Memory Tracer & Memory Compass: Investigating Personal Location Histories as a Design Material for Everyday Reminiscence

by

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Abstract

With the massive adoption of smartphone, location trackers, and GPS-based applications, data is being generated that captures people's geographic locations in more precise detail than ever before. These personal location history data archives offer a potentially valuable and overlooked resource for supporting reminiscence on past life experiences. Yet, little design research has explored how location histories can be applied as a material in designing such experiences. I describe the Research through Design process of two novel design artifacts: Memory Tracer is a device that occasionally, yet perpetually surfaces location moments from the past bound to today's date. Memory Compass is a smartwatch application that uses a 'casting' interaction metaphor that enables a user to retrieve and explore location moments from their past, across space and time. I unpack and reflect on key decisions in my design process and conclude with opportunities for future HCI research and practice.

Keywords: Location history; Temporality; Design Research, Reminiscence; Interaction Design processes and methods; Human-centered computing

In memory of my loving grandparents

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I love you Mom and Dad.

Finally, I thank Jesus Christ my Lord and Savior, the guiding voice of the Holy Spirit, and my Heavenly Father from whom all creativity originates. I will conclude with a short quote from a children's book:
"Because when you work or you make something new, you are doing what God has made you to do. You are showing the world what your Father is like—a God who creates to bring people delight." - *The Creator in You* by Jordan Raynor

I am grateful, that for the past 3+ years I got the chance to explore, create, and design things that (hopefully) bring delight into the world.

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List of Acronyms

IxD	Interaction Design
RtD	Research through Design

Glossary

Location Day	All *Moments* from a specific 24-hour day from a location history archive
Moment	A single point from a location history archive; contains at least latitude, longitude, and timestamp among other potential information
Reminiscence	The practice of recalling memories from one's past experiences. In the context of this thesis, reminiscence includes (i) an unstructured storytelling of events and episodes, and (ii) a structured, evaluative process of reviewing past experiences to promote positive self-identity.

Preface

In the early 1940's my Great-Uncle Sam was preparing to be deployed from America to the European front. The only means of communication he would have with his family were letters, which the US military would screen for any sensitive information. Sending word of any location he was at, was strictly forbidden. My great-grandfather, however, wanted to know the general location his son was, if he were to be killed in duty. So, my great-grandfather devised a simple encoded system which allowed Sam to notify the family of his position through his letters.

Two identical letter sized maps of Europe were purchased, and they agreed upon the orientation of how the map would line up with the letter. Each time Sam mailed a letter home, he would place his map on top of the letter, then poke a pin through both the map and letter. This left a pin hole on the letter corresponding to his current location.

Back in Ohio, when the family received the letter, they would place it on top of their map, then poke a pin through the hole in the letter, leaving a hole in their map which indicated the location where the letter was written. The pinhole in those letters was essentially a latitude and longitude, marked on a piece of paper. While to anyone else, the pinhole was unnoticeable and meaningless, to my family it was one of the most important pieces of information in any letter from my Great-Uncle Sam.

At the start of my masters, I remembered hearing my grandfather tell this story to me as a boy. It made me think about how powerful a single location coordinate can be, given relationship and context. This was an initial inspiration to explore what could be done with the many (many) location points we now have saved about ourselves and our loved ones.

Chapter 1.

Introduction

From keeping an old passport to displaying travel mementos to curating a map with pins showcasing locations visited, tracking the places that one goes is a common practice. The capture and recollection of locations visited across one's life can play important roles in supporting self-reflection, social connection, and the construction of memories [3, 4, 46]. As interactive technologies have become woven into the fabric of everyday life, the capacity to precisely capture, track, and reflectively consider places one has historically traveled to has greatly expanded. The convergence of social, mobile, and cloud computing services and increasing ubiquity of location acquisition technologies (e.g., GPS, GSM networks, etc.) have created a world where digital devices and services generate logs that capture a person's location in precise and varied ways [80, 125]. For example, as a by-product of people using services such as Google Maps Timeline [40], a standardized form of metadata is now generated that captures exactly where someone is (and sometimes what they are doing) at any point in the day.

Figure 1.1 Memory Tracer (left) is a device that occasionally surfaces location moments from the past bound to today's date. Memory Compass (right) is a smartwatch application that uses a 'casting' interaction metaphor that enables a user to retrieve and explore location moments from their past, across space and time

While nascent research has shown that location data can aid in the recollection of memories (e.g., [53, 67, 106]) the sheer size and scale of personal location history data that now exists presents new challenges for the HCI and design communities. Location history data itself is largely invisible, often buried in software applications or across online servers and databases. This can cause losses in awareness over precisely what is contained in a one's personal location data, as well as where it is kept as 'it' becomes fragmented across services and devices. Location history data largely lacks a distinct material form and presence which restricts people's ability to casually engage with it as an everyday resource for reflecting on past life experiences [78, 80]. These issues make it hard for people to get a "grasp" on what their location history data is, what is captured within it, and how it might be drawn on as a valuable resource for reflective consideration of places bound to one's past.

The emergence and accumulation of large and continually growing personal location history archives creates new opportunities for people to reflect on places they have traveled to and the role such places played in shaping who they are today. Yet, most contemporary commercial location-based applications emphasize the personalized recommendation of nearby products and services. The productive application of location history data to support open-ended experiences like everyday reminiscence is underexplored in design. In parallel to these shifts, there are calls in the HCI and design communities for research that investigates how alternative forms of personal data can aid people in exploring their life from different perspectives and gain self-knowledge through these processes as they unfold over time (e.g., [30, 49, 75, 100]). However, examples illustrating how such engagements with personal location history data can be mediated through the creation of new design artifacts remains sparse.

How will personal location history archives be meaningfully experienced as they continue to evolve and expand to scales that people have never previously experienced? How might inquisitive, emergent, and ongoing experiences be supported as the data ages over time? What opportunities are there to use personal location history data as a resource for everyday reminiscence on the places and activities bound up in one's past?

To investigate these questions and ground my own thinking in this emerging space, I adopted a Research through Design (RtD) approach [21, 37, 105, 127] over three years where I, along with research collaborators, leveraged my own personal location history data as a design material. I wanted to explore how making personal location history data more materially present or more interactive might open new possibilities for reflection on and exploration of places visited in my past. I also wanted to inquire into the intersection of personal life history and personal location history as aspects of temporality raised by slow technology [45, 76] and how this design-theoretic framing might offer rich ways to support experiences with location data that change over time. The RtD process produced two design artifacts that reform location history data into a material that can be tangibly experienced and lived-with. Memory Tracer is a device that occasionally, yet perpetually surfaces location "*moments*" from the past, bound to today's date from the user's location history data. Memory Compass is a smartwatch application that uses a 'casting' interaction metaphor that enables a user to retrieve and explore location moments around them from their past, across space and time (see Figure 1.1).

Despite exhibiting numerous differences, Memory Tracer and Memory Compass both offer user interface feedback, aesthetics, and interaction qualities that are minimal. This high-level design decision enabled me and collaborators to design for a rich range of open-ended experiences of everyday reminiscence with location history data from a person's past. Following prior research [82], open-ended experiences aim to capture the wide range of reflective, curious, intriguing, and contemplative experiences that can result from encountering artifacts and memories tied to places visited in one's past.

Yet, engaging in the design of both artifacts produced challenges in balancing the sheer quantity and diversity of information, captured in a single person's location history data archive, with the goals of supporting open-ended and evolving engagements. The experiences that I encountered through the RtD process provoked critical reflection on how designers interested in making technologies that manifest personal data in new forms, can support open-ended experiences, like everyday reminiscence. It is these insights that emerged through the making of Memory Tracer and Memory Compass that I reflect on in this thesis.

Through the designing, making, use, and critical reflection on two research products – Memory Tracer and Memory Compass – my thesis makes the following contributions to the HCI design research communities as well as design practitioners in industry. First it offers the first known account of a RtD process of using location data as a design material. Second, it highlights and reflects on particular design qualities of the two research products that, taken together, add to a larger body of research into slow technology and using metadata as a design material. Third, it provides broader suggestions for how personal location data could be better used as a resource for creating technology for reminiscence and reflection. My hope is that this work can inspire designers in both academia and industry of the possibilities of using personal location history data to support everyday reminiscence.

1.1. Overview of Chapters

Chapter 2: Background and Related Work

Chapter 2 presents a literature review of relevant areas. The first section is an overview of reminiscence, location, and technologies of memory. The next section looks at designs which utilize digital records as design materials. The last two sections describe related temporality and interaction design research, along with design-led research in HCI.

Chapter 3: Design Research Process

Chapter 3 describes the methodological framing of the research (in my case a designer-researcher approach), along with research objectives, research questions, and initial explorations into using location data as a design material. Chapter 4 and Chapter 5 are the core of the thesis, describing the two research design products.

Chapter 4: Design Research Case: Memory Tracer

Chapter 4 describes Memory Tracer, a device that invites people to live with and experience their location history data in a gradual and evolving way. The chapter begins by visually showing a condensed version of the progress from the initial design insights to the finished form. Then there is a short scenario describing how Memory Tracer works. This is followed by a collection of key decisions from the design process. I conclude by reflecting on the design.

Chapter 5: Design Research Case: Memory Compass

Chapter 5 describes Memory Compass, a smartwatch app that provides an embodied experience of retrieving personal location history moments based on one's current location. The chapter begins by visually showing a condensed version of the progress from the initial design insights to the finished form. Then there is a short scenario describing how Memory Compass works. This is followed by a collection of key decisions from the design process. I conclude by reflecting on the design.

Chapter 6: Discussion

Chapter 6 discusses implications and findings that came from designing Memory Tracer and Memory Compass. I discuss how both Memory Tracer and Memory Compass leverage pre-interaction as a key element of the design, tools which could aid designers in working with location histories as a design material, and some of the practical challenges of location histories. The chapter concludes with a look at future questions and where the research might go from here.

Chapter 7: Conclusion

Chapter 7 concludes the thesis by providing a reflection on the research questions and contributions.

Chapter 2.

Background & Related Work

Related work falls into four sections: reminiscence, location, and technologies of memory; digital records as design materials; temporality and interaction design research; and design-led research.

2.1. Reminiscence, Location, & Technologies of Memory

Reminiscence is an informal, situated, everyday activity broadly described as "the recall of personally experienced episodes from one's past" [118]. While reminiscence in therapeutic settings is highly structured (e.g., [50]), in everyday contexts these experiences are often spontaneous, idiosyncratic, and open-ended. Everyday reminiscence has been characterized as unstructured autobiographic reflection that is often bound to a location (e.g., a childhood home) as well as life events that can be recurrent (e.g., anniversaries, reunions with loved ones) or singularly unique (e.g., traveling to a foreign country for the first time) [3, 10, 14, 46, 48, 55]. Reminiscence is a valuable practice across age groups that can produce a range of benefits that include self-discovery, maintaining relationships, accepting the past, and preservation of self and familial history [9, 119]. Reminiscentia [10] are triggers that prompt or prime everyday experiences of reminiscence and, while they can be diverse, are most commonly associated with letters and photographs, mementos and relics, places, media, and other people (c.f., [38, 87, 126]). Yet, despite reminiscence being a fundamental part of human experience and having various benefits, it is a practice that most people do not experience as frequently as they would desire [19].

The increasing prevalence of personal digital data, along with a growing interest in HCI toward designing for everyday life, has led to a stream of research exploring how reminiscence could be better supported. One key research area has focused on the creation of new technologies that enable people to attach digital content, such as images or audio recordings, to existing physical mementos (e.g., [36, 73]). Other research has investigated how the acts of capturing and exploring of specific forms of media, such as images, video, and audio recordings, can effectively prompt reminiscence [57, 69, 88–

90, 103, 114]. There also exists a growing body of research that highlights the value of revisiting personal data, including social media, emails, online maps, chat logs, photos, and music to support reminiscence [8, 25, 26, 29, 52, 81, 86, 88, 89, 108, 111, 114]. Peesapati et al. [85] present an exemplar of this approach in the form of Pensive, a system that sends memory triggers collected from previously posted social media content back to end-users paired with reflective prompts. This approach proved effective at supporting "individual, spontaneous reminiscence" [85]. Extending this work, Cosley and colleagues reflect on designing for everyday reminiscence, articulating key opportunities at the intersection of leveraging data that is already captured by people as design resources through re-presenting this past information to them in new forms that can be experienced over time [18, 19].

In the context of location specifically, it is well known that location cues can trigger everyday experiences of recollecting memories [115] and reminiscing [87]. van Gennip et al.'s [38] more recent research found references to location were among the most common and important prompts for open-ended reminiscence experiences. While there exists a range of HCI research investigating locative media and geolocative games (e.g., [5, 92]), only a handful of studies have explored how aggregated location data might support reminiscence. Rewind [106] investigated how a person's location data can be used to reconstruct a first-person point of view video of their movement through space on a given day using photographic data provided via Google Street View. Findings indicated that re-presenting spatial pathways could be valuable in supporting recollection of memories, yet frictions also emerged as precision of Rewind as an algorithmic system could conflict with the interpretive and inexact experiential qualities of reminiscence. McGookin's Reveal [67] application leveraged geo-locative photo data on a user's iCloud account to resurface locationally relevant photos on their mobile phone. This research showed that location histories can effectively support situated experiences of reminiscence and, in this way, suggested new opportunities to explore this promising yet underexplored design space. Finally, Ritual Machine V [11] explored how a parent's location data can be used when traveling away from home to map their geographical place onto an illustrated world that children at home can curiously explore through a tangible near eye device. While not explicitly aimed at recollection of the past, this project does offer early evidence of how making location tangible, embodied, and embedded in everyday life can open new opportunities for rich, ongoing interactions.

The works reviewed here highlight the HCI and design communities' ongoing interest in developing novel ways to support people's experiences of reflecting on the past. Nascent works have begun to investigate new roles that personal location data could play in developing this research area, often through pairing it with visual media. These strands of research make clear that this emerging design space needs more research to better understand the potentialities and limits for location history data to operate as a resource for reminiscence and reflection. I extend this research area through proposing and reflecting on two novel systems that concretely make location history data more embodied and embedded in everyday life.

2.2. Exploring Digital Records as Design Materials

My approach to designing interactions with personal location history data is highly influenced by research that characterizes data as a "*design material"* [12, 76, 77, 82]. Using digital data as a design material can best be understood through the analogy of how a carpenter uses wood as a material. Through use, carpenters become attuned to the physical qualities of wood, and they learn how to manipulate a piece of wood through various techniques of cutting, joining, and sanding to craft it into something new. In the same way, designing with data as a *design material* seeks to use data as a resource for creating a new interaction. The aim is to understand the nuance and limitations of the data, the potential forms in which it could be expressed, and ultimately explore what can be created using it.

As evidenced by the Quantified Self movement [95] in the last two decades, there has been a proliferation in the amount of personal data which can be recorded about one's life and the number of people recording vast amounts of precise data about their day to day lives [64, 123, 124]. The Quantified Self movement is succinctly summed up in its motto: "self-knowledge through numbers" [95]. It proports that the data intensive way of tracking many different aspects of one's life, behaviors, and activities can be helpful for the purposes of reflection, self-improvement and self-knowledge. Lupton critically examines this trend and notes the variety of personal benefits the movement promotes, but she also notes potential downsides of how this personal data can be used for commercial, governmental, and research purposes that do not have the creator of the data in mind [64].

In parallel to the Quantified Self movement, there has been ongoing interest in the HCI community around how personal data and metadata might be mobilized as a design material. For example, through the Curatorial Agents project, Gulotta et al. propose that metadata related to time or location can be considered highly important contextual factors “that help situate digital information [for] evocative, meaningful, or relevant experiences” [43]. This research, along with a trajectory of related work on digital possessions (e.g., [20, 32, 80, 97, 98]), opened opportunities for seeing data, like location histories, in a new way – not solely as a by-product of using systems that passively track one’s life, but rather as a design material for supporting new ways of viewing one’s past from alternative perspectives.

Building on many of the works outlined above, Elsden et al. critiques the notion of the Quantified Self movement and argues there is a need for future research to investigate the design of interactions with personal data that expand beyond “an exclusive interest in performance, efficiency, and rational [self] analysis” [31]. These authors make a compelling case for inquiring into how alternative representations of personal data can help people see their life from different perspectives and gain self-knowledge through this process over time. They argue interaction design must expand to include an emphasis on creating personal data “representations that support multiple perspectives rather than reductive explanations” and which embrace “the often complex and ambiguous relationships [we have] with our digital records” [31]. Elsden and colleagues assert the place of personal data collected through passive tracking applications remains unclear and more research is needed to understand how such records can be transformed into design materials that reinforce human agency through new forms and interfaces [32].

My work seeks to directly build on this prior research and contribute a reflexive design-led case investigating how location history data can operate as a rich design material for supporting open-ended experiences of reflection on places bound up in one’s past. Beyond work that has come before, I investigate location history data as a material in-and-of-itself to better understand it in relation to design practice and how it can be given new forms and interactions.

Considering the scale and depth of different points in time that are captured in a one’s location history archive, my research is also influenced by prior works on designing for temporality and slowness. In their original works on slow technology, Hallnäs, Redström, and Mazé argue that design practice must expand to create "technology that surrounds us and is a part of our activities over long periods of time" [45] and inquire into "what it means to design a relationship with a computational thing that will last and develop over time" [65]. These works brought attention to the need to consider time and temporality as more central generative qualities in interaction design research targeted at everyday life. Extending this work, Vallgarda and colleagues [113] frames temporal interaction as aiming to "slow down the expressions of computations enough to let us experience them." This statement is foundational to their argument that interaction design practice ought to be considered through a set of relations among physical form, interaction gestalt, and temporal form [112]. In parallel, Pschetz [93] makes a compelling argument that it is essential for design research to inquire into generating new possibilities for people to perceive and consider multiple temporalities. Yet, Pschetz and colleagues [94] also caution that, while well intentioned, projects aimed at designing for slowness may result in an oversimplification of the dichotomy between fast and slow by treating 'time' as solely a matter of pacing. They highlight the need for research that explores temporal diversification through design and people's lived experiences of it. A handful of nascent design research projects have illustrated different ways slow pacing or temporally diverse interactions can be effective in supporting revisitation and reflection on the past, most notably with photographs and music [17, 75, 83, 109]. Yet, to date no known research has explored this framing in relation to personal location history.

My research aims to contribute to these strands of research on slowness and temporality. I want to inquire into how digital history tied to locations can be explored as an aspect of temporality in slow technology. Exploring this framing may offer rich ways to support unstructured, curious, and embodied experiences of reminiscence with personal data that changes over time.

2.3. Temporality and Interaction Design Research

Considering the scale and depth of different points in time that are captured in a one's location history archive, my research is also influenced by prior works on designing for temporality and slowness. In their original works on slow technology, Hallnäs, Redström, and Mazé argue that design practice must expand to create

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2.4. Design-Led Research in HCI

There is an ongoing interest in the development of new knowledge through the construction of design artifacts in the HCI community. Fallman [33] argues the core activity of design research is giving form to previously nonexistent artifacts to uncover new knowledge that could not be arrived at otherwise. Researchers such as Gaver [37], Sengers et al. [101], Zimmerman & Forlizzi [128], Bardzell et al. [2], Stolterman and Wiberg [105], and Wakkary et al. [116], among others, have articulated design-oriented approaches that are united in their emphasis on the act of making as a means to critically investigate emerging issues in HCI research. Most recently, a diversity of design research continues to emerge that closely attends to the processes of creating design artifacts [1, 7, 21, 34, 51, 70, 91, 107, 117]. Collectively, these works highlight the need for more examples of reflexive design-led research to develop a foundation from which future concepts, methods and theories can be developed.

My work modestly attempts to bring these different strands of research together. I want to investigate how technologies might be designed to embody alternative expressions of personal location history data that can support ongoing experiences of reflection and reminiscence that can evolve over time. I do this by grounding discussion around the design of two highly finished design artifacts that, in quite different ways, aim to make concrete new ideas for using data as a material to support diverse ways of interacting and living with one's own personal location history archive.

Chapter 3.

Design Research Process

The approach to my research inquiry originates with and is tied to design-led research in HCI. I adopt a designer-researcher position that gives prominence to first-hand insights emerging through the creation of real things that materially ground conceptual ideas through their actual existence—"a process of moving from the particular, general and universal to the ultimate particular – the specific design" [71]. Designer-researchers often function as a small but multi-disciplinary team that is reflexively focused on the experimental and novel outcomes of the design process that are critically and reflectively arrived at through design practice. Thus, design research can contribute a highly insightful, first-hand, and reflexive view of practices of making design artifacts in relation to higher-level concepts framing key decisions in the design process and in light of materials, tools, methods, and competencies.

While there are some overlaps in my work with the autobiographical design approach, my aim in this work is not to offer an in-depth autobiographical accounting. Autobiographical design is the process of living with a design over an extended period of time and conducting a proper user study on oneself [72]. As part of my process, I did need to live with these two artifacts as I was iteratively building, making, and creating them to gain insights into potential experiences of reminiscence. However, I did not conduct an autobiographical design study. Thus, my approach, reporting, and accounting of the design research process is more closely aligned with the design journey approach [23, 27, 54] . With this approach the journey of a design process is accounted, and key moments of frictions, tensions, and design moves are reflected on.

I, along with research collaborators designed Memory Tracer and Memory Compass to explore potential future interactions and experiences with location history data in everyday life and the role it might play in supporting reflective consideration of places visited in one's past. I aimed to create devices that might contrast the utilitarian qualities of many everyday products, to give rise to open-ended experiences of reminiscence, contemplation, and curiosity. My design research process is highly influenced by conceptual propositions from the slow technology design philosophy [44, 45, 65] because I am interested in exploring personal life and personal location histories as aspects of temporality. My design attitude is most specifically shape by the propositions that slow technology is a technology that requires time to understand and changes through time [45]. To investigate different parts of the design space and inspire my design-led process, I am also interested in mobilizing the somewhat oppositional design qualities of *implicit slowness* – a quality where the end user is able to freely control the design artifact while it still retains its 'slow' reflective character – and *explicit slowness* – a quality where the design artifact operates on its 'own time' and the pacing cannot be changed or modulated [76].

With this in mind, the development of Memory Tracer and Memory Compass consisted of the following. Over the course of three years, I reviewed theoretical literature, studies, and a range of design works. Similar to Schön's notion of design as a conversation with materials [99], I engaged in a reflexive dialogue with theoretical and design materials, and iterative development and critique of design concepts, to arrive at the Memory Tracer and Memory Compass designs. The studio environment and culture in which I designed and created supported me to experiment with digital prototypes and physical forms iteratively and simultaneously. This process enabled me to reflectively examine the interplay among interaction, interface, physical form, and materials, and their individual and collective relation to my conceptual framing.

I have formal education and training in computer science, interaction design, and industrial design, but I immensely benefited from collaboration with other researchers. Over the entire course of my thesis research, I worked closely with my supervisor Dr. William Odom on everything from higher-level conceptual framing, down to nuanced decisions of the interaction design. We met regularly to hold informal design critiques of the current state of the work. I also often worked with Nico Brand on the interaction design and visuals of both research products. Ce (Kimi) Zhong assisted me with the form, materials, and industrial design of Memory Tracer. Throughout my research, I was a member of the Everyday Design Studio, a research design studio. I was surrounded by other talented peers with expertise in graphic design, digital fabrication, industrial design, electronics prototyping, software development, and user research. Throughout the research, I occasionally sought their assistance on aspects of the design and making.

I primarily leveraged my own 5-year-old location history dataset from Google Maps Timeline throughout this research and draw on my own experiences with the two research products. Obviously, there are limitations to this approach. It cannot be assumed that my experiences of reminiscence with the research products will scale to others. My experiences may be unique to my data, travel history, or the way I think about and remember places. However, by using my own data to design with, I was provided access to a dataset that would otherwise be very difficult to access. It gave me the ability to quickly and iteratively see which designs sparked everyday reminiscence and which did not.

I documented the design process as it progressed and annotated key design decisions relevant to the conceptual framing as I moved toward highly robust and finished artifacts. This thesis offers an account of the design process; however, it does not aim to report on every design decision. I offer a post-mortem accounting that attends to specific design decisions that were productively shaped by key higher-level concepts, as well as cases in which frictions emerged.

In the next chapter, I detail my initial research into working with location history data as a design material. I then introduce Memory Tracer and Memory Compass and offer a synthesized account of key design decisions.

3.1. Research Objective

3.1.1. Research Questions

1. How will personal location history archives be meaningfully experienced as they continue to evolve and expand to scales that people have never previously experienced?

2. How might inquisitive, emergent, and ongoing experiences be supported with them as they age over time?

3. What opportunities are there to use this personal location history data as a resource for everyday reminiscence on the places and activities bound up in one's past?

3.2. Working with location history data as a design material

I decided to focus on Google Timeline as the platform to collect and work with location history archives for a few important reasons. First, the service is robust; it constantly tracks the user's phone giving a continual dataset of locations. While many apps such as Strava, Nike Fitness Club, and Slopes track location during a specific activity, Google Timeline is always tracking in the background. Second, the service is available in one of the most widely used apps ever: Google Maps. And the feature has been around since 2015 [41] with a similar feature called Location History limitedly available since 2013 [129], making it possible to engage with large archives of continuous location data. Third, it is relatively easy to access one's own data through Google Takeout (Google's service for downloading account data). Fourth, Google not only collects latitude, longitude, and timestamps, but it also generates semantic location data by inferring activity and location place names.

However, this decision did come with trade-offs. There is no easily available API to work with Google Timeline data. It also requires a 3rd party corporation to store immense amounts of personal geographic whereabouts on their servers, something many are not comfortable with. A different kind of limitation is that Google Timeline obviously will not contain 'all' locations a person has visited in their life. Only ones where the feature is enabled on an internet connected phone. However, it is likely the most substantive data set of location history that any person has on themselves. It offers a continually growing location history data archive contained within a widely adopted service that is already becoming a major type of personal data that individuals accrue over time.

```
{
    "timestampMs" : "1492552922083",
    "latitudeE7" : 372242977,
    "longitudeE7" : -804198727,
    "accuracy" : 19,
    "activity" : [ {
      "timestampMs" : "1492552924862",
      "activity" : [ {
        "type" : "STILL",
        "confidence" : 100
        } ]
    } ]
}
```


Figure 3.1 A "*moment*" from my Google Timeline archive

Working with location history data as a design material to support everyday reminiscence was not immediately straightforward. I have recorded my location via Timeline for the past 5 years, which I directly drew on to support the design research inquiry. The raw downloaded Timeline data from Google consists of a JSON file with a single array of objects that I dubbed "*moments*". Each moment is an object that always includes a timestamp, latitude, longitude, and accuracy value. Some moments also contain various other information (see Figure 3.1). I dubbed a "*location day*" the list of all moments that took place on a given day.

An unexpected encounter during the design process emerged when Google updated the downloadable Timeline data to also include a semantic location history which generates either an "Activity Segment" or "Place Visit" depending on the movement of the phone and the time and distance between location points. Another change was the array of moments no longer contained "activity" information and the format of timestamps was altered. This required me to adjust and refactor my code for parsing, classifying, and surfacing moments from the archive.

The sheer amount of location data available made it challenging to work with at times. At the time of this writing my location history contained 56 months and over 130,000 unique *moments*. While I explored design ideas related to interaction and form in parallel, an important early decision was to develop working software that could help me explore the possibilities of this data. I began building crude prototypes and software scripts to help "get a handle" on what could be extracted from the data and the kinds of interactions and forms which might be possible (during this initial process, the location data from Google only consisted of the list of moments). What follows are key insights I drew from this initial prototyping process, which further built the design space and ultimately shaped the form of Memory Tracer and Memory Compass.

3.2.1. Early Explorations with Location History Data

The first phase of my design process was characterized by frenetically developing Python scripts and experiments that enabled me to begin to grasp potentialities that location history data may hold. I began by generating relatively simplistic scripts that enabled me to infer different possible themes and insights. For example, by adding the total distance between coordinates on a given day, I could figure out which days I travelled for trips. These days and locations often were bound to numerous specific memories that require no other stimuli to evoke, other than this raw information. Conversely, I also was able to generate a list of the cities I most frequented. This script did not spark specific memories but primed my recollection of many different memories across time and place. I ran the location data through different APIs to extract additional information such as weather, point of interest, and address (at this time in my design process, the “Place Visit” semantic data was not provided by Google). This script, coupled with inferred activity, provided an output something akin to: ‘biking for 2 hours on a sunny Sunday afternoon in San Francisco.’

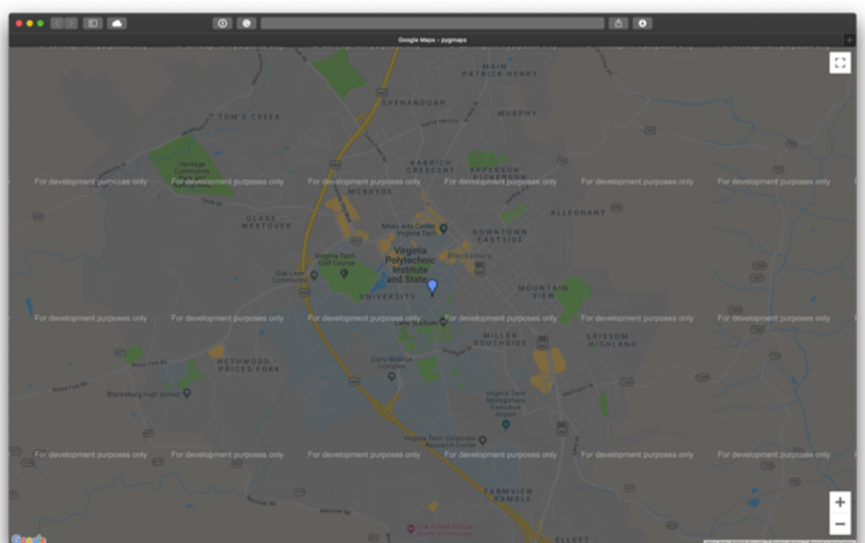

Figure 3.2 I found that mapping a single moment from today's date in history could spark a memory

During this process, a key insight emerged from a specific Python script I designed that mapped a random moment from the current calendar date but from a previous year. After running it a few times, I could see a few different points throughout the day. Through testing it on myself, I subsequently found that mapping a single moment from today's date in history could spark a memory (see Figure 3.2). Clearly this approach has similarities to Facebook, TimeHop, and Apple Photos' 'On This Day' features that pair a 'day in history' with photos taken on that day. Yet, even early on, I found that not having a single photographic representation, but rather simply a locational point in my past shown on a map could stimulate diverse, and at times multiple, memories and reflections to be trigger. For example, in some instances, a randomly surfaced moment would spark a memory of a specific trip when it landed on an interstate roadway or one-off location. Other times it would spark a collection of memories when it landed at the location of a weekly activity. And many times, it landed in an area that I frequented almost daily, sparking and amalgamation of memories which were often not related to the current date.

In parallel I began exploring how to tangibly represent location data. While I came up with several physical prototypes, none felt right for the kind of open-ended qualities I wanted. Most required knowledge of locations previously or frequently visited to build the device. I wanted something tangible, yet something that could work for anyone's location history, not needing to be specifically designed for each user. While most initial prototypes were scrapped, the explorations helped me know the kinds of qualities I wanted. One prototype that sparked a lot of discussion between me and other collaborators was a sand tracer, that could trace out a pattern in sand (see Figure 3.3). The quality we liked most about it was the continual and slow reveal of an aesthetically pleasing pattern over time. We were intrigued by how a slow reveal of a pattern could represent a moment being surfaced from the archive.

Figure 3.3 Sand tracer prototype would trace out a pattern representing "today's" location data

Another early script I designed explored returning moments near a particular location. After inputting a location, the script would calculate and return all moments in serial order of the distance away from that location. The ability to see all the moments regardless of time but in relation to a particular location triggered my next design move. I prototyped an app that enabled me to ‘cast’ out a discrete distance in a defined orientation. Wherever the cast landed, it returned the nearest photo to that point from my photo library (see Figure 3.4). This prototype sparked further ideas for a more embodied interaction that could be situated within a user’s everyday life that enables them to explore their past based on their current location and direction.

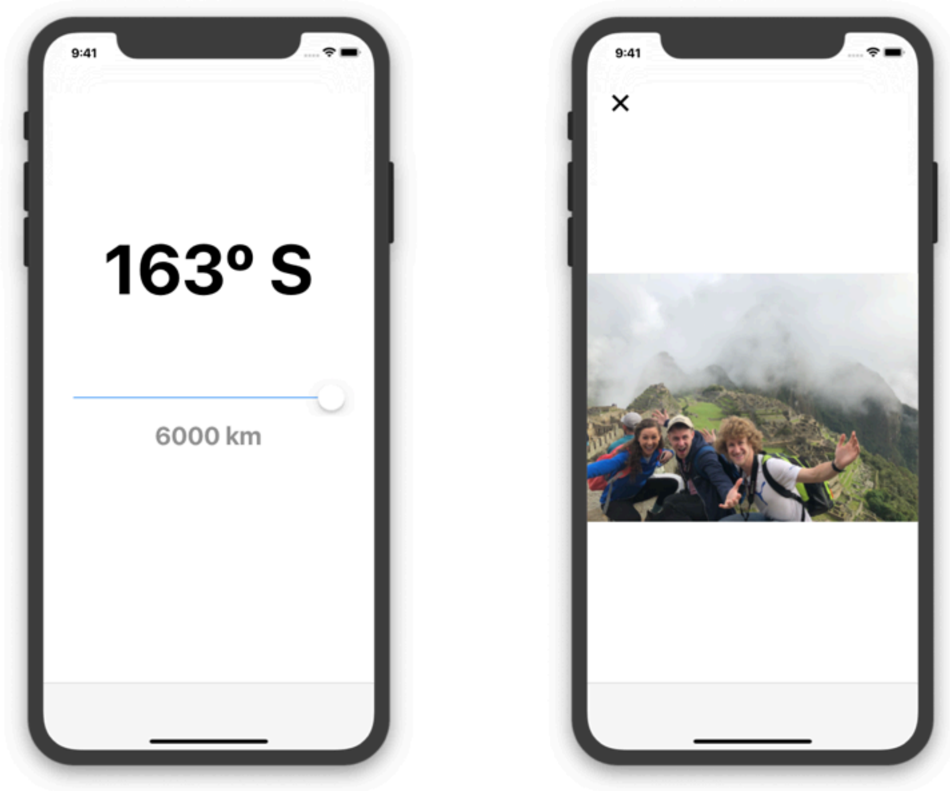

Figure 3.4 Photo Compass prototype allowed 'casting' out in a certain direction and distance to return to the nearest photo to that point, from your photo library

Collectively, insights revealed through these early explorations provoked me to use only location history data as the sole material in the design inquiry; and not merely treat it as a "connective glue" for other kinds of data. The initial design initiatives of working with location history data as a design material to support the open-ended everyday reminiscence seemed laudable. Additionally, I was interested in how the 'limitation' of only using location history as a primary form of data could push me, on creative, conceptual, and practical levels.

Chapter 4.

Design Research Case: Memory Tracer

This chapter describes the design of Memory Tracer. It begins by visually showing a condensed version of the progress from the initial design insights to the finished form. Then there is a short scenario describing how Memory Tracer might be used and experienced in everyday life. This is followed by additional details of the interaction design. Next, I interweave a description of retrospective reflections that provide insights into how these key design decisions were made in dialogue with my higher-level conceptual framing. I conclude with reflections on conceptual elements of the interaction design as well as personal experiences using the device.

4.1. Memory Tracer: The Design Process

In this section, I visually highlight and annotate the main progressions from the initial design insights through to the final form (see Figures 4.1 – 4.13).

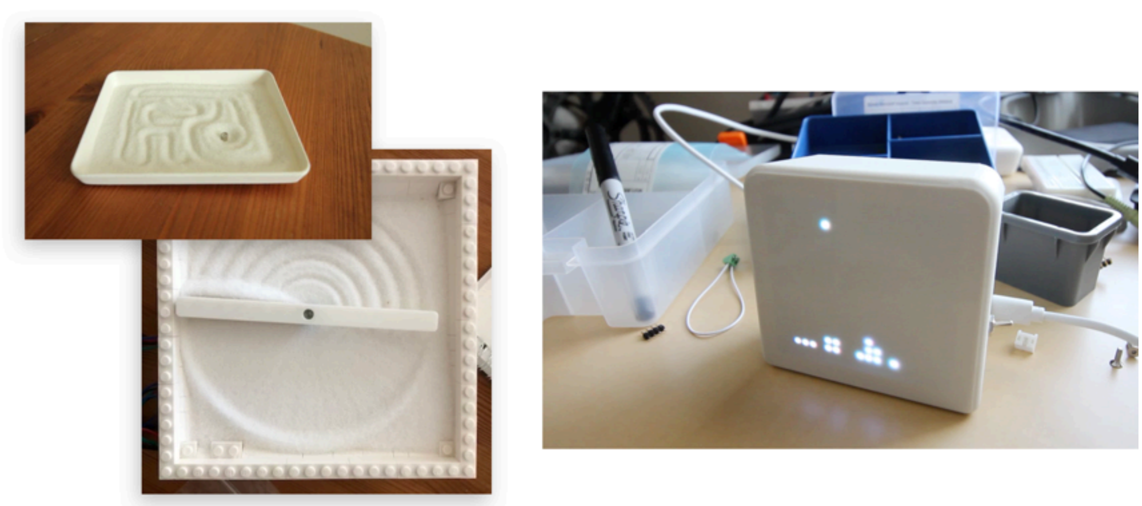

Figure 4.1 Early in the design process, I moved away from the sand tracer concept (left) towards a LED display and 3d printed enclosure (right). This form was easier to work with and had a much higher fidelity output.

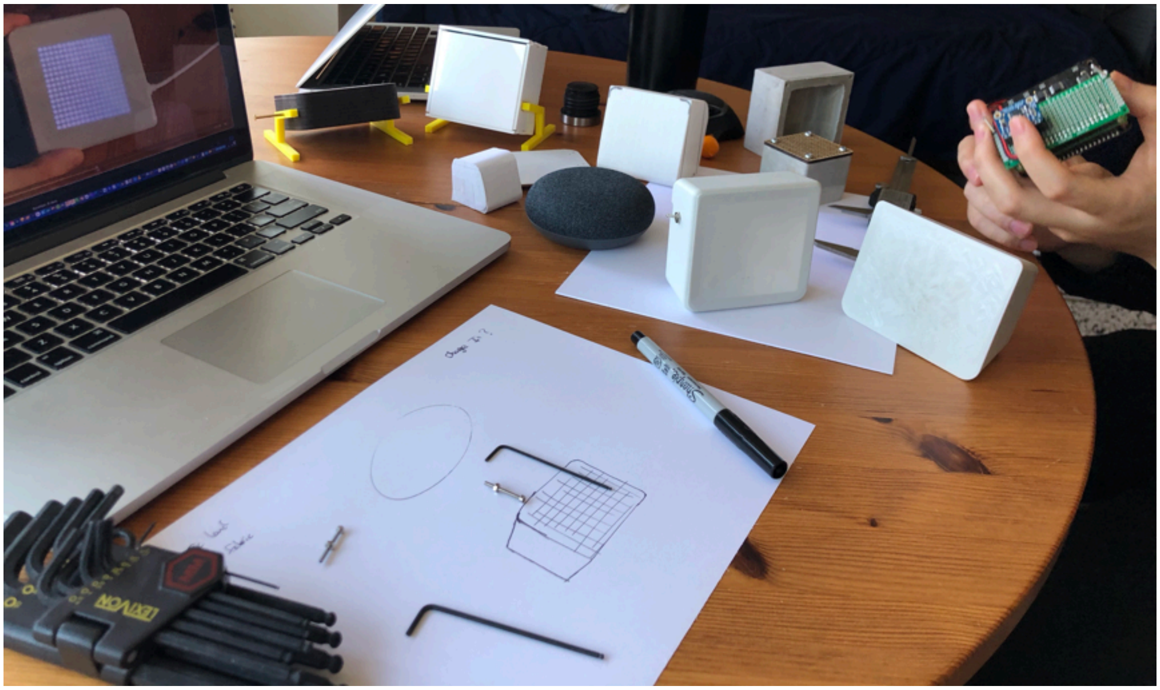

Figure 4.2 However, the 3D printed form felt too cheap and typical of common consumer technology. Thus, I kept designing and exploring different forms.

Figure 4.3 This form was the next major iteration. While it had a more pleasant aesthetic, it still felt very “screen-like”. It did not feel like something that could be lived with, over extended periods of one’s life.

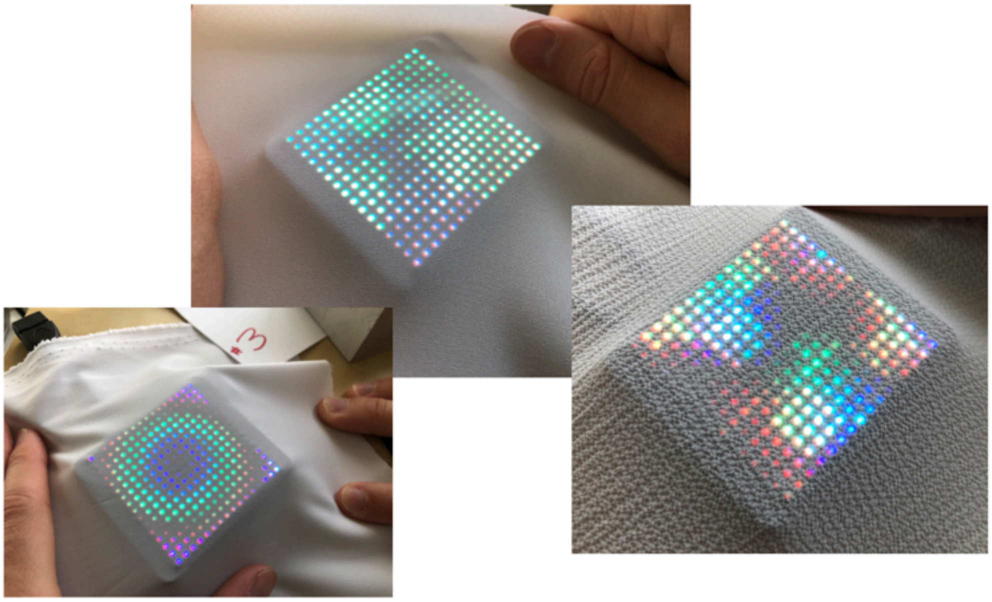

Figure 4.4 I began exploring different materials that could be used to diffuse the light, in particular fabric.

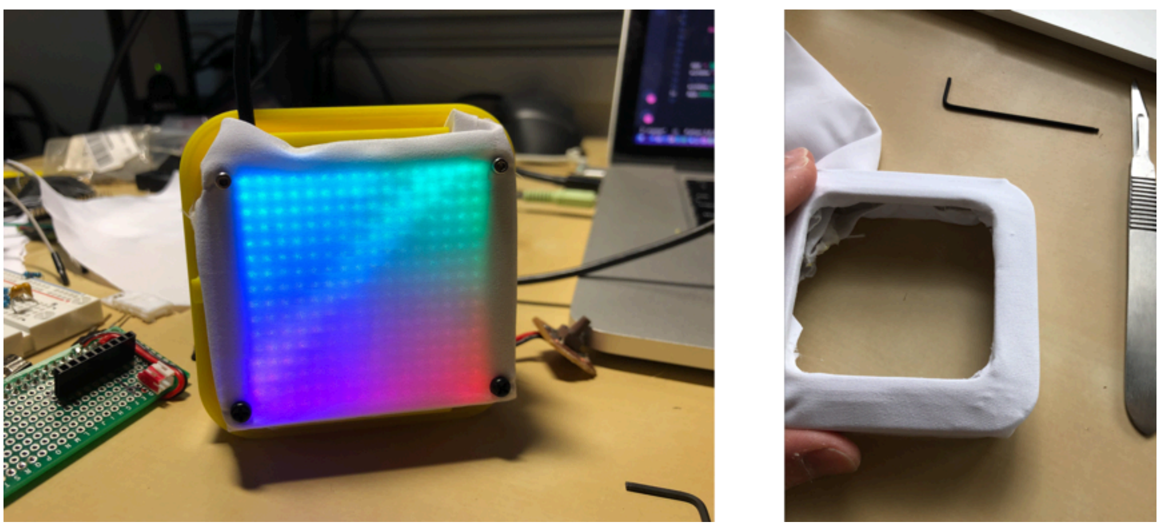

Figure 4.5 While the fabric visually looked nice with the light; it was difficult to integrate the fabric with the rest of the design in an aesthetic way.

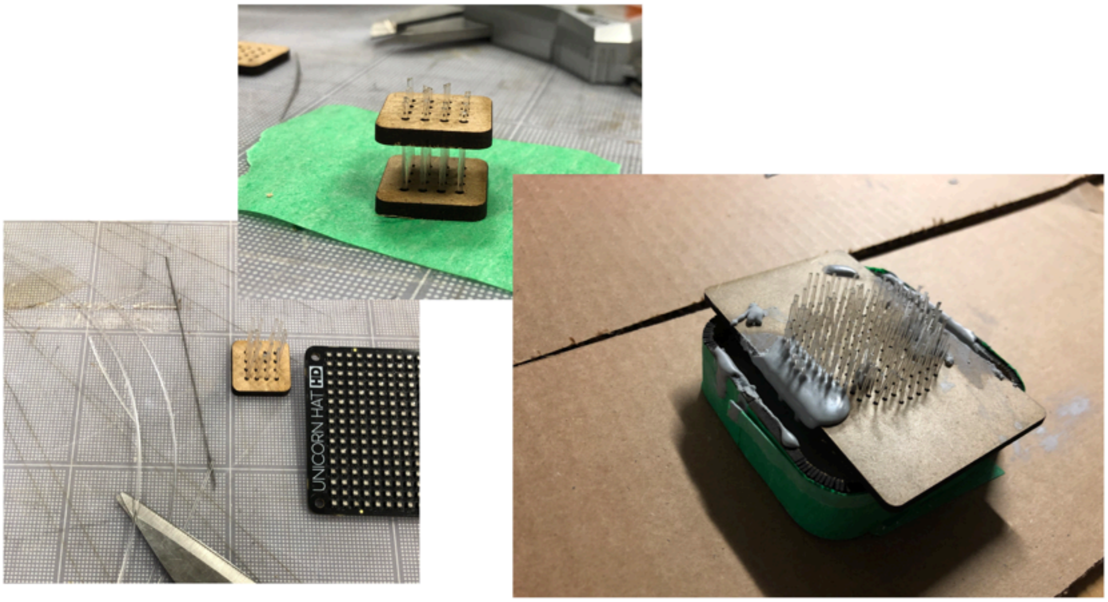

Figure 4.6 Around this same time, I began exploring using fiber optic cable to pass light through concrete.

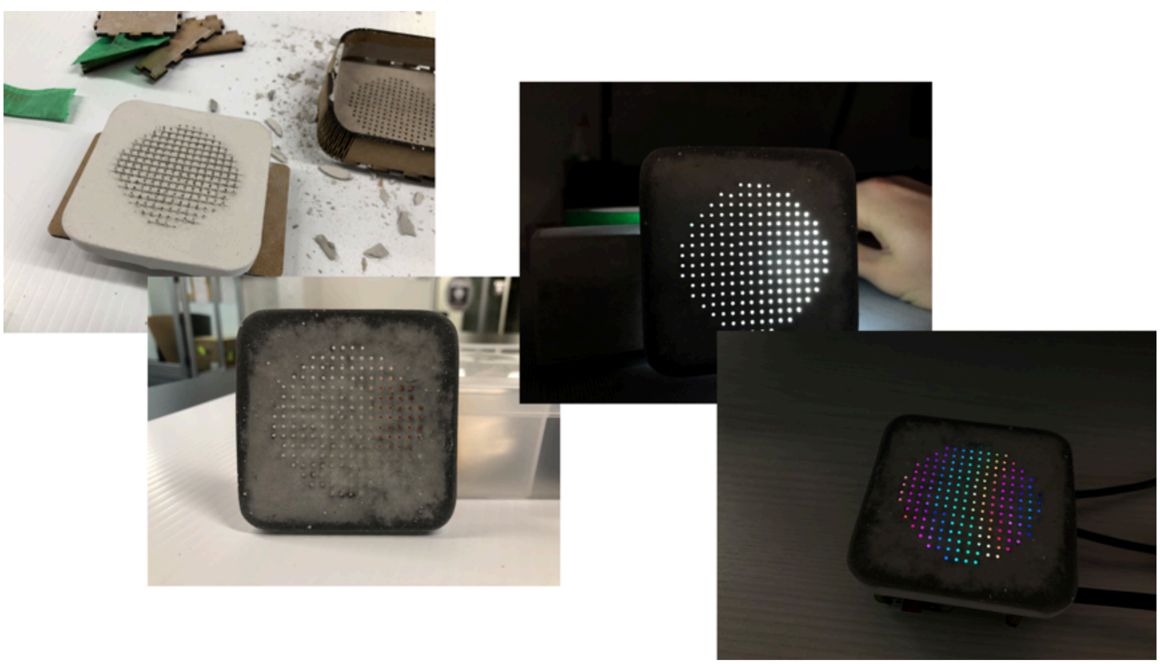

Figure 4.7 Fiber optic cable allowed a way to pass light through a material, such as concrete, in a very visually appealing way. I also tried rounding the edges of the display to achieve a look that was less “screen like.”

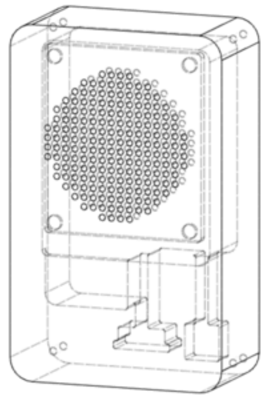

Figure 4.8 3D model of the form I ended up on, which was inspired from the explorations with fiber optics.

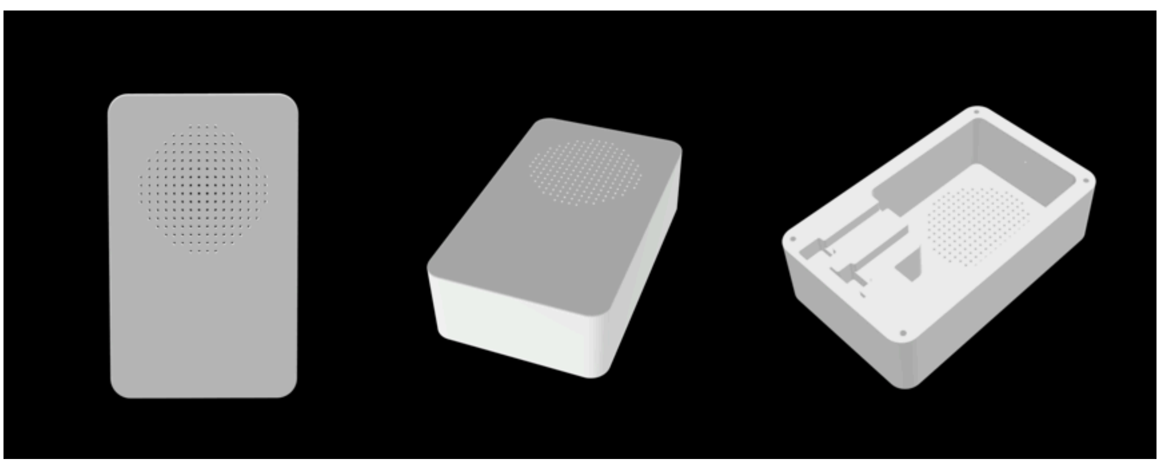

Figure 4.9 More angles of the 3D model for the final form.

Figure 4.10 **3D printed parts and various materials in preparation for mold making.**

Figure 4.11 **The various stages of mold making and casting. The final form was cast using Rockite cement.**

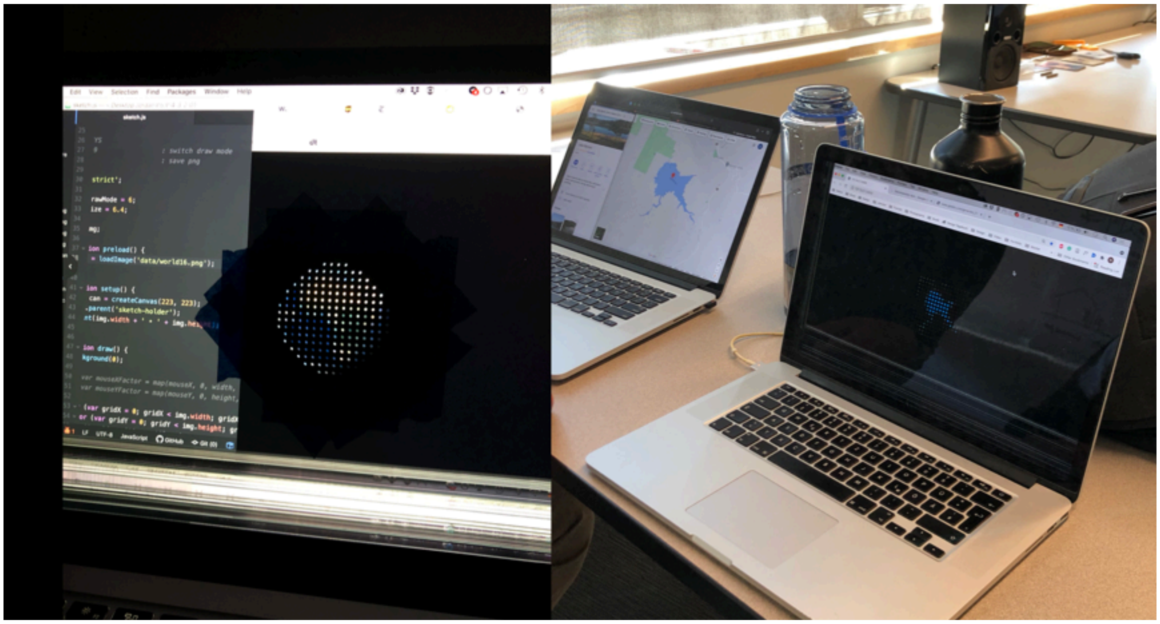

Figure 4.12 **In parallel with the iterations of fiber optics and casting, I explored displaying a map on the display.**

- **Does not look like merely an enclosure for a screen**
  supports higher level aim of being a unique object within a person's environment
- **Invites peering into**
  supports looking at and pondering about what is being surfaced and eventually revealed
- **Feels durable and weighty**
  supports goal of evoking a physical sense of long lastingness and ongoingness

Figure 4.13 **The design process ultimately led to this final form, guided by the following goals: 1) does not look like merely an enclosure for a screen, 2) invites peering into, 3) feels durable and weighty**

4.2. Memory Tracer: The Finished Design

Figure 4.14 Memory Tracer showing a surfaced moment

4.2.1. Scenario

Memory Tracer is a tangible device that invites people to live with and experience their location history data in a gradual and evolving way. Memory Tracer slowly, yet indefinitely selects and traces past moments from where the user was on “this day in history”, although the frequency at which it surfaces past moments varies and subtly changes over time. When Memory Tracer is on, it connects to the user’s location history archive and randomly selects a number that is between 1 and the total age of the archive. For example, if a user’s location history archive spans 10 years, Memory Tracer will randomly choose a number between 1-10. As the archive ages, this temporal spectrum continues to slowly widen (e.g., next year when the archive is 11 years old, the random selection will be between 1-11, and so on). A cornerstone of the design is this random number is used for two things: forecasting how many days into the future until a new location day will arrive and selecting how many years from the past that location day will be.

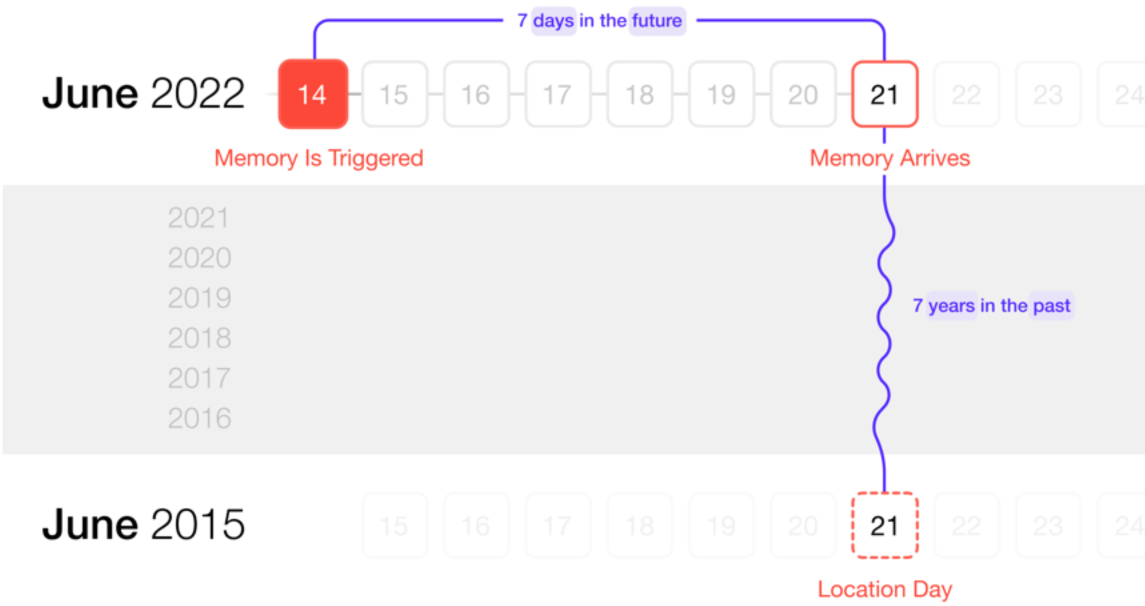

Figure 4.15 In this scenario, there is a 10-year archive, and 7 was randomly selected. Today is June 14, 2022. The algorithm will forecast 7 days into the future to June 21, 2022. It then looks 7 years in the past to June 21, 2015.

For example, consider the scenario visualized in (see Figure 4.2). Here, the current date is June 14, 2022, and Memory Tracer's random algorithm selects a "7" from a 10-year-old archive. Memory Tracer then forecasts out, from the present, 7 days in the future to June 21st and selects a moment 7 years in the past (on June 21, 2015, in this case).[1] The system finds that 7 years ago on June 21st the user was in Key West, Florida, USA. Memory Tracer will then begin slowly tracing the moment by gradually producing a map of Key West on its 16x16 pixel display. The map will come into view pixel by pixel over the course of the next 7 days until June 21st when the moment is fully revealed. During this tracing process, the user can press a button on the back of Memory Tracer to toggle through additional hints about the moment and day: 1) distance away from current location, 2) total distance traveled, 3) altitude, 4) temperature, 5) activity, 6) point of interest, 7) city name, 8) year. As the reveal date nears (June 21st), more of this information is available.

[1] If it is the case that there is no moment found the be surfaced, the random selection will repeat until a moment is found that corresponds with the randomly selected number.

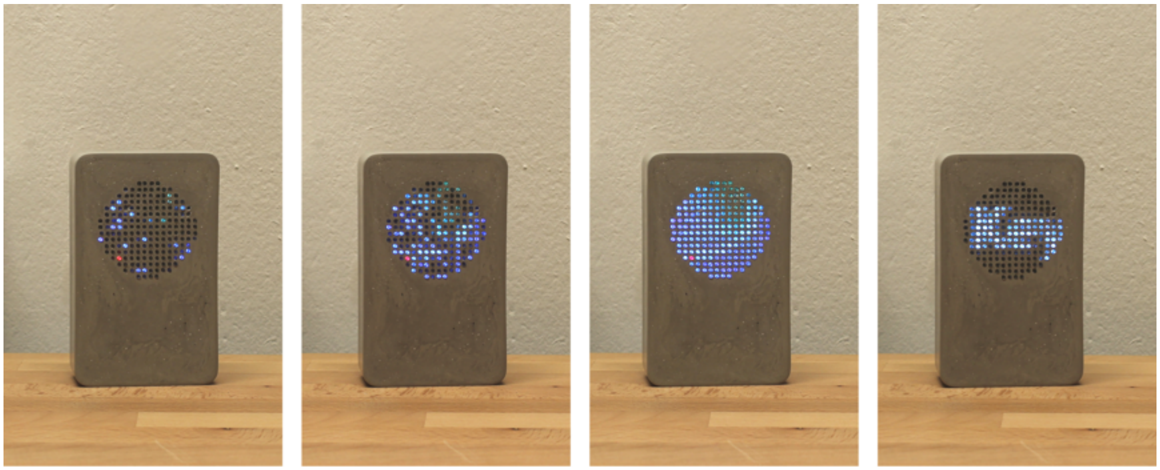

Figure 4.16 As Memory Tracer surfaces a moment, the map visual slowly comes into view. On the day the moment is from, the full map is shown and all additional hints are available.

In this scenario, on June 18th approximately half of the map will be visible, though likely it will not be intelligible to the user yet. “Distance away from current location”, “distance traveled”, “altitude”, and “temperature” will be available as indirect hints that could help spark anticipation and reflection, but “activity”, “point of interest”, “city name”, and “year” will be unavailable. On June 21st the final form of the moments is revealed: a completed map view and access to the “point of interest”, “city name”, and “year”. Access to the moments remains present for the full day (i.e., 24 hours). Then, Memory Tracer conducts the next selection, setting the date and location for the next moment to be revealed, which will begin to surface on June 22, 2022. This process continues indefinitely. The user has no control over when or what moment’s will be traced.

4.2.2. Details of the Design

Showing a Moment

Since there are many moments from any given day, the specific moment Memory Tracer displays is the one closest to the current clock time. For example, if it’s 9:45am, the moment currently shown is from ~9:45am from the *location day* that was revealed. This means that throughout the day, there will be a slow changing of the red dot on the map as it replays that day in history in real time. Interacting with Memory Tracer at different times of the day will reveal different information as the location hints (activity, point of interest, altitude, weather, etc.) would change during the day.

Paring the specific moment shown with the current clock time solved two challenges in a way that was consistent with my design goals of a slow and curious experience. Based on my data, there could be anywhere between 10 to 1500 moments recorded for a particular day. The resolution of the display was too small to show a route traveled on a given day. The display was most discernible when showing one place at a time. I tried developing an algorithm that could figure out the "best" or a more ideal moment to be shown. However, there were too many assumptions baked into the decision logic and myself, along with research collaborators, decided it would be too closely tied with my data. I also considered just purely choosing a moment at random from a given day, however this felt unsatisfactory. The design primes anticipation over multiple days, so to be left with only one moment after waiting for many days felt disappointing.

These explorations led me to having one moment shown at a time, but the moment updates throughout the day. This also fit within my goals of creating a device which prompted open-ended engagement, explicit slowness, and ongoingness. The red dot moving around the screen slowly traces out the path that was traveled on that day in the past. If the user wants to engage with the device, they may choose to frequently look at and interact throughout the day to try to recall more of that day. However, the device does not demand this attention and can easily fade into the background, while still slowly tracing out days from the past.

Final Form

The final version of Memory Tracer consists of the following. I implemented a Python program on a Raspberry Pi Zero connected to a LED display embedded in Memory Tracer's enclosure. The program generates a database from the user's Google Maps Timeline location history archive and uses the timestamp metadata of each unique 'moment' as a key factor in its selection algorithm. As noted before, the application randomly selects moments using a random number generator that spans the age of the archive (e.g., from 1-10 in the case of a ten-year-old archive). The database of location history data is stored locally on the Raspberry Pi. Memory Tracer's enclosure is cast from Rockite, which is a water based rapid setting fine cement. After casting the enclosure, I sanded it to a glossy finish using 2000 grit sandpaper. The display uses a Unicorn HAT HD, which is a 16x16 super bright multicolor LED matrix. Each pixel is connected to fiber optic cable, which is routed through the concrete to ensure optimal light diffusion on the front of the device.

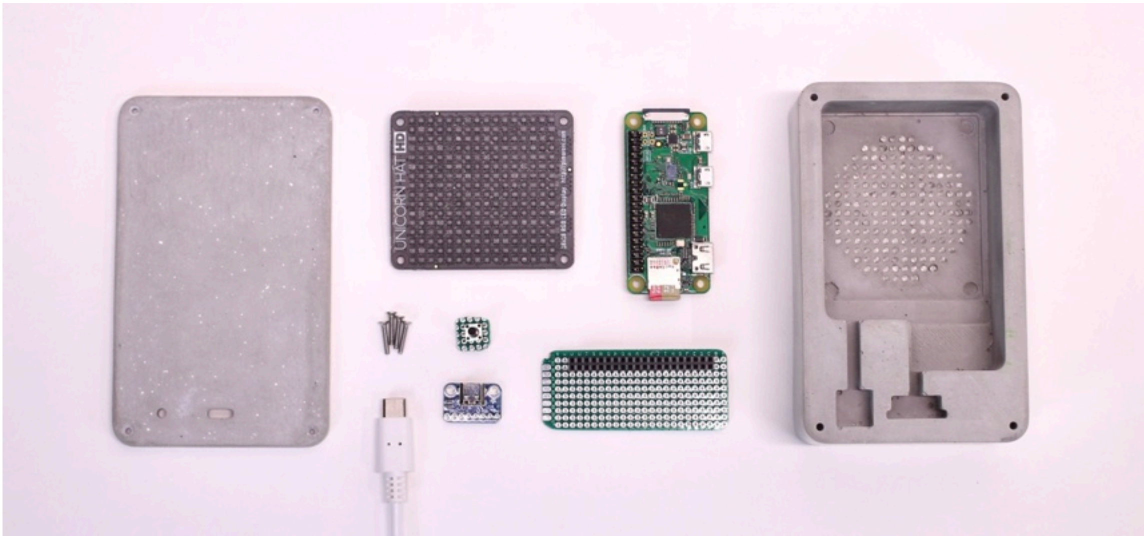

Figure 4.17 The main components of Memory Tracer: casted Rockite enclosure with embedded fiber optic cable, LED display, Raspberry Pi, protoboard for connections, push button, USB-C breakout board, power supply, enclosure screws

4.3. Memory Tracer: Reflections

4.3.1. Reflecting on temporal expression: working with randomness & aging in location history to explore interconnections among the past, future, & present

My RtD process for making Memory Tracer was influenced by the qualities of explicit slowness and ongoingness which require the speed of the design artifact to not be controllable such that it expresses its “own time” [76]. Thus, my practice of designing Memory Tracer required attending to the connection between pacing and intelligibility. This came with the added challenge of designing a technique that would subtly grow and develop as moments were surfaced, until they were revealed. Initially, I developed a random selection algorithm that was inspired by prior work demonstrating that randomness can help sustain ongoing cycles of everyday anticipation and retrospective reflection [62, 77, 83].

Selection of a Moment

Over the course of a six-month period, I lived with prototypes of Memory Tracer and experimented with different pacing algorithms. I explored algorithms where a new moment was surfaced every day. I found the shorter time duration to be useful at first to become accustomed to Memory Tracer's behavior, but eventually the pacing became too frequent and demanded too much attention (in simple terms, it was moving and changing too quickly). Conversely, I tried longer fixed periods of 1-10 days and 10-25 days regardless of how old the archive was. I found that the longer pacing periods could require so much time for the surfaced moment to become revealed, that it largely faded out of mind entirely. Both instances complicated the higher-level goal to create a slow technology that could move in and out of perceptual view and "become part of our lives over long periods of time" [45].

Pacing

These experiences prompted me to revisit slow technology theoretical propositions, which led to discussions with my collaborators around how the pacing of Memory Tracer itself could be leveraged to provide added context to each moment and to support ongoing, subtle change through time. At this point, the moments Memory Tracer revealed were tied to 'today's date in history', but the number of days they took to surface was entirely random. Critically reconsidering the way that Memory Tracer's pacing could express time eventually motivated the decision to connect the number of days that a moment required before it was revealed to be the same number of years in the past of the moment that was being surfaced. This idea was inspired from previous RtD products that have used the pacing of the device to indicate the age of data that is being surfaced [58, 77].

The location history archive's age is always increasing as time passes, which causes the temporal spectrum for a moment to grow and expand and the pacing of the device to slow down over time. For example, if a person's location history archive was 7 years old, Memory Tracer would only forecast out moments a maximum of 7 days. Yet, as the archive grows older (e.g., 25 years) moments from deep in the past near the beginning of the archive would take nearly a month to surface, all the while more recent moments would take only a few days to surface. This technique to structuring and expressing time highly resonated with me – practically, it meant that when one's location history archive was relatively young (e.g., 7 years) it would surface at a rate that would enable the user to have more chances to understand and become accustomed to it. As the user becomes older and experiences accumulate with Memory Tracer, they could develop a sensibility for 'reading it' as the tracing periods became longer and more gradual when older moments are surfaced. This, in turn, could enable the longer periods of pacing to be less disruptive while building in subtle anticipation as the user reflectively considers moments from much deeper in their past. Yet, Memory Tracer would still retain the capacity to select, surface, and reveal moments that are more recent (e.g., from 1-2 years back), thus offering an unpredictable balance of showing younger and older moments and the different memories potentially tied to them.

Ultimately, this design decision enabled me to manifest a sense of cumulative growth and aging over time that encompasses both the user and their location history, while, in effect, bringing together a near future date, that is connected to a time and place in one's past, that is experienced in the present through situated encounters with Memory Tracer in everyday life. I also was able to leverage slowness and randomness to enable Memory Tracer to evoke its 'own time' while using the user's 'own' unique location history as the key factor of the pacing tempo.

4.3.2. Reflecting on data presence and material form: priming pre-interactions and lived-with experiences

In designing Memory Tracer, I also wanted to leverage the quality of pre-interaction and give emphasis to "designing for the time and space prior to the moment the artifact is directly interacted with" [76]. I wanted to investigate if this design quality could be extended to prime everyday reminiscence through expressions of location history data that gradually change as moments are traced and eventually revealed.

Taking inspiration from Japanese Zen gardens, initially I envisioned the form for the Memory Tracer to trace moments in a miniature sandbox (see Figure 4.5) that were drawn daily and represented the total path that the user had taken on that 'day in history'. The tracing pattern would be created using a magnet set in the sand bed connected to a subsequent magnet underneath the tray where a machine head moved on an *xy* axis. Although the traces were precisely tied to today's date and drawn to a precise relative scale, they remained unintelligible; there was not enough context to trigger everyday experiences of reminiscence.

Figure 4.18 The 3 major forms for Memory Tracer. Sand tracer form (left) would trace a pattern representative of a location. Hourglass form (center) showed time flowing through the device as it surfaced a moment. Final form (right) slowly revealed a trace of a map showing both location and time flowing through the device.

In the next phase of my process, I settled on using a 16x16 LED matrix as the primary visual output for Memory Tracer (see Figure 4.5). Inspired by the way time moves through an hourglass, I diverted from the explicit 'tracer' metaphor and designed an animation resembling an hourglass, that progressively became more saturated until the display was entirely full, at which the moment is revealed. In this version, when Memory Tracer finds a moment, it begins a slow animation while that moment is being surfaced. For each year in the past, it took 1hr to surface; e.g., a moment from 2016 would take 6hrs to surface. Once the animation stops and the display is filled, it lightly pulsates. The same amount of time it took for the moment to surface, the user has to engage with it. By tapping on the device, the user can see information about the moment. A touch sensor in the device allows the ability to tap through contextual hints extracted from the moment: year, distance away, city, activity (if available), and location name. These hints slowly become more specific until they give the name of the location. This was to prompt an open-ended contemplation of what the moment might be, as opposed to immediately showing the location name. When all details have been viewed, the grid goes empty until another moment is eventually selected.

While moments in this iteration became more intelligible via the contextual details, the overall experienced was underwhelming. The temporal expression associated with when a moment was being surfaced had been reduced to a form of clock time that did not correlate with the location history data. While initially delighted by the design, I felt the capacity to support pre-interaction and prime everyday reminiscence was largely diminished. I had designed the form to closely fit the 16x16 LED matrix which inadvertently produced a highly contemporary consumer electronics aesthetic that did not express a long-term, lived-with quality. The diffusion of the LEDs through white plastic also produced an overly bright presence that, over time, became difficult to ignore; thus, again complicating the Memory Tracer's ability to oscillate between the foreground and background in everyday life.

Between the hourglass form and the final iteration, I explored a variety of form alternatives. Learning from what worked and did not work with the previous two forms, I set the following goals for the final design. I kept these goals in mind as I explored various form designs.

- Does not look like merely an enclosure for a screen
  – supports higher level aim of being a unique object within a person's environment

- Invites peering into
  – supports looking at and pondering about what is being surfaced and eventually revealed

- Feels durable and weighty
  – supports goal of evoking a physical sense of long lastingness and ongoingness

Collectively, these experiences and experiments motivated the final iteration. I decided to cast the enclosure for Memory Tracer from Rockite, a water based rapid setting fine cement, which gave it a look, feel, and weighty durable aesthetic that could stand up over time. I adjusted the form of Memory Tracer to resemble a more rectangular monolith shape that was counter-weighted in its foundation and set the LED matrix display in the upper portion of the enclosure. I also cropped the corners of the matrix to create a more circular display. Together, these decisions generated a more organic, unobtrusive aesthetic that I found could fit in the backdrop of everyday life, support causal glances as moments were traced, and invite the user to more directly look into the device to consider places from one’s past. A challenge of using concrete was that it does not allow light to pass through it. However, I discovered a way to route the light from the LEDs inside through fiber optic cable to the front of the enclosure. Beyond making it possible to only use concrete for the material of the form, this method helped to create a quality of light that was vibrant and alluring, yet less intense and attention demanding.

Figure 4.19 Final form, casted from Rockite with embedded fiber optic cables to allow light to pass through the concrete

At this point, I also made the design move to make the focal point of the Memory Tracer interface a “trace” of a map of a moment. As the moment is surfaced, the display slowly dissolves in more pixels from the map. This gradually traced map, paired with slowly revealed contextual clues (that can be accessed if desired) provided enough context for Memory Tracer to remain intriguing, to trigger anticipation, and to support experiences of everyday reminiscence on and, at times before, the moment is revealed.

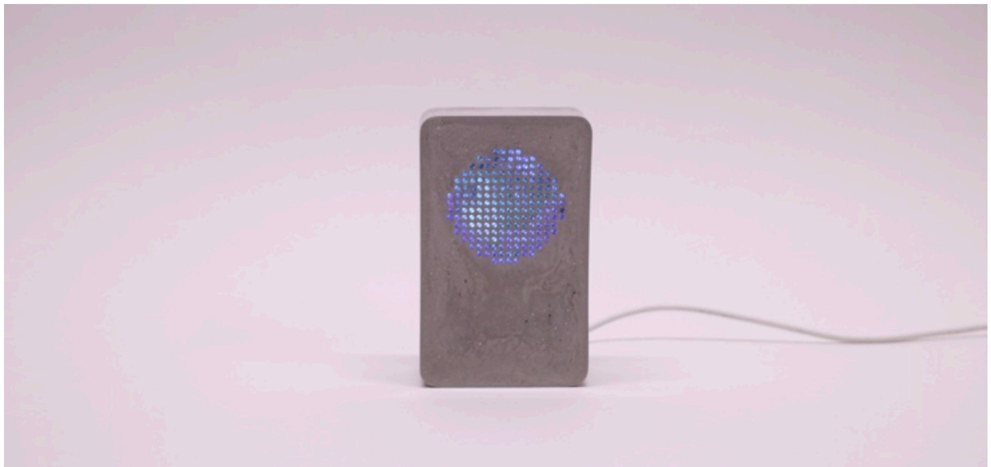

Figure 4.20 Memory Tracer visualizing a map of North America. Instead of merely using the display as a way to indicate the passage of time, I used it to visualize a low-fidelity map of the moments it was surfacing.

4.3.3. Reflecting on experiences with Memory Tracer

Across making Memory Tracer and ultimately living with its final form, I found it was consistently able to present an inviting, but subtle lived-with quality. Equally, I found it easy to deeply reflect on its presence, glance at it via a fleeting reflection or, momentarily, forget about it entirely. The tracing tempo frequently prompted prospective reflections on what date in the future the moment would arrive and from what year in the past a memory might be triggered. As tracing progressed, this could lead to a satisfying confirmation that the location I speculated was the moment being surfaced. Or this could lead to a change in perspective entirely if the map-based representation remained difficult to interpret (e.g., a heavy amount of blue was projected on the map, but I had no recollection of being close to large bodies of water). Often, I decided to let the moment trace over time and see if the map visual offered enough context to recollect and reminiscence on the prior time in my life it was bound to. Although sometimes I interacted with Memory Tracer to provide contextual hints, as the traced map visual was too undiscernible to prompt much reflection and pondering.

Experiences with Memory Tracer also provoked me to think about time and my past in a unique way. Looking at Memory Tracer causes a dual consideration of how far in the future the date is and how far in the past the year is. Initially, this felt like a distinctly different approach to priming reminiscence and recollection. It often caused a higher-level reflection on what activities I was doing during a calendrical spectrum (i.e., 1 week, 1 month, 1 season) that cut across the years of data. As the tracer revealed more context, often this manifesting moment served as a narrowing of mental guiderails on what I likely should consider as the place in my past it is originating from. Occasionally, the revealed moment would leave me with a perplexed feeling when I could not recollect the location or was not sure why I was there on this particular ‘day in history.’ In several instances this prompted me to look back through old calendars and photos, to try to remember why exactly I was there. Yet other times, moments were revealed that tied to a particular location or travels that had unique and specific memories attached.

Chapter 5.

Design Research Case: Memory Compass

This chapter describes the design research product Memory Compass. It begins by visually showing a condensed version of the progress from the initial design insights to the finished form. Then there is a short scenario describing how Memory Compass might be used and experienced in everyday life. This is followed by additional details of the interaction design. Next, I interweave a description of retrospective reflections that provide insights into how these key design decisions were made in dialogue with the higher-level conceptual framing. I conclude with reflections on conceptual elements of the interaction design as well as personal experiences using the device.

5.1. Memory Compass: The Design Process

In this section, I visually highlight and annotate the main progressions from the initial design insights through to the final form (see Figures 5.1 – 5.5).

Figure 5.1 I quickly moved to the Apple Watch as the form for the following reasons: 1) wearable, 2) built-in technology, 3) embodied interactions

Figure 5.2 **These are some of the initial embodied interactions that were explored. I particularly liked the idea of a casting motion similar to fishing. However, this was too imprecise and left a feeling of total randomness in the interaction.**

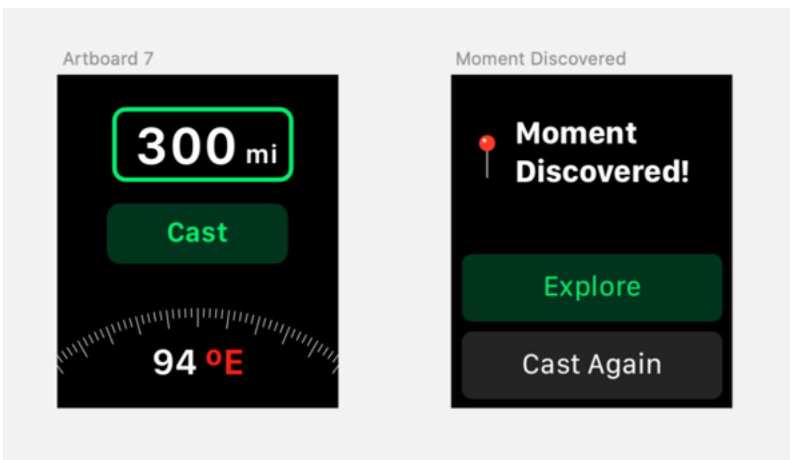

Figure 5.3 **I tried precisely fine-tuning the values of *distance* and *direction*, but found this was too exact and did not have the kind of open ended qualities I wanted.**

Figure 5.4 I went back to the drawing board and explored many different options for the visuals and interaction.

Figure 5.5 Eventually, this final design was arrived at. Both the visuals and the interaction balances precision and imprecision.

5.2. Memory Compass: The Finished Design

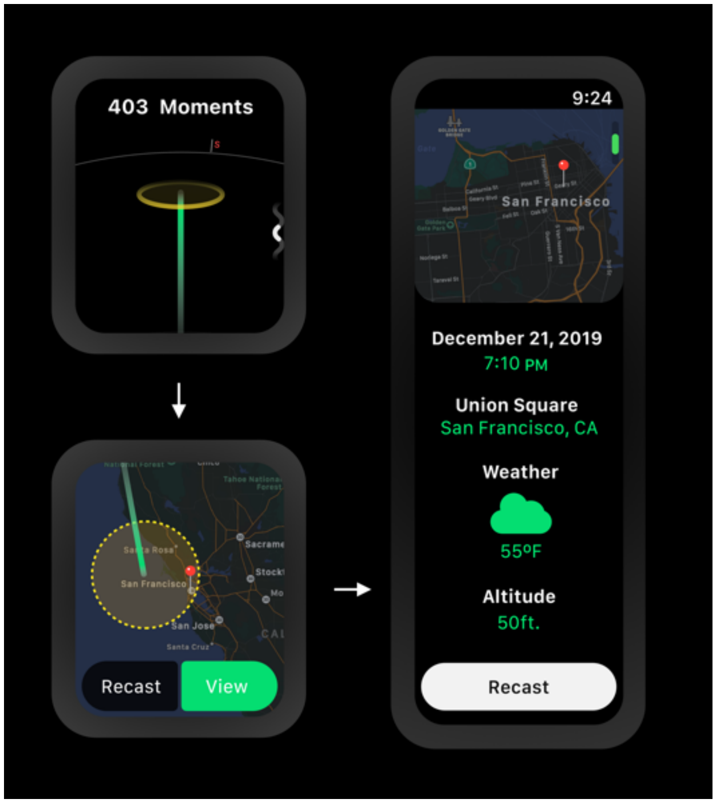

Figure 5.6 Memory Compass's user interface flow of filtering, casting, and viewing moments.

5.2.1. Scenario

Memory Compass is a wearable smartwatch application that enables people to retrieve personal location history moments from other geographic places in relation to their current location. Different from Memory Tracer, Memory Compass offers the user interactive control and direct manipulation over the experience of searching, finding, and reflectively interpreting location histories across space and time.

The user's physical location and directional orientation are what dictates where a moment will be retrieved. In addition to **direction**, there are three other filters the user can configure before 'casting' out to retrieve a moment: distance, radius, and year. **Distance** is how far away the cast will land. **Radius** is how wide of a 'net' around the landing point moments will be collected. **Year** denotes which year or all years to select moments. As these filters are changed and adjusted, the number of moments within the ‘net’ is updated and shown at the top of the screen. This allows the user to see if the current filter settings have found any moments or if they should keep adjusting. Once the user has the desired filters, they can ‘cast’ by swiping up on the screen. Upon casting they are presented with a map of where the cast landed, the size of the radius, the direction back to them, and the year selected. If there are moments within the ‘net,’ then one is selected at random, and the user has the option to view it. When the moment is shown to the user, they can see a close-up map of the moment along with date and time, location name (if available), activity (if available), weather, and altitude. The user is free to reflectively consider when and where in their past this moment ties back to, adjust the filters and recast, or simply go about their day after a brief moment of reminiscence.

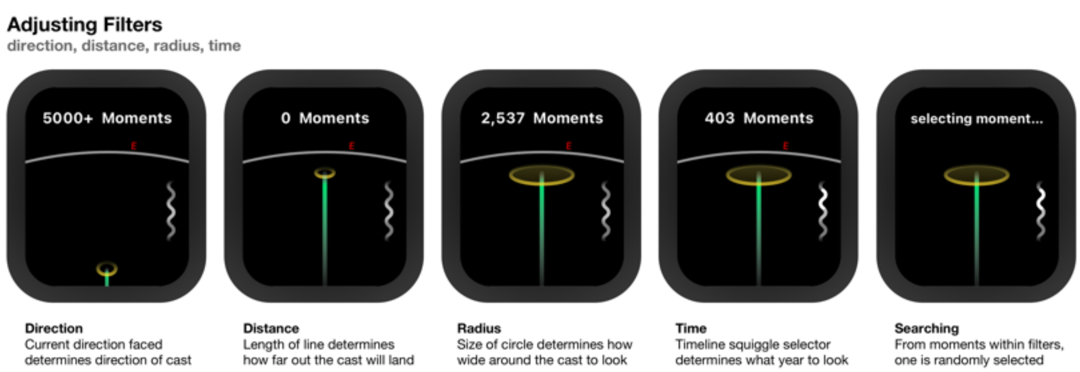

Figure 5.7. Progression of adjusting the different filters for Memory Compass

5.2.2. Embodied and Haptic Interaction

Each of the filters has a unique embodied interaction along with visual and haptic feedback. The **direction** filter is set by pivoting left and right, similar to how one would use a real compass. The digital compass in the smartwatch provides the precise direction. As the user turns, they can feel haptic ticks for each degree, even though visually they only see indicators every 45º.

The **distance** filter is set by rotating their wrist outward to increase or rotating their wrist inward to decrease. The precise value is provided by the watch’s gyroscope. Visually a line extends to indicate the increase of distance. Haptic pulses are also given to indicate the change. As the user keeps their wrist rotated outward, the length of time between pulses increases, as does the distance. When they rotate back inward, the length of time between haptic pules decreases as does the distance.

The **radius** filter is set by turning the digital crown outward to increase or inward to decrease. Visually and haptically the feedback is similar to distance. As the user scrolls the digital crown outward, away from them, the length of time between haptic pulses increases as does the radius size. Visually, this is shown by the increase in size of the circle on screen. As they scroll the digital crown toward them, the time between haptic pulses decreases as does the circle, and radius size.

The **year** filter is adjusted through a long press on the screen. The longer the press, the deeper in time the year will be. As the user presses the screen a continuous haptic pattern will start. Initially the intensity of the haptic pulse will be quite high, indicating a recent year. The longer the press, the fainter the pulse will become, indicating a year deeper back in time. Eventually the pulse will stop, meaning that All Years are selected. They can re-press again to change the year filter.

I was purposeful in designing a level of ambiguity into the experience. I do not show the precise direction, distance, radius, or year. At a computational level each of these filters has a precise value which is used for a precise calculation to find moments. However, the user sees and feels an abstracted form of these precise values through the onscreen UI and the haptic feedback.

Figure 5.8 How a user adjusts the filters for Memory Compass.

The final version of Memory Compass was designed as an Apple Watch application. This enabled me to take advantage of the internal compass and gyroscope native to the Apple Watch. It also enabled me to leverage the integrated Taptics Engine and the Core Haptics library for non-visual feedback. The Memory Compass app works in conjunction with the iPhone it is paired. A native iPhone app manages data flow and the computation of searching through a database of hundreds of thousands of GPS coordinates.

5.3. Memory Compass: Reflections

5.3.1. Reflecting on temporal expression: working with implicit slowness by balancing precision and imprecision in design

My process for designing Memory Compass was influenced by the quality of implicit slowness where the pacing of the artifact is not enforced and can be freely controlled but, when combined with other design qualities, it retains its slow, reflective qualities (c.f., [76]). I was inspired by prior design research that productively balanced user control with relatively minimal feedback to craft technologies that required time to understand, where a sensibility for 'reading' and exploring the system gradually developed through use and reflection [15, 56, 60, 75].

Over a six-month period, I lived with prototypes of Memory Compass where I iteratively developed the working system in light of my conceptual framing. Initially, I and research collaborators considered different forms for Memory Compass, which ranged from handheld compass-like forms to bespoke near-eye devices that could guide one's gaze as potential moments were viewed and explored, to augmented reality apps that allowed seeing markers on the horizon representative of nearby moments. While I liked the potential of a bespoke tangible device, I realized that this would limit the ability to use it casually throughout everyday life. If I made it a tangible device, it would mostly become out-of-hand, either tied to the home or stored elsewhere which would limit the kinds of experiences I hoped to evoke. Ultimately, this led me to explore using a smartwatch for a few important reasons.

First, as a commonly adopted technology, a smartwatch not only already fits within people's lives, but the wearable nature of it also means it will travel in, around, and outside of the home. I saw that these qualities could be important for supporting unstructured, spontaneous experiences of everyday reminiscence. Particularly I liked the idea of being able to explore your location archive based on different locations you would travel to. Second, on a technical level, its integrated combination of a gyroscope, compass, haptics, and connection to a smartphone made it possible to rapidly prototype different interaction design alternatives based on ongoing cycles of use and reflection among the design team. Third, it enabled tangible, embodied interactions that could be leveraged to afford a way of 'grasping' or physically engaging with location data that could potentially develop and evolve over time as one became more familiar with it. The smartwatch presented a great way to build a simple, highly embodied experience that a person could always have with them and use throughout everyday life. Collectively, these qualities offered potential to support my higher-level goal of creating an implicitly slow design artifact that offers control, while requiring time for a sensibility to develop around it.

Initially, I envisioned an almost exclusively non-visual user interface for Memory Compass. I wanted to foreground attention and interpretation to the embodied act of retrieving (or 'casting') out into a geographic trajectory in the world, that primes a space for pause and reflection on the moment that was retrieved. In the first major iteration of Memory Compass, I experimented with concepts of physically throwing my wrist outward (similar to the motion of casting a fishing pole) in order to set the distance. I was able to pull the speed of the throw from the accelerometer to calculate the distance. The underlying system could be highly precise in translating the physical force for casting from the accelerometer and determining where it should land at a discrete point in the world, but it was challenging to make sense of how I arrived at a moment that was returned. Put simply, although the way the system operated was not random, it felt random because it was so challenging to 'learn' how to cast and explore places it landed in the world. The nature of the feedback was so minimal, imprecise, and unintelligible that it complicated my higher-level goals of supporting longer-term experiences of everyday reminiscence.

Eventually, I arrived at a visual style that was a representation of the precise underlying values used by Memory Compass. Once I combined the interface design with unique, embodied interactions and rich haptic feedback for each filter, I arrived at an optimum balance of precision and imprecision. Through having a unique method of input for each filter, I eliminated the need for extra buttons and screens in the interface. This combination gave a much higher degree of understanding of the system initially, which opened the possibility to live, learn, and evolve with the Memory Compass as the sensibility for using it slowly develops over time.

5.3.2. Reflecting on embodied presence of intangible data: priming pre-interaction and lived with experiences

During the design process, after realizing the shortcomings of physically casting, I pivoted to a visual interface for setting distance, while still embodying qualities of minimalism. My first iteration was certainly easier to use and afforded more understanding of where the cast may land, as you could see the actual miles it would cast out. While this did open some experiences of pre-interaction contemplation – "what moments might be 1500 miles away in this direction?" – it did not provide the curious experience I had set out to create and overall felt too precise and quantitative.

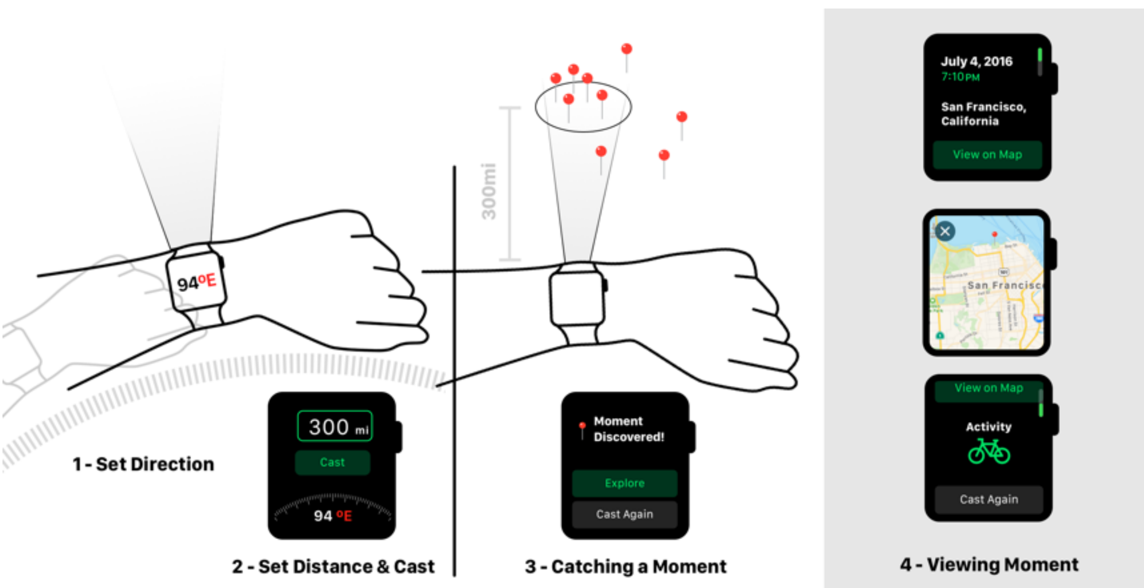

Figure 5.9. Second major form for Memory Compass allowed precisely setting the *direction* and *distance* of a cast

Another challenge was that so far, none of the designs provided a way to know if the cast would land on any moments at all, prior to casting. The lack of feedback about nearby moments prior to a cast required the user to cast and re-cast repeatedly to attune themselves to what was around them. While this fit with my goal of creating an implicitly slow experience, it also made Memory Compass frustrating to use.

Figure 5.10 UI Explorations of how to visualize where moments are prior to casting. From left to right:
1) Colored bands signify a large amount of moments in a particular direction;
2) A graph shows the amount of moments from a given year in the current direction;
3) A radar style visual shows where clustures of moments are relative to the current location, with the ability to filter based on *year*, *distane*, and *activity*.

I began exploring ways to represent nearby moments prior to casting (see Figure 5.5). The main challenge with these visual representations, was that it was still unclear where exactly these moments were. A user could see that there were moments in a certain direction, but were there a lot of moments 10 miles away or 1000 miles away? However, the added information on which direction to explore, did improve the experience and gave way to more curious and contemplative reflections prior to casting. It prompted contemplation and geo-spatial awareness as to why there might be so many moments in this direction. During these iterations, I also began exploring other filters such as “year” and “activity” which could help prime the user for a narrower selection of moments that might be returned.

Eventually, a research collaborator and I arrived at an interface design that provided an abstracted visual representation of where a cast would land. It took the precise underlying values for *direction*, *distance*, *radius*, and *year* and presented it in an abstracted way. We found that we could mediate the tension of not really knowing where a cast would land, by showing how many moments were within the cast’s filters. This provided the intended interaction of more curiously exploring and searching through surrounding location moments, while providing enough information to help attune the user to their location data prior to casting. This iteration was particularly helpful at providing pre-interaction contemplation – "Why are there so many moments right here? What could this area be?" – "Oh, I really thought that there would be some moments around here." – were thoughts I had while experimenting with the design.

Figure 5.11. The final version combined abstracted visuals for the precise underlying filter values, while providing exact values for the moments within the filters

Through this design process, I found that the visual representation I used changed how I thought about and considered my intangible data that I was seemingly emersed. In every direction I turned, there was the potential to rediscover a point from my past. However, how I thought about the data and the ease at which I could explore that data was heavily shaped by the representation and feedback on the smartwatch.

5.3.3. Reflecting on experiences with Memory Compass

From a high level, Memory Compass' design qualities physically situates the user within their location history data and provides a casual method of curiously exploring one's past based on their current location. Over time it became clear that Memory Compass could support a wide range of experiences, from casting and pulling moments more locally to where I currently lived, to supporting long distance casts that pulled back moments from various places around the world, to exploring memories across time by adjusting the year filter of an existing cast. Across all these uses, the experience with Memory Compass and the types of memories it might spark were deeply shaped by where I geographically was when I used it. When casting a short range around where I recently lived, I found Memory Compass could return moments that are bound up within a recent time period. However, when I temporarily relocated to my family childhood home, moments were easily pulled back from much deeper in time. This proved to be an interesting use case where, after finetuning direction, distance, and radius, I could pull moments at random across the years or use the year filter to pull moments from a specific year. Perhaps unsurprisingly, when I occupied a location never visited before, short casts were not intriguing since the only moments that could be pulled back had just recently occurred.

Medium casts (10-100 miles) could offer mixed results, sometimes landing near forgotten moments, other times near frequented places. I found medium casts were productive in exploring near a place I had lived for several years. The distance is quasi-familiar and relatively close, but it is also a range where one does not visit every day, week, or even month. It could pull in weekend trips and one-off visits to different locations around the greater area. Long range (100-1000 miles) nearly always generated a sense of anticipation and contemplation around what might come back. At first, they were challenging to grasp and required adjusting the filters to find any moments at all. The ability to see a continually updated number of moments within the casting area, was particularly helpful for this range. Yet over time I developed a sensibility for working with the casting interaction. I then began to land on faraway moments that brought back a range of memories I often had not considered or recollected in several years. As I used the casting interaction on the long rang setting, the ability to execute multiple casts to 'hone-in-on' more specific areas of the world I had visited, continually improved.

Yet, my cultivated sensibility had its limits. Super long casts (1000+ miles) remained hard to control as a couple degree direction shift could change the cast point by hundreds of miles. Nonetheless, this unpredictability added an intriguing quality – whichever moment was retrieved remained a unique result from the combination of my embodied actions in the present and unique location history from the past which was bound up in 'some part' of the world over the horizon. Over time, I began to reflectively consider the relative direction, distance, radius, and year that I would be applying to a cast, before I would cast, and thought more deeply about the memories that might be returned.

Chapter 6.

Discussion

Developing approaches and strategies to create design artifacts that express different perspectives on and representations of personal location history data to support open-ended experiences of everyday reflection, recollection, and reminiscence over time presents important opportunities for the HCI community. Through a critical reflection on my design-led research process of Memory Tracer and Memory Compass, I highlight opportunities and challenges that come with this emerging space, and insights into how they could be better grappled with in future research and practice.

6.1. Leveraging Pre-Interaction and Anticipatory Interaction to Prime Different Forms of Memory-Oriented Experiences with Location History

Investigations into the experience of anticipation with interactive systems is an ongoing area of research in the HCI community. Here, anticipation is commonly characterized as unfolding in two stages: First, in a phase where experiences accumulate and intrigue, contemplation, and tension build over time. Second, when tension is released and one interprets the content that is revealed (e.g., see [66]). Designing for anticipation is important for slow technology design artifacts because it can lead to sustained interactions that may strengthen attachment and enable them to become embedded within people's lives over time – a crucial quality for supporting ongoing experiences of everyday reminiscence. Recent research [76] has pointed to pre-interaction – the expanded set of experiences that could be designed for prior to interaction in the first phase of anticipation – as a productive design quality for priming reminiscence by prompting people to interpretatively connect elements of personal data to prior points in their life (and vice versa). However, while promising only a handful of design artifacts exist that mobilize this approach (e.g., [17, 74, 79]) and none have explored it in the context of location histories. My work extends this nascent and growing research area by concretely demonstrating new forms of pre-interaction, and anticipatory interactions that may follow, can prime memory-oriented experiences with personal location history data in valuable ways.

6.1.1. Memory Tracer: Combining Randomness, Temporal Expression, and Pacing to Gradually Interweave Moments in the Future, Past, & Present

Prior HCI research has shown how randomness can operate as a resource for catalyzing reminiscence and reflection with large archives of personal data [62, 79, 109]. Yet, in my case, making Memory Tracer's moment selection algorithm entirely random in an unbounded way would have disconnected it from "todays date", a contextual clue that was necessary to form meaning from the location. And without the pacing of the reveal being tied to the age of the moment, would have rendered each moment to be from this 'day in history' with no reference to how deep in the past it originates.

Memory Tracer illustrates how unique, evolving pre-interaction experiences could emerge through randomly selecting a near future calendrical day of the year that a moment had occurred on in the past; and, then using this historical 'age' as a factor shaping the number of days the moment was traced until it was revealed. This technique came together as a synthetic experience where **a day in one's future** was tied to a specific **time and place in one's past**, that was **experienced in the present** through ongoing cycles of tracing and revealing. This quality catalyzed various experiences to accumulate through Memory Tracer in the pre-interaction phase.

The early stages of a moment's tracing (and tracing tempo) gave rise to anticipatory reflections over which date the future 'day in history' might be anchored. The map progressively becoming more visually present—indicating that the moment would soon be revealed—often triggered a shift toward priming retrospective reflections that cut across life experiences from prior years that were situated around a particular calendrical date (or set of nearby dates). Such situated encounters gave rise to a range of recollections–from where one may have been and with whom, to considerations of how one's life has changed across years around this point in the calendar, to simply recalling fuzzier associations tied to a particular season or annual event. These open-ended experiences of everyday reminiscence ranged from a few fleeting moments, prompted by casual notice of a nascent visual trace, to deeper reflective considerations as a potentially recognizable map-based moment came into perceptual view and the relative age could be inferred through the tracing tempo.

6.1.2. Memory Compass: Foregrounding Geographic Awareness to Prime Interactions with Moments Across Space and Time

Memory Compass also embodies a minimal character across its interface, form, and aesthetics, though it is notably different through adopting an implicitly slow design quality that enables user control of retrieving specific spatial-temporal moments in their past. These qualities prompted a remarkably different form of pre-interaction that was more geographic and embodied. In the pre-interaction experiential space, after configuring the casting filters but prior to enacting the cast, I was compelled to pause and consider my current location, geographic orientation, and what specific moments in my past may come back. This memory-oriented way of contemplating geographic space and place over time, configured how I thought about the relations of my own life stages and memories tied to places across time which often led to cycles of interaction and reflection. These could range from anticipating other geographically clustered moments that could be retrieved through similar casts after an initial moment triggered a significant recollection, to simply adjusting the strength or orientation of the cast in anticipation of the surprising discoveries that might be revealed. My own movement through space also led to an increased awareness of how location shaped the moments returned. This was particularly revealing when I temporarily moved from where I had attended university to my family home, thereby shifting the relative ‘nearby’ moments more easily accessible via shorter casts from recent, largely mundane, moments in my life to a rich pastiche of places bound up in earlier formative years.

6.1.3. Comparison of Explicit and Implicit Slowness as Design Qualities for Supporting Everyday Reminiscence with Location History Data

Collectively, these findings demonstrate an advance for how the HCI and design communities can leverage qualities of pre-interaction and anticipation to design for everyday reminiscence. The case of Memory Tracer illustrates how the design quality of pre-interaction can be mobilized and extended not only through subtle, gradual changes in the design artifact’s output (e.g., light-based visual changes) but also through leveraging the pacing itself as a form of shifting temporal expression. These qualities can come together to prime experiences of reminiscence on past experiences bound to places that continually recur and diverge across the calendar year, and which subtly expand as the location history archive and user cumulatively age across time. The case of Memory Compass shows that users can be extended a degree of control in ways that does not compromise the ability to support experiences of pre-interaction that prime reminiscence. Memory Compass' minimal design paired with spatial and temporal filters as well as one's own embodied sensibility for retrieving moments through casting, generate a sense of unpredictability that support cycles of anticipation and reflection. Yet, these design qualities equally could prime a space for reflection prior to casting where a user can anticipate what might emerge from their past in relation to their present geographical orientation.

In this way, my work bridges research on designing for pre-interactions with techniques for supporting interactive cycles of anticipation and reflection. I see a need for future research to explore how these combined techniques can give rise to products and experiences for supporting ongoing experiences of everyday reminiscence with location history data. While rarely considered in prior research, the combined creation of both Memory Tracer and Memory Compass – and the productively different perspectives on location history they generated – suggest there are opportunities for exploring how multiple design artifacts with differing design qualities could work together to enable users to develop rich memory-oriented perspectives on, pathways through, and interactions with large and growing personal data archives capturing one's history. There is an opportunity to develop design patterns that illustrate how people can move among ceding autonomy to explicitly slow systems, like Memory Tracer, that make time for pause and reflection through uncontrollable, gradually changing expressions of location histories, and to enacting control of implicitly slow systems, like Memory Compass, to anticipate and explore different moments in one's history across space, place, and time. In addition to creating new systems and artifacts for supporting everyday reminiscence, future research could equally extend concepts for slow technology by contributing to the call for more diverse exemplars of how speed and pacing are conceptualized and how more temporally diverse design strategies can be enacted [16, 63, 94, 94, 96, 120].

6.2. Tools for working with location history as a design material

My design research revealed a need for new interactive tools to better support designers in working with location history data in the design process. Despite location histories existing as one of the most abundant and detailed forms of personal data that people generate about their daily lives, tools available to interaction designers to work with it as a design material are highly underdeveloped. My initial, early experiments for organizing and working with location data was incredibly crude on a tangible and visual level. This part of the process required developing a way to parse and grapple with different elements that comprise location history data within huge JSON files. This initially hampered my efforts to develop a sensibility for understanding and working with spatio-temporal aesthetics of the data and the potential value they could have as a resource for everyday reminiscence. In working through these challenges, my early decision to create a framework for classifying location data as *moments* and preserving strands of metadata critically informed my design approach and, ultimately, both of the final designs. Through iterative explorations I progressively worked toward developing a range of visual assets that helped me grasp what location history data is and develop techniques for organizing location history archives into different spatial, geographic, and temporal formats. These experiments ranged from visual map-based representations to visual traces of one's locational movement across days, weeks, and years. This proved critical for gaining a better handle on how I might conceptually and practically deal with the sheer size and scale of location history datasets. Another challenge I encountered centered on the changing stability of location history data. Despite my decision to use Google Timeline, which seemed like a relatively reliable aggregator of personal location history data, several months into my design process the platform introduced several significant changes in the way the data was stored and structured. This required me to adjust and refactor my code for classifying and surfacing moments from the archive. To date no further disruption have occurred, yet it remains unclear if or when more may emerge.

These collective issues present very real complications that challenge the capacity for design researchers – and indeed the users that 'own' the data itself – to create new relations to and perspectives through personal data. These challenges intersect with calls for more diverse and extensible approaches for "breaking data free" in the service of creating stable versions that can be safeguarded, creatively manipulated, and given new and unexpected forms [22, 121, 122]. Building on recent work situating data as a design material to be better understood through practice [16, 24, 61, 82, 110, 122], there is an opportunity to create new interactive systems that stabilize and support designers in organizing, visualizing, and prototyping different spatial and temporal patterns, themes, and variations in large personal historical archives. Like how our early experiments in working with location data to understand what it 'is' (through visualizing it on map-based representations) played critical in developing interaction and experience designs, such resources and tools could actively support the development of richer inspirational resources, that can be scaffolded in the next stages of the design process. While GPS and GIS data visualization tools exist, they are cumbersome and not well suited for the creative, fast moving creative explorations that are needed in the early divergence stage of the design process. I imagine that this will not only enable designers to diversify and extend their capacity to work with data as a design material, but equally help generate opportunities that better respond to calls in the design research community to create design artifacts that exemplify rich and diverse alternative expressions of personal data in everyday life [30, 31, 49, 58, 100]. Indeed, researchers have already begun to develop initiatives to support designers in getting a grasp on the immateriality of data, algorithms, and network connectivity [13, 28, 35, 84] that could be leveraged in support of future research in this direction, as could research on developing tools for designers [68, 104].

6.3. Practical and Logistical Challenges of Personal Location Data as a Design Material for Reminiscence

While the quantity and scale of personal location histories present exciting possibilities for designers and the potential for new experiences of reminiscence, there are practical and logistical challenges with recording and using this data. First, there is a high level of privacy needed for such an exacting record of ones' location over the course of years and eventually decades. This quantity of private information can introduce frictions for people to record it and challenges when accessing and using it. Additionally, there is currently no standardized format for location data. Next, I reflect on these challenges and offer some potential solutions.

While the security around any form of personal data (documents, photos, music, etc.) is important, location data poses a particularly high risk due to its ability to reveal a magnitude of sensitive personal information bound up within the data. Naturally this makes many people resistant to using location tracking services such as Google Timeline [39]. There is a tension between the value of recording a personal log of one's previous locations and the fact that this data is collected and stored by a corporation that has economic incentives to profit from that data and already has vast amounts of other personal data about users. And because there is still a lack of novel devices and experiences to surface location data in ways that deliver value, there is even less incentive for people to collect it.

While Google Timeline is by far the best option for generating an accurate and precise personal location history over time, there are other services that can continually track location such as LifeCycle, Arc, and Gyroscope. Additionally, there are many activity specific (mainly fitness) services like Strava, Nike Run Club, Slopes, among others. However, Google Timeline and most of these location tracking apps require storing the data on an external server where the data could be hacked or compromised. There are also concerns that the data will be used for advertising and monetization. More people are likely to use personal location tracking if there was a privacy focused capability for storing their data. Such capabilities would allow storing encrypted location history on the user's phone, without it ever being uploaded to a separate server. Any backup options would be end-to-end encrypted.

Another potential solution is an open source, non-profit organization dedicated to personal location logging. This could provide a service for people to track their location securely and safely without the conflicting interests present with a for-profit company tracking it. Such an open-source organization might be similar to how Signal [102] provides encrypted communication, giving consumers a choice over applications owned by Google, Facebook, or Apple. This could also address the issue of popular location trackers eventually being shut down. Moves was shut down 4 years after being acquired by Facebook [130], and Fabric was sunset after seemingly running out of cash[6].

A specific challenge I encountered while using Google Timeline data during my research, was the lack of an API. This posed an inconvenience for me as a designer – I needed to regularly login to Google Takeout and manually export and download my most recent data. This was, however, a positive trade-off for me as the owner of my data – I knew my entire location history could not be accessed, unbeknownst to me, by an unscrupulous third-party software. Giving end users better options on how to store and sync their private location data with other devices and services is needed. Any use of the cloud for syncing between phone and other devices must be end-to-end encrypted. Ideally there would be an option to backup or sync the data directly from one's mobile phone where it is being recorded to external devices via Wi-Fi, without ever sending it to a remote server. All data should remain encrypted, and as much computation as possible should occur locally on the devices.

Finally, another current challenge is that there is no universal format for location data. While there have been attempts at creating such a standard, namely GPX [42] and KML [59], there is not an agreed upon exporting format among popular location logging and fitness tracking services. Often custom JSON or CSV formats are used when a user requests an export of their data. This is in addition to a service changing their own formats, which happened with Google Timeline during my thesis research project. This inconsistency poses a challenge for designers and end users alike. For designers, they need to be comfortable parsing large data sets with custom scripts in order to easily work with location data as a design material. For users, it is challenging to know how to directly engage with their data—to view and experience it—outside of the application that created it. Both situations can make location histories feel intangible and unable to be owned and possessed, explored, and lived with in an ongoing way.

6.4. Where Does the Research Go from Here?

Memory Tracer and Memory Compass both demonstrate potential in using personal location histories as a resource to spark reflection and reminiscence on past events and experiences. Design qualities of pre-interaction and slowness appear to be particularly promising qualities to leverage when engaging with this data. And while my research through design process has indicated potential futures for how location histories might be used and experienced as people continue to accumulate this form of data, my research also opens more questions and opportunities for the HCI community to research and explore.

6.4.1. Location Data + Other Data

My research focused on only using a single person's location history data without combining it with any of their other data or another person's location history. As I described previously, I chose to do this for strategic reasons, namely how the 'limitation' of only using location history as a primary form of data could push me and my design collaborators on creative, conceptual, and practical levels. However, combining location histories with other forms of personal data and other's location data is certainly an area which should be further explored. Combining personal location histories with other forms of personal data and metadata such as notes, voice memos, music listening history, fitness health data, etc. could open unique ways to remember and explore one's past. Following recent HCI designs with music histories [75, 77], the pairing of music and location histories appears to be an area full of potential for curious, open-ended, everyday reminiscence. Drawing from initial explorations I did, comparing location histories between close friends and family seems to be ripe with potential as well.

6.4.2. Pacing and Selection Logic

Memory Tracer and Memory Compass show the pacing and way of retrieving data is critical to the design. At the most basic form, both Memory Tracer and Memory Compass simply show a point on a map. It is the pacing, context, logic, and interaction surrounding the selection of which point to show and how that point is shown that make both designs so effective. Future HCI research should continue to build experiences which further expand on how nuanced decisions around pacing, context, logic, and interaction can be leveraged to create unique and delightful products that prompt reflection and reminiscence.

Chapter 7.

Conclusion

Through grounding my design-led research in the proposals of Memory Tracer and Memory Compass, my work contributes to growing calls in the HCI and design communities to create design artifacts and exemplars capable of a) supporting situated experiences of everyday reminiscence and reflection [8, 18, 38, 47]; b) opening broader possibilities for forming relations to and interpretations of our growing amounts of personal digital data [30, 31, 49, 82, 100]; and c) extending and critically reflecting on concepts of slowness and temporality through design [63, 76, 93, 113]. My detailed unpacking of the Memory Tracer and Memory Compass design cases helps make concrete differing, yet complementary approaches to making use of location history data as a design resource to offer alternative forms of exploring, contemplating, and reflectively considering places bound up in one's life history.

Both design cases show how inquisitive, emergent, and ongoing experiences with location history might be supported as the data ages over time. Based on initial use and testing of the two products, I offered initial insight and speculation on how personal location history archives might be experienced as they continue to evolve and expand to scales that people have never experienced. The designs showed that location data can stand on its own as a powerful data which can spark reminiscence. Collectively, these design artifacts offer promise to support a range of open-ended experiences of everyday reminiscence that can scale over time.

Importantly, my aim is not to be conclusive. Rather, I aimed to unpack and critically reflect on Memory Tracer and Memory Compass in a generative way to inspire future design research that inquiries into the spatial, locational, and temporal expressions of personal data in people's everyday environments. On a broader level, I hope that my critical-reflexive description of Memory Tracer and Memory Compass, and discussion of the resulting opportunities and challenges they raise, can be appreciated as an effort to better support design-oriented forms of knowledge production in the HCI community.

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