Portrait of a Concert

Gareth H. Griffith

Thesis submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of:

Master of Fine Arts in Creative Technologies

Keywords: data visualization, concert, music, biometric

Dane L. Webster, Chair

Troy D. Abel

Carol S. Burch-Brown

Meaghan A. Dee

May 7, 2014
Blacksburg, Virginia

Abstract

Portrait of a Concert
Gareth H. Griffith

Through the use of biometric data and audio recordings this research explores the body as it engages the concert environment. With the help of wearable technology and digital audio recording devices, data from four concerts was documented. Additionally personal reflections were recorded at the conclusion of each concert to serve as the qualitative data and a point of comparison between the quantitative recordings. These records were then used in the construction of an interactive data visualization that allows further exploration of the data collected by means of a visual interface.

To my Mother –

It is you who I owe the greatest debt. Through you I discovered the arts and your influence is why I continue to explore them today. Thank you for all of your love and support, I would truly not be the man I am today had it not been for you.

Acknowledgements

The conception and development of this thesis would not have been possible without help from a number of individuals.

First and foremost, I would like to thank the chair of my committee, Dane Webster. This thesis would not have been possible without his support, inspiration and our frequent discussions. I would like to thank the rest of my committee, Troy Abel, Carol Burch-Brown, and Meaghan Dee for their guidance and support.

My supreme gratitude goes out to Michael Bunnell, who taught me many best practices in code, helped me problem solve, and spent countless hours of his own time. This project would not have turned out as well as it did without his help.

To all my friends and family who supported me as I left Richmond to come to Virginia Tech and welcomed me back with open arms whenever I returned.

Lastly, my wife Suhani – thank you for your love and support throughout these last three years. I would not have made it through without you.

Definitions

Biometric – quantifiable data related to the physical, chemical, or behavioral attributes of an individual (Jain and Ross, 2008).

Data Visualization - The representation and presentation of data that exploits our visual perception abilities in order to amplify cognition (Kirk, 2012).

Galvanic Skin Response (or skin conductance) – an electrical phenomena in skin, directly related to moisture levels, that shows variances in DC voltage while monitoring is constant (Boucsein, 1992).

Hearables – a wearable technology that an individual wears in the ear (Glazer, 2014).

Wearable technology - electronic technologies or computers that are incorporated into items of clothing and accessories which can comfortably be worn on the body (Wearable Technology, 2014).

Social media – virtual communities where individuals interact and information is created, shared and exchanged (Ahlqvist et al., 2008).

Contents

Abstract	ii
Dedication	iii
Acknowledgements	iv
Definitions	v
List of Figures	vii
Introduction	1
Background	2
The Data Visualizer	6
The Data	7
Process	10
The Visualization	12
Conclusion	15
References	16

List of Figures

Figure 1 – Flight Patterns 2

Figure 2 – U.S. Gun Deaths (accessed May 2014) 3

Figure 3 – New York Times Word Frequency 4

Figure 4 – The Feltron 2008 Annual Report 5

Figure 5 – Umphrey's McGee, 8-17-13 7

Figure 6 - Umphrey's McGee, 12-31-12 7

Figure 7 – Basis Band (accessed May 2014) 8

Figure 8 – Biometric data processing 10

Figure 9 – Audio data processing 11

Figure 10 – Various Concert Views 12

Figure 11 – Event Notes View 12

Figure 12 – Concert Informational View 12

Figure 13 – User Interface 13

Figure 14 – Song Selection 13

Figure 15 – Song View 13

Figure 16 – Time Marker 14

Figure 17 – Biometric Averages 14

All images property of the author, unless otherwise noted

Introduction

As technology advances, computing devices grow smaller and new methods of interaction emerge. Mainframe computers become personal computers, personal computers become handheld devices, and in recent advancements these devices have become wearable.

Wearable technology opens up an entirely new realm of possibilities. Google Glass[1] invites the wearer into a new world where application interaction and internet access becomes nested in a window at the top right corner of his or her field of vision. The Basis Band[2] monitors a broad range of health-oriented metrics and allows access to the recorded data via the band's interactive screen. Even newer devices, coined "hearables," place the computer in the wearer's ear altering the current interaction paradigm where verbal commands replace touch interactions.

With the advent of these new, small, and portable technologies a colossal amount of information is emerging. At the user level the individual has the opportunity to monitor personal information. Applications and their devices track location information, search histories, and biometric data just to name a few. The question that arises is: what do we do with this data now that we have access to it?

[1] Google Glass: http://www.google.com/glass
[2] Basis Band: http://www.mybasis.com

Background

Humans have always had an innate desire to try and make sense of the world. Through methods of deconstruction or dissection we seek underlying structures. These explorations expose smaller individual components that help explain the inner workings of the whole.

Data combined with code present a similar environment. Code consists of individual building blocks that when assembled can reveal greater structures. If code presents us with the disparate pieces of a larger framework, data could then become the fuel that these systems rely on to run.

Data Visualization presents a viable means by which the layman can access data. Visualization has an amazing power to open up ones eye to a hidden world once masked by complex languages and cryptic numbers. Once visualized, interesting and compelling stories often emerge from the data that previously lay hidden.

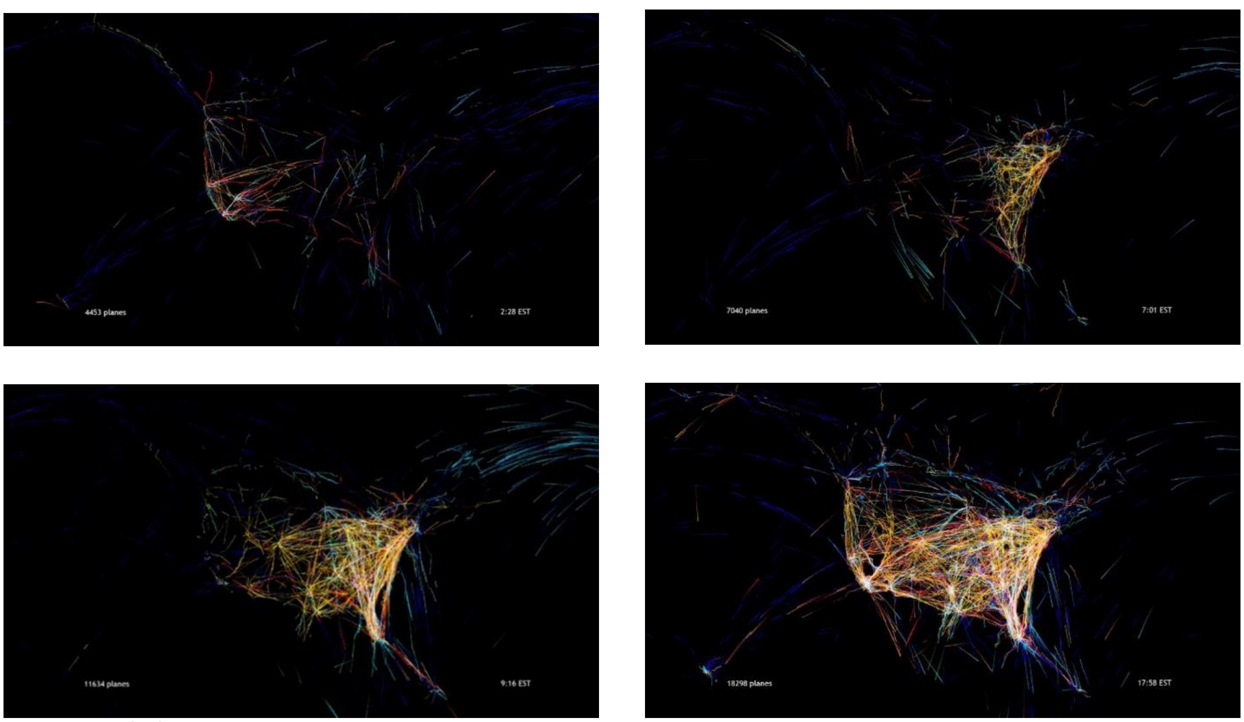

Figure 1 - Flight Patterns.

Aaron Kolbin's ***Flight Patterns (see Figure 1)*** exposes twenty-four hours of flight data as colors streak across the screen. Quickly one can see the massive web of air traffic that is constantly moving above the United States. Patterns emerge as night turns to day and a wave of streaks wash across the country from east to west. These new systems help tell different stories that would otherwise lay dormant.

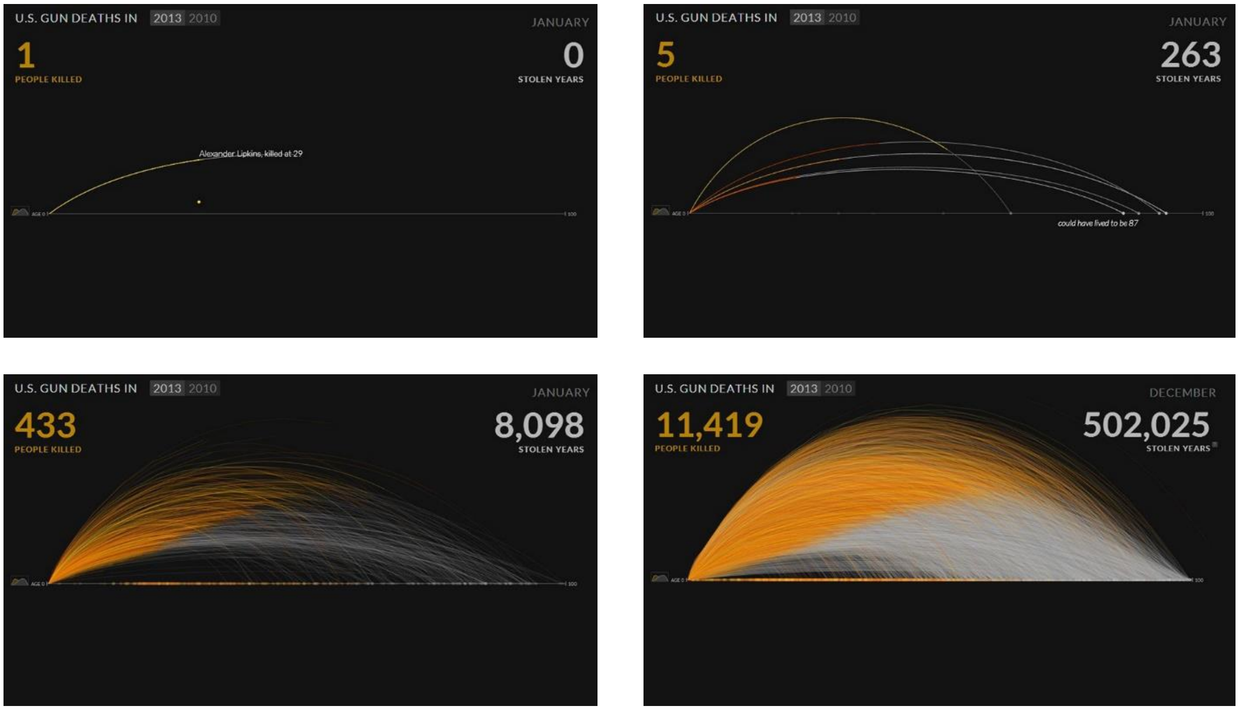

Figure 2 - U.S. Gun Deaths (access date May 2014).

The ability to craft a story from a series of data points is an extraordinary feat on its own but data also has the power to elicit powerful emotions. Arcs stream across the viewer's field vision like projectiles in search of a target but fall short as they are literally gunned down before they can reach their destination in Periscopic's ***US Gun Deaths (see Figure 2)***. These arcs flood the screen as the death toll rises exposing the very dark side of guns and bringing attention to the potential impact guns can have on society.

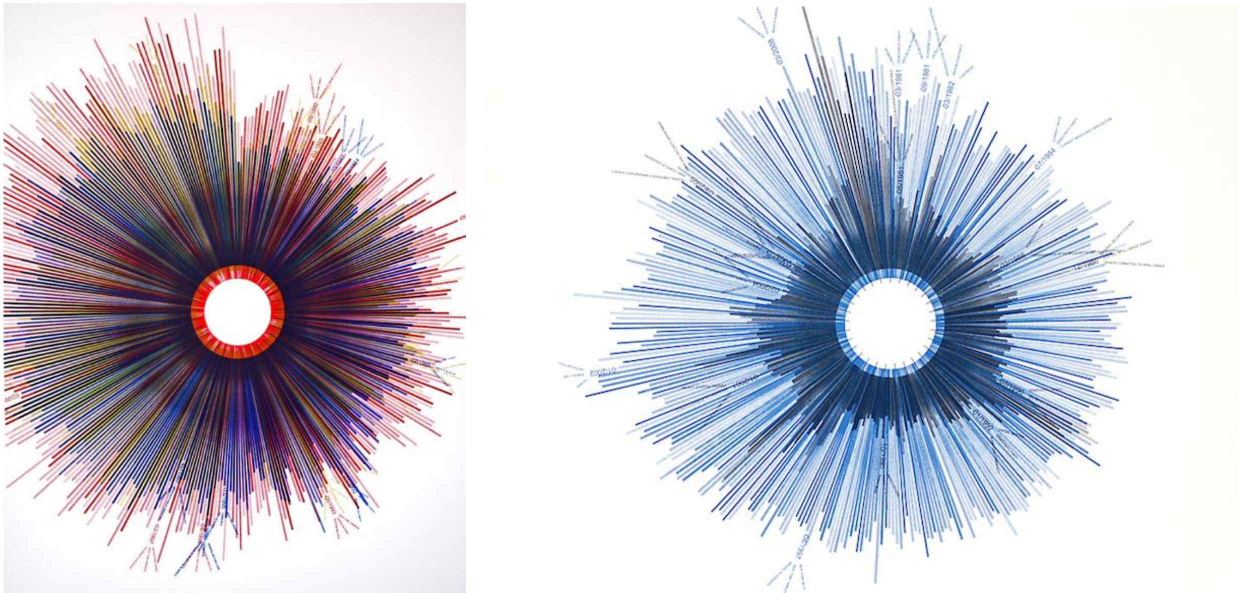

Figure 3 - New York Times Word Frequency.

Outside of the realm of storytelling data visualization can simply exist to be beautiful. Jer Thorp's ***New York Times Word Frequency*** explores the appearance of specific words in the New York Times from 1981 to 2012. In the left image of Figure 3, the words red, blue, and green define the composition of this radial graph. In a similar fashion the graph on the right is constructed using the words hope and crisis. Although the story might not be readily apparent the data drives the underlying structure of these depictions.

Among the many varied sources for data available, this research focuses on content generated about the human experience. With the advent of portable technology, users of these devices have access to a variety of recordable metrics. While many of these metrics were accessible previously, recent advances allow much of this information to be recorded with little to no thought. Global Positioning Systems (GPS) can monitor and record user locations. Wearable devices can track activities associated with the body such as elevation, steps taken, sleep quality, ambient temperature, heart rate, skin temperature, and galvanic skin response.

These new technologies also allow users to generate their own content effortlessly. Social media applications such as Facebook[3], Twitter[4], and Instagram[5] present forums for individuals to publish and record information about their daily lives. Users share feelings, opinions, location updates, pictures, and activities that are logged in an ongoing public dialogue that catalogues their lives.

[3] Facebook: http://www.facebook.com
[4] Twitter: http://twitter.com
[5] Instagram: http://instagram.com

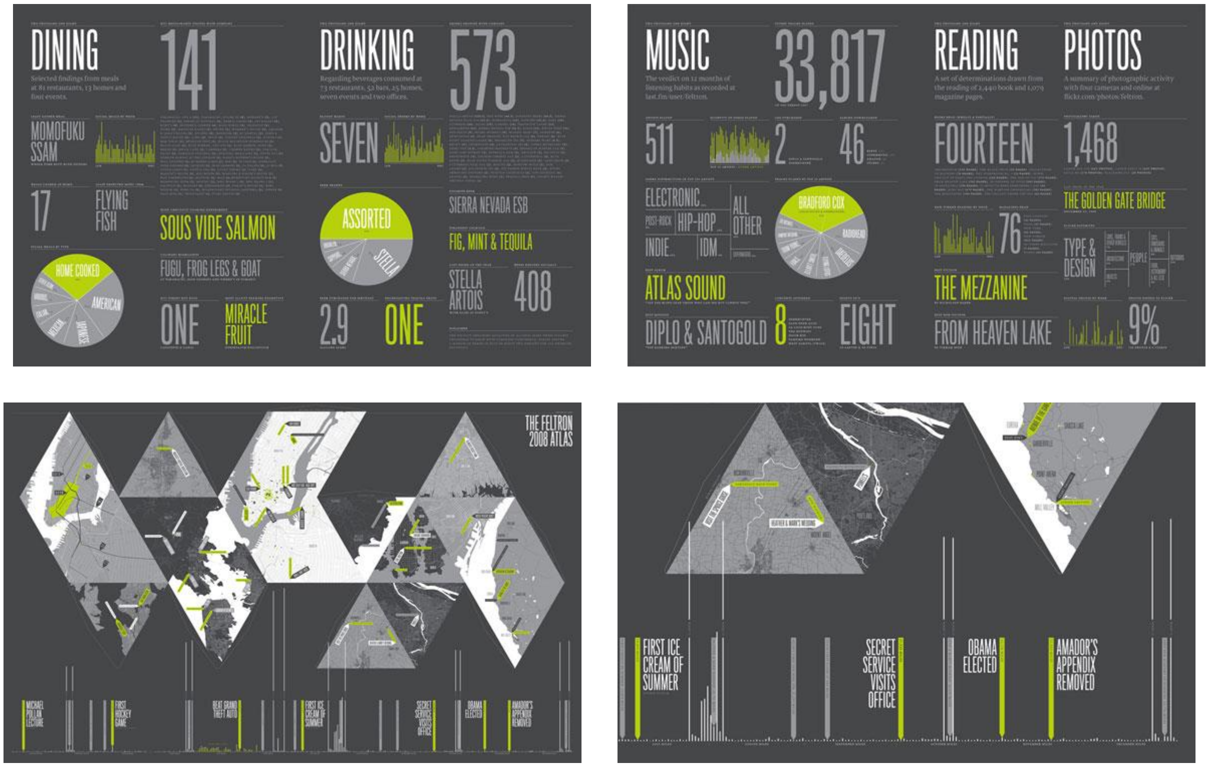

Figure 4 –The Feltron 2008 Annual Report.

Nicolas Felton, a graphic designer from Brooklyn, NY, annually catalogues various aspects of his life that culminate in his annual report. Felton doesn't isolate his collections to any one type of information but rather embraces all potential data and decides later what material should ultimately populate each year's report (see Figure 4).

The Data Visualizer

Alone, recorded numerical data might only be interesting to the statistician so in an effort to make this information more accessible a new role will need to be defined: the data visualizer.

Traditionally, standardized charts such as the bar chart, pie chart, or line graph have been used. The layouts are easy to read, familiar, and consequentially easy to understand. These traditional formats provide an effective means of representing data and are often the best choice but have a tendency to underwhelm the reader. In an effort to reengage the audience new methods of thinking about data should be considered. Representations of data should speak directly to the information itself. If the representation of the data correlates directly to the data that is being discussed, then the bond between the viewer and data is strengthened.

The data visualizer then becomes the storyteller. They guide the reader, directing them down the path that unveils this hidden world masked in a sea of data. Much like a photographer tells a story with the lens, the visualizer sets the scene, adjusts the lighting, and tweaks the zoom. When the moment is right, they then push the shutter release that focuses the reader's attention. Additionally similarities arise between the visualizer and the journalist as there is a degree of authorship involved when crafting a visualization. There is a conscious decision of what to include, what to discard, and the ultimate decision as to whether or not a topic is worth addressing. (Stefaner, 2014)

The Data


Figure 5 – Umphrey's McGee, 8-17-13.


Figure 6 - Umphrey's McGee, 12-31-12.

I wanted to build a visualization that was personal to me, on a topic that I could explore on a deeper level. I have spent a substantial portion of my life as a student of the arts and music has always been my first love.

I am infatuated with music. I have been playing music for about twenty years. I attend somewhere between fifty and one hundred performances a year, and I myself have performed. I value that I am a part of one of the oldest crafts, a craft that has existed since someone figured out how to manipulate their voice well enough to produce a melody. With this in mind I began to consider how I could contribute to this field.

I began watching people in different environments: how they interacted with each other and how they interacted with their environment. More specifically, I started to monitor people in the concert environment.

For some time I have been fascinated by the concert environment and upon closer observation I developed some questions:

- What is it that makes this environment so powerful?
- What draws people in droves to these environments, willing to endure less than ideal conditions for hours on end?

- Why do people enter into this environment and suddenly seem to lose their inhibitions?
- Are there any positive benefits to attending a concert?

With this in mind I began to focus on how I could quantify the event. I knew I would need to be as connected to the environment as possible. This would exclude any sort of note taking. I also knew that I did not necessarily want to photograph or film the event unless it was a secondary element in my process. What could I do that would keep me connected to the experience but allow me to monitor the environment? It was then that I began to think of the body as the vehicle. What if the body could record the event? This brought me to the idea of biometric data collection and to the devices that could capture this experience.

Figure 7 - Basis Band (accessed May 2014).

The emerging products in wearable fitness trackers presented a wide variety of devices that have the ability to monitor bodily functions. One device in particular seemed to rise above the rest: the Basis Band. The data that the Basis Band is able to capture is not necessarily unique but the number of different metrics that it monitors is. Most devices of similar fashion focus on two or three metrics. The Basis Band on the other hand has the ability to monitor:

- Steps Taken
- Calories Burned
- Sleep Quality
- Ambient Air Temperature
- Galvanic Skin Response
- Heart Rate
- Skin Temperature
- If the user is walking
- If the user is running
- If the user is bicycling

There have been numerous studies that focus on music and its effect on the body. These studies typically focus on two categories: physiological and physical responses.

- Physiological responses include internal bodily processes, such as heart rate. Although these internal processes are reflected in observable changes, for the most part detection requires some type of monitoring device (Hodges, 2011).
- Physical responses are external, readily observable, reflexive motor movements such as foot tapping (Hodges, 2011).

The majority of studies within this arena focus primarily on a singular response. It is common to see an entire study that focuses solely on skin temperature or on facial expressions. My intention varied in that I wanted to focus on how these responses related to each other and how these responses might relate to the environment. Of the possible metrics that can be recorded by the Basis Band I decided to focus on galvanic skin response (GSR), heart rate, and skin temperature.

Galvanic skin response is the electrical conductance of the skin that change based on the moisture content present on the skin. These changes in conductance are a reflection of mental activity, usually of an affective nature (Venables, 1987). Multiple studies have linked the act of listening to music to fluctuations in in skin conductance (Hodges, 2010).

Extensive studies have been carried out relating music listening to changes in heart rate. In general, high arousal or stimulative music – characterized by fast, loud, staccato passages – tends to cause an increase in heart rate or pulse rate, while sedative music – characterized by slow, soft, legato passages - tends to cause a decrease (Hodges, 2009).

Skin temperature fluctuations in response to listening to music were reported in a number of studies. While changes have been noted in these studies, consistency has not. Most cases show when listening to music the skin's temperature rises (Hodges, 2010).

In addition to the biometric data that was being recorded another reference point would be needed that directly correlated to the environment. In an attempt to stay as focused as possible on the experience, I chose to record the audio of the event. This method allowed me to fully immerse myself in the event while another device documented the environment.

Process

The actual data recording process would involve me wearing the Basis Band and either simultaneously recording the audio myself or pulling the audio from the web at a later date. Since the audio and the biometric data are not linked by a common device, a method for aligning the data would be needed. A method was devised where at the onset of the first played note, of each set, the time displayed on the watch would be recorded. Additionally the final notes of each set would also be recorded to serve as an error-checking device.

Both the biometric data and the audio data would be pre-processed in an effort to maintain efficiency in the data visualization.

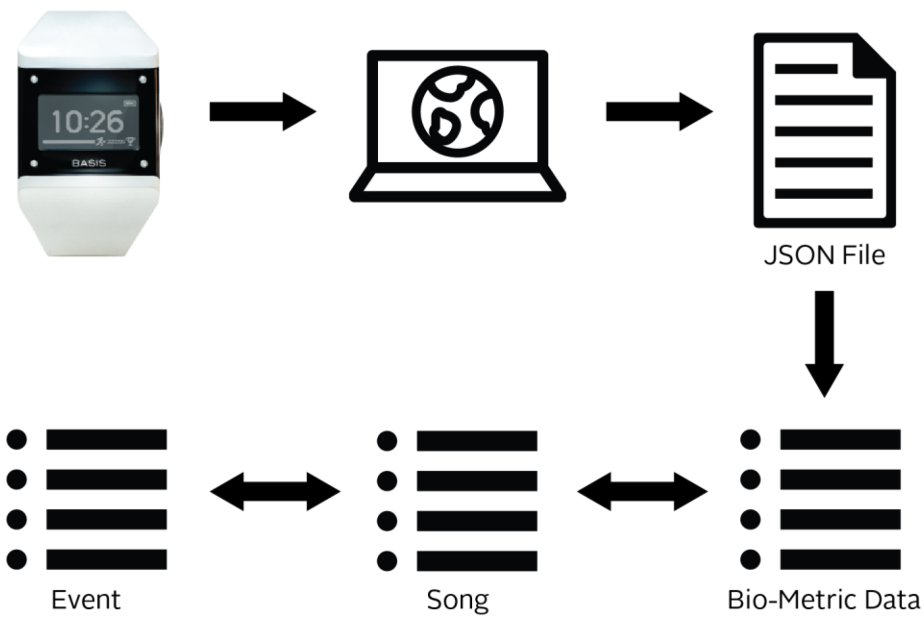

Figure 8 - Biometric data processing.

Recorded data from the Basis Band was uploaded to the web and retrieved via a web service that produced a JSON file. The data from the JSON file was then parsed, cleaned, and cropped to align with the data needed to build the visualization. The cleaned data was saved in a CSV database. Pointers in the database linked the individual elements in a structure that at the top most level referenced an event and at the bottom a specific biometric data point.

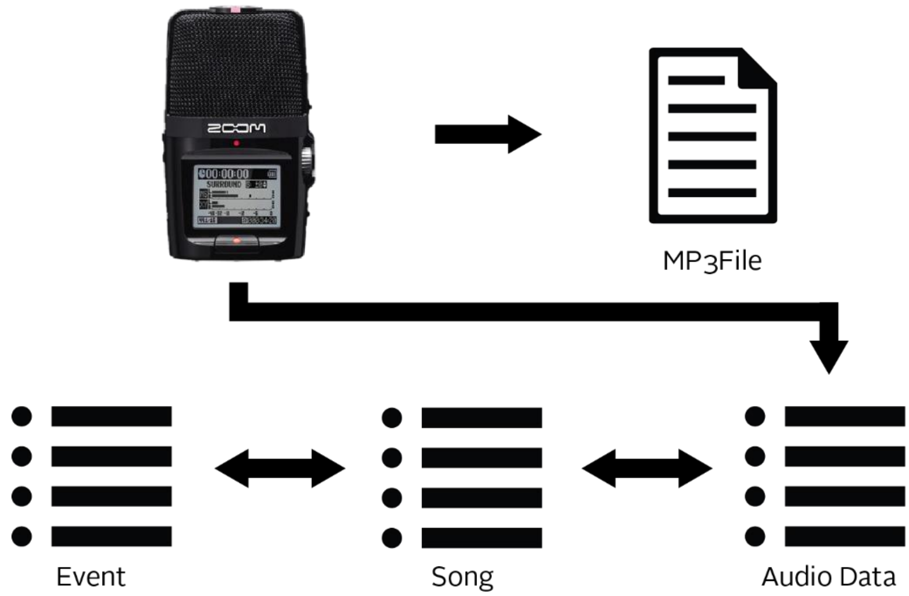

Figure 9 - Audio data processing.

A somewhat similar process was used with the audio. Audio from the concert was recorded, cleaned, and mastered. Each concert was divided into individual songs and saved as an MP3. The individual MP3's were then analyzed by a Fast Fournier Transform algorithm, examined for variances in volume and the data was saved to a separate CSV file alongside times that coincided with the data from the biometric data.

The Visualization

The final visualization resides in a dashboard layout that contains the various interactive elements. A large, centrally located radial graph houses the interactive data from each concert. This clock-like design reinforces the notion of time, placing individual data points around the perimeter of the circle. Each concert has varying levels of interaction based on selections made within the user interface.

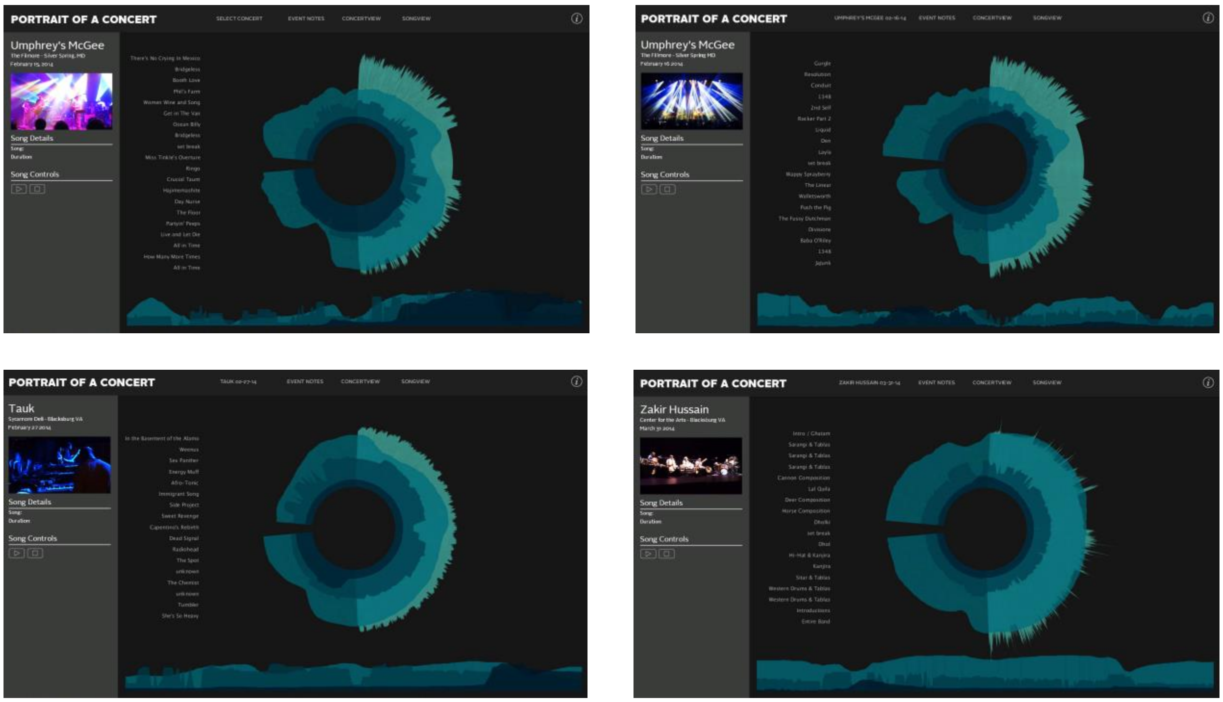

Figure 10 - Various Concert Views.

When the first concert is loaded on the screen the user is presented with the dashboard interface. Within the visualization there are four separate concerts that can be accessed via the interface's various menus (see Figure 10).

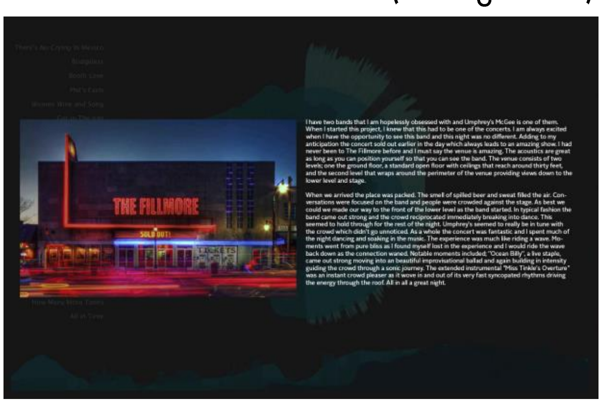

Figure 11 – Event Notes View

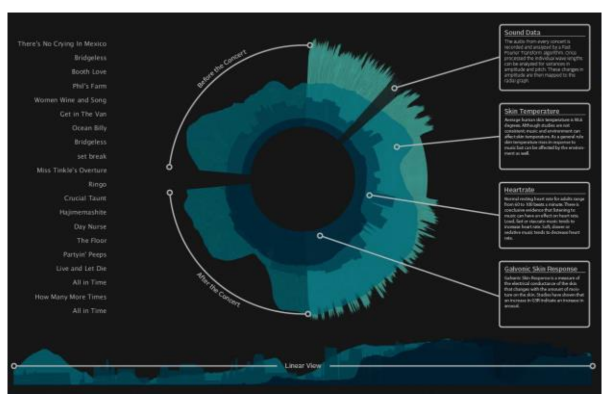

Figure 12 – Concert Informational View

Descriptive and informative screens are some of the various views available. The ***Event Notes*** button presents the viewer with an image of the concert venue along with a personal reflection of the event (see Figure 11). While in *Concert View* the information button may be selected. This presents the user with descriptive text that outlines the individual elements of the visualization in greater detail (see Figure 12).

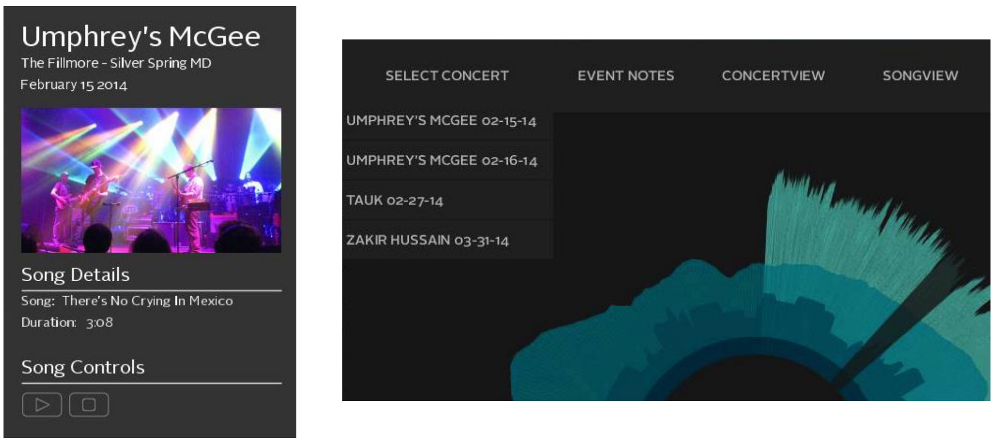

Figure 13 - User interface.

Based on element selections the interface changes to reflect the interactions of the user. Informational windows, drop down menus, and buttons control access to the various components (see Figure 13).

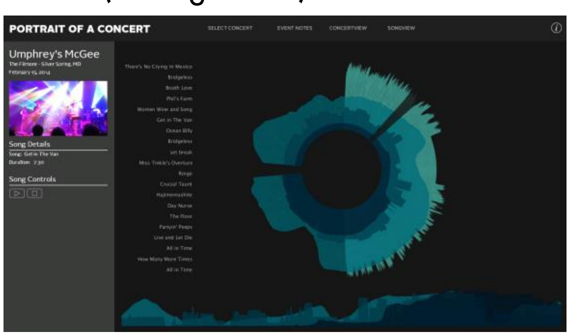

Figure 14 – Song Selection

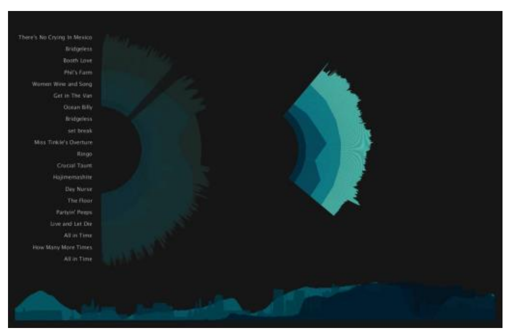

Figure 15 – Song View

After selecting a song a dark wedge appears (see Figure 14), highlighting the portion of the timeline that the song occupies. If desired, the option to view the data in greater detail is available when in *Song View (see Figure 15)*. This screen presents a detailed view of the current song choice.

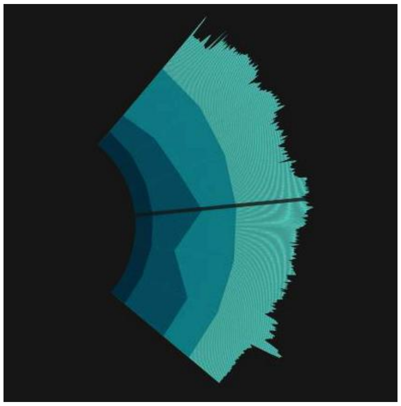

Figure 16 – Time Marker

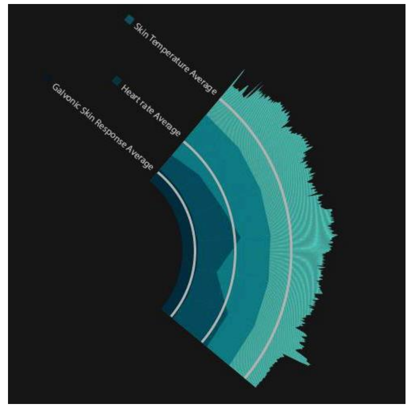

Figure 17 – Biometric Averages

Once in *Song View* the audio for the individual songs can be accessed. Upon playing a time marker appears that assists in the visual alignment of the various data points (see Figure 16). Additionally an informational overlay screen is available to display average human biometric data references (see Figure 17).

Conclusion

Data visualization presents itself as a particularly useful exploratory tool. These often complex worlds of data that we are constructing would otherwise lay dormant if new tools were not being assembled to comprehend them. These new tools are allowing us to view our world in a completely new way and with these tools we have the opportunity to turn the "lens" inward and explore. With each advancement we further our understanding of who we are as individuals.

The concert and physiological domains are incredibly curious and complex worlds, each with their own intricacies. *Portrait of a Concert* takes us one step closer to understanding the individual pieces of each environment and how they interact.

Further Direction / Research

There are several points in this study that could still be addressed:

- This research only explores the concert environment using a single participant. Further explorations could be made using multiple participants of varying demographics.

- Additionally this study did not explore other potential biometric recording devices. Benchmark testing and consistency checking of other devices could yield a stronger, more appropriate device.

- This study focused on audio as its environmental reference. Other reference material in the form of still images or live video could also be used to document the event.

- Another area to investigate further would be varying the analysis of the audio. Outside of the already used volume variances, methods for detecting specific beat or tempo could be employed.

References

Ahlqvist, Toni; Bäck, A., Halonen, M., Heinonen, S. "Social Media Roadmaps: Exploring the Futures Triggered by Social Media". VTT Tiedotteita – Valtion Teknillinen Tutkimuskeskus (2454), 2008. Print.

Boucsein, Wolfram. *Electrodermal Activity.* New York, NY: Plenum Press, 1992. Print.

Glazer, Jessica. "Psst! Wearable Devices Could Make Big Tech Leaps, Into Your Ear." NPR. Web. 23 May 2014.

Hodges, Donald and Sebald, David. *Music and the Human Experience*. New York, NY: Routledge, 2011. Print.

Hodges, Donald A. "Psychophysiological Processes." *The Handbook of Music and Emotion* (2010): 279-311. Print.

---. "Bodily Responses to Music." *The Oxford Handbook of Music Psychology* (2009): 121-30. Print.

"Introduction to Wearable Technology: What is Wearable Technology? What are Wearable Devices?" Wearable Devices. Web. 23 May 2014.

Jain, Anil K. and Ross, Arun. "Introduction to Biometrics." *Handbook of Biometrics* (2008): 1-22. Print.

Kirk, Andy. *Data Visualization: a successful design process.* Birmingham, UK: Packt Publishing, 2012. Print.

Stefaner, Moritz. "Selfiecity: Investigating Selfies Using a Mix of Theoretic, Artistic, and Quantitative Methods." Times Center Manhattan, New York, NY. 7 February 2014. Lecture.

Venables, Peter H. "Electrodermal activity." *The Oxford Companion to the Mind* (1987); 213-214. Print.