„Rendering for an Interactive 360◦ Light Field Display”

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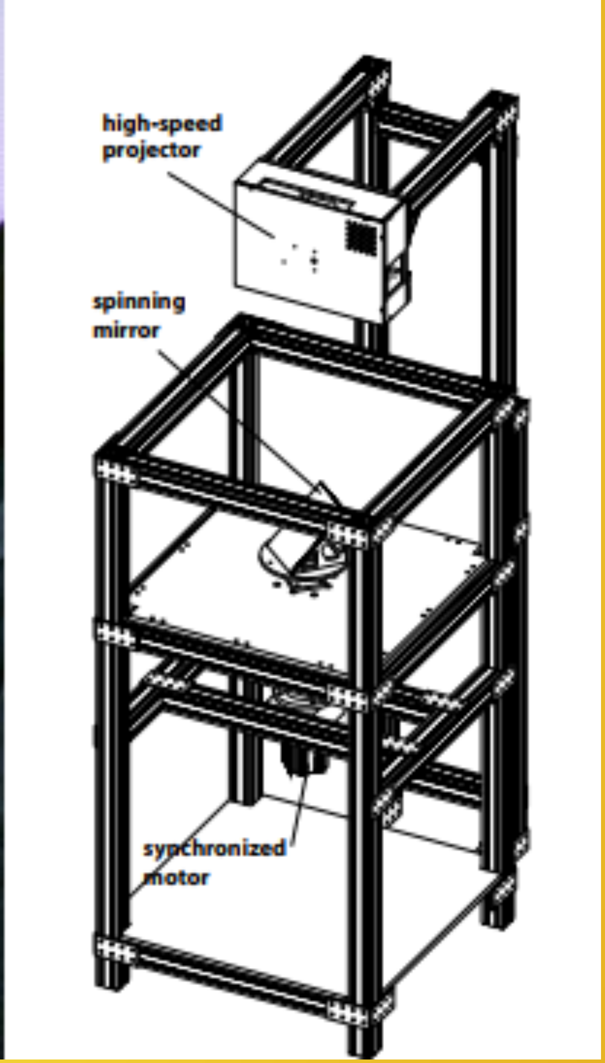
SIGGRAPH 2007 Papers Proceedings
SIGGRAPH 2007 Emerging Technologies

System Overview

- The system used to achieve the display consists of a:
- High-speed projector
- Spinning mirror
- Motion-controlled motor
- Standard PC

System Overview

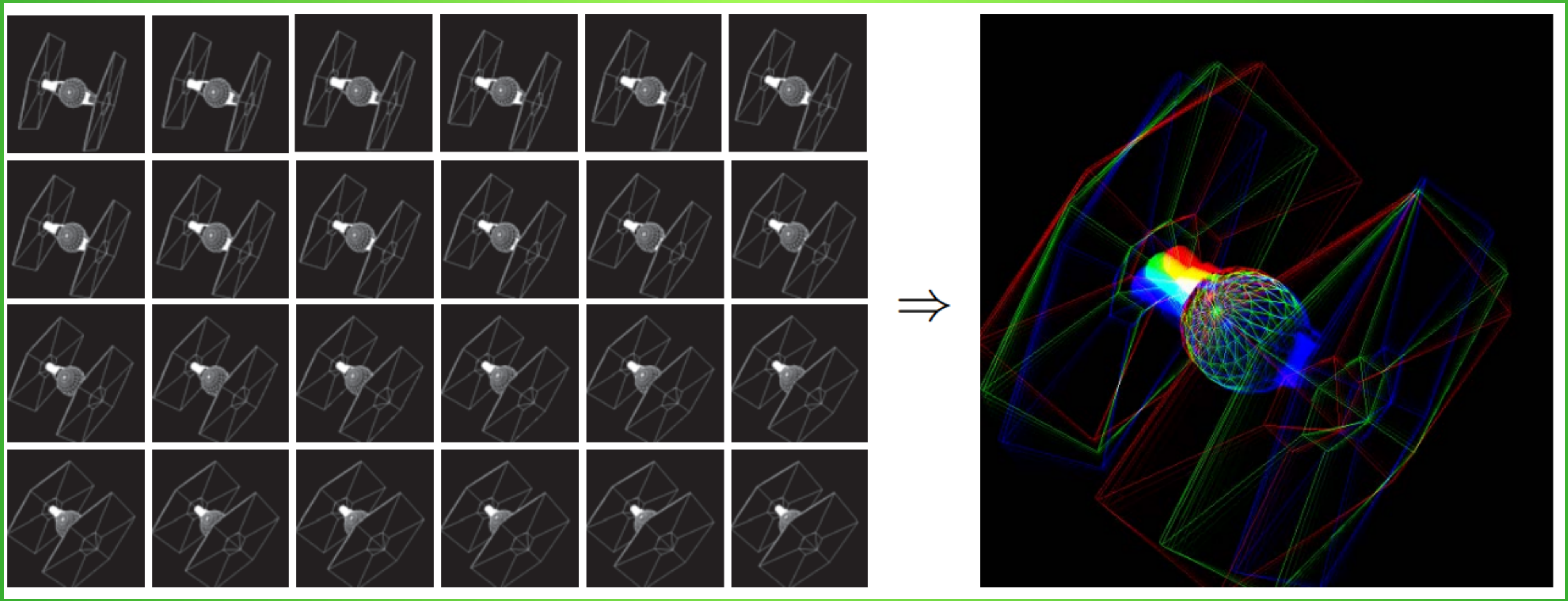


High-speed Projecting

For that purpose, a specifically modified off-the-shelf projector is used. It decodes the DVI signal from the graphics card. Yet, instead of rendering a color image, it takes each frame of the video, encoded with 24-bit color depth and displays each bit sequentially as separate frames, which gives 1440 frames per second with a 60Hz video.

High-speed Projecting

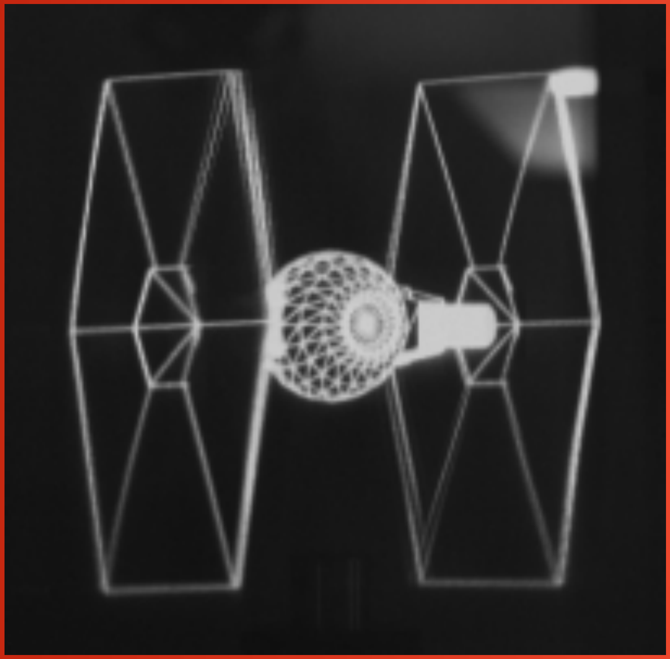
As the mirror rotates, the number of 288 views per full rotation is rendered (1.25deg angular resolution). Those are later encoded into 24-bit color images and sent to the projector.



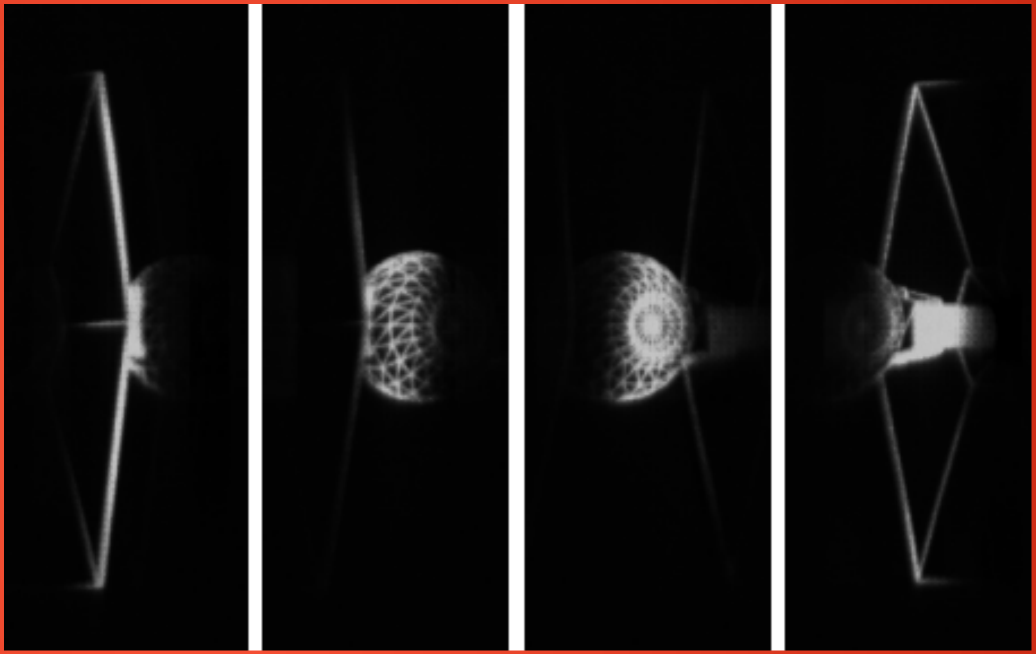
High Speed Projecting

- The image seen from each viewpoint is made out of a number of images, which differs depending on the distance from the scene. The closer, the more images are needed.

High Speed Projecting

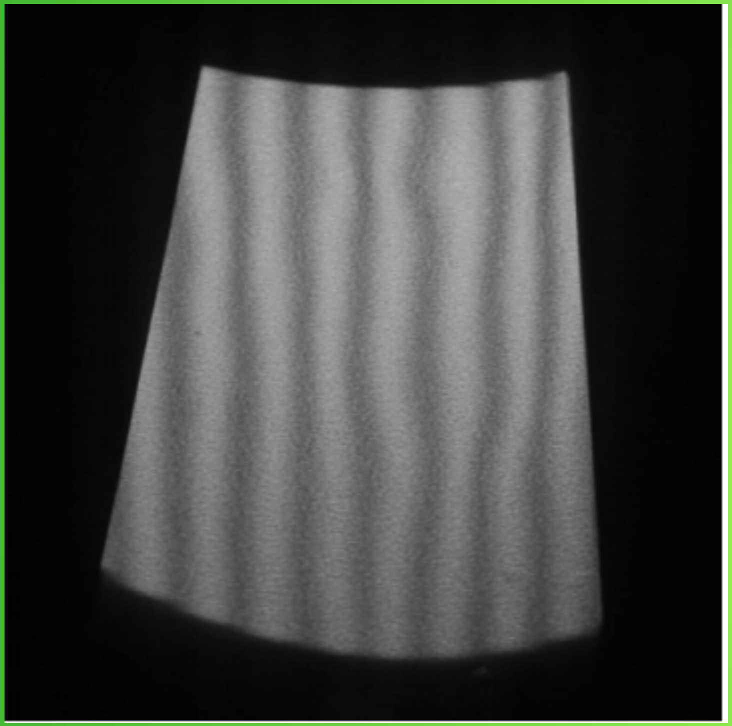


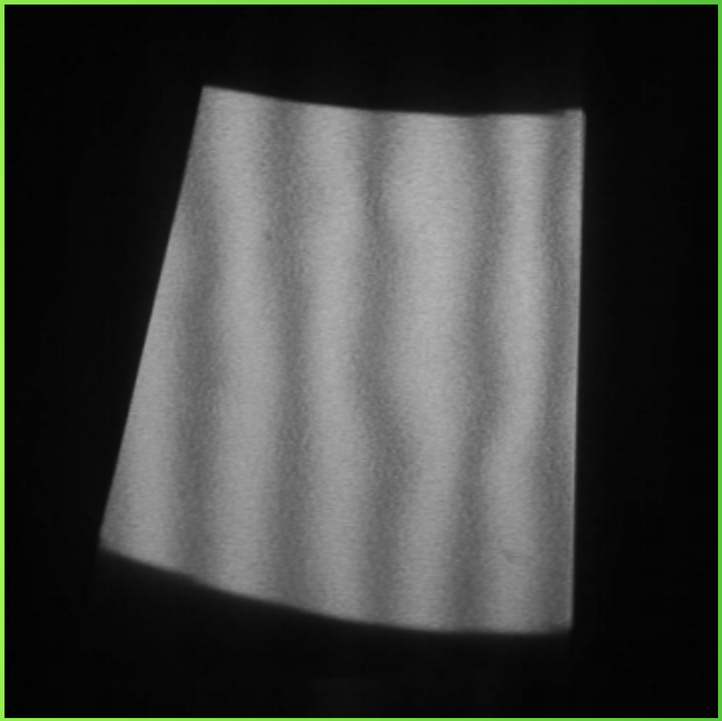
Single view from a certain viewpoint



The same view, cut into slices, that can be seen from the viewpoint at fixed camera position

High Speed Projecting





Photographs of the mirror reflecting a sequence of alternating all-black and all-white frames at 56cm and 300cm respectively. At higher distances, the number drops to an approximate minimum of 10 images.

Spinning mirror system

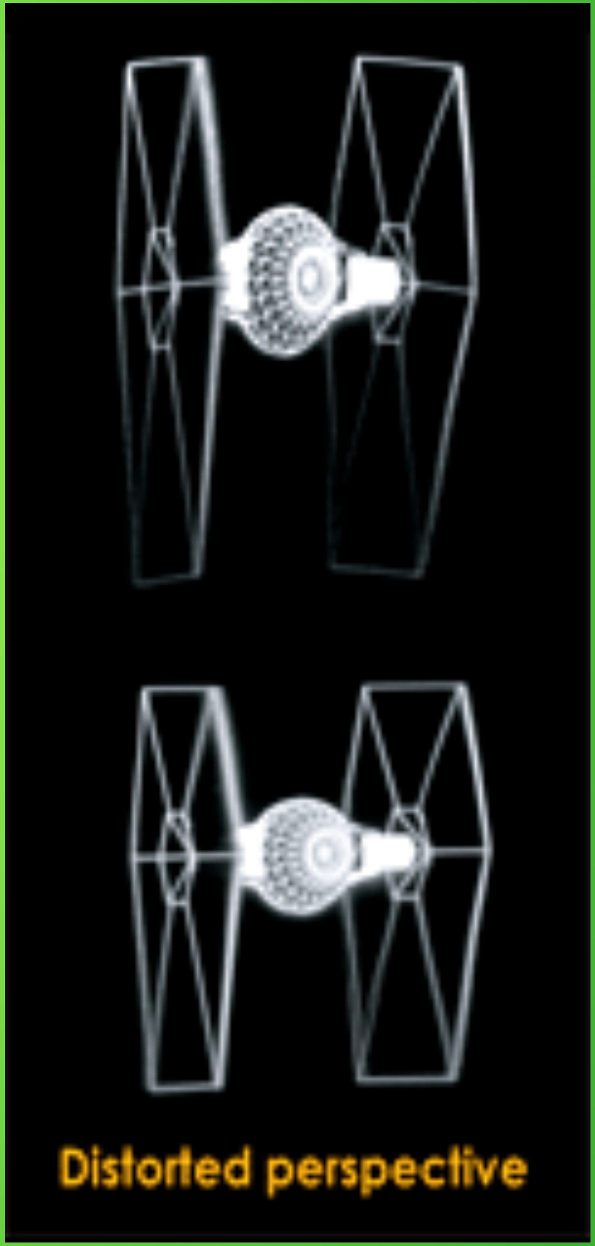
- The system consists of a mirror, tilted at 45deg, covered with an anisotropic, holographic diffuser, which provides control over the width and height of the surface onto which the mirror can reflect each projector pixel. In the system, it’s designed to provide an x to y diffusion ratio of 1:200.

Spinning mirror system

- The mirror is attached to a flywheel, which spins synchronously to the images displayed by the projector. The master syncing signal is the PC video output frame rate signal, which is also sent to the motor, which then ensures, that motor velocity stays in sync with the projector signals.

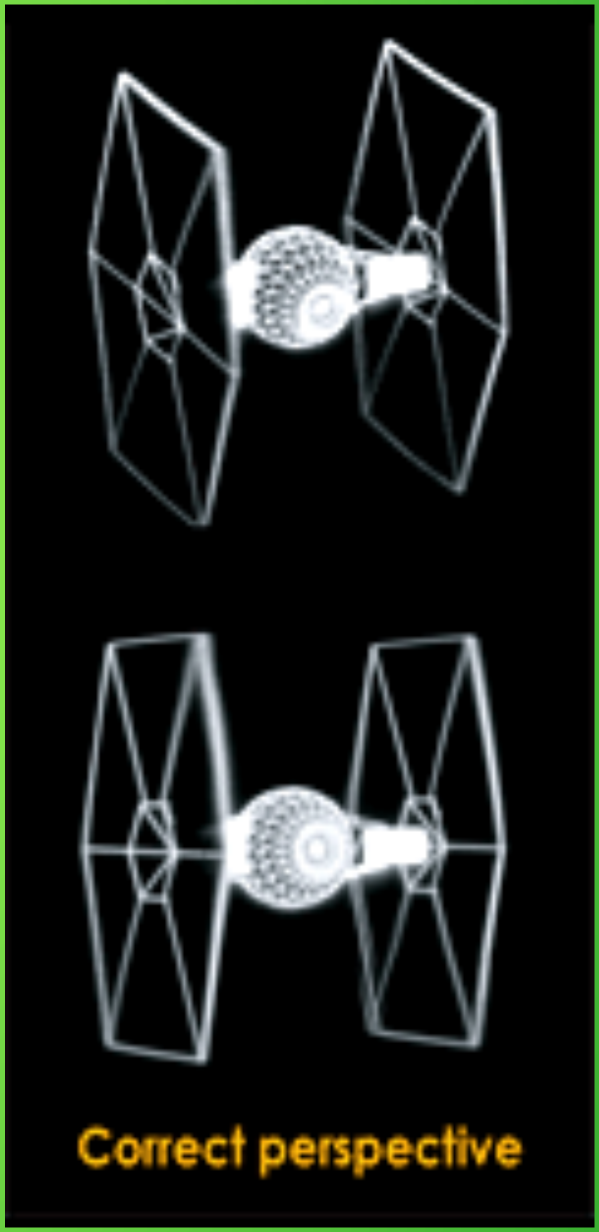
Tracking for Vertical Parallax

- The system consisting of the projector and the mirror yields only a horizontal parallax, the view perspective does not change correctly as the user moves up and down or back and forth.



Tracking for Vertical Parallax

To achieve this, an electromagnetic tracking system is utilized to compute user's height and distance from the rendered object, where the user holds a sensor to his temple.

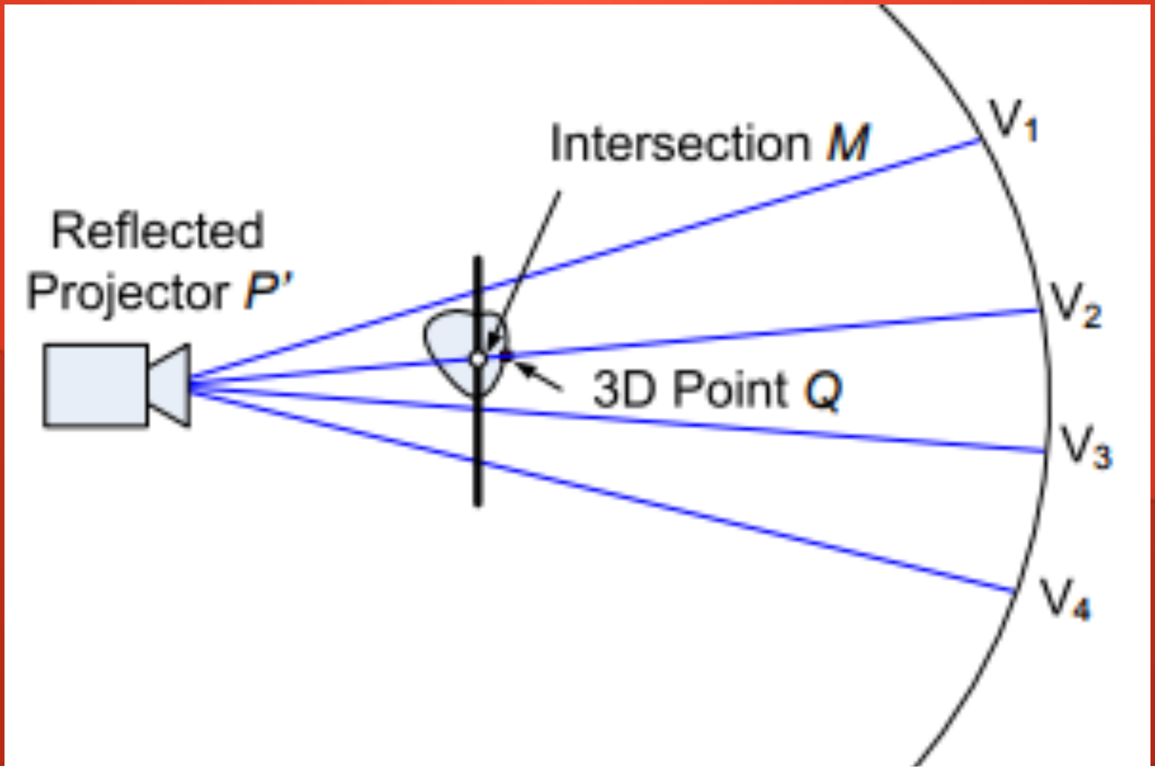


Tracking for Vertical Parallax

- Then, the tracking data is used by the projection algorithm to provide correct display according to user’s height and distance. Only the views in vicinity of the user need to be adjusted.

Projecting from the Scene into the Projector

- If our scene is a polygonal 3D model, we need to determine for any world-space vertex Q where it should be rendered on the projector's image for any given mirror position.
- We can reflect the projector's position across the mirror plane like on the image. V is the viewing circle, where the viewers are located. Q is a vertex of the 3D model in our scene, while M is its intersection with the mirror.



Projecting from the Scene into the Projector

- With the mirror frozen in one position, any ray originating in P’ and coming through Q will continue out towards the viewers. In general, this ray does not intersect the viewing circle V.

Projecting from the Scene into the Projector

We assume the mirror diffuses rays into a vertical plane due to the anisotropic diffuser properties. Thus, we can intersect a vertical plane containing ray P'Q with the viewing circle to establish the viewpoint V' from which the vertex Q is visible with the current mirror position.

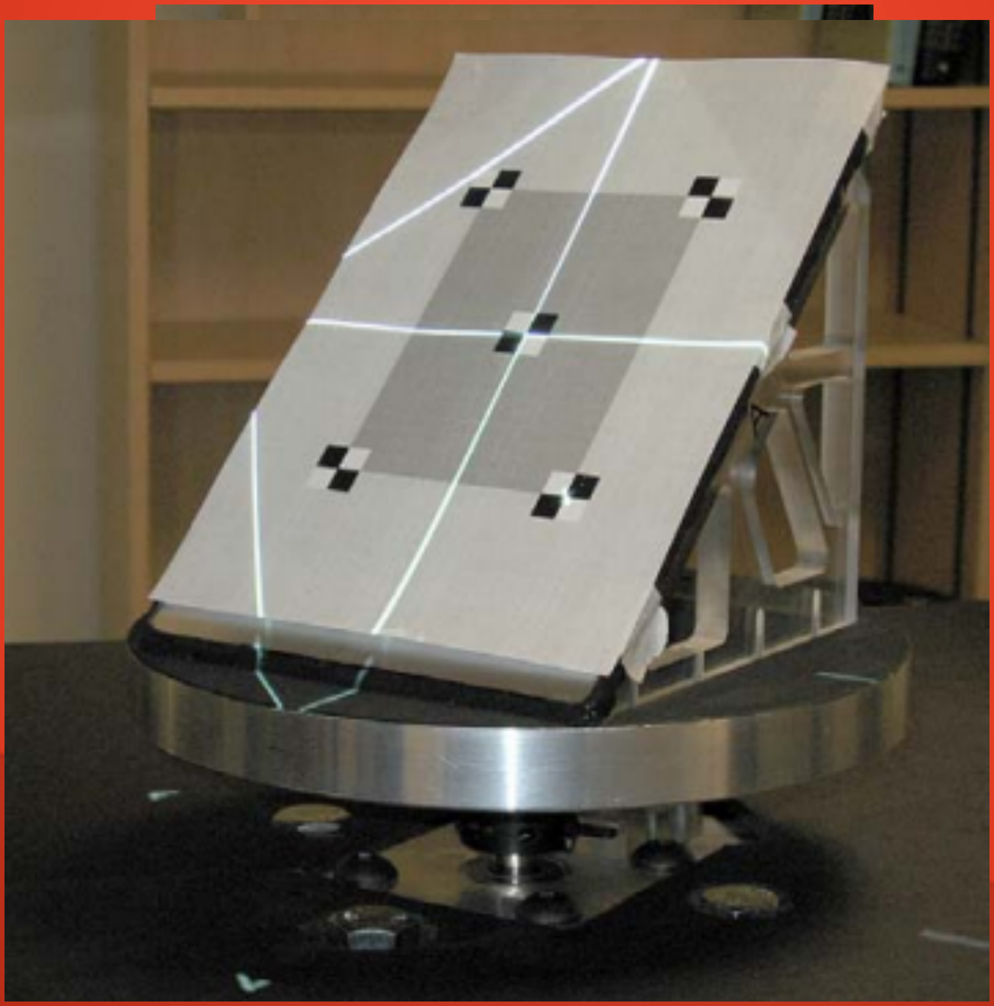
Projecting from the Scene into the Projector

- We can then trace a ray from V' towards Q until it reaches the intersection M to find the point on the mirror which reflects light toward the V' viewer. If we project M up, toward the projector we can find the corresponding pixel at (u,v), whose illumination will make Q visible to V'.

Geometric Calibration

- The projection requires knowledge of the intrinsic projector parameters, as well as its position relative to the mirror. In order to do that, we need to carry out a calibration process, to obtain at least 6 correspondences between known 3D points in space and their 2D pixel positions.

Geometric Calibration



Displaying Photographic Light Fields

- To project a real object, we first need to capture its light field. We place the lit object on a turntable in front of a video camera at distance D=1m. Then we capture a movie sequence of at least 288 frames for a 360deg rotation. After that, we raise the camera's height by 1.25cm and do the same. We repeat this process until a full light field is captured.

Preprocessing the Light Field

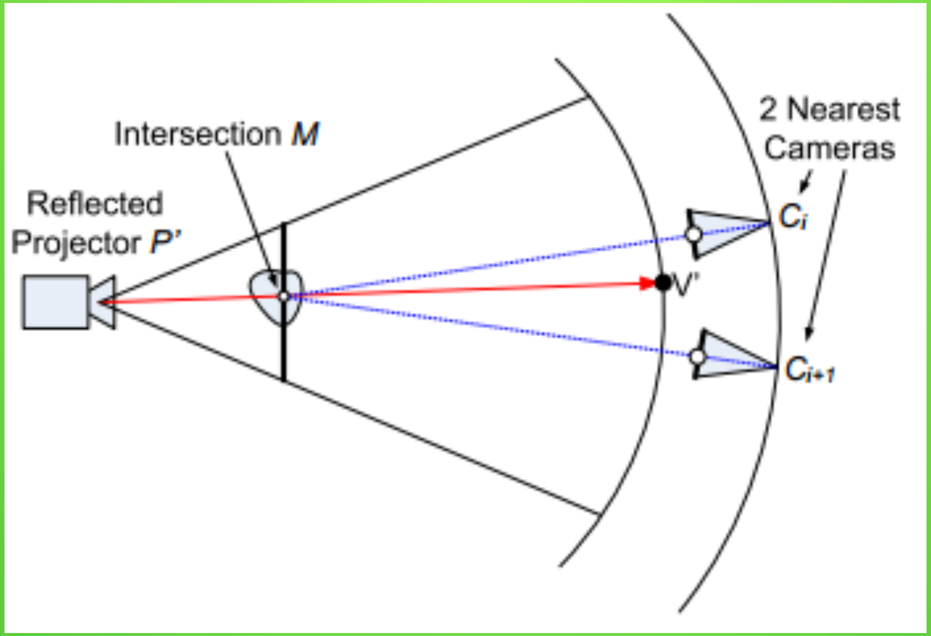
- Regular perspective images, taken by the camera, will not produce correct perspective to viewers around the display. Thus, we need to pre-process the light field. For each 'slice' of the captured light field taken from camera's height H, we generate a new light field as follows:

Preprocessing the Light Field

- We place a virtual viewing circle V around the display at height H and distance D and then trace rays from P’ through each pixel (u,v) to the mirror at M and to viewpoint V’ found on V like previously. Then, we need to query the light field for its radiance along ray V’M.

Preprocessing the Light Field

- Since V is chosen to be coincident with the current H and D of the light, V' should lie on or between two consecutive camera positions. To get final pixel value we bilinearly interpolate between pixels at those camera positions.



Displaying Color Imagery

- To display the scene in color, we will need a two-sided tent-shaped diffusing mirror. Between the mirror and the diffusing holographic film we place a color filter. Thus, the RGB color is converted, by projecting the linear RGB vector onto the plane spanned by the two colors.
- To render in color, we calibrate each plane of the mirror independently, and then we render the scene twice, each sub-frame in one color.

Sources

- All information and images are taken from the paper pdf:
- http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.108.4744&rep=rep1&type=pdf
- Movie:
- http://gl.ict.usc.edu/Research/3DDisplay/