Visualization of Cultural Heritage

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Summer 2010

Who am I?

- 2nd year BS Computer Science student at University of California, San Diego
- UCSD Mentor: Jurgen Schulze
- Host Mentor: Shinji Shimojo

Proposed Research

- The goal of our collaborative project is to visualize cultural artifacts on a tiled display wall (TDW)
- We hope to incorporate camera-based user tracking so that the perspective of the 3D object will change in accordance to where the audience is located

My Component

- Responsible for generating the content that Lex would interact with
- Base off the existing Bundler algorithm and improve to accommodate stereo image pairs

What is Bundler?

- "Bundler is a structure-from-motion system for…image collections…written in C and C++"
- "Bundler takes a set of images, image features, and image matches as input, and produces a 3D reconstruction of camera and (sparse) scene geometry as output"
- Similar to Microsoft Photosynth

Motivation for this Project

- Stereo Image Pairs
  - Generate a better, more detailed point cloud
- SURF over SIFT
  - Speeded Up Robust Features
  - Scale Invariant Feature Transform
  - Faster and more robust
- Openness
  - "In-house", "done at UCSD"
  - Greater understanding of internal workings
  - Easier to modify/change

Initial debate: CGLX vs. COVISE

- Both are options to interact with TDWs
  - CGLX – Falko Kuester
  - COVISE – Jurgen Schulze
- Decided to use COVISE
  - Sasha Koruga's PhotosynthVR plugin
    - "in-house", "done at UCSD"

What I Do (in a nutshell)

- Calculate certain parameters and values and print output in a certain format so that PhotosynthVR plugin can handle it
- What format? Bundler format

What I Need

- I need to generate / calculate / provide the following values and parameters
- Camera entry
  - <f> <k1> <k2> [the focal length, followed by two radial distortion coeffs]
  - <R> [a 3x3 matrix representing the camera rotation]
  - <t> [a 3-vector describing the camera translation]

What I Need (cont.)

- Point Entry
  - <position> [a 3-vector describing the 3D position of the point]
  - <color> [a 3-vector describing the RGB color of the point]
  - <view list> [a list of views the point is visible in]

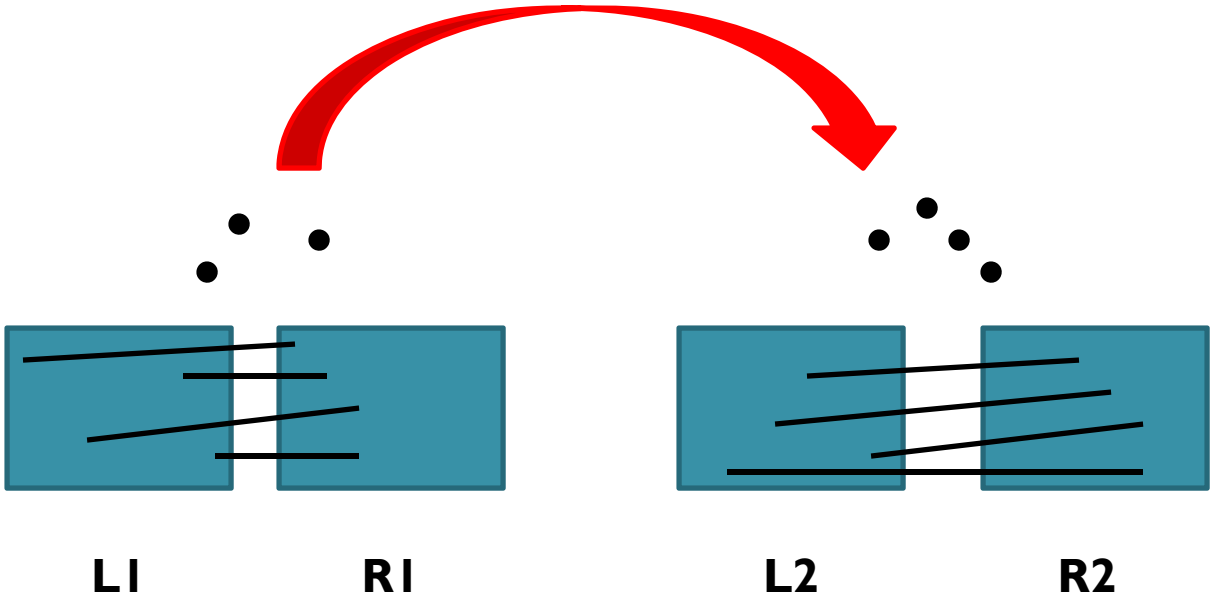
How I Do This

- The crux of my work involves calculating:
  - 4x4 matrices (the <R> and <t> values mentioned earlier)
  - positions of the 3D points

OpenCV

- Utilize OpenCV, a C++ library for computer vision
- Use cvExtractSURF method to extract Speeded Up Robust Features from an image
- Find correspondences between two images of the same object

Overall Diagram



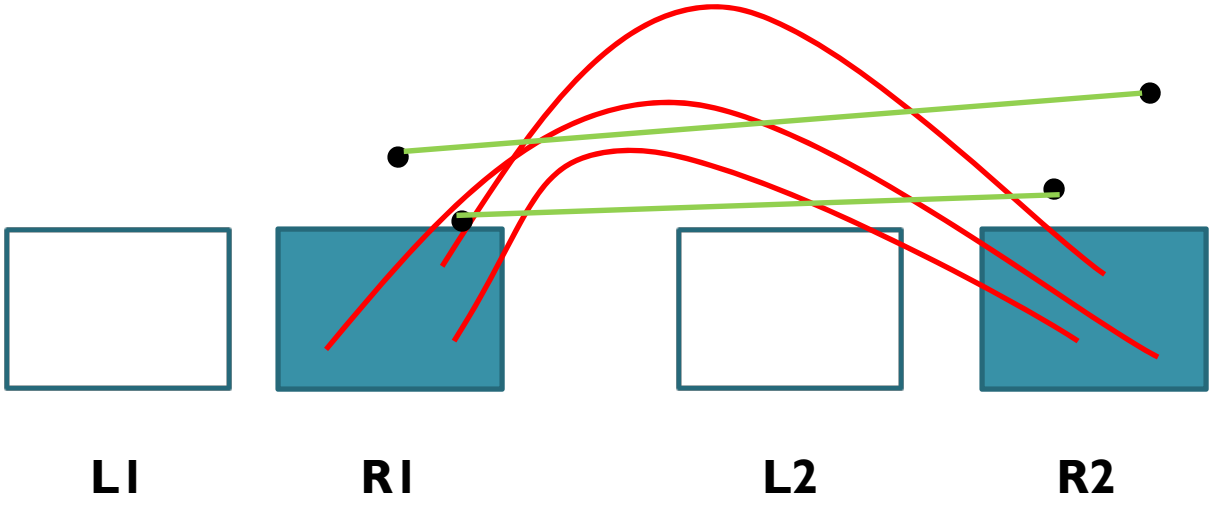
There are 2 stereo image pairs, L1 R1 L2 R2

Explanation

- I am able to say, "this feature point in image1 (x1,y1) corresponds to that feature point in image2 (x2,y2) and the associated 3D point (using cvTriangulatePoints) is (x, y, z)"
- The 4x4 matrix is “the red arrow” that correlates the two views, from one coordinate system to another

Explanation (cont.)

- I use C++'s std::map functionality to find the 3D points associated with the points that match in 2D (R1 and R2)
- NOTE: R1-R2 is arbitrarily chosen, could have also done L1-L2



The 4x4 Matrix

- I isolate 4 of those 3D points to create the 4x4 matrix:

  [x1 x2 x3 x4; y1 y2 y3 y4; z1 z2 z3 z4; 1 1 1 1]

  for both the views P and P'

  (<x, y, z, 1> is a position vector)

  And solve for the transformation matrix X:

  $$X*P=P'$$

  $$X = P' * inv(P)$$

- I then apply the transformation matrix to all the 3D points in P to determine their location in the coordinate system of P'
- So now points should be in same coordinate system?

Reprojection Error

- BUT, this is not a rigid transformation!
- Objects will be skewed a little due to errors stemming from:
  - Imperfect projection model
  - Inaccurate camera calibration
  - Inaccurate 2D feature coords in image space
  - Numerical errors
  - Etc.
- Matrix will transform a point to another location correctly for only the four points used in the calculation but not for an arbitrary case…

Solution: Orthonormalized Matrix

- I take the rotation part (3x3) as [X Y Z] (making sure |X| = |Y| = |Z| = 1) and make a new Z' = X x Y, then Y'= Z' x X, to get [X, Y' Z']
- I finally have the values I need
  - <R> [a 3x3 matrix representing the camera rotation]
  - <t> [a 3-vector describing the camera translation]
  - positions of the 3D points

Camera Calibration Matrices

- To get "<f> <k1> <k2> [the focal length, followed by two radial distortion coeffs]" I calculate the camera intrinsics and extrinsics
- Utilize the provided OpenCV sample code, stereo_calib.cpp along with photographs taken from my Fuji W1 stereo camera
  - Use StereoPhoto Maker to break up MPO file format into left and right side images

Problems

- Unfortunately, due to errors in logic and/or in my code, I continued to experience issues in displaying the point cloud correctly
  - Outliers…
- I need to consider "bandle adjustment" to find a matrix that minimizes the reprojection error

Nara Festival

- FALLBACK PLAN
  - We resort to using Bundler to create bundle.out, which is fed to PhotosynthVR plugin to display on TDW
- Will work with Professor Jurgen Schulze upon my return to get algorithm to work correctly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下り
Down
2
電気街口
Akihabara Electric Town Exit
电器街出口 전기 상점가 출구
1
上り
Up


YOKOHAMA
COSMOWORLD


Hard Rock
CAFE


京都
きょうと
Kyōto
京
しんおおさか
Shin-Ōsaka
まいばら
Maibara


NiCT


平城宮跡
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1300年祭
ぜんとくん

Acknowledgments

- University of California, San Diego, PRIME, Calit2
  - Professor Jurgen Schulze
  - Dr. Peter Arzberger
  - Dr. Gabriele Wienhausen
  - Teri Simas
  - Jim Galvin
  - Tricia Taylor-Oliveira
  - Haili Wang, Phi Nguyen, Sasha Koruga
- NiCT(Koganei/Otematchi/Keihanna/Osaka)
  - Professor Shinji Shimojo
  - Yoshinori Kobayashi
  - Masaki Chikama
  - Professor Kiyoshi Kiyokawa