Visual Focus-Aware Applications and Services in Multi-Display Environments

Jakub Dostal
School of Computer Science
University of St Andrews
St Andrews, UK
jd67@st-andrews.ac.uk

Per Ola Kristensson
School of Computer Science
University of St Andrews
St Andrews, UK
pok@st-andrews.ac.uk

Aaron Quigley
School of Computer Science
University of St Andrews
St Andrews, UK
aquigley@st-andrews.ac.uk

CHI 2013 Workshop on Gaze Interaction in the Post-WIMP World, April 27, 2013, Paris, France.

Abstract
Multi-display environments are continuing to become commonplace, from the next generation desktop to second and third screen experiences at home. In this paper we first provide an overview of three areas where "visual focus-aware" applications and services can bring benefits to people in multi-display environments. We then discuss the design of multi-display applications from the perspective of proxemics, territory and workflows. We conclude by discussing some of the challenges to be addressed before visual focus-aware applications can become widespread.

Author Keywords
visual focus; distance-aware; multi-display; proxemics

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous.

Visual Focus-Aware Applications and Services
Researchers have investigated applications designed specifically for a multi-display environment. Some examples include a mapping application [6], a game [4] and a TV entertainment application [2]. These applications have not been designed to be aware of the user's visual focus, but may benefit from it. Here, "visual

focus" is context that refers to the display that a person's gaze is currently attending to.

We partition the design space for visual focus-aware applications and services into three areas based on their relevance to the user's interaction goals. These three areas are 1) the primary task, 2) maintaining and re-establishing context, and 3) state-change information.

Area 1: Primary Task
Due to the complexity of task or use of visual information, applications such as computer-aided design, software development environments and data visualisation tools are well suited for multi-display environments due to their attentional demand on the user. We conjecture that these types of applications are also most likely to benefit from the application being aware of the visual focus of the user.

Some of the benefits of integrating visual focus-awareness for primary interaction tasks in multi-display environments come from the increased interactional complexity of the multi-display environment. Awareness of the visual focus of its users would provide the application with valuable context information.

Area 2: Maintaining and Re-establishing Context
The increased interaction complexity of multi-display environments is more pronounced when considering the environment as a whole, rather than only the primary task. The results of a study by Grudin [7] show that users tend to dedicate different tasks to different displays. This means that switching between displays tends to be accompanied by a context switch. Currently, applications are not designed with this type of multi-tasking in mind, leaving it up to the user to keep track of the different contexts and to deal with the associated cognitive costs. We therefore see an opportunity for visual focus-aware applications to aid the user in maintaining and re-establishing the context of use.

Techniques developed by Dostal et al. [5] are an example of visual focus-aware interaction techniques that help users re-establish their context after a context switch. This is achieved by visualising changes that occurred while a display was unattended. Ashdown and Sato [1] developed a system, which can be considered an example of a context-maintaining system as it automatically moves the mouse pointer to the display the user is looking at.

Area 3: State Change Information
The third area where visual focus-aware applications and services may be of benefit is in providing state change information. These tend to be persistent applications that inform the user about events relevant either to the task at hand or to the user's personal context. Examples include notification and reminder systems.

Tan and Czerwinski examined the effect of various placements of notifications relative to the user's visual focus [8]. However, to our knowledge, a visual focus-aware system that displays notifications on a display the user is attending to, has not yet been examined.

Interactional Aspects of Visual Focus-Awareness

There are three characteristics of multi-display environments that designers of visual focus-aware applications should consider due to their influence on the quality of the interaction.

Proxemics
The distance between the user and the interaction surface plays an important part in interaction both due to the social notions of space as well as the physical constraints of human vision. The social understanding of distance can

be used to change interactional styles of visual focus-aware applications. An example of this type of change is a system by Vogel and Balakrishnan [10], which uses distance to switch between implicit and explicit interaction. This system could be adapted to take advantage of gaze tracking and focus awareness to provide even more nuanced interaction.

The distance between the user and the interaction surface also determines how much visual information we are able to perceive. First, we are only able to resolve a certain amount of detail due to the limitations of the human eye. Second, as the distance between the user and the display changes, the angular size and the shape of the interaction surface changes with it. Modelling these limitations and integrating them into visual focus-aware applications could provide important additional contextual information for better adapting the display for the user's particular position relative to the display. For example, an ambient notification system could alter the form of the notifications to ensure these are always readable or at greater distances, perceivable.

Territory
In addition to the physical interaction space, visual focus-aware applications may also change user interactions within the logical display space of the multi-display environment. In particular, if the space is shared between multiple users. The tightness of display coupling (alternative, secondary, coherent), the type of audience [3], the type of interaction [9] and the visual focus enables new sharing strategies that are not possible without knowledge about the user's visual focus.

As an example, consider a technique allowing temporal sharing between two users of a display. Such a technique could use the visual focus to display the workspace of only the user whose visual focus is on the display. In case of a conflict (i.e. both user's are looking at the display), the two workspaces could be made semi-transparent, providing an overview of the content to both users. This transparency could be further modified based on recency and the relative time users looked at the display. When there is a conflict, a spatial version of this technique could split the visible area of the display between the two users, either symmetrically or semantically.

Workflow
Visual focus may also be used to assist with directing workflow-related information in a multi-display environment. Information delivered to an active display that the user is focused on could be restricted based on the primary task associated with that display. For example, displays allocated to the primary interaction task could be restricted to only show notifications relating to the task itself, or emergency-level information, while peripheral displays could be designed without this restriction. Another example could be using the visual focus and the user's distance from the display to choose the most efficient way of displaying information on a given display. Consider a visual stock trading system that alters between raw numeric data, graphs and abstract visualisations to display trading data depending on the location, and hence user distance along with the visual focus of the user.

Discussion
Aside from the challenges of designing novel visual focus-aware interaction techniques and support systems, several related challenges need to be addressed before visual focus-aware applications become widely available.

OS/HW design challenges
One challenge is system integration. Operating systems (OSs) provide only limited facilities for defining the physical space in which the multi-display system exists. At best, they provide logical positioning of display surfaces. Integration of this type of awareness within the OS as well as exposing it to applications is essential for the types of applications we propose here.

Directing Information Flow
While low-level integration is essential for broad adoption of visual-focus aware applications and services, a deeper understanding of the mechanisms governing human information processing is also necessary. Without deeper knowledge of how to encode complex information in physically diverse environments (such as a multi-display environment), the context information provided by tracking gaze or visual focus cannot be efficiently used.

Conclusions
In this paper we first provided an overview of three areas where visual focus-aware applications and services can bring benefits to multi-display environments. We then discussed the design of multi-display applications from the perspective of proxemics, territory and workflows. We concluded by discussing some of the challenges that need to be addressed before visual focus-aware applications can become widespread.

References

[1] M. Ashdown and Y. Sato. Attentive Interfaces for Multiple Monitors. In *Proc. CHI 2005 Workshop on Distributed Display Environments*, pages 4–5. ACM, 2005.

[2] S. Basapur, G. Harboe, H. Mandalia, A. Novak, V. Vuong, and C. Metcalf. Field trial of a dual device user experience for iTV. In *Proc. EuroITV '11*, pages 127–135. ACM, 2011.

[3] A. Dix, C. Sas, D. Ramduny-Ellis, S. Gill, and J. Hare. Sociality, Physicality and Spatiality: touching private and public displays. In *Proc. PP08*, number ii, 2008.

[4] T. Döring, A. S. Shirazi, and A. Schmidt. Exploring gesture-based interaction techniques in multi-display environments with mobile phones and a multi-touch table. In *Proc. PPD10*, pages 47–50. ACM, 2010.

[5] J. Dostal, P. O. Kristensson, and A. Quigley. Subtle Gaze-Dependent Techniques for Visualising Display Changes in Multi-Display Environments. In *Proc. IUI '13*, 2013.

[6] C. Forlines, A. Esenther, C. Shen, D. Wigdor, and K. Ryall. Multi-user, multi-display interaction with a single-user, single-display geospatial application. In *Proc. UIST '06*, page 273. ACM, 2006.

[7] J. Grudin. Partitioning Digital Worlds: Focal and Peripheral Awareness in Multiple Monitor Use. In *Proc. CHI '01*, pages 458–465. ACM, 2001.

[8] D. S. Tan and M. Czerwinski. Effects of Visual Separation and Physical Discontinuities when Distributing Information across Multiple Displays. In *Proc. INTERACT '03*, pages 252–255, 2003.

[9] L. Terrenghi, A. Quigley, and A. Dix. A taxonomy for and analysis of multi-person-display ecosystems. *Personal and Ubiquitous Computing*, 13(8):583–598, June 2009.

[10] D. Vogel and R. Balakrishnan. Interactive public ambient displays: transitioning from implicit to explicit, public to personal, interaction with multiple users. In *Proc. UIST '04*, pages 137–146. ACM, 2004.