

Interactive cartographic visualization of satellite data and their orbits based on user-centered design



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In the present context, more than 11,000 satellites have been launched in Space. This huge amount of data has challenged the cartographers in terms of finding the proper representation method. Cartography and visualization intersect at a point where accurate satellite visualization can be done through the tool of interactive real-time maps, serving a role to help end-users be aware of the available satellites, analyze the pattern of satellite increment, and be informed of the existing problem of satellite crowding [1].

This study proposes the development of an interactive visualization of satellites and their orbits based on user-centered design (UCD). The designed application is evaluated with the help of user test to check its utility and usability. The effectiveness of the application is evaluated with benchmark tasks and several satellite visualization questions has been analyzed.

OBJECTIVE

1. To design a prototype of an interactive web-based application to visualize satellites and their orbits.
2. To explore the various satellite visualization aspects in the designed application.
3. To evaluate the designed application.

METHODOLOGY

A mixed research method was used.

1. A background study of the existing satellite visualization applications was performed to select the data, type of representation, and the interaction of the interface.
2. These representing elements selected were implemented in the application design.
3. An online-based survey was performed to check the preference of the end-users for the satellite visualization.
4. The evaluation of the designed application was done based on utility, usability, and effectiveness.
5. A quantitative and qualitative analysis approach was chosen for the evaluation of the survey result.

PROTOTYPE DESIGN

The prototype interface is designed considering the user-centered design workflow, which is in its initial phase. The workflow is designed to iterate through three evaluation components. For instance, work domain analysis (1) and prototype interaction (4) check the interface with the perspective of **users**; conceptual development and revised interface concept (2) examine the application based on the **utility**; prototyping (3) and implementation (5) evaluate the **usability** of the interface.

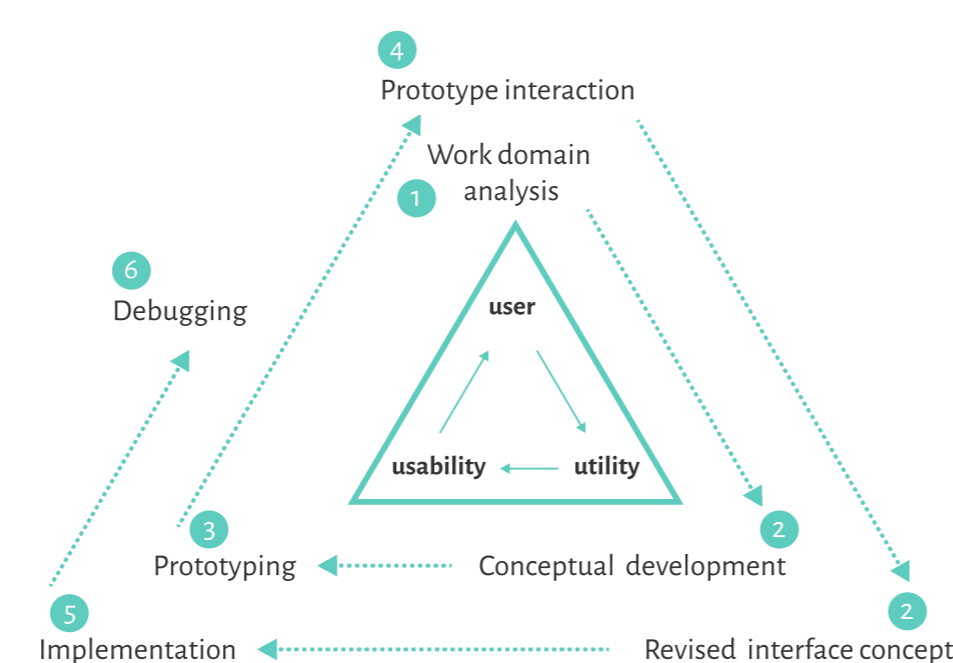


Fig.1. User-centered design workflow.

USER TEST

A total number of 40 participants partook in the survey, out of which 28 were males, and 12 were females with the age range of 18-54. The goal of the visualization part to find an effective way of representing satellites was supported by the prototype design and the user study.

The participants were asked to interact with the interface where two benchmark tasks were assigned. The total of 20 utility and usability questions in a form of discrete scale rating were designed to evaluate the interface.

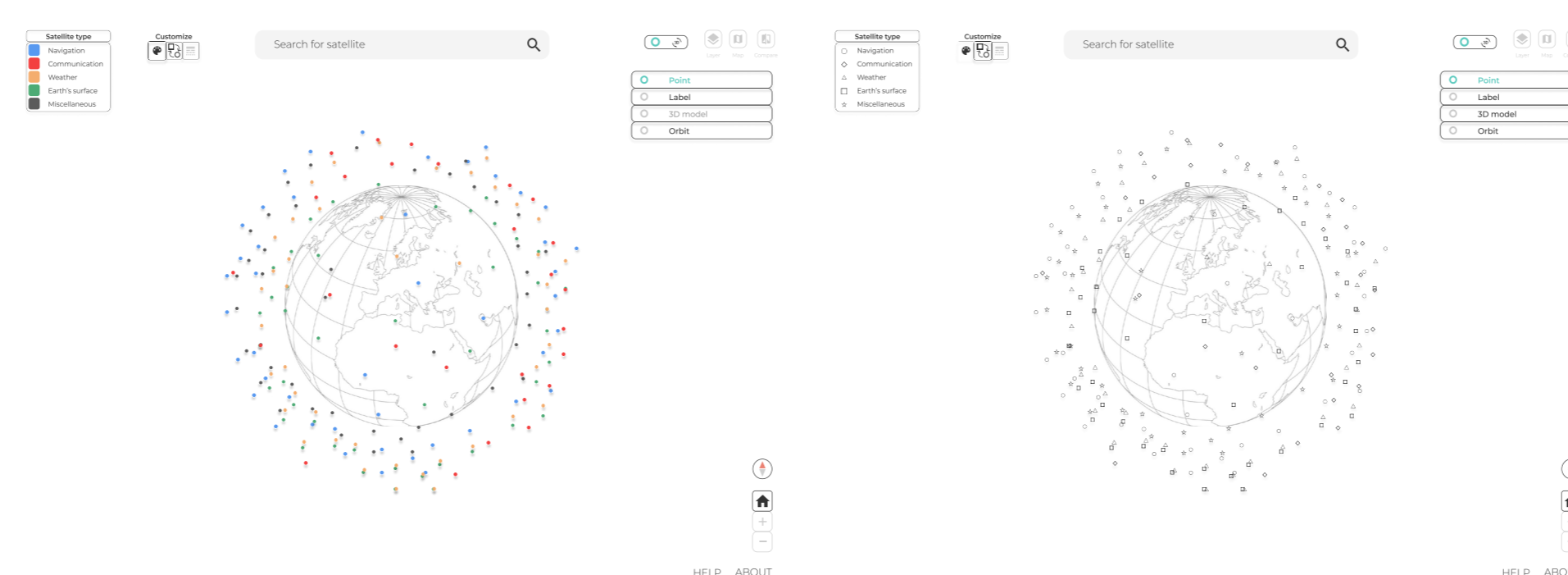


Fig.2. Outlook of the prototype visualizing the satellites based on different colors and shapes.

EVALUATION

The success rate implies that the interface was satisfactorily designed. The utility of the interface was convincing to the users as against the usability of the application. This depicts that the interface is useful for the visualization of satellites for the various target audience, but the interface should be further revised for the improvement of usability.

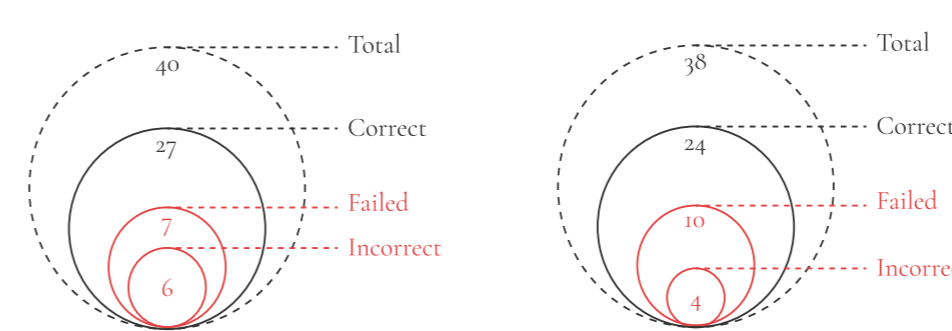


Fig.3. Result of finding operational (first) and junk (second) satellite; benchmark tasks

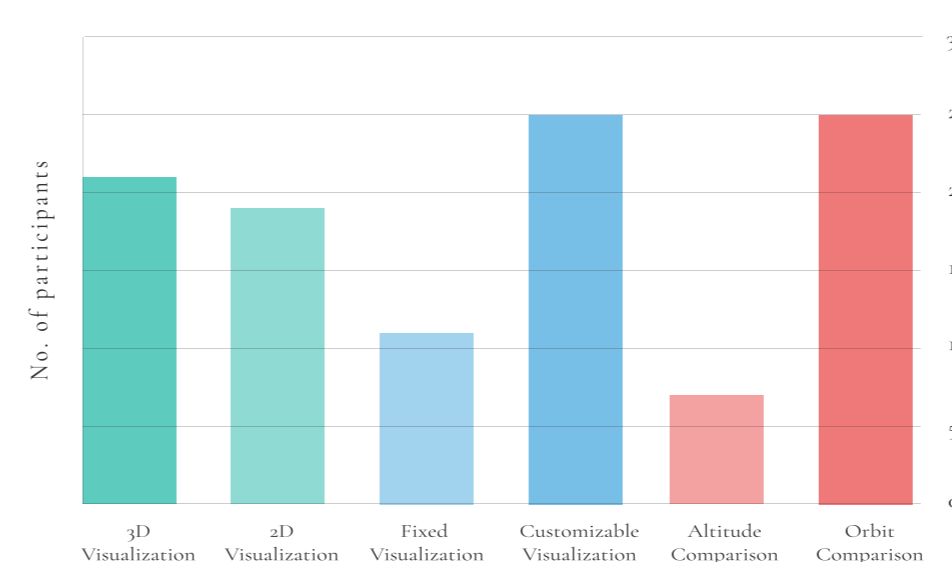


Fig.4. Result of the visualization questions.

FINDINGS

- The use of multiple colors can be used when the application demands to visualize the satellites based on their classification. If the goal is to visualize the total number of satellites, then a single color visualization can be used.
- When the multiple satellites are to be displayed at once, then the virtual 3D globe is preferred. The use of a 2D flat map is suggested when the individual satellite is visualized. The combination of the 3D and 2D maps in an interface is considered to be effective.
- The inclination of the users towards having a customizable interface as compared to a fixed interface was found.
- Orbit comparison method was chosen over the altitude comparison for the comparison of user-selected satellites.

CONCLUSION

This research put forwards the interactive web-based application to visualize the satellites and their orbits considering the concept of user-centered design for cartography. The theoretical analysis of the existing applications determined the requirement of the interface be designed.

The evaluation of the designed interface was done by considering the success rate of the benchmark tasks, utility, and usability. The satellite visualization preference of users was analyzed based on the online survey.

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KEYWORDS

user-centered design, satellites orbit, interactive web map, interface evaluation

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