Attentive Probe: Design of 3D Geometry-based Information Visualization Tool for ActiveHome

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ABSTRACT

While the technology paradigm is shifted to ubiquitous computing, the fundamental interface for human and computer interaction is still invariant and users are often suffering from information overload by interacting with ubiquitous computers. In this paper, we present the Attentive Probe, an information visualization tool based on 3D geometry and user attention in the ubiquitous computing environment. It is designed to help users find information that may be of interest. The Attentive Probe offers the ego-centric view of the detail information from its current location to the direction that users are looking. The tool allows users to glimpse a view of what is important and meaningful to them beyond the objects and the walls that human can see. The current prototype is installed and used in ActiveHome.

Keywords: attentive user interface, direct manipulation, two-handed interaction, ActiveHome, ubiquitous computing environment

1. INTRODUCTION

With an advent of ubiquitous computing technologies, it is now possible to realize an affordable environment for supporting intelligent services for better life. While there have been many ubiquitous computing tools developed by industry and research institutes, especially for the home environments, they have not received a wide public acceptance since they often over- or under-estimate user's intention. Sometimes the tools are more tedious to use since they attempt to do a certain action that users may not want it.

One of the promises of ubiquitous computing is that it will enable the information systems proactive, that is, information will be available when users need it, rather than having them to request information explicitly. The proactive systems need to support techniques for direct manipulation with the 3D worlds; that is, users have to touch an object to perform an operation on this object. This interaction style works well when the manipulative objects are known and at hand. The means for selecting and performing actions on these objects are relatively straightforward.

Unfortunately, this direct manipulation would not work for the objects of user's interest that are unknown or at a distance. To cope with such problems, some researchers have developed the extreme direct manipulation, such as creating devices with many buttons and modes[15], arbitrarily stretchable arms[14], and 3D graphical user interface menus [16]. However, these interfaces may require users to perform far more actions than such GUIs can realistically provide.

In this work, we aim to develop a tool to support better user interaction for the ubiquitous computing environment using information about user attention and 3D geometry of the environment. Figure 1 shows the picture of a user using the current prototype of the Attentive Probe to search for the important status of information devices at ActiveHome. ActiveHome is a ubiquitous computing environment built at the Digital Media Laboratory at the Information and Communications University to support design and

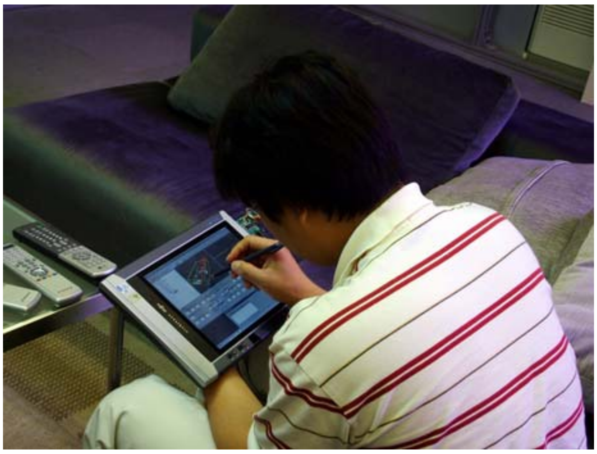

Figure 1: The Attentive Probe, a 3-dimensional geometry-based information visualization tool for the ubiquitous computing environment.

development of intelligent tools for better life. This paper presents the motivation, system architecture, and current uses of the Attentive Probe in the ubiquitous computing environment.

2. Related Works

Easy Living[7][8] emphasizes the importance of the explicit geometry information in smart home, and provide scenarios for location-aware service, based on 3D geometry model. WIM[6] provides users with handheld representations of distant location. Users manipulate a distant object by manipulating a copy of it in a handheld representation In addition to allowing users to work at a distance, a representation allows users to get a better view of the manipulated object by viewing it both up close and at a distance. This technique thus provides users with better feedback than arm-extension technique, which only allow users to view manipulated objects at a distance. XWand[13] intuitively can point and take a action about the targeted object Despite a new six degree-of-freedom to manipulate objects in a living room, it can't select the object in a remote region that user wants, due to the lack of the explicit geometry model. Similarly, Ed at all [5] present a multimodal interface in order to cope with selection problem using a pointing volume in VR. Fitzmaurice[2] presents virtual information associated with real objects in space with a palmtop display. David[3] also reveals a spatially aware graspable display that is similar to Fitzmaurice[2]. Using spatially aware PDA, Ka-Ping[12] shows the information that can be spread out on a flat virtual workplace larger than the display by tracking the position of the display. So the display shows a movable window on the space.

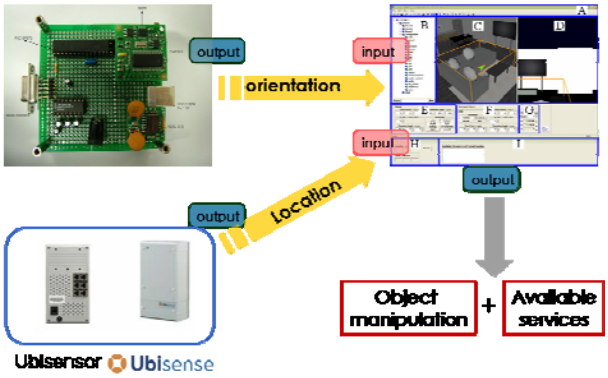

Figure 2: Overview system architecture for the Attentive Probe.

3. System Architecture

The Attentive Probe is a spatially aware handheld display similar to Chameleon [2] or Peephole Display [12]. This tool provides information sensitive to its current location and orientation. The difference is that it provides the features of object selection and manipulation, viewpoint control, and direct system control. Users can point and move this tool to the direction that users are of interest. They can scan the whole house using this tool to search for interesting objects both within and behind the room that they are located. Users can also zoom in or out the view frustum of the tool, i.e. users zoom in to get a wider field of view.

As shown in the Figure 2, the Attentive Probe receives its location and orientation in real time using the Ubisense location tracking system and a specially designed tilt sensor attached to this tool. UbiSensor™ receives ultra wideband (UWB) pulses from Ubitags™ which are then used to determine the exact location based on Time Difference of

Arrival (TDOA) and Angle of Arrival (AOA). The orientation consists of each of the 3 orthogonal axes of the magnetometer that can sense the degree to which it lies along the direction of the Earth's magnetic field, such as yaw, pitch, and roll.

Figure 3: Hardware prototype of the orientation sensors.

It then visualizes the first-person view of detailed information about home information device status from the current location to the direction that the user is oriented. The visualization tool is written using Microsoft Visual C++ and OpenGL graphics library and the models are constructed from Maya 3D modeling toolkit. This tool also allows users to adjust the range of field of view by manipulating the view frustum on the visualization.

Figure 3 shows the hardware components of the orientation sensors in the Attentive Probe, which are following:

- It uses the ADXL202 2-axis MEMS accelerometer for sensing the pitch and roll angle.
- The PIC16F873 is a flash programmable micro-controller running at 20MHz that reads the sensor values, formats data communication packets, decodes received packets, timing controls and power management.
- The CMPS03 is a robot compass module that computes the direction of the horizontal component of the Earths magnetic field, thereby sensing the yaw angle.
- The FTDI single chip USB is used for asynchronous serial data transfer.

4. Interactive 3D Environment

In the existing smart home projects, researchers only seek to distribute computing, perception and interfaces is widely

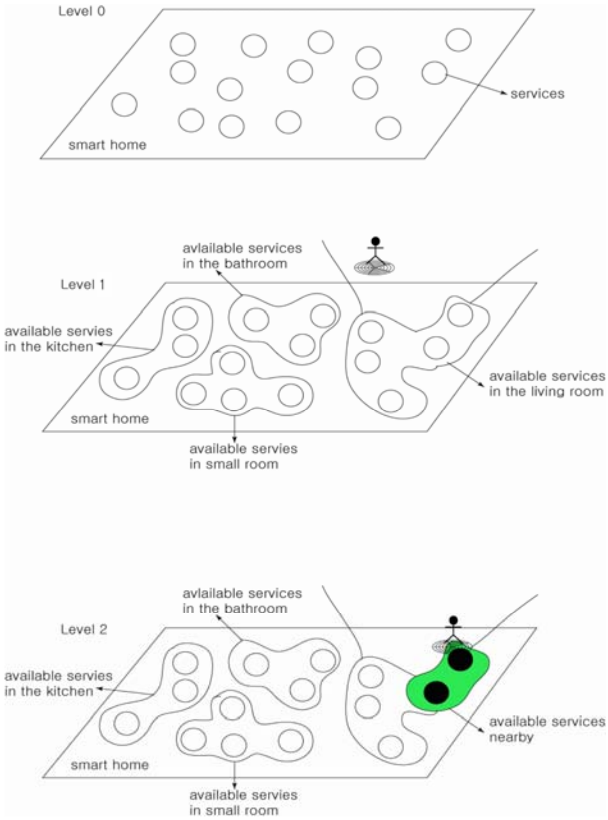

Figure 4: An available service according to levels.

recognized. The importance of an explicit geometric model for enhancing the user's experience of a ubiquitous computing system has not been well articulated.

The classification of the levels for the user-oriented service is typically based on user's location and the relative distance between the user and artifacts[9]. Figure 4 shows an available service according to the levels. Level 0 indicates the initial state that describes the stand-by for activating all devices at home. Level 1 describes the grouping services that are in the same room and the procedure that checks whether the user is in the available region for using the device in front of the user. Based on 3D geometry, collision detection would be helpful to find overlapping regions of the available areas between the user and the devices. With the user's location of the user and FOV (field of the view), the user can select available services. Level 2 shows the user's location and 2 selected services among the available services. (Figure 4.)

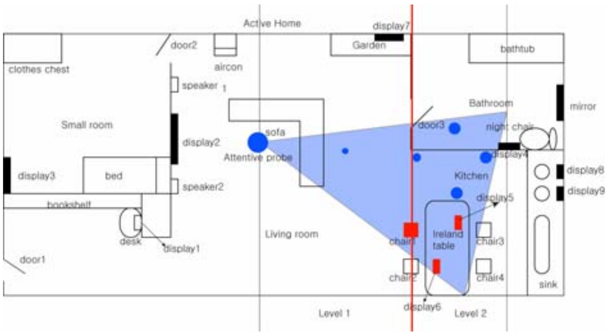

Figure 5: The viewing coverage of the Attentive probe.

The Attentive Probe shows the region of user's interest, which is shown as the field of view (Figure 5). The Attentive Probe can highlight the artifacts in the region of user's interest. The artifacts in the FOV are identified by geometric calculation about the objects that the FOV view frustum intersects with them. At home, users cannot see objects in the remote region that is occluded by the walls. However, the Attentive Probe overcomes such visibility problem by allowing users to view the objects behind the physical walls. Figure 5 shows the objects grouped with the same color, indicating that they are in higher priority of user's interest. Ranking the priority of the objects that users are interested can be specified by user's input on this tool.

5. Conclusion

This paper describes a new interface for the ubiquitous computing environment, called the Attentive Probe. The Attentive Probe is a 3D geometry-based information visualization tool that senses its location and orientation and then displays the important detail information to its users within the range of the field of view. It provides a glance view of what is important and meaningful to the users beyond the object's physical locations. We illustrated the tool's functionalities and practical example of its application to real world.

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