Multi-Display Map Touring with Tangible Widget

Marco Piovesana
Dept. of Math and Computer Science, University of Udine
marcopomail@alice.it

Ying-Jui Chen
Graduate Institute of Networking and Multimedia, National Taiwan University
springgod@gmail.com

Neng-Hao Yu
Graduate Institute of Networking and Multimedia, National Taiwan University
d96944013@ntu.edu.tw

Hsiang-Tao Wu
Graduate Institute of Networking and Multimedia, National Taiwan University
ndhumuscle@hotmail.com

Li-Wei Chan
Graduate Institute of Networking and Multimedia, National Taiwan University
d93944008@csie.ntu.edu.tw

Yi-Ping Hung
Graduate Institute of Networking and Multimedia, National Taiwan University
hung@csie.ntu.edu.tw

ABSTRACT

Many map systems are created to help the user finding a place or define a route to follow. Google Map extends the concept of "surfing the map" by adding a street view that allows the user to explore a place from real pictures, creating the same feeling of walking through the streets. The horizontal 2D map and vertical panoramic street view, however, cause usability problems, while operating with traditional computer mouse and keyboards and presenting by single vertical or horizontal display. This paper presents a new table system composed of a horizontal tabletop screen and a vertical screen. The map view and the street view are displayed on the horizontal and vertical displays of our system respectively. Users can place the tangible pawn on the 2D map to have direct access of the street view from the pawn's point of view. In the user study, we compare our system with a standard computer system in the navigation task. The results reported that our system improves the intuitiveness of use, efficiency of city exploring and ease of remembrance on spaces that are not familiar beforehand. We also discuss limitations of using tangible objects for map navigation.

Categories and Subject Descriptors

H5.2 [**Information interfaces and presentation**]: User Interfaces.

General Terms

Human Factors

Keywords

Tangible user interface, tabletop, HCI, interaction design, navigation

MM'10, October 25–29, 2010, Firenze, Italy.

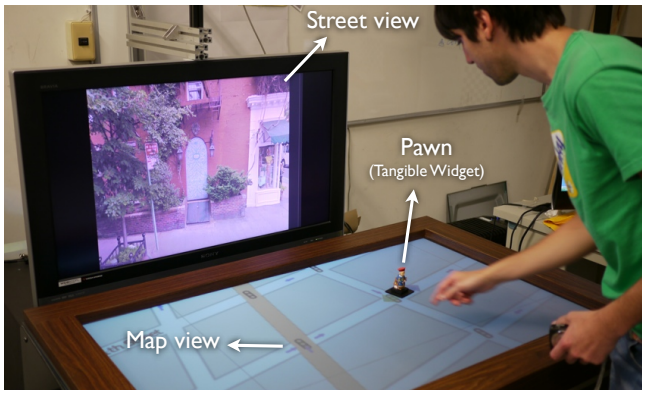

Figure 1: Tabletop System
Our tabletop system combines a vertical display and a horizontal display. The street view is displayed on the vertical screen and the map view is displayed on the horizontal one. Our system supports multi-touch input and tangible input.

1. INTRODUCTION

Navigation is "the process whereby people determine where they are, where everything else is, and how to get to particular object or places"[1, 2]. As we all know this is a common problem and many are solutions proposed during the years.The common goal of all these applications is to improve the navigational knowledge of the user, so he or she can find the direction also in an unknown space. However this concept of knowledge can be divided into subcategories. The two on which we want to focus our attention now are called: route knowledge and survey knowledge. The first is gained through personal exploration and allows reaching a destination just through a known route while the second describes the relationship among locations and can be gained through the study of a map.

In the Google Map web application there are two views called street and map, as shown in Fig. 2. The map view is focused on the street topography while the street view is made by pictures taken from the streets and shows the real appearance of the city. Using a combination of these two views the user can acquire both route and survey knowledge in the same moment, simply using a PC. Studies about

Figure 2: Map view and street view of the Google Map application.

human navigation [3] show the importance of landmarks for routing and way finding. The landmarks are particularly recognizable elements of various kind (buildings, signboards....), normally used to easily remember a path. The street view, being made by pictures from the city, can truly help the user identifying those landmarks and exploit the advantages given from their use.

However, with Google Map, surfing the street view using the mouse directly on it or using the mouse to move the virtual character on the map view requires users who have good recognition on correlation between virtual character, map and street view. This motivation pushes us to create a Tangible User Interface on map touring applications. Our goal is to provide simplicity and intuitiveness on this system.

2. RELATED WORKS

Fallahkhair et al. [4] created a system composed by multiple devices, discussing the potentials of this choice. The design constraints are more fluid, there are more input/output options and the designer can take advantage from the characteristics of each device to model a better interaction between system and user. When we talk about maps the first type of interaction that we normally think about are the hands; we use our fingers to move, rotate or follow a street on the paper. To be able to perform the same type of interaction in the virtual world we need a touch screen device. Smartphones and PDAs have the advantage of being small and portable, in the other hand the dimension of the screen and the input/output possibilities are limited. If portable is not our goal, devices like tabletops can solve the dimension and interaction problem. The screen dimension is much bigger that any portable device and the interaction with the system can include not only fingers but also TUI (tangible user interfaces). Maher and Kim [5] presented a 3D design system that uses tabletop and TUI to improve the perception of space and the relation between the elements in the scene. They discuss the advantages of using physical objects into virtual world; how manipulability, tactile feedback and kinesthetic information can improve the interaction between user and system. In Wagner [6] compare TUI and GUI, showing the advantages called double feedback loop and persistency of tangibles given from the use of TUI.

All the following systems show how the interaction with an application like Google EarthTM can be revisited using devices like screens, tabletops or projectors and different kind of input methods. S. Kim et al. [7] presented a system based on a tabletop device that allows the user to completely control the map using hand gestures. Kim, Cho, Park, Han [8] focused their attention on TUI interactions. They create a device called SmartPuck that can be used to substitute all the mouse (or finger) interactions with the map, introducing in the system all the advantages given by the use of tangible widgets. More connected to immersible 3D experience is Liquid Galaxy [9]. The system is controlled by a special joypad and is composed by eight screens that provide the sensation of immersion in the virtual world. A mix between art and technology is The Earthwalk [10]. The map is projected on the floor and the interaction is driven by the feet through the use of footpads. The user is not just browsing the map, but has also the feeling of walking on it.

All the projects we just mentioned are presenting different kind of interaction, but all of them are focused on just one type of map. What we want to do is to improve the interaction for a system that uses two maps in the same time, taking the benefits from the use of different types of visualization. In [11] lines et al. present a solution for this issue of interacting simultaneously with different views of the same map. However the goal of this system is analyze the map and incentive the collaboration between users during this analysis. The navigation needs more grades of freedom and this affects the system usage, which is therefore more complicated.

We want to present a way of showing and interacting with these two maps that is focused on simplicity, intuitiveness and allows the user to navigate and remember more easily the environment.

3. SYSTEM COMPONENTS

Our system is composed by tabletop system, a vertical display and tangible UI. We implement a tabletop system that can detect fingers and tags by an infra-red system composed by several illuminators and two wide-angle cameras. The Tangible UI is a pawn with a specific tag applied on the bottom (Fig. 3). A vertical display (LCD 42 inches) shows the street view corresponding to the current point of view of the pawn.

3.1 Tabletop Configuration

What we decided to do is to split the two views into two devices. As shown in Fig. 1, the map view is shown on the table while the street view is shown on the LCD screen, positioned vertically in front of the table. The management of the two views is done by two different programs, each responsible for controlling the corresponding view and maintaining the consistency between the two views.

3.2 Interface of Map View

The 2D map view is shown on the tabletop surface. Users can interact with the map by using their fingers and the widget. The recognized finger actions are two: move and zoom and are used to control the map view. The movements that the user has to do to perform these actions are exactly the same movements presented by S. Kim, Arif, J. Kim and Lee[6] for the same actions.

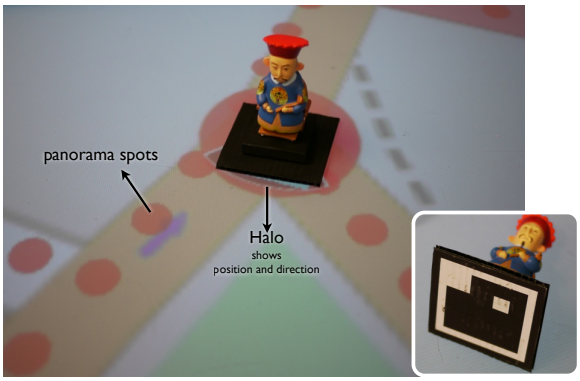

Figure 3: The visual user interface on the map view and the tag under the widget.

3.3 Interface of Street View

What we have to control, however, is not only the map view but also the street view. The first possibility is to increment the number of gestures. Nevertheless this idea make it possible to use only the hands to control both views, it increases the complexity of the system. This because the user need not only to learn a new set of gestures, but also how to perform them correctly to manipulate the system. What we decided to do is to use a pawn. This not only simplifies the number of gestures required to use the system but also exploits a mental process known as recognition over recall[8]. The shape of the pawn is exactly like a person, including the face. Therefore, It's easy for the user to associate the rotation of the pawn to the rotation of the view on the screen and the movement of the pawn with the change of the panorama's image. The functionalities connected to the pawn are two: move and rotate. When the user places the pawn on the surface of tabletop the closest panorama is shown on the screen; moving the pawn the panorama changes according to the new location, rotating the pawn is possible to see all the 360 degrees of the current panorama.

As the pawn is placed on the map, some visual hits are shown under the pawn (Fig. 3). One is a halo which indicates the position and direction. Another is the panorama spots. Since the google map street view are discrete panorama pictures, the red spots can notices user how far will the street view is going to change on vertical display.

4. USER STUDY

We want to test if our system helps user search and memorize an unfamiliar region. We take the widespread google map and street view web service as our baseline. Therefore, we tested the user response of our system and the google map to the efficiency of map exploring and memorization.

4.1 Task

For each participant 2 routes, one for the tabletop and one for the desktop system, are randomly selected between 4 different options, equivalent in length and complexity, in an unfamiliar city. Participants had to surf the specified route and after every one minute of map operation they had 40 seconds to answer 15 constant single-choice questions. Each experiment consisted of 10 rounds of this alternation of operation and examination.

The question consisted of two categories, 5 store locations and 5 corner sets. For store location question, participants searched the route and figured out where are the locations of 5 given stores. For corner set question, participants memorized the correct directions and correct locations of 5 turning corners in the route.

The route, stores, and corners were revealed to the participants in the beginning of each task. The participants had a tutorial task consists of 5 rounds only. They learned how to operate the map and understood our examination program. A formal task consists of 10 round came right after the tutorial. Participants then switched to the other system. A set of tutorial and formal task was applied as well.

4.2 Experiment Environments

We tested two systems in our experiment, the google map system and our tabletop system. In Google Map environment, we use the google map and the street view web service. Participants may use keyboard and mouse to control the map through the street view or the map view (Fig. 2). In tabletop environment, participants use both multi-touch and tangible widget to control the map (Fig. 1). We positioned 22" LCD screen in Google Map environment. At the same time, we positioned 42" vertical screen and 50" horizontal screen in tabletop environment. The distance between user and the screens maintained the similar resolution in perception for each environment.

4.3 Participants

10 volunteers, between the ages of 22 and 26, were recruited from our laboratory. 7 were males and 3 females. 2 of them are not computer science related major students. All of them had experience with touchscreens and google map. None of them had experience with multitouch tabletop system.

4.4 Results

Our experiment is designed to measure the learning curve of exploring and understanding the environment along the route. The result shows that our tabletop system makes the map navigation easier than the desktop system. (Fig. 4)

The difference between two system is accumulated as the round goes. Due to some limitations, learning curves of both system are mean to converge eventually. There are three limitations in this experiment, limited time, limited human short term memory, and the question set.

The learning speed curves diverged well in the beginning, but an early converging emerges in round 6 of the table top system, which is average 8.5 correct answers. The learning speed decreased around 10 questions in both systems. The question set is blamed for the decreasing. These users answer the corner questions than the store questions. The location of the corner questions is known and no searching operation is required. An other factor is the limited number of questions. In round 6 and after, 3 participants completed the problem set and 7 participants answered more than 10 questions with our tabletop system. On the other hand, no participant completed the question and only 3 participants answered more than 10 questions with desktop system. Thus, two curves begin to converge in round 6, which is much earlier than we expected.

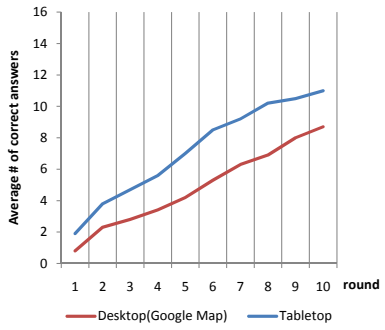

Figure 4: Learning curve of two systems

5. DISCUSSION

5.1 Direct mapping V.S. Indirect mapping

One important characteristic of TUI is physical contact of the widget. When holding the real widget, users get a better understanding about orientation, position and they can control the street view angle without focusing on the widget. In map navigation, the street view and the map view are separated in different region and moving or rotating the avatar is frequently involved. We observed a very much higher frequency of re-focusing with mouse-keyboard than with tangible widget. In addition, participants manipulated the movement of the widget more intuitively under our horizontal setting of the map view.

5.2 Place-and-Direct

Tangible widget offers an important feature, that it can specifies both the position and the orientation. This characteristic is especially crucial in controlling the virtual navigation. Users have to specify the pose frequently in map navigating application. In our experiment, participants completed repositioning more efficiently with the tangible widget than the mouse and keyboard.

5.3 Physical Widget in Virtual World

Mapping the position and the orientation of the real widget to the virtual world brings convenient operating manners. But it has an problem that how to map the virtual position and orientation back to the real world. Moving and rotating the map will lead to the disorder of the street view and the widget. In our application, we fix the map position and orientation when the widget is placed. An alternative way is to display visual aid to help user understand the relationship between the shifted map and the real widget.

Using the tangible widget brings an serious problem when users scale the map. Once the map zoomed, the region and the distance between neighboring panorama spots also scaled. However, the real widget is not able to perform resizing to keep the consistency. In our observation, we found a common mistaken idea if we use a constant size widget. Participants tried to move the widget a relatively tiny step which is out of the resolution that the device can provide. In our experiment, we ask participants to utilize the zoom function to avoid such problem. We are planning to introduce level of detail concept to the map system. If the level of detail is integrated properly, users can manipulate fixed size widget under different scale level and obtain important information as well.

6. CONCLUSION

In this paper, we tested the combination of the multi-screen and the tangible UI. As the experiment pointed out, the tangible UI is very suitable to the map navigation. We also found several advantages and limitations about the tangible UI. First, the tangible object offers better perception about the position and orientation of the virtual avatar. Second, placing the tangible object indicates both position and orientation. However, properties of the real tangible object, such as position, orientation and size, cannot be modified if the system has to.

7. ACKNOWLEDGEMENTS

This work was supported in part by the Excellent Research Projects of National Taiwan University, under grants 98R0062-04, and grants from Intel Corporation. We would also like to thank Su-ting Chuang, Heng-yu Chou and Ling-Erh Lan for their helps in the experiments..

8. REFERENCES

[1] S. Jul and G. W. Furnas, "Navigation in electronic worlds - workshop report," *SIGCHI Bulletin*, vol. 29, pp. 44–49, 1997.

[2] M. D. A. Tom, "Referring to landmark or street information in route directions: What difference does it make?" vol. 2825, 2003, pp. 384–397.

[3] P.-E. Michon and M. Denis, "When and why are visual landmarks used in giving directions?" in *COSIT 2001: Proceedings of the International Conference on Spatial Information Theory*. London, UK: Springer-Verlag, 2001, pp. 292–305.

[4] S. Fallahkhair, L. Pemberton, and J. Masthoff, "A dual device scenario for informal language learning: Interactive television meets the mobile phone," *Advanced Learning Technologies, IEEE International Conference on*, vol. 0, pp. 16–20, 2004.

[5] M. L. Maher and M. J. Kim, "Studying designers using a tabletop system for 3d design with a focus on the impact on spatial cognition," *Horizontal Interactive Human-Computer Systems, International Workshop on*, vol. 0, pp. 105–112, 2006.

[6] H. S.Wagner, Nusbaum and S. Goldin-Meadown, "Probing the mental representation of gesture: Is handwriting spatial?" *Memory and Language*, vol. 50, 2004.

[7] S. gook Kim, S. N. Arif, J. woon Kim, and C. woo Lee, "Multi-touch tabletop interface technique for hci."

[8] S. P. M. H. Laehyun Kim, Hyunchul Cho, "A tangible user interface with multimodal feedback," *Lecture Notes in Computer Science, Springer*, 2007.

[9] Google, "Liquid galaxy live demo at ted," *Lecture Notes in Computer Science, Springer*, 2010.

[10] T. Glaeser, "Google earthwalk with arduino at berlin design mai 2007."

[11] C. Forlines, A. Esenther, C. Shen, D. Wigdor, and K. Ryall, "Multi-user, multi-display interaction with a single-user, single-display geospatial application," *UIST*, pp. 273–276, 2006.