A Constant Atlas:
Designing Cumulative Daily Interactions with Urban Data for Individuals and Their Cities

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**Table of Contents**

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**Abstract**

The ability of institutions and businesses to capture and process data aggregated from individuals has grown significantly in the past ten years as we increasingly integrate digital technologies into our daily lives. In the urban planning context, computational social science projects use data collected about the urban environment to solve problems from traffic congestion and public safety, to targeted advertising and the development of entire neighborhoods. Although projects using aggregate data ultimately benefit individuals by making improvements on their environment at large, an individual citizen often does not engage with the data collected from them directly nor the decision making process at large.

The proposed research uses a series of design experiments to engage citizens directly with publicly available data, giving residents the ability to use their physical location over time as a lens to understand aggregate data of their environment.  In order for such tools to be effective, they not only have to efficiently communicate data, but also be intuitive enough to encourage repeat use, and cumulatively build personal narratives from the user's perspective. This research addresses two key questions. The first is: Can we design effective visualization tools for daily interactions between individuals and data about their city? The second question is: How can the potential interactions enabled by the understanding of urban data in the context of daily experiences influence a user's perception and usage of the city in ways beyond efficiency?

In order to answer these questions, I propose to build the "Constant Atlas" platform for users to dynamically generate unique atlases of publicly available data(from the Census and other sources) based on their movement in the city. These atlases combine interactive visualizations with the principle of self quantification to contextualize a user's daily behavior within larger datasets. By visualizing users' movements over time, the atlases provide a site for self reflection. The completed platform uses public data to communicate context to the user about the places they frequent, places that are just beyond their routines, and implications of the self-imposed boundaries etched by their daily movements.

**Introduction**

Studies of the behavior of city residents using aggregated data are increasingly common as the ability to capture and process data from various sources have grown. Overarching datasets of the behavior of citizens are often automatically collected through a growing number of digital devices and services. Various projects in the field of computational social science have been productive in using this type of data to solve larger infrastructural problems[Lazer, et al] such as the alleviation of traffic [Krambeck & World Bank, Zhang], optimization of placing smart infrastructures [Link at Sidewalk Labs], identifying changing qualities of "urban attractors" that begat revitalization or development[Berger & Williams], qualitatively evaluating the perception of neighborhoods [Naik, Philipoom, Raskar, & Hidalgo], and even affecting policy in the criminal justice system [Kurgan]. All these projects benefit the individual living in the city by making improvements at large.

Many Urban Planners frame and study cities as complex systems with their own ecology using the movement patterns of citizens[Ciuccarelli & Lupi, Duarte & Ratti] . They analyze aspects of the system by following the traces of data people leave behind as they travel throughout the city GPS enabled devices. GPS as a technology not only facilitates and records our movement in the city, its usage also informs how we perceive places[Rankin].

As daily users of digital devices, we are aware and complacent to a degree that some level of surveillance is implied by the use of digital tools[Young]. However, as digital tools become increasingly entrenched in daily tasks of coordination and communication, it is no longer convenient nor practical to question the roles they serve in recording and aggregating our usage patterns into valuable datasets. Within the landscape of automated collections of personal behavior data, individuals remain data sources, and do not participate in the process of decision making based on the data collected from them. We can however, subvert this technology by making interventions that are individually facing by using GPS to navigate data landscapes as well as physical ones.

There are cases in which we as individuals do use data directly for self monitoring in our daily lives. Devices and applications that measure physical and financial health are common[1]. Self quantification, the use of self data collection to generate insight for self knowledge and assessment is not a new idea. The regular recording of a person's internal and external states have been around since the Middle Ages. However, the extent to which we are now able to record our actions with increasing ease and automation has allowed anyone to create extremely detailed portraits of themselves[Young]. This proliferation of self monitoring technologies is key in the proposed research as I am developing a framework for tracking civic health that combines data about the city with location tracking.

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[1] Fitbit, a fitness tracking device has sold more than 20 million devices as of its IPO in 2015. For financial health, mint.com which monitors spending also has over 20 million users. [www.sec.gov, mint.com]

The Aristotelian belief that we are defined by what we repeatedly do is one that the proposed research shares with the Quantified Self movement. The QS movement promotes "self knowledge through numbers", and uses quantification of daily actions as a site for self assessment and reflection[Wolf & Kelly]. In the movement, the act of self quantification is a process of externalizing internal states through data. My research differs in its use of external data to contextualize and make visible patterns in our daily behavior. Allowing users to view their own behavior through the lens of larger socio-economic datasets is not only informative, contextualization also has the potential to expand the self reflective power of self quantification.

The socio-economic datasets used in this project represent another departure from other types of self quantification. Data of many aspects of our daily lives are publicly available as aggregates through public institutions, government agencies, and the Census. While not as detailed and numerous as data gathered from personal devices and sensors, these public facing datasets can be useful when broken down with geographic specificity for individuals. They can facilitate informed decision-making about places and behaviors for individuals that go beyond their roles as consumers of goods and services.

Data and its representation have been controversial since its earliest use. As the technology to make maps and visualizations become democratized online, visualizations that take complex or large datasets and make them digestible to a non expert audience are increasingly common. Visualization platforms from institutions focused on particular demographic categories have produced public facing data visualizations on topics from race to education. Many platforms also exist to make public datasets digestible by the public[socialexplorer, dataUSA]. However, it is equally important to design tools for individuals that coordinate and communicate public facing data directly with specificity to an individual's experience. Given that we have a greater ability to understand individual experiences through data collected on personal devices, we can begin to engage in personal narratives of data in a new way.

The platform I propose uses an individual's self tracking of location to generate dynamic highly personalized interactive atlases. The resulting atlases' scopes are defined by the user's paths through the city(cities) and is formulated around 3 themes: "rituals", "sightlines", and "intersections". "Rituals" map city data according to a person's daily habitual paths. "Sightlines" create data landscapes out of the user's views from specific vantage points. "Intersections" characterizes frequented locations by examining how a place can be defined by the overlapping, sometimes conflicting boundaries of different datasets. I propose to use public data as a lens through which a user can come to understand the demographic makeup of their repeated daily physical excursions through the places they live, and at the same time examine the implications of the boundaries imposed by those experiences.

Is it necessary for individuals to understand the data collected from them? I propose that it is not only necessary in sense of surveillance and privacy, but personally meaningful and beneficial to create tools that facilitate direct interactions between individuals living in a city and data aggregated from them. The quotidian rituals we perform cumulatively formulate perspectives that impact how we view our environment. It is necessary to understand not only that an individual's experience of the city is unique,

but how it differs and how a single experience resides in the whole. For example, it is important to understand not only that some cities are both diverse and segregated, but how as individuals we contribute to that phenomenon on a daily basis. The goal of this project is to use data to help us understand our roles as individuals in the places we build our lives.

**Motivation and Research Questions**

The proposed dissertation comprises of a set of tools (visualizations and written) that enable individuals to understand their interactions with the city through urban data. The planned research combines the proliferation of self assessment technologies(smart watches, fitness monitors, other personal devices) with data about places to communicate the breadth and limitations of the user's experience based on their daily physical excursions through the city.

Understanding existing large datasets from the perspective of a single person can be powerful and informative. Instead of taking a bird's eye view of the city, an individual human perspective has the



potential to communicate insight as much as a comprehensive dataset. A year ago, I created a twitter bot to share biographies of real Americans by breaking census data into individual rows (Figure 1) [fivethirtyeight.com]. The goal of the @censusAmericans twitter bot was to create an individual presence using quantitative data and use single data points to communicate the larger phenomenon described by the whole dataset. By breaking down monolithic statistics to a diverse sequence of entries each describing just one person, this project communicates data as a collection of individuals. As mini biographies on social media, Census data originally intended for research can become public facing in an everyday context and easier to understand.

**Figure 1:** Tweeter feed sample of @censusAmericans

Some individually focused data projects take the form of a quiz or a calculator where the starting point is the user. For example, in the interactive calculator "Here's Where You Should Live to Find Your Perfect Match", Time Labs uses the user's likelihood of finding a partner as a lens to understand the population distribution of different states[Wilson & Ho]. These interactive formats are important methods of interacting with data because they originate from the highly engaging premise of using data to place where users belong in the world.

An individual's daily diet of information, no matter where they receive it nor how diverse their interests, constructs and reconstructs unique perspectives they take into the world. Our increasing awareness of the effects of media on our point of view is leading to experimentation with technologies designed to let us monitor, understand and alter our consumption patterns. Discussions of the filter bubble have already inspired experimental tools that monitor and sometimes actively challenge our political perspectives [Flipfeed]. Other types of quantitative self assessment through data and sensors measure our mental,

physical and financial health(Figures 2 - 5). The ability to assess one's own behavior through data is increasingly enabled by mass produced wearables and applications.
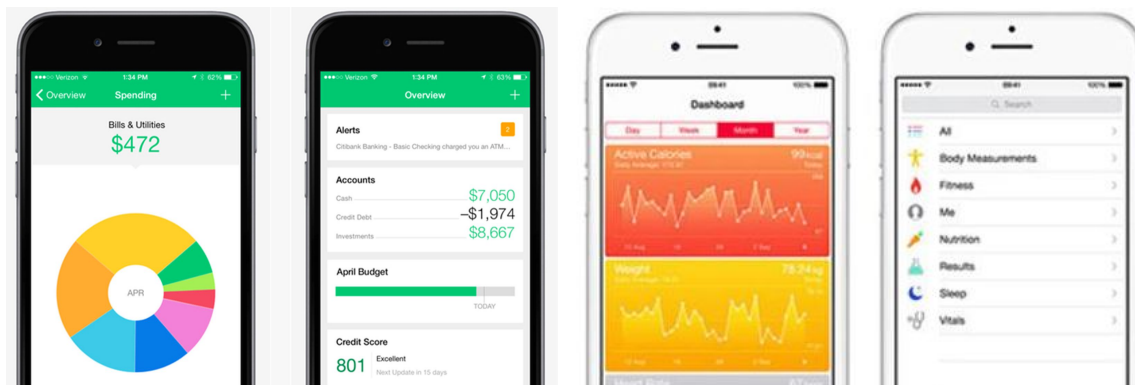


Figure 2 & 3: Mint.com tool for categorizing spending. Figure 4 & 5: iphone's health monitoring app.

Our geospatial diets are as important as our financial, media, and physical ones. Using publicly available data about the city, combined with self-collected data about our own patterns, to assess our geospatial diet is one method of understanding the city from the perspective of the individual. Specifically, self assessment of everyday exposure to the city as understood through data has the ability to inform our experiences, provide contextual understanding, highlight limitations in our experiences, and potentially give us opportunities to balance our perspectives.

This yields two research questions. First, Can we design tools that show daily interactions between individuals and data about the city that are effectively communicative, intuitive enough to encourage repeated use, and able to cumulatively give users an understanding of their environment using data? And second, can the potential interactions enabled by the understanding of urban data in the context of daily experiences influence a user's perception and usage of the city in ways beyond efficiency?

The research to answer these questions draws on the rich existing literature in experimental geography, cartography, studies of cities, as well as related work in narratively driven data visualizations.

**Background and Related Work**

The background research includes works and ideas from five main areas: experimental geography, navigation, experiences and portrayals of the city, atlases in the context of narrative visualization, and self assessment.

*Experimental Geography: Experimenting with Place*

The proposed research draws on the ability of experimental geography to provide a critical lens for people to view their relationship to their environment. Experimental geography deals with the notion that cultural production is inextricably tied to the physical production of space [Thompson, Kastner, & Paglen]. By

building experiences(films, performances, music, instructions), spaces(observatories, ditches, walls, windows, etc.) or tools (augmented reality, maps, gps applications) that alter our perspective of the built environment, works in this field have the potential to bring forth conditions (preconceived notions and behaviors) that otherwise go unquestioned [Woods, Crompton & Kryier, Thompson, Kastner, & Paglen]. Particularly relevant to the work at hand are the maps of critical cartographer Denis Wood, the idea of "geographical intimacy", and the Situationist concept of the dérive(Appendix 1).

Cartographer Denis Wood's atlas *Everything Sings* is important to note. In it, Wood demonstrates the
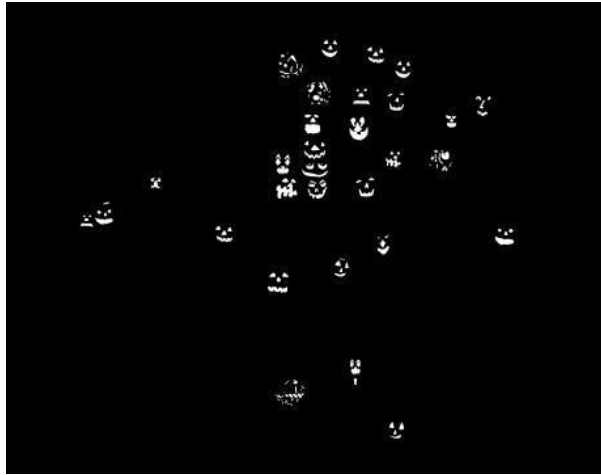


highly selective nature of maps by using formal cartographic language to depict his hometown with idiosyncratic data. In doing so, the top down viewpoint that give traditional maps so much power is subverted by the content. More important to my research, Wood's topics are vernacular, the maps evocative and memorable because they are driven by a slowly formed familiarity with place that is based on first hand experience(Figure 1).

**Figure 1:** Wood's map of his home town according to the jack o'lanterns on porches. The data Wood used to map his town also included the pathways of squirrels.

The experimental geography concept of "geographical Intimacy" captures the ability of some artifacts to contextualize our larger environment. The feeling evoked by the concept is best expressed by facts or stories that have the power to connect the awareness of a small detail to larger phenomenon [Paglen]. For example, the factoid that your fingernails grow at the same speed as tectonic plates move has the power to reduce large global phenomenon to human scale [St. Fleur].

For the Situationists, experiencing the city through daily acts such as walking can be a way to change one's mindset. The practice of a dérive, developed by the Situationists, asks urban residents to become conceptually untethered to daily purpose by physically becoming lost [Debord]. Because of the overwhelming proliferation of GPS usage (1 billion receivers by 2010), engaging in the fields of experimental geography and critical cartography today involves a look at the ways in which we use and subvert technology and data to navigate spaces. How can we best utilize the affordances of having live data constantly on hand and still use the city as a site for self reflection as the Situationists had?

*Reshaping Navigation*

When we use GPS to navigate, our highly directly experiences of the city are enriched by a diverse set of data that is available to us on our phones. This information is often organized by applications using a single unifying coordinate system provided by GPS. The use of GPS is a critical shift in how we understand places. Specifically, applications using GPS has little incentive to contextualize places with

what it deems to be irrelevant, and through it is use, one is able to abstract away real physical features (like trees we literally walk into), while adding virtual ones (metadata and augmented reality) in its representations of places (Figure 2) [Rankin].
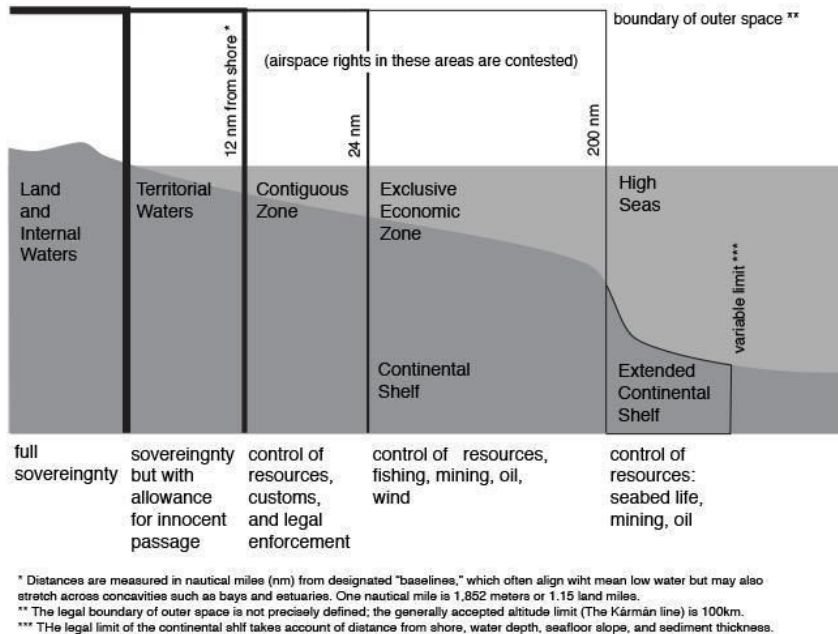


**Figure 2:** Cross section of ocean with limits defined by UN Convention on the Law of the Sea. Reproduced from Rankin. Not only do we place virtual features with GPS in a gaming context such as "Pokemon Go", we also impose very real boundaries virtually where no physical ones can exist.

Through the use of review sites and social media, we have unprecedented ability to contribute to how places are depicted and viewed, but the goals and premise for sharing are often driven by platforms. These platforms inform not only our navigation in the city, but also our destinations. Definitions of place can be massively participatory and manifest in consumer products like Yelp. The proliferation of these same technologies that mediate our experience of places at every turn may be determining not only how we see them, but if we see them at all in the first place.

*The City*

Many experimental geography projects focus on our relationship with the urban environment. While artist and critical practitioners use the city as a tool for self reflection, others take stock of the city in order to understand it as a whole in order to plan for the future.

We have no shortage of theories on how entire cities operate nor of attempts to codify and replicate successful places. Lewis Mumford's 1937 essay "What is a city?" emphasized the shape and size of a city "as a function of social relationships to be served"[Mumford]. Jane Jacobs' advocacy of diversely dense urban environments is no longer controversial, yet how best to achieve them within current systems of planning remains a challenge[Goldsmith & Elizabeth]. Capturing the essence of vibrant neighborhoods is often elusive to those who live outside them[Certeau]. When Lynch conducted his landmark study in

1960 of how residents perceive the city of Boston, he produced a language of nodes and links with which planners can use to articulate cities within particular perspectives[Lynch]. In 1977, Christopher Alexander takes the idea of codifying descriptions of environment a step further to provide a instructional language that allows anyone to articulate their built environment as a part of a larger system[Alexander]. Jacobs, Lynch, and Alexander all relied on direct observation and first hand experiences to construct their views of the city. These formulations are all examples of practitioners attempting to make sense of their environment prior to the introduction of data intensive methods of capturing a place.

Presently, there is a wealth of data-centered studies of cities from the quantitative to the highly qualitative, as well as hybrid perspectives (Lupi, Dubey, et al., Currid & Williams, Duarte & Ratti, Kurgan). The data that is available on a city ranges widely, and are included in both state-sponsored and private endeavors. It is increasingly important to connect these images of the city(both data-driven and theory oriented) back to the people that experience it first hand.

*Atlases and Visualizations as Narratives*

The increasingly complex and creative web-based work being conducted in information visualization today are occurring after a period of proliferation of works in creative and social visualization field [Fry, Viegas, Harris & Kamvar], research in visualization taxonomies[Card, Schneider], democratization visualization through platforms and declarative visualization grammars [Heer, Bostock], as well as the popularization of visual journalism[2]. However, it remains an exciting and overwhelming time to work on visualizing data. As visual and interactive modes of transmitting information takes up a larger space within data consumption, it becomes increasingly important to use visualization as a way to communicate complexity rather than its historical place of erasing it.

Today, as the work in this sphere grows more experientially and structurally sophisticated, it begins to resemble well crafted creative non-fiction literature. As a 2010 study's (Segel & Heer) comprehensive taxonomy of visual structuring and how it affects story shows, great visual and interactive stories are constructed much in the same way great creative nonfiction is written. Authors of visualizations and writing alike negotiate a complex landscape of values and truths in order to communicate to the reader a condition, perspective, or object in the world they were previously unexposed to. The resulting works encourage readers in turn to use their own judgement and sometimes imagination, to draw connections between the characters, places, worldviews, and themselves.

The ability to not only convey, but contextualize information is one of the most powerful qualities of atlases(excluding gazeteers). An atlas assembles a collection of maps with shared geography, timeframes, or themes into one place. Not merely a reference tool, an atlas requires the juxtaposition of individual maps in a highly directed manner from which narratives of various scales often emerge[Wood].

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[2] New York Times, Quartz, Fivethirtyeight, Washington Post, Pew Research are just a few among many trusted institutions that have dedicated and productive visual journalism teams.

> "An atlas is a map of maps, and its editor a meta-cartographer. The editor's primary role in the creation of an atlas is not to draw maps but to make sense of them through the logic or structure of the entire book." - Ackerman

The users of the platform I propose are meta-cartographers themselves, creating highly individual series of maps through their own actions. As both editor and reader, they use the atlas created through their experiences as a tool for self reflection.

*Quantification: Assessment and Reflection Through Data*

The quantified self movement uses self data collection to generate insight for self knowledge and assessment. The movement encompasses self measurement of many aspects of daily life, from food intake, to mood, to air quality(see example Figure 7).
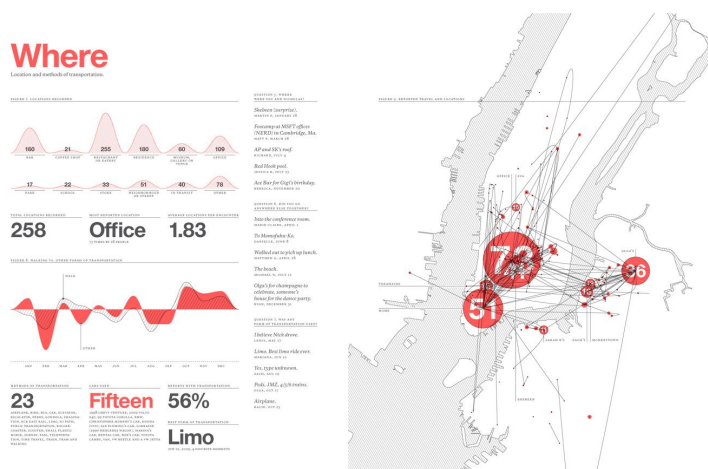


**Figure 7:** The Feltron reports (2005 - 2014) where Nicholas Felton compiles personal annual reports on many aspects of his life  are a notable example self assessment. In 2005 when the first report began, tracking one's habits was a technical and logistical challenge. By 2014 when the last Feltron report was compiled, one's means of transportation, location, eating, sleeping, spending, and heart rates can be recorded through many consumer devices and applications, and be readily available for deep diving and soul searching by any self quantifier.

The relationship between a person and their experience of a city is a slightly different kind of self assessment. Representing and communicating highly individual perspectives of the city show that while spaces and places are shared, experiences do not have to be (see example Figure 8). Moreover, experiences often cannot be wholly shared due to limitations of time, knowledge, interests, and economics.  Highlighting this difference in experiences between each resident of the city is important because it aids our understanding of our place in relation to the whole.

**Figure 8:** Rankin's maps Chicago and Philadelphia represent his unique personal experiences of the two cities. For historian cartographer William Rankin, a city that he calls home is depicted differently from a city without a single familiar face. You may have experienced both of these cities. If told to draw a map of each city using the exact same parameters, you would still have made something that is possibly unrecognizable to Rankin.



No Friends In This Town.
Philadelphia, 2000–2001.

The Same House For Eighteen Years.
North Chicago Suburbs, 1978–1996.

Understanding which slice of the city a resident routinely occupies, and how diverse or uniform their experiences are is yet another type of self assessment. For the proposed project, we use external data about the environment to contextualize a person's experience, and to describe the relationship between that person and a larger community. By using available data that has locations attached to them, we can paint self portraits using the city and our geospatial diets.

Taken together, these five areas of research mentioned above address the potentials for using of a person's physical presence to filter urban data and how interacting with urban data can potentially aid individuals in forming a critical and unique understanding their city and themselves in ways that are useful beyond the utilitarian.

**Research Plan**

*Completed Work*

I have completed background research on the topics of information visualization, mapping, and urban data while a research assistant in the Social Computing group. Most relevant here is the set of approximately 150 maps of 20+ cities contained in the "youarehere" project(youarehere.cc). Within the framework of this mapping project, I have worked individually and collaborate on mapping a range of city data including social, physical, and demographic datasets. Through this process, I have also become familiar with the conceptual work framing visualizations and the mapmaking.

My experience with "youarehere" also highlighted two issues that I hope to address through my dissertation prototypes. The first is the difficulties encountered when converting interactive visualizations for "reading" into tools for use. The second is the overall coherence and cumulative power (and by association longevity) of collections of interactive visualizations.

*Proposed Work*

The first part of the proposed work is conducted through a series of cartographic experiments, culminating in an autobiographical atlas made with Census data and tracking of my own location over an extended period of time(2 month and ongoing). The second part is the construction of a set of tools that enable other users to similarly interact with data based on their own experiences. In conjunction with 3 themes of "rituals", "sightlines", and "intersections", I focus on solving design problems related to the inclusion of flexible units of measurement, the juxtaposition of experiences with data, and dynamic atlas structures.

Themes

The experiments organize diverse urban datasets [Appendix 2]  into the three themes of "rituals", "sightlines", and "intersections", each acting as a lens through which viewers can understand their own interactions with the city.

The goal of these experiments as framed by the main research questions is to situate data within the context of the everyday experience of the individual and design interfaces for their regular use. Therefore, we use "rituals" as a starting point to look at where individuals physically travel throughout the day and the traces they leave out of habit. Through cracks in buildings, and reflected in glass facades, sights in the city are an unpredictable and important part of the daily experience. Our familiarity with the sights we see everyday doesn't necessarily translate into knowledge of those places. "Sightlines" is intended to conceptually orient the views out of our windows into literal data landscapes. Finally, we traverse multiple areas (neighborhoods and other units of measurement) without noticing the conceptual boundaries overlaid on the landscape. Visitors of places can be homogeneous or as diverse as the entire city. "Intersections" highlights the underlying mechanisms that brings different parts of the city to a single place.

### *Rituals*

Ritual maps orient data according to a person's habitual experiences of the city. By orienting data in this way, this group of maps can describe a person's relationship to the city as a whole by addressing the



limitations or range of a person's experience. The city according to a long time resident who never travels above 14th street is entirely different from that of a newlly arrived commuter, or an avid sports fan, or seeker of new food (Figure 9). Most people's experiences will not fall into this extreme, but every resident is nevertheless making their own slices of the city by living in it. What is your experience in terms of demographics, history, and the culture of the city? And how does it compare to others or to the whole? The ritual maps address this question by mapping demographic, quality of life, and other urban data onto the paths you frequent.

**Figure 9:** Zach Seward's heatmap of everywhere he checked in on foursquare over  the course of 1 year in New York City.

### *Sightlines*

The second orients data according to direct sightlines in the city by mapping what you see from where you are standing. There are vantage points with spectacular views of New York City from observation centers atop high towers, platforms on bridges, ferries, new jersey, and many more. Every place has at least three types of distance. Jersey City has a visual distance that is quiet close, it is a familiar background to many of our views of Manhattan, it has a physical distance defined by somewhat convenient transportation, but its conceptual distance from the city is entrenched in demographic divisions and rich in social implications. Rikers Island, a prison in New York City sits in the center of three boroughs and visible to many without being a part of a city. The sightline maps tell you what you

are looking at in terms of data given your vantage point. It reconnects the act of looking to thematic maps that are often divorced from the physical experience of a landscape.

### Intersections

A last lens looks at specific locations as the center of it's own ecosystem. The ecosystem of a bodega is often only a block, a playground encompasses a slightly larger and very different set of characters. A supermarket on Staten Island that seats in an area that are equal parts Clinton and Trump voters describes an entirely different dynamic. The "Intersections" view shows what a neighborhood containing all three and many other characters looks like throughout the day and year. Specifically it highlights an entity according to complementary and competitive entities, connectivity, physical and temporal diversity. It potentially aids the search for locating new entities in the city by describing the existing environment with data.

Taken together these maps are intended to show the marks we leave through mundane everyday activities as trails that mark the larger city. Where we are, what we see, and how we are connected is used here to represent who we are to the city. And it is only with this understanding in mind that we can use our daily experiences and urban data to our own ends.

### Features

Previous studies in interactive narratives have established design principles that increase the effectiveness of information transfer. These methods are "consistency of visual frameworks", using "transitions as guidance", "object continuity", providing "establishing shots", and "tacit tutorials" [McCloud, Segel & Heer, Cleveland]. The proposed experiments utilize the outcomes of prior works, but will also test these methods against the unique needs of writing geospatial, personal, and daily stories. In particular, the work going forward will apply these established methods to incorporate 3 central features. These features are the utilization of new units of measurement, using physical features or experience as orienting concepts to structure data stories, and creating more fluid structures for the integration of multiple maps and visualizations as a collection over time.

### Units of Measurement

The data being recorded about cities range from automated readings of temperature by the National Oceanic and Atmospheric Administration to subjective blog posts about issues as specific as the status and location of a pothole. These datasets are differently constrained by physical, economic, and methodological factors in collection. To understand cities which draw people from surrounding areas, maps of a place must include areas within commutable distances by many different modes of transportation. Many available datasets are calculated according to tabulation areas for government efforts such as the census. The delineation of such areas often ignore, out of necessity, the flow and concentration of people within the area as well as more nuanced observations that do not have a formal function in the government context. Informal or colloquial delineations such as newly named neighborhoods may appear inconsequential, when in fact, in cases of real estate, the seemingly arbitrary

invention of new names for emerging neighborhoods are rich in socio-economic implications. Besides the traditional measurement of metropolitan statistical area, county, zip code, and census tabulation units, new units of measurement have to be named in order to better describe the nuanced data that is available to a city (Figure 10).

Social media data has been used to demarcate areas within a city that have similar characteristics as digitally defined neighborhoods [Anselin & Williams]. Historical units are formed around common heritage such as architectural character or cultural legacy[nypl]. Real estate units are based on the naming conventions derived from real estate trends of areas that have seen population and price increases and demographic shifts. These naming conventions are subjective and often highly contentious [Woodruff & Wallace]. Time based units are determined by the walking, transit, and driving ranges using time distance rather than physical distance. Amenities determined units are formed by a division of different entities such as coffee shops, supermarkets, and houses of worship [Hidalgo & Castaner]. Sides of streets can be divided as separate units because of how places behave differently according to the quality of light they receive. Finally, temporal units share cycles of activity and hibernation, ranging from over the course of a day for businesses to many years for infrastructural change (Figure 11). All these units of measurement can be used to visualize data and provide a more evocative picture of a place. Utilizing the relationship between these datasets and understanding their unique limitations is an important aspect in describing a place with layers and nuance(Figure 12).
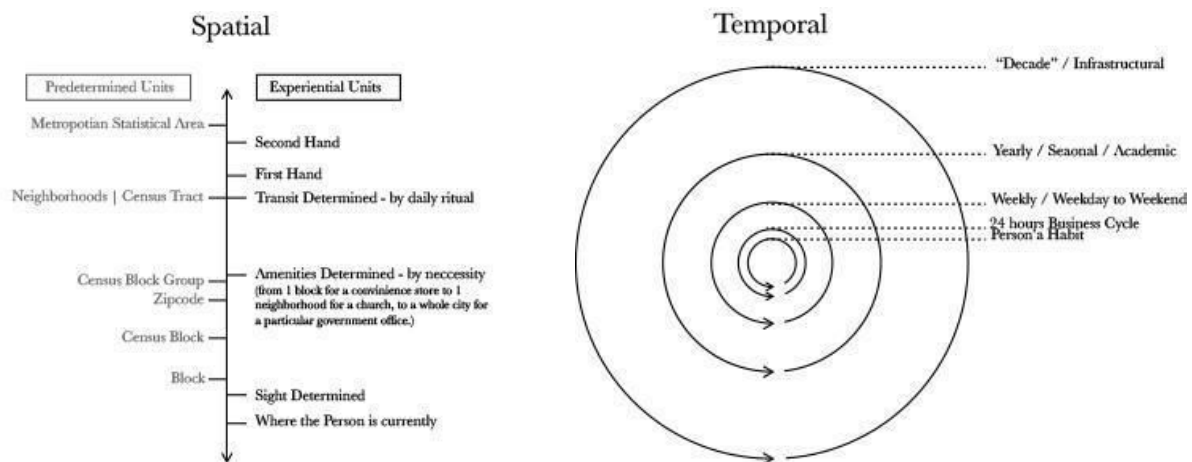


**Figure 10 (above left):** A overview of spatial units as they are matched to experience
**Figure 11 (above right):** A overview of temporal units and their subjects
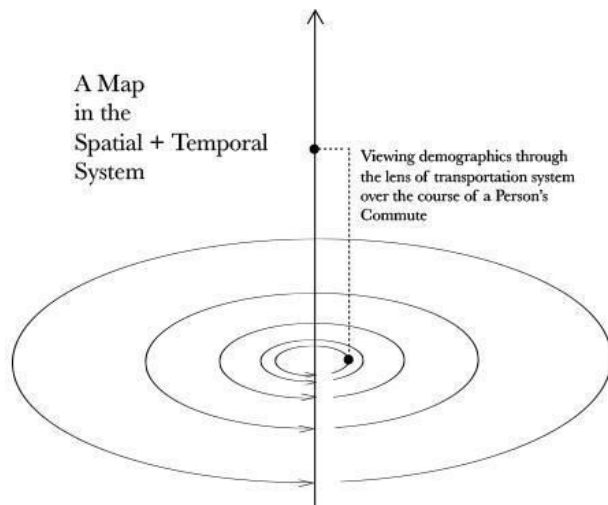
**Figure 12:** An example of how a map is situated in the system, for reference in how maps might be related.

*Juxtaposition and Orientation*

Without clear orienting concepts for representing data, maps of areas often remain abstract, and maintain a broad view. While these are extremely useful for providing overviews, the inclusion of cues from a personal perspective are important to communicating place. We come to know the cities we live in through daily experience, and experience is a useful orienting concept for the organization of data. For example, in the New Yorker map of incomes by subway stop, we can see how the infrastructure of the city's transportation system can be used to provide structure to income data(Figure 13) and tell a different story than an summary map of the city (Figure 14). Similarly, our daily travel experiences can be used to map the data we literally come in contact with. The experiments will focus on how to utilize the paths we cut across cities to provide more relevant and insightful visualizations.
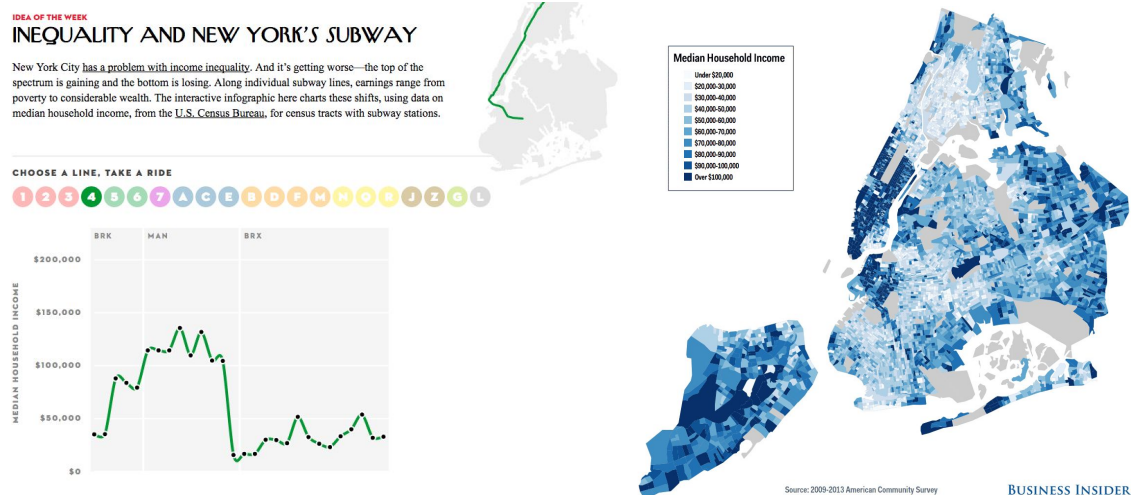


**Figure 13:** Interactive map from newyorker.com using subway system as way to illustrate economic inequality.
**Figure 14:** More traditional choropleth map of income data from Business Insider.

*Digitizing the Structure of the Atlas*

Single maps being produced alongside news stories are often event driven and lack the ability to reflect the complexities of the system view that we prescribe to cities. Interactive visualizations and open datasets remain distinct entities and articles from each other and rarely have cumulative power. In truth, both the visual grammar and the technology exist to support linking of data between a collection of maps in order to make more complex and nuanced descriptions of cities. While ecosystems that allow greater flexibility of interaction between visualizations are possible, variety and efficiency rather than cumulative power is often the focus of such endeavors. These experiments will focus on not only the structures within maps, but also coherence in the relationship between them.

## Initial Experiments

I am currently planning the first prototype and have produced the following experiments.
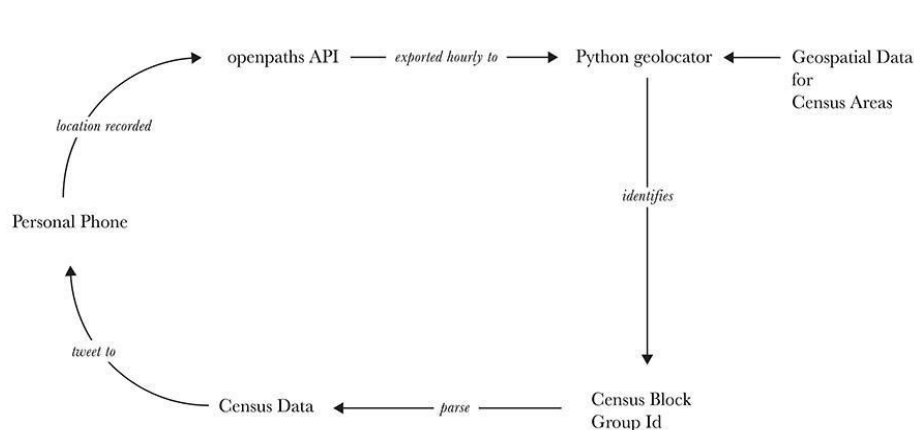


1. Census Data Follower is a twitter application that follows me daily and tweets the demographic information of my location when I go to a new place(new census block group).

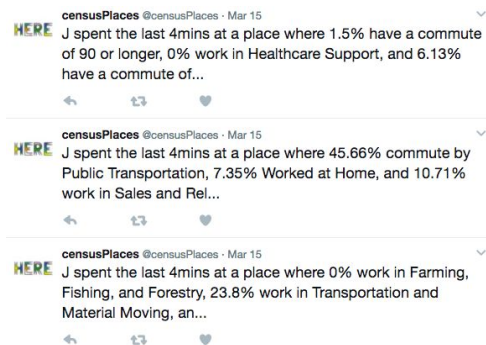**Figure 14:** Overview diagram of twitter application.



**Figure 15:** Sample tweets.

2. Interactive Visualizations

Dataset: The current prototype is using every location I visited over the course of 1 month. Data is being collected in an ongoing tracker to continue this prototype.



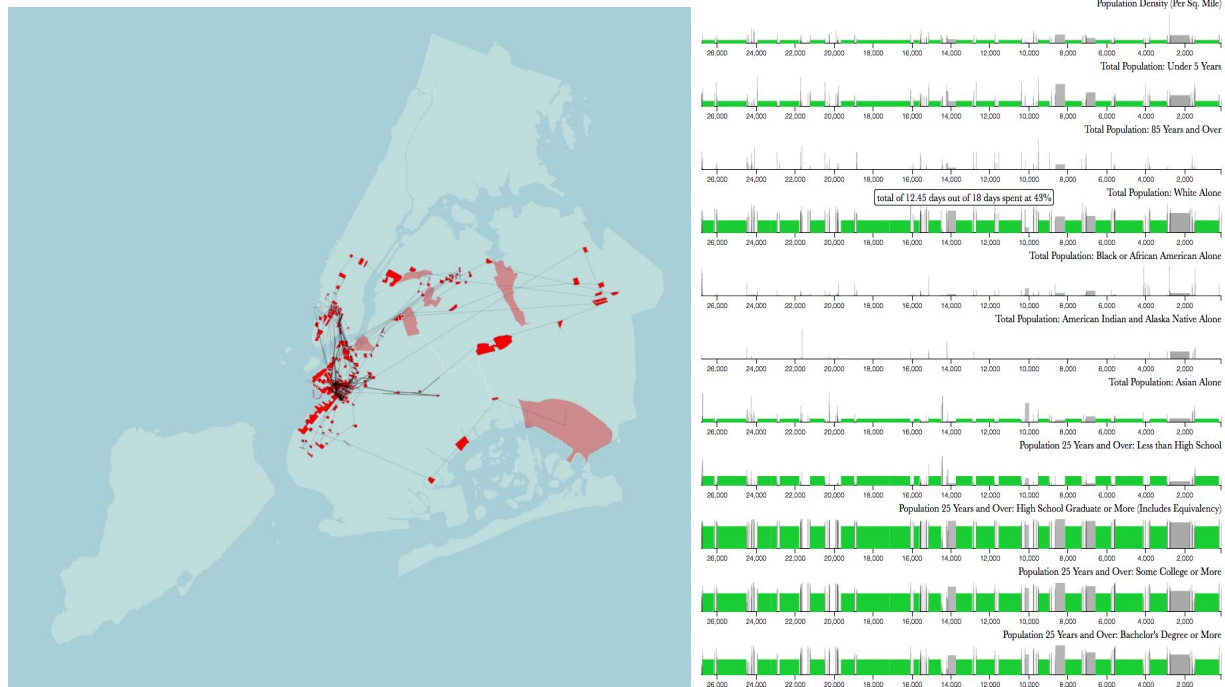**Figure 16 and 17:** Work in progress screenshots **Left:** paths  **Right:** Census data by duration with green highlights on home.
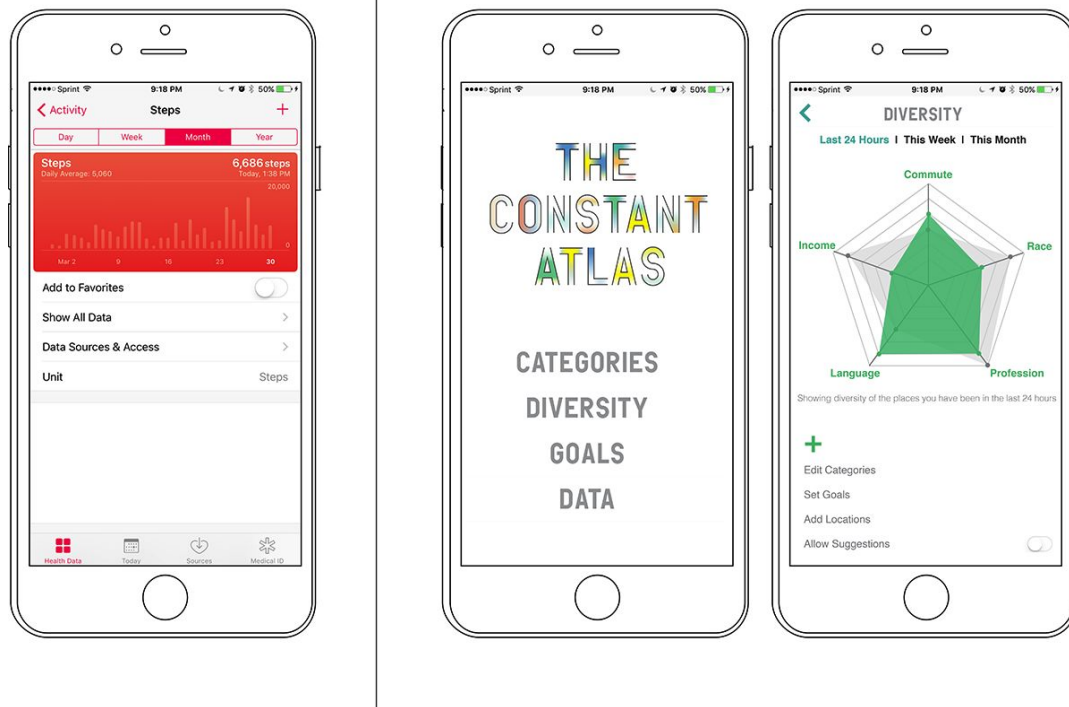


**Figure 18(left):** Interface of iphone health application. **Figure 19 and 20:** Sketch of interface of iphone atlas.

**Evaluation**

Can highly personalized and location specific interactive visualizations of public data be constructive to an individual navigating the urban environment? Traditional evaluation of interactive visualization work have been based on graphical perception and efficiency by task. These evaluations test the speed and accuracy of a user's perception, and the user's understanding of contents[Chen, Cleveland & Mcgill, Rowley, Schneiderman]. The other component of my proposed research is location driven applications, which benefits from field testing. As a result the evaluations process I propose has 2 parts. The first addresses the clarity and accuracy of the visualizations. The second field tests the platform with users by allowing them to generate their own atlases.

*Initial User Test for Visualizations Alone*
To receive initial feedback on the visualization design, users will interact with a small set of visualizations of anonymous location data on a simulated mobile interface. The location data used will come from users currently registered with openpath.cc. Openpath.cc is a platform which provides location tracking for personal devices and collects and distributes data anonymously through an API for research purposes. The goal of the this test will be to assess the clarity and effectiveness of the visualizations to communicate data alone before implementing them on the geolocated application.

Approximately 20 participants will be asked to complete a short questionnaire after interacting with several visualizations on screen*. This user test will be web-based and completed remotely. The questionnaire will first assess basic understanding by asking precise "what", "where",and "when" questions about the visualized data. The questionnaire will then include some questions involving the interpretations of the visualized data such as trends and comparisons [Merson]. In addition, users may be asked for their preferences in other aspects of the designs. For example, whether types of transitions are effective in creating continuity between views of the same data, and if the scales of the establishing overviews are suitable for the tasks of framing the project. The feedback generated from this initial test will be incorporated into the implementation of the later platform.

*Note: Some parts of this initial test may be completed with the assistance of the Accessibility & Usability Team at MIT. I have been in contact with Chris LaRoche, a consultant at the UX center to conduct this user test at the end of the fall semester and will consult him when the initial visualizations are completed and ready for testing.

*Location User Field Study*
To test the application itself, I will recruit approximately 10 participants who are daily users of smartphones(with preference for familiarity with health tracking applications) for a field study. Users will be asked to sign up for a location tracking platform(openpath.cc or others) on their personal devices and to submit their data api keys anonymously. They will be given an unique url through which they can view the atlas that their location data has generated as a web page on screens of their choosing. Users will be

asked to interact with the atlas at least once a day for the duration of 10 days(number of days may change).

Location data is highly sensitive and require careful experimental design. As this field test requires the use of sensitive data, the process will be designed according to guidelines provided by and preapproved by COUHES requirements at MIT. Based on previous experience with conducting field studies at MIT, this approval process may take up to 2 months. The current timeline is to submit a comprehensive proposal as well as be recertified through the COUHES test in mid August to seek approval for the study in September and October.

The web-based form of interactive visualizations allows for extensive data gathering on user interactions. For this study, the data will be collected through built-in features of the application consisting mainly of JavaScript listeners. The listeners will record data on aspects of the user's interactions including time of day, location, length of interaction, features, as well as specific views, settings, and filters used on the data. At the end of the testing period, the data will be analyzed to determine the frequency and duration of interactions, and the popularity of particular data views and features.

*Post-study Interview*
At the end of their field test period, users will be prompted to reset their data api keys for their location tracking service if they do not wish to continue to use the atlas. A in-person semi-structured interview will be conducted with each user. Interviews conducted with the users after their completion of the study focus on understanding of data, ease of use, and reflection on the content.

The interview will begin with basic assessment of understanding, and ask users to explain aspects of the data displayed in the atlas. The main portion of the interview will then address usability by asking questions on the intuitiveness of the interface and the overall presentation of information. Specifically, it is the objective of this part of the interview to understand how successful the atlas was in communicating personalized and location based public data and in what contexts and which views the application was most informative. Finally, users will be asked to reflect on the contents of the application and on the atlas they generated. Specifically, if/how the atlas has changed a participant's understanding of their city, and if/how using the atlas has encouraged them to think about their own routines and behaviors. To end, participants will also be asked if there are additional datasets and data views that would have improved their experience for future development.

**Expected Contributions**
The expected contributions of this dissertation includes the following:
*1. A set of interaction, interface, and structural design principles for building long-form geospatial information visualizations.*

> Spatially and user specific visualizations of urban data aimed at individuals in an everyday context are useful, but remain largely unexplored. Within this dissertation, we introduce principles for designing interactions with data that are driven by individual experience, using a

human perspective to depict the city, focused on self reflection, and for repeated daily use on mobile interfaces.

*2. Stemming from the principles above, the conceptualization, design, and implementation of a digital atlas platform for visualizing the city through public data.*

There are two physical outcomes of this proposed dissertation. The first is an autobiographical interactive atlas composed of experimental interfaces. The second is a set of interactive tools for use by others that provide the opportunity for self reflection through visualization of urban data based on their experiences in the city.

*3. Evaluation and analysis of engagement with urban data and the environment enabled by this new system.*

The final component is the evaluation of the design principles established within this dissertation. The evaluation is done through people's resulting interactions with visualized urban data, and if and how the designed tools have changed a user's knowledge and perception of their environment within their daily routines.

## Timeline

| | |
|---|---|
| 3/2017 - 4/2017 | Proposal Writing and Submission |
| 5/2017 | Presentation Presentation |
| 6/2017 - 8/2017 | Implementation |
| 9/2017 | Data Collection and Evaluation |
| 10/2017 - 11/2017 | Dissertation Writing |
| 12/2017 | Dissertation Draft Submission to Committee |
| 1/2018 - 2/2018 | Revision and Writing |
| 3/2018 | Submission to Committee, Revision and Writing |
| 4/2018 - 5/2018 | Dissertation Defense and Submission |

## Resources Required

1. Storage for data and hosting of platform.
2. Additional resources may be required for developing some parts of the platform.

## Author Bio

Jia Zhang is a PhD candidate at the MIT Media Lab Center for Civic Media directed by Ethan Zuckerman. Prior to joining the Center for Civic Media, Jia was a research assistant and graduate student in the Social Computing group directed by Sep Kamvar also at the Media Lab. Her research resides at the intersection of critical design, information visualization, and cartography. Jia holds a BFA in industrial design from RISD, a MFA in Design and Technology from Parsons, and a MS in Comparative Media Studies from MIT.

**Committee**

**Ethan Zuckerman**
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Ethan Zuckerman is director of the Center for Civic Media at MIT, and an Associate Professor of the Practice at the MIT Media Lab. His research focuses on the use of media as a tool for social change, the role of technology in international development, and the use of new media technologies by activists. He is the author of Rewire: Digital Cosmopolitans in the Age of Connection (W. W. Norton, 2013). With Rebecca MacKinnon, Zuckerman co-founded the international blogging community, Global Voices. It showcases news and opinions from citizen media in more than 150 nations and 30 languages, publishing editions in 20 languages. Through Global Voices and through the Berkman Center for Internet and Society at Harvard University, where he served as a researcher and fellow for eight years, Zuckerman is active in efforts to promote freedom of expression and fight censorship in online spaces. In 2000, Zuckerman founded Geekcorps, a technology volunteer organization that sends IT specialists to work on projects in developing nations, with a focus on West Africa. Previously, he helped found Tripod.com, one of the web's first "personal publishing" sites. Zuckerman blogs at ethanzuckerman.com/blog. He received his bachelor's degree from Williams College, and as a Fulbright scholar, studied at the University of Ghana at Legon.

**Sep Kamvar**
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Sep Kamvar is the LG Career Development Professor of Media Arts and Sciences, and director of the Social Computing group at the MIT Media Lab. His research focuses on how social software can shape our cities, and his lab consists of computer scientists, electrical engineers, mechanical engineers, designers, architects, urban planners, educators, and permaculture farmers—all working together to shape educational, agricultural, and transportation systems in our cities. From 2003 to 2007, Kamvar was the head of personalization at Google. Prior to Google, he was founder and CEO of Kaltix, a personalized search company that was acquired by Google in 2003. He has been a consulting professor at the Institute for Computational and Mathematical Engineering at Stanford University. Kamvar is the author of three books and more than 40 technical publications and patents. He is on the technical advisory boards of several companies, and his artwork has been exhibited in museums worldwide, including The Museum of Modern Art in New York, the Victoria and Albert Museum in London, and the National Museum of Contemporary Art in Athens. Kamvar received his PhD in scientific computing and computational mathematics from Stanford University, and an AB in chemistry from Princeton University.

**Sarah Williams**
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Sarah Williams is currently an Assistant Professor of Urban Planning and the Director of the Civic Data Design Lab at Massachusetts Institute of Technology's (MIT) School of Architecture and Planning

School. The Civic Data Design Lab works with data, maps, and mobile technologies to develop interactive design and communication strategies that bring urban policy issues to broader audiences. Trained as a Geographer (Clark University), Landscape Architect (University of Pennsylvania), and Urban Planner (MIT), her work combines geographic analysis and design. Her design work has been widely exhibited including work in the Guggenheim and the Museum of Modern Art (MoMA) in New York City. Before coming to MIT, Williams was Co-Director of the Spatial Information Design Lab at Columbia University's Graduate School of Architecture Planning and Preservation (GSAPP). Williams has won numerous awards including being named top 25 planners in the technology and 2012 Game Changer by Metropolis Magazine. Her work is currently on view in the Museum of Modern Art (MoMA), New York.

**Appendix 1:** Relevant Terms

*Geo-epistemology* - How we come to know the things we know about a place.

*Quantified Self* - "Self Knowledge through Numbers". The quantified self practitioner uses a variety of digital and analogue recordings to externalize otherwise unseen patterns of behavior in order to better understand and improve on themselves.

*Situationists or Situationist International* - A group formed in 1957 that used performance, instruction, writing and other means of art making to critique commodified culture. For the purpose of this dissertation, the idea of psychogeography is important.

*Derive* - Practice of "continuous drifting" is a foundational situationist practice. It is the practice of removing oneself from daily routine by drifting physically without intention. "In a dérive one or more persons during a certain period drop their relations, their work and leisure activities, and all their other usual motives for movement and action, and let themselves be drawn by the attractions of the terrain and the encounters they find there. Chance is a less important factor in this activity than one might think: from a dérive point of view cities have psychogeographical contours, with constant currents, fixed points and vortexes that strongly discourage entry into or exit from certain zones." - Guy Debord

*Psychogeography* - "the study of the precise laws and specific effects of the geographical environment, consciously organized or not, on the emotions and behavior of individuals." - Guy Debord

**Appendix 2:** Datasets and Themes

*Relevant Data Sources:*

| Community Generated Data | Monitoring Systems | Open Data | Proprietary Data |
|---|---|---|---|
| Blogs<br>Social Media<br>Reviews<br>Images/Shared Photos<br>Geolocated | 311<br>Satellite<br>Traffic Camera<br>Sensors | Census<br>Government Agencies<br>Transit<br>Police Reports<br>Urban Municipal<br>Agencies<br>Streetviews | Mobile<br>Energy<br>Financial Transactions |

*Relevant Data Themes:*

Architectural Heritage

Communities Identification
Connectivity - Internal and External
Education Level and Area
Growth over Time
Housing Quality and Longevity
Perceptions of Quality from Outsiders and Residents
Public Space Availability, Accessibility, Usage
Public Safety Perceptions and Incidents
Quality of Life Indicators in Social and Economic data
Quality of Light and Color
[Kloeckl, Fonseca, youarehere.cc]


**Appendix 3:** Related Work in Creative Nonfiction and Digital Atlases

Creative Nonfiction
**The Marshall Project - Nonprofit journalism about criminal justice**
https://www.themarshallproject.org/
The Marshal Project informs the public of the state of criminal justice system with the methods of biography, event driven reporting, curation, and simulation. Criminal justice as a subject is not only complex and highly politicized, it is also requires combining a substantial amount of background(sometimes archival) work with breaking news.

Stories of individuals affected by the criminal justice system can be seen in 2 sections. A evocative image centered section called "Next to Die" simply highlights down to the minute between the present and the next scheduled execution along with a descriptive account of the person's background. A second individual perspective called "Life Inside" contains first person accounts of lives affected by the criminal justice system. Traditional event driven reporting are produced by an in house staff in the form of short articles. The collection of internal articles are supplemented by a comprehensive curated archive of criminal justice reporting from around the country. Finally, a more experimental approach produces interactives such as simulations on the effects of sentencing and Policy.

These 4 components work together to provide readers with comprehensive coverage of a single complex topic. The project(a website) acts as a single work of creative nonfiction, it strives to remain neutral as a data collection project and at the same time present stories in highly stylized and readable formats with multiple scales and perspectives. With it's combination of old and new, readers are invited back as events occur to use it as contextual reference, to seek out the opinion of domain experts, but also to view the site as a memorial as the next execution approaches.


**Interaction of Color by Josef Albers - App for iPad**
http://yupnet.org/interactionofcolor/
The original Interaction of Color is a foundational text in color theory that has recently been translated into a iPad application. The book teaches readers about how we see color using intricately printed plates that illustrate how colors are perceived in different contexts. For example, a gray square placed in the center of a dark page appears lighter than the same gray square placed

on a lighter background.

The series of comparisons that make up the book invite experimentation, which is what the digital translation of the work has capitalized on. The iPad version reproduces all the original color studies digitally, and in some cases allows users to interact with them to further demonstrate the effects of the original. In addition to interpreting the book into this digital format, the creators of the app also included discussions on color by others, as well as the history of the author and the original work. The object of teaching how colors interact with each other and extrapolate those interactions to the outside world is at the heart of both the book and the ipad app. The book is now read differently and often viewed as a highly prized art object on its own. The app can also be read differently, it creates an ecosystem that is also about the history and theory of the work, providing function that is beyond a tool. For that reason, it is not only highly reusable, but readable as well.

## Thunder and Lightning: Weather Past¨ Present¨ Future by Lauren Redniss and The Influencing Machine∫ Brooke Gladstone on the Media by Brooke Gladstone
Books in print

Graphic nonfiction is a genre of creative nonfiction that I have only recently learn about. Many nonfiction graphic novels are biographical, the most well known being Spiegelman's Maus. More recently, authors have used the format to talk about a range of contemporary subjects from a personal account of growing up in Gaddafi's Libya to a biography of Donald Trump.

Thunder and Lightning is unique in that it is a book about weather. It covers a range of topics from the explanation of basic meteorological phenomenons and the histories of observing them to the implications of our belief systems about weather on the future of our environment. Its author's process is a combination of illustration, archival research, as well as extensive interviews. The author describes her work as a blend of "fact and feeling" that is achieved by the unique method of combining the production of imagery within the process of writing and research.

The Influencing Machine is an illustrated nonfiction book on the state of the media. It discusses central themes in the production and consumption of mass media using studies, excerpts from speeches, interviews, historical documents, as well as first person accounts. Unlike Thunder and Lightning, the author of Influencing Machine is not the sole producer, and divides the book with Illustrators.

Despite their different subject matter and visual style, both work on similar underlying mechanisms. Both of these printed books cover their subject from multiple angles and sources. They are reliable references on their topics, but they are also deeply personal works and highly subjective. I have drawn the following observations from the above and other examples to serve as guide for designing longform interactive narratives. These observations address the ability for projects to act as intermediaries between audience and database, the hybrid and diverse production processes, the design of experiences for different readers, and the longevity of projects.

Digital Atlases
**50 Years of Change**
http://50yearsofchange.com/
Atlases that Describe a History

"50 Years of Change" is a historical atlas that looks at LGBT rights through the lens of legislative changes in the United States from 1963 to the present. The atlas is structured by issue, and each issue is illustrated chronologically and then further divided by state. The interaction of the user is directed to drill down to individual years and states. The driving narrative behind this atlas is chronological and describes both setbacks and progress. Legislative changes have mostly been in the positive direction for LGBT rights, thus also highlighting the states in which they have stalled or regressed. This atlas does not include a call to action or provide summaries of what progress has been made or is needed. As a result, even though it depicts a social issue, it is a historical atlas rather than one that champions a cause or idea.

**Atlas of Emotions**

http://www.paulekman.com/atlas-of-emotions/

Atlases that Explain an Idea or Philosophy

The Atlas of Emotions takes the reader through 5 emotions by associating each emotion with states, actions, triggers, and moods. The structure of this atlas's main component is branching and the goal is to define each emotion through different lenses and not view the emotions as compared to each other. The lenses are presented in a linear fashion from the top down. As emotion is a fairly complicated topic, a section with supplementary materials is also provided but not the focus of the visualizations.

**Elephant Atlas**

https://elephant-atlas.org

Atlases that champions a Cause

The visualization of the Great Elephant Census shows the decline of elephant populations in Africa by country. The Elephant Atlas has 4 equally prominent main sections, detailed reports by country, a queryable database, the context of conservation, and the unique method through which data was collected. This atlas is structured as a standard research paper with conservation as framework, followed by methodology, presentation of the data and its analysis.

**Social Explorer and Gapminder**

http://www.socialexplorer.com/ and https://www.gapminder.org/tools/

Explore, Compare, and Export Atlas Types

Social Explorer is a visualization platform for government data rather than an atlas. Nevertheless, it provides some of the most traditional and intuitive map interfaces with simplified customization tools. The user is able to choose any dataset from the census to map and can compare across different topics or time periods. Gapminder functions similarly by allowing users to explore the data then export their findings with the addition of chronological animations.

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