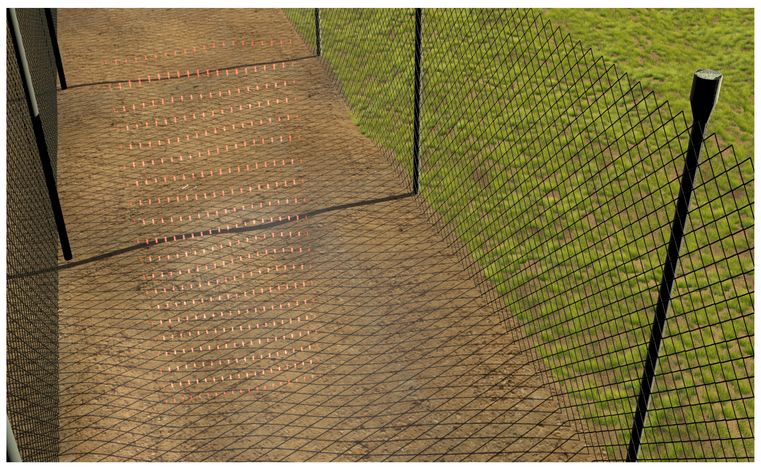

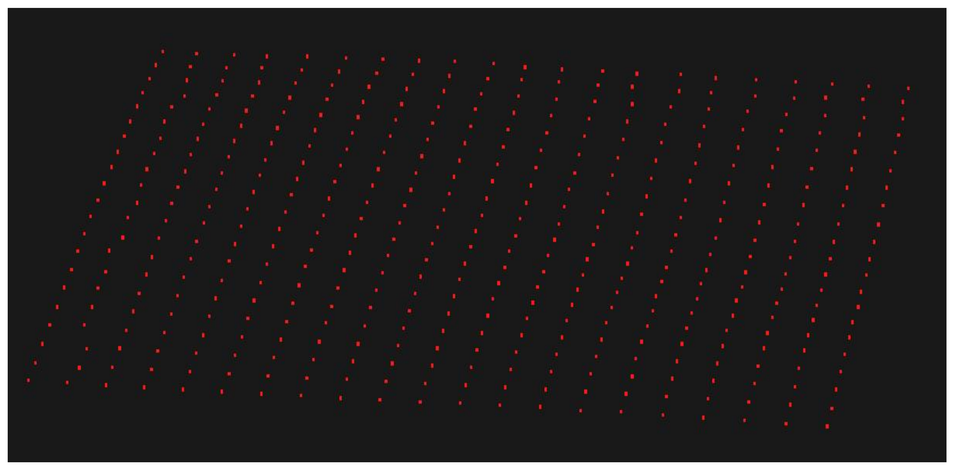

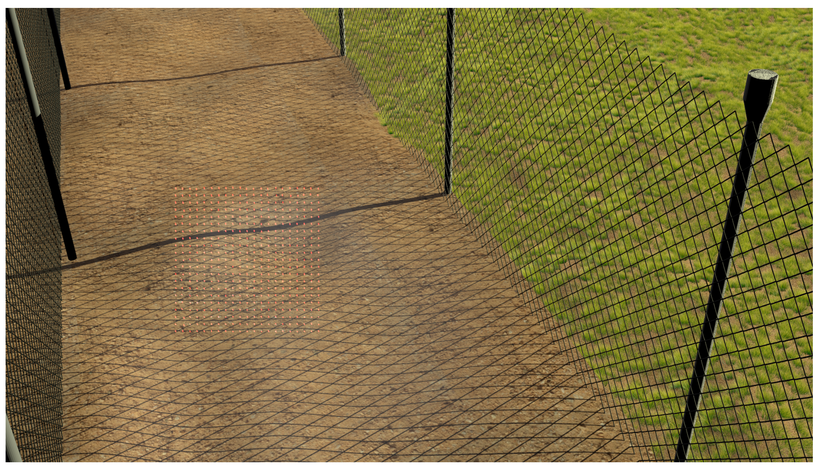

Rectification of Projected Images Using Piecewise Homographies

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Abstract

Security camera feeds can be analyzed through image processing to detect anomalies within a system, such as human activity. A projector can be used to supplement these systems by projecting arbitrary patterns onto areas of higher importance, which can be more easily monitored for changes. Projecting arbitrary rectified images is accomplished by developing a piecewise network of homographies which can account for depth variations throughout a complex scene.

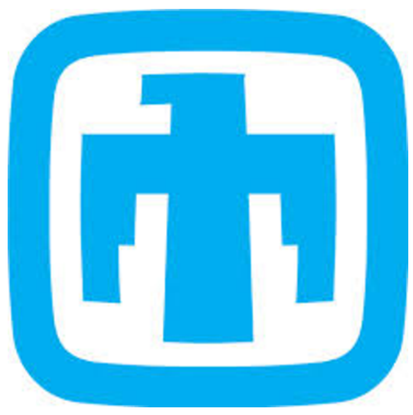

Figure 1a: Original image to be projected

Figure 1b: Projected image as seen by camera

System Overview

A piecewise mathematical relationship can be established between a projector and a camera, called a piecewise homography. This relationship can be used to:

- Project grid points onto arbitrary locations on a complex scene.
- Pre-skew images to correct for variable depth prior to projection [3].
- Supplement security camera systems to focus on regions of interest.
- Simplify change detection systems.

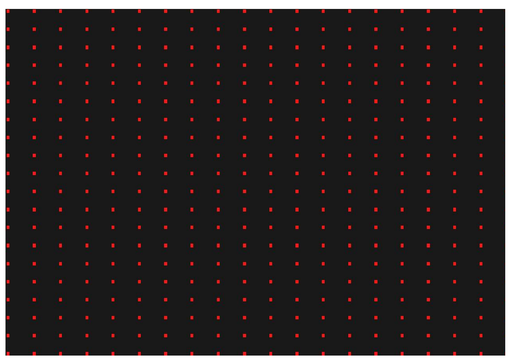

Figure 2a: Rectilinear grid points

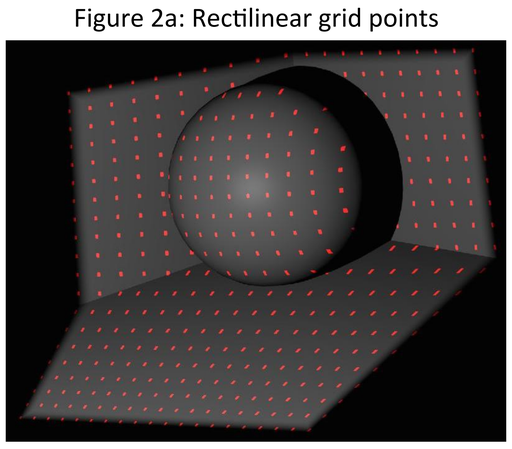

Figure 2b: Rectilinear grid points as seen by camera

Foveated System Applications

- The resolution in foveated systems vary around fixation points [4].
- Variable resolution is computationally economic [4].
- A course grid can be projected and monitored for changes.
- A localized finer grid can be projected when changes are detected.
- Pre-skewing images allow for fast, arbitrary placement of finer grids.

Method

1. Split image into sub-windows using grid points.
2. Determine rectified image location and determine rectilinear grid point locations.
3. Determine location of the pre-skewed grid points on the projected image such that they appear rectilinear to the camera.
4. Create a homography between the pre-skewed and rectilinear grid points for each sub-window.
5. For each sub-window in the original image, apply the corresponding homography to pre-skew the image.

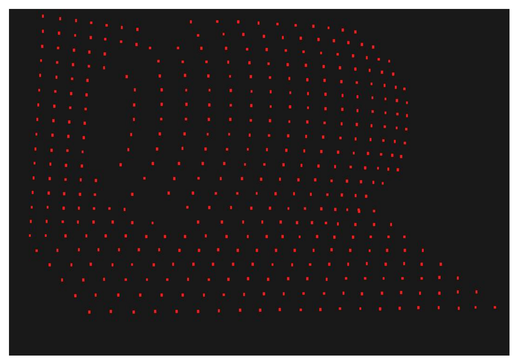

Figure 3a: Anti-skewed grid points

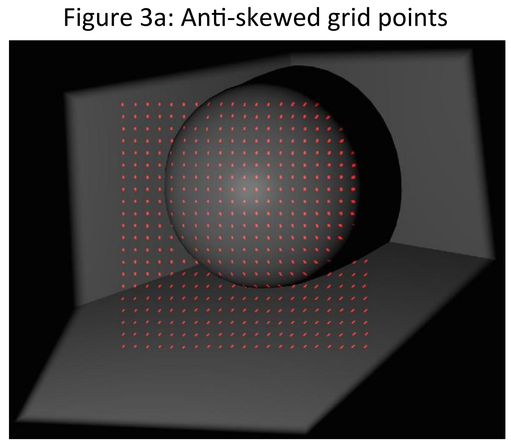

Figure 3b: Anti-skewed grid points as seen by camera

Homography

- It is an application of the projective transform, which is a linear, continuous geometric transform [1,2].
- It relates the position of corresponding pixels in stereoscopic systems [1,2].
- At least four pairs of corresponding pixels is required to develop a homography [1,2].

$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} H_{11} & H_{12} & H_{13} \\ H_{21} & H_{22} & H_{23} \\ H_{31} & H_{32} & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

Figure 4a: Pre-skewed image to be projected

Figure 4b: Anti-skewed image as seen by camera

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SAND No. 2011-XXXXP