Perspective Correction of Singe Distorted Projector on Horizontally-Discontinuous Flat Surface with an Uncalibrated Camera

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We demonstrate image processing algorithms that achieve the distortion-corrected projection on surfaces with horizontal discontinuity, with casually placed camera and projector. Image pre-warping is used to achieve any projector keystone correction and screen geometry correction. This project involves one projector (Epson H382F, aspect ratio 4:3), a right-angled corner (or a folder/curved paper screen), a camera and a control laptop. This project doesn't involve Android devices.

With algorithm modification to achieve geometry registration and photometric alignment between projectors, users can project extremely wide field preprocessed images with multiple projectors. This algorithm may also be modified for projectors located at the back of the projection screen. It has application in art visualization, Head-Up Displays, and virtual/augmented reality.

Step 1 Flat Screen Projection

The user is provided with eight test images with black background and white dot arrays and white lines. The user can decide any fixed camera position, where he takes a few pictures of the flat screen with projected test images. The camera serves as the feedback system that tracks the extrude screen shape and the projectors' distortion, illumination, color, image size relative to the test images. By analyzing the images and the standard image from data base, transformation of the images to the actual projected screen is calculated. After this step, any feedback images from the users will be adjusted by the above transformation to recover the projection screen. Processing includes

- Calculate dot coordinates in the standard test image and from camera captured image (labeling algorithm).
- Calculate the perspective transformation matrix Mcp from camera to projector coordinate using dot coordinates standard test image and camera captured image.
- For each target image, find a large inception rectangle of the same aspect ratio in the projected area. Apply Mcp to obtain the desired projector coordinate. Calculate Mpp to transform standard projector coordinate to the desired one.
- Image warping the target image with Mpp to generate a pre-distorted image for corrected projection.

Step 2 Right-angled Corner Projection

Repeat above procedures for projection on a right-angled corner (now we need edge detection and two perspective transformation for two sides of the wall separately). Pre-distorted images on corner allow people, standing at the camera location, to see the perspective-corrected test images. This achieves camera-position perspective correction.

We paste images onto the right-angled corner and take a picture. This serves as input image upon which we apply the improved algorithm, so that after the corner projection, people could feel the depth in the 2D image. This achieves position-independent perspective correction by wall-papering the projected image.

Step 3 Multiple Projectors on flat surface

In this step we will need two projectors placed to have small overlapping region, and two laptop computers. Image processing is performed on a panorama images. The processed images are separately projected by the projectors to achieve seem-less superposition effect.

During geometry registration, calculate the perspective transformation matrix for individual projector. For a projected panorama, calculate the image splitting and warping for each projector.

During photometric alignment process, the intensity of the projected region is taken into account to adjust brightness difference (assuming small chromatic difference between two projectors). A alpha-mask is calculated for each projector to achieve intensity smoothing at the overlapping edges.

Reference

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