AuraMirror: Artistically Visualizing Attention

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ABSTRACT
We present AuraMirror, a system that visualizes *virtual windows of attention*: the commodity of visual attention people exchange during interactions in small groups. AuraMirror acts as a dynamic 'painting' that passively gathers and displays attentional data by superimposing *auras* over each viewer's head in a real time video mirror. This permits users to see how they distribute their attention in group interactions, and the effect of interruption on this process. Finally, we describe how AuraMirror can be extended to model attention among both participants and ubiquitous devices.

Keywords
Information Visualization, Media Art, Ubiquitous Computing, Attentive User Interfaces, Computer Vision.

INTRODUCTION
To improve our ability to work with the growing number of computers that surround us, we propose coordinating the activities of computers based on user attention. To achieve this, different methods of gathering and codifying user attention need to be evaluated. AuraMirror takes an exploratory approach, using an artistic rendering to produce attention auras whose accuracy can be appraised and critiqued by participants in real time.

Visual Attention
Human attention can be defined by many generic criteria, most of which are difficult to measure. In contrast, visual attention can be measured passively, without encumbering the user. Research suggests that visual attention plays a crucial role in negotiating turn taking among participants in group conversations [6]. Before speaking, a participant may establish whether her request for attention has been granted by observing whether others look at her. Visual attention is a sociable and efficient mechanism to regulate group conversations [4,6]. In addition to a communication protocol, eye gaze is also a way for people to *implicitly* identify what is currently important to them [1].

By tracking people and their orientation with respect to each other, the system hypothesises to whom each audience member is paying attention. AuraMirror conveys this information by overlaying attention auras on the images of each audience member. The purpose of this display is to present a dynamic, artistic representation of attention negotiation in small groups. As such, AuraMirror can be described as *informative art* [2] in the periphery of the audience's *attention space* [4].

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SCENARIO
Imagine walking into a room in an art gallery, to face a mirror video image of yourself and other people in the room. You appear with a translucent, blue aura shimmering around your head. As you turn to your friend to discuss the meaning of the 'painting', he sees your head turn and your aura grow towards him. When he faces you to reply, the other audience members see the two auras merge, forming a visualization of an attention tunnel. Perceiving movement in your peripheral vision, you turn your head back to AuraMirror, in time to see the tunnel break and the attention auras spring back to their original shapes.

This example is meant to illustrate how AuraMirror works as a visualization tool, communicating its knowledge of the attentional network within its audience. As artwork, the dynamic 'painting' challenges observers to be aware of their own attention and the effect of interruption in conversations. By dynamically changing the shape of the auras to reflect the observed activity, AuraMirror stimulates iterative looking between the audience and the mirror, serving as a metaphor for attention and interruption.

IMPLEMENTATION
To take advantage of the high correlation between head orientation and visual attention [5], eye gaze is estimated by projecting a ray in the direction a person is facing. AuraMirror is implemented using four cameras. One camera is used for the main video feed displayed on a 50" plasma display. AuraMirror superimposes translucent, 3D bubbles on the reflection of each person standing in front of the mirror. The bubbles, which represent attention, are modelled as particle systems that act as viscous fluids. The placement of the auras is dictated by the system of other cameras. One takes an overhead view of the audience and identifies people based on motion using background subtraction. Two side cameras are positioned to observe the audience's faces. A skin-colour tracking algorithm uses these cameras' images to identify and determine the orientation of faces in the scene. The data gathered is guided by information from the overhead camera. Working

Figure 1 - Sequence of images in the mirror showing the auras grow, join and then pop with the attention of the participants.

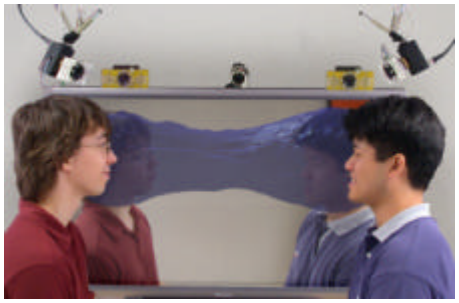

Figure 2 - AuraMirror prototype with eye contact sensors.

in concert, the three cameras give a robust, if coarse, approximation of who is paying attention to whom.

EXTENDING AuraMirror

Current limitations of AuraMirror include the sensitivity of camera and audience placement within its environment, the narrow field of view of the cameras, and the limited number of participants permitted in the room. With more cameras, and faster, more accurate image processing, many of these problems can be mitigated. Adding person and object identification capabilities [3] will extend knowledge of the users' attentive context [4], which can be used to inform a more attention sensitive interface presentation.

Person Identification: By augmenting users with unobtrusive tags, the identity of interacting users can be determined. Based on historical data, the importance of the interaction can be estimated relative to potential interruptions.

Object Identification: By augmenting objects with sensors [3], such as eye contact sensors [7], the items in the room users are interested in can be determined. In this way, attention-seeking devices could partake in the negotiation of the group's attention. For example, mobile phones, and the humans on the other end of them, could become part of the audience.

DISCUSSION

AuraMirror's real time feedback to the audience during the performance can be used to rapidly prototype and evaluate other representations of group dynamics. The lessons learned by modeling attention with AuraMirror can be applied to design systems that demonstrate sensitivity to a user's attention space. Ideally, this permits users to assume that the perceptual abilities of the system are similar to the perceptual abilities of people, promoting transparency in interactions between humans and groups of computers [4].

The real time display makes the surveillance that the audience is under explicit, in order to provoke feedback on how participants feel about a computer system publicly communicating a representation of their attention. As the audience becomes aware of the negotiation of attention, the dynamics of their interaction is affected.

CONCLUSION

We have presented AuraMirror, a video mirror that displays the audience's visual attention in real time. Participants will be able to judge the accuracy, usefulness and desirability of the attention visualization from both an aesthetic and qualitative perspective. We also present our vision of how AuraMirror can be expanded to identify participants and objects to contribute to the development of future attention sensitive user interfaces.

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