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Projection surfaces

Chris Brammer (brammer@extend3d.de), Nicolas Heuser (heuser@extend3d.de)

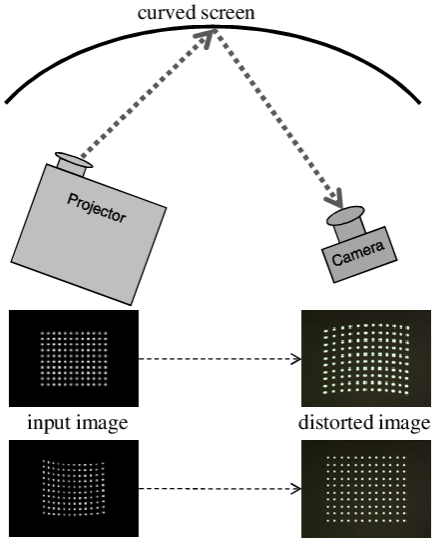
Projecting on surfaces is a simple concept. The results will heavily depend on the used projector as well as the properties of the surface that is projected on. In the following, you will find a summary of different aspects that influence the projection.

Surface geometries

Planar surface

Traditionally, projection surfaces are planar. Starting with a traditional cinema screen to most modern TFT, screens and projections surfaces have been planar. This is because the projected content assumes a planar projection surface. On modern projectors, any distortions towards parallelograms can be offset using the keystone feature.

Projecting a regular video onto non-planar surface results will at least result in distortions. In the worst case the surface occludes part of itself and therefor also the projection.



Park, Junhee & Lee, Kyung-Mi & Lee, Byung-Uk. (2011). Perturbation of quadric transfer due to deformation of curved screen displays. Optics express. 19. 16236-43. 10.1364/OE.19.016236.

Continuous curved surface

Modern cinemas and events often use a curved projection surface. While being non-planar, the surface is known and can be approximated with a simple geometry, i.e., sphere, or cylinder. Such curved surfaces do not have self-occlusion.

The following image visualizes the distortion of a continuously curved screen as seen from a camera. Since the surface geometry is known, it can be compensated for when rendering the image.

Non-planar surface

In General, in contrast to planar surfaces, non-planar surfaces requires further knowledge about the surface geometry and cannot be approximated with a simple geometric figure. For years, "projection mapping" leveraged buildings and sight marks as projection surfaces. The construction of the virtual projection surfaces for projection mapping was initially done manually. Today photogrammetric

reconstruction, scanning of the actual surfaces, or the usage of the original construction 3D model allows for a far easier setup and more correct representation of the original surface geometry.

With the knowledge of the projector position and orientation relative to the projection surface (extrinsic parameters), and the intrinsic parameters (focal length, optical center, radial- and tangential-distortion) the projected images can be composed and pre-distorted to match the surface geometry. A non-planar surface can potentially occlude itself.

Example of projection mapping from the Karlsruhe Schlosslichtspiele. https://www.schlosslichtspiele.info/

Material properties

Color

While surfaces can physically distort the path the projected light takes, the material and its color can have further effects on the projection.

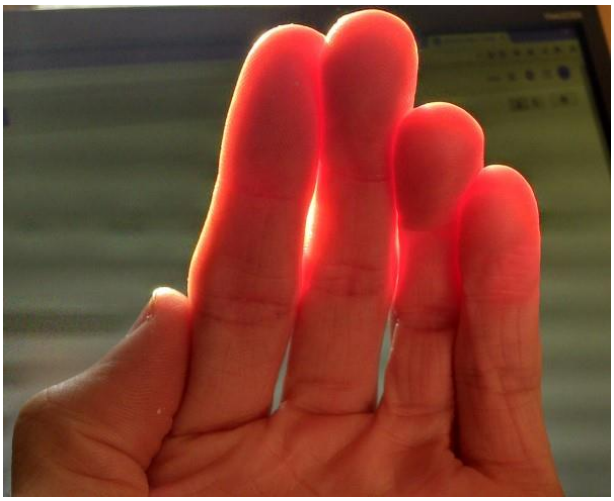
Color does play a major role when it comes to visibility and perceived quality of a projection. For example, trying to project a mostly red image onto a red piece of paper will be perceived as a bad projection. The perceived color and contrast range does depend on the surface color and material, for example, how rough or smooth the material is. Some materials may absorb certain colors, which leads to the fact that color reproduction is limited by the color scheme of the projection surface.

Texture

The texture of a surface can enhance or degrade the projection quality. Homogenous surfaces usually lead to a better projection. Heterogeneous surfaces will distort the projection in multiple different ways, which can lead to a degraded projection.

Reflectivity

When dealing with highly reflective (mirror-like) surfaces, a projection is hard to see from almost all perspectives since the light does not scatter on the surface, thus not reaching the observer's eye. The less light scatters, the worse the viewing angle of the projection. Furthermore, different materials depending on their structure will reflect colors differently, which can further degrade a projection. On low reflectivity objects, for example black surfaces, a very high intensity of the projection is needed to overcome the material's light absorption capabilities.



Source: Wikipedia
https://en.wikipedia.org/wiki/Subsurface_scattering

Self-Illumination

Light scattering under the surface/in the object can be a problem for some materials like resin or hollow plastic parts to a point that the intended projection cannot be recognized because of missing contrast. A common example of this effect is light passing through a human hand.

Tables as projection surfaces

Typical cooperative surfaces are surfaces that are generally adequate to project onto and the projection is visible to the spectator. Examples are white walls and projector screens. Uncooperative surfaces are surfaces that tend not to reproduce the projected image adequately for visual perception. Typical examples are mirrors, glass, very dark surfaces or surfaces that from the view of the projector produce many occlusions. Tables, on the other hand, cannot be mostly categorized as one or the other. The planar geometry of a table suits projections. If a table is useable as a projection surface depends on the material and color use:

Coated Wood

- Cooperative depending on color (white is good, black is bad)
- Homogenous texture
- Might have self illumination depending on thickness and material structure

Natural Wood

- Cooperative depending on color (bright is good, dark is bad)
- Texture can cause issues
- Might have self illumination depending on thickness and material structure

Steel

- Mostly cooperative (tends to have a dark color)
- Good reflectivity
- No self-illumination

Stainless Steel

- Uncooperative

Brass

- Uncooperative

Glass

- Uncooperative

Other materials that cover the table (e.g., a table cloth) need to be evaluated separately, as their properties vary drastically. When projecting, not only the surface can occlude itself. Tables for example are rarely empty. As soon as any object is present on the table, the table is not a planar surface anymore and occlusions can occur.

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