearly hear the playback grainable stepping from one grain to the next, each grain being looped until the next one takes over.

Comparison & Contrast

My virtual instrument sits in the stringed family. Which makes sense, as I began the process by recording a nylon stringed guitar. The similarities between my instrument and an acoustic guitar are in its vibrations when a note is played. However, where they differ is in how I mixed my instrument. Acoustic guitars have large, hollow bodies. As mentioned by Spindity, the sound chamber plays a big role in the amplification and tone. Therefore, the size and shape of an acoustic guitar body has an impact on the volume and the sound of the guitar. For my instrument, the size and shape of the guitar only plays a part in the recording process. Post recording, it's the mix that sets the instrument aside. I designed this instrument to be played comfortably on a midi-keyboard, as that is my go-to in my writing process. The velocity & articulations at which you play at are the biggest determining factors in regard to its sound. As my instrument is no longer constrained/influenced by the tone-woods, there is a lot more flexibility in the sound and articulations of my virtual instrument.

You could argue my instrument is more similar to an electric guitar. Electric guitars do not require large, bulky bodies like acoustic guitars. The wood and construction are still important properties in the output of an electric guitar, but the biggest impact on its output is the role of an amplifier. Compared to an acoustic guitar, you have much more control over your sound, and a much wider palette of tones and effects to work with (Spindity, 2020). My instrument is similar in this way, because as mentioned previously I put my instrument through a virtual amp and the sounds can differ greatly depending on what pre-set I pick.

Comparisons can also be drawn to percussive instruments. Namely, the piano. Although there are strings in a standard piano many consider it both a stringed and a percussive instrument. As stated on Britannica, the vibrations on a piano are initiated by hammers hitting the strings rather than by plucking or by moving a bow across them. So, the piano falls into the realm of percussion instruments. As a result, today the piano is generally considered to be both a stringed and a percussion instrument. As previously mentioned, the intention of this instrument was to be played on a midi-keyboard. Therefore, there are similarities in the way my instrument is played to a piano.

It is difficult to draw comparisons between my virtual instrument and wind-based instruments. This is because woodwind instruments differ in pitch when air travels through the tube of the instrument and escapes the holes. The further the sound has to travel, the lower the pitch gets. While stringed instruments produce sound when you bow the strings which causes vibration. The only similarity that can be drawn with my instrument and a wind instrument is during the recording process. Both guitars and wind instruments have a chamber in which the sound is amplified.

One of the big differences between a string instrument and a wind instrument is that with a wind instrument you don't have as much control over the wave velocity. The wave is moving through a column of air, so the speed is the speed of sound in air, which is temperature dependent. As with strings, resonance plays an important role for wind instruments. The wavelengths at which resonance occurs are proportional to the length of the instrument, so you can play different notes by changing the length. In general, the larger the instrument the longer the wavelength of the fundamental and the lower the frequency range of the instrument.

Conclusion

Overall this process was challenging but extremely rewarding. I was able to push myself musically, technically and creatively. I applied new processes and techniques that I had not experimented with before and I'm keen to explore these things even further. As I predominately produce hip-hop and R&B I envision the use my instrument to make multiple samples for me to flip into full-fledged beats. I can also envision it being used as a solo for a track. An example of these ideas can be found in the "Examples of my instrument in use:" section in this essay.

APPENDIX: FIGURES and PRIMARY RESEARCH

Fig.1a: Microphone Selection

The Lowdown on Mic Types Be sure to take the following considerations into mind when you're deciding which mics to use for different applications—each mic type has its pros and cons.

DYNAMIC	CONDENSER	RIBBON
• Physically durable • Withstand high sound pressure levels without distorting • Moderately wide frequency response • Generally inexpensive compared to other mic types of similar quality • Punchy, warm sound	• Typically less durable than dynamics • Handle moderate sound pressure levels and may require a "pad" (which reduces the level) to cleanly deliver high-volume signals • Offer an excellent, wide frequency response • Range in price from inexpensive to super expensive • Usually require external power (called "phantom power"), though some can use batteries • Use onboard tube or solid-state electronics • Generally have hi-fi sound quality with excellent clarity	• Generally more fragile than other mic types, though newer designs are more durable • Don't handle high sound pressure levels well (at high levels, the ribbon may stretch or even break) • Don't handle bursts of air—such as from a voice or a kick drum—well (this may also stretch or break the thin ribbon) • Limited frequency response • Generally expensive, though inexpensive models have appeared recently • Sensitive to preamp coloration (though some modern models have electronics that eliminate this) • Renowned for warm, natural sound quality

Fig.2a: Granular Synthesis Grain Creation

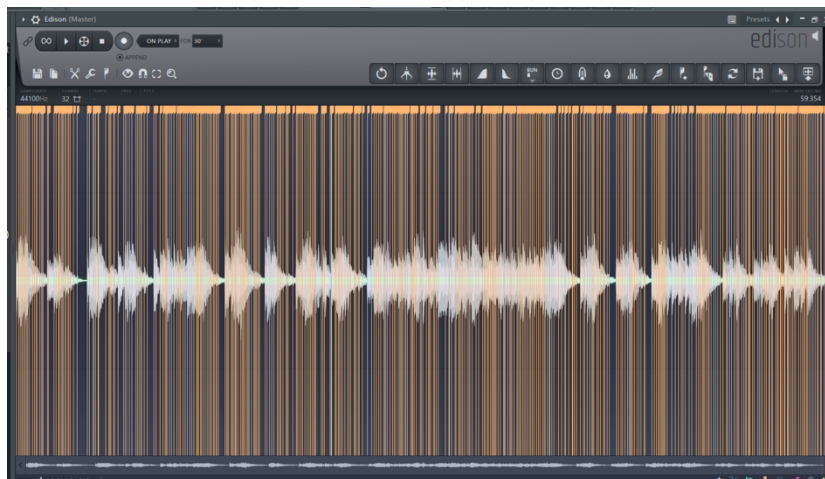


Fig.2b: Granular Synthesis Time Machine



Fig.3a: Guitar Rig 5



Fig.4a: Basic Mixing - EQ

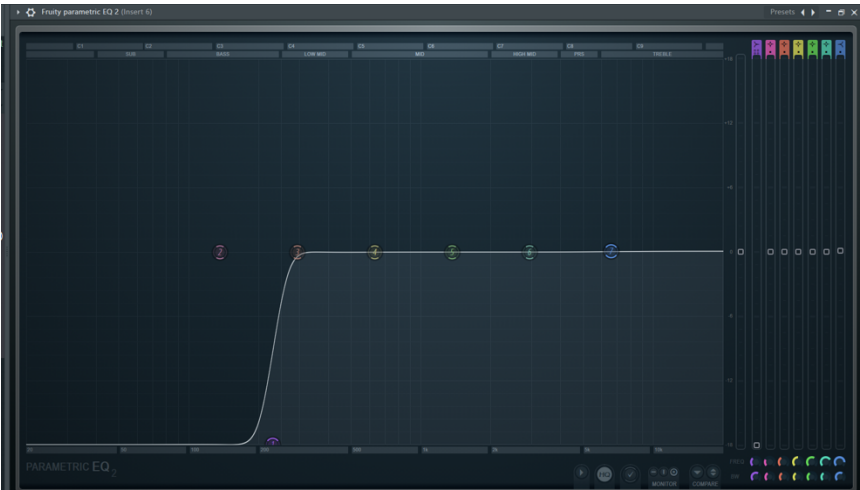


Fig.4B: Basic Mixing - Reverb

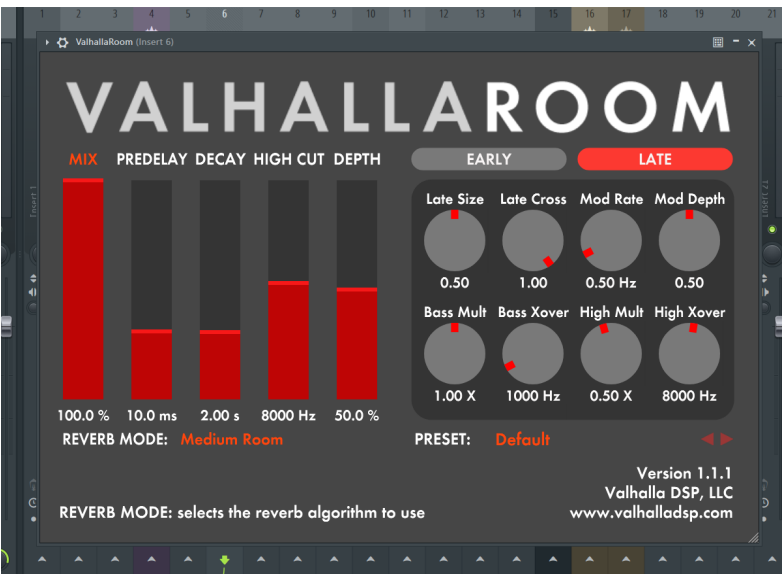


Fig.4C: Basic Mixing - Delay



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Curtis Road, (2001) Microsounds

Examples of my instrument in use:

Main sample: <https://soundcloud.com/danielzenith/dz-ready-102/s-WSi0wZFVwiW>

Guitar solo as an outro: <https://soundcloud.com/danielzenith/dz-chrysalism-93/s-Z5b8zMKPoqS>