Automatic Panoramic Image Stitching

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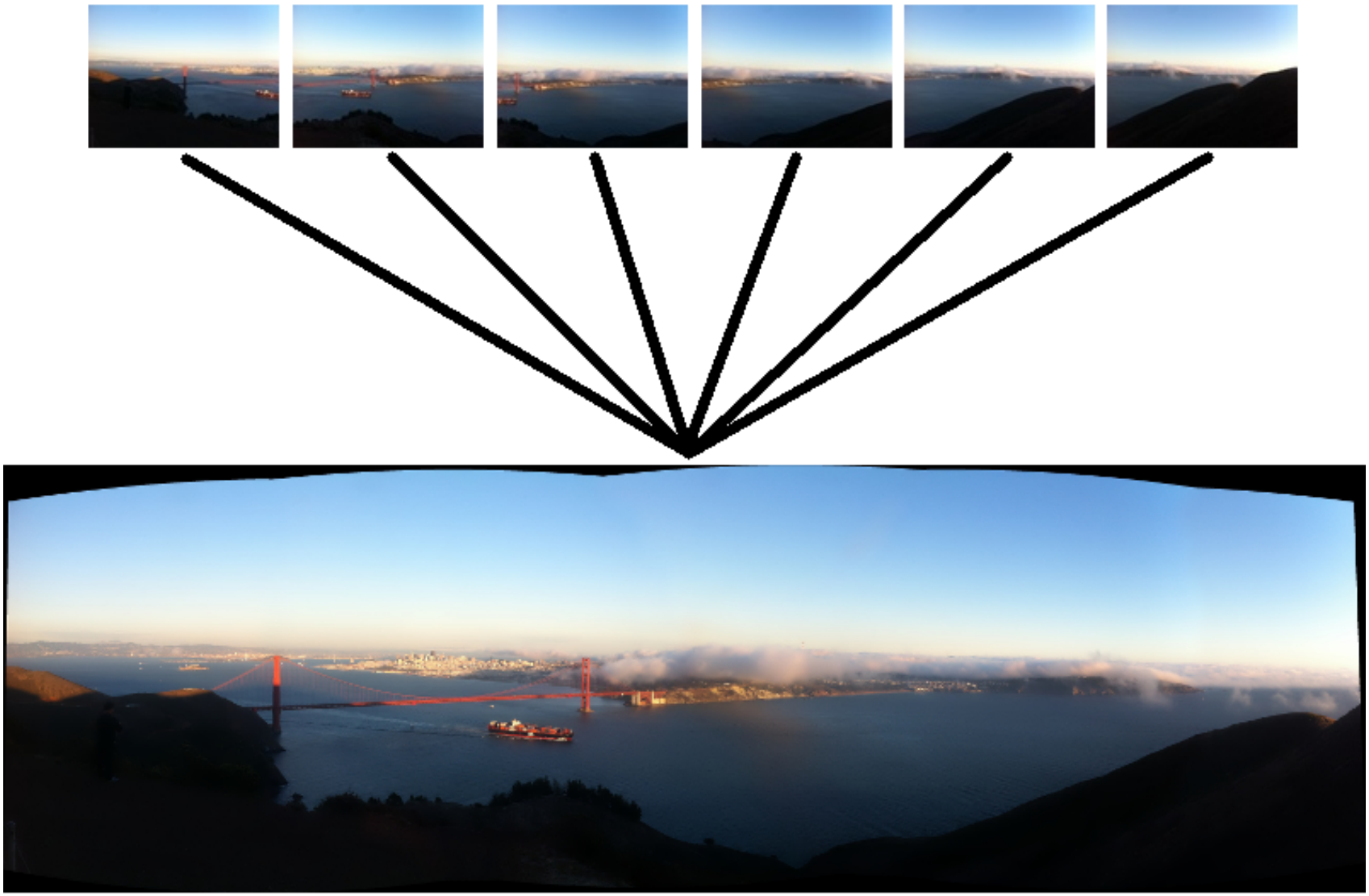
Example



Problem Definition

- Given an unsorted collection of images
  - Images may or may *not* fit together
- Find corresponding points in the collection of images
- Determine whether or not correspondences are valid
- Align images properly
- Warp images so corresponding points overlap
- Correct gain

Finding Correspondences

- In order to find correspondences between images, a homography for each image must be estimated
- This can be done in two different ways
  1. Direct: search for alignments of given images that minimizes the differences between overlapping images. Typically require initialization by the user and give a very accurate representation due to using all available image data.
  2. Feature-Based: involves identifying features within each image and then aligning images based on occurrences of matching features
- We are focusing on feature-based matching using SIFT (Scale-invariant feature transform) features to characterize our images. This allows for us to handle images with varying orientation and zoom.

Validity of a Correspondance

- In order to properly match images and align them to form a panorama it is important to verify that the image matches found using image features are accurate and valid.
- For each pair of matched images, a probabilistic model can be employed to verify that the match is correct.
- This process involves computing the probabilities that the set of geometrically consistent feature matches and feature matches that occur in an area of overlap but are not consistent were generated by a correct image match or a false image match.
- Once pairwise matches between the images have been verified, panoramic sequences can be expressed as connected sets of matching images.

Alignment with Bundle Adjustment

- Matching homographies would lead to issues
- Not all images would align
- Bundle adjustment [TMHF99] solves this problem

Straightening

- The resulting panorama may not be perfectly level
- Cameras are not perfectly level
- Assume camera is level relative to the horizon
- Straighten so the null space of the covariance of the horizontal axis is up

Gain Correction

- Modern consumer cameras adjust gain automatically from image to image
- Variation of lighting conditions over an image may necessitate changes in exposure and aperture settings across the panorama
- Minimize the gain normalized intensity error over all overlapping pixels ($\mathcal{R}(i,j)$)
- Solve for the gain parameters g_i, g_j.

$$e = \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}|\mathcal{R}(i,j)|\left(\frac{(g_i\bar{I}_{ij} - g_j\bar{I}_{ji})^2}{\sigma_N^2} + \frac{(1-g_i)^2}{\sigma_g^2}\right) \quad (1)$$

$$\bar{I}_{ij} = \frac{\sum_{u_i\in\mathcal{R}(i,j)} I_i(u_i)}{\sum_{u_i\in\mathcal{R}(i,j)} 1} \quad (2)$$

References

- W. Triggs, P. McLauchlan, R. Hartley, and A. Fitzgibbon. Bundle adjustment: A modern synthesis. In Vision Algorithms: Theory and Practice, number 1883 in LNCS, pages 298 373. Springer-Verlag, Corfu, Greece, September 1999.
- M. Brown and D. Lowe. Automatic Panorama Stitching using Invariant Features. IJCV, 2007.