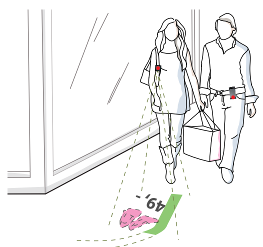
Peripheral Interaction On-The-Go

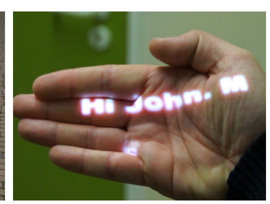
Christian Winkler
Ulm University
James-Franck-Ring
89081 Ulm, Germany
christian.winkler@uni-ulm.de



(a) Vision

(b) Peripheral display

(c) Floor interaction



(d) Hand interaction

Figure 1: (a). The vision: a wearable peripheral display (e.g., on the floor). (b) A user serendipitously discovers information. (c) The user has received a text message and picks it up from the floor. (d) The scrolling message text is read in the user's hand.

Abstract
This paper assesses, discusses, and presents first solutions, to the challenges of Peripheral Interaction on-the-go. The on-the-go scenario is substantially different to previous peripheral interaction as the space for display, interaction, and sensing is much more confined.

Author Keywords
Peripheral Interaction, Peripheral Display, Implicit Interaction, Personal Projection

Introduction
Peripheral interfaces are deeply rooted in the vision of calm and ubiquitous computing. Without peripheral interaction, the original vision of using dozens of computers in our environment simultaneously would never be able to come true – at least not without putting excessive demand on the user. Only by providing the right set of implicit, casual, and active interactions and seamless transitioning in-between, we will be able to leverage humans' abilities for multitasking, which especially lie in parallel processing of different senses and actuators.

In recent years we have seen a lot of great work on peripheral display and interaction. Most of them focused on static scenarios like office work and not on mobile scenarios as there was not much digital information available on-the-go. With the emergence of smartphones, constant connectivity, and all sorts of cloud-based information services, the amount of data imposed on the user on-the-go has drastically increased. Many of the techniques used in static setups assume a known environment not available in the mobile scenario. For instance, there are no commonly available smart artefacts in users' mobile environments that could act as ambient displays. Smartphones that are carried in pockets or bags have only very limited capabilities in form of vibration or audio for ambient alerting. Upcoming smartwatches allow to reach to the device much quicker and can be instrumented to sense the user's context (e.g., [3]), but are still not in the visual periphery of the user on-the-go.

In the following the inherent challenges for peripheral interaction on-the-go are presented as well as some possible solutions to such as implemented in the *Ambient Mobile Pervasive Display* [5].

Challenges of Interaction On-The-Go

The following challenges especially distinguish peripheral interaction on-the-go:

- The user does not maintain a known position: In traditional scenarios of peripheral interfaces the peripheral devices, be it displays or smart artefacts, maintain their position. The user can be assumed to take a similar position whenever interacting with the device. The primary tasks and positions are often well known and thus good places for peripheral display are known as well. In the on-the-go scenario, the current context of the user is not obvious and the environment might change quickly. Tracking of the user and the environment is required to compute both the right time intervals and suitable positions for peripheral display.
- In traditional scenarios, the rooms, displays, or smart artefacts can be instrumented to facilitate tracking of the user's context. On-the-go, the user must be instrumented to different degrees to achieve the desired context or interaction sensing.
- The user is in motion and might have only one or even no hand available for interaction. Techniques to display as well as to interact with peripheral information have to consider this and adapt to changing situations and requirements.
- Peripheral information always bears the risk to disrupt users from their primary tasks. While this is troublesome at most in indoor scenarios, it may easily become dangerous on-the-go if the primary task is crossing a street or setting foot on elevated stairs.

The Ambient Mobile Pervasive Display

In this section we want to highlight three aspects of the Ambient Mobile Pervasive Display (AMP-D) [5] that contribute to the field of Peripheral Interaction and address some of the aforementioned issues. AMP-D is a wearable multi-display system that provides a pervasive window into the user's virtual information world on the floor. Unlike smartphones which have to be taken out to be operated, the AMP-D display is constantly available through constant personal projection. Therefore it is suited for peripheral alerting to many kinds of public or personal information that is available via the user's connected smartphone. Additionally, many information is not only visualized, but can be transfered from the floor to the user's hand (back and forth) using gestures to deal with the content in the hand or on the connected smartphone. AMP-D achieves this multi-display setup by means of a shoulder-worn projector-camera system that

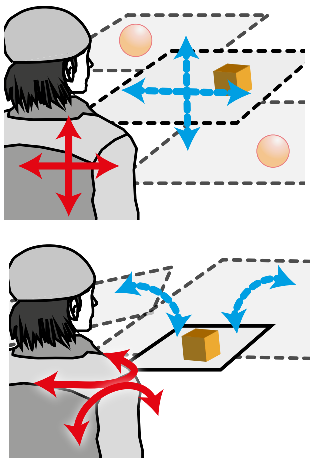


Figure 2: The virtual window follows the user's movement (top) and orientation (bottom).

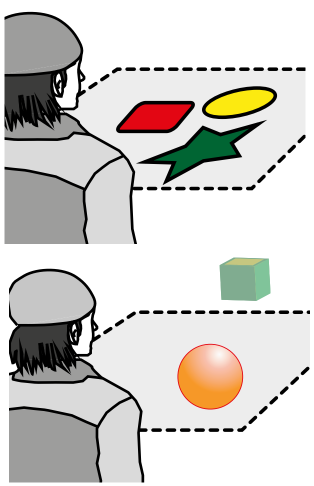


Figure 3: 2D World Graffiti (top), spheres and boxes as interactive elements (bottom)

measures the distance to the floor, surrounding walls, and the user's primary hand to deliver precise, perspectively aligned 3D augmentations on these surfaces (cf. [5]).

AMP-D's Support for Mobile Peripheral Interaction
Pervasive and Ambient Floor Display
To provide a mobile peripheral display, the floor is well suited since it is the only space that is always existent on-the-go. Further it is easy to glance at quickly and most of all, the floor display lies in the visual periphery of the user. Research on peripheral vision and cognitive psychology offers evidence that peripheral vision supports a separate cognitive channel, thereby reducing overall cognitive load [4]. More importantly, the effect of tunnel vision supports users in effectively blending out unnecessary information in the periphery when their cognitive load is high [2]. Inversely, when users' cognitive load is low, the display supports the serendipitous discovery of new information. Thus, AMP-D projects the permanently available display on the floor, yet content is only displayed when required.

AMP-D refrains from including any typical GUI elements such as windows or buttons on the display. Instead, the projection only shows a projected window into the user's virtual world, i.e. invariably, all projected content is clearly located in the worldwide coordinate system. This concept builds on Spatial Augmented Reality as opposed to the standard display-fixed presentation. In the context of projections, it feels like uncovering the virtual world with a spotlight. The system tracks users' movement and orientation to provide the corresponding illusion (Figure 2).

Information Space: World Graffiti, Boxes, and Spheres
To make the type of information discernible in the user's periphery, the virtual world of AMP-D consists of only two distinct types of visualizations: two-dimensional *World Graffiti* and two three-dimensional objects; *boxes* or *spheres* (Figure 3).

The two-dimensional graffiti is a stationary texture on the ground. Its flatness indicates that it is not meant to be interacted with. In contrast, the three-dimensional box and sphere items indicate that they are supposed to be interacted with.

Interactive items (boxes and spheres) typically lie at static places. If they are new and supposed to have an ambient alerting impact on the user (e.g. a notification), they roll into the user's field of view. If the user is currently moving, they further accompany the user for several seconds before coming to rest.

Boxes and spheres have defined content types which the user can quickly recognize from their different textures. Additionally, new boxes the user has not yet interacted with, carry a yellow border. In this manner, unlike with the use of ambient vibration alerts in smartphones, the user can quickly discern the type and novelty of new notifications by just glancing at the projection.

To further interact with the box or sphere, and change from peripheral vision to active interaction, users use their bare hands which are tracked by the system. By reaching out with their splayed hand towards the object, a green selection disk appears in the projection. It acts as hand extension that can be moved beneath the object of interest. By closing their fingers, the user selects the object (picks it up) and the object performs a jump animation into the user's hand (Figure 4). When picked up, many objects can disclose more sensitive information. Message boxes, for example, can show a picture of the sender of the message. Hand gestures allow the user to

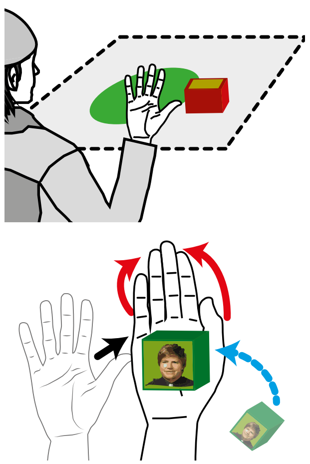


Figure 4: Object selection (top) and pick-up of objects by moving the fingers of the hand together (bottom).

interact further with the content. By turning the hand 90 degrees towards the center of the body, the user switches to *reading mode*. The box held in the hand shrinks and a preview of the content is displayed. For instance, a text message or the subject of an email as scrolling text. Finally, users have two options how to proceed with the object: By splaying out their fingers again, the item falls down back to the floor in front of them. Or, by performing a gesture as if to throw the item over one's own shoulder, the item is removed from the virtual world. Because the user is moving, many ordinary gestures that inhibit movement do not work. Gestures based on hand postures, like the ones presented, work best, followed by gestures that only inhibit horizontal movement.

History and Overview through Implicit Interaction

The concept of spatial augmented reality also allows for implicit and peripheral interaction with AMP-D . The implicit revealing or hiding of information using body motion can be used to look up upcoming content or to revisit past content. For instance, when a user recognizes content on the floor projection too late, walking a few steps back or just turning around will bring the item back into the projected window. Similarly, when users share their foot trails as World Graffiti, they can revisit them later, e.g. to find their way back to their car. As opposed to that, for instance, tilting the projection far ahead during navigation tasks allows users to preview directions further ahead. Results from a study by Billinghurst et al. [1] indicate that people can easily navigate and relocate spatially augmented information as they are used to the interaction from real life.

Possible Improvements to Advance Peripheral Interaction

AMP-D's support for implicit or peripheral interaction is limited to body movement at the moment. It is interesting to think of gestures that are explicitly designed to work in the user's periphery. A waving gesture, for instance, would be nice to make items in the periphery tumble away. But at the same time these gestures must be robust enough that they are not performed accidentally.

Conclusion

The paper presented some initial solutions to peripheral display and interaction on-the-go, which will be necessary to fulfill the future vision of ubiquitous computing, but at the same time entails a lot of new challenges that go beyond traditional peripheral information systems for confined spaces.

References

[1] Billinghurst, M., Bowskill, J., Dyer, N., and Morphett, J. Spatial information displays on a wearable computer. *IEEE Computer Graphics and Applications 18*, 6 (1998), 24–31.

[2] Costanza, E., Inverso, S. A., Pavlov, E., Allen, R., and Maes, P. eye-q: eyeglass peripheral display for subtle intimate notifications. In *Proc. of*, MobileHCI '06, ACM (2006), 211–218.

[3] Slawik, B. Micro manage me! - peripheral context annotation for efficient time management. In *Proc. of the first workshop on Peripheral Interaction: Embedding HCI in Everyday Life at Interact 2013*, Doris Hausen, Saskia Bakker, Elise van den Hoven, Andreas Butz, Berry Eggen (2013).

[4] Treisman, A. Preattentive processing in vision. *Computer Vision, Graphics, and Image Processing 31*, 2 (Aug. 1985), 156–177.

[5] Winkler, C., Seifert, J., Dobbelstein, D., and Rukzio, E. Pervasive Information through Constant Personal Projection: The Ambient Mobile Pervasive Display (AMP-D). In *Proc. of CHI'14*, ACM Press (2014).