Archeoviz: Improving the Camera Calibration Process

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Project Description

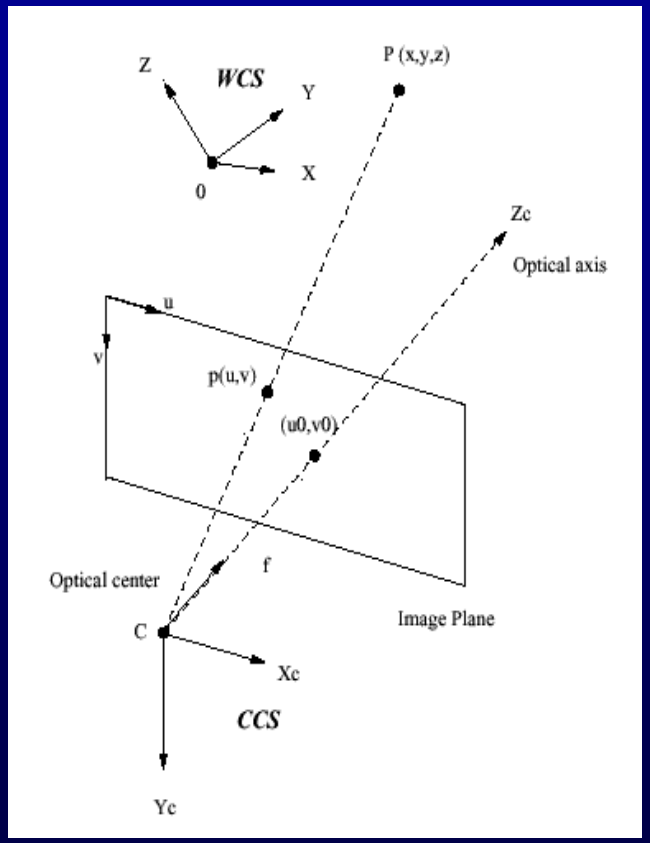
- Problem
  - Complete 3-D reconstruction of site in Tiwanaku, Bolivia
  - Program for archeologists in field
  - Accurate 3-D displays from photos of scenes
  - Easy and helpful tool for studying sites, collecting data
  - Create displays in only a few minutes

Mathematical Background

- Mathematical Components
  - Camera calibration
    - Intrinsic Parameters – Pixels to Rays in space
    - Extrinsic Parameters – Location of Camera
  - Stereoscopic reconstruction
- Calibration necessary before any model building
- Main Goal – Develop program to make calibration fast, easy for user
- Allows user to quickly proceed to building models for study, data collection

Approach to Solution Calibration of Cameras

- Uses markers placed in photos at locations with known world coordinates
- To calibrate, user locates markers and records their image coordinates
- From correspondences, solve linear system and compute projection matrix



The Search for Markers

- Previously, user locates markers and records image coordinates by hand
  - Long process, markers small and often difficult to find
- Calculation of projection matrix done in separate program
- Implemented new algorithm where user only needs to locate six points in image
- Calculates projection and predicts location of remaining markers automatically
  - More accurate if points are farther apart

The Search Simplified

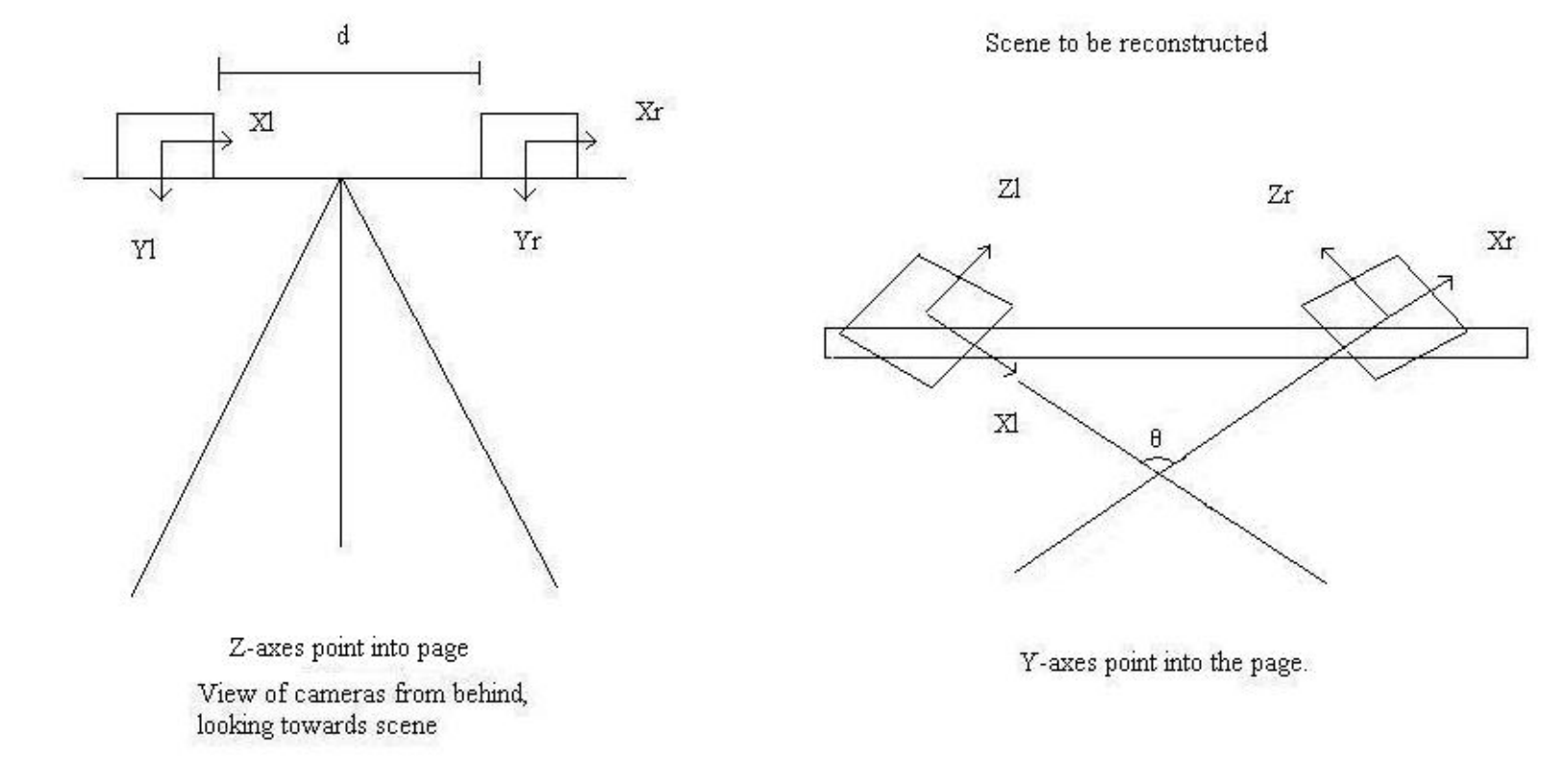
Six Points Algorithm

- Program zooms to each predicted location one by one to allow user to click on marker
- After all markers found, recalculates projection and automatically records image coordinates
- More friendly graphical user interface
  - Easy to use zooming to get accurate coordinates
  - File browsing – loading images, saving calibration data
- Implemented in C++, OpenGL graphics library
- Makes calibration easier for user and faster by eliminating time needed to find markers

Stereo Pairs Of Images

- Stereoscopic reconstruction requires “left” and “right” images
- Extract intrinsic and extrinsic parameters from projection matrix
- Estimate “right” projection matrix using “left”

Left and Right



- Translation along x-axis by distance *d*
- Rotation about y-axis by angle *θ*

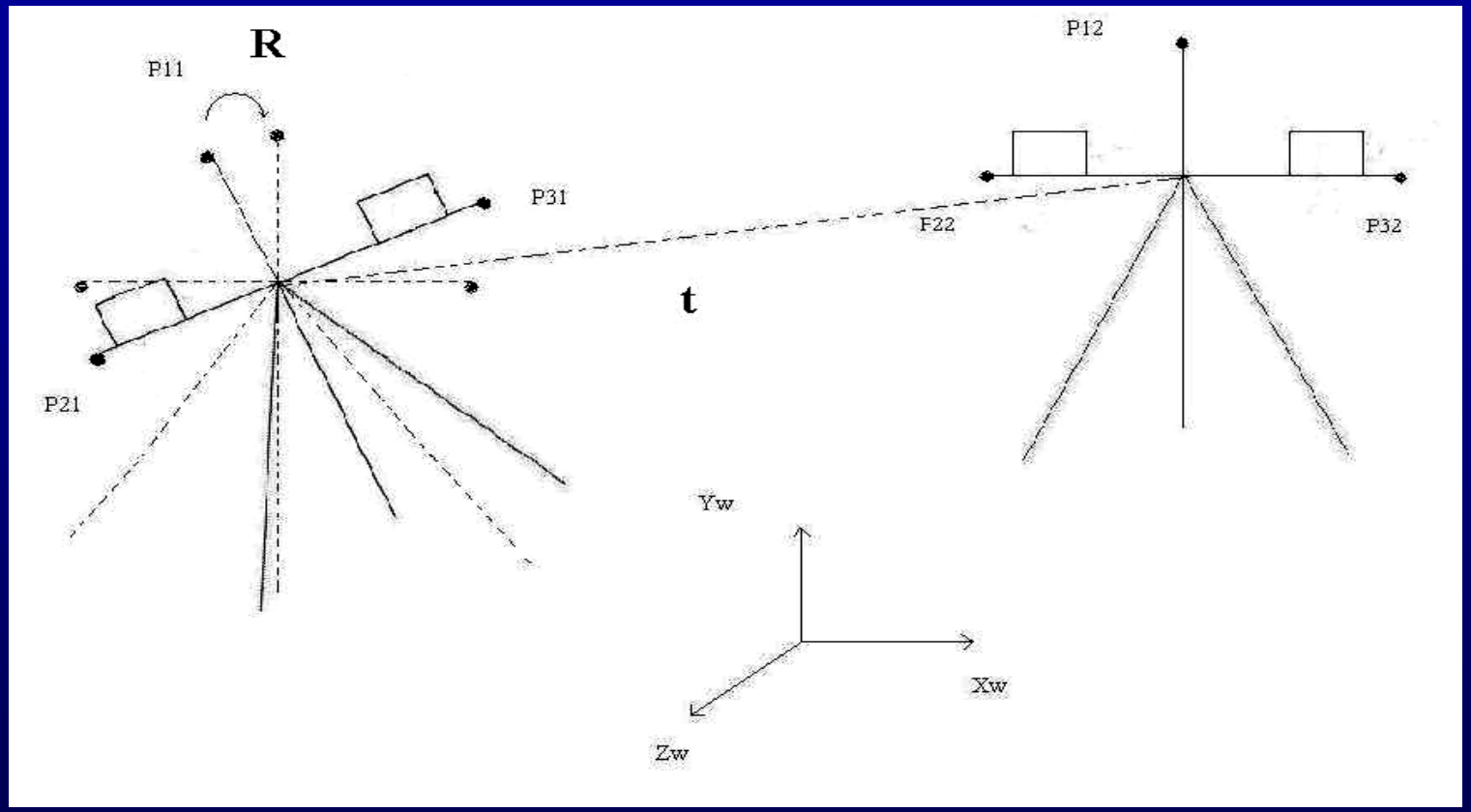
Program Extension I

- Extension to original program, calibrate left and right at once
- Left calibration done exactly as before
- User specifies d and θ
- Calculate transformation from left to right
- Using transformation, projection matrix from left, estimate projection matrix for right image
- Predict location of all markers in right image, draw blue circles as before

Tripod Points

- To get full 360º, have stereo pairs from multiple view points
- Need calibration for 6 to 16 stereo pairs for each scene
- New method can estimate projections of all stereo pairs from projections of first pair
- New data from archaeologist, measure world location of three points on tripod
- For each subsequent picture location, measure same three points

Program Extension II



- Rotation and translation between tripod positions
- Cameras attached rigidly, same transformation between cameras

Conclusions

- Major goal was to make calibration as fast and easy as possible
- Included easy to use graphical interface
- Use three methods of predictions to greatly speed up locating of markers
- Now, user needs only to find 6 markers themselves to do calibration for all images for a given scene
- User can more quickly proceed to building valuable models