More people than nature: monitoring the experience of crowding at Þingvellir National Park

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Abstract

People come to Iceland to visit the land, in greater numbers than ever before. The infrastructure of national parks and natural areas needs to be extended to accommodate this larger wave of visitors. In locations which are highly popular and frequently visited, the perception of crowding diminishes the authenticity and quality of the experience. Monitoring this phenomenon is a crucial step towards successfully preserving the area without closing it completely to traffic. Once monitoring data has been collected then it is possible to use the data to calibrate a computational model and use it to test possible infrastructural interventions. In this project a new method was developed to study and monitor crowding as experienced by tourists visiting a tourist site, with the aim to calibrate computational models. The project involved the design and building of a new monitoring device, as well as collecting data at Thingvellir National Park. Preliminary results indicate that the method is capable of capturing essential tourist data that has never been captured before, making us more capable of responding to the influx of visitors based on science rather than a hunch.

1 Introduction

People come to Iceland to visit the land, in greater numbers than ever before. The infrastructure of national parks and natural areas needs to be extended to accommodate this larger wave of visitors. Extension of infrastructure is already planned for Þingvellir and future designs are in evaluation for Jökulsárlón. Both areas, unique in the world, are going to have an estimated 1.5M visitors per year. Such high numbers require attentive considerations in the planning of visitors centers, parking areas and general infrastructures for visitors attendance. The problem is complex because the infrastructure needs to accommodate and route a certain high number of visitors per day and doing so while preserving nature as much as possible. The challenge is to benefit from the popularity of a protected area without wearing out its pure authentic character which is the reason why people visit the area in the first place and the very essence of a quality travel experience.

The purest and most authentic experience of nature is one of solitude, where someone can have an intimate encounter with nature itself. On the other hand, we all have experienced a naturalistic area where we feel surrounded by "more people than nature". In locations which are highly popular and frequently visited, the perception of crowding diminishes the authenticity and quality of the experience. Such reduction in authenticity is an indicator that management and preservation of the area can be improved, to great benefits in the perspective of sustainable tourism. The dynamic interplay between the visitors' behavior, the infrastructure and the perceived authenticity of the experience is so complex and nuanced that stakeholders alone, through meetings and personal opinions, lack the capacity to thoroughly investigate the consequences of certain decisions without technological assistance. Monitoring the phenomenon is a crucial step to provide insights on the authenticity of the experience and therefore the efficiency of the preservation. Once monitoring data has been collected then it is possible to use the data to calibrate a computational model and use it for the speculative investigation of plausible scenarios generated from the proposals of future infrastructural interventions. We cannot monitor the subjective experience of authenticity in its entirely but we can focus on the *experience of crowding* which is known to directly affects the former.

2 Motivation and Background

Crowding has a significant impact on the quality of the experience of visitors to national parks. In our study we focused on the social carrying capacity[1, 2, 3] of the infrastructure at Þingvellir National Park. We attempted to assess the the degree of disturbance that people are exposed to because of crowding.

People tend to report a sensation of crowding in places that become congested. It's indeed a perceptual experience about a certain location but it would be a mistake to think that it is caused solely by the number of people - timing is a factor as well. In order for people to feel crowded they have to be in the same place and at the same time with a higher number of people. Being at the same place at the same time isn't always granted in outdoor context like a national park. There are several locations to visits, points of interest and pathways that might take people to spread across the entire area of a park in several ways. Indeed it is a phenomenon of people flowing through the area and distributing themselves around based on their interest, itineraries, available time or simply where they are allowed to walk. The perception of crowding affects the experience of visiting a national park, likely in a negative way. If we look at the experience of a naturalistic area through the spectrum of a purism scale, then we can expect crowding to affect the experience by reducing its purity. Of course the extent of the disturbance is likely to be subjective. Certain people will be more sensitive to crowding than others. This is quite common sense but we can say more. If we think of an experience as an activity extending over time and space, then we can imagine people reporting a sensation of crowding at different time and places along their journey through the national park. People arriving at a certain place but at different times might report entirely different perception of crowding. Same for people arriving at the park at the same time but at different locations. The synergy created by having a certain number of people congregating or walking through a certain space at the same time is what seems to affect in the most significant way the perception of crowding.

In many field studies that attempt to measure how crowding affects the experience of a naturalist area the instrument par excellence of such investigation is the questionnaire: a collection of questions handed over to a visitor at some point of their tour or on their way out. This approach can provide some indication of how much the visitors were disturbed by the crowding but it has a main limitation: it captures the impression of a person after the fact, providing little information about where and when they felt crowded. Imagine to interview a person after she took a tour for about two hours, she might not recall precisely where she felt crowded and/or not be able to explain it accurately. This might inject some degrees of error in the statistical data but more importantly it doesn't give us an accurate depiction of the phenomenon of feeling crowded as it unfolds in space and time. What is missing in this type of investigation is the possibility to observe a person as it walks around the park. Observation is a typical technique both in ethnographic field studies and user research. Having well developed observational skills is a great asset for anyone investigating on people experiences. Recognizing the value of observation we decided to overcome the limitations of questionnaires by integrating them with a specially designed portable device. The device allows the recording of a visitor's perception of crowding while walking around the park, both in space and time, and collect the data for further analysis.

3 Approach

The overall approach of the project can be summarized by the following steps taken by us, with the central data collection concept summarized in Figure 1:

1. Design and construct a novel electronic device to record the perception of crowding in space and time.
2. Prepare traditional interviews and questionnaires which would frame the data collection with useful demographic information and provide further subjective insights into the park experience.
3. Design and prepare a field study at Thingvellir National Park (including putting together signage, uniforms, badges and organizing rewards).
4. Recruit people at Thingvellir, collect and verify successful recordings.
5. Organize the data and start the data analysis process.

To carry out these tasks, we needed access to a number of essential resources outside our research group. We received contact information of people that were there to help us. Most important was Hannes Páll Þórðarson who manages the Electronic Lab at RU and showed us a few tricks on how to produce the device in terms of hardware. We were given access to the the 3D printer in the Machine Shop at the university so we could test print the models for the case of the device to its final iteration.

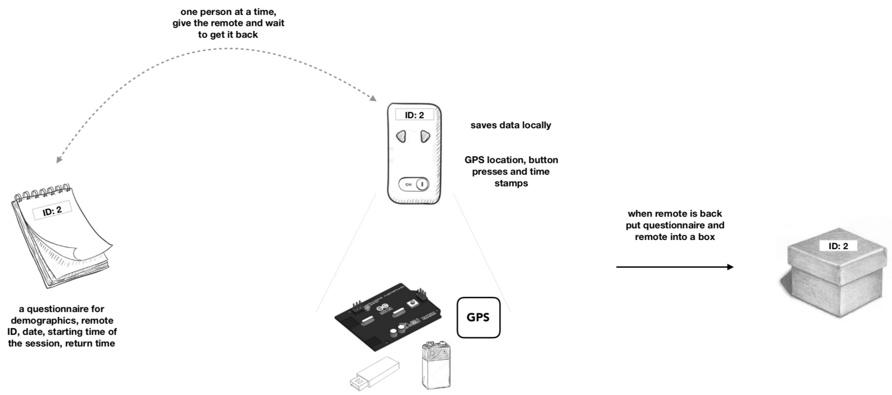


Figure 1: Main concept of the research

4 Implementation

4.1 Device Design Requirements

We organized the requirements into a simple table that would explicitly specify what the device would look like and its particularities:

Table 1: Table of design requirements

Functionalities	Track time and the location of a visitor. (GPS) Two buttons, and only two, to record when the person feels crowded or isolated Record all this data locally. (data logger)
Size	Big enough not to be lost. Not too big or heavy to be bothersome to carry. Fit an average person's hand. Big enough to fit the hardware inside.
Shape	Can't feel like a TV remote or a phone but somewhere in between. Easily carried and not feel like a rock. Round edges, long enough to fit the hardware inside.
Color and material	Robust and lightweight material. (PLA material) Smooth to the touch. Spray paint. Waterproof. Dark-gray colored

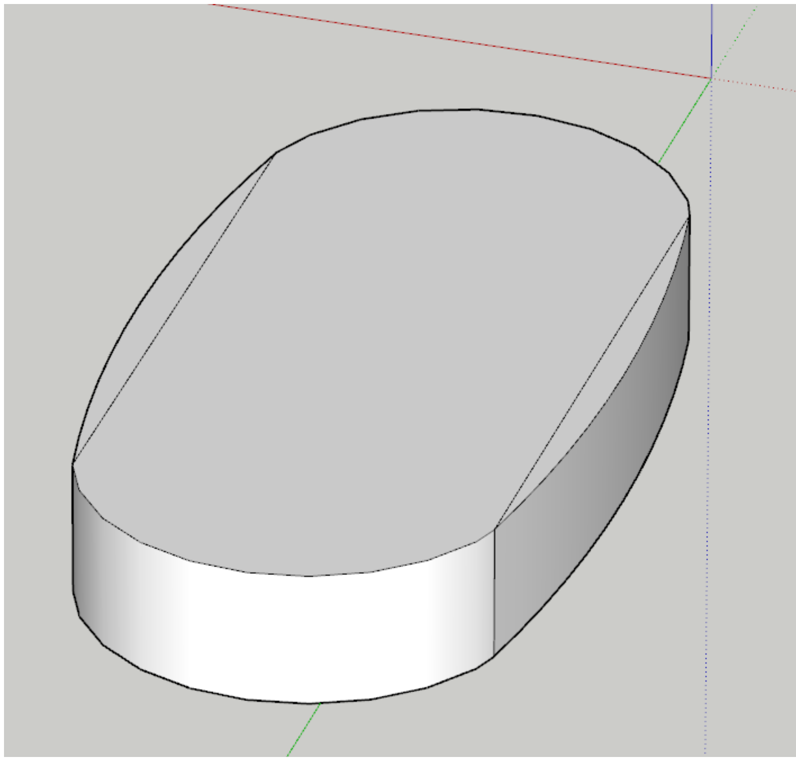


Figure 2: First design iteration in the SketchUp 3D modeling package

The positioning and appearance of the two buttons was also another important part of the design we spent a lot of effort on. We went with vertical alignment of the buttons, which made it pretty intuitive that the two buttons have opposite functions, one to report a feel of crowding and the other to report isolation. We also drew two visually different icons on the buttons to reinforce their intended purposes.

4.2 Creating the Device Casing

The idea was to 3D print the case for the device, so that all the electronics would fit inside and it would still fit in one hand. A montage of different production iteration can be seen in Figure 3). To 3D model the case we used *SketchUp* (see Figure 2), to convert to *gcode* (for 3D printing) we used *Cura* and we used the *Ultimaker 2 extended+* printer to print the case. 3D modelling took most of our time since if the model had holes the printer would fill up the whole interior of the case. This is because we couldn't model the filled area effectively with SketchUp. The printer failed printing multiple times, but that is just how it goes for 3D printers, they are still not perfect technology. We also had to repair the printer twice, once we were switching nozzles and it was tightened to much while the filament was cold that the nozzle broke and only left the screw part left in the extruder, but a smart trick of sticking a rod into the broken nozzle, heating the filament and then cooling it down so it would solidify around the rod and could then be removed easily, which would otherwise have been impossible to remove without power tools. In other words breaking a nozzle on a 3D print is not as bad as breaking screws on other devices.

After printing the best iteration at that point we began researching how we could finish it up by dry and water sanding as well as painting the cases.

4.3 Creating the Device Electronics

To produce the electronics that would be up to the task, we were provided with parts to build an Arduino embedded microcomputer (also see Figure 3):

- Adafruit Ultimate GPS, the GPS module.
- Adafruit feather M0 express, The micro computer chip.

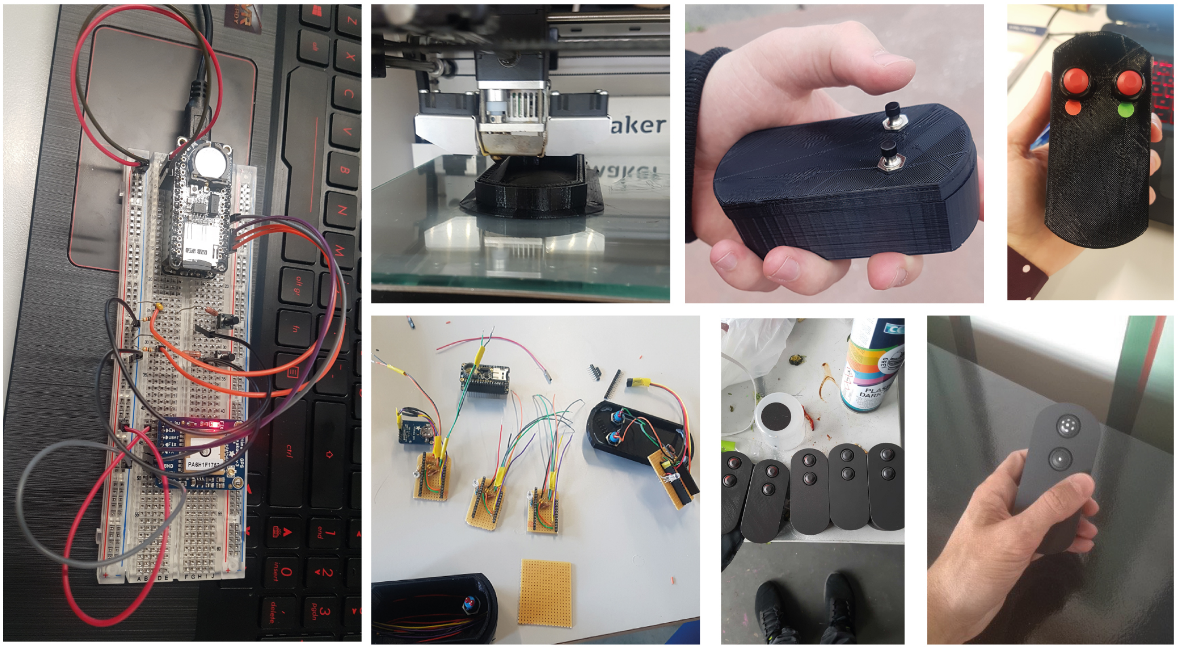


Figure 3: Montage of the different production iterations - **1:** First hardware build; **2:** First case print; **3:** First device iteration; **4:** Second device iteration; **5:** Multiple devices in the making; **6:** Devices in the painting process; **7:** Final product

- Adafruit feather M0 addalogger, the SD card receiver.
- Breadboard, to test out circuits.
- varying circuit units, Resistors, capacitors, copper wires, buttons.

And we were given access to the Electronics Laboratory at Reykjavik University that contained everything we needed from wires to soldering irons.

An important factor for the device was that the button presses needed to be consistent, so it was necessary to use a debounce. When a button is pressed as soon as the metal makes contact multiple small signals might get sent instead of only one constant one. When going between states several currents will get through and the bigger the button the worse this is, so we had to add a so called debounce. The debounce filters out these small currents so each press is only one single current. The rest of the functional requirement was a GPS module, we add it to our plate and soldered the circuit and we had our prototype ready.

We realized early on in the production that the clocking rate of the processor of the micro-chip was too high, so that we couldn't create a serial for the GPS. The clocking speed of a processor is how many times it can calculate per second, and uses the measurement unit hertz. The hertz was too high so we had to find a chip with a slower clock rate we found the Adafruit 32u4 radio, and we could make a serial for the GPS on that chip. A serial is a way to use regular wires that pulse on regular intervals and reads the a pulse as a 1 and no pulse as a 0, thus we can move data through wires with binary pulses.

First we made our device on a breadboard so that changing or fixing the device takes little to no time, but a device on a breadboard is not a permanent solution. We then mapped the wiring and circuitry to a soldering plate, were we soldered each part down, this is results in a permanent device and is what you should always end up with while doing engineering.

A slight change in the production was that we wanted to decrease the height of the device so we ordered a different kind of chip, the Adafruit 32u4 adalogger, since it was a all in one micro-chip and Adalogger

4.4 Testing

Testing is always an important part when making a device of any kind. We needed to make sure to cover the most important points:

- Is the data being logged?
- Is the GPS getting a fix?
- Is the GPS logging the correct location?
- Do the buttons work at all times?

To thoroughly test these points we needed to be able to know, without access to a computer if all of the above were working, the solution to this was an LED that blinked red if the GPS had a fix, green whenever a button was pushed and blue if the SD card wasn't connected properly.

Subsequently, we began the test. Testing was done outside of HR, a walk around the university with the devices open in the beginning to check the fix of the GPS and then closed as we walked to test the buttons (see Figure 4).

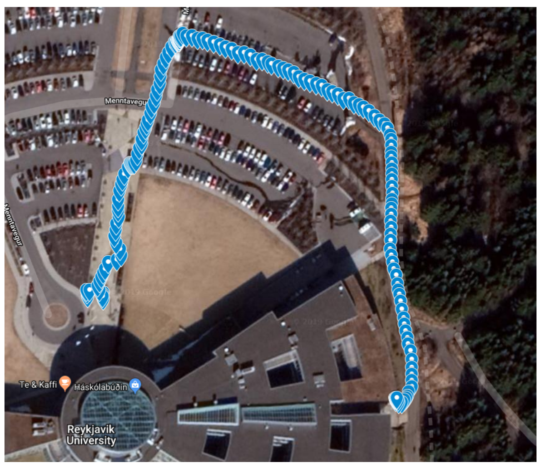


Figure 4: Testing device 1 around the University of Reykjavik

Upon testing the first time, we noticed that the GPS wasn't logging the coordinates accurately, with the help of teacher Marcel from the university we fixed it by adding a battery to all the GPS so it would save the last location where it was at, meaning that it would be faster to get a fix and it would also be more accurate.
To further test the accuracy of the device's GPS we tested for 30 minutes in the same exact location without moving. Accuracy was an important factor because it is imperative that we know the exact location of the device holder to have usable data to analyse.

Tests were conducted throughout the design process of the device, the GPS Was the main reason we had to conduct a lot of test, since we didn't have a digital screen to show us the GPS was working all we could do was look at the data after leaving it on to determine whether it was working or not.

5 Field Study at Þingvellir

5.1 Preparation

To properly recruit visitors for our research we positioned ourselves before the Information Center in Þingvellir as every data recorded starting in that point was important, seeing as there are also attractions inside the Information Center and different visitors take different paths.

To make sure we were seen as researchers we wore Identification Cards we made using Photoshop and yellow vests with the Reykjavik University logo, and in the first couple of days we simply approached tourists and asked if they wanted to participate in a research to preserve the park. The issue was that most people didn't want to be bothered and thought it was a charity program. As it was taking too long to reach the milestone of data collected we came up with the idea of having a sign briefly mentioning that we were doing a study to preserve the park in a sense and that the participants would be rewarded with cookies at the end, to attract the attention of potential participants alongside with the first approach of walking up to people. The sign ended up attracting the attention of way more people than we thought, as these people were concerned with national parks and its preservation in many different ways.

5.2 Obstacles

When we started using the devices out in the field we noticed a few things. We didn't want to expose the volunteers to the inside of the device so we had to turn on the device before we started recruiting. We soon noticed an oversight in our design is there was no clear visual difference between the device working correctly and the GPS module not being powered. In both cases the device would not blink any lights, meaning OK, but it would blink green if a button was pressed as intended. However we found a way around this by making sure the GPS was actually on. We lost 20% of our recorded data from the devices, either the GPS wasn't on or device malfunctioned, it is still a low percentage, but we were hoping for a 0% loss.
After and throughout some of our on-field iterations we had to do some quick fixing for the devices. In the end we couldn't foresee all the problems that would happen but we were able to fix them and make notes of which problems could happen and how to fix them.

5.3 Recruiting Process

The data collected was completely anonymous and the use of the custom device that we designed assured that the data were not taken from a personal device such as a smartphone. The data was stored locally into the device and therefore, in accordance with the GDPR, it was enough to give every participant a paper explaining the purpose of the research, the lack of risks involved and their agreement in letting us work with the anonymous data collected. To get a profile of the participant we gave them a short questionnaire, where we gathered information on how to classify them as a participant. Upon getting the consent of the participant the process was to give out a simple explanation of the device, which included two buttons:

- "You press the UPPER BUTTON whenever you feel there are too many people in the park."
- "Instead, you press the LOWER BUTTON whenever you feel the park is too empty."

When the visitors were back from their visit, they would return the device to us and go through a second questionnaire about the quality of their experience while visiting Þingvellir National Park (see Figure 5).

CROWDEDNESS EXPERIENCE STUDY
IN THINGVELLIR

PART 1 - DEMOGRAPHICS

Date: ____/ _____/_____

Time of day: ____: ____

Device ID: _____

Season

☐ Summer
☐ Winter

Weather today (check more than one):

☐ Sunny ☐ Cloudy
☐ Rainy ☐ Windy
☐ Warm ☐ Cold

Cruise Ships today:

☐ none
☐ ____ tiny cruises (< 250 passengers)
☐ ____ small cruises (250 – 500)
☐ ____ big cruises (500 – 1000)
☐ ____ huge cruises (>1000)

Nationality:

____

Biological Sex

☐ Female
☐ Male

Age group

☐ 18-30
☐ 31-50
☐ 51-65
☐ Over 65

How many people live in your city?

☐ 10K or less
☐ 10K - < 150K
☐ 150K - < 500K
☐ 500K - < 1M
☐ 1M or more
☐ Other

____

How many times have you been to Iceland (including this visit)?

☐ 1
☐ 2
☐ 3 - 5
☐ 6 or more

Is this the first place you are visiting?

☐ Yes
☐ No

How many times have you been to Thingvellir (including this visit)?

☐ 1
☐ 2
☐ 3 - 5
☐ 6 or more

How did you come to the park?

☐ By bus
☐ By car
☐ Other, _________________

How long are you planning to stay in the area?

☐ ______, minutes
☐ ______, hours

Are you visiting alone or in group?

☐ Alone
☐ Group, how many?

____

PART 2 - QUALITY OF EXPERIENCE

What have you enjoyed the most about your visit?

____

What have you enjoyed the least?

____

What do you think they could improve?

____

Would you like to come back to visit Thingvellir?

☐ Yes
☐ No
☐ Not sure / Rather not say

Did you expect to find fewer or more people?

☐ Fewer
☐ As expected
☐ More

Which places were the most crowded?

☐ Look out terrace
☐ Ramp into Allamannagja
☐ Logberg
☐ Oxafoss
☐ Others

____

Did the crowdedness detract from your experience of the area?

☐ No
☐ Yes, in what way?

____

Did you enjoy your visit at the park overall?

☐ Yes
☐ No

COMMENTS (here we write down ourselves anything interesting or spontaneous that came out talking with the visitor)

____
____
____

Figure 5: Questionnaire - Part 1 Demographics, Part 2 Experience of the visit at the park

5.4 Data Processing

To make analysing the data more computerized and automatic we needed to post-process it into a compact format suitable for calculations, plotting and graphing.

During field study

While we were still going to Þingvellir we would process the data from the device so it could be used on google mymaps to test if the devices were recording properly. That entailed converting the GPS coordinates to Decimal and putting it all into one Excel file.

After field study

Most processing was done on the questionnaires, they were originally designed to have this in mind so most of the important questions were answered through marking the checkbox that was applicable to each participant, this means the data is more similar and it can actually be compared. We changed each question into a column name and each answer from a participant was in the rows below the question in the simple form of an integer or a single character. We then added personal id for each participant ranging from 0 to the last participant, we needed these id's to map the device recordings to each person. We then added these same ID's in the device data files. Now we could connect a questionnaire to a certain amount of lines in the device data file. In other words, all device data that had the same person ID as a questionnaire were from that questionnaire and person.

Mapping

During the field study we would regularly map the data from the devices of each day, to get an early look at how the data was mapping out. Figure 6 is an example of on such early mapping.

Figure 6: Early mapping from a device, each red dot represents a crowded button press

After the field study, we started focusing on better ways to map the data. We realized that getting the client for *Google Earth* and using *KML* files we could make a way more detailed mapping of the data. Figure 7

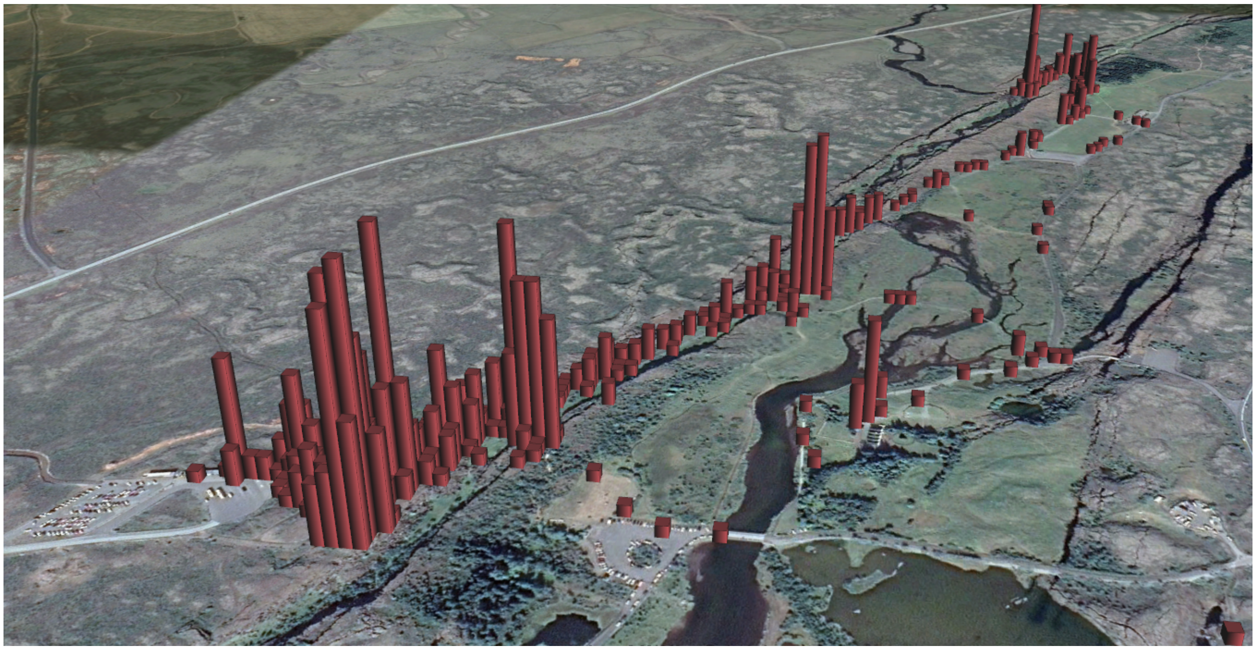


Figure 7: A data visualization showing how people experience crowding at Þingvellir National Park. Higher bars mean a more intense sensation of crowding and therefore a lost in authenticity and quality of the experience.

6 Preliminary Results

6.1 Collected data

Data was collected from 60 participants which for a first data analysis was good enough to make us perceive what could be done with the data.
The data collected was split into two parts for each participant:

- Answers for the questionnaire
- GPS tracking with button presses

Both of which could be analyzed with queries using the Pandas library in python to further organize the data and answer questions about the experience at the park. Furthermore the GPS tracking files can be put on Google Maps for further visualization of the crowding experience.

Figure 8: An example of one of the participant's crowded button presses on Google Maps

From figure 8 we can see the specific points in the park where one of the participants felt crowded. The sensation of crowding in these locations can be explained by the fact that there are attraction points (specific places which are meant for visitors to stop) whether it be a map layout of the park or one of spots where visitors like to take pictures. And these are issues within the park that need to be looked at as it is having a negative impact on the experience of the park.

It is important to note factors that may influence a person's sensation of crowding, some of those include the size of the city the participant is from, as from their perspective, when used to being around a certain amount of people, will impact their crowding experience at the park. Hence, we made sure to collect data from a large number of diverse participants to reduce such bias, but since we included this information in the background questionnaire, further analysis may help us reveal such differences.

6.2 Analysis

The following figure 9 shows, that we can map the visit of the participant and analyze the direction, average length of the visit, speed at which they were walking. These are important measures to have a better understanding of where and how people walk which could help addressing the congestion of visitors in paths.

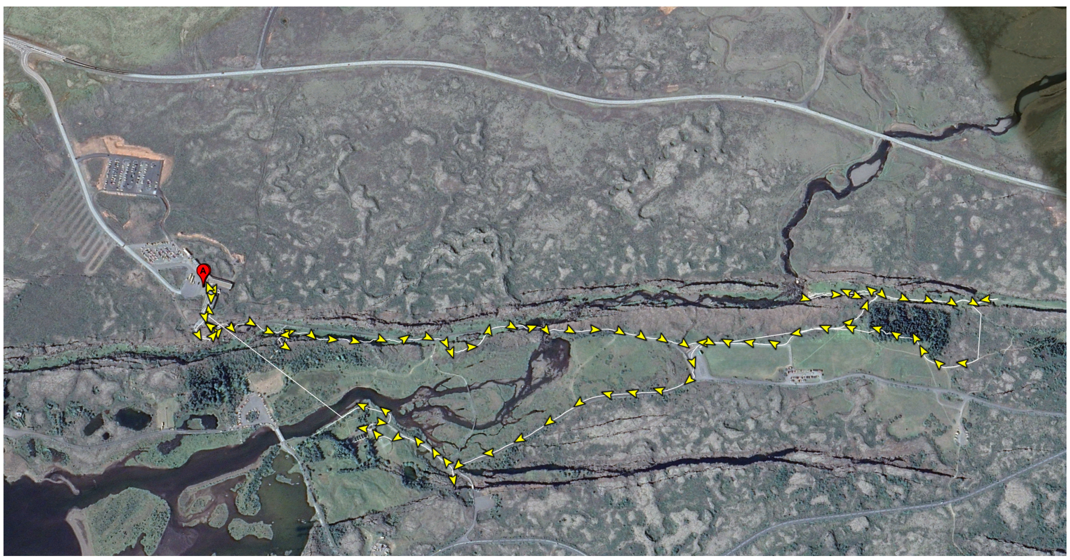
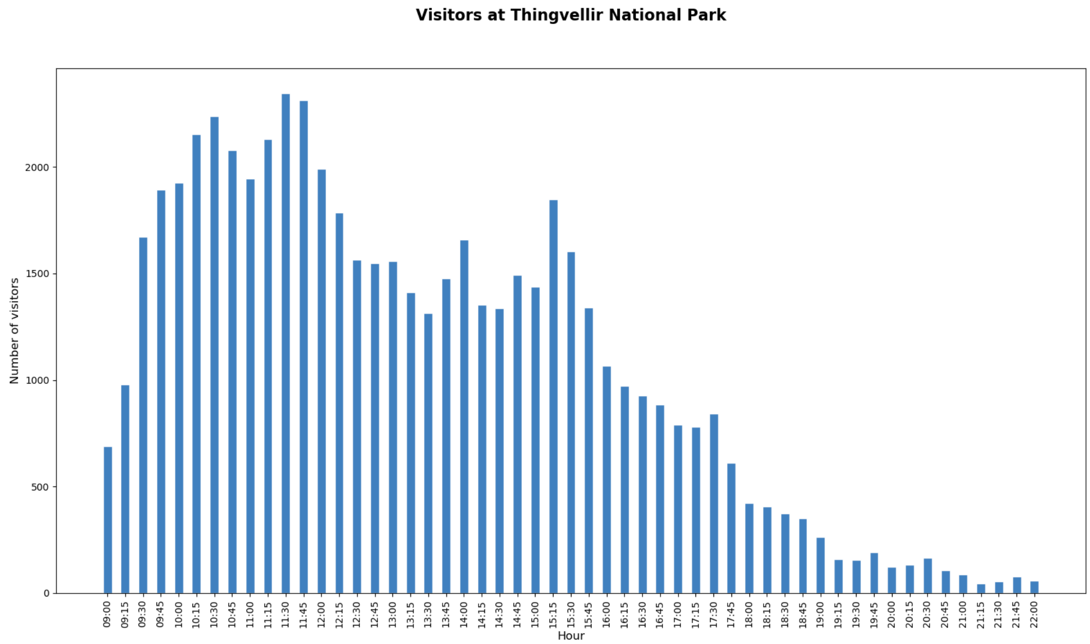
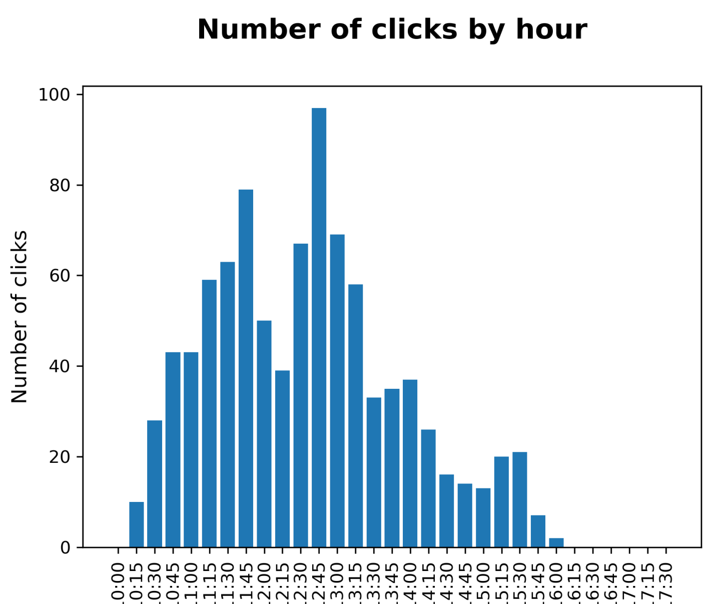


Figure 9: Vectorization of the path of one participant

Initially, plotting the following graphs (Figure 10) showed also that the peaks of crowded presses happened during the peaks of people at the park, mainly at 11:30 which is the highest. The source of the number of visitors came from the gate counters of the park, provided by Harald Schaller.



(a) Number of visitors



(b) Number of crowded presses

Figure 10: Comparison of the sensation of crowding and the number of visitors at the park

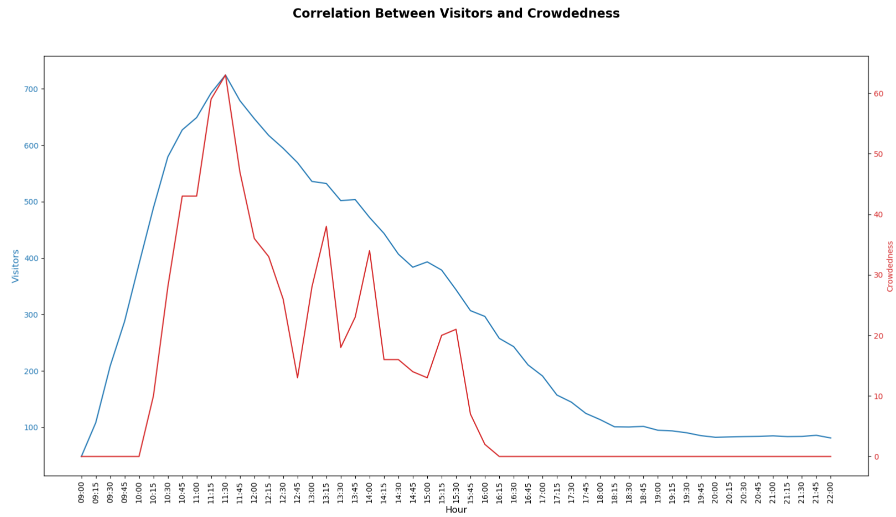


Figure 11: Correlation between visitors and crowding

Furthermore the quantitative measures collected can be analyzed in multiple ways to bring out the issues with the experience at the park.

Our first iteration of data analysis was presented with the correlation between the experience of crowding and the amount of visitors at the park, Figure 11. With this, we can easily note that the expected results of the experience of crowding increasing with the amount of people was indeed correct, providing some evidence for the valididty of the approach. The data is now ripe for further analysis and simulation work.

7 Conclusion and Future Work

The goal of this research was to develop a new interviewing method that would allow us to analyze the social carrying capacity of the national park in question which was achieved and explained above. The field study conducted showed satisfactory results as seen in the correlation graph (Figure 11). With more thorough analysis the data collected may bring up problems with the park's infrastructure and details that weren't looked at before which could make a big difference and have a substantial impact on the preservation of the park.

The focus of future work is the collection of more data using this method and creation of research queries on the data for the park in question, that will address many of the research questions that fall outside the scope of this project, such as correlations between different variables (e.g. demographics and experience).

A concrete final result of this project is new data that really shows that Þingvellir National Park has crowding problems in specific areas as seen in Figure 7 with the highest peaks, and that resolving these issues will likely increase the social carrying capacity and help preserve the park.

References

[1] George McIntyre et al. *Sustainable tourism development: guide for local planners.* World Tourism Organization (WTO), 1993.

[2] Alexis Saveriades. Establishing the social tourism carrying capacity for the tourist resorts of the east coast of the republic of cyprus. *Tourism management*, 21(2):147–156, 2000.

[3] Stephen F McCool and David W Lime. Tourism carrying capacity: tempting fantasy or useful reality? *Journal of sustainable tourism*, 9(5):372–388, 2001.