Real-Time Compositing Framework for Interactive Stereo fMRI Displays

Fiona Rivera	Phil Watten	Patrick Holroyd	Felix Beacher	Katerina Mania,	Hugo Critchley
University of Sussex, UK	University of Sussex. UK	University of Sussex, UK	University of Sussex, UK	Technical University of Crete, Greece	University of Sussex, UK

This research concentrates on providing high fidelity animation, only achievable with offline rendering solutions, for interactive fMRI-based experiments. Virtual characters are well established within the film, game and research worlds, yet much remains to be learned about which design, stylistic or behavioural factors combine to make a believable character. The definition of believability depends on context. When designing and implementing characters for entertainment, the concern is making believable characters that the audience will engage with. When using virtual characters in experiments, the aim is to create characters and synthetic spaces that people respond to in a similar manner to their real world counterparts. Research has shown that users show empathy for virtual characters. However, uncanny valley effects – ie dips in user impressions – can arise: behavioural fidelity expectations increase alongside increases in visual fidelity and vice versa. Often, characters used within virtual environments tend to be of fairly low fidelity due to technological constraints including rendering in real-time (Garau et al. 2003). This problem is addressed here by using non-linear playback and compositing of pre-rendered high fidelity sequences.

Previous research into evaluating whether virtual characters placed in immersive collaborative environments fulfil their role, is limited to acquiring ratings of pleasantness or user fidelity impressions through self-report after the experience has occurred (Vinayagamoorthy 2005). It is challenging to derive neuroscientific correlates of subjective feelings and emotions when interacting with virtual characters. The ultimate goal of this framework is to explore whether natural and artificial characters of varied fidelity engage common perceptual or neuroscientific mechanisms. Such input is non-obtrusive and is derived at the same time as the experience occurs. However, it is not straightforward to provide synthetic stimuli to be displayed in fMRI displays due to the infrastructural and technical demands. Until now such investigations utilized still pictures or non stereoscopic 3D. In order to address such requirements, the framework puts forward a sophisticated real-time compositing system which takes input from a variety of media inclusive of graphics, video or a combination. The novel computational framework also enables stereo viewing while immersed in an fMRI scanner allowing for user interactivity throughout. The system presented here is a real-time nonlinear video compositing engine designed to play back and composite video on demand. The aim is to produce the effect of real-time interactive 3D animation where, in reality, long render cycles are required in order to generate high quality images.

The framework is written in Cocoa, the native application program environment for the OS X operating system, and is reliant on the Quartz graphics subsystem. Whereas the logic is written in code, all of the compositing has been developed with Quartz Composer: the graphical environment for building graphics applications in OS X. Quartz Composer takes uncompressed video frames from the video playout back-end and renders them onto the screen for presentation. The use of Quartz Composer significantly reduces development time and introduces little overhead. To provide interactivity from pre-rendered video clips, the video sequences are designed to seamlessly combine with each other while individual parts of the scene are composited at play-out time.

The framework presented enables strictly controlled experimental paradigms for neuroimaging. Neuroimaging experiments benefit from utilizing synthetic stimuli in the form of virtual characters instead of real world confederates since the synthetic stimuli are not bound by the same ethical constraints. User interactions as well as the actions of synthetic characters are synchronised to the fMRI scanner by using trigger information. A frequency modulated audio signal is generated at prescribed times within the experimental phase. The audio signal is fed into a biometric recorder, which also records heart beat information, scanning synchronisation information etc. Simultaneously to this, a log is generated marking the exact time the sync pulses are sent to the biometric recorder as well as logs for user interactions. As the final output is generated from pre-rendered video sequences, the temporal resolution is guaranteed. There will be no animation glitches or artefacts distracting the engagement of the participant.

The system presented is being used to investigate neuro-correlates of empathy in addition to ways of creating believable characters. An economic game, combined with Milgram's original experimental scenario, is interactively played in an fMRI scanner (Milgram 1963). The system presented incorporates digital characters, thereby eliminating any discrepancies between performances (Fig. 1). The scene comprises a digital character who sits behind a desk and offers money to a participant located in an fMRI scanner. Indications of the amounts given and received are represented by score boards. As the final output is in stereo, a video for each number is generated for each required depth, while the system chooses the appropriate clip to be composited at play-back time. Expected neuro-imaging data will serve as objective measures of believability of animated characters in relation to communicating empathic responses. Such experiments showcase whether common perceptual and neuroscientific mechanisms are triggered by stereo-rendered synthetic characters of varied realism.

Figure 1: Scene displayed in the fMRI scanner

GARAU, M., et. al (2003). *The impact of avatar realism and eye gaze control on perceived quality of communication in a shared immersive virtual environment*. In *CHI*. 2003: ACM Press.
MILGRAM, S. (1963). "*Behavioral Study of Obedience*". *Journal of Abnormal and Social Psychology* 67: 371–378.
VINAYAGAMOORTHY, V., et. al (2005). *Building Characters: Lessons Drawn from Virtual Environments.* Toward Social Mechanisms of Andriod Science: A CogSci Workshop 119-12