CENTRAL MINDANAO UNIVERSITY
ISOMETRIC INTERACTIVE MAP APPLICATION

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Chapter II
REVIEW OF RELATED LITERATURE

2.1 Review of Related Concepts

2.1.1 Interactive Map

Interactive maps have gained popularity as interfaces for geo-referenced data or digital images of a topographic map in mobile applications (Oulasvirta et al., 2008). These maps are defined as maps that allow navigational or viewpoint interactivity. Herman, et al. (2018) revealed that 89% out of 76 participants found task-solving and navigating easier with interactive conditions. The study identified several factors that affect the map's effectiveness, specifically, the map's interactivity, the type of task to be performed, and the expertise level of the user. It also showed that tasks were completed faster on static maps, while interactive maps facilitated freedom to explore the map but took more time to complete wayfinding tasks. Lastly, the study shows the fact that all the necessary data becomes easily accessible with interactive maps, highlighting the significance of interactive maps for navigation.

Interactive visualization of maps fixes the problems of inflexible static maps (e.g. paper maps) which can't show all relevant data. Static maps in general put too much information in small spaces which makes it hard for users to read (Konečný et al., 2011)

Interactive visualization and incorporating navigational interactivity enables a broader range of information retrieval compared to static visualization. As a result, navigational interactivity is seen as the next frontier in visualization (Kubíček et al., 2017). In summary, interactive maps are more suited for achieving accurate wayfinding with fewer time constraints, especially for complex wayfinding tasks, and are recommended for users who are less familiar with maps.

2.1.2 2D VS 3D maps

Designing a mobile map that is suited to users' needs is a challenging task, creating such a map may require several trade-offs such as higher system requirements for a more detailed map (Meng & Reichenbacher, 2005). Harrower (2020) stated that when looking at a city on 3D maps at an angle, the sizes and distances seem to change all over the place. Because of this, figuring out how far and big things are can be very difficult due to the 3D maps' elements distorting. On the other hand, looking at a basic 2D map makes displaying mapping information easier. However, according to Nurminen and Oulasvirta (2008), orientation can be performed visually by direct comparison between the map and the environment. 3D mapping can focus on direct visual cues such as landmarks instead of labels such as street names. To benefit from the strengths of both 2D and 3D maps, the study will utilize an isometric map model which is a map that is rendered as a 3D model on a 2D plane. By doing so, we can preserve the distance between map elements and assist navigation by including visual cues.

2.1.3 Mobile Mapping

Bartling et al. (2021) stated that mobile map applications have been increasing in usage in different aspects of people's daily routines and are used by both professional and private users alike. These applications can be used for various purposes and by users differing in demographics, digital literacy, and spatial literacy. These applications have helped solve problems in wayfinding, localization of accident-prone sites, and mapping the topography of different areas.

The study of Sarjakoski and Nivala (2005) discusses the enhancement of maps for users by using context awareness. The context involves factors such as users' locations, preferences, environment, etc. Integrating these factors into maps allows the map to provide better navigational information compared to traditional maps. In the case of mobile maps, implementing these factors can improve the user's navigation experience and understanding of the maps. This study suggests that enhancing maps using these context awareness factors could potentially enhance the map's overall usability which will help users fully utilize the map.

2.1.4 Web-based Maps

Web-based maps are the process of generating maps where users can search for places, browse locations, and find routes in the World Wide Web (WWW). These maps have been developed for over two decades, beginning in the mid-nineties. One of the first of these maps is Mapquest, it is an American free web-based mapping service that was launched in 1996. It was followed by another web-based mapping service based in the United Kingdom which included location-based services and driving directions. Several years later, on February 8, 2005, a web-based map that is still widely used today was released, namely, Google Maps, and in July of the same year, Microsoft announced the release of Virtual Earth or Live Search Maps. Both have since released their Application Programming Interfaces (API) so that others can easily integrate their web-based maps into other web applications (Näslund, 2007).

The research of Näslund (2007) specified the use of four web-based APIs which are the Google Maps API, the Multimap API, the ViaMichelin Maps and Drive API, and the Microsoft Virtual Earth Map Control API. The researcher stated that the four were chosen because they are the most commonly used and well-known APIs. After testing all four APIs and evaluating them, Näslund (2007) states that there is no best mapping API as each of them showed varying strengths, weaknesses, benefits, drawbacks, and differences when developing web-based maps. Also, depending on the type of application, they vary in functionality, compatibility, usability, and development support. According to Näslund (2007), when it comes to compatibility, Google Maps and Multimap were more compatible on most browsers. Lastly, out of the four APIs, Google Maps performed better out of all four APIs with ViaMichelin performing the worst out of all four APIs.

2.1.5 Map Wayfinding

Ishikawa et al. (2008) stated that navigation is a straightforward and effortless task that also involves multi-level cognitive processes. With technological advances in this generation, maps have been developed and studied by many. This has resulted in easily accessible outdoor wayfinding using our mobile devices. One of the applications that have been developed and currently has 64 million users is Google Maps (Mehta et al., 2019).

A previous research by Ishikawa et al. (2008) showed the comparison of results with the use of wayfinding with GPS-based mobile navigation systems and direct navigation experience with traditional maps where sixty-six college students, specifically 11 men and 55 women, participated in the experiment and were then grouped to two. “Group GPS” were given a GPS-based navigation system and the other is “Group Map” and “Group Direct experience” which has the traditional map for navigation with direct experience of navigation or prior experience of navigation of the location. The results were as follows, surprisingly the GPS-based navigation system group traveled longer distances and made more stops compared to the participants who navigated based on experience or the Group Map. The Group GPS was going off the route indicated on the GPS screen and wandered around and stopped a lot to get reoriented with the surroundings, the Group GPS basically did not take the shortest route to reach the destination. The GPS users did not have prior experience of the routes which ultimately resulted worse than the direct-experience group.

At the end of the experiment, the majority of the GPS-based participants and the Map and direct-experience participants reached the specified destination. “There was no significant difference in the success rates among the three groups” stated by Ishikawa et al. (2008), ultimately all the groups found their way to the designated location. The direct experience groups were the fastest when navigating with having experience as an advantage over the other groups, followed by the Map Group which had prior experience when it comes to using traditional maps, and the group who had no experience with map navigation and no prior experience about the location whatsoever were the GPS-based group. Ishikawa et al. (2008) also stated that a possible reason why the GPS-based group was having trouble navigating was because of the small size of the map that is being shown, measuring 4 x 5 cm on the GPS screen compared to the paper map. Despite all that, the GPS-based participants with no prior knowledge or experience of using the GPS system. Due to this result, the proponents will be using an interactive map model as it is easier to use for people unfamiliar with maps and map wayfinding (Herman, et al., 2018). To make using the map another step easier, the map will use isometric models with 3D-looking models to enable students to navigate using visual cues (Nurminen & Oulasvirta, 2008) while still maintaining the integrity of a 2D map layout (Harrower, 2020).

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2.1.6 Indoor Map Wayfinding

With the study of Näslund (2007), there are already several outdoor GPS maps such as Google Maps, Microsoft Virtual Earth Map, etc. However, according to Basiri et al. (2017), there are very few maps focused on Indoor Positioning Systems (IPS), and there is only poor mapping coverage for indoor spaces from projects such as OpenStreetMap. This is because there are huge difficulties in developing indoor maps due to the unreliability of GPS indoors (Attia, 2013; Cheema, 2018). Navigation using GPS is limited indoors as the signals are blocked by walls or ceilings (Razlan, 2012). Despite the difficulties, there have been attempts at using indoor positioning technologies, however, they require special hardware such as RFID readers, Bluetooth beacons, and Wi-Fi-based positioning technologies. While getting indoor positioning information using these technologies is possible, it requires manually mapping signal strengths at different indoor locations, which is labor-intensive and time-consuming (Cheema, 2018). Also, getting indoor information using these methods, another critical issue is highlighted. It is an issue regarding privacy as it raises concerns because of potential invasive monitoring and the fact that many private establishments may not want to publish maps of private indoor property (Basiri et al., 2017).

2.1.7 Web Based 3D rendering using WebGL across various platforms

Enabling hardware-accelerated 3D content in browsers expands the possibilities for web app development that were previously exclusive to desktops (Devaux et al., 2012). Hamdi and Prayudi (2023) conducted a benchmark study comparing WebGL performance on Google Chrome across desktop and mobile devices. They rendered a 3D First Person Shooter game with realistic graphics and particle effects like stormy weather. On a mobile device running Android 8.1.0 with 4GB RAM and a 2.0GHz Octa-Core processor, the game achieved 25 FPS at lower graphics settings, taking around 38 seconds to load all assets, reaching a temperature of 41°C. In contrast, on desktop, the game runs smoother at 40 FPS, taking around 36 seconds to load assets, with a higher temperature of 63°C on maximum graphics.

The study concluded that low-spec devices struggle with WebGL-supported browsers due to hardware limitations and high RAM usage. Internet speed significantly influences WebGL game responsiveness, as these games rely on it to load necessary data assets within web browsers.

While high-quality graphics remain important in modern video games, developers face the challenge of selecting detailed game models carefully. This decision is influenced by hardware limitations and the significant processing power required for real-time rendering (Amarasinghe & Parberry, 2011). The proponents will be using WebGL to port the campus map from Unity to a web-based map, this will give students another choice for methods to access the application with the mobile application for the other. The application will consist of polygonal graphics which will require minimal specifications to run which will increase accessibility further.

2.1.8 Campus Maps

Campus maps play an important role in the overall experience of students within educational institutions. These maps serve as navigational aids for students and contribute to students’ sense of belonging, but they can also contribute to exclusion among students (Rosati, 2019). According to Omwega (2007), the reliance on static paper maps limits its efficacy in meeting the dynamic needs of modern campus environments. However, due to the evolution of technology, navigation within campuses has had significant advancements notably the development of online and 3D electronic maps.

Technological innovations have revolutionized the accessibility and functionality of campus maps. An example of this is the integration of the Google Maps API which enabled developers to create comprehensive campus maps based on the spatial information of buildings. This has given users campus maps that are informative, interactive, and can easily be navigated (Yang, 2009).

2.1.9 Evolution of graphics used for maps.

Over the years, there have been major changes in how maps present information using graphics. During the earlier stages of electronic mapping, Fulton (1977) discussed the importance of having really good tools to create map graphics. This is since software that is able to make effective graphics were scarce during those times. Fischer and Nunley (1975) also discussed a similar topic but the discussion was focused more on having graphics systems that work well with presenting geographic information. In future studies, Yan (2004) introduced Scalable Vector Graphics (SVG) for maps on mobile devices, this way of creating graphics became a big deal during its time. It created a standard style on how maps should look on mobile devices. Zhang (2015) figured out a way to show detailed map symbols on the internet, this was especially useful for maps that use vectors instead of regular images. These studies show that graphics have been evolving and constantly improving over time.

2.1.10 Synthesis of Related Literature

The proponents have discussed the relevant studies related to developing interactive maps. The related literature has discussed the increasing popularity of interactive maps as a method of displaying geo-referenced data (Oulasvirta et al., 2008). It was stated that interactive maps are easier to pick up and use for users that are unfamiliar with mapping systems (Kubíček et al., 2019). It has also highlighted the importance of campus maps for the experience of students within educational institutions. Campus maps not only give students navigation aid within the institution but also give them a sense of belonging (Rosati, 2019).

The proponents have also discussed justifications regarding the choice of using isometric models instead of the usual 2D models and 3D models. This is because it contains the strengths of 2D models, which can display mapping information easier and do not distort distances between locations (Harrower, 2020), and the strengths of 3D models which can display navigation information using visual cues such as landmarks and buildings (Nurminen & Oulasvirta, 2008). Another justification for the use of isometric models is that it should use less resources to run compared to the result of the study by Hamdi and Prayudi (2023) which shows that lower-end devices have trouble running 3D models.

The current wayfinding solution of CMU is an interactive map that uses a birds-eye view perspective which only addresses the spatial location of buildings within the campus. This study could provide better visualization of the campus through the use of isometric models instead of the 2D visualization that the current map provides. It can also address the issue regarding the current map's lack of indoor information and navigation.

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