Superimposing Pictorial Artwork with Projected Imagery

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1 Motivation

Pictorial artwork, such as paintings and sketches, can tell interesting stories. The capabilities of museums to communicate such and other information, however, are clearly limited. Text legends and audio guides can mediate facts, but offer little potential for presenting visual content, such as embedded illustrations, pictures, animations, and interactive elements.

2 Technical Solution

A seamless and space efficient way for integrating visual information directly into pictorial artwork is to use the artwork itself as information display. It can serve as diffuse projection screen and conventional video projectors can be applied to display computer graphics together with the painted content. To perceive the projected imagery in the correct colors and intensities, however, requires that the influence of the underlying physical color pigments is neutralized. In most situations, this is not possible if untreated images are simply projected directly onto arbitrary colored surfaces. The problem is that the projected light interacts with the color pigments on the canvas and is partially absorbed if the pigment's color isn't fully white. A solution to this problem is provided by a new film material which has two properties: first, it is completely transparent and second, it diffuses a fraction of the light that is projected onto it. Initial measurement results with the film material used for our experiments have revealed that in average *20%* (*+/- 1%*) of the light that strikes the film is diffused while the remaining fraction is transmitted towards the canvas. This *0.1mm* thin transparent film can be seamlessly overlaid over the canvas by integrating it into the frame that holds the artwork. We use off-the-shelf 1100 ANSI lumen XGA digital light projectors to display images on film and canvas. Ultraviolet and infrared blocking filters must be applied that to prevent the artwork from being damaged.

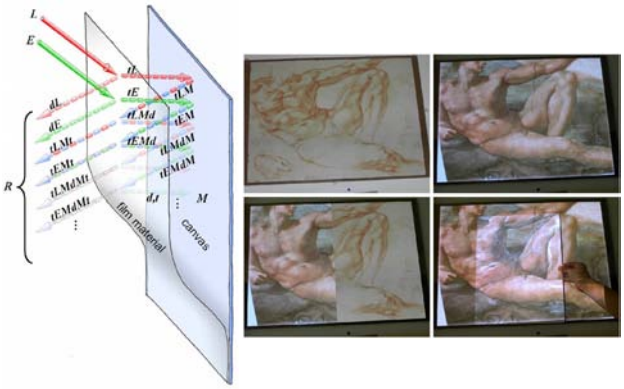

Figure 1: Interaction of light with canvas and film. Results of real-time color correction.

If a light beam with incident radiance *L* is projected onto the transparent film material that is located on top of the original artwork, a portion *d* of *L* is directly diffused from the film while the remaining portion *t* of *L* is transmitted through the film. The transmitted light *tL* interacts with the underlying pigment's diffuse reflectance *M* on the canvas, and a color blended light fraction *tLM* is diffused. The portion *tLMt* is then transmitted through the film, while the remaining part *tLMd* is reflected back towards the canvas where it is color blended and diffused from the same pigment again. This ping-pong effect between film material and canvas is repeated infinitely while for every pass a continuously decreasing amount of light is transmitted through the film that contributes to the resulting radiance *R*. Mathematically, this can be expressed as an infinite geometric series that converges towards a finite value. The same is true for the environment light with incident radiance *E* that is emitted from uncontrollable light sources. Since these light sources also illuminate the canvas and the film material, the environment light's contribution to *R* has to be considered as well. Figure 1 describes this process in form of a sequence diagram. This mathematical concept can be implemented as a pixel shader to compute the color corrected image *L* which results in the expected image *R* in real time.

Figure 2: Integrating visual effects into a real sketch: embedded objects, interactive magnifying glass, high-lighting, 3D fly-through. The underlying sketch is real.

3 Result

With our method, interactively rendered or pre-recorded 2D/3D visual content can be integrated directly into the artwork (cf. figure 2 for examples). Thereby, the underlying portion of the canvas can be made temporarily invisible. This allows displaying context information and creating special effects while keeping the observers' attention on the original artifact. It does not require additional screens. The application of two-dimensional artistic filters even allows a synthetic modification of the painting style or a re-illumination without physically altering the artwork.

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