Automated Anamorphic Projections on Planar Surfaces

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Introduction

An **anamorphic projection** is an image that is intentionally distorted so that the original image can be seen only from a certain perspective, or using a special device, for example a mirror. The origins of anamorphosis can be traced back to the 16th century art, but beyond the aesthetic values, anamorphosis has found its uses in many practical settings, such as road signs and keystone correction.

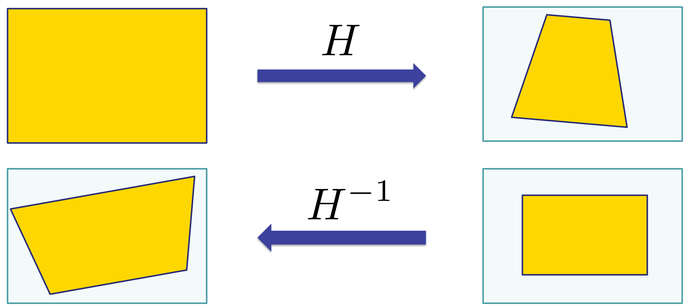
Example of anamorphosis in street art:

Make Poverty History by Julian Beever

This project applies computer vision techniques to create a program that automates the process of generating anamorphic projections. We use a projector-camera system to derive homography mappings between the projector image and the projection surface, and propose a method for generating an optimal anamorphic image for multiple viewers using the least-squares estimation.

Homography

Projector Image ***Camera Image***

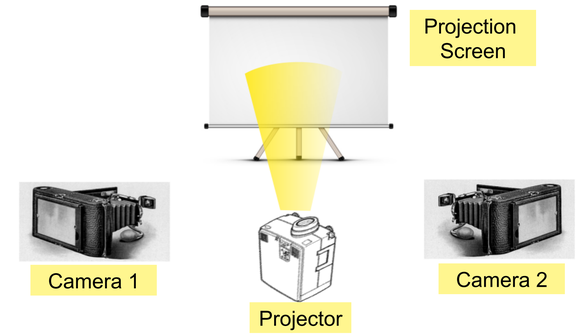


$$H = \begin{pmatrix} p_1 & p_2 & p_3 \\ p_4 & p_5 & p_6 \\ p_7 & p_8 & p_9 \end{pmatrix} \qquad H \begin{pmatrix} x \\ y \\ 1 \end{pmatrix} = \begin{pmatrix} x' \\ y' \\ \omega \end{pmatrix}$$

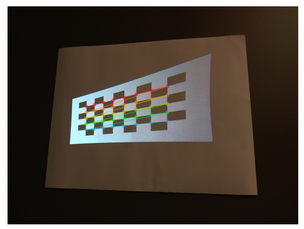
A **homography**, or projective transformation, is a transformation of a two-dimensional image I to another two-dimensional image I' (called the anamorphic image), such that all lines in I are preserved in I'.

Sukthankar, R., et al**. Smarter Presentations: Exploiting Homography in Camera-Projector Systems**. International Conference on Computer Vision, 2001.

Experimental Setup

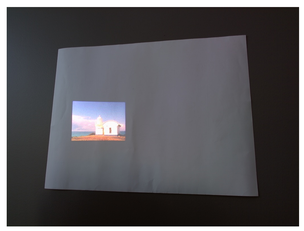


Planar Anamorphosis Model



1. Project a chessboard pattern.
2. Find the chessboard corners in the camera image.

3. Estimate homography H using the least squares method.
4. Apply H^{-1} to the original image to warp it.



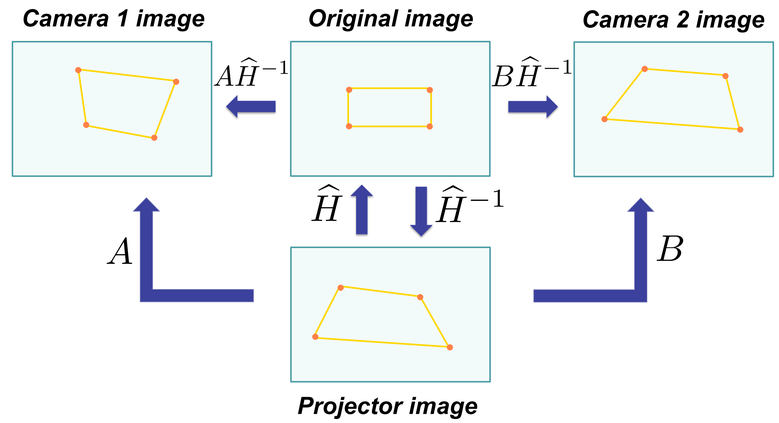
5. Project the warped image. Now the camera should see it correctly.

The error function:

$$E = \sum_{i=0}^{n-1} \|Hp_i - q_i\|^2$$

n – number of point correspondences
H – projector-camera homography
p_i – original chessboard corners
q_i – chessboard corners detected in the camera image

Two-View Model

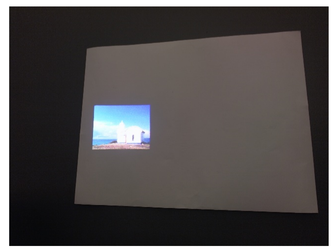


The error function:

$$E = \sum_{i=0}^{n-1} \left\|A\widehat{H}^{-1}p_i - v_i\right\|^2 + \left\|B\widehat{H}^{-1}p_i - w_i\right\|^2$$

Preliminary Results:

Warped image



Result in Camera 1

Result in Camera 2

Future Work

- Generate anamorphic images that can be projected on more complex surfaces such as multi-planar and curved surfaces.
- Improve the optimization for multiple-viewer system.
- Explore other types of anamorphosis such as mirror anamorphosis.