Towards the Living Canvas

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Abstract

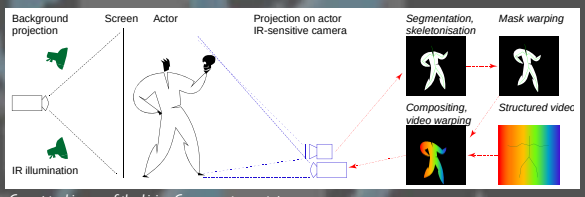
The Living Canvas initiative aims to explore the novel artistic possibilities of using the performer's body and clothes as a projection surface in the context of a stage performance. A new projection system will enable a dynamic or even improvised performance by detecting the posture and silhouette of the performer and projecting imagery precisely to the selected parts of body. This will enable the performer to "wear virtual costumes" that adapt to the body, or even receive a different face. The dynamic nature of the system will give full control to the performer who can freely move around on the stage, with the projection always "following" the performer. The Living Canvas is a collaborative initiative between the Glasgow School of Art and Theatre Cryptic and has acquired funding from the UK Arts and Humanities Research Council to implement the vision.

Simulated result of the proposed projection system

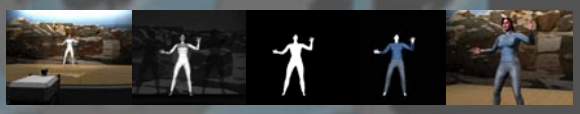
Concept

The Living Canvas project solves the inverse problem to acquiring an image of the user inside a spatially immersive display for tele-presence applications. Using a pair of cameras, one color, one IR sensitive, we can acquire an image of the user independent from the dynamic background [Rhee, IEEE TVCG 1/2007]. The IR camera is used to acquire a segmentation mask by illuminating the user in the invisible near-infrared spectrum to create a contrast against the non-illuminated background. The mask is then warped into the space of the adjacent color camera to identify foreground pixels to be transmitted to a remote site.

The Living Canvas system replaces the color camera with a projector. Instead of acquiring an image, the system uses the mask to restrict the projection to the actor, avoiding spill to the background or stage set.



Conceptual image of the Living Canvas system setup



The pipeline simulated: Actor wearing white garment - IR image - Mask - Virtual clothes - The final result

Prototype

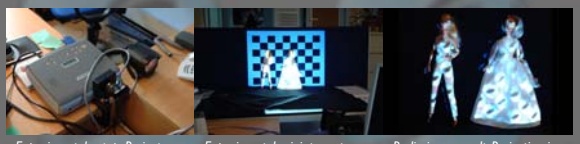
The first stage of the initiative is a technical feasibility study to prove the concept and to identify the performance bottlenecks and their implications on the stage performance.

We have developed a small-scale "theatrical stage" including all basic components (projector, IR camera, IR illuminator) to test the principles of the system:

- High-speed image acquisition in the near-infrared spectrum at 200 Hz
- Image segmentation based on background subtraction and de-noising operations
- Point detection to capture position of IR LEDs to track individual body parts
- Video-masking and mask-warping using multi-texture graphics hardware

Additional software components include a basic calibration system to match projector and camera views and various debugging tools.

Near-infrared camera image | *Image mask after segmentation and warping* | *Masked video image*

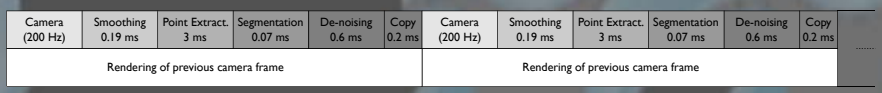


Experimental setup: Projector, camera and IR light-source | *Experimental miniature stage with calibration pattern active* | *Preliminary result: Projection is restricted to the "actor"*

Performance

The latency from the image acquisition to the image output is the critical factor that limits the speed of movements of the performer. We chose a 200 Hz high-speed firewire camera (PtGrey Dragonfly Express) to minimize the acquisition delay. All image processing has been carefully optimized to run within the 5 ms time period. Image rendering runs in its own thread and minimizes latency through a single-pass rendering method that avoids the necessity for double-buffering by exploiting the multi-texture capabilities of the GPU.

Running the input side of the pipeline at maximum speed, the resulting overall latency is dominated by the inherent delay in the digital projector running at 60 Hz and typically introducing an internal processing delay of one frame (16 ms). Preliminary tests on the prototype suggest that the system will be fast enough for theatrical performance.



Future Work

The project is currently at the feasibility study stage scheduled to complete Nov. 30th 2007. By the end of the project, we expect to have a thorough understanding of the latency issues, which fabrics to use that exhibit both good IR reflectivity and good projection properties, and the limitations of the system to guide the artistic exploration.

Phase 2 of the project aims to add basic posture recognition to adapt the video to the actor on stage, hence creating the illusion of virtual clothes by dynamically warping the video to match the posture of the performer.

Finally, Theatre Cryptic aims to bring the technology on stage by 2010.

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