A Context Visualization Model for Wearable Computers

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Abstract

Context-aware systems observe the user's current context and apply this information to the user's benefit. When implementing context-awareness, several issues need to be considered and this paper concentrates on presenting the context information to the user. The key components needed to construct the context are identified, and a model, which allows using different visualization techniques for the context, is proposed. In order to make the model more concrete, four use cases are presented, and the expandability of the model is discussed.

1. Introduction

A central concept in wearable computing is context-awareness. A context-aware system uses information that characterizes the situation of any entity that is relevant to the interaction between a user and an application in order to provide relevant information to the user on his/her task. The context is often based on a location and several studies about the context-awareness are related to it [1].

Information visualization techniques for mobile devices are emerging slowly. Their design is demanding because the mobile devices have poor interaction capabilities as well as limited memory and computational power. The main problem is the limited screen space and one way to solve this problem is to use so-called focus+context visualizations (*e.g.* fisheye view [2]) that enable the user to see an interesting object in detail while having the context (overview) available at the same time.

We have developed a wearable computer prototype platform for studying wayfinding and navigation. A part of this work is Context Compass [4] that is a linear compass displayed on the top of a head-worn display (Figure 1). In addition to compass, it displays contextual objects of the environment; as the user turns his/her head, the objects on the compass display move accordingly and the object that the user is currently looking at is displayed in the middle of the compass. Preliminary user evaluation showed that Context Compass is a promising technique for accessing context (especially real world) objects [3].

Figure 1. Context Compass

The method used in Context Compass decided to be developed further to make it more general and cover more tasks. The aim was at a model that enables presenting the context visually with different display devices and visualization techniques. This work is related to context adaptation (*i.e.* system sense the context and reacts accordingly [4]) and how the context information is gathered or processed is not considered.

2. The context visualization model

The context for the model include the following variables

V1. The user's current location (mandatory).
V2. The user's direction of sight (mandatory).
V3. The target, if known (for navigating).
V4. Calendar entries (predicting the future actions).
V5. Address book entries (for communicating).
V6. The users nearby (to promote *ad hoc* grouping).
V7. The history information from the listed sources.
V8. The user's profile – interests, hobbies *etc*.
V9. The derived variables, *e.g.* direction and speed.

A set of rules determines how these variables are applied; how large an area the context covers, and what contextual objects are included and displayed. These rules are not formally defined since they depend on the user's task, the system, *etc*.

Two central concepts of the model are the visibility range r (as in Context Compass), and the view angle α. The context area contains objects that are inside the circle, which radius is r. Only the objects in a sector, which angle is α, are visualized. The view angle α may have a value from 0° to 360° (Context Compass displays always

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360°). The exact values for these concepts depend on, *e.g.* task and environment. The model is shown in Figure 2, where the You-Are-Here (YAH) symbol shows the user's location and the direction of sight.

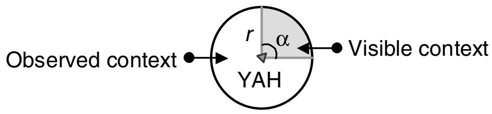

Figure 2. The view angle α and the visibility range *r* define visible objects of context area.

As the context changes, it affects the visibility range and the view angle. The invisible objects inside the area belong to the context and they are constantly observed and indicated, if they are considered of interest. Varying the size of visible area reduces the amount of data that needs to be visualized as well as displays only the relevant information to the user and the hardware limitations of mobile computing may be bypassed.

The model augments the visual system of a human. If the person is walking, the view angle is, *e.g.*, 15º, which extends human's parafoveal vision (parafovea is 5º to both sides of a fixation and it is used for guiding the gaze). One could argue that the view should be wider, but the model takes that into account in visibility range since the view angle and the visibility range control the visible area and it is widened proportionally to the range. This helps the user to see the nearest objects in detail, while the objects further away form the context.

The model may be used either with a see-through display or a hand-held terminal. Since rules determine the size of visible area, it does not require manipulation by the user. This also enables applying different visualization techniques.

The cases in Figure 3 are simple illustrations how the model works. In the figure, the content area is displayed as a tilted plane that could be a digital map. The user's current position and direction of sight are shown with a triangle (YAH) on the plane. The visible part of the context is displayed as a dark gray area. The user's location is determined by V2, while V3, V4 and V9 affect α and *r*. The rest of the variables affect the contents.

The basic use case is shown in Figure 3a, where the user is walking. The view angle is narrow (*e.g.* 15º) and the visibility range is high. If the user's destination and the route are known, they are displayed. If the destination is not on the viewable area, an indicator pointing to the direction of the destination is displayed. Figure 3b shows a situation where the user is not in a hurry; the view angle increases and an optional route via interesting objects is displayed. In a situation of Figure 3c the user is in a hurry (prediction is based on next calendar event, current location and speed) and the system is a mere navigation aid. When the user is stationary, the view angle is 360º and the visibility range increases slowly (Figure 3d).

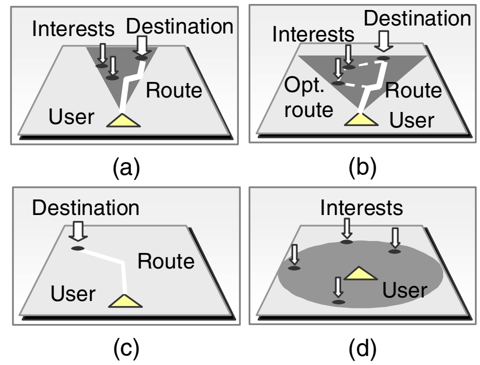

Figure 3. Visualizations when the user is walking (a) normal speed, (b) slowly, (c) fast and (d) standing.

3. Conclusions and future work

A model for presenting the context information with different kinds of visualizations and display devices is proposed. It uses three factors for filtering the visible objects: the visibility range, the view angle, and the user's location. As a result, only the relevant objects to the user are displayed. The rules are used for determining values for the view angle and the visibility range, which simplifies the interaction since no manipulation is required. The model may be expanded by adding new context variables and rules.

More studies are needed in order to find values for the view angle, the visibility range and the context variables as well as testing the usability of visualizations.

4. References

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