



VISUAL IMPRINTS

UNDERSTANDING LOCATION DATA THROUGH
INFORMATION ARCHITECTURE



CHRISTINA LIDWIN

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ABSTRACT

Wearable technologies are creating new ways for people to discover and record personal data. While these devices are raising awareness about biometric information, there is a larger **quantified self** movement encompassing any type of personal data collected by any means and recorded and shared in a variety of ways. Participants in this movement are experimenting with new ways to view and interact with their generated digital information. On a societal level, as we collect more **data** (personal or otherwise) we are questioning who should have access to different types of data and how collected data should be used.

Visual Imprints documents an exploration into how location data is collected, visualized, and understood by people with varying degrees of data literacy. Through the design and development of the Android application **Data Atlas**, this exploration utilizes aspects of **information architecture** to illustrate how we as a society might come to better understand what technologies and applications record personal data and how collected information can be seen and used. The exploration also illustrates how creative technologists can contribute to societal questions on **data literacy** and user privacy as well as create work as a part of the quantified self movement.

KEY TERMINOLOGY

data: a set of observations without context or assigned meaning

Data Atlas: an Android application created to allow people to explore and understand personal location information

data literacy: the skill of being able to understand and communicate information

information architecture: transforming observations into meaningful content

quantified self: a movement where people record and analyze their own information to learn more about their lifestyles and habits

Visual Imprints: the title for the process of creating the master's thesis application Data Atlas

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Institute of Creativity, Arts, and Technology (ICAT), School of Visual Arts (SOVA), and **Graduate Research Development Program (GDRP)**, thank you for your generous support.

“To visualize is to make certain phenomena and portions of reality visible and understandable; many of these phenomena are not naturally accessible to the bare eye, and many of them are not even of visual nature.”¹

– **JOAN COSTA**

¹ Joan Costa, *La esquemática: visualizar la información*, Barcelona: Paidós, 1998. (quoted in A. Cairo 18)

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PREFACE

In Fall 2013, I was not quite a grad student, but I had started unofficially taking graduate classes while I finished my undergraduate work in computer science. During this transition semester, I remember meeting a professor who mentioned he was “familiar with [my] work.” He was referencing my application to the graduate program, but I was confused by his comment since I didn’t consider a Wordpress website with writing samples and a sample Android app “work” in the same way it is used to refer to sculpture, paintings, etc. I also had not taken a designated art class since sixth grade, so this comment from Sam was something I was not sure how to respond to at the time and has stuck with me throughout my experience. I attribute this interaction to when I first started asking myself “what is my work?” and perhaps more importantly, “what do I want my work to be?”

These questions about what we are working on and why are we working on it are ones I think we should continually ask ourselves no matter our discipline or level of experience, and I found my personal answer changing quite a few times throughout my studies in the Creative Technologies program. From applying with the proposal of exploring augmented reality, I took coursework that would help me develop a skill set to create motion-enhanced interfaces before developing a large project based on what it means to create and interact with data.

My experience is as much a reflection of the work I have created as much as it is a reflection of many meaningful interactions with my thesis mentors, professors, classmates, coworkers, friends, and family. Throughout this journey, they have all helped shape my thesis project and views in technology, art, design, and life. Their thoughts and feedback improved every iteration of my work and supported every step of this creative process.

Because I consider my thesis project to be a reflection of my entire master's experience, this document, *Visual Imprints*, highlights some of what I consider to be the core experiences of my master's education and (though I didn't know it at the time) how these lessons contributed to my thesis project. I also describe the design and development of *Data Atlas*, an Android application I created to understand how location-based information can be better displayed to users who have varying degrees of experience with this type of information. To get a sense of how people might use and interact with this application, I supplemented my work with two user studies where participants used Android cell phones to access *Data Atlas* and interact with location data.

While I consider *Data Atlas* to be the culmination of my master's experience and discuss future developments in my concluding section, I mainly reflect on how data visualizations impacts technology, what happens if I work on all aspects of a project instead of just focusing on software engineering or design, and why I look to position myself as a prototyper or front-end developer in my future career. The Creative Technologies program has had a tremendous impact on the ways I view my own career and challenged my preconceived notions of technology, and I am excited to share this journey with you through *Visual Imprints*.



Christina Lidwin
August 10, 2015

“A beautiful question is an ambitious yet actionable question that can begin to shift the way we perceive or think about something—and that might serve as a catalyst to bring about change.”²

– **WARREN BERGER**

² Berger, Warren. *A More Beautiful Question: The Power of Inquiry to Spark Breakthrough Ideas*. 18. New York: Bloomsbury, 2014.

1 INTRODUCTION

Studying Creative Technologies at Virginia Tech creates opportunities to learn how to use art and design as a way to communicate information. I began by developing skills in animation, modeling, and web development, and through these studies I discovered my interest in how these creativity-based skills blended with software development to create unique interactions and experiences.

In Summer 2014, Google unveiled a visual language called Material Design, which combined interface design and motion into a flexible

framework focused on creating “delight” for users. The motion elements in particular were something I saw as a potential for a thesis based on the artistic skills I had been learning this master’s program and supplemented by the background I had in computer science. I then read *Enchanted Objects*, a book about the future of technology, and began thinking about how motion could be used to enhance data-driven ambient displays.

Ultimately I found motion elements and ambient technologies did not focus on interaction, the element I found most exciting about the intersection of art and technology. This realization helped me begin conceptualizing an interactive Android application incorporating the principles of motion and ambiance.

QUESTIONS

³ Berger, Warren.
"Forget Resolutions,
What's Your
'Beautiful Question'
For 2015." Co.Design.
FastCompany,
13 Jan. 2015. Web.
14 Jan. 2015.

"Forget Resolutions, What's Your 'Beautiful Question' For 2015?"³ As I began forming my thesis project, this headline captured my attention and inspired an integral part of the thesis process along with the accompanying book *A More Beautiful Question: The Power of Inquiry to Spark Breakthrough Ideas*.⁴ Author of both the article and book Warren Berger suggests by being deliberate about the questions we are asking, we can solve more interesting problems and better understand the projects we work on.

⁴ Berger, Warren.
*A More Beautiful
Question: The Power
of Inquiry to Spark
Breakthrough Ideas*.
New York:
Bloomsbury, 2014.

From the perspective of analyzing creative technologies, I found one of Berger's comments especially thought provoking on how a machine "is better suited for responding to questions — not so good at asking them."⁵ We choose to incorporate technology in our lives because it can be a solution to an issue or offset an inconvenience, but it does not create anything for us without our input (or at least will not until we have substantial artificial intelligence). As users of technology, we are the source of intellect because we provide technology with the resources to solve problems.

⁵ Ibid., p. 35. |

Berger's insights inspired a restructuring of the way I went about my thesis project. Instead of a solution-centered approach and saying "I want to create a piece of technology that allows people to interact with it and view it at a glance" without first having a set of questions, I focused on asking better questions and strengthened the core aspects of my thesis process.

WHY ARE PEOPLE AFRAID OF DATA?

The first step in Berger's suggestions for a more beautiful question is to "take a step back" and "[g]ain a deeper understanding of the situation or problem at hand,"⁶ which is done by asking why. In the context of technology, I thought about how my confusions and frustrations could be phrased in question format. Why does the battery life of a tablet never seem long enough to last through the day? Why doesn't a news feed help me understand current events? Why do some people not trust large companies with their personal information?

⁶ Ibid., p. 85.

Brainstorming why questions helped me articulate my interest in how data is perceived and used, summarized by the question "why are people afraid of data?" This simple yet concise question captured the content I wanted to spend more time with and could be meaningfully answered in a variety of ways complimenting my creative and technical skill sets.

WHAT IF PEOPLE COULD INTERACT WITH THEIR RAW DATA?

After finding the core idea in a why question, the next step to inquiry is to "think without limits"⁷ by asking what-if questions. The concept of impossible is not allowed in this stage, but instead, the goal is to "combine ideas or influences that, on the surface, have no logical or natural connection—yet, once combined, form something powerful."⁸

⁷ Ibid., p. 112.

⁸ Ibid., p. 115.

To progress from a why to what-if stage, I generated possible answers for why people might fear data and from this list was interested two situations: when people do not know what data means and when people have trouble reading their own raw data. I then imagined how people's reaction to how data is used might change if there were a way to improve data accessibility and literacy. This what-if scenario also piqued my interest because I could combine the capabilities of technology and the impact of visual communication in a solution.

HOW MIGHT WE ACCESS AND UTILIZE LOCATION DATA?

The last stage of inquiry is to make the impossible possible, situated in the context of a how or how-might-we question. Berger suggests asking how is "the point at which things come together."⁹ To get from "what if people could interact with their raw data" to a solution-based question, I first needed to bring together ideas and define a data set.

⁹ Ibid., p. 127.

There is a wealth of information being digitally accessed and collected, but only a few data sets (such as health information) being shared with the people producing the data. Location information, for example, is a native feature on many smartphones, but users cannot easily see what their phones are recording about where and when they are somewhere. Since I frequently carry around a mobile device and knew traveling would be a part of my coursework, I saw this issue of accessing location information as one I could meaningfully contribute to and help make users more aware of what this data looks like.

PROCESS

¹⁰ Cairo, Alberto. *The Functional Art: An Introduction to Information Graphics and Visualization*. Berkeley: New Riders, 2013.

Among the books and articles read in preparation for the later half of coursework and this thesis project was *the functional art* by Alberto Cairo.¹⁰ Cairo is a professor and journalist who creates infographics or information-driven graphics, and his book both documents his thoughts on creating infographics and the thoughts of some of his peers.

While the book is mainly focused on graphics for journalism, *the functional art* is applicable to any discipline focused on turning information into something visual. Cairo focuses on how infographics are about telling a story, helping people understand a set of data, and letting people “dig into the information, explore, and come up with their own stories.”¹¹

¹¹ Ibid., p. 195. |

One of the most valuable aspects about *the functional art*, though, was the explanations of how to create a graphic. This thesis project was structured based on a process from an interview Cairo had with data visualizer Moritz Stefaner.¹² His workflow is described below.

¹² Ibid., p. 318. |

CLARIFY WHAT & WHY

DECEMBER TO FEBRUARY

The first stage of Stefaner’s project workflow focuses on setting up a context and high level goals. His title for the stage “Clarify What & Why” echoes the why and what-if questions from *A More Beautiful Question* and so much of the work described in this section fell under this stage of development. Much of the content from the Influences section of this document was also completed as a part of this stage.

EXPLORE & SKETCH

FEBRUARY TO APRIL

“Explore & Sketch” is about getting data and brainstorming ways to go from what-if to how-might-we thinking. This stage in terms of the thesis project involved creating a proof-of-concept Android app to begin collecting location data. This stage also involved attending an Edward Tufte workshop, beginning an online course in data visualization co-taught by Alberto Cairo, and seeking other forms of inspiration for visualizations.

DEFINE & PRODUCE

APRIL TO JULY

Deciding and acting on a how-might-we question is what the “Define & Produce” stage is all about. The visual and interaction design elevated the prototype to a more production-ready state, and inspiration for these components was found through international travel. While traveling, additional personal data was collected and a user study was conducted to assess the overall concept.

MAINTAIN & ANALYZE

JULY TO AUGUST

“Maintain & Analyze” unifies the previous stages and acts as a check by verifying the product is a solution to the how-might-we, what-if, and why questions. As a part of this stage in the process, a task-based user study helped identify strengths and future features for the app. The reflections in this document’s “What’s Next?” are also contributing components.

PERSONAS

Questions and processes provide a strong foundation for a project but what makes a product successful is satisfying its users. To help identify who these users are and understand their motivations behind using the product, designers and product managers develop **personas** or characters to help identify different use cases for a product and specify users' needs.¹³

In terms of thinking about people's relationships with location data, five groups of users were considered, with each group represented by a persona based on how familiar/comfortable this fictitious user is with data (full descriptions of each persona available on pages 7-8). Richard represents the group least familiar with their location data; he is unaware that his device is recording this information and is considered data blind. The next group is represented by Aahna, who is data disconnected; she is aware that location data exists but does not know when and where it is used or accessed. June represents the data literate group, able to identify which of their apps use location information but unsure of what this information looks like. The group who is data savvy, knows what location data is, and wants to know how to use and manipulate it is represented by Jason. Finally, Maria represents the group of people most knowledgeable about location data, the people comfortable with manipulating location data and using it for their own purposes; they are data hackers looking for product tools and inspiration.

These five personas can be categorized in terms of data familiarity as shown below, ordered from the left being least familiar with data to the right being most familiar with data.

BLIND → DISCONNECTED → LITERATE → SAVVY → HACKER

¹³ For more on what personas are and how to write effective ones, read medium.com/down-the-rabbit-hole/replacing-personas-with-characters-aa72d3cf6c69

TARGET USERS

While these five personas help identify many of the possible users who might want to access and utilize their location information, only a subset of people are referred to as primary users (and marketing calls them the target audience), user experience's term for main users of the product.

This application is based on accessing and utilizing location data. Its primary users are the data literate (June's) group who have a sense of how location data is used and want to see learn more about it.

The data disconnected and data savvy groups (Aahna and Jason) are referred to as secondary users because they have a strong influence in creating and refining an application but are less emphasized than the primary users.

The data blind and data hacking groups (Richard and Maria) are tertiary users, the third sphere of influence. Their feedback has the least impact on the application.

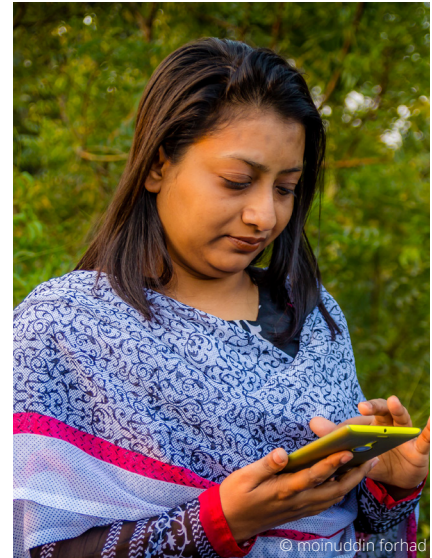
RICHARD // DATA BLIND



Richard, age 70, just celebrated his retirement and moved to Florida to be in a warmer climate, but he misses his family in Connecticut. As a birthday and housewarming present, his children bought him a tablet for him to use for video calls and photo sharing. Richard has never owned a tablet or smartphone before now, but he is interested in his new device and will occasionally open installed apps to see what they can do.

When a pin icon appears in Richard's notification bar, he tries to press it to get more information. He has not yet used his device settings to see his location preferences.

AAHNA // DATA DISCONNECTED



Aahna, age 37, uses her smartphone to get directions for her three kids' activities. Her children are all under the age of eight, so they do not yet have smartphones. As a single parent, Aahna spends her free time with her kids and does not go looking to explore other apps on her device, but she will look at links and recommendations within the apps she uses for directions, email, and texting.

Sometimes Aahna cannot access her map app outside of public Wifi zone and does not know why. She also wishes she could access her previous locations by date to help her get directions to places she's been before.

JUNE //DATA LITERATE



June, age 16, is a junior in high school who uses her smartphone for most things digital. She considers it an extension of herself and will change settings of her phone to match the demands of the newest apps. In college, she hopes to pursue a career in physical therapy, so she is especially drawn to fitness and goal-tracking apps.

Although June is aware many of her applications use location data, she is not sure what that data looks like. She is also always interested in new ways to catalog life events and share them with friends.

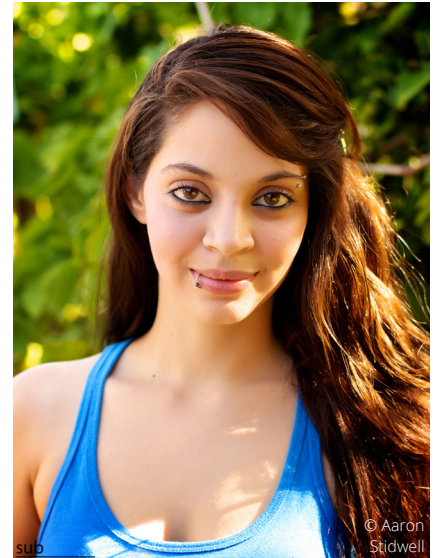
JASON //DATA SAVVY



Jason, age 28, is a financial analyst and entrepreneur. When he is not working on Wall Street, he enjoys brainstorming new app ideas. Recently, Jason has discovered the quantified self movement and has a fitness wristband he uses to track his physical activity.

Excited about the possibilities with wearable technology, Jason wants to learn more about the data he generates and how he might use it for both personal and professional use. He knows a little bit of programming and would also be interested in learning how to mine and utilize data sets for his own apps.

MARIA //DATA HACKER



Maria, age 20, is a sophomore studying computer science at Virginia Tech. She attends university and corporate hackathons across the country and Maria is especially passionate about developing new schemas for collecting and storing data. When she's not studying or hacking, Maria can often be found playing video games.

When Maria starts developing a new application, she often starts by searching app stores to look at what others have done to collect and store information. She is especially enthusiastic about apps with interfaces she can either add to or use to compliment her work.

“Through visits to museums/sites/institutions, reading, research, sketching, note taking, photo taking, and a general... immersion, I find my way to a story.”¹⁴

– **MARIA KALMAN**

¹⁴Bader, Sara. *The Designer Says: Quotes, Quips, and Words of Wisdom*. New York: Princeton Architectural, 2013. 137. Print.

2 INFLUENCES

I used to consider “research” the intentional process of using books and journal articles to produce something (usually a paper or lab experiment). There was not any reason for this belief, but I thought any “research” I conducted had to follow this sort of definition in order for it to be legitimate or justifiable.

During this master’s education I realized a formulaic approach to obtaining knowledge is not the only

document-able way to discover new things. While some the wisdom has come from traditional texts, many of the foundational pieces of my experience came from less-usual sources such as attending visiting artist talks and conferences, traveling abroad, working as an intern and graduate assistant, and reading online content.

Now I redefine “research” as a process of accumulating influential experiences and knowledge. In regards to this thesis project, the meaningful of these influences are described in this section, including what they are and how they became part of my Visual Imprints.

ICAT

In Fall 2012, I enrolled in an interdisciplinary course called Create! and started what turned into a two-and-a-half year affiliation with the Institute for Creativity, Arts, and Technology (ICAT). Create! not only introduced me to interdisciplinary design processes but also invited me to explore new opportunities. I met Dane Webster through ICAT as a result of the Create! course, and it was based on our conversations I applied and joined the Creative Technologies master's program.

My positive experience with the Create! class motivated my continued involvement with ICAT, and I began volunteering at ICAT by creating prototype to track people's movements using a camera and computer. The project morphed into National Science Foundation-funded research centered around "develop[ing] a computing research infrastructure... [to support] research and exploration at the boundaries of science, engineering, art, and design." The project was titled "Living Lab for Asynchronous and Synchronous Investigation of Virtual and Real Environments,"¹⁵ or Mirror Worlds for short.

¹⁵ For details on the computing research infrastructure grant, visit grant award number 305231 the grant award page on the National Science Foundation's website www.nsf.org.

When I became a graduate student in Creative Technologies, I also transitioned from an undergraduate researcher to graduate assistant on this project and I adopted a variety of roles including software engineer, project manager, and lead on visual identity. In each position, I gained a different perspective on the core goal of the project — to create a computing system capable of connecting the physical/real world with digital/virtual sites. I used my different roles to better understand how technology might be perceived and used by different types of users and their environments.

Many of the challenges I tackled on Mirror Worlds revolved around the questions "how might we use technology to enhance a physical space?" and "how do people interact with space in digital and physical environments?" From spending an average of 15 hours per week throughout my graduate (and a year of my undergraduate) education on these Mirror Worlds questions, it reflectively has been no surprise that my thesis project emerged from a related question "why is technology usually not recognized as an active participant in an environment?" In developing the Android application Data Atlas, I addressed an aspect of this why question by implementing a solution that showcases how a single piece of mobile technology regularly engages with an environment (retrieving location-based information), while on Mirror Worlds this why question was addressed through showcasing how people in an environment can be affected by the environment's technologies.

My two year involvement in Mirror Worlds gave me a multitude of ways to explore the intersection of technology with its emerging environments and helped shape the motivation behind Data Atlas. Since Mirror Worlds was housed in and based on ICAT principles, I also benefited from this experience by being immersed in a like-minded culture that valued intersections of creativity, arts, and technology.

VCD

During my first semester of graduate school I served as the Graduate Teaching Assistant (GTA) for FourDesign, a faculty-led, student run digital and print design agency. The students working for FourDesign were juniors and seniors in the Visual Communication Design program (VCD), an area of study within the School of Visual Arts, and as the GTA I received first-hand experience in and contributed to turning a concept into a client-ready product. This assistantship gave me a stronger understanding of real-world client relationships as I began studying user experience.

My work with FourDesign inspired me to spend over 15% of my coursework in VCD-related classes. Through Meaghan Dee (who was FourDesign's director the semester I was a GTA), I had the opportunity to explore the question "how might we create a resource to teach others about web development?" in an independent study and learn the foundations of typography in her introductory course on the subject. Dr. Troy Abel's Human-Centered Design (HCD) graduate certificate curriculum and coursework taught me to think more about the interdisciplinary conversation surrounding the word design and provided me with frameworks to conduct user studies such as the ones described in the Feedback section.

Within the Visual Communication Design area of study, I also participated in a month-long study abroad program, traveling Italy and Switzerland to learn about different aspects of art and design. I conducted a user study during this experience, but equally valuable to this thesis project were the museums I visited and related experiences gained during this time in Europe. Two of the visualization formats in Data Atlas were inspired by the work seen in Italy: the Tile visualization was based on the *Composition in Gray (Rag-time)* (found on page 34) on display in the Guggenheim Museum in Venice and the duomos (churches) in each Italian city had stained glass used as inspiration for the Mosaic visualization.

While the works in Europe were inspiring, I was most impacted on this study abroad by the presentation of work at the Zürich University of Design. The Master of Art in Design students¹⁶, like Virginia Tech's Creative Technologies program, had different "Fields of Excellence" students focused on, and I was most impressed by how all of these students came together for a final exhibition showcasing their thesis projects. I found inspiration in what information these students chose to highlight in their final showcases and incorporated aspects of those exhibitions into my oral defense. Their process books also served as a strong foundation for Visual Insights and impacted what information was included in this document, and photos taken from the design exhibition can be found in the Appendices section.

Creative Technologies is ultimately what my master's education has been focused on, but Visual Communication Design has been a strong influence in my education as well. Through gaining experience in interacting with clients, studying user experience, developing an understanding of typography, and traveling in a design-focused study abroad program, my knowledge gained in VCD gave inspiration, frameworks, and structure to Data Atlas.

¹⁶ More about the Master of Art in Design program can be found at master.design.zhdk.ch/en/

GOOGLE, INC.

ICAT was not the only relationship inherited from my undergraduate work and strengthened by my master's experiences in Creative Technologies. In summer 2012, I began interning for a modestly-sized technology company with a reputation for innovation and discovered a company culture that has impacted my mindset toward technology and excitement for interfaces. Of all the characteristics this company possesses, perhaps the most inspiring is its strong mission statement, one every employee can recite and every product can be considered an affirmative response to:

“ORGANIZE THE WORLD’S INFORMATION AND MAKE IT UNIVERSALLY ACCESSIBLE AND USEFUL”

¹⁷ More about Google's culture and core principles can be found at www.google.com/about/

Google's mission statement¹⁷ is one I have adopted personally and reframed as a “how might we” question for many of my Creative Technologies pieces, which is a direct reflection of the nine months I spent at the company as an intern (spread over the course of three summers) and two years as an ambassador from Google to Virginia Tech. Most notably, the Android application Data Atlas can be seen as an attempt to organize the personal world's location information and make it accessible and useful to users with varying degrees of data literacy.

The decision to choose the Android platform for Data Atlas also directly relates to experiences I have had at Google. During my first internship, I learned about how Android user interfaces (UIs) operate from a technical perspective and used a UI testing framework to understand how machines might go about verifying features work the way they are intended to. Since then, the Android platform has been an integral part to my life as I use a Nexus 7 daily for doing everything from checking email to reading books and articles.

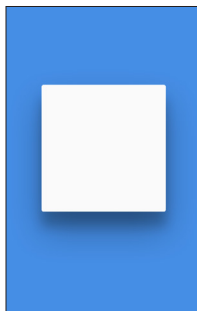
Studying Creative Technologies impacted my third internship and conversely the experience during the internship impacted the remainder of my master's education. In Summer 2014, I worked on a new interface feature based on designs given to me by a user experience designer. While each summer I had worked on an interface in some capacity, learning about visual communication gave me the vocabulary and awareness to ask specific questions about interface components such as typeface selections and icon usage. Conversely, this internship impacted my coursework by teaching me how the visual components of software connect to the unseen portions of the code within an application.

Google transforms the lives of millions of people around the world with its products, but my direct interaction with the company culture has especially impacted my work. Google's ideologies and mobile platform are incorporated in Data Atlas based on my experiences, and likewise the wisdom I have gained from Creative Technologies has impacted my experiences in the industry.

MATERIAL DESIGN

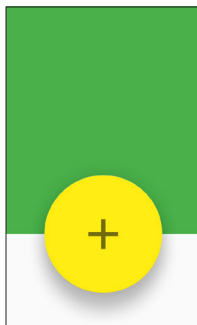
Data Atlas's visual design, including typography, color, animation, and element choices, descend from Material Design, a visual language released by Google in 2014.¹⁸ This comprehensive framework gives suggestions on how to create a cohesive visual design that connects with and stretches trends in the modern user interface while also connecting to similar fields such as print design and cinematography. I chose to use Material Design as my visual design framework based on how its core three principles reflect Creative Technologies, Human-Centered Design, and my experiences in this master's education.

¹⁸The Material Design guidelines are found at www.google.com/design/spec/material-design/



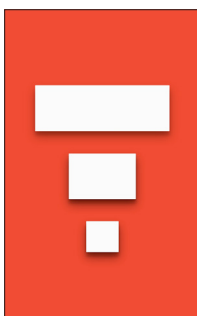
“MATERIAL IS A METAPHOR”

In prototyping Material Design, the designers used paper as a way to understand how light and material interact in the physical world. In digital spaces, Material Design translates the concept of paper to digital elements by incorporating similar shadows, elevation, and thickness properties. This use of physical principles as the inspiration for digital components is not new to digital technologies (often called **skeuomorphism**), but Material Design enhances the pre-existing notion and standardizes it with the paper-like material for all digital elements.



“BOLD, GRAPHIC, INTENTIONAL”

The typography and color palette provided by Material Design echo concepts in print design by emphasizing hierarchy and focus. The visual language emphasizes the use of color to highlight actions, providing a visual and attention-grabbing cue for users. Most notable is the Floating Action Button, which is used to showcase the primary actions within a single window of an application or webpage; it not only attracts users' attention with its bold action color but also is established as the top of the hierarchy for interactivity.



“MOTION PROVIDES MEANING”

With Material Design, the user interface is treated like a scene with the device serving as a camera or window into it. Elements are encouraged to interact with one another in the scene and the principles of animation help define how those interactions might occur. Echoing back to Material Design as a metaphor, the paper-like properties of this visual language's elements behave similarly to how users would expect paper to behave in the real world; animations show actions such as (de)levating, folding, and sliding paper as though it were resting on a smooth, flat surface.

ENCHANTED OBJECTS

¹⁹ Rose, David. *Enchanted Objects: Design, Human Desire, and the Internet of Things*. New York: Scribner, 2014.

I credit *Enchanted Objects: Design, Human Desire, and the Internet of Things*¹⁹ for being a catalyst for my thesis project; reading this text helped me begin thinking about the possibilities of future technology and the limitations of our present devices. To set the tone for this line of thinking, author David Rose presents four possible futures for how technology might look and feel to users, using both present day technologies and descriptions in fantasy works to showcase the wide range of ideas contributing to technological innovations. In greater detail, Rose focuses on a class of technologies known as **enchanted objects**, which

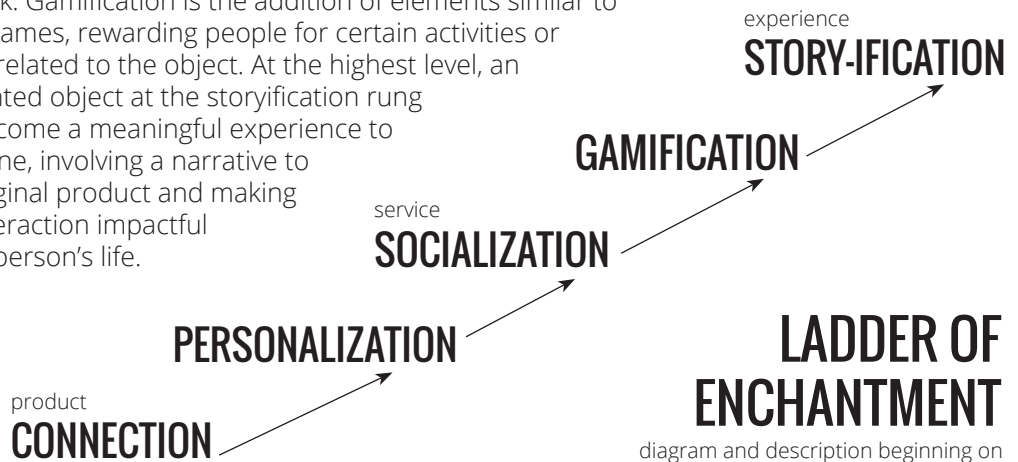
²⁰ Ibid., p. 47

“start as ordinary things — a pen, a wallet, a shoe, a lightbulb, a table... [and are] then augmented and enhanced through the use of emerging technologies — sensors, actuators, wireless connection, and embedded processing — so that [they] becomes... more useful, more delightful, more informative, more sensate, more connected, more engaging than [their] ordinary sel[ves]”²⁰

²¹ Ibid., p. 194

What most interested me about *Enchanted Objects* are the properties of and processes for making an enchanted object, and what became most applicable to my thesis was the Ladder of Enchantment²¹ (shown below) David Rose used as a way to explain the levels at which something could be considered enchanted. While Rose used this system to describe objects, I see this structure to be a good system for describing the characteristics of any technology, including mobile applications such as Data Atlas (the ladder’s application to my thesis project is described on page 51).

Each rung of the Ladder of Enchantment implies a different level of sophistication and personality for the item in question. The most basic of these levels, connection, Rose defines as the addition of a sensor or other “smart” technology to an otherwise ordinary object. Once connectivity is a status, a device goes through “personalization” for it to become meaningful to a particular user. When a personalized device is capable of sharing this personalized view with others, it has reached the socialization rung on the ladder and is no longer considered to be a product, but more of a service to someone and his/her network. Gamification is the addition of elements similar to video games, rewarding people for certain activities or habits related to the object. At the highest level, an enchanted object at the storyification rung has become a meaningful experience to someone, involving a narrative to the original product and making the interaction impactful to the person’s life.



THE FUNCTIONAL ART

Based on its title, I had expected *the functional art*²² to be about how different components are used in visualizations, but author Alberto Cairo's commentary on how to conceptualize information-based stories turned out to be a more valuable introduction for me to the subject of data visualization. As described on page 5, Cairo's interviews influenced and outlined the process I followed for developing Data Atlas, but his text also contained ways of thinking I adopted and used in structuring my thesis project.

²² Cairo, Alberto. Ibid.

One anecdote I found particularly meaningful was a process Cairo described as taking a concept "from reality to people's brains."²³ The process transforms details in the world (called unstructured information) into known insights affecting our behavior about related fields (referred to as wisdom) through levels of encoding (listed in the diagram below) and presentation. People who "anticipate this process and generate order before people's brains try to do it on their own" are called **information architects**.

²³ A full explanation of the process can be found on pages 15-17 of *the functional art*. The quote can be found in bold at the end of the section.

Data Atlas embodies this process and is an instance of information architecture through its purpose as a tool to provide access and structure to location data. Through multiple visual formats, Data Atlas creates stories about the data for the user to explore. The different types of users (exemplified by five personas described on pages 7-8) were also conceptualized based on how far along in Cairo's process they are in translating reality into wisdom.

This content comes directly from a real-world source and is viewed as a singular piece of information rather than a part of a group. Each data point generated by a mobile phone is a piece of unstructured information in Data Atlas.

Each piece of unstructured information can be understood by its context and relationship to other information pieces within a group. This encoding or grouping of information is known as **data** and is shown to Data Atlas users through dates on the "Raw Data" screen.

Representing data with a system of text or visuals provides structure for information, making it communicable to a variety of audiences. Each visualization in Data Atlas is a solution for structuring information and helps to provide meaning to location information.

When someone is able to understand the structured information being portrayed and derive meaning from it, they are considered to have gained knowledge about the data. The user studies for Data Atlas were conducted to show this part of the process.

As we acquire enough knowledge in a particular area, we develop the wisdom to anticipate and understand new forms of information. The goal of Data Atlas is to provide the means for people to obtain wisdom, but testing surpassed the obtainable scope for this project.

**UNSTRUCTURED
INFORMATION**



DATA



**STRUCTURED
INFORMATION**



KNOWLEDGE



WISDOM



“Information design is defined as the art and science of preparing information so that it can be used by human beings with efficiency and effectiveness.”²⁴

– **ROBERT E. HORN**

²⁴Jacobson, Robert E. *Information Design*. Cambridge, MA: MIT, 2000. Google Books. Google, Inc. Web. 12 July 2015.

3 DATA ATLAS

In industry, my experiences as a front-end engineer got me into the habit of seeing the processes of designing and developing as integrated parts of creating a unified experience. Data Atlas reflects this combined mindset as well, with the features and forms being created in conjunction with one other.

This Android application was made to give people an opportunity to

experience the location information they collect on their phones. Each half of the process, the design and development of Data Atlas, incorporates aspects of a creative mindset and technical perspective, showcasing how engineering and the arts affected all facets of the final application.

In addition to describing the components of Data Atlas, this section gives insight to the development and evolution of the project as a whole. It builds upon the influences described in the previous section and includes progress work that contributed to the August 10th, 2015 version of the app.

DEFINING CONTEXT

²⁵ For more on the idea of what it means to be "full stack", read medium.com/@chrismessina/the-full-stack-employee-ed0db089f0a1.

Creating a mobile app in its entirety from ideation to publishing involves applying a variety of different fields to the same goal. Depending on the scale of the application being made, this creation process can include anywhere from one person creating the application to hundreds of people working on different components. The term **full stack developer** refers to someone who is able to navigate between different fields in this process,²⁵ and in Data Atlas, I worked as a full-stack developer, mainly using the fields of engineering and art to create a solution for viewing and analyzing location data.

While full stack development describes the process for Data Atlas, I would categorize the deliverable as an instance of information architecture; the app was created using a variety of fields to supplement the process of translating information into content (as described on page 16). The location data in Data Atlas became meaningful content through combining principles of research, creative coding, interaction design, and user experience into the overall process and execution.

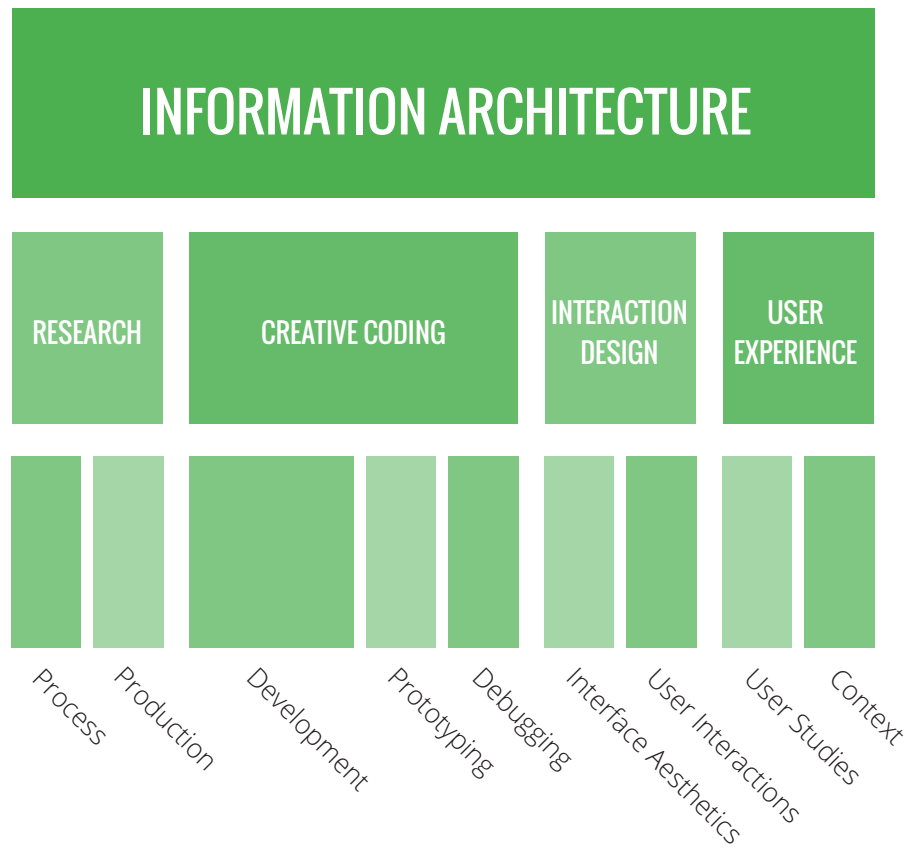
The research portion of Data Atlas includes the influences mainly described in the previous section and can be further broken down into two components: research about process and research about production. The process portion of the research included discovering ways in which people create data visualizations and applications such as the ones used by Moritz Stefaner and Alberto Cairo; these processes were then applied to Data Atlas to give structure to the development of the app. The other half of the research process included finding influences and resources contributing directly to the aesthetics, user experience, or code.

Creative coding includes the technical components of the project, including the prototyping, software development, and debugging pieces. The prototyping stage laid the foundation for Data Atlas as an application because in this portion I implemented a way to collect location data on a mobile device. The majority of time in this stage was spent developing the application, which included refining the algorithms for collecting and displaying information as well as translating the visuals into algorithms. Troubleshooting issues that arose also contributed to this part of the project.

In interaction design, the parts of Data Atlas visible and usable by people were created. This included deciding to use Material Design as the language for the app navigation as well as iterating through possible user interactions. Interaction design is closely intertwined with Creative Coding since the visuals gave guidance to the code development and the code made the visuals functional.

User experience includes the process of understanding what people would use this application for and how they respond to using Data Atlas. Defining the context involved creating the personas and the overarching questions for this application. Two user studies provided feedback on the creative coding and interaction design as well as helped refine the target users.

FIGURE 1: CONTEXTS OF DATA ATLAS



DISCOVERING IMPACT

Throughout the process of developing my thesis project, I have been asked some variant of the question "what is the purpose/motivation of Data Atlas?" My first attempts at responding to this question were to describe the flaws in existing applications and how I saw my solution as providing something different to location data. This answer neither satisfied me nor people wanting to know more about this app, so I tried a new strategy of describing Data Atlas as a solution for learning more about location data. I thought questions about purpose were essentially asking me to define my why, what if, and how might we questions (as described on page 3-4), but these questions are only part of the answer to describing Data Atlas.

In addition to knowing the questions my thesis project is answering, it is important to also be able to answer the question of "what is the impact?" of answering these questions with my thesis project. On a more macro level, my committee and others interested in my thesis were asking me to define why I chose this thesis project and where I saw Data Atlas being impactful. When I realized this, I started defining the different potential users of Data Atlas and began seeing this thesis project from a user perspective instead of a project one.

²⁶ Urist, Jacoba.
"From Paint to
Pixels." The Atlantic.
Atlantic Media
Company,
14 May 2015. Web.
23 May 2015.

The article "From Paint to Pixels"²⁶ appeared in my inbox as a suggested article to read by [quantifiedself.com](#), a community I had been following since I became interested in **quantified self**, a movement where people record and analyze their own information, usually utilizing technology to do so. As I read the article and considered its alternative title, "How Data Became a New Medium for Artists," I found several of author Jacob Urist's points about embracing data and considering data as a tool for art resonating with the work I was doing with Data Atlas.

I read through Urist's article quite a few times, highlighting and annotating a digital copy on my tablet before I got to thinking there was something even more related about the content I was highlighting. With a clean whiteboard wall in front of me, I began writing quotes I found most meaningful on the whiteboard in the order in which they appeared in the article. With four quotes selected, I started to see the four quotes described a process and began connecting the quotes by drawing arrows between them. The arrows soon had annotations beside them, and I scanned through the article to find a fifth quote to set the tone of what, all together, helped me answer the question "what is the impact of creating data visualizations?"

On the right is the diagram I generated from my whiteboard brainstorm, based on and using quotes from "From Paint to Pixels." Through this diagram, I came to realize what Data Atlas meant to me was creating the application is a way to make data meaningful to a larger audience than statisticians and programmers. The project excites me because data visualization is an area of creative technologies combining my diverse skill set, and Data Atlas impacts others by providing ways for people to see meaning in their data and where that meaning is derived from.

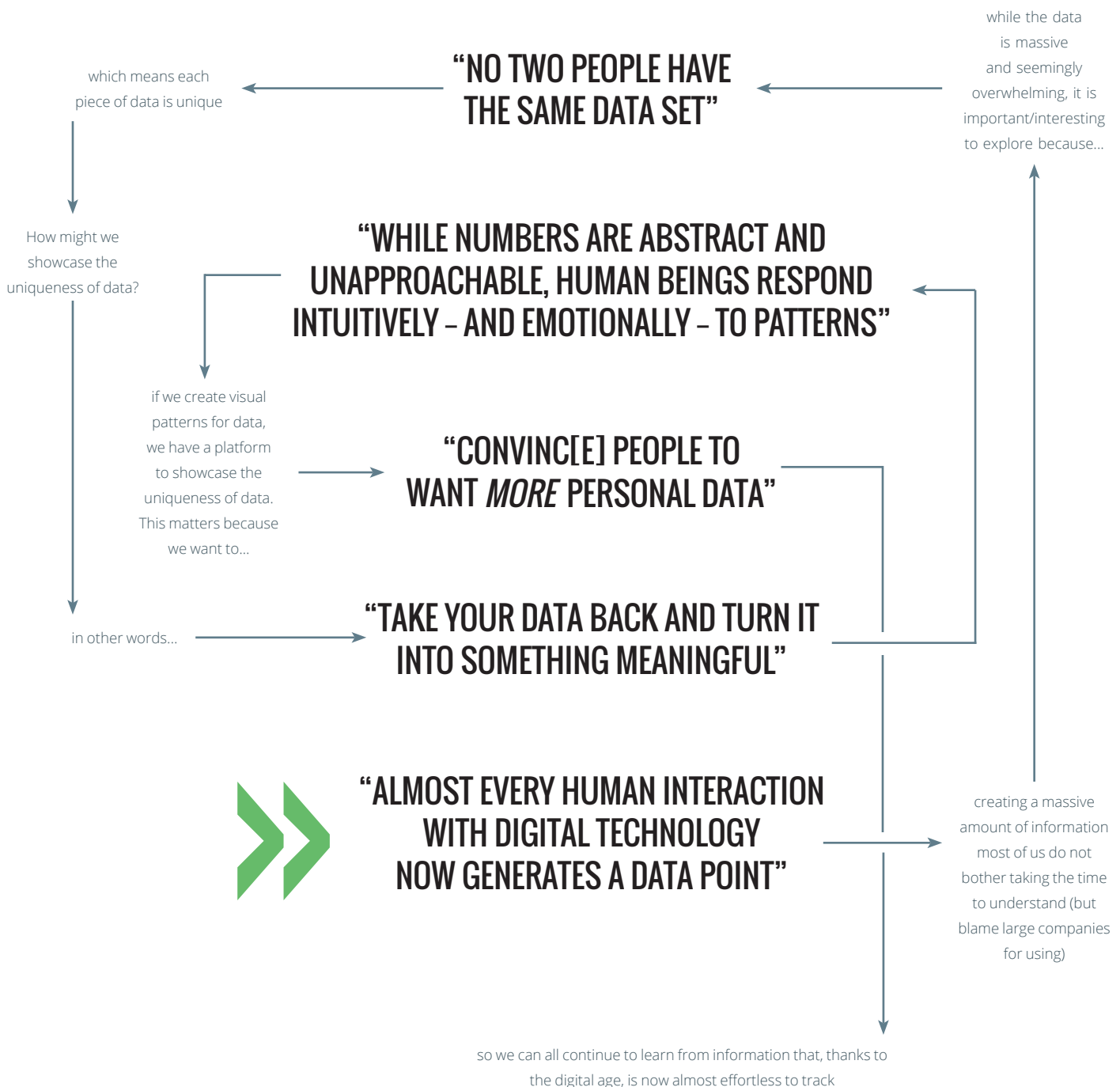


FIGURE 2: THE IMPACT OF DESCRIBING DATA WITH ART

COMPARING CONCEPTS

Data Atlas is not the first application to embrace the concept of quantified self and show people their personal information, but it does focus on a less-commonly featured data set and different ways of visualizing data. In approaching the question "what if people could interact with their raw data?", this app allows users to analyze and view their own location information gathered by their mobile devices.

To better understand how this solution fits in with and distinguishes itself from other applications, I found three applications featuring location information and explored what each one contributes to this area of knowledge. Below is a summary of each application, its perceived main goal/purpose, and how it compares to Data Atlas.

OPEN PATHS OPENPATHS.CC

²⁷ Jer Thorp's TEDxVancouver talk was similar to his talk at Virginia Tech can be viewed at ted.com/talks/jer_thorp_make_data_more_human.

In March 2014, Jer Thorp visited Virginia Tech and gave a talk on his work as a Data Artist in Residence at the New York Times.²⁷ During his tenure, he worked on ways for people to discover/remember their own stories using data and OpenPaths became one of the tools he worked on to give people to access to their location data. In addition to people being able to access this information, the platform also was created to act as an intermediary between people and research groups; users of OpenPaths can share their location information with researchers through the platform and get a better sense of who has access to this data.

As a platform, OpenPaths has a web viewer and a mobile app with the location data being recorded through the mobile app and the data being sharable through the web interface. Each access point has a map with pins on each position and the ability to "playback" a pre-defined time frame of information, showing the order in which the data points were recorded. Users can remove sections of their location data as well as enable/revoke permissions for data sets to be used in research studies as part of their experience too.

OpenPaths is similar to Data Atlas in the sense that both applications are based off making location data transparent to the users. Data Atlas expands on this concept by offering a variety of ways to view this data and distinguishes itself from OpenPaths by allowing people to view information by custom time frames and in non-geographically-based visual formats.

GYROSCOPE GYROSCOPE.PE

Quizlet designer Anand Sharma wanted to showcase aspects of his life and developed a personal website featuring his running, location, and code history data in an interactive, visual format. After receiving attention and enthusiasm for his visualization, Sharma decided to make his work into something anyone could use. In March 2015, Gyroscope became available in a public beta for people to use their own data as source for the visualization.

Gyroscope is a web application and features a visualization with three categories of content: health data (called Sport), location data (called Explorer), and other digital information (called Digital). Clicking on the text for each category of information updates a circular diagram showcasing the most recent information in each category. For further details, users can click on aspects in the visualization and enter a dashboard view for more detailed summaries of the data.

The simplicity of the visualization and ability to interact with data in either a summary or more detailed view is something Gyroscope has in common with Data Atlas. The eye-catching visualization is something that draws users into the application, but beyond this initial view, the user interface adopts more traditional practices with its dashboard layout and graphs. Data Atlas builds on the concept of interacting with the visualization by focusing on interactions in the initial visualizations and being able to dive into individual pieces of location information.

TIMELINE GOOGLE.COM/MAPS/TIMELINE

Starting on July 22, 2015, Google account holders could start to see a history of everywhere they have been based on their Android devices. While this information was previously available as raw information in Google's account settings, it was the first Google product since Google Latitude (retired in August 2013) to put this information in a user-friendly format.

Available as a web and mobile application, Google Maps Timeline shows points plotted on a map and a summary by day of where someone has been. Users can adjust and edit this information by clicking on different components, can add custom names to places, or erase extra information on a case by case basis. Google Maps Timeline also includes a bar graph showing how many places someone has been each day and will automatically label places based on their coordinates when available.

Part of the inspiration for Data Atlas came from frustrations in trying to access location data through Google products. Until three weeks before Data Atlas was released, there was no easy way to view both summary and raw location data in a mobile app, and the web interface provided by Google was difficult to read and understand because the data was shown as either XML-formatted text or clusters of data on a map. Data Atlas matches Timeline's functionality of showing location data on a phone (and both applications use the same data source) and summarizing information in map/bar chart formats but distinguishes itself by providing three alternative visualizations and allowing users easier access to their raw data.

FINDING LOCATIONS

The first step in implementing a new application focusing on providing users with ways to “access and understand their location data” is to know how a device records and processes this type of information. While there are a few different alternatives to achieving this goal, Data Atlas leverages the Google Play Location API since it provides multiple ways of accessing GPS coordinates and was built to work with both the latest and previous versions of the Android operating system.

Because the Google Play Location API uses system settings in addition to code written in the app, getting location data is a two part process, with one part relying on one-time user actions and the other relying on automatic code executions. These pages indicate how a new piece of information is obtained and analyzed by Data Atlas to become a part of the app data set.

USER ACTIONS

1

POWER ON ANDROID DEVICE

Location data can be recorded in a variety of ways, most commonly of which is through interactions between a device and a network or satellite. Powering on the device allows the device to interact with these different sources.

2

ENABLE LOCATION DATA

Android's personal settings include a "Location" category, which allows applications to use current location information. Enabling "High accuracy" or "Device only" mode lets apps get data anytime the device is on.

3

ENSURE DATA ATLAS IS RUNNING

In the Notifications Bar of an Android device is a series of icons for running processes and app updates. Data Atlas has an icon in this list when the location-gathering service is running. If it is not visible, open the app.

4

CHECK LOCATION EVERY 30 SECONDS

Data Atlas has a background service called GpsLocationService, which requests a location update every thirty seconds when all of the user actions have been completed. This service will also use other location updates requested by the device.

5

CALCULATE NEW DISTANCE

Before a new location update can be added to the database, it is compared to the most recent entry in the database. Calculating the distance and time between the two locations indicates how far and fast the device traveled.

6

PROCESS THE NEW LOCATION

When the distance between two locations is negligible, the captured location is discarded since it is considered a duplicate of existing data. If the location is new, Data Atlas adds it to the database. The app then returns to step 4.

DATA ATLAS PROCESSES

COMMITTING UPDATES

Just like with design, coding is an iterative process with each stage building on the previous one from idea to final product. Milestones are noted when a new feature is implemented or an issue is resolved, and coders can document their work like designers by saving incremental files (file1.java, file2.java, etc.) or creating folders for the different stages of their work.

²⁸ More information on versioning control, git, and GitHub can be found at github.com.

A third way to save work is by using a **version control system (VCS)**, which is a tool used to keep track of changes for the same set of files instead of people managing this themselves; Data Atlas' code was managed using GitHub (a more user-friendly a branch of a VCS called git) with web and desktop interfaces for accessing work and synchronizing changes.²⁸

In addition to being able to access different versions of the project, GitHub proved useful to Data Atlas by allowing descriptions to be uploaded with a **commit** (submission of a new project version), tagging each version of the software with a summary of what is different in the new version. This allows coders to make notes outside their code about the new version and makes the update more readable for people who have not contributed to the change.

Commits are used mainly for creating new versions of a file set, but they can also be looked at independently of the code to see when the project was most active. GitHub provides graphs to help visualize commit information such as Data Atlas' activity shown below. In this case, height indicates the number of commits in a day beginning just before April 19th, 2015.

LOCATION UPDATE // MAY 6

Building on previous commits, this entry uses accelerometer data in addition to the Locations API to get accurate location data.

ALPHA RELEASE // MAY 12

This version was used in the first user study; its interface allowed people to view their data by date recorded.

INITIAL UPLOAD // APRIL 19

The first upload of Data Atlas included a prototype using the Google Play Locations API to collect mobile phone GPS information.

DRAWING TEST // JUNE 1

Since Processing.java is incompatible with Android, I used this update to learn how to use Android's canvas and drawing libraries.

The annotations for the graph highlight some of the progress points made in Data Atlas starting with the first project commit on April 19th. Each of the following changes was based on this original code base (which was uploaded in five commits on the same day), including the location algorithm update on May 6th and the alpha release on May 12th.

One of the reasons I like visualizing Data Atlas' code history is the commit activity matches my productivity with the app development throughout summer 2015. Between May 17th and June 28th there was limited access to Internet during the VCD study abroad and only one commit was made, a test of Android's graphics libraries to prep for implementing the visualizations. Activity picked up with my return to Blacksburg in late June, peaking and leveling off as the development moved from large feature implementations to visual updates and bug repairs.

Overall, the code for Data Atlas in the August 10th version of the application included over forty commits to a private GitHub repository.

BETA RELEASE // JULY 21

This update includes three of the five visualizations in Data Atlas and was sent to the Google Play Store as a beta app.

TIMEFRAME DIALOG // JULY 7

Users can adjust what timeframe is being visualized through the dialog implemented with this update.

ACTION BAR // JUNE 28

In preparation for multiple visualizations, this version includes an implementation of navigation at the bottom of the app.

MATERIAL DESIGN // JULY 16

Using Material Design, this update applies a consistent visual language in the dialog and navigation portions of the app.

FIGURE 3: GITHUB COMMIT HISTORY

ORGANIZING CODE

No matter what scale project, having a way to organize code helps keep things understandable and cohesive. While code can be organized through written documentation, a **Unified Modeling Language (UML) diagram** visually shows behavioral or structural relationships between sections of code called **classes**.

Data Atlas builds upon classes in the Android framework to let users view and analyze their location data; it also uses classes from third party sources and classes specifically for this app. The UML diagram on this spread showcases the behavioral relationships between these custom classes to help visualize how these different components work together.

CATEGORIES

Many of Data Atlas' classes are related by how they are used in the code. This system diagram shows the categorical relationship of classes with the following color scheme.

ACTIVITIES

User-activated visuals and actions

FRAGMENTS

Customized parts of an activity

INTERFACES

Custom blueprints for classes

STORAGE

Database-related content

SERVICES

Multi-application components

UI ELEMENTS

Customized visual components

ARROWS

The following arrows help indicate potential behavior flows between the different classes.

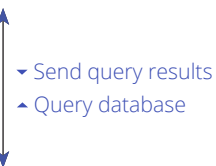
↔ Between two classes, one class's action causes a reaction from the other

→ Reactions stemming from the GPS Location Service

→ Reactions from using the Set Time dialog

DATABASE HELPER

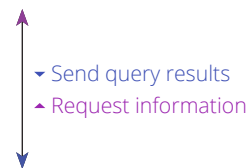
Uses a structured query language (SQL) to modify content in the database



DATABASE ADAPTER

Connects with other classes in Data Atlas to make complex database queries

→ Send query results



GPS LOCATION SERVICE

Listens for and gathers location information from device and network sources (when applicable)

→ Broadcasts updates

FIGURE 4: UML DIAGRAM OF DATA ATLAS

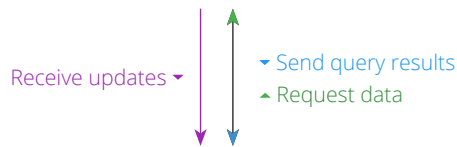
RAW DATA ACTIVITY

Showcases location data
in a textual format



APP ACTIVITY

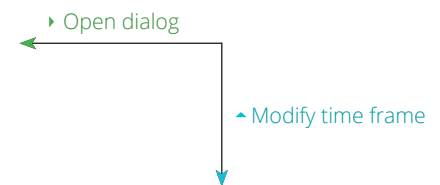
Implements methods used by all activities



VISUALIZATIONS ACTIVITY

Handles all interactions for the five
visualizations in Data Atlas

Modify time frame (blue arrow pointing down)
Receive updates (purple arrow pointing down)



VIEW PAGE ADAPTER

Manages full screen fragments

Modify time frame (blue arrow pointing right)

Receive updates (purple arrow pointing right)

SET TIME DIALOG

Dictates what time frame of data
is shown in the visualizations

MAP VIEW FRAGMENT

Handles rendering and interactions
for the Google Maps visualization

VISUALIZATION FRAGMENT

Handles rendering for the
non-map visualizations

Modify time frame (blue arrow pointing down)
Receive updates (purple arrow pointing down)

PARENT VISUALIZATION

Blueprint for non-map visualizations

Receive updates (purple arrow pointing right)

Modify time frame (blue arrow pointing right)

BAR VISUALIZATION MOSAIC VISUALIZATION NETWORK VISUALIZATION TILE VISUALIZATION

Each class dictates how to draw and
interact with its own visualization

NAVIGATING AN EXPERIENCE

The interface for Data Atlas contains two primary visual components: imagery/text for the location information recorded in the app, and a structure connecting the components. This overarching structure is what allows users to navigate different views and interact with the application in a learn-able and understandable way. As features of the visualizations were developed, the navigation evolved to suit different user needs and preferences.



TWO CARDS

Data Atlas' first versions used a single view with two Material-based cards showing raw data captured in the application. The top card showed the most recent information and had no defined interaction. The second card let users click on a displayed date to reveal the associated data points.

While this model helped with the proof-of-concept application, it was not sustainable for multiple visual forms. It stayed the format for interacting with raw data in each new model.



SLIDING TABS

Focusing on a tab-based navigation, this version of interaction allowed users to see all of the possible content in the application at the top of the app. The visualization was set as the default tab to encourage a focus on engaging with this view, and users could either click a tab or swipe to change to a raw data view.

This model became outdated when new features were added such as changing the time frame shown, but was an influential predecessor to the desk analogy model.



ACTION BAR

Placing the primary app actions in easily accessible locations, this model was inspired by photo-based applications like Snapchat. Also similar to the Android system model, it featured an action bar at the bottom of the app to let users view raw data, share, and change parameters on visualizations.

Usability issues arose because this model did not include a visual cue to navigate between different visualizations. It did, however, assist in defining a hierarchy of actions in the final navigation design.



DESK ANALOGY

The final version of the navigation combined elements of its three predecessors to focus on the visualizations in a fullscreen format. Users can view the visualizations by either swiping or accessing a drawer at the top of the screen, which shows all of the visualization options. Using the Material Design concept of a floating action button, users can click on an accented circle to perform the primary user action, changing how the time frame used in the visualizations.

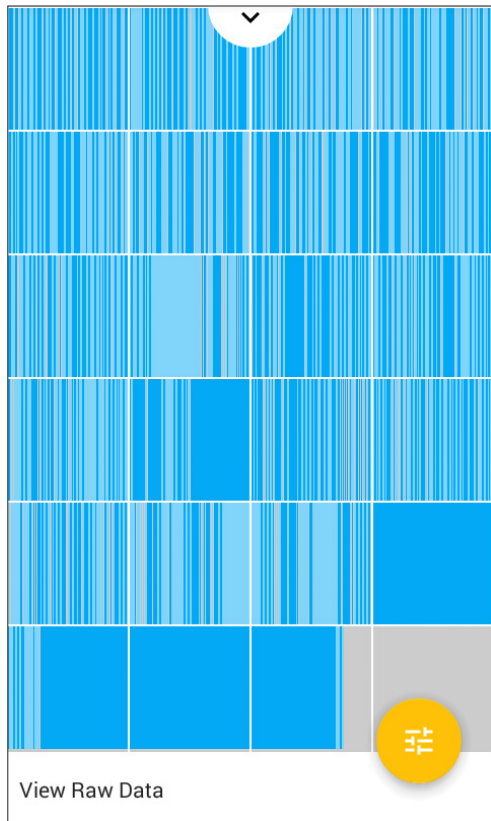


VISUALIZING DATA

Because location information includes geographical coordinates, the data is often visualized with the familiar representation of a map. Existing applications such as OpenPaths and Google Maps Timeline rely on the map structure to emphasize a distance relationship between data (represented by digital pins or discs) in their interfaces. Gyroscope shows distance-based fitness data as geographically-accurate shapes which could overlay a longitude and latitude-based grid to show where someone has moved. While the map representation is familiar to many users, it only reveals one possible story to be told from this data set.

By only showing location data in geographic contexts, users are unable to see or experience the impact of their data in terms of other variables such as how the arrival time and proximity components of location data can be used to understand a person's routine and level of comfort with their surroundings. Not seeing this information creates a disconnect between mobile users who produce location data and the companies who use this information to provide more personalized suggestions and advertising to consumers.

To help solve this disconnect, Data Atlas uses six different ways of presenting data (including viewing the raw data) and draws attention to pieces of location information often omitted in traditional geography-based visualizations through focusing on non-coordinate components.



TILE VISUALIZATION

The Tile Visualization began as a test for the Android graphics libraries and was created in response to the question "how might we create a visualization using either circles or rectangles to show the quantity of data being collected?" After proving visualizations could be drawn on an Android canvas with simple shapes, the original intent was for this visualization to morph showcasing a summary of each location's data rather than each individual piece of information.

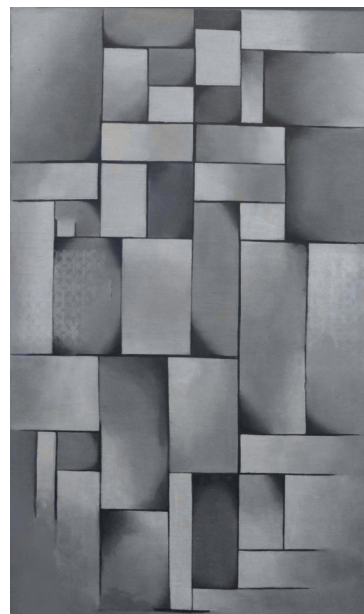
Feedback on the initial prototype (showing all data instead of a summary) created the illusion the user was almost constantly moving and gathering data. Although this was not a true description of the data people gathered, their devices are almost constantly engaged in a task when powered on and the visualization showed this activity. This visualization was then maintained as showcase for phone data activity to expose this information to the user.

INSPIRATION

In its simplest description, the Tile Visualization lays out information within a grid and draws inspiration from modular grid structures taught in graphic design, mathematics, and many other fields. During a visit to the Venice Biennale, the painting *Composition in Gray (Rag-time)*²⁹ (shown on the right) exemplified and inspired the idea of having the grid act as a summary for the data where each rectangle would represent a different location visited and its size the amount of time spent there..

INTERACTION

Each grid cell in the visualization above shows one hour of data and each line within that cell is a piece of information. The color alternates to indicate each individual point. Users can interact with the Tile Visualization by tapping on any of the grid cells, revealing a pop up with an expanded view of the data within that cell. Additionally, users can press and hold on a particular grid cell and view floating text indicating what unit of time the cell represents.

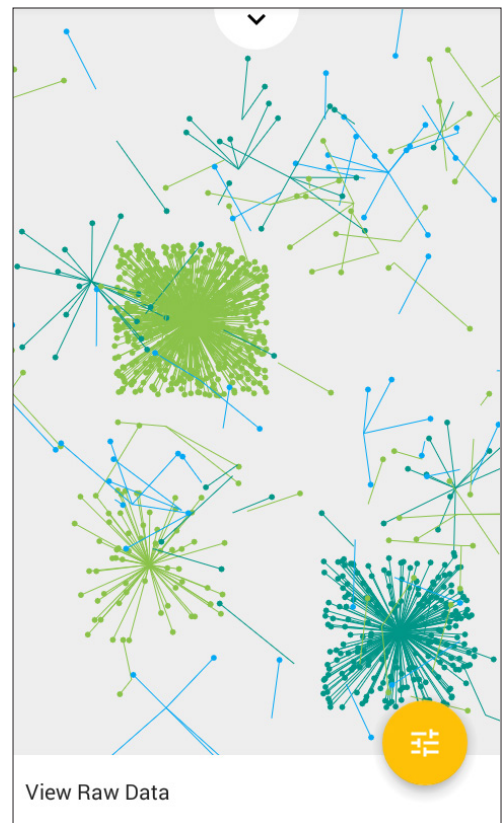


²⁹ Van Doesburg, Theo. *Composition in Gray (Rag-time)*. 1919. Oil on canvas. The Solomon R. Guggenheim Foundation Peggy Guggenheim Collection, Venice.

NETWORK VISUALIZATION

This organic-looking concept began as an idea show location information's ability to reveal how people inhabit space (as recorded by their devices). In its original form, the visualization was intended show several "blob" objects with each one signifying a unit of time and its appearance affected by how many locations were visited and the time spent at each location. This concept, though, seemed more similar to the tile and mosaic visualizations, so the concept was re-evaluated to find a new variable for the visualization conc.

Ultimately, the network visualization became a way for users to view and interact with clusters of data, where each cluster grouped a set of locations relatively close to one another geographically. The placement of these clusters in the canvas is not geographic in order to invite users to create their own associations for the data rather than focus on multiple aspects of the data's geographic



INSPIRATION

The network diagram has appeared in multiple formats throughout this thesis process as inspiration (page 16), brainstorming (page 22), and organization (pages 29-30), so it is no surprise for it to also manifest as a way to organize location data. What helped push the concept of an organic-looking view into a reality, though, was a piece called "The One Machine: Map of the internet" from the book *The Visual Miscellaneum: A Colorful Guide to the World's Most Consequential Trivia*.³⁰ The network diagram showcases different domain extensions in the world and what nations use them, literally creating a visual web of the Internet and the feeling as a viewer of looking at this data set as though it was under a microscope.

³⁰ McCandless, David. *The Visual Miscellaneum: A Colorful Guide to the World's Most Consequential Trivia*. New York: Harper Design, 2012. 90-91. Print.

INTERACTION

Tapping on any of the clusters in this visualization grays triggers a pop up to appear with details of data for each node in the cluster. This is also a more dynamic visualization than many of the others in Data Atlas in the sense that each time the Data Atlas application is started, the position of the clusters and their colors changes.



BAR VISUALIZATION

Though the Tile Visualization summarizes how much data is collected over time, it is difficult to grasp how much data is being represented in a grid cell since many of the lines are too narrow to easily count. While developing the Tile Visualization, it became clear that a solution was needed that quantified how much data was being collected for each unit of time, and the Bar Visualization became a temporary solution and quantified how much data was being recorded on a per hour basis.

The Bar Visualization was intended to be deprecated once the Tile Visualization was finished, but became its own feature in Data Atlas so it could continue to provide answers to quantity-based questions about the data rather than qualitative comparisons shown in the others. Because many people are familiar with the concept of a bar chart, it also serves as a way for people less familiar with location data or data visualization to get started in understanding their location information.

INSPIRATION

No particular existing work of art inspired this visualization, but ironically Google Maps Timeline utilize this visualization format too; the feature in Timeline compliments the main map display and can be used to navigate between different dates of data. Since Data Atlas implemented a bar chart visualization before Google Maps Timeline was released, it is interesting to note two different apps saw the use of bar charts for location data as an important tool to help people easily access and begin to understand more of their location information even though it is less commonly used for this data set than maps.

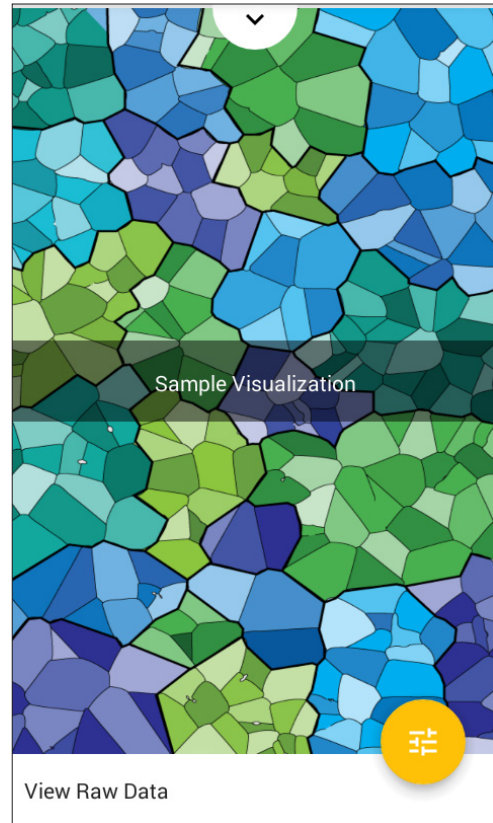
INTERACTION

Tapping any of the bars will trigger a pop up with details on the data contributing to the height of the bar. Data is ordered in this view by time of arrival, and it is important to note that unlike other visualizations, the Bar Visualization only uses arrival time directly in the visualization as opposed to arrival time and duration to determine the bar height.

MOSAIC VISUALIZATION

While two other visualizations in Data Atlas focus on how location information's time is depicted (Tile and Bar Visualizations), the Mosaic Visualization is the only one based on the amount of time spent at a particular coordinate. The concept for this visualization is each data polygon takes up space proportional to how much time it represents of the total data time frame.

From a software engineering perspective, this was also the most technically challenging visualization to implement because it involved the most dynamic content. Unlike the other visualizations which have a constant element to use as a point of reference, the Mosaic Visualization relies completely on the data set to indicate position and size of elements. To implement this visualization, the algorithm calls for spreading out all of the data on the Android canvas and then using the Voronoi algorithm to draw the surrounding polygons.



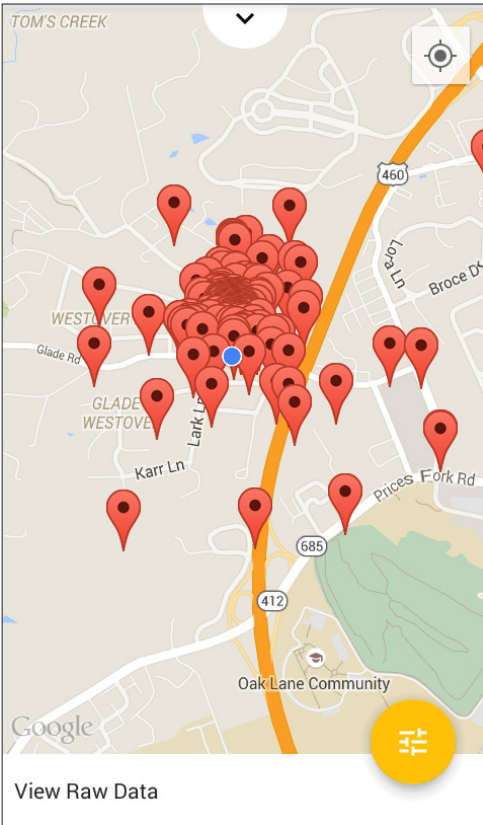
INSPIRATION

For over a year, Delauney triangles (which are based on the same algorithm as this visualization) have been a visualization format I have been inspired by for my data visualization work. In addition, the glass, ceramic, and stone artwork seen throughout the VCD study abroad experience contributed to the concept of this visualization, especially the stained glass at the Vatican and mosaics at Ostia Antica.

INTERACTION

Since creative coding was not the only aspect of this thesis project, Data Atlas features a sample image and not a dynamic visualization of the Mosaic Visualization. If there had been more time to dedicate to perfecting the algorithm to spread out the data points and implement an Android Voronoi solution, the interaction would have been to tap on a region of similarly-colored polygons. In a similar fashion to the other visualizations, the tap would have triggered a pop up with more details.

The sample image was created based on an evenly distributed, randomized data set. Once the diagram was generated, it was touched up and recolored to simulate what 24 hours of data might look like if the data was composed of location information with similar durations.



MAP VISUALIZATION

The most classic of views for location data, the Map Visualization uses the common reference of geography to showcase where location information is collected. Each data point is represented by a pin on the map, creating natural groupings of pins where multiple data points are recorded at the same location. The blue dot indicates the current location of the device.

While this visualization duplicates features of existing applications, it has been incorporated into Data Atlas to provide a familiar point of reference to users. It is the least abstract of the visualization options presented, and heavily relies on familiar structures to assist users who fall in the more novice stages of data literacy or users who are new to the application and want something to orient their understanding of what data the application is making accessible.

INSPIRATION

This visualization is based on a tutorial provided to Android Developers. It utilizes the same Location API used in Data Atlas' GpsLocationService and provides the map through the Google Maps API.³¹ My contribution to this visualization was implementing the tutorial as a part of the Data Atlas system, which involved providing up-to-date location information used to generate the pins drawn in the view and connecting the application navigation components.

³¹ The tutorials for "Making Your App Location-Aware" can be found at developer.android.com/training/location/index.html

INTERACTION

Users can pinch and push the view to rotate, zoom, and move around the world map. Tapping on the GPS icon in the upper right corner will center the view around the device's current location. The pins are interactive as well, and tapping on a pin will produce a tag showing details about the data point.

“By placing data into a human context,
it gains meaning.”³²

– **JER THORP**

³²Thorp, Jer. “Make Data More Human.” *TED*. TED Conferences, LLC, Nov. 2011. Web. 12 Aug. 2015.

4 FEEDBACK

While generating personas and interacting with a product are good ways to create and self-evaluate user experience, it is important to get feedback from people who aren't involved in the development process. This ensures the product reflects all users' needs instead of just the preferences of the design/development team.

To get Data Atlas seen and used by potential users, two user studies

were conducted. The first study entailed students on a study abroad program carrying Android phones with the application installed and commenting on their experience with Data Atlas in surveys and an interview. The second study followed a task-based approach, and volunteers answered questions about the app by exploring its contents and commenting about their first-impression experience.

These live studies identified new features users would like to see incorporated into Data Atlas as well as highlighted frustrations people had in using the app. Both forms of feedback impacted the final solution.

CREATING THE STUDIES

Early in the prototyping phase of Data Atlas, I realized the importance of being able to use and test the application with multiple data sources. My personal device, a 2013 Nexus 7, worked well for collecting my own data and provided a large screen to interact with, but it meant my thesis project was tethered to my only Android personal device and included a visualization data set for one user. User studies could help solve the problem of me being the only user of Data Atlas, but I needed to find ways to distribute Data Atlas other than sharing my personal device with potential study participants.

I found two student grants as a solution for my need to share Data Atlas with others. The Institute for Creativity, Arts, and Technology (ICAT) Student Grant and Graduate Research Development Program (GRDP) each accepted my application for a set of Android tablets, which I planned to distribute user study participants so they could collect and analyze their personal location data and I could have a device to dedicate thesis content to.

While the funding applications were under review and Data Atlas was transitioning from a proof-of-concept prototype into an alpha application, I also submitted a two-part user study proposal to the Institutional Review Board (IRB) to ensure my project met Virginia Tech's standards for human subject testing. Each part of the proposed study focused on a different circumstance of location data: the first featured students traveling internationally and the second would use Android devices locally. In this way, students would be gathering a diverse set of data with some sets spanning as small as a ten mile radius and others covering hundreds of miles. Both studies were originally proposed to last four weeks, include weekly survey to get a sense of how people felt about their experiences with the app over time, and contain final interviews to get more in depth feedback.

My original grant applications differed slightly from what was ultimately done in regards to user testing for Data Atlas. Though I was most familiar with tablets and had been developing on one beginning in the proof-of-concept stage, the funds were used to purchase twelve Android cell phones and microSD card memory instead of tablets in order to accommodate a device size more students were familiar with. This size device also made it easier for participants to carry around with them, since a 7" tablet was easy to misplace or leave untouched in a bag.

Though there were twelve study phones, there were at most seven devices in use at the same time during any study. This was because I gave each of my three committee members a phone for interacting with the app during the summer since we not all be in Blacksburg at the same time, dedicated one for development purposes, and set aside a spare in case something happened to a study phone and needed quick replacing.



EACH USER STUDY PARTICIPANT USED A BLU NEO 4.5
ANDROID CELL PHONE FUNDED BY A VIRGINIA TECH ORGANIZATION

DATA FROM AFAR

For the first part of the user study, I wanted to look at how Data Atlas would be used in cases where people traveled between cities; this type of test would allow me to get a more diverse data set than my personal one from Blacksburg, Virginia and it would also let me see how people reacted to Data Atlas in a use case where their location changed drastically and somewhat frequently. Approval of the grants and IRB coincided with the start of the VCD study abroad program I was participating in, so the first group of participants were chosen from the people in this program. Six of the seven participants used one of the study phones obtained through a grant, and one participant used their personal Android device.

The original plan for this study involved the participants carrying their devices with them throughout the study abroad experience and responding once a week to a survey about their perceptions of Data Atlas. This proved problematic, however, due to unforeseen factors with setting up new devices in a different country. In particular, limited access to Internet posed three major problems with the study: downloading a necessary support application (needed by the Locations API) onto each device, access to send/respond to surveys, and troubleshooting device-specific issues regarding connectivity and recording. Only two of the seven study participants were initially able to record and view their raw data.

Despite these setbacks, I still encouraged participants to carry their devices with them in case we were able to resolve the technical challenges. The first survey went out the third week of the study, and four of the seven participants were able to respond (however, three had no data visible in their app). At the end of the study abroad, all seven users were able to participate in the final interview . Because the majority of users were unable to view raw data and the first visualization did not update to the devices, I treated the final interview as more of a needs analysis interview, focusing on how the participants felt about the concepts behind Data Atlas and (where applicable) how they would like to use the app. The feedback was incorporated into versions of Data Atlas from June 12th, 2015 onward, and the full interview questionnaire can be found on page 65-64.

Only four of the seven participants were able to view data at any point during the study, but all seven thought Data Atlas was an appropriate app for travelers (and four thought it might be useful for more localized data). Several suggestions for features were given such as a pin-and-zoom feature for viewing different pieces of information, the integration of other data sources such as a pedometer, and being able to toggle or flip quickly between the raw data and the visualization. Since a few of the participants mentioned having a map view of the data would be useful, one of the changes implemented based on this study for the next study was the inclusion of a map view. Many of the other requests have been added to the to-do list shown on page 52.

One last notable takeaway from this study was an interesting use case for Data Atlas brought up by two of the participants: business. Both participants talked about how Data Atlas could be used to keep track of time spent for work travel or types of work where employees are in a different location than their supervisors. In these cases, it seems another possible extension for future Data Atlas work is to capitalize on the relationship between location and time.

SAMPLE QUOTES FROM THE FINAL INTERVIEWS

“Have the data interconnected with the visualization [such as] if you’re in the visualization... if it was possible to zoom and select certain points to get back to the raw data.” - Participant 101

“I used OpenPaths after the Jer Thorpe talk and used to use apps that track calories. I stopped using [OpenPaths] because it wasn’t useful in Blacksburg ...it’s cooler to see how far away you are..” - Participant 103

“People who travel for business or who are kind of on vacation or in other settings [might use this app]. Day to day settings don’t seem like anything special.” - Participant 104

“Have a map view too to really understand the data from a geographic point of view. I want to see [a map] more simplified... gets the duration and incorporates that... That’s what’s interesting, to have the points but not necessarily the connecting lines” - Participant 105

“Hypothetically the visualization would be more engaging [than textual data]... [Apple Health Kit] doesn’t let you go back and do total miles per day. It would be cool to compare days and information in more ways.” - Participant 106

“This study made me more aware that something is tracking where you’re going. On one hand cool to see where someone was going but weird to think that people could see where you’re going.” - Participant 107

“I checked the app for the coordinates of a restaurant I visited and used them... to find [the restaurant] again.” - Participant 110

LOCAL FIRST IMPRESSIONS

Since the first part of the user study had changed from participants testing Data Atlas to more generally thinking about how they might want to interact with location information, I re-evaluated my user testing before proceeding with the second study. The original concept was to have the same one-month study planned for the VCD study abroad group where a group of participants would take Android devices with them, answer weekly surveys, and participate in a final interview after four weeks. The difference between this study and the first one was the participant pool would only consist of people staying in southwest Virginia for the four weeks (preferably within an hour of Blacksburg) so the study could be compared to the international use case.

The second user study evolved into a one-time, task-based study instead of a study based on people using Data Atlas for an extended amount of time. Similar to the task-based studies I had done as a part of the human-centered design coursework, I created five tasks for participants to attempt using Data Atlas on an Android device with data I generated. Participants were told at the beginning of the study Data Atlas contains ways to visualize location information and were invited to explore the app as they attempted to answer different questions about the data they had available. After they had attempted all five tasks, participants were asked to answer a series of questions, including a system usability scale (SUS)³³ and some short answers about their experience and first impressions (the SUS questions and results are shown on the right and the remaining elements of the survey can be found on pages 67-68).

³³ More the system usability scale's origins and purpose can be found at www.measuringu.com/sus.php

Five participants were recruited for this study based on Jakob Nielson's theory on how testing five users will expose 85% of the issues with the application.³⁴ As with the previous task, feedback from the users was either implemented into the August 10th version of the application, added to the to-do list in the next section, or consolidated with other feedback. Overall, feedback from the SUS indicated the app was learn-able and understandable to navigate, but it was unclear to users what the visualizations symbolized and how users could interact with them.

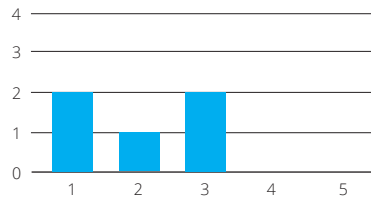
³⁴ More on Jakob Nielson's theory can be found at www.nngroup.com/articles/why-you-only-need-to-test-with-5-users/

While the first study used the Sliding Tabs navigation, this user study utilized the Desk Analogy. Interestingly enough, the first study (perhaps because of lack of visualizations) did not have trouble finding where to view raw data, whereas only three of the five participants recognized clicking on the "View Raw Data" text at the bottom of the screen would show a text-based view. The feedback in the second study, in contrast, focused more on the way the data was presented instead of veering in the direction of the first study and contemplating what data was being used and what users would find it interesting.

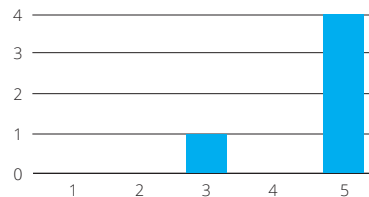
As indicated by the figures on the right, the second user study overall found Data Atlas to be an interesting app and was less difficult to use than its former iteration, but the complexity of the data had many of the participants leaving comments about the necessity for "Getting Started" screens or a way to access general information about the visualizations to better

SYSTEM USABILITY SCALE FEEDBACK

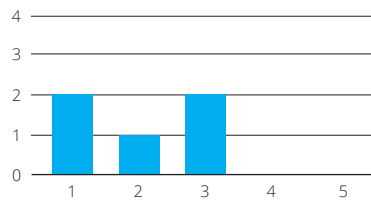
I thought the application was easy to use.



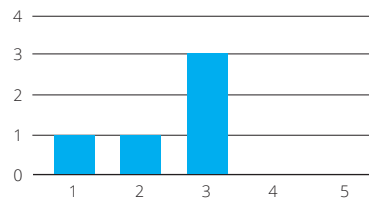
I felt very confident to use the application.



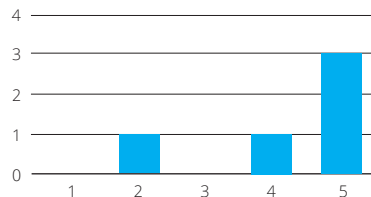
I think that I would like to use this application frequently.



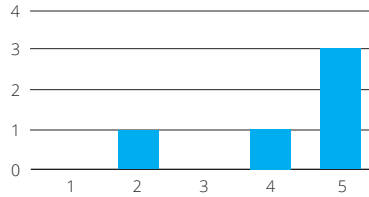
I would imagine that most people would learn to use this application very quickly.



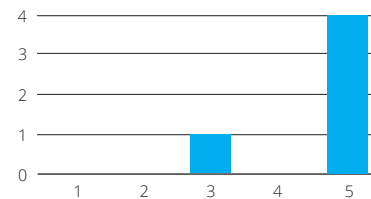
I found the application unnecessarily complex.



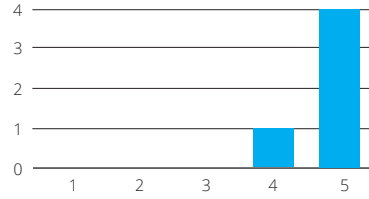
I found the application very cumbersome to use.



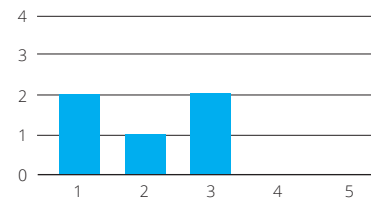
I think that I would need the support of a technical person to be able to use this application.



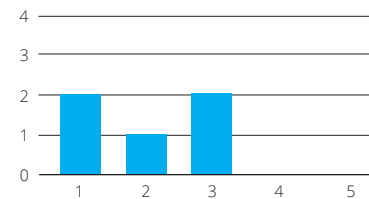
I thought there was too much inconsistency in this application.



I found the various functions in this application were well integrated.



I needed to learn a lot of things before I could get going with this application.



COMMITTEE INSIGHTS

Before Visual Insights had its name or Data Atlas was a concept, I first went through the process of selecting a committee to mentor me throughout this project. Though at the time I selected my committee I had only finished one semester of graduate school, I asked Meaghan Dee, Dane Webster, and Troy Abel if they would be interested in working with me on my thesis based on their unique skill sets I hoped to learn from and be inspired by. Even though my discipline within the School of Visual Arts is Creative Technologies, I knew I wanted to treat my product (Data Atlas) with as much importance as the way I communicated my process, which is why there is also a heavy influence of Visual Communication Design in Visual Imprints.

Each faculty member was just as influential in creating this experience as any of the topics were in the Influences section, and their feedback provided invaluable guidance and direction throughout the design and development of Data Atlas. We met as a group three times throughout the year (and multiple times on a 1:1 basis) and each interaction I had with these individuals provided invaluable direction and guidance on Data Atlas and my process as a whole.

MEAGHAN DEE

Meaghan's attention to detail and emphasis on making intentional decisions were two qualities of hers I experienced while I was her graduate teaching assistant in FourDesign, and I asked her to be on my committee (and then to be the chair) because these aspects were just as important to me as my final product. She quickly became the person I went to with my big picture "why" questions about Visual Imprints and Data Atlas.

Most significantly, Meaghan introduced me to *Enchanted Objects* and suggested I treat Data Atlas as an information architecture project to combine my skill sets instead of just focusing on creative coding or user experience. She was also instrumental in my grant and IRB proposals, encouraged me to create Visual Imprints as a print document rather than website, and suggested I have a target audience for Data Atlas instead of treating my personas equally.

DANE WEBSTER

Dane's work in data visualization, creative code, and animation meant he was experienced (and had taught content) in about every possible topic I was considering for a thesis project. I asked him to be on my committee because I knew no matter what topic I focused on, his knowledge and expertise would help me better understand connections between art and technology. He has been the person I have gone to with many of my "what if" questions.

I was inspired by Dane's Processing class (Processing is a Java-based library for creating visuals with code) to use data as the source of a piece of art, and built a visualization based on components of weather. In both the web-based processing piece and Data Atlas, Dane encouraged me to explore multiple connections between data and its visualizations. He also helped refine the way I describe my coding process and suggested I spend time thinking about the question "why is data visualization important and why does it matter to me?"

DR. TROY ABEL

Well-known both in and outside Virginia Tech for his expertise in human-centered design and user testing, I asked Troy to be on my committee because I knew he would help me prioritize the role of the user in the product. In both of his classes, he prepared me for this thesis project through having me conduct user studies and create process books. Troy was the person I went to with many of my "how might we" questions.

Troy from the very beginning asked me questions such as "who is Data Atlas for?" and suggested I change from getting Android tablets for user studies to getting Android phones. He also influenced Data Atlas' navigation by suggesting a balance between simple and complex components, keeping the raw data as a part of the app experience, and encouraging me to think about why having multiple visualizations is important to Data Atlas.

“Design is a way of looking at the world. You produce an artifact or create a system with a set of conditions, an infrastructure or an apparatus where you’ve done half the equation and you leave the rest for whoever wants to participate.”³⁵

– **LUCILLE TENAZAS**

³⁵ Bader, Sara. *The Designer Says: Quotes, Quips, and Words of Wisdom*. New York: Princeton Architectural, 2013. 137. Print.

5 REFLECTION

It seems impossible for anything digitally made, especially software, to be considered “finished.” No matter how much time is spent developing, designing, or refining an application, there always seems to be one more bug to fix, one feature to tweak, or something new to be added and because the work is electronic, the cost of making changes appears relatively low. Data Atlas is no exception to this sentiment on digital processes.

August 10th, 2015, though, marked a point to pause work on the Android application, reflect on its current state, and process the work it took to get to the most recent version. Analyzing its accomplishments and next steps also helped me understand how it impacted and concluded my master’s experience in Creative Technologies.

Encompassing the scope of Data Atlas is Visual Imprints, and pausing work on Data Atlas also allowed for me to analyze how this process overall has affected my perceptions on future career paths and the field of data visualization.

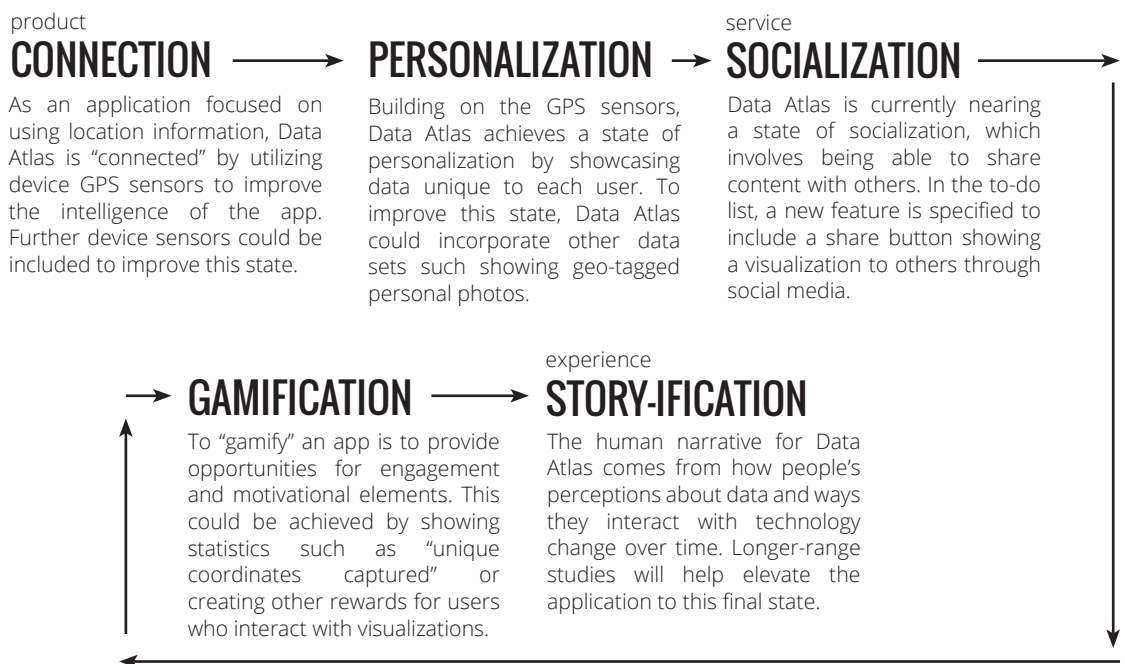
DATA ATLAS

Over a nine month time period, Data Atlas evolved from being a set of questions about how people interact with information to an Android Application with six different representations for location data. Through an information architecture process, the application incorporated components of research, creative coding, interaction design, and user experience to highlight areas I have focused on throughout my master's experience.

In its current state, Data Atlas is a beta application privately available on the Google Play Store. To balance the four pillars of the information architecture process, some of the features of the visualizations were left as concepts rather than fully developed components, and some new features would help bring the application into a state where any user could download and interact with Data Atlas. The to-do list found on the right highlights what these modifications and new features would be as well as what other steps would help this application get to a more widely-distributable status.

While the status of different features and components is an important part of judging the success of a mobile app project, equally important is to look at how close the application comes to being a true user experience. To evaluate this aspect of Data Atlas, I referred back to the Ladder of Enchantment (described on page 26) and generated the visual below to show case why Data Atlas can be, in its current state, considered a service and what components would elevate the app to becoming an experience.

FIGURE 5: DATA ATLAS' JOURNEY TO ENCHANTMENT



DATA ATLAS TO-DO LIST

MODIFICATIONS

- Add the Raw Data view to the navigation drawer
- Apply material design elevation (drop shadow) to the navigation drawer
- Implement a Voronoi algorithm to make the Mosaic Visualization dynamic
- Indicate the current data point in each visualization
- Show the same time frame in the Raw Data view as the visualizations
- Use Material Design Date & Time Pickers (custom dialogs) in to set a time frame

NEW FEATURES

- Add a “Learn More” feature describing each visualization and what it might be used for
- Begin the application with a “Getting Started tutorial” describing how to use Data Atlas
- Enable search to let users find data points in visualizations
- Implement a “one time setup” guide to enable data collection
- Use a second floating action button to allow a visualization to be shared with others
- Utilize motion to transition between different components in the application

OUTSTANDING BUGS

- Application assumes powered off devices remain in one location
- Lag occurs inconsistently between visualizations and raw data view
- Location service does not automatically restart when Data Atlas crashes
- Raw data loads slowly when a data is clicked
- Updating the time frame to more than 24 hours causes the program to end abruptly

FEEDBACK

- Add Data Atlas to a public beta so people outside Virginia Tech can participate
- Conduct a user study with the current version of the app based on long-distance travel
- Run task-based user studies as new features are developed
- Survey to see what other data sets users would like to use with Data Atlas

VISUAL IMPRINTS

People with a combined skill set of technical and artistic skills are sometimes considered “unicorns” or rare commodities in industry, and because of their diverse capabilities they often wind up working on the intermediate stages of a project, bringing separate components together and unifying an experience. When I started conceptualizing Data Atlas, I realized this full-stack project (as described on page 19) is the type of work I might find myself doing more of in the future. Creating this Android application gave me an opportunity to test out being a unicorn and use Visual Imprints as a way to reflect on this process and find my niche before entering the workforce.

One important distinction about Data Atlas is it has been developed from the ground up and designed by one individual (with feedback) instead of a small team. This had its advantages because I did not have to worry about other people contributing conflicts to my code base, but it did mean every contribution was something I had to develop to bring it to fruition. When I first started coding, I also recognized there were quite a number of technical topics I knew very little about and I had to learn these before focusing on the interface. I had not used Android Studio before for development, had never set up my own database, knew very little about services (and even less about how to make one), or practiced mining location data. Despite enjoying the challenges of learning these aspects of development, I found myself yearning to focus on user-facing features but restrained these desires because I prioritized having a functional and robust application.

Because of the intricacies of and learning curve with the software development components, the visual aspects of Data Atlas were developed in more of a technical frame-of-mind and involved more code-based prototyping than sketching in notebooks. This meant my work was easy to document in the same commit system I used for the code, but prototyping on the computer meant I was not fully devoting time to the visuals themselves (and more to making them functional) and slowed down the process of deciding on a final set of visualizations and navigation schema. When I did set aside time to sketch, my focus was on creating three different components: the six visual forms, the navigation schema, and the structure and figures for Visual Imprints.

Overall, I am most proud of defining a process and documentation of Visual Imprints. This experience has given me a strong sense of how I want to articulate and showcase my work, whether that work is in the realm of information architecture, software engineering, data visualization, interaction design, etc. While developing Data Atlas highlighted my tendency to gravitate to a comfort zone of coding, I also discovered my main interest lies in thinking through how users connect with information.

In the future, I see myself successful and excited about prototyping experiences to help balance my diverse skill set in industry work. Also incorporated in front-end development, my technical skill set can be used to make visuals functional while also providing ways to contribute to the aspects of technology people interact with. Whether my work is more about prototyping or front-end development in the future, I can continue to answer the question “why are people afraid of data?” by focusing on a subset the skills I have shown in creating Visual Imprints and Data Atlas.

DATA VISUALIZATION

While Data Atlas incorporates many different disciplines in its design and development, it exists as an information architecture project aimed at answering the question “how might we access and utilize location data?” through data visualization. The six forms of viewing location information give users a variety of ways to translate these pieces of reality into insights about user patterns, activities, and trends.

Throughout the design and development of Data Atlas, I asked myself why it was important for this Android application to include multiple ways of viewing information as opposed to focusing on one concept. It would have been easier to develop and iterate upon one idea from a software development standpoint, but focusing on one visual has the large cost of providing users with a biased and incomplete representation of their information. The commonly used map representation, for example, highlights location information, but often does a poor job of expressing the time factor also embedded in these sets of data.

A biased and incomplete experience is not one we can completely rectify in data visualization, since sharing this information in visual ways is dependent on designers and/or developers who provide these solutions. Data Atlas, for example, provides six ways for viewing the time, date, latitude, longitude, and duration components of location data, but does not utilize the altitude, velocity, or other information which can be included in the location data sets.

What providing multiple visualizations and opportunities for interaction does do is give information a more dynamic voice and enable a more well-rounded experience. Compared to existing applications, Data Atlas uniquely provides six ways for engaging with location information. In the Tile, Bar, and Mosaic Visualizations, users can engage with their information through different time-based lenses, while the Network and Map Visualizations visualize this information in reference to distance.

Quoted on the next page, David Rose suggests we look at information as an entity coordinating between aspects of itself and serving us, the end users. Thus information begins conversations, and data visualization creates a louder voice for information than text alone. Data Atlas creates a voice for location information, but it is ultimately up to each individual user to join the conversation by interacting with their information. Choosing to do so in the case of Data Atlas opens the door to an opportunity to improve a user’s own data literacy about location information because they are communicating with the information available on their devices. What can be learned from the data is left up to the user, but Data Atlas (and in a larger scope, data visualization) helps start the conversation for users uninterested in raw or textual data and continue the conversation for those more well acquainted with the different aspects of information.

“Try to think of the [information/data] network as you (don’t) think of electricity... You won’t exactly know or care how [the network works] — as long as the goal of this constant communication is for them to coordinate with each other and to serve you.”³⁶

– DAVID ROSE

³⁶ Rose, David. *Enchanted Objects: Design, Human Desire, and the Internet of Things*. New York: Scribner, 2014.

6 APPENDICES

While the main content for Visual Imprints is included in the previous sections, the items in this section provide supplements or summarizing information meant to identify the main sources and documentation crucial to Data Atlas and Visual Imprints.

The terminology and references sections highlight key materials

included in Visual Imprints and identify access points to further information related to this thesis project. The sketchbook excerpts give a preview into the rough drafts of this project as well, covering every aspect from concept to execution of Visual Imprints and Data Atlas. Since this process included two user studies, IRB documentation is also provided in this section along with excerpts from each study's protocol.

TERMINOLOGY

class: a section of code used to define how an element interacts and behaves with a system

data: a set of information without context or assigned meaning

enchanted object: an item enhanced by sensors to make it a more engaging and useful contribution to life

full stack developer: someone who is able to navigate different fields (such as design, software engineering, and business) while creating technologies

information: a singular observation that has not been encoded or given context

information architecture: the practice of transforming observation into meaningful content

personas: summaries of people created to describe a product user group, define key product features and functionalities, and guide the development of the overall user experience

quantified self: a movement where people record and analyze their own information to learn more about their lifestyles and habits; many participants in this movement use technology as a way to assist in gathering and understanding their information

skeuomorphism: using physical objects or principles to inspire the look and feel of digital components (e.g. the save button often resembles a floppy disk)

unicorn: an individual who has both artistic and technical backgrounds, capable of completing both design and development work

Unified Modeling Language (UML) Diagram: a software engineering way of visualizing the behavioral or structural relationship between classes

IMAGE CREDITS

With the exception of the following attributions for photographs shown on pages 7-8, all images were photographed or otherwise generated by Christina Lidwin.

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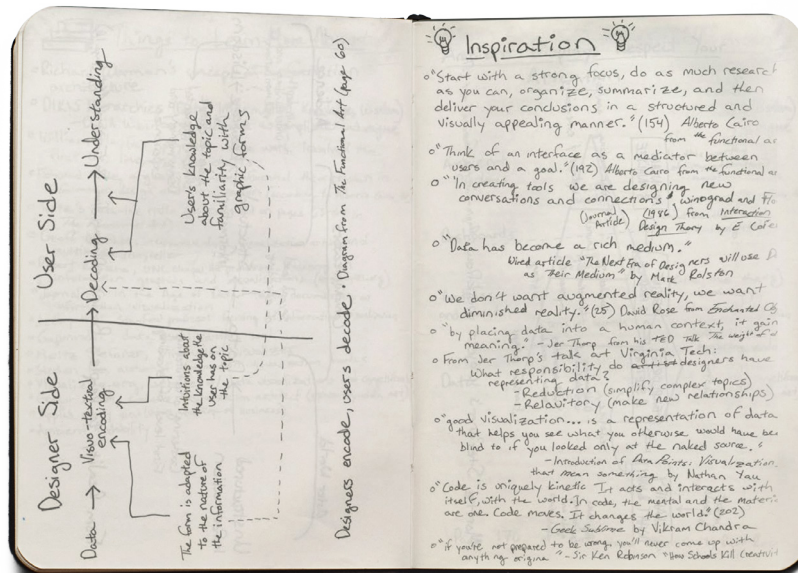
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van Doesburg, Theo. *Composition in Gray (Rag-time)*. 1919. Oil on canvas. The Solomon R. Guggenheim Foundation Peggy Guggenheim Collection, Venice.

SKETCHBOOK SAMPLES

A diagram from the functional art, redrawn in the sketchbook for portability and reference purposes.



Quotes from a variety of sources. All are loosely related to the topic of coding, interface development, and visual communication.

A draft of the diagram on page 31 mapping a relationship between quotes in "From Paint to Pixels."

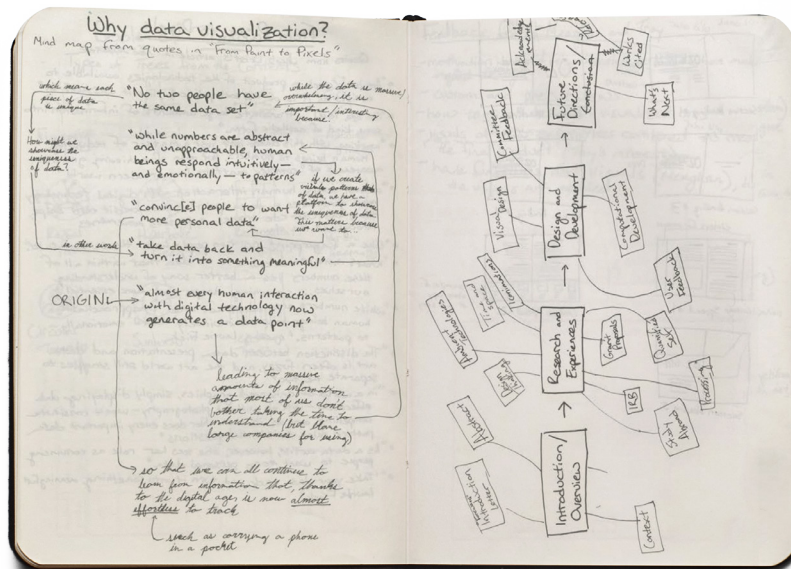
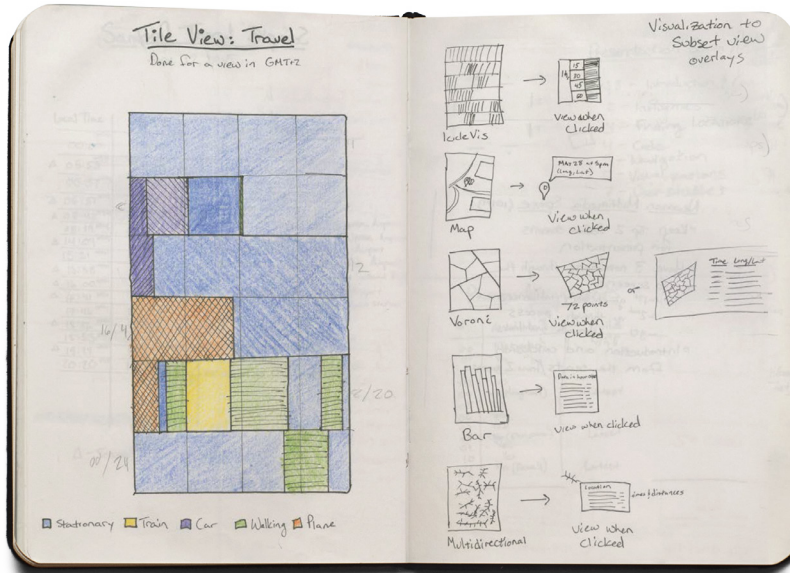


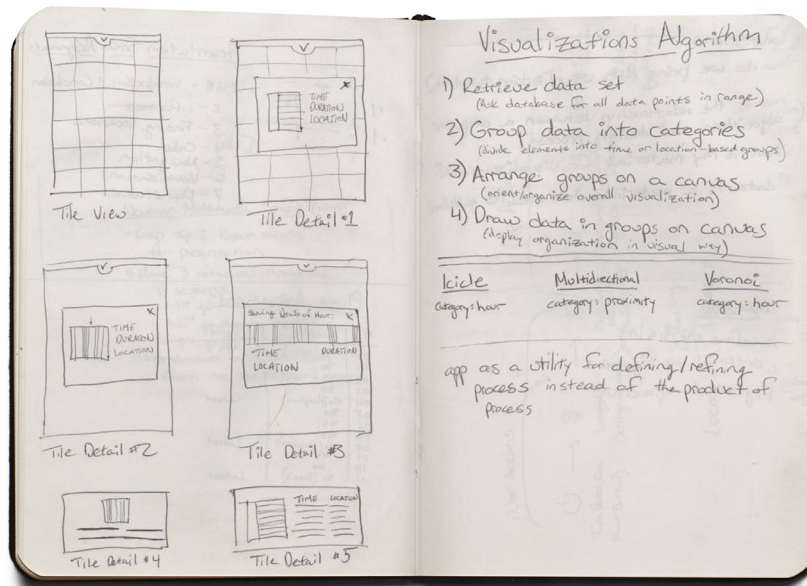
Diagram of the different components of Visual Imprints and a brainstorm of what sections each might belong to in the final document.

Sketch for the Tile Visualization based on data from June 12, 2015. Color is based on mode of transportation.



Summary of each data visualization and a brainstorm of how location data can be accessed by interacting with the visualization.

Iterations on the detail view for the Tile Visualization, showing information about individual pieces of data.



Description of how each visualization is generated by code and miscellaneous thoughts about how the Data Atlas app is structured.

IRB DOCUMENTATION



Office of Research Compliance

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300 Turner Street NW
Blacksburg, Virginia 24061
540/231-4606 Fax 540/231-0959
email irb@vt.edu
website <http://www.irb.vt.edu>

MEMORANDUM

DATE: May 4, 2015
TO: Meaghan Anne Dee, Christina Lidwin
FROM: Virginia Tech Institutional Review Board (FWA00000572, expires April 25, 2018)
PROTOCOL TITLE: Visualizing Geospatial Data as Interactive Displays
IRB NUMBER: 15-449

Effective May 4, 2015, the Virginia Tech Institution Review Board (IRB) Chair, David M Moore, approved the New Application request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

<http://www.irb.vt.edu/pages/responsibilities.htm>

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As: **Expedited, under 45 CFR 46.110 category(ies) 6,7**
Protocol Approval Date: **May 4, 2015**
Protocol Expiration Date: **May 3, 2016**
Continuing Review Due Date*: **April 19, 2016**

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

Invent the Future

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Date*	OSP Number	Sponsor	Grant Comparison Conducted?

* Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this IRB protocol is to cover any other grant proposals, please contact the IRB office (irbadmin@vt.edu) immediately.

INTERVIEW QUESTIONS

DESCRIBE YOUR INTERACTIONS WITH THE APPLICATION OVER THE PAST FOUR WEEKS.

Related Questions: How many times per day/week would you estimate you engaged with the application? Has the application changed how you interact with mobile devices?

IN WHAT SITUATIONS DID YOU FIND THE APPLICATION MOST HELPFUL TO UNDERSTANDING YOUR LOCATION-BASED ACTIVITIES?

Related Question: In what situations have you found would find this application most useful?

WERE THERE SITUATIONS IN WHICH THE APPLICATION WAS NOT USEFUL OR DIDN'T FUNCTION AS EXPECTED?

HAVE YOU USED ANY SIMILAR LOCATION-BASED APPLICATIONS TO TRACK YOUR MOVEMENTS OR TRAVELS?

Related Questions: If so, how does your experience with this application compare with other applications you have used? Did you use any location- or travel-based applications at the same time as you used this application? If so, what were they?

THIS APPLICATION PROVIDES TWO DIFFERENT WAYS OF SEEING YOUR DATA. WHICH FORMAT DID YOU FIND MORE USEFUL OR ENGAGING?

DESCRIBE ANY ADDITIONAL FEATURE(S) YOU WOULD LIKE TO SEE ADDED TO THIS APPLICATION.

Related Question: Why would these additional features be useful?

WHAT TYPES OF PEOPLE DO YOU SEE ENGAGING WITH THIS APPLICATION?

Related Question: What is the primary use you see for this application?

DO YOU THINK THIS APPLICATION WOULD BE MORE USEFUL FOR MORE LOCALIZED (DAY TO DAY) MOVEMENTS OR LONG-DISTANCE TRAVEL?

Many smartphones automatically record location information (time and longitude/latitude) when powered on.

DID USING THIS APPLICATION AFFECT YOUR PERCEPTIONS OF THIS NATIVE SMARTPHONE FEATURE? WERE YOU AWARE OF THIS NATIVE SMARTPHONE FEATURE?

IS THERE ANYTHING ELSE YOU WOULD LIKE TO SHARE ABOUT YOUR EXPERIENCE WITH THE APPLICATION?

USER STUDY TASKS

INTRODUCTION

Thank you for participating in this user study. Today you are going to be exploring Data Atlas, an Android application aimed at providing you with different ways to view and interact with location data commonly collected and recorded from mobile devices. The prototype you will be interacting with today has location data for you to explore; this data has been collected by a researcher over the past two months.

As you navigate throughout the application, I ask you to speak aloud and say why you are interacting with the application in the way you have chosen. There are no wrong answers or actions. If you have any questions as we go along, please don't hesitate to ask. I may not be able to answer your question, but I will do our best to unblock you so you can continue with the task. I can answer additional questions at the end of the task or study and you are welcome to pass any tasks you would not like to complete.

With your permission, I will also be taking observational notes throughout the study. To indicate your permission, please sign the provided consent form and check the box on the screen. All information gathered will remain anonymous in any publications from this study.

TASK PROMPTS

Name the four visual-based ways to view location data in Data Atlas.

Ideal Answer: Tile, Bar, Voronoi, and Map (Available in the Visualization Drawer)

Over the past twenty-four hours, which hour had the most data points recorded in it?

Ideal Answer: User points to the tallest bar in the Bar Visualization View

In the map visualization, find the data point closest to your current location. What time was that data point recorded?

Ideal Answer: User clicks on the nearest data point in the map view

Change the visualization time frame to show the past week of data information.

Ideal Answer: User goes to the tune button and changes from one day to one week

When was the most recent data point recorded?

Ideal Answer: User opens the raw data view and uses the top card to find the time/date.

TASK QUESTIONS

FOLLOWING EACH TASK

THIS TASK WAS EASY TO COMPLETE.

Strongly Agree ○○○○○ Strongly Disagree

ARE THERE ANY ALTERNATIVES YOU WOULD PREFER?

AFTER ATTEMPTING ALL TASKS

WHAT WAS YOUR FAVORITE FEATURE ABOUT THE APPLICATION?

WHAT WAS YOUR LEAST FAVORITE FEATURE IN THE APPLICATION?

IS THERE ANYTHING YOU WOULD CHANGE ABOUT THE APPLICATION?

ANY ADDITIONAL COMMENTS?

