Live Event Audio Engineering

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Abstract

Team Audio's goal was to learn about audio engineering and sound design, and applying these lessons to practical use. This paper will reflect upon our group's experiences with the GSET 09 Talent show, specifically regarding the audio engineering that translated the original sound to the final sound. Behind every concert and performance is a crew of individuals who make it possible, enjoyable, and high quality. These audio engineers manipulate the sound of the performance in every way in order to produce a finished product for the audience. Our group used the elements of a sound system, which converts acoustic to electric energy, edits the signal, and returns the energy to an audible form.

In order to accomplish the goal, our group prepared several major documents. We created a systems flow diagram to detail the individual characteristics of the talent show system. Additional diagrams included charts of the venue, major cable runs, performance listings, and patch lists.

All of these documents helped us reflect upon the successes and failures of our project, and discuss what could have been improved. For the most part, there were no large issues that we would have like to correct. Afterward, we realized that a sound check would have been quite beneficial, as it would have allowed us to become familiar with the performances. Overall, however, our project was a successful venture.

1 Intro

The field of audio engineering encompasses a wide variety of processes ranging from live playback to signal processing. The responsibilities of the audio team vary from power and structural concerns to the actual acoustic issues. The most important priority for an audio team is to produce a show that can be enjoyed by the performers and audience alike. This is done by building a sound system, just as we did for the GSET Talent Show. Engineers must concern themselves with every aspect of the design from the microphones to the speakers.

An essential issue in production is keeping all of your equipment and crew safe. Planning ahead of time saves an enormous amount of time and allows for the rest of the process to run smoothly. It is necessary for the audio team to have strong and reliable documentation of everything that will take place, including a set list and output/input lists. The show will be less stressful for the performers and for the audio engineers if there is a proper plan which will prevent any large mistakes from occurring. Only with careful planning and resolve can a smooth and organized show materialize. All of these separate factors must be combined and molded together in order to produce a finished product.

Our project revolved around taking these elements and applying them to the Talent Show process. We were concerned with providing the right amount and type of equipment that would be specially suited for our show and venue. This was done

efficiently and in an organized fashion due to our precautionary measures. As a result the performance was entertaining and enjoyable

2 Background

Live audio engineering deals with sound and its manipulation. A basic understanding of sound and how it acts is therefore beneficial. Sound is simply what we perceive when our ears detect changes in air pressure.

Sound is created by a vibrating source which sends longitudinal waves of compressed air molecules spherically outward, although this shape may change if disturbed by another object. Basically, kinetic energy is transferred from the source to the surrounding air molecules, which then collide with those surrounding them**,** and so on. However, the individual air molecules themselves don't move very far in the process. Because sound acts in this way, it requires a medium to move through. In most cases, the medium we perceive sound moving through is air. However, sound can also move through other objects, such as different gasses, solids, and liquids.

The speed of sound is not a universal constant and depends on the medium it is moving through. For room temperature air, sound's average speed is around 343 meters per second. The denser the medium, the faster sound moves, so sound in water moves faster than sound in air, and waves in a solid move more quickly than those in water. The temperature and humidity of the medium also affects the speed of sound, with warmer air allowing sound to travel more quickly.

Sound waves exhibit a cyclic nature that is linked to harmonic motion, and they repeat in identical oscillations. The frequency of a sound is the number of cycles which occur in one second, measured in Hz (Hertz, or cycles per second). Human hearing detects sounds with frequencies from about 20 Hz to about 20,000 Hz. What we understand as pitch is simply our response to different frequencies; the higher the frequency of the sound, the higher the pitch we perceive. The wavelength of a sound wave is the distance between each cycle, and is inversely related to the frequency.

The loudness or intensity of a sound is measured in a logarithmic scale with units called Decibels (dB). Breathing is about 10 dB, normal conversation is about 60 dB, and a rock concert is about 110 dB.

As sound waves propagate from their source, they interact with other objects as well as other sound waves. One major interaction is sound waves reflecting off of other surfaces. Like light reflecting off a mirror, the angle at which sound hits the surface, known as the angle of incidence, is equal to the angle at which it will reflect, known as the reflected angle. This leads to phenomena such as reverb, which occurs when the decay of sound waves is prolonged as they bounce against reflective materials.

Sound waves also interfere with each other, and can do so either constructively or destructively. For example, if two identical waves are completely in phase with each other, they will combine and effectively double the amplitude of the sound. If two identical waves are 180 degrees out of phase, they will cancel each other out and result in silence. However, this rarely happens so precisely, and often waves combine to form odd waves that can be represented by the sum of several sinusoidal waveforms, known as a Fourier series.

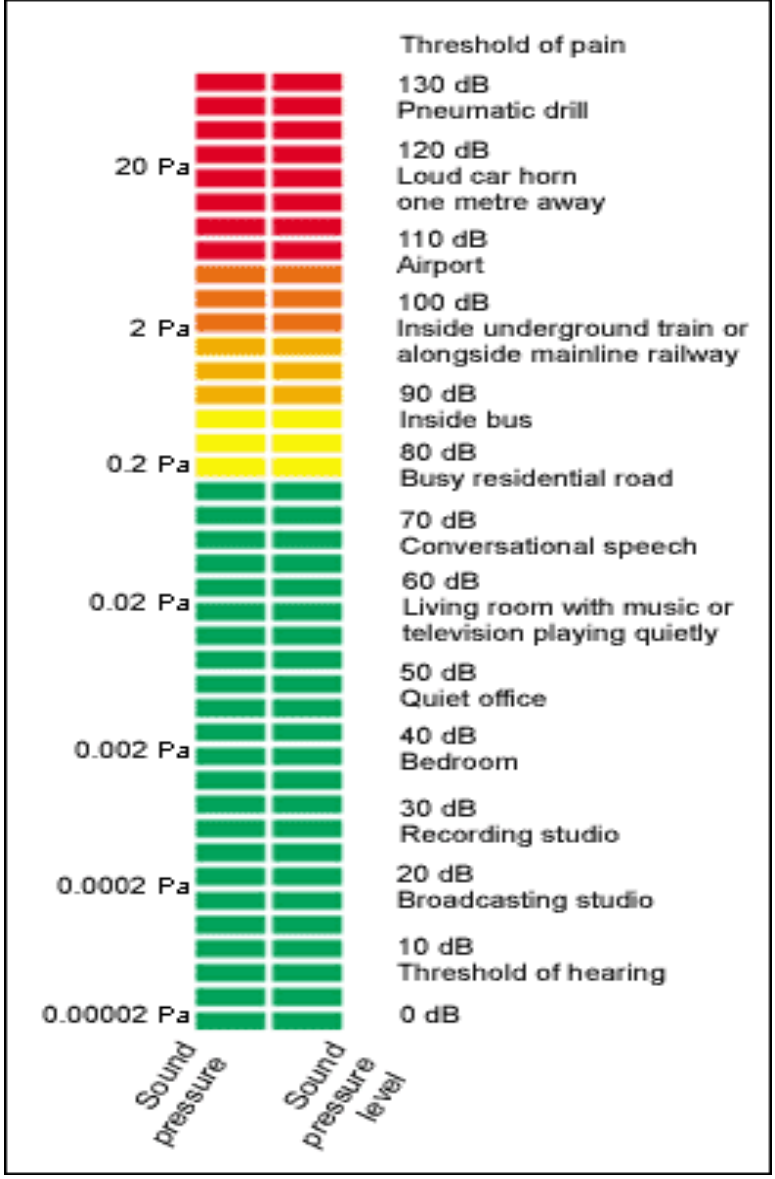
2.1

The understanding of a basic sound system is also required for audio engineering. The first component of a modern sound system is a microphone. The microphone's function is to take the kinetic energy of the sound waves moving through the air and convert it to an electrical signal. Microphones accomplish this with a structure called a diaphragm, which oscillates in response to incident sound waves in a magnetic field, and creates an electrical signal with voltage and amplitude corresponding to that of the original sound.

The two main types of modern microphones are dynamic and condenser microphones. Dynamic microphones are generally preferred for live events for several reasons. First of all they are more durable than condenser microphones, therefore they can be used for years and retain the same sound quality. Additionally, dynamics are known to "smooth" out the sound input, adding color and richness. However, this type of microphone is known to perform poorly at very low or very high frequencies. Conversely, condenser microphones offer a higher performance standard at these frequency ranges. This type also has its faults and is very fragile and expensive. Our group made use of dynamic microphones simply because we had no need and no budget for the exceptional quality associated with condensers. The signal from the microphone is next sent to a mixer.

A vital component of the sound system we used was a direct box or direct input, commonly called a DI. The function of the DI is to take a signal coming from an instrument, in our case keyboards, and change it to the equivalent of a low impedance microphone signal so that it may be sent directly to the mixer.

The mixer takes multiple inputs and mixes them together into one output. Mixers



generally offer some ability for equalization (EQ) for each channel independently. EQ allows the user to augment or diminish the power of certain frequency ranges of the sound coming through the channel in order to shape and change the sound. Mixers also have auxiliary outputs which send duplicates of the channel signals to other system components, such as effects processors. Each channel of the mixer has a gain knob, which allows the user to change the volume of the incoming signal by altering the sensitivity of the individual input, and a fader, the function of which can be compared to that of a water faucet, which is used to boost or lower the strength of the sound being processed each channel.

Another important element of a sound system is the signal processing unit.

Our project dealt with the three most common types of processors. EQ processors, have a similar function to the EQ on a mixer, and allow a user to lower or raise the strength of a signal for a specific frequency range. Each type EQ has its own specific reason for being used, which allows for an even greater amount of sound control. Another type of processing unit is the dynamic processor, which helps to avoid clipping a signal. Clipping is a type of sound distortion that results from too much power which essentially creates a signal that is represented by a squared off sine wave instead of smooth one. The signal becomes too overpowering, and the top of the sine wave has so much energy that the top is literally "clipped" off. This is an undesirable effect which can be unpleasant to hear in certain contexts. Dynamic processors also open and close signals by letting only certain frequencies pass through. Effects processors are those that create different effects, such as reverb and distortion. These offer a great deal of creative license, allowing the performers to develop their own individual sound.

The signal subsequently goes to an amplifier. The amplifier electronically increases the voltage and the amperage of the incoming signal, which allows it to make significant sound when it reaches the speakers.

Finally, the signal goes to the speakers, where it is converted from an electrical signal back to sound waves due to an electromagnet in the speaker that is attached to a paper cone. As the varying signal enters the speaker, the electromagnetic field fluctuates, moving the magnet and therefore the cone back and forth. The cone moves the air adjacent to it, producing sound.

Each individual component is needed to have a complete system. They all work together by individually modifying the signal and sending it along the chain in order to continue the process. These elements transform the sound through several different stages until its completion, upon which it is transmitted to the audience for their enjoyment.

3 Method

Our research project revolved around coordinating and creating the audio system needed to run the Governor's School and Engineers of the Future Talent Show. Our job entailed manipulating the sound of the performance in order to produce a finished product for the audience.

The venue for this event was the Fiber Optics lecture hall at Rutgers University's Busch Campus. The auditorium was relatively small, with seating for approximately 150 people. Upon conducting our site survey, we noticed several points about the room that needed to be considered. The entire auditorium sloped downwards toward the stage, while the ceiling curved upwards with an equal slope. The aisle between the house right seats and wall was considerably wider than that between the house left seats and wall. Additionally, the house left wall was padded with a sound absorbent material, while the other was naked. The speakers on stage would have to be angled so that all parts of the room received sound and so that sound did not pass over the heads of those in the front rows. Finally, at certain specific focal points, sound waves bouncing off the walls combined to create standing waves, and therefore pockets of volume variance.

In order to have a successful show, we would need to cater not only to the requirements of the room, but also to that of the performers. Each group needed a different combination of equipment, and we would need to move all of the equipment and cable after each act in order to accommodate the next group. Up to 4 vocal microphones and 3 instrumental microphones would be needed simultaneously, and coordination was needed to incorporate a DJ during certain acts.

Console Input	Description	Snake Channel	Device	Mic Accessories
1	Vocal 1	1	Shure SM58	Big Tripod
2	Vocal 2	2	Shure SM58	Big Tripod
3	Vocal 3	3	Shure SM58	Big Tripod
4	Vocal 4	4	Shure SM58	Tripod
5	Guitar	5	Shure SM57	
6	Bass	6	AKG D-112	
7	DJ	7	DJ	
8	DJ	8	DJ	
9	Keys 1	9	DI 1	Keyboard Stand
10	Keys 2	10	DI 2	Keyboard Stand
11	Violin	11	Shure Beta 58	Stand
12	MC Mic	12	Fender D-51	
13	VOG	13	Shure SM58 switch	
14	Playback Channel Right	14		
15	Playback Channel Left	15		

Table 1: This table is the input list for GSET 2009 Talent show. It shows the equipment used and what it was used for, along with what was needed to support the equipment. There are empty spaces because the microphones used for the instruments did not need accessories or there was no microphone required for that particular instrument.

This equipment was all amassed from personal collections, borrowed or rented from various sources. We proceeded to take note of the names and model numbers of all our equipment in order to get specific details and capabilities. We arrived at the scene of the show several hours in advance in order to set up. We set about transporting all of the equipment to the auditorium in a specific way in order to facilitate an easy setup. The gear was placed strategically by function so that we could construct the system in pieces if necessary. We proceeded to build the actual sound system, keeping in mind both the requirements for the show and relevant safety precautions needed to prevent injury. We then prepared for the show by using the Klark Technic EQ to equalize the entire system for the individual characteristics of the room, bearing in mind the aforementioned issues. After testing all of the inputs, connections, and outputs, we were satisfied that the system was fully functional and that the show would be a success.

Our project group carried out the project in such a way as to minimize stress and maximize productivity. For example, by carefully compiling a list of performances and the requirements for each, we were prepared for each act beforehand. This was slightly hampered by a small number of last-minute set changes and the late arrival of the DJ, but we still managed to run a successful show that was both enjoyable and practical. In order to keep track of the enormous amount of cable and wiring, Gaff tape and Sharpie markers were used to label all connections and keep track of the system flow. We left an ample amount of time to set up the system and run sound checks, and for the most part we were able to solve any issues before they blossomed into something more serious. For example, a single misplaced cable can result in the entire system failing, and the performance ending in failure. Cost efficiency is often a considerable factor in determining how a sound system will be designed and built. Since our group received equipment from our project mentor and counselor, we did not have to concern ourselves with this aspect of system design.

However, we did need to choose which pieces of equipment would be best suited for certain uses. We had a vast array of different microphones, each with its own specific characteristics, and we paired each with an instrument or microphone in order to take advantage of these features. For example the AKG D-112, which is normally a bass drum microphone, was selected to be used on the bass guitar amp, as it is best suited for very low frequency ranges.

Altogether the method that was used for our talent show allowed us to accomplish our goals of producing a successful show. Our equipment and experience enabled us to accomplish this task, and we balanced a combination of acoustic science and artistic expression.

Group Name/Description	Equipment Necessary	Input Channels
1. Gospel Group	4 Vocal Microphones, Electric Guitar, Bass Guitar, Drums	1, 2, 3, 4, 5, 6
2. Dueling Pianists	2 Keyboards	9,10
3.Spoken Words	Vocal Microphone	1
4. Vocalist	Vocal Microphone	1
5. Viva La Vida Band	Vocal Microphone, Acoustic Guitar (plugged into guitar amp), Keyboards, Violin	1, 5, 9, 11
6. Dance Face Off	Playback	14, 15
7. Juggling	Playback	14, 15
8. Rave	Playback	14, 15
9. Dance Freestyle	DJ, Playback	7, 8, 14, 15
10. Folk Song Band	2 Vocal Microphones, Keyboards	1, 2, 9
11. Acoustic/Vocal Solo	Vocal Microphone, Acoustic Guitar (plugged into guitar amp)	1, 5
12. Rap	2 Vocal Microphones, Playback	1, 2, 14, 15
13. Rock Band	Vocal Microphone, Electric Guitar, Acoustic Guitar (plugged into guitar amp), Bass Guitar, Drums	1, 5, 6
14. Spoken Words	Vocal Microphone	1
15. Rap Battle	2 Vocal Microphones, DJ, Playback	1, 2, 7, 8, 14, 15
16. Dance Tribute	DJ, Playback,	7, 8, 14, 15

Table 2: This chart details the specific setup for each act at the GSET 2009 Talent show. The acts are sequenced in order of appearance, and the pertinent equipment and inputs are listed next to them. This table helped us keep track of our responsibilities for each performance.

5 Results

This talent show proved to be a great event. The sound quality turned out to be excellent, everything was properly labeled and acts were tended to as quickly as possible. Our group worked together as a coherent unit in that we provided quick and efficient transition between acts.

It was very important that the show order give enough time space for us to move instruments around or out of the way for dancing acts. This did not prove to be a problem as mentioned before, and all the equipment was returned safely. None of the performers had any dangerous mishaps, and we made sure to take all precautions necessary.

The GSET 2009 Talent Show proved to be organized and professional. Our audio team collaborated in order to present the audience with the best results and provide an entertaining experience. The talent show proved that we could handle the stress and successfully run a quality show.

There were many things that could have gone wrong with the talent show. For example, we could have had malfunctions with the equipment or the cables. Another possible scenario could have that we did not have all the equipment that was needed to set up the performance. There also could have been the chance that we ourselves made mistakes, like mixing up our inputs and outputs.

All of these hypothetical situations were avoided due to careful planning and premeditation. In the case that the cables malfunctioned we were prepared with spares. Any faulty connections were prevented by careful labeling and diligent cataloging. Other obstacles presented themselves as the show progressed, but we managed to overcome all of them. After it was realized that two keyboards were going to be used simultaneously, we needed to purchase a DI in order to accommodate this performance. A small number of performers canceled their acts immediately before the show started, but we dealt with this issues and reformed the set lists to accommodate the new changes. Certain groups ended early or played an extra song, but problems were avoided as we bent our own actions around theirs.

The actual event was successful in the fact that there were minimal if any acoustic issues and the show ran smoothly. All the acts performed without any technical difficulties, and we proceeded to prepare the system for each group between performances, by altering the inputs and outputs in order to suit the specific requirements. During the acts we monitored the mixer in order to prevent any sudden mishaps or spikes and to allow for the best experience for both the performer and audience. After completing the show, we proceeded to tear down the set, again with consideration for safety. The pieces of equipment were sorted by owner and then redistributed.

6 Conclusion

Throughout the project, our group learned several invaluable lessons. The talent show allowed to us get a taste of the audio engineering field and we plan to continue to explore the discipline. The sound system was designed with special consideration towards the venue and purpose of our show, which provided an enjoyable and pleasurable experience for all those present. Safety was also of the utmost importance. Wellbeing of one's person, coworkers, and equipment need to be constantly considered, in that order of weight. Organization is of high significance as well. The two go hand in hand, as an organized project results in a safe project. We managed to keep track of all important information and present a planned and structured show to the audience. Our group concluded that an immense amount of planning is needed to run a show. The experience demonstrated that like any other form of engineering, the audio process involved designing the system, setting parameters, and then actually bringing the design to life.

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