How useful is 360-degree view for Cognitive Mapping?

by

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Abstract.
We aim to evaluate the efficacy of 360-degree view compared to limited view, i.e. 90-degree front view only, on the development of cognitive map in an unknown environment. Participants were asked to explore the virtual environment (VE) and construct a map-sketch based on their exploration. The map-sketch topographical relationship was evaluated to examine the cognitive map. Interfaces were compared based on map-sketch scoring. Results show better cognitive mapping with 180x2 compared to other user-interface (UI) designs, indicating a better spatial compatibility with 180x2 UI design. Further, gamers scored better than non-gamers across the interfaces. The current pilot data suggest that the complete 360-degree view, specially 180x2 UI design, supports constructing cognitive map. In addition, the data indicates that it's not only the UI designs, but the individual capabilities such as gaming experience and gender also influence the given task performance.

Keywords: cognitive mapping, map-sketch, field of view

1 Introduction

360-degree field of view (FOV) is gaining widespread importance across various technologies ranging from entertainment to security and surveillance. It is assumed that 360-degree view, especially desktop 360-degree view will enhance the remote operators' perception and decision making, by enabling them to access both central and peripheral view in a single glance [1,2,3]. However, presenting 360-degree view on a single desktop screen leads to horizontal compression and spatial relationship distortion between objects in the camera's view. This put forth a challenge on 360-degree user interface(UI) designers to develop an intuitive display design which would enable remote operators to develop a spatial knowledge or cognitive map as effectively as they would develop in real-time settings. Cognitive map can be defined as a mental representation of the layout of one's environment[4]. Despite growing importance of 360-degree view, its impact on cognitive mapping is still unknown. [3], has shown a better egocentric spatial perception (object-to-self spatial relationship) with non-seamless displays compared to the seamless or panoramic display [see 3]. However, the non-seamless display did not favour the cognitive mapping (object-to-object spatial relationship) when assessed through the spatial memory task [3], indicating

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a disparity between the spatial perception and cognitive mapping task. Developing and utilizing cognitive map becomes pivotal in conditions ranging from remote monitoring to specialized patrolling tasks for military purposes. It can be assumed that if 360-degree view enables effective remote navigation and spatial perception [3], it might affect the construction of cognitive map as well. However, despite its relevance and importance in various task performances, no study has evaluated the impact of desktop 360-degree view on cognitive mapping which is the focus of the current study.

2 Methodology

2.1 Development of Interface

We chose a reconnaissance task situation to develop the virtual interface. Our choice was primarily based upon the task requirement, i.e. cognitive mapping. The VE was developed in Unity3D. To display a 360-degree virtual scenario on 2D display, we have used multiple camera views, adjusted their aspect ratios and positions to stitch them together without any noticeable boundaries [similar to 3].

Fig. 1. Three Interfaces used for the experiment, from left to right: a. 90x4 Interface consisted of 4 views each covering 90-degree view (from top clockwise, left, front, right and rear view around the UGV); b. 180x2 Interface with 2 views each covering 180-degree (the top view is front 180-degree and below is 180-degree behind the UGV); c. 90x1 Interface with the front 90-degree view only.

2.2 Experimental setup and tasks

The experiment was conducted in a dimly lit, sound-proof room. The participant sat at a distance of approximately 60cm from the screen. The experiment consisted of three interfaces (as described in Fig. 1). The front 90-degree view was considered as a control condition to avoid the disorientation if any. We hypothesized that if 360-degree view facilitates the cognitive mapping, then better mapping would be reported with the 360-degree view than the front only 90-degree view.

Twenty-four naive IIIT-Hyderabad students (13 Male) were recruited from either phone calls or emails to participate in this pilot study. Participants were randomly assigned to one of the three interfaces, with an equal distribution. Since cognitive mapping was an essential aspect of the study, we conducted a between group study to avoid any learning related to the spatial layout from one interface to another. The experiment consisted of two tasks: exploration and map-sketch task. During exploration task, each participant was instructed to explore the VE, for maximum 15 minutes. They were instructed to end the game near the starting point. In this task, participants were instructed to gather as much as possible information about the scene presented by the virtual environment(VE), to develop the cognitive map. In the map-sketch task, they were asked to reconstruct the layout from memory by sketching the map on a given A4 sheet (Fig. 2). The order of the tasks was fixed i.e. exploration followed by map-sketch task across the three interfaces.

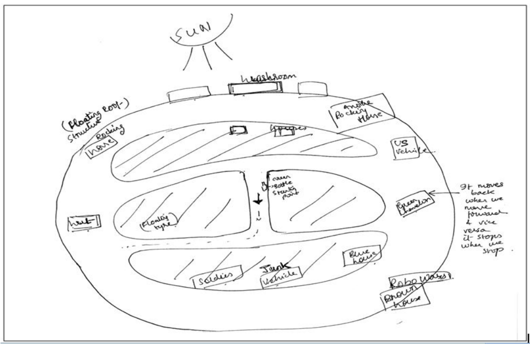

Fig. 2. Map-sketch of a participant from the current experiment

2.3 Measure of Performance

Participant's cognitive mapping was assessed by evaluating the map-sketch as a function of interface designs. The map-sketch was analysed using the topological technique described in [5], which involves evaluation of following three factors:

- Map Goodness: Each map was scored on a scale of 1-3 based on how close it was to the original layout of the environment.
- Object Classes: Scoring was based on the number of object classes present in the map-sketch, such as trees, buildings, cars, mountains, cloud, people etc.
- Relative Object Positioning: Scoring was based on topological position, i.e. the relative position between the objects, compared to specific object position in the environment. Such as, the spatial relationship between the two horses that were present at diagonally opposite ends in the environment were scored '1' when reported similarly in map-sketch, otherwise scored '0'.

3 Results and Discussion

We observed a trend of better map-sketch score (described above) with respect to 180x2 interface design (median: 24) compared to 90x1 (median: 19) and 90x4 (median: 14) interface designs (Fig.3). The varying map-sketch score across the interfaces indicates the role of interface design in cognitive map construction. The pilot data shows a promising trend that 360-degree view facilitates the cognitive mapping. However, it favours only the 180x2 display designs. The higher score with 180x2, suggests the ease of navigation and orientation, supporting cognitive mapping. The current result is in contradiction with the [3] findings, which showed no effect of the interface on spatial knowledge construction. To the best of our knowledge, no other study has reported the impact of 360-degree UI design on cognitive mapping, which could recommend the 360-degree view for better spatial knowledge. The current pilot data will lead to future examinations of 360-degree UI designs, specifically desktop user-interface, because of its wide-ranging applications from gaming to security and surveillance task performances.

We further looked at the individual differences to understand the relationship between individual capabilities and interface designs. Previous research has shown a difference in spatial abilities, especially spatial knowledge or cognitive mapping, based on individual differences such as gaming experience, or gender difference. Studies investigating the causal effect of video gaming on spatial skills [6, 7], reported comparatively better task performances, such as faster tracking of moving objects, and efficient mental rotation. Studies showed gender related difference as well [9] men showing more abstract and Euclidean relationship whereas women showed a more concrete relationship, using landmarks [10]. However, gaming experience has shown to reduce the gender disparity in spatial abilities [8]. This led us to investigate whether individual difference based on gaming and gender, affects the map-sketch score, i.e. cognitive mapping across interfaces. The current data shows the advantage of gaming experience on cognitive mapping task performance (Fig. 4b), suggesting that gaming experience facilitates the cognitive mapping in 360-degree VE. Further, the analyses based on gender, demonstrates no clear difference between men and women map-sketch scores (Fig. 4a). The current pilot data contradicts the previous findings on gender disparity in spatial abilities.

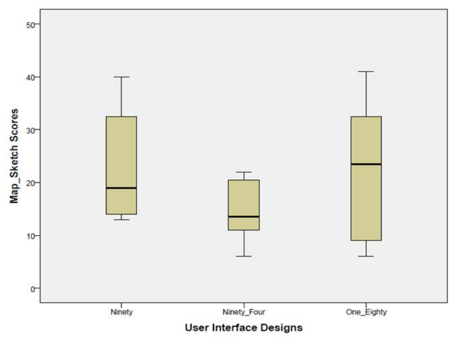

Fig. 3. Difference in map-sketch score across the three interface

4 Conclusion

Based on the current pilot results, 360-degree view compared to front view only, showed an advantage in cognitive mapping. More specifically, it was 180x2 compared to 90x4 UI that supported the cognitive mapping. Further, gamers outperformed non-gamers in constructing a map across the interfaces, favouring more

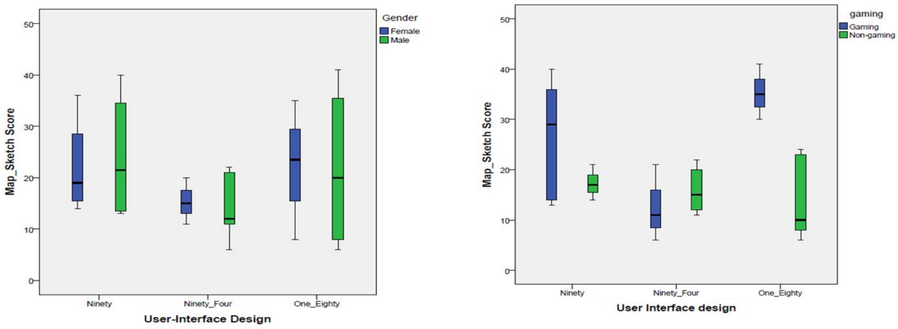

Fig. 4. Individual differences on map-sketch scores as a function of gaming (a) and gender (b) on UI designs

180x2 UI designs. Based on current trends, we recommend the 180x2 UI design for an effective teleoperator's cognitive mapping task performance. However, the current data does not support any conclusive recommendation because of the small sample size.

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