The FogDetector: A User Survey to Measure Disorientation in Pan-Scalar Maps

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Abstract

When we navigate into interactive multi-scale maps that we call pan-scalar maps, it is usual to feel disoriented. This is partly due to the fact that map views do not always contain visual cues of the location of the past map views of the navigation. This paper presents an online study that seeks to understand and measure this disorientation occurring when zooming in or out of a pan-scalar map. An online study was designed and more than 150 participants finished the survey. The study shows a very small difference between the time to succeed in the memorising task after a zoom and a pan, but the difference is more significant when we compare zooming in with a large scale gap to panning. The study also shows that disorientation is not similar when zooming in and zooming out.

2012 ACM Subject Classification Applied computing → Cartography

Keywords and phrases disorientation, zoom, pan, multi-scale map, desert fog, user survey

Digital Object Identifier 10.4230/LIPIcs.GIScience.2023.73

Category Short Paper

Supplementary Material *Software*: `https://doi.org/10.5281/zenodo.7561925`

Funding *Guillaume Touya*: this project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No. 101003012 - LostInZoom).
Justin Berli: this project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No. 101003012 - LostInZoom).

Acknowledgements The authors want to thank all the anonymous participants of the FogDetector survey

1 Introduction

When we use pan-scalar maps, i.e. interactive, zoomable, multi-scale slippy maps [5], it is usual to experience disorientation when zooming in and out. As the use of these pan-scalar maps is quite recent, we do not really know much about this disorientation feeling. Between two zoom levels, particularly when they are not consecutive, the style and content can change drastically, which does not completely remove the visual cues but reduces their number: zooming from one scale to the other might thus cause disorientation [13].

The consequences of pan-scalar disorientation cannot completely be compared to geographic disorientation. People do not stop using pan-scalar maps because of this disorientation. But it can force us to zoom out (or zoom in if we were zooming out), or at least cause a delay in our use of the map. Disorientation makes the pan-scalar map exploration a more tedious task. Though the need for more research on pan-and-zoom interactions with maps was identified almost twenty years ago [6], disorientation is still significant in current pan-scalar maps. Our long-term goal is to design pan-scalar maps where interactions are smooth or

Table 1 Distribution of the ages of the 160 remaining participants after the cleaning step.

	18-24	25-34	35-44	45-59	60+	no answer
nb of participants	12	41	39	51	16	1

fluid [3]. But before designing better pan-scalar maps, we argue that it is necessary to better understand disorientation, to know when and how much a map reader can be disoriented. Montello defines geographic disorientation as a phenomenon occurring " when people are aware they are not certain about where they are and/or where they need to go to get to their destination." [9]. In this definition, we can see two components of disorientation, the objective uncertainty about where we are, and the subjective awareness of this uncertainty [4]. When it comes to the virtual disorientation occurring during the exploration of a pan-scalar map, it can be modelled as a reconciliation problem between the visual cues in the current map view and the mental map of the user [13]. There are different forms of a failed reconciliation, i.e. disorientation, and different causes [2]. In this paper, we present a user survey that seeks to measure disorientation. The desert fog effect identified in human-computer interaction [7] is one of the possible causes, hence the name of the presented survey. The desert fog is the disorientation occurring in multi-scale interactive environments when the current view does not contain visual cues referring to the past views. From a cognition perspective, this disorientation could be caused by change blindness[14] as the display changes after a zoom, or inattentional blindness [11], the map readers cannot focus their vision on all the details in the map. More generally, this disorientation can be related to limits of our visual working memory [10]. The paper is structured as follows. The survey is presented in Section 2. Section 3 presents and discusses the survey results.

2 The FogDetector survey

2.1 Hypotheses

There are many interactions possible with an interactive pan-scalar map [12], but we are only interested here in the two main displacement interactions available in such maps: pan and zoom. When you switch the layers of the map or change the style of the base map, disorientation can also occur but this case is beyond the scope of this study. Based on our understanding of the disorientation phenomenon, we make the following hypotheses:

- it takes longer to know where you are after a zoom, than after a pan (H_1).
- disorientation occurs differently when zooming in and zooming out (H_2).
- there is more disorientation when the scale difference is bigger (H_3).
- the style and generalisation have an effect on the intensity of the desert fog (H_4).

2.2 Participants and Apparatus

We tried to select a purposeful sampling for the participants of the survey, i.e. a sampling that represents the envisioned end-users. As anyone can be a user of a pan-scaler map, we wanted users with very diverse ages and experiences with interactive cartography. 160 participants were recruited online. There is a fairly good distribution of ages which confirms that it is a purposeful sample (Table 1). However, the gender distribution is skewed with 98 men, 53 women and 9 who preferred not to answer.

Table 2 shows the declared usage of pan-scalar maps by the participants of the survey. The distribution is clearly skewed towards the regular use of such maps. Though we do not have data on the use of such applications by the general public, our sample seems to use

Table 2 Distribution of the declared usage of pan-scalar maps by the 160 remaining participants after the cleaning step.

	every day	once a week	once a month	almost never	no answer
nb of participants	82	55	16	4	3

Figure 1 Three of the chosen targets, a building at zoom level 17 on the left, a crossroad at zoom level 12 in the middle, and a point of interest (a fountain in a square) at zoom level 17 on the right.

maps more regularly. Both to deal with potential COVID-related limitations and to access our purposeful sample, we opted for a fully online survey, based on a web application. The code of the application is openly accessible on Github[1]. The data are collected anonymously to follow the guidelines of GDPR legislation.

2.3 Procedure

The FogDetector survey follows a within-subject design, *i.e.* the participant carries out the task for all variable conditions, and even several times for each variable condition. The main variable of the survey is the interaction techniques performed before the task: either a zoom or a pan. Each of the techniques can be decomposed into several sub-techniques. A zoom can either be a zoom-in or a zoom-out and can cover a large scale gap (4 zoom levels difference) or a small scale gap (2 zoom levels difference). To balance the number of interactions, panning is also divided into two sub-techniques, panning at a large scale (zoom level 17) and panning at a small scale (zoom level 12).

In order to address (H_4), the other variable in the survey is the pan-scalar map used to perform the task. Three maps were selected: Plan IGN, OpenStreetMap, and IGN classic. IGN classic is composed of scanned paper topographic maps produced by IGN. Plan IGN is a new map designed by IGN as a pan-scalar map with a consistent style across scales to reduce disorientation. Finally, OpenStreetMap is the default OpenStreetMap pan-scalar map.

As disorientation can be caused by a loss of visual cues, we selected a task that requires the use of visual cues to be completed. We designed a recall task [1] where a target is shown on a map for 30 seconds. Then, the map switches to a different map view, and an animation navigates from this map view to the area of the target, with one of the sub-techniques (zoom or pan). Then, the user has 60 seconds to click on the location where they recall the target. The interaction is passive to make sure the participants directly go to the good view, at the cost of realism. The success of the task is assessed by the time of completion. The 31 targets

[1] `https://github.com/LostInZoom/lostinzoom-experiments`

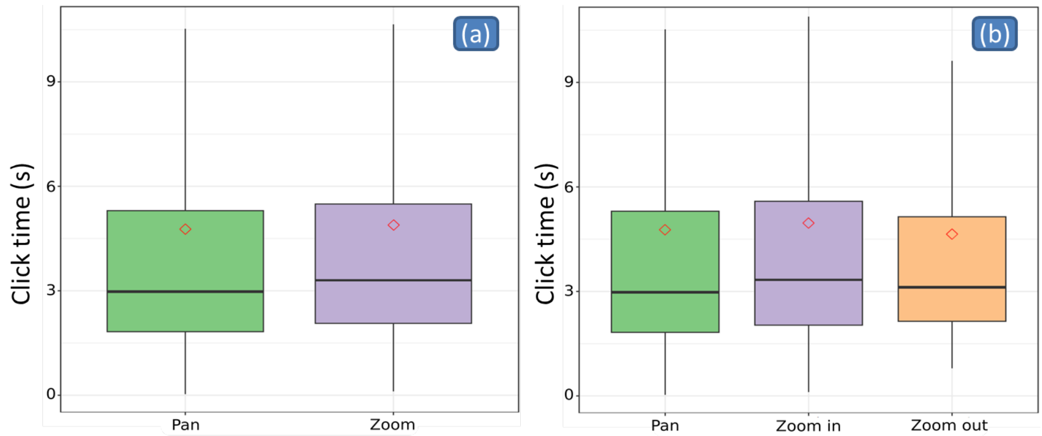

Figure 2 (a) Box plot of the click time according to the interaction (pan or zoom). (b) Box plot of the click time according to the type of zoom. The red diamond shape shows the mean value.

are either buildings, crossroads, or points of interest (e.g. a specific symbol on the map, the centre of a lake, etc.) (Figure 1). The procedure is composed of a training phase, 2 blocks of 8 trials where all the sub-techniques are proposed to the participant with the same map, and 3 blocks of 6 trials where the three map designs are proposed, in order to compare them.

3 Results

Figure 2a shows the results of task completion time for pan vs zoom interactions. The difference of median time is 312 milliseconds (2.921 s for pan, and 3.233 s for zoom). A one-way repeated measures ANOVA was performed to compare the effect of general interaction techniques (pan or zoom) on task completion time. The ANOVA revealed that there was no statistically significant difference in mean completion time between the two groups ($F(1, 158) = [0.676], p = 0.41$). These results invalidate (H_1) in general, as the time difference between all types of zoom and all types of pan is not statistically significant. Figure 2b shows the results for the completion time difference between pan, zoom-in and zoom-out. The mean time for zoom-in is 4.866 s ($median = 3.257$), which makes a 218 milliseconds difference with pan (336 ms for the median). The mean time for zoom-out is 4.573 s ($median = 3.104$), which makes a -75 milliseconds difference with pan (183 ms for the median). A one-way repeated measures ANOVA was performed to compare the effect of interaction techniques (pan, zoom in, or zoom out) on task completion time. The ANOVA revealed that there was not a statistically significant difference in completion time between two groups, though the p value is not too important ($F(2, 346) = [1.747], p = 0.17$). ($H_2$) is not validated by this result but the difference we can observe is not the one we expected, because if zooming in seems to cause more disorientation than panning, zooming out appears to be an easier task.

Figure 3 shows the box plot of the completion times for each type of precise interaction: pan at small scale, pan at large scale, zoom in with a small scale gap, zoom in with a large scale gap, zoom out with a small scale gap and zoom out with a large scale gap. Results about (H_3): A one-way repeated measures ANOVA was performed to compare the effect of the six precise interaction techniques on task completion time. The ANOVA revealed that there was a statistically significant difference in completion time between at least two groups ($F(5, 790) = [5.550], p = 0.00005$). A post-hoc Tukey test found that the mean completion time value was significantly different between the two zoom-in interactions. These results

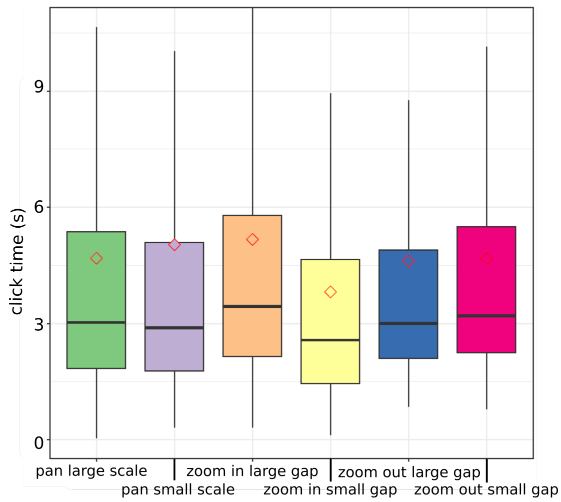

Figure 3 Box plot of the click time according to the precise interaction used in the trial.

confirm (H_3) for zoom-in, with a completion time significantly higher when the scale gap is large. But the hypothesis is not confirmed for zoom-out where no significant difference was found in the Tukey test. These results also partially validate (H_1) and (H_2). Indeed, the mean time difference of 506 milliseconds between zoom-in large gap and pan large scale is statistically significant, but the difference between both zoom-out interactions and the others are never statistically significant.

To verify (H_4), we also looked at the differences in time completion between OpenStreetMap and both IGN maps. A one-way repeated measures ANOVA was performed to compare the effect of the map on task completion time. The ANOVA revealed that there was no statistically significant difference in mean completion time between the three groups $(F(2, 316) = [1.020], p = 0.36)$.

4 Conclusion and future work

To conclude, the FogDetector survey allows a first measure of the disorientation occurring during a zoom interaction in a pan-scalar map, more than with a pan interaction. But the difference is only measured as significant when the scale change is large during a zoom-in. Surprisingly, the survey does not show any significant difference for zoom-out, probably due to the visual complexity of the maps displayed after our zoom-in interactions, compared to the maps displayed after a zoom-out. The survey shows no influence of the three maps used in the survey, so disorientation will not be significantly reduced just by adjusting the multi-scale style and content of the map.

To go further, the survey confirmed that the impact of disorientation was generally comparable to the duration of the pre-attentive phase of visual search [8], i.e. the time before we are able to focus our gaze on some target, and future studies should use quicker tasks, where pre-attention is even more crucial. One of the problems with our protocol is the fact that the interaction was passive, and we would like to perform a survey with active explorations from the user. Another direction is to couple a recall task with eye-tracking to measure cognitive load [15], as disorientation can be seen as a cause of cognitive load. Finally, as our final goal is to reduce disorientation, this survey is a first effort to work on pan-scalar design [5], but we know that just changing the style will not be sufficient.

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