ScaMP: A Head Guided Projection System

Gregory Hough, Cham Athwal and Ian Williams
Faculty of Technology Engineering and the Environment
Birmingham City University
Gregory.Hough2@mail.bcu.ac.uk

ABSTRACT
This work presents a system for providing ubiquitous visual information to actors in a virtual studio, blue screen, or other mixed reality environment. The Scanning Mirror Projector (ScaMP) system uses steerable projection and head pose estimation to form a new type of ever-present display that projects visual information of a virtual world to the gaze direction of the user. This system allows improved interaction between the real and virtual environments.

Author Keywords
Personal display, visual feedback, virtual reality studio.

INTRODUCTION
A virtual studio [1] is a television studio designed to merge real and virtual environments for live television broadcast. A virtual set is constructed of virtual objects, which are invisible to an actor within the studio unless feedback is provided. Typically, feedback is given in the form of an out-of-shot static video monitor. The static nature of this monitor can cause the actor difficulty when attempting to locate or interact with virtual objects. The ScaMP system overcomes this issue by steering a projection to multiple locations based on the actor's gaze direction, therefore improving the quality of the feedback offered.

RELATED WORK
Two types of steerable projection systems currently exist. The first of these is based on dynamically moving the projector itself using two servo motors to control both pan and tilt [5]. The second system is a servo controlled mirror fixed in front of the projector lens which is used to steer the projection [13]. Comparable steerable projection systems have been used for a variety of applications, namely augmented reality [6], as a form of ever-present display [13] [4] and for feedback in an 'Intelligent Space' [9]. The advantage of using a steerable projector in these applications is that it enables information to be provided to a user in multiple locations. A similar form of steerable projection to ScaMP that is guided by gaze direction has recently been reported at the University of Texas at Austin as part of their ECE Senior Design Contest [3].

Using projection technology for actor feedback in a virtual studio has been developed before, notably the Cave Automatic Virtual Environment (CAVE) [2] style approach [11] [15]. This benefitted actor feedback, but also had large area and resource requirements. A single projector with low area and resource requirements has since been developed [8], but only provides static feedback to actors. ScaMP system maintains the ever-present nature of the CAVE style systems, whilst reducing their cumbersome nature.

DEVELOPMENT
Instead of using the multiple projectors, ScaMP uses a single projector and a servo guided mirror. This reflects the projection to the actor's gaze direction, which is determined from head tracking data.

Figure 1 illustrates an actor using ScaMP (compared to a static monitor). While travelling from location A to B the actors view of the virtual object will change respectively. Consequently their gaze direction moves from point 1 to point 2. The static monitor is only visible when the actor is at location A, while the ScaMP system ensures the projection is visible at A and B, as well as locations in between.

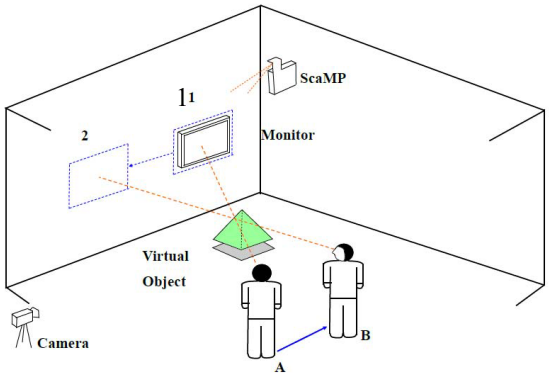

Figure 1. Illustration of an actor looking at a virtual object whilst travelling from location A to B, and a comparison of monitor and ScaMP feedback systems.

Head tracking
In the current version of ScaMP head tracking and gaze estimation is achieved by using FaceAPI [7], which provides Six Degrees of Freedom (6DOF) head tracking data. This information is used alongside ScaMP's position to give the correct pan and tilt angles for the servo guided mirror.

Alternative tracking technologies, such as Inertial Measurement Units (IMU) and potentiometer based systems are also being implemented with ScaMP. This will overcome the common problems associated with camera based tracking systems (occlusion, resolution, etc.)

Image correction
When ScaMP is operating it projects at arbitrary angles to match the actors gaze direction. This results in projected

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image warping known as the Keystone effect (figure 2a). To correct this, our research involved the implementation of a dynamic affine transformation using OpenCV [12]. Similar correction systems exist in [10] [14]; ScaMP uses a comparable method of image correction, shown in figure 2b

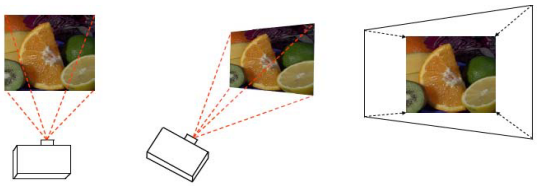

Figure 2a: Keystone effect **Figure 2b: Image Correction**

Figure 2: Illustration of keystone effect and image correction.

RESULTS

Two forms of dynamic visual feedback have been used to support our application of virtual studio interaction using the ScaMP system. These are:

- Standard broadcast render – Mixed render of the real and virtual sets, similar to the broadcast output.
- Point Of View (POV) render – An image of the virtual set dynamically rendered from the actor's perspective as illustrated in figure 3

Preliminary tests have been conducted to evaluate the improvements offered through the ScaMP system. Five actors were initially timed completing a navigation task within the virtual studio. This task involved orientating to the location of an unknown virtual object and both time accuracy and location accuracy were measured for completing the task. It was found that actors could complete the task in 3.2 seconds using ScaMP and 3.7 seconds using the static monitor, but accuracy was slightly reduced.

In addition to this it was found that taking an average measurement of the actor's gaze estimation over time was more suited to calculating the projection location. This overcame problems associated with moving the projection based on very fine movements of the actor's head when orientating within the studio.

Figure 3: ScaMP projecting POV to gaze point of actor.

CONCLUSION

This paper discussed the development of ScaMP, a visual feedback device designed to support actors in a virtual studio. ScaMP guided a projected image using a servo-guided mirror to the actor's gaze direction.

Future work will move to multiple planar surfaces, extending use of ScaMP to all walls and the floor within the studio. The blue wall will require the projection to be adjusted to enhance visibility; or alternatively, use a retro-reflective surface as used in [15]. Any projection visible to the studio camera could be removed using LCD shutters [8]

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