Mosaicing Scenes with a Quadcopter

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Is mosaicing a solved problem?

- Visualizing large scenes with high quality requires camera movement along two dimensions (too tiring)
- Orthographic view of scenes may be infeasible
  - Too tall
  - Approach unavailable to people

Is mosaicing a solved problem?

- When scene patterns and texture are *repeated* (too many similar features), matching algorithms gets confused

Input Scene

AutoStitch[2] Output

- Also, matching algorithms fail if there are '*vacant spaces*': little or no overlap (in feature space) between images

Input Scene
Approx. 10 ft. height with gap of 2 ft.

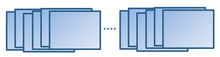
AutoStitch[2] Output: Second Picture Missing

Solution: Use an inexpensive quadcopter!

- However, even a 3 minute video overwhelms any mosaicing program such as Microsoft's ICE[1] (too many images)

Mosaicing with Quadcopter: Naïve Attempt

- Linear Scanning: attempt to create a mosaic in an incremental linear fashion by combining adjacent frames (circumvents vacant space problem?)

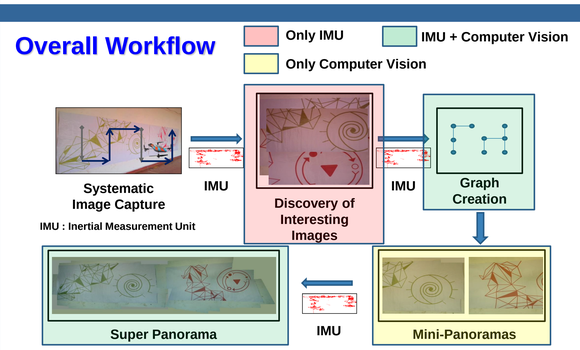


- Prone to loss of two-dimensional spatial proximal information

Quadcopter benefit: IMU

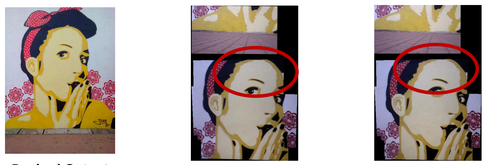
- Inexpensive quadcopters contain an inertial measurement unit (IMU)
  - After calibration, the IMU gives reasonable information of positions
- However,
  - Pitch and roll may be completely off due to jerky movement of the low cost device
  - Only IMU cannot be used to scale and reposition input images
  - GPS may not be present, and cannot be used in indoor environments

Overall Workflow

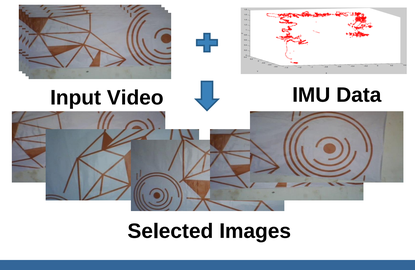


Interesting Images With Imprecise IMU!

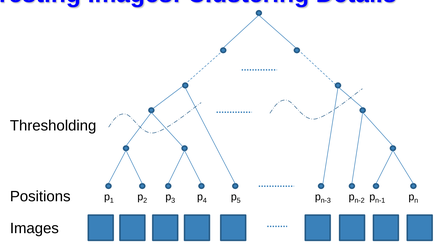
- Need to find minimum number of images from the video which 'covers' the scene
  - Uniform time sampled images does not help



- Scene coverage: IMU positional information gives us the clue
- Hierarchical agglomerative bottom-up clustering on the IMU data with appropriate threshold gives us the necessary positions
  - If pictured from only these locations, entire scene is covered



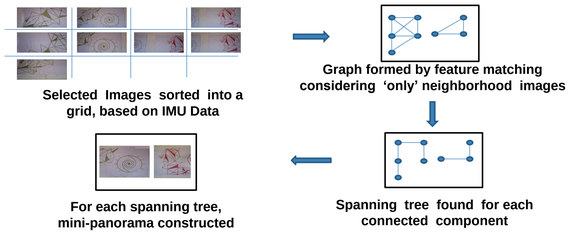
Interesting Images: Clustering Details



Interesting Images: Algorithm Validation

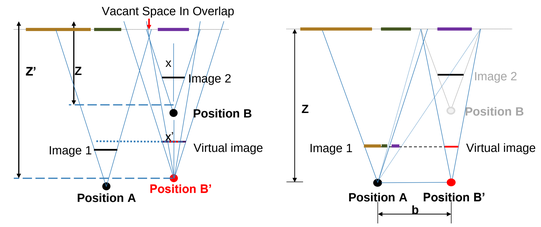
Graph Creation and Mini-panoramas

A mini-panorama is the desired output if there are no vacant spaces
IMU data is used to create mini-panoramas in O(N) time compared to O(N^2) time



Super Panorama as Stereo

A super panorama is the desired output in the presence of 'vacant' spaces



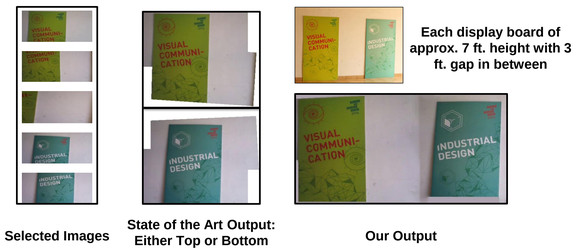
- "Move back" mini-panorama pictured from lesser depth to the depth of another mini-panorama
  - Zoom-out by the fraction proportional to the depth ratio

$$\frac{x}{x'} = \frac{Z}{Z'}$$

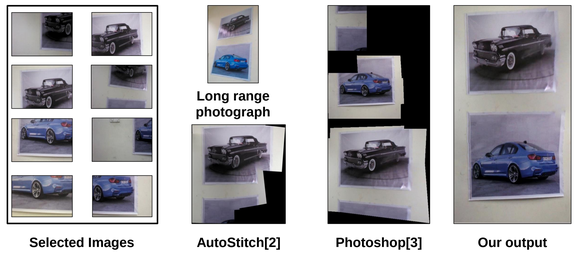
- Find disparity using stereo formula, i.e.,

$$\text{disparity} = \text{focal length}\,\frac{\text{displacement}}{\text{depth}}$$

Results: Vacant Spaces

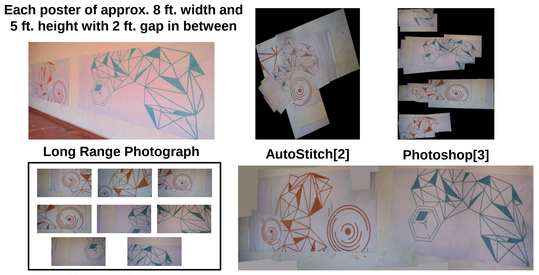


Results: Orthographic View



Original Dimensions: Each poster of approx. 4 ft. height with 2 ft. gap in between

Results: Confusing Features



Contributions

- We proposed a new problem of mosaicing large scenes orthographically
- Traditional mosaicing methods fail when scene contains repetitive patterns or vacant spaces
- We solved these problems efficiently using a combination of computer vision techniques, and with IMU data from an inexpensive quadcopter

References

[1] Microsoft Image Composite Editor, research.microsoft.com/en-us/um/redmond/groups/ivm/ICE/
[2] AutoStitch, matthewalunbrown.com/autostitch/autostitch.html
[3] Adobe Photoshop CS6, www.adobe.com/products/photoshop
[4] M. Brown and D. G. Lowe. Automatic panoramic image stitching using invariant features. International Journal of Computer Vision, 74(1):59–73, 2007
[5] M. Brown and D. Lowe. Recognising panoramas. In ICCV, 2003