Projector-camera Based Solutions for Simulation Systems

by
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Overview

- Motivation
- Projector-camera based system
- Previous work
- Problem definition
- Our approach

Office of the future

- Ceiling mounted digital cameras and projectors.
- Anywhere multi-projector display.

Projector Based System

- Offers dense pixels over wider area.
- Advantages of projector based system
  - Size of projector
  - Size of displayed image
  - Multi-projector Display
  - Blending of heterogeneous image
  - Display surface

Issues Regarding Projector Based System

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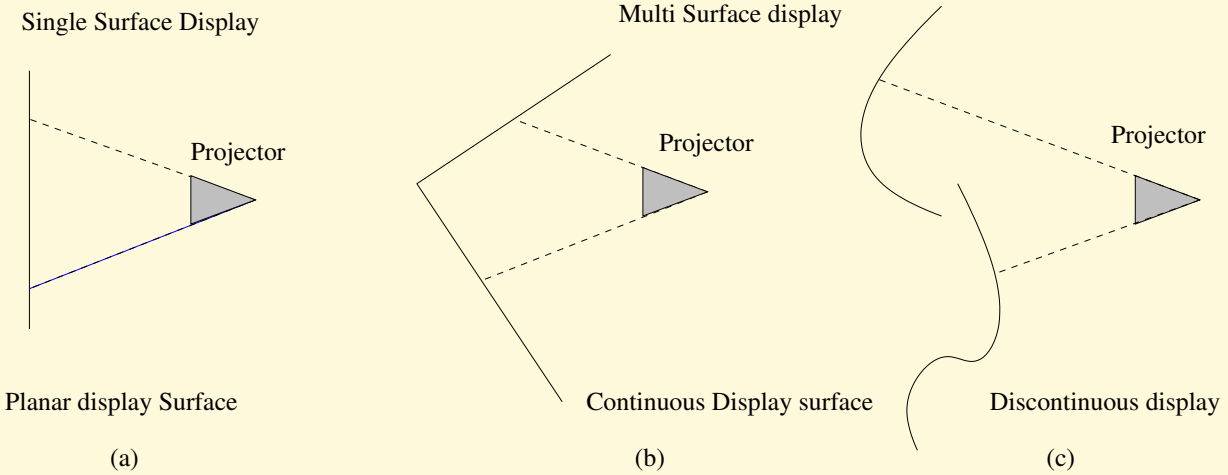
- **Geometric Issues:**



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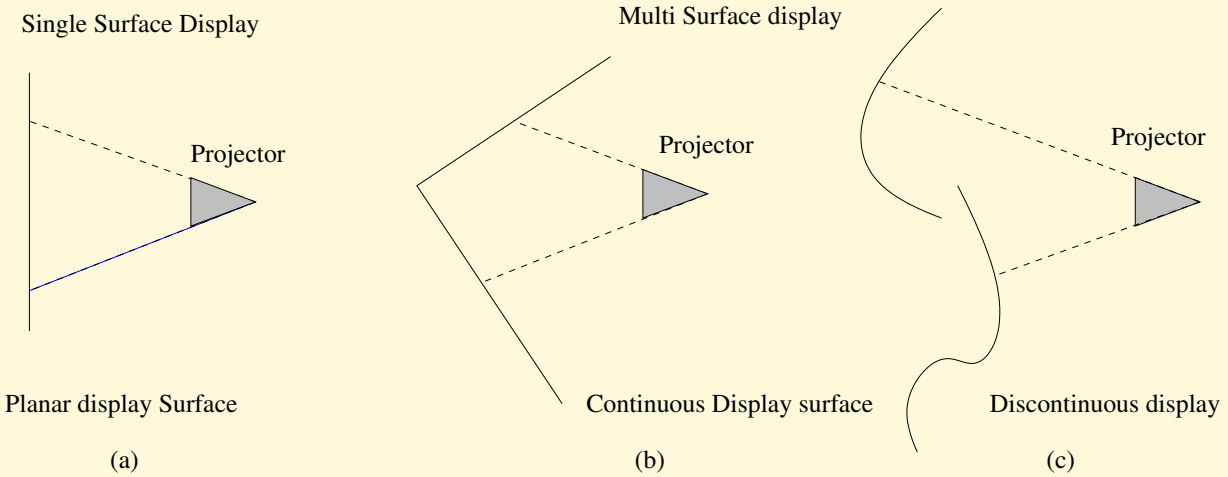
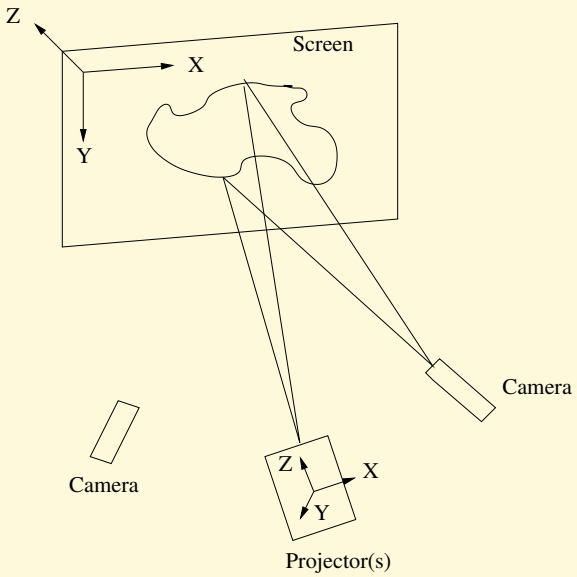


- **Image Intensity and color:**
  - Non-uniform Intensity
  - Overlapped region

Projector-camera based System



- Display surface
- Projectors
- Stationary cameras
- Projector-camera homography

$$\begin{pmatrix} xw \\ yw \\ w \end{pmatrix} = \begin{pmatrix} p_1 & p_2 & p_3 \\ p_4 & p_5 & p_6 \\ p_7 & p_8 & p_9 \end{pmatrix} \begin{pmatrix} X \\ Y \\ 1 \end{pmatrix}$$

Previous Work

- Automatic keystone correction
- Laser pointer based presentation control
- Multi-planar display system
- Multi-Projector display system

Automatic Keystone Correction

What is Keystone ?

Automatic Keystone Correction

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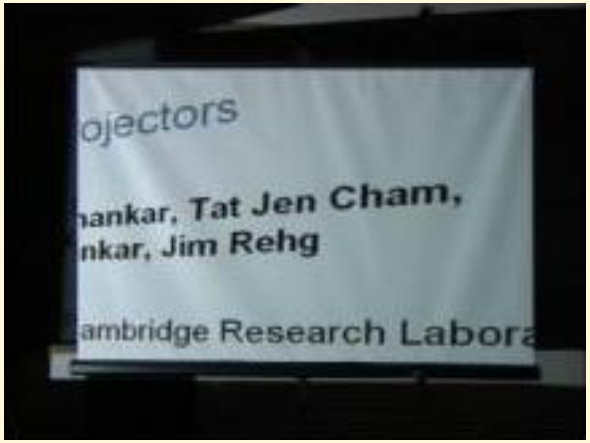
Distortion in projected image due to misalignment between projector and display surface.



Automatic Keystone Correction (contd.)

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- **Why it is undesirable:**
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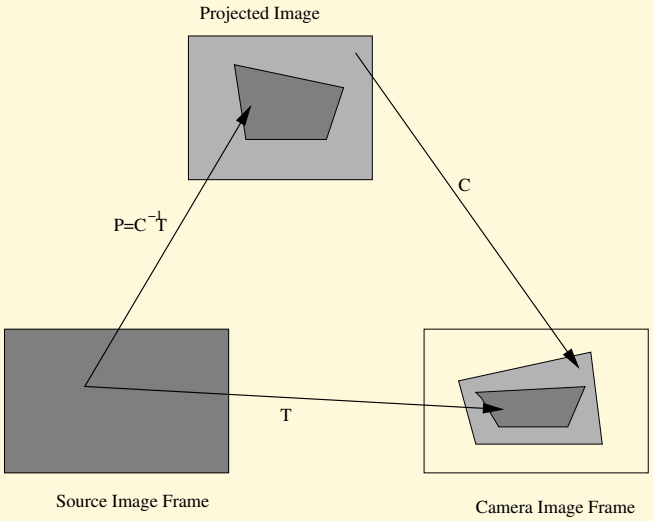
- **How it can be prevented:**
  - By aligning projector's optical axis perpendicular to screen.
    - But suitable for fixed projector.
    - Alignment will be tedious for portable projector.

Solution using Projector-camera System

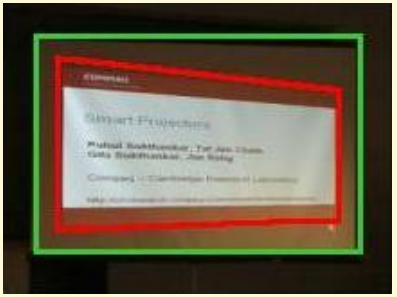
- Determine the rectangular region in the camera image where contents should appear.
- Use the Homography to back-project this rectangle into projector coordinates.
- Determine the projective transform that warps the slide to this desired quadrilateral.



Results of Projector-camera Based Solution

Projector image

Camera image



Audience sees

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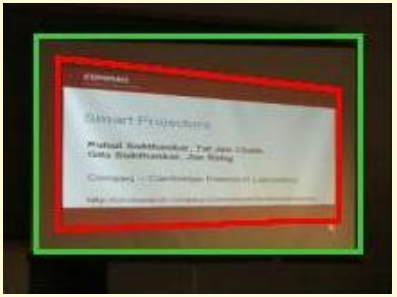
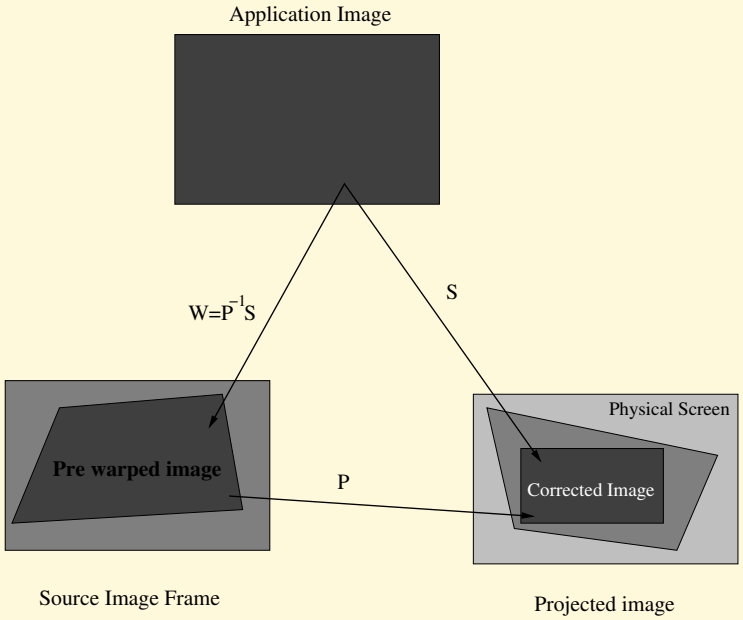


Audience sees

What about alignment of camera?

Improved Solution using Projector-camera System

- Need to model Projector-screen distortion.
- Apply the pre-warp so that application image appear rectilinear adn best-fitted after projection through misaligned projector.



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Laser-pointer Based Presentation Control

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- **Pointer device for projector camera system:**
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- **Interface provided:**
  - Active regions
  - Freehand drawings

Multi-planar Display

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- **Shape adaptive projector:**
  - All point on display surface should be undistorted when viewed along the surface normal.
  - Need to determine the mapping between input image and corresponding areas on display surface.

Before correction

After correction

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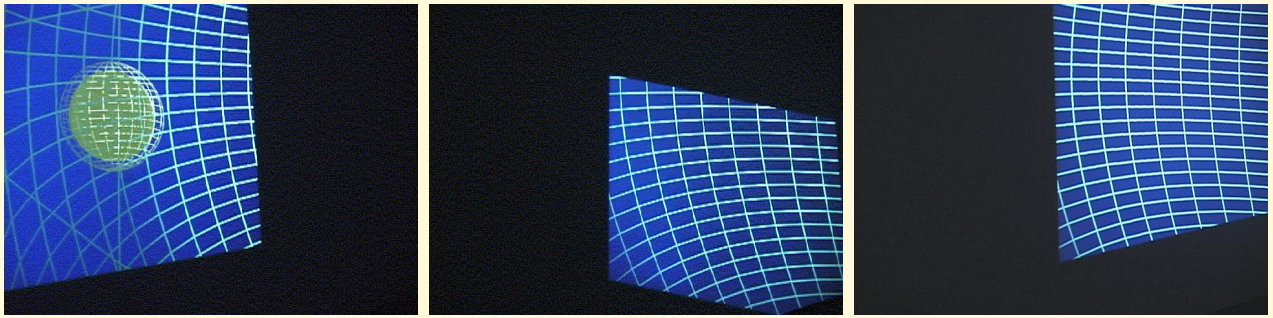
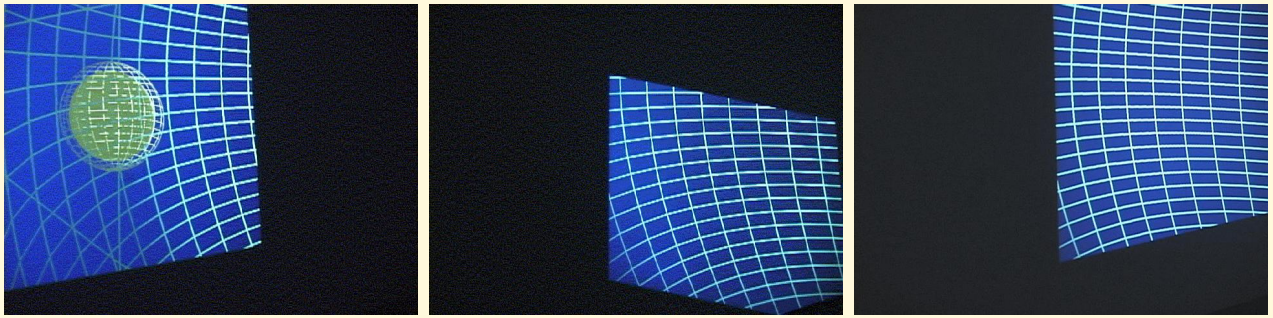
- **Issues:** Brighter image at overlapped region.
  - Can be corrected by attenuating projector pixel intensities in the overlapped regions.

Multi-projector Display System



Images from individual projector

Multi-projector Display System



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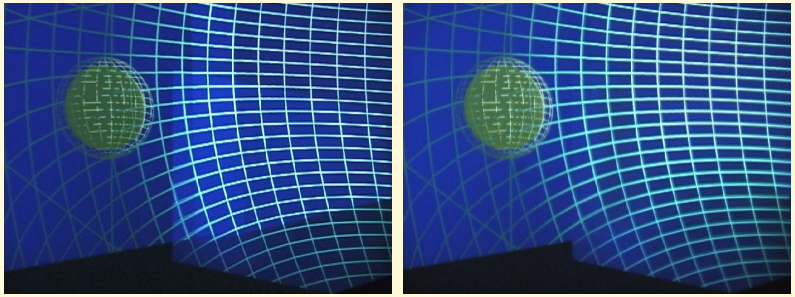


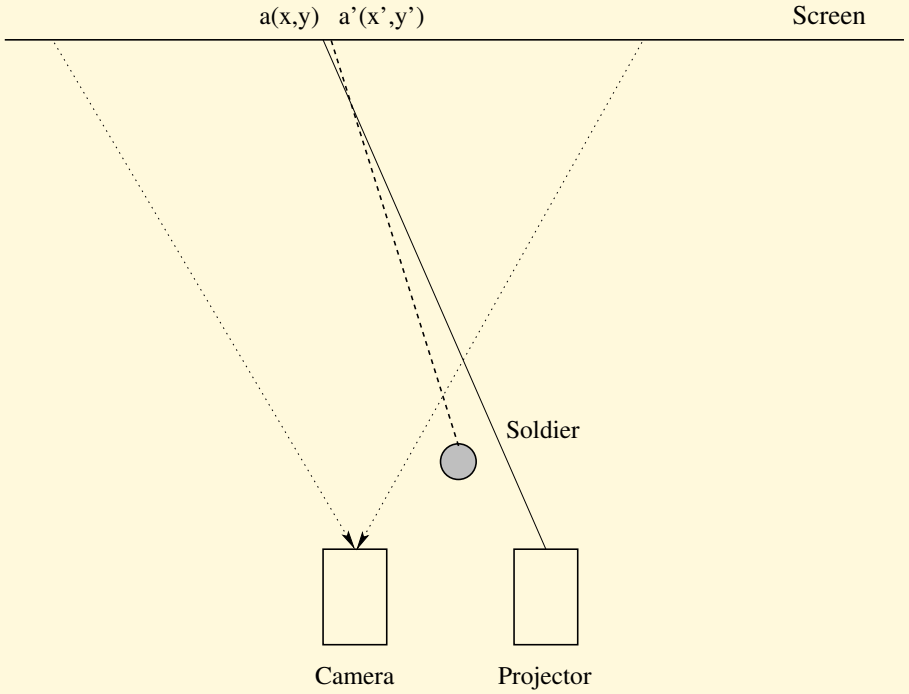
Image before and after brightness correction

Problem Definition

The aim of our project is to create a virtual environment, for shooting range simulation using projector-camera based solutions.

Our Approach

- Projector creates simulated environment.
- Shooter(s) are sitting in a simulated environment.
- Shoots with the laser-gun on a screen.
- The camera(s) captures the hit screen.



Important Components

- **Virtual World:**
  - Created by system.
  - Rendered as First Person View.



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- **Projector-camera system:**
  - Projector projects virtual world.
  - Camera detects the hit.

Algorithm

1. The virtual world is created inside the computer.
2. The scene is rendered as first person view.
3. It is projected anywhere irrespective of *projector* position.
4. Shooter is positioned in front of display surface, facing the screen.
5. Shooter is asked to shoot the target on screen by laser-gun (Gun with laser pointer attached). The Laser point will help to detect the hit.
6. The hit by laser-gun will be detected by camera.
7. From projector-screen-camera homography, we can determine the actual hit in virtual world.
8. From target and hit information, accuracy of shooting can be determined.

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- **Pointer detection:**
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- **Homography between screen and projector:**
  - Required for accurately mapping back screen coordinate to virtual world coordinate.

Action Plan

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1. Implementation for single shooter planar display.

Action Plan

1. Implementation for single shooter planar display.
2. Displaying on any surface.

Action Plan

1. Implementation for single shooter planar display.
2. Displaying on any surface.
3. A multi-shooter team arena situation.

THANK YOU !!