TouchPosing - Multi-Modal Interaction with Geospatial Data

Florian Daiber, Sven Gehring, Markus Löchtefeld and Antonio Krüger
German Research Institute for Artificial Intelligence (DFKI)
Saarbrücken, Germany
{firstname.lastname}@dfki.de

ABSTRACT

Multi-touch interaction offers opportunities to interact with complex data. Especially the exploration of geographical data, which until today mostly relies on mice and keyboard input, could benefit from this interaction paradigm. However, the gestures that are required to interact with complex systems like Geographic Information Systems (GIS) increase in difficulty with every additional functionality. This paper describes a novel interaction approach that allows non-expert users to easily explore geographic data using a combination of multi-touch gestures and handpostures. The use of the additional input modality – handpose – is supposed to avoid more complex multi-touch gestures. Furthermore the screen of a wearable device serves as another output modality that on one hand avoids occlusion and on the other hand serves as a magic lens.

Keywords

Multi-touch Interaction, Handpose Interaction, Geographic Information System, Mobile Devices.

Categories and Subject Descriptors

H.5.2 [**Information Interfaces and Presentation**]: User Interfaces. - Graphical user interfaces

General Terms

Design, Human Factors

1. INTRODUCTION

Multi-touch has great potential for exploring complex content in an easy and natural manner. Designers often make use of the geospatial domain to highlight the viability of their multi-touch interfaces since it provides a rich testbed. This is due to the fact that the command and control of geographic space (at different scales) as well as the selection, modification and annotation of geographic data is complicated [16]. One important observation of previous studies [12, 7, 14] shows that users initially preferred simple gestures resembling mouse input of systems following the Windows-Icons-Menus-Pointer (WIMP) principle. After experiencing the potential of multi-touch, users tended towards physical gestures [17] to solve spatial tasks. But users still prefer single hand gestures or gestures where the non-dominant hand just sets a frame of reference that determines the navigation mode, while the dominant hand specifies the amount of movement.

Figure 1: Multi-modal interaction with geographic data.

While hand gestures are good for precise input it is difficult to input continuous data with one or two hands for a longer period of time [4]. For example, panning a map for a larger distance on a multi-touch wall through a repeated "wiping"-gestures may lead to ergonomic problems (arm fatigue). The human hand on the other side is trained for fine motor skills. Using handpose for continuous input can overcome the problem of arm fatigue and at the same time still allows the performance of multi-touch gestures.

In this paper we present a set of novel interaction techniques that allow the navigation and manipulation of geospatial data using a combination of multi-touch and hand postures as input and touch-enabled displays of various sizes (board- to tab-sized) and form-factors (table and wearable) as output. The remainder of the paper is structured as follows: the next section places this paper in the context of the related work that provides the basis for this research. Thereafter we describe our novel interaction techniques and our prototypical implementation. We conclude with a discussion of the results of an informal user study and ideas for future work.

2. RELATED WORK

Today mice and keyboards are still used by most GIS users to navigate, explore and interact with a GIS even though they are not optimal devices for this purpose. Nowadays several hardware solutions exist that allow the realization of GIS with multi-touch input on surfaces of different sizes (see Buxton's comprehensive overview on the current technologies as well as the history of multi-touch surfaces and interaction [2]). Additionally the emerging commercially available multi-touch products have brought up a variety of novel gesture-based interaction techniques.

Much work is done on the definition of frameworks and taxonomies for such gesture-based multi-touch input. Wu et al. defined the principle of Gesture Registration, Relaxation and Reuse [20]. Wobbrock et al. investigated user defined gestures and developed a taxonomy of gestures for surface computing [18]. Daiber et al. [4] proposed a framework for multi-touch and foot interaction. One main idea of the latter work is the separation of continuous and discrete input. We take this separation to a different and easier modality.

In the field of wearable computing some approaches for gesture tracking exist where the wearable is used as an ubiquitous input device. GestureWrist [10] and GRacelet [6] are two examples for ubiquitous wearables equipped with various sensors. These wearables have in common that they are used to track handpose for free-hand gestures. Another approach is PhoneTouch [13] that uses sensors of mobile devices for personalized interaction with multi-touch tables.

The concept of magic lenses [1] is a well-known and profound approach for focus and context interaction. There are various approaches where magic lenses are used to interact with geospatial data on mobile devices (e.g. [11]), on tabletops (e.g. [5]) and even above the table (e.g. [8, 15]).

3. MULTI-MODAL INTERACTION WITH GEOGRAPHIC DATA

Multi-touch interaction is well suited for navigation in and manipulation of geospatial data. But as already mentioned above it has also shown that while hand gestures are good for precise input it is difficult to perform continuous input with one or two hands for a longer period of time [4]. To overcome this issue we propose the incorporation of hand posture of the user as an additional input dimension. Inspired by the idea to allow continuous input through whole body pose [4], we exchanged the feet input with handpose input. The substitution of feet input with hand posture promises to lower the entry barrier since most people are used to fulfill motoric complicated actions with their hands rather than their feet. Several handpostures and combinations of touch and handpose gestures are identified. After that the basic commands and controls of a GIS are mapped to these interactions. In the following these interaction styles as well as the application of these interactions to the field of geographical data are discussed in detail.

3.1 Multi-touch and Handpose Interactions

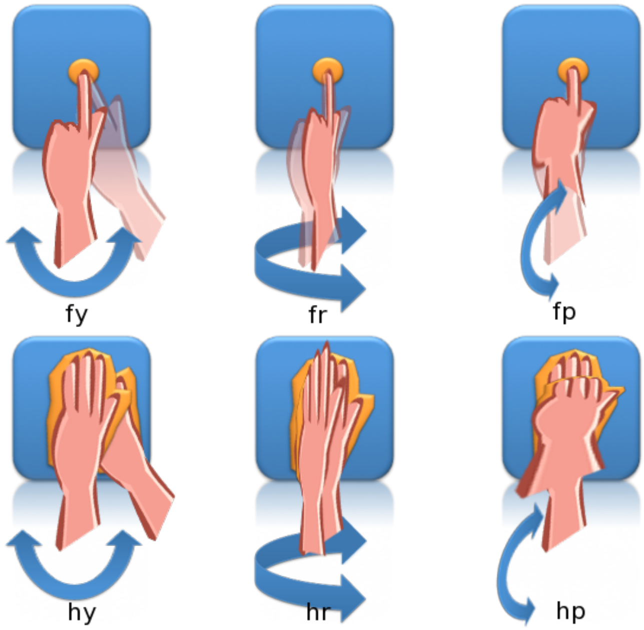

Figure 2: Touch and Pose. Finger- (f) or handpalm-touch (h) combined with yaw-, roll- and pitch-like poses (y, r, p).

The combination of touch gestures and hand postures results in a set of novel gestures. For multi-touch input three classes of these patterns were defined by Daiber et al. [4]: simple fingertip, palm-of-the-hand and edge-of-the-hand input. Similar to the *form* dimension of Wobbrock's taxonomy [18] for handpose there are three modes: while touching the user may move her hand around the three axes (cf. pitch, yaw and roll). Simple touching with one finger enables the user to virtually point on objects to select them ("select gesture"). The "pan gesture" allows dragging a map or globe. The "zoom gesture" enables resizing of the map as well as objects. Tapping and changing the pose of the hand allows an intuitive manipulation of the object the user is pointing on. Pointing on an object and rotating allows a rotation of the object in a pitch-yaw-roll style ("rotate posture"). Another posture arises when touching with the palm of the hand and tilting the hand ("tilt posture"). Figure 2 illustrates these postures. Another modality is the "pick posture" that allows touching the wearable display while tilting it.

3.2 Magic Lens Interaction above the Display

The use of a wearable device that contains a display with good resolution enables an additional output mode for the display of personal and/or additional data above the interactive display. The knowledge of the position as well as the orientation of the device allows the manipulation of the display with respect to the interactive surface below. Depending on the interaction modality the wearable display might be used for different output. There are two modes: (1) (Multi-touch) interaction on the interactive surface (2) Magic Lens Interaction above the interactive surface. During multi-touch tabletop interaction the wearable display shows the occluded information that is displayed on the interactive display beneath the wearable display. This reduces

Device	Mode	World	Objects	Layers
Tabletop	Multi-Touch	pan zoom	select move zoom	
	Touch&Pose (Finger)	tilt roll	rotate tilt	pick
Wearable	Touch&Pose (Hand palm)			pick
	Handpose	pan lenszoom		browse

Table 1: Interaction styles for multi-modal interaction with spatial data.

occlusion and supports the user in not losing the interaction context. Tilting the whole palm of the hand while touching the tabletop surface enables the user to change the visibility of different layers in the view. When the interactive display is not touched the wearable display allows browsing through and zooming in geographical information (e.g. layers) in a magic lens style. Depending on the height of the wearable above the display different layer of geographical information are displayed. Selecting one specific layer on the wearable device with a finger allows a reorganisation of the layer stack.

3.3 Interaction Styles for Multi-modal Interaction with Spatial Data

The proposed interaction styles for various selection and manipulation tasks are summarized in Table 1. The Table is organized as follows. The columns represent the most common commands that are needed for geographical tasks to navigate and manipulate the geographic space, geospatial objects and layers mapped to the gestures and postures (see above). The rows are again subdivided into interaction devices (tabletop display and wearable display) and modes (touch, touch&pose and handpose). Most of the map interactions take place directly on the tabletop through pure touch (pan, zoom) or touch and pose input (tilt, rotate). While more complex (e.g. navigation in layers) or additional (e.g. magic lens zoom) interactions are performed on the wearable device.

4. IMPLEMENTATION

The hardware setup consists of a multi-touch tabletop and a wearable device. A FTIR-based multi-touch tabletop serves as interactive surface. As wearable a Google Nexus One, an Android-based mobile phone, attached to a glove is used (see Figure 3). These components are communicating with each other via socket connections.

The touches are tracked by *Core Community Vision* [3] and streamed via TUIO [9] to the gesture recognition component. The orientation of the wearable and with that the handpose is determined by the built-in sensors of the mobile device. This device provides orientation and acceleration sensor data that is streamed via UDP to the gesture recognition component. To track the position and the orientation of the hand relative to the multi-touch surface three infrared LEDs are attached to three edges of the mount of the mobile device. These LEDs are recognized by a camera above the surface (see Figure 1). *NASA World Wind Java SDK* [19] serves as testbed to evaluate these novel GIS interactions. For that purpose a World Wind based prototype was developed and adapted to multi-touch and handpose input.

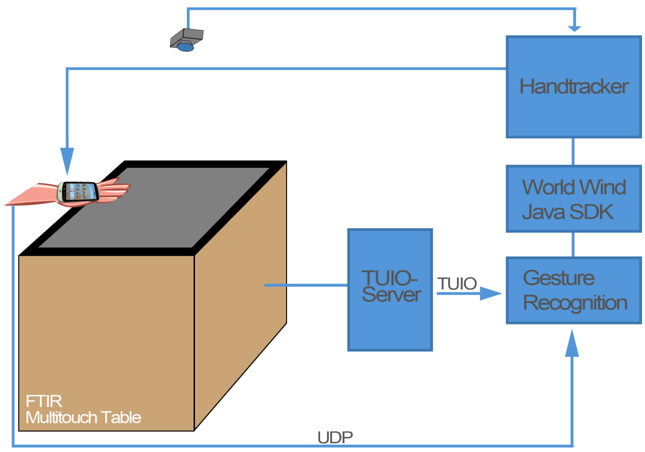

Figure 3: Overview of the implementation.

5. EVALUATION

We conducted an initial informal user study with seven participants (six male, one female) who stated that they regularly interact with virtual globes e.g. Google Earth. The average age of the participants was 28. The users were free to choose either one of the hands for the wearable but all chose their dominant hand. After a short introduction phase we asked the participants to freely explore the globe with different layers using touch and pose gestures while we observed them.

Altogether the comments regarding the whole setup were very positive. Just three participants complained about the slow update rate of the image on the device's screen. Another technical issue that was raised by one participant was the demand to personalize the sensitivity of the sensors. Apart from this feedback the performance of the system met the expectations. The most remarkable observation we made while the users interacted was that all of them started to use only the non-augmented hand (in each case the non-dominant hand) for panning. The other hand was only incorporated for actions that required multiple fingers e.g. zooming. After the test we asked the participants what they would change in future usage, and five out of seven stated that they would change the chosen hand for the wearable.

6. CONCLUSION AND OUTLOOK

In this work a novel input modality for multi-touch enabled devices is presented. Besides touch our approach additionally takes handpose into account. Discrete input is performed by touch gestures while continuous input is managed by rotation and tilt gestures of the whole hand. Besides tracking postures a wearable device with a built-in display allows an intuitive method to virtually browse through different geographic layers through the use of a wearable magic lens approach and - as a nice side-effect - an easy method to solve the occlusion problem when interacting with backprojected multi-touch screens. Using a combination of touch gestures and hand postures results in a set of novel multi-modal interaction styles that are easily learnable for non-expert users. An initial informal evaluation of the interaction concepts has shown the viability of this approach. However there is also a need for further refinements as well as additional investigation on other input modalities. Furthermore we want to address the problems outlined in the evaluation and plan to improve the update rate of the image on the devices screen to enable comparison of task completion time with and without the wearable. User adopted as well as user generated gestures also have to be investigated in detail.

7. ACKNOWLEDGMENTS

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