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Balloon Pops, Convolution Reverb, and You!

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When people talk about famous music venues such as Carnegie Hall or Madison Square Garden they often talk about the acoustics of the room and how it helps create a distinctive sound. An essential characteristic of any venue's sound involves reverb. In the world of audio software there exists many different options available to manipulate and enhance reverb. This software can either be costly or incredibly complicated to use. In this project I set out to prove that Convolution Reverb can not only be achieved at a relatively low cost, but with an ease of use as well. My goal was to create a package of Impulse Responses for convolution reverb units that could fit on a thumbstick, in order for people to nostalgically revisit the sounds of the California State University at Monterey Bay campus. We all get nostalgic sometimes right? What better way to remember the fun times you had at this campus than have the physical sounds of the campus available to you at all times?

There are many companies that sell impulse response packages for a hefty amount, while some of them even give them away for free. Many modern DAW's (Digital Audio Workstations) such as Logic Pro X, Ableton Live, and even Propellerhead Reason now include convolution reverb units as part of the stock plugin set. My intention is to share the reverb package that I create for free within the CSUMB community. For this reason, I chose to create impulse responses in order to make the reverb not only accessible, but universal for most units. I specifically chose to record WAV files in order to make the pack both Macintosh and Windows PC compatible. The goal of the project was not to strive for scientific accuracy, but to capture a product that achieved the sonic result that I desired.

A Brief History Of Convolution Reverb Usage

Many classic songs in the 20th century I've been made famous by their distinct Reverb. For instance, a large majority of crooner Frank Sinatra's album "Tone poems of Color" (as well as The Beach Boys "Surfin' USA") was recorded at Capitol Records in Los Angeles. Capitol records are known famously for their distinct echo chamber which gives them their signature Reverb. Although Capitol Records is a record label, it is also a recording studio as well. Many artists flock specifically to Capitol records specifically to record and have their vocals processed with this Reverb. Up until recently you had to physically travel to Los Angeles specifically to this building to get this all sought after Reverb. However, as of recently Capitol records has released the famous Reverb as a VST plugin for your computer to use in a DAW. Music technology company Universal Audio located in Scotts Valley, California only recently created this plugin last year in 2019. The plug-in, titled "Capital Chambers" faithfully recreates the echo Chambers of Capitol records with the ability to digitally move the microphones about the space, as well as switch out microphones entirely; all for the low price of \$350! Using high-quality digital signal processing, you too can sound like Frank Sinatra in the 1960's. This plug-in is in the vein of what I wish to achieve with this Capstone. I set out with a simple goal, to capture the essence of the Music Hall at CSUMB. Through literal days and numerous hours using various methods I have found a way to achieve my goal.

A Brief Explanation of Convolution Reverb

Convolution Reverb seeks to emulate the real physical space of a room. Let's say hypothetically, you are in a rock band. Perhaps a punk rock band not unlike famous 1970's act

The Sex Pistols. Imagine you're the singer similar to Johnny Rotten and you want your record to quote on quote sound "dirty" perhaps you took this idea quite literally. What if you were to propose that you wanted your bass guitar to sound filthy? How would you achieve this? One might think that you would boost frequencies in peculiar places to make your bass sound terrible. But what if you wanted your bass guitar to sound like it came from a literal filthy dumpster (complete with buzzing flies!) Well I'm here to tell you that you can! But Why Convolution Reverb?

Taking inspiration from former student Sam Kantoric, as well as many other software companies such as Altiverb and Impulse Records, I decided to create my own package of impulse responses for a Convolution Reverb Unit. Similar to a former high School football star framing their letterman jacket in a glass case, I understand that many students who graduate from CSUMB might become nostalgic for this institution as the years go by. The idea is to create a package in order to "capture the sound of the music building" so that years later wherever they are around the world they still have the sound of the Music Hall in the palm of their hands. I can imagine a student similar to myself pursuing graduate studies and traveling to a faraway land such as Eastern Europe wanting to have the sound of the room 100 Lecture Hall the music building. Many of my fellow students including myself all have laptop computers. Some of us even carry microphones and audio interfaces with us at all times in our knapsack. This is why I have made the package for the Mobile international student on the go. but it's not just music students who could benefit from this package, filmmakers could as well. Many movies need to match Reverb with dialogue-heavy scenes. Sometimes a conversation takes place in an automobile, without convolution Reverb it would be incredibly hard to make the conversation

sound like it's actually happening in a car. This is often the case as to why many movies have automatic dialogue replacement (ADR) department. But thankfully I have recorded the impulse response of my 2004 Ford Taurus, not just the main cabinet but the trunk is well!

But how does one capture an Impulse Response for a Convolution Reverb you might ask? There are two primary methods one is a sine sweep, and the other is a by inducing a sharp transient.

Successes and failures

When I started the project I had high hopes and was full of energy with hope for success. It was foolish of me to expect results from the start. From the beginning I had hoped that I would be able to achieve a proper convolution using a sine sweep method, but this had failed.

At this point I had elected to use the balloon pop method. With this method I would be able to create a short and predictable impulse response in order to get the results that I so desired. I started off trying to replicate the sine sweep method. This was achieved by utilizing a playlist of my telephone. The video list consisted of one minute of silence followed by the sine sweep, and then another minute of silence. I would wait patiently for the end of the sine sweep, as well as the minute of silence to make sure that I did not disturb the recording.

But how does the sine sweep even work?

A sine sweep utilizes the sine wave which is a near perfect harmonic waveform. How this works is The sweep runs all the way down the spectrum. To the untrained ear it would sound like a slowly rising and (and incredibly annoying police siren). The range of human hearing goes all the way from 20 Herz, all the way up to 20000 Kilohertz (or 20Khz for short) Naturally over the

course of time (through no fault of our own) the human ear tends to lose cycles in their range of human hearing. Luckily for us, robots have perfect hearing and are able to take the data of the sine sweep in order to almost perfectly emulate the sound of the room. This method did not work the way I wanted. It takes more than just the act of recording a sine sweep and importing the audio file into a convolution reverb plug in. There are quite a number of computer programs that are able to take the audio of the sine sweep and turn it into an IR file. The problem with this is most of them are expensive. There are free ones available, however, they require a little bit of computer coding and seem incredibly complicated. I tried my hands as a few of these programs and was ready to tear my hair out in frustration within a half hour. The other expensive programs like altiverb include its own sine sweep function. This would present another program, in order to properly capture a sine sweep sound, I would have to construct a cart in which I place a laptop and portable generator (perhaps a car battery) and transport not only a microphone stand, but some portable monitors as well. The computer program itself initiated the sine sweep and does all the calculations for you in order to generate a custom patch for the program. The problem is that often the file is stuck being native to said expensive program. I also discovered that I would need a completed program to process what was known as a .ess file. This process is known as deconvolution and can be incredibly complicated. The voxengo deconvolver was confusing. I followed instructions and got no results. In order to process the sine sweep files, the computer software would be expensive as well around \$70 which would once more defeat the purpose of this project. This capture would not work out if everyone who wanted to use my package had to purchase a \$700 VST plugin, Remember, *the goal of the project was geared towards creative artistic effects*, not sonic accuracy.

Forming a Methodology

After watching numerous videos in an attempt to grasp the concept of what I wanted to achieve I believe that I need the most to preserve the sound of the room. Unfortunately in order to achieve the most accurate version to capture the sound I wanted I would have had to assemble a sort of rolling mobile recording studio on a utility cart. I would have had to be able to transport large and heavy speakers on tall tripods in order to play the sine sweep. On top of that I would have to have a mobile power source to power all the equipment. Seeing how I was about to enter an old abandoned building with numerous health code violations, this was clearly out of the question. So I opted for an alternative method, playing sine sweeps from a bluetooth speaker. Capturing the sine sweeps was not hard. I downloaded a sine sweep video off of the internet alongside a one minute video of pure silence. I created a playlist of videos to play, one minute of silence, followed by the sine sweep and another minute of silence. I went through the effort of capturing my entire dorm room on East Campus until I discovered that you simply cannot just import the raw audio files of the sine sweep. What I discovered was slightly disheartening. In order to process the sine sweeps, you either had to have an expensive plug in like Altiverb, or you needed to download a dodey program from a shady corner of the internet and code it yourself. With altiverb, you would have needed to have your audio interface hooked in to generate the tone. This brought me back to my need to have a mobile recording station, which was still out of the question. So with little options left, I decided that a sharp transient is what would be best needed. It was then that I set out to the Music Hall with my Tascam DR-40 Field Recorder and borrowed a few thick books from my professor Lanier Sammons. I made sure to wear hearing protection in order not compromise my hearing for the sudden sharp noises. The book method was

satisfactory, but not entirely accurate for what I wanted to achieve. Many of the transients were off kilter, on every single file, either the left or right channel was slightly delayed. I needed predictability, I needed sonic perfection.

Refinement of the attempt

I knew that in the back of my mind I would have to attempt a “balloon pop” method as a last resort in case the sine sweeps did not work (which they did not). I went to the party store and purchased a few bags of regular sized balloons for capturing the sharp transient. So for hours on multiple Saturdays I would record the sounds for my IRs I even through in a few unorthodox ones as well such as “Inside a Kick Drum” and eventually when recording building 48 Main Lobby Under a chair”

Implementing the Balloon pop method

Starting in the Fall semester of 2019 I had experimented with capturing IRs attempting to use the sine sweep method. This proved however to be an utter failure. After hours of researching on youtube I had stumbled across a video of a former student from middle tennessee university who also created an impulse response package for his senior thesis. In the video, he had constructed his own clapping device using two pieces of wood that had door handles drilled into them. Soon after I discovered that he had created a profile on free sounds.com I had attempted to get in contact with him, but he has yet to respond. After that I had attempted to capture the IRs through transients. At first I had attempted hand claps and slamming books together. The results were adequate, but not as accurate as I wanted them to be.

Round 2

Soon after talking to my advisor, Doctor Lanier Sammons, I had decided to try the balloon pop method in order to have better results. Balloon popping is a common technique used in computing IRs for reverb. All it took was a simple push pin. The idea is that a balloon being popped with a needle often has the same attack with short transients.

Figure 1 is a graphic representation of what a transient of a balloon pop looks like.

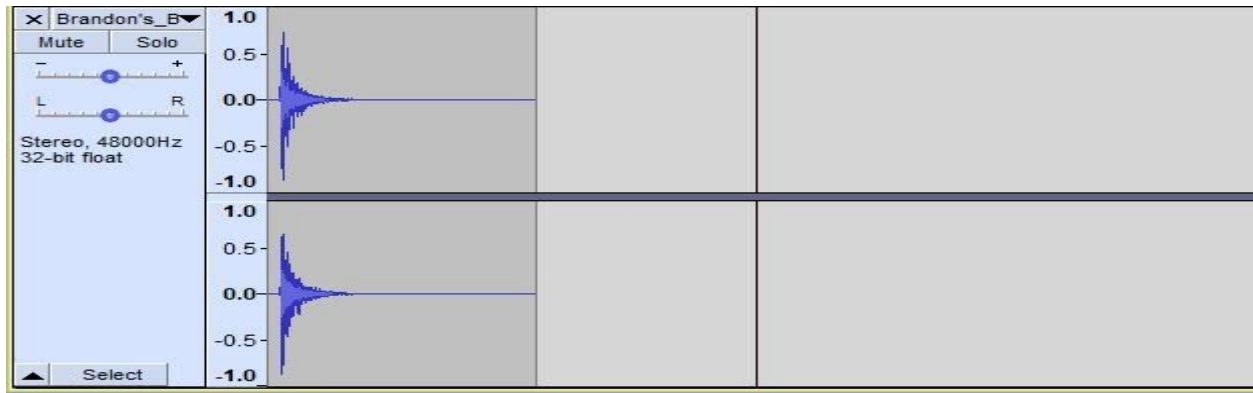


Figure 1. Transient of a balloon pop in my bedroom on East Campus.

It has a fast and large attack with an incredibly short decay. You might be asking why the balloon pop? The balloon pop is a short and violent burst of air that reverberates around the perimeter of the entire area. For instance, Figure 2 presents the impulse response of a so called (Acoustically) “dead room” like Lanier's (old) office from Music Hall, Building 31.

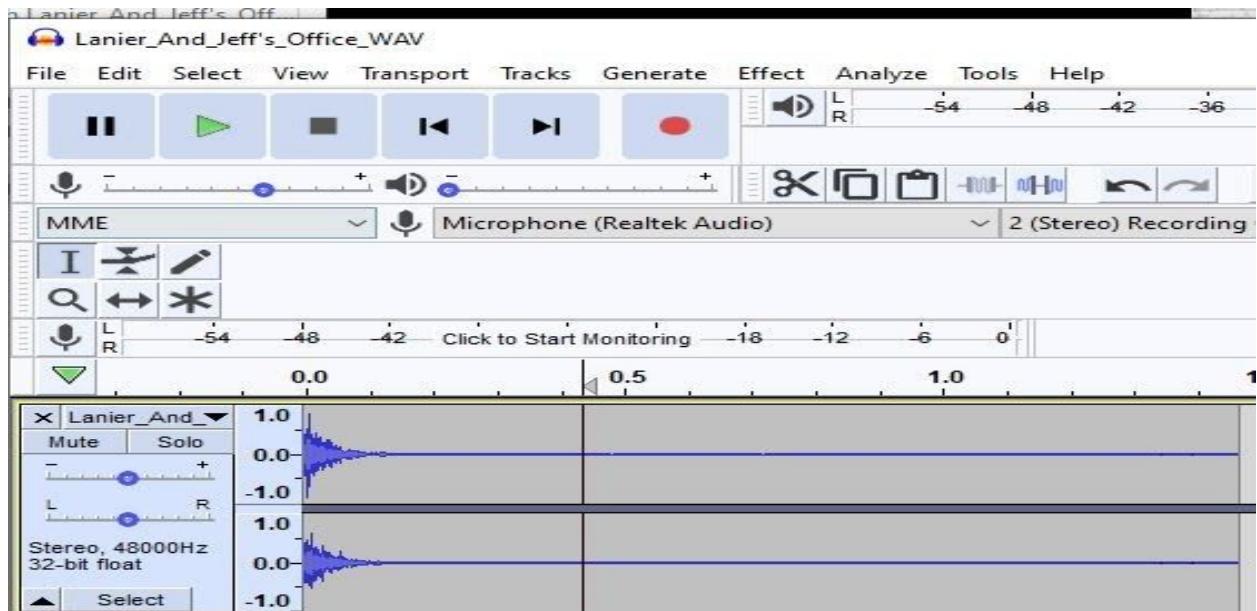


Figure 2. Transient of a balloon pop in an office in Music Hall.

For comparison, Figure 3 is “live” room, the men's bathroom at building 48.

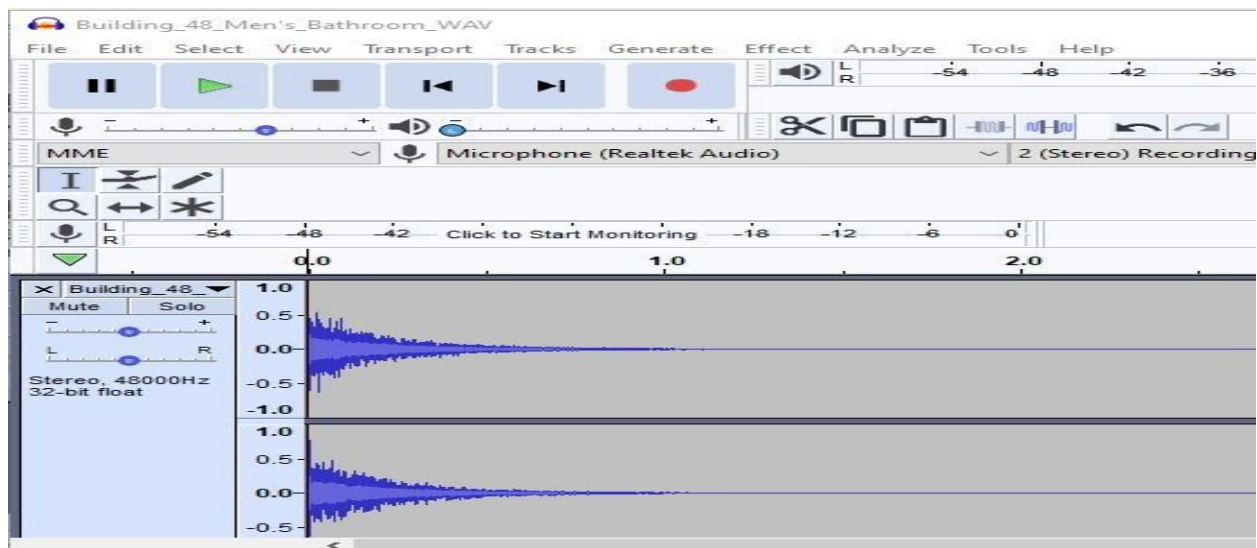


Figure 3. Transient of a balloon pop in the men’s bathroom, building 48.

Results

Using a spectrum analyzer I took a look at what the IRs currently do to dry audio when it becomes affected by the signal of the impulse response. After that, I created an audio sample of myself simply saying the phrase “Hello, I am speaking into a Microphone.”



Figure 4. Audio sample, “Hello, I am speaking into a microphone.”

As you can see, Figure 4 conveys a typical male vocal frequency along with a spectrum analyzer to show what my vocals look like. Keep in mind that I am using a Shure SM7B, so it is entirely possible that my voice is being colored. I have also taken the liberty of making sure the frequencies on the mic are neutral, that meaning no bass roll off and vocal presence booster. Now let's take a look at what it looks like when I add the Bottom of Stairwell IR patch to the vocals.

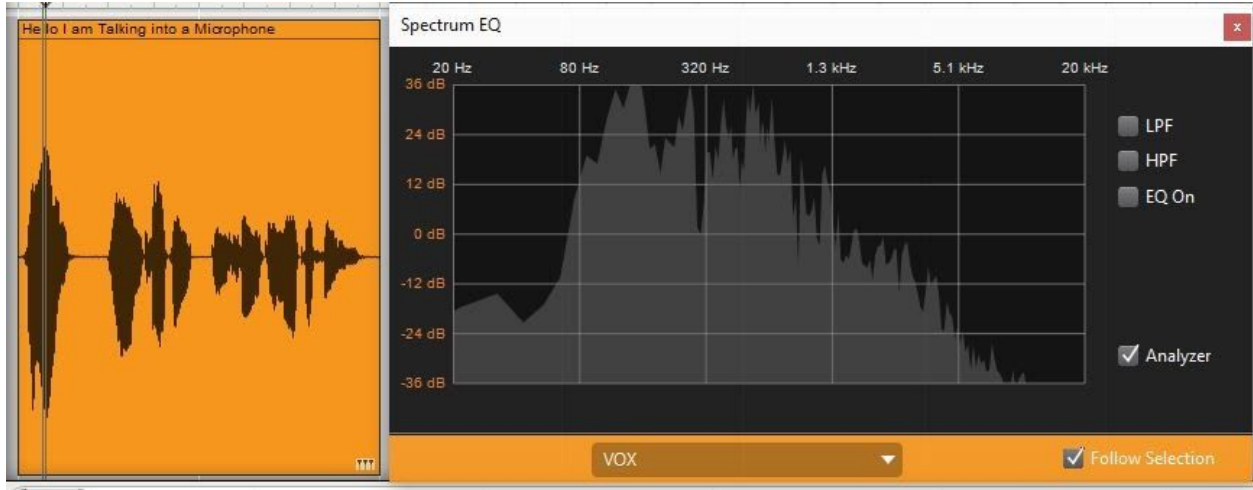


Figure 5. The voice when accentuated with a Convolution Impulse Response

Figure 5 demonstrates that this is quite an interesting effect as it not only lowers the low frequencies but boosts the low mid frequencies as well, and an extreme amount of added amplitude to boot. A patch like this would sound not too out of place in an electronic dance song perhaps on a bass synthesizer, or perhaps even as an effect on dialog in a horror movie.

The Results are in...

To my surprise the balloon popping method worked out better than expected. Although it does not completely have the Sonic accuracy of a sine sweep, the sharp transients of a balloon pop gave me exactly what I needed to produce the results I desire. This is however a creative project with a technical aspect, I was not going for complete Sonic accuracy. The only thing that mattered to me was if I could pardon the layman's term "record stuff and make cool sounds" Which I have completely achieved with breathtaking results.

Creating a few demos to show to professor Lanier Sammons made for interesting results. For instance, on a Trap influenced hip-hop song many people know that the rapid 32nd pattern high hats are of utmost importance. On a demo track, I included the convolution response of the front lobby of the Music Hall which created incredible Sonic results. For the snare, I included an IR of the Room 100 Lecture Hall. If memory serves me right, I took three distinct recordings. One in the front, one in the middle, and one in the very back by the entrance door. This gave the snare a nice mid-range punch. There was a shrill and sharp sawtooth wave synthesizer included in the track, I tried cutting off frequencies below 18 KHz, but it still sounded harsh! My solution was to use the IR of the faculty supply closet. Not only did it dampen the sound, but made the sound far more interesting.

The idea behind the project was to “capture the sound” of the CSUMB Music Hall as well as a few select locations throughout campus. The equipment I used was a Tascam DR40, a standard field recorder that can capture audio up to 96KHz. The model is similar to a Zoom H4N, however, what sets apart the DR40 from the H4N is the ability to change the polarity of where the audio is captured from. Many digital field recorders have the microphones positioned at 90 degrees, the DR40 has the ability to widen the scope at 120 degrees giving the recording a wide spread resulting in a larger stereo field. Which would sound not too out of place in an electronic dance song perhaps on a bass synthesizer, or perhaps even as an effect on dialog in a horror movie.

Taking a step back to look at the project in retrospect

From this project it's taking me a while to realize that I can do a lot with so little. And although I have currently failed in my attempt to create IR's with a sine sweep, I have to say the balloon popping method has worked exquisitely. In fact, it has exceeded my expectations. Out of all the IRs that I captured, I must say that "Creepy Staircase" from the abandoned barracks (which are soon to be demolished) truly gives the music the character that I'm looking for. Sometimes the sound might be too harsh, and when that occurs I simply pull out the supply closet IR in order to dampen the vocals.

In the end I got exactly the results that I wanted. The goal of the project was for an "average Joe" to be able to create their own convolution reverb for relatively cheap and or free and I must say that I achieve my end goal; with flying colors. It took me multiple literal days in order to create the Convolution Reverb impulse Response Package, It is well over 50 files and each sound has three different formations in order to be flexible with the user.

The Creative aspect of the Project

Having the package of IR's in mind I envisioned a small music EP that would coincide with the IR package in order to show it's capabilities. However, due to the Covid-19 Pandemic I am no longer able to gain access to the studio on campus. My dreams of releasing an EP have been crushed. I did however, create a few songs and videos showcasing the IR's in action. Here is a brief rundown of the material. Keep in mind that the Audio Visual examples will also be available in the package. It will be available in folder #6 titled photographs and information.

Early Morning Trappin' -- <https://www.youtube.com/watch?v=rYdffTQJYXA>

For this song, I decided that the use of the Reverb IR had to be far more subtle. Therefore, I decided to only use it on the vocals, utilizing the “Decrepit Bathroom Shower Stall Patch” The song really shines at 1:43 where the track strips down to just vocals and drums to bring out the character in the reverb. A link to the song is available below.

Ice on my Wrist -- <https://youtu.be/NmfdaBo9Ju8>

If that song was not “Gangsta” enough for you, I also have “**Ice on my Wrist**” a Trap song in C minor that utilizes the “Long Hallway” Impulse response on the vocals. The vocals get a chance to shine at 1:29 when there is a refrain. But beware, the song contains profanity.

The entire package (demonstration) -- <https://youtu.be/XIYe15InlvY>

In this video, (also available on Youtube) I demonstrate the utilization of these Impulse Response packs on a single drum loop. The Video is extensive going over every single solitary Impulse response available in the package. There is also a link to the video available down below In yet another video I have automated the wet/dry knob of the reverb unit in order for the viewer to hear a before and after effect on a short percussive piece of music.

Shorter example video -- <https://www.youtube.com/watch?v=YIzDn2foPIo&feature=youtu.be>

If you so choose, you can see a short video of me attempting to capture sine sweep from the initial stages of the project.

Initial sine sweep experiments -- <https://www.youtube.com/watch?v=4Jv4RrG2pGk>

You may also find a video of me popping balloons in the abandoned barracks here. Don't worry, I did not get injured, And no, I did not go on the roof.

Exploring the abandoned barracks -- <https://youtu.be/gwniWPZlf5s>

Issues Conflicting With The Project

The initial idea was to have a listening station for my EP at Capstone Festival. The computer would have had my entire EP in a long session being looped in my DAW. The session would have included mirror image faders for all the tracks so the listener could affect the reverb while listening to the song, essentially being able to create a “before and after” effect musically. Due to the fact that quarantine has effectively shut down campus, my package of sounds will have to suffice.

Putting Together the Package

The hard part was not capturing the sounds, rather the organization and labeling of them. Many hours, every day were spent inputting midi data organizing the files into precise folders in order to make finding the sounds smoother. In an effort to give the user more flexibility when utilizing the sound I decided to export the IRs in three different formats including MP3, WAV, and full quality uncompressed FLAC. This would insure not only cross compatibility between Mac and PC, but program compatibility as well. Some Convolution Reverb Units can only

accept input from a WAV file, while other people have computers with weaker processors and can only handle MP3 files. Flexibility was the key. After that, I then used a free program called *Foobar 2000* in order to embed photographs into files so that the user would have a rough idea of what the impulse response would sound like.

Conclusion

As I prepare to graduate and end my CSUMB career I hope that I have left a lasting impact, not only on the campus, by my professors and peers as well. And as much as some people want to stay in College forever, we all must move on. But there will come a day where you are far away in a foreign land, perhaps up on a tall balcony overlooking the skyline of a mega city. I can imagine you (Yes, You, The Reader!) sipping on a mocha chai double espresso latte and fawning over all the fun times that you had being a student at California State University Monterey Bay (perhaps playing hide and seek with Monty Rey?) Whether you came in as a freshman living in Tortuga Hall, or transferred in as a commuter student like me, the experience is all the same. You were here and it changed your life. You might sit there sipping your coffee and suddenly remember playing billiards at the student union and suddenly shed a tear of joy over a happy memory. You suddenly remember that you have a usb flash drive in your pocket that a kind fellow student of yours created with Impulse Responses of your alma mater CSUMB campus. You load up your DAW of choice, perhaps Ableton live, or maybe even Cubase. You then proceed to make the "Phattest Beat" you have ever made in your life, and the icing on the cake is an Impulse Response from the Reverb package. You quickly export your song and post it onto the internet. You take one last sip of your coffee and look up at the clouds.

All is at peace in the world. This who I made this for, I made it for you! All the countless hours in the studio recording a rock band, all the late nights chugging gallons of coffee trying to finish up a term paper. It was all for you.

And so fellow travelers who read this paper, we shall both ride off triumphantly into the sunset, knowing that we have a piece of home in our pocket.

Enjoy using my package, my gift to you.

**Here is a List of People Who I would like to Personally Thank, people who helped me along
on my journey:**

First off I would like to thank my professors at Cabrillo College, Especially James Durland and Dcotoc Cheryl Anderson. You both pushed me hard, and taught me an insurmountable breadth of knowledge. CSUMB Department Technician Drew Lassen, My academic counselor Karren Wallace. My Math Professor Doctor Donal Pierce. My Italian Language Professor Michele Santa-Maria. My music profesors at CSUMB, in closing Aimee Puentes, Carlos Totress, Doctor Enrique Rios-Ellis. MPA Department head Doctor Jeffrey Jones, and of course professor Lanier Sammons, It was Lanier who advocated for me when I could not meet my transfer requirements due to not being able to pass a math class because of my learning disabilities. Thank you Lanier, truly from the bottom of my heart. For Literal years I would dream about being a student at CSUMB and presenting my project at the capstone festival. And while only one of those things came true, I am truly happy at the short time I got to spend with you and amongst my peers at this school. It wouldn't have happened without you, *and for that, I thank you.*

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