WorldViewer
A Personal Interaction tool for Visualization of Geo-data

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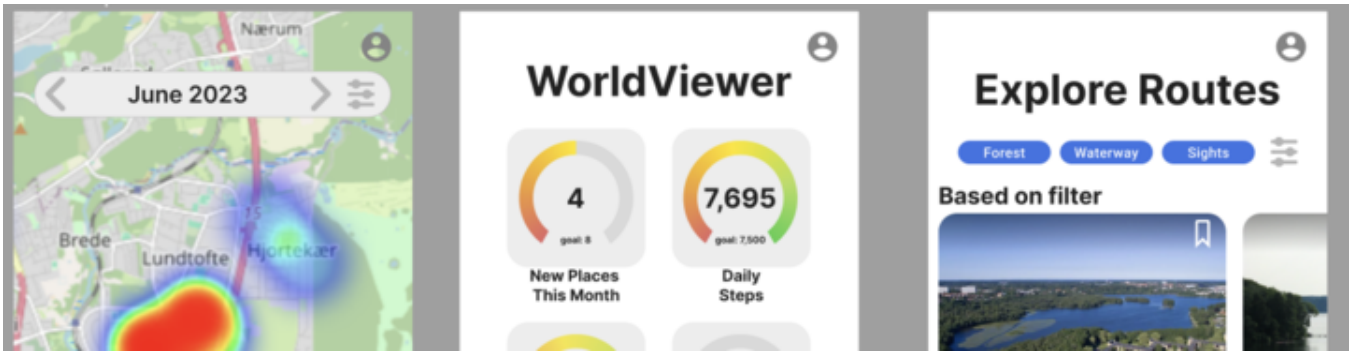

ABSTRACT

This project aims to address the common challenge of falling into the same old habits, which can prevent us from exploring new environments. We've developed an interactive tool that utilizes personal geo-location data to inspire users to break out of their routines and encourage them to explore new places. By analyzing user habits and daily routines, our tool seeks to encourage new experiences, leading to improved physical well-being, mood, and a deeper connection with nature. Using data from Google Takeout, our tool generates a heatmap, providing users with a visual representation of their visited locations. This visual aid facilitates introspection and informed decision-making for future outings, helping users to decide where to go on new journeys. Comparative assessments against established platforms such as Google Maps, Strava, and AllTrails highlight the unique features and benefits offered by our solution. We integrate Figma for interface design and Observable Framework for dynamic data visualization. Iterative design cycles, guided by user feedback, helped us prioritize the most important features of this program. In conclusion, this project offers a promising tool for empowering users to embrace new experiences, embark on unique journeys, and cultivate well-being.

CCS CONCEPTS

• **Human-centered computing** → **Ubiquitous and mobile computing**.

KEYWORDS

HCI, Interaction, App, Mobile, Personal Data, Tracking, Prototype, Map, Heatmap, Health, Statistics

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1 INTRODUCTION

Humans are creatures of habit [11], often following similar routines each day. Unfortunately, these routines can include unhealthy practices like staying in familiar places. Exploring new locations can benefit one's health [12], but many rarely venture out due to the nature of their habits.

The goal of this project is to make an interactive visualization tool that makes use of a person's already existing navigation data, to encourage exploring new areas in their local area, or on a broader national/international scale. The tool will work by showing a heatmap of locations that the user has visited, giving a simple idea of how they could take trips to new places.

Three common problems are being solved with the use of this tool:

- Going out more regularly, besides just going to work or school
- Visiting new places to get a positive mood, excitement and inspiration
- Spending more time in nature, to get more fresh air and clear one's head

Our proposed solution is an application that takes geo-location data from Google Takeout [5] and uses this data to visualize where the user has been on a day-to-day basis. By using the app, the user is encouraged to regularly explore new places.

In the rest of this report, we will describe how our proposed solution differs from other similar products, and which methods we used to create our product. we will also describe how we improved the product through multiple iterations, with reviews from other people at each iteration [3]. Lastly, we will give a conclusion on how well the proposed program solves the issue of finding new places to visit.

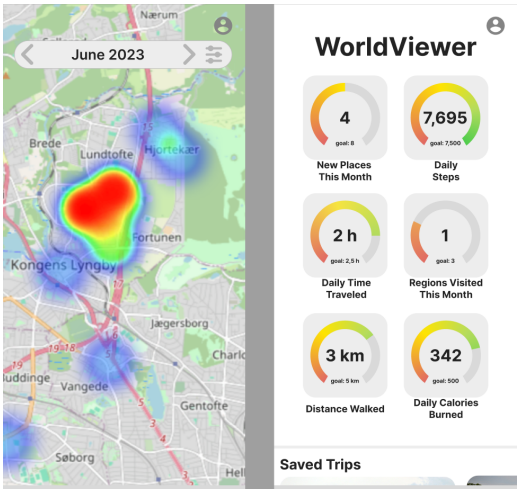

Figure 1: A part of the User interface prototype (Designed as a mobile app that the user can interact with, in Figma)

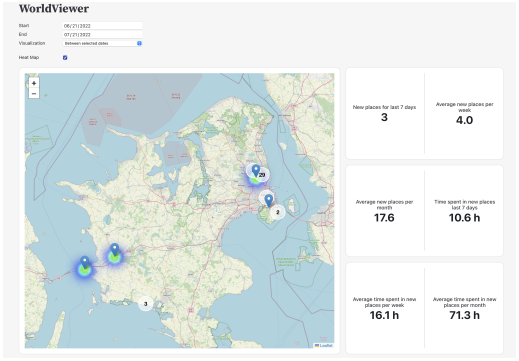

Figure 2: A Heatmap in Observable Framework that utilizes real data to show where a user has been in a set time period

2 RELATED WORKS

Our project is of course not the only example of tracking locations. Many other programs do that, including Google Maps and Strava. There are also other applications that suggest walks and hikes for the user, like AllTrails. But where our program differs from these other programs, is in what we try to accomplish.

For example, Strava [15] has a tracking feature where you can see where you have been, but the program is solely a fitness tracker, so it focuses on routes you have taken for running, cycling, or other exercise. Our program should track all places the user has been, whether it is for leisure, work, fitness, or something else. Strava also uses a lot of its resources to ensure precise tracking for the whole exercise route, while we aim to merely show the user the general location they have been in. Therefore our data collection is done in brief intervals, in the background.

Google Maps [4] tracks the user as well, and as mentioned earlier, we use the data from Google Takeout for our project. However, Google Maps is focused on giving directions to a destination of your choosing, and not so much for suggesting where you could go next. They do have Google Timeline, which is similar to our project, but that feature is not very intuitive to use, being buried in menus of the Google Maps app, and it doesn't do a great job showing how many times you have been in a certain area.

The last program mentioned as similar work is AllTrails [1], but they don't focus on tracking the user to suggest new locations. They function more like a restaurant menu card, where you are given some general suggestions between which one can choose from.

3 METHODS

We have focused on two pieces of software to develop the desired program. We used Observable Framework [10] to develop the interactive data visualization aspect of the project. That is where we utilize the gathered data to make various visualizations, such as heatmaps, graphs and plots. The second program we used was Figma [2]. We used this program to design the app look/feel, and interactions that we imagine a real app with our desired purpose would have.

When starting the project, we focused primarily on the Figma prototype. This was for two reasons. Firstly, we were more familiar with Figma, so while learning how the Observable Framework environment worked, we could already make some progress on how the app should work. Secondly, we didn't know which interactive elements could work, and which couldn't. By having the simple Figma prototype up and running, we could test with other people earlier in the process and know which interactive elements to focus on.

Another program we briefly worked on was a Jupyter Notebook [7]. We used this to create the first draft of the heatmap. This was decided, as we have more experience with Jupyter Notebook than with Observable Notebooks. This way we could more quickly visualize the heat map over our data, and see if the program could even be feasible with the data we have available. The downside with Jupyter Notebook was, however, that interactive elements are more difficult to create, so we quickly moved away from this program.

When having a basic setup in Figma, we could start getting feedback from others. We used this feedback to initially improve the Figma side of the project while keeping in mind how some of this feedback should translate to the Observable Framework part. After the third iteration of tests, we had the Observable Framework up and running well enough to begin testing with that as well.

In the following, we will discuss how the project follows the Stage-Based Model of Personal Informatics Systems [8]. Based on our own experience with personal data collection, we would often find it cumbersome to manually input new data every day, to feed the program. Therefore, we decided to focus on a personal interaction tool that can harvest data more or less on its own (a passive self-tracking system), without the user having to intervene on a regular basis. This approach is also supported by previous research [13]. Therefore, we figured that a program that tracks your locations could be ideal, and it can tell a lot about your daily habits, while only requiring that you have your phone on you, which we all already have. This also makes the frequency of data collection directly tied to how many locations you visit. For the project, this approach was also ideal as we already have a set of data to work

with. One of the group members have had Google location tracking on for the last couple of years, so we had loads of data to use. We decided to use a subset of this data, consisting of location data from 2022, which consisted of roughly 275.000 lines of data.

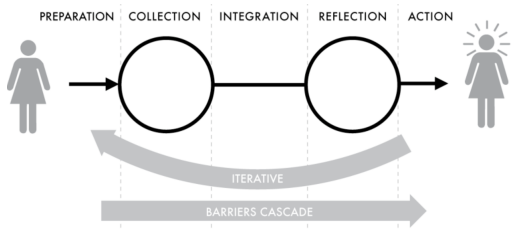

Figure 3: The Stage-Based Model of Personal Informatics Systems

In the Integration Stage we use the collected data to create a heatmap for the user to visualize their location habits. This heatmap can then be used by the user, to reflect on where they spend their time. It can also help them take action on where they might want to go for a walk, or spend time, while visiting a new location. To further increase the influence of the reflection and action stages, we have added various statistics for the user to see, along with goals to reach, in the form of the statistics bar that can be seen in the front page of the Figma site, or on the right in the Observable Framework. These stats can help the user get a simple overview of their progress, and how far they are from reaching their goal. The goals also gamifies the experience, making the goals more endearing to reach.

4 RESULTS

The project started out by proposing our solution as a short one-minute presentation. After that, the idea was revised by the received feedback and the first prototype was made.

4.1 Iteration 1

For week 1, we made an initial prototype of the app, consisting of 4 pages - a dashboard, exploration, heatmap and profile overview. Additionally we made a Python notebook for visualizing the GPS data in an interactive view.

The dashboard page of the app consists of visual indicators that the user may want to observe - new routes per month, daily steps taken, daily time spent.

Exploration page suggests new locations to visit, based on previous routes. Every location has a name, preview image, average time spent, distance and the "difficulty". Difficulty is a combined criteria of the landscape (hilly or flat), price (free or paid), accessibility (wheelchair accessible or not).

The heat map shows visited locations on a graphical map, defaulting to current month and user's current location. The visited locations are indicated by colored blobs, ranging in color and opacity from semi-transparent to opaque, blue - green - yellow - red. Therefore the least visited locations have semi-transparent blue blobs and most visited opaque red blobs. The heat map view can be filtered to a specific date range, panned, and zoomed in and out.

The profile page in its first iteration contains two toggles - Apple Health and Google Fit. Upon authenticating with one or two of the services, the navigation data and health details (e.g. step count) are synced, and personal attributes imported (health, weight and others).

To improve on the concept, think-aloud testing [9] was done with two users. The users had to click around in the prototype, announcing their thoughts out loud. The creator team was also available to answer any questions.

Some of the more important received feedback is as follows:

- home button should be moved
- circular indicators should vary in color by their competition
- a manual way to input missing data (e.g. visited locations) should be considered
- a wishlist for places to visit was suggested
- radius configuration, to require the user to go further or nearer before a place is considered "new"
- differentiation of intentionally and unintentionally visited places (e.g. going to work is required, not initiated as leisure time)

After collecting the feedback, additional discussion was held with the professor on how to proceed. The professor suggested on focusing on user goals as questions, with answers suggesting features to implement [6]. Every feature should have a specified goal as a question.

For example,

- Question: Where have I been to this month?
- Solution: Have a feature to let the user find where they have been to in the selected interval.

With this, we proceeded to improve on the prototype on the next iteration.

The Python notebook in its first iteration mapped out location data from Google Maps location tracking as pins and as a heatmap. Per given feedback, additional improvements were done on the next iteration.

4.2 Iteration 2

On the second iteration, the app prototype was changed as follows:

- "Home" was renamed to "Overview" and placed in the middle of the navigation bar
- The Overview now lists places that the user has saved to visit in the future, called "Saved Trips"
- "Profile" was moved from navigation bar to top right corner, as it currently contains only settings that don't need to be changed often
- Dashboard replaced a duplicated "daily steps" with "regions visited this month", referring to 5 Danish regions (and similar distinctions in other countries)
- Explore received additional filters: "Nearby", "Forest", "City", "Waterway", "Shop"
- Added an option "place definition" which defines, in kilometers, what range of a location is considered "one visited place"

Another think-aloud testing was done with another user.

The received feedback was as follows:

- The step count is not very informative as a general number, perhaps it would be better to count the steps around a single place visited (e.g. how many steps were taken in a park)
- The distance to the place should consider the transport method, e.g. on foot or via bicycle, and it should consider actual roads. Distance transport method should be selectable in filter settings.
- It would be useful to have a numeric radius filter, e.g. see places around 15 km
- For sport purposes it might be useful to add indicators for distance traveled in a day (km), and calories burned
- Every place should have a detail page, which lists what actions can be done in the place (e.g. running track, swimming place), the costs etc
- Every place should have an short informative summary text of the place itself, its history etc, along with a button to read it out loud
- The difficulty level could be toggleable, and it should have criteria to whom it applies to (adult, elderly, families with children, wheelchair etc)
- It should also be possible to permanently apply some filters in profile, like wheelchair and having children
- The time usually stayed in the place seems like an informative metric, which shows how much there is to see in the place
- "Latest New Discovery" is positive, serves as a reminder of what the person did/saw in that place
- Generally the more filter options there are, the better
- Maybe implement "subplaces", e.g. the goal is to visit a city and in that city see at least one shop, cafe, park etc.

For enhanced interactivity, we decided to transition to the Observable Framework, which offers more straightforward tools for creating interactive plots and maps. This week, our primary focus was on migrating our visualizations from Jupyter Notebooks to Observable.

In the Observable Framework, we successfully implemented an interactive map that displays visited locations both as individual pins and as a heatmap. Additionally, we integrated a time interval selection feature. Users can now view the places they've visited within a selected timeframe. Nearby locations are grouped together into clusters for a more organized and intuitive display. This functionality allows users to easily observe patterns over time and identify areas they frequent or explore new territories.

4.3 Iteration 3

According to the given feedback, a detail page was implemented on the app prototype, containing the following:

- Name and preview image
- Short description
- Distance to the location by various forms of transportation
- General features like accessibility, suitability, opening hours
- Specific features like sights to see
- Recommended route preview, distance/time, and directions button
- A button that reads the name, short description, and details out loud

We decided that the step count should not be changed to be place-specific, as it still serves as a general overview. However, we added "daily distance traveled" and "daily calories burned".

The list view now separately lists the distance to the place and the route in the place.

The filter selection bar now has a button to open a detailed popup, and the bar only shows the selected attributes.

We discussed within the group and realized that the aforementioned "subplaces" are already a part of the app, because the app suggests routes which can encompass several sights.

Then we did a think-aloud test with the next three users.

The received feedback was as follows:

- Maybe make dashboard widget titles a bit bigger
- Dashboard indicators look very similar, try different colors and plotting types
- Maybe show indicators in different screens to not overwhelm the user
- Call "Nature hikes" section "based on previous trips"
- In the heatmap, also show unvisited possible routes

We also used this feedback to make further progress on the Observable Framework.

- Added date filters for the map visualization
- Made a graph to indicate visited places per week throughout 2022.
- Added numeric counts of new place visits for last week, average per week, and average per month

In Observable Framework, we introduced a new feature to visualize "new places" on our dashboard. We first filtered the dataset to identify these new places. A location is classified as "new" if it hasn't been previously recorded within a 50-meter radius. After identifying these new places, we proceeded to visualize them on the map. This enhancement allows users to clearly see areas they are exploring for the first time, offering a more dynamic and interactive experience as they track their travel patterns and discoveries.

4.4 Iteration 4

In the app, "Popular Routes" was renamed to "Explore Routes", to better indicate the variety. "Nature Hikes" was renamed to "Similar to your trips".

A detailed review section was implemented, with an easy way to add a rating and comment, and see the average of other ratings and two individual ones.

We then proceeded to have a presentation with the lecturer and TA. They mentioned that we now need to work on developing and iterating the Observable notebook more. As such, we slightly refined the Figma prototype and decided not to implement any more new features to it.

We then had a talk-aloud test with 2 students about the Observable Framework and did the following changes:

- Limited our dataset to 2022 between January and August, to avoid having gaps in data; the dataset was already sufficiently large.
- Computed specific metrics, such as the average number of new places visited per week and the new places visited this week.

- Calculated the duration of time spent at new locations.

These statistics are now clearly presented on the dashboard, allowing users to easily access and understand their travel patterns. This information not only serves to quantify their explorations but also encourages further discovery by highlighting recent activity.

4.5 Iteration 5

For this iteration, we expanded our Observable Framework dashboard by adding visualizations for the top 10 most frequently visited locations and the top 10 locations where users have spent the most time. We also generated statistical charts for these places to facilitate easy observation and analysis of personal data by the users. Additionally, we introduced a trend chart for new places visited. Users can select different time periods to view and analyze trends, enhancing their ability to monitor changes and patterns in their visiting behaviors over time.

4.6 Iteration 6 (Final Iteration)

In the final iteration, we did a 4-minute presentation for the class and the teachers. Using the received feedback we did a final iteration on our work. We discussed with the teacher, about how some elements of the Observable Framework could have been programmed with dynamics in mind, so it could be fed data continuously. And we talked about why we went with only using a subset of 1 year worth of data. The rest of the feedback we received was about smaller points in the presentation that were not covered in depth, due to the time constraint of 4 minutes but are covered in detail in the report.

Then we did a final talk-aloud iteration with a student and received the following feedback:

- In the map bubble, labels "country" and "postcode" do not always contain what they describe. As the data points of the address vary per country and region, we just removed the explanatory prefixes.
- In the rank graph, it is unclear what the "value" is (should say "frequency"/"time spent") and the index should start from 1.
- When the map is set to top 10 visited or top 10 time spent, make the pin icons or bubbles show the index too. We were not able to implement this right now, but the user can continue to see the values in the rank graph.

With those fixes, we considered the Figma prototype and Observable Framework to be finished and went on to finalize the report.

5 DISCUSSION

At the beginning of our project, we planned to run a survey for people testing our app prototype - before and after using the app [14]. However, in practice, we skipped that evaluation and used think-aloud tests instead, as that method was able to give faster, more detailed, and direct feedback, and it worked better for a prototype that is not directly functional. We believe that the combination of think-aloud tests and teacher feedback was sufficient for achieving a user-friendly interface. In the Figma Prototype, it can be seen that the program should give the user recommendations on new places to visit based on their previous location data. This, however, would be overly complicated to implement in Observable, as we would also need a database of those locations, and we considered it to be out of the scope of what we wanted to achieve with the product. Therefore this part was left out of observable, also so we could spend more time optimizing the heatmap and data visualizations.

Currently, our Observable dashboard built with the Observable Framework utilizes a static setup, where the data is pre-processed and stored in a CSV file that the dashboard references. However, for practical applications, a more dynamic approach would be required. This would involve refreshing the data every few seconds to provide real-time updates. To achieve this, we would need to establish a server that runs scripts for live data processing. Implementing such a system would allow for continuous data updates, enhancing the responsiveness and accuracy of the dashboard in real-time scenarios.

6 FUTURE WORKS

In the Observable Framework we had an idea of indicating distances, and occurrences per traveling method, such as "In July, you walked for 10,5km, which is 7.7% of your distances that month. You walked 34 times, which is 47.9% of all trips taken that month."
In our Google Takeout's JSON data structure, each node has two subnodes - "activitySegment" and "placeVisit". In most of our work, we have used "activitySegment", but for this we'd need to use "placeVisit". The nodes do not contain identical data, so they'd need to be carefully correlated, otherwise, the structure of the output data is inconsistent, making odd rows have one piece of data and even rows the other pieces. Therefore, we decided to not implement this feature right now and instead consider it more as a possible future implementation.
It is also important to note that our dataset came from Google Takeout, which means that we have designed the notebook and data extraction scripts to solely work with the way Google Takeout formats its data. This means that the program might struggle if we wanted to use data from other providers (such as Apple Health). It wouldn't be difficult to make the program able to use other data points, but since it doesn't provide any new features in itself, we didn't spend time making this implementation, and left it as potential future works.

7 CONCLUSION

The final product that we wanted to develop was well achieved. We believe that the deliverable can provide as a solid foundation for a fully-fetched program with the same features in mind. The iterative process of testing new features on a weekly basis greatly helped steer the project in the right direction, and ensure that the product was developed with an end user's wishes in mind. Additionally, the idea of starting out testing in Figma, while learning the structure of the Observable Framework made sure that we could design, test, and iterate the program from the very beginning. This meant that we didn't lose 3-4 weeks of iteration, that we otherwise would've done if we only focused on setting the Observable up first.
We are happy with the solution we came up with, and believe that this kind of system could really help some people reflect on their exploration habits, and perhaps change them for the better, for improved mental health and increased happiness.

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A CONTRIBUTIONS

In the table, we have highlighted how the main contributions were split among the group members for the project.

	UEL	SD	MO
Abstract	x		
Introduction			x
Related Works		x	
Methods	x		x
Results		x	x
Discussion	x	x	
Future Works	x		x
Conclusion		x	x
Appendix	x	x	x
Figma	x		x
Observable	x	x	x
Python Notebook		x	
Video Recording	x		

B FIGMA PROTOTYPES

The following are images of the different iterations for the Figma prototype, along with the URLs for the prototypes

First Iteration of the Figma Prototype:
https://www.figma.com/file/cLJ4QxdbHlrVDoE4uKitvb/Final-Project---UI?type=design&node-id=32-64&mode=design

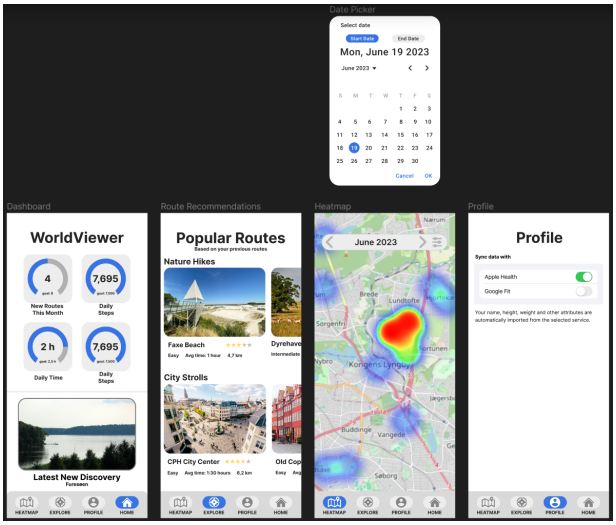

Figure 4: First iteration of the Figma Prototype

Second Iteration of the Figma Prototype:
https://www.figma.com/file/cLJ4QxdbHlrVDoE4uKitvb/Final-Project---UI?type=design&node-id=0-1&mode=design

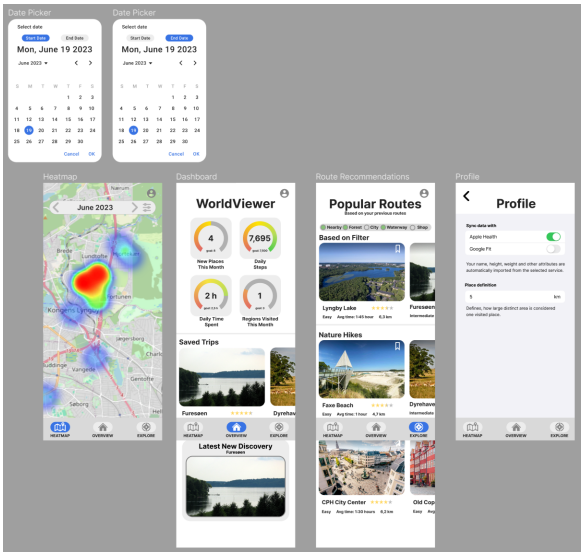

Figure 5: Second iteration of the Figma Prototype

Third Iteration of the Figma Prototype:
https://www.figma.com/file/cLJ4QxdbHlrVDoE4uKitvb/Final-Project---UI?type=design&node-id=188-53&mode=design

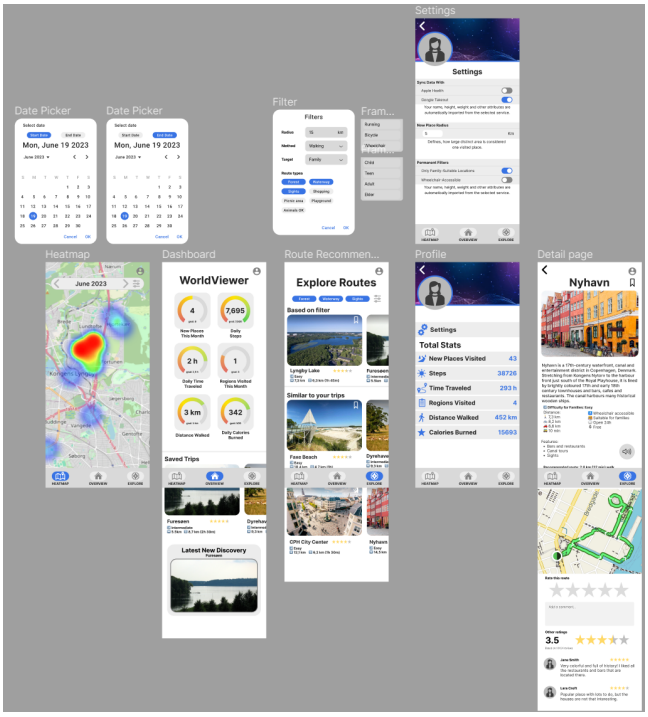

Figure 6: Third iteration of the Figma Prototype

C OBSERVABLE FRAMEWORK

The following are images of the Observable Framework Notebook

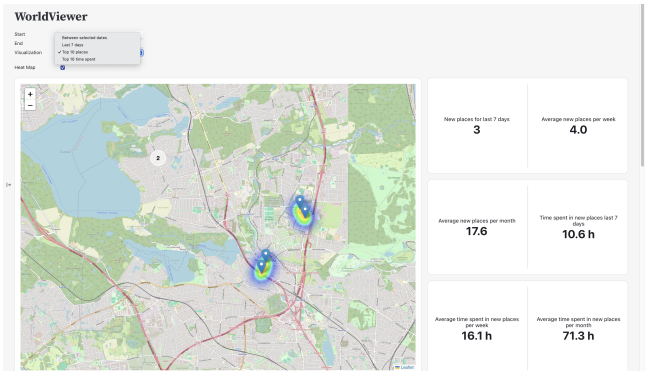

Figure 7: The selection map as seen in Observable Framework

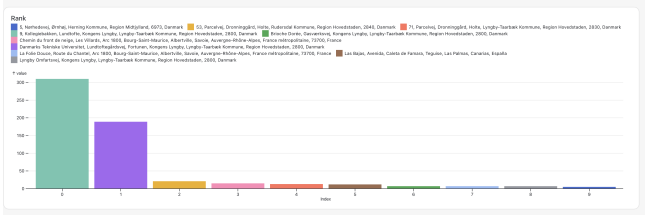

Figure 8: The place rank as seen in Observable Framework

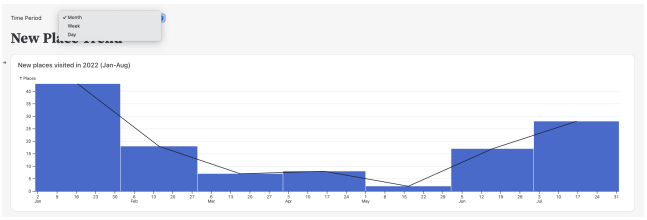

Figure 9: The new place trend as seen in Observable Framework

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