Rapid Processing of Unmanned Aerial Vehicles Imagery for Disaster Management

Marcus Arthur, Raid Al-Tahir, and Dexter Davis
The University of the West Indies, Trinidad and Tobago

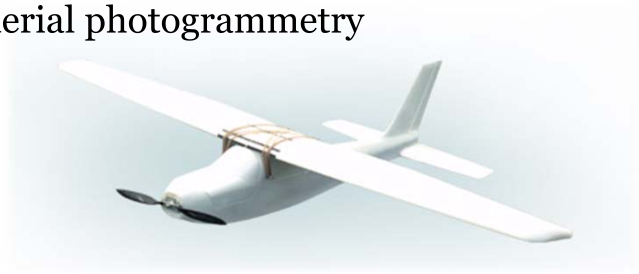
Presentation Outline:

- Unmanned Aerial Vehicles.
- SIFT Feature Extraction And Matching.
- Automatic Processing Workflow.

Key Words:
- Aerial Mapping,
- Unmanned Aerial Vehicles,
- Automatic Image Matching,
- Natural Disaster Management.

Unmanned Aerial Vehicles

- UAVs are increasing in popularity
- Low cost, high resolution, multi-temporal
- Close range aerial photogrammetry



Post Disaster Risk Management

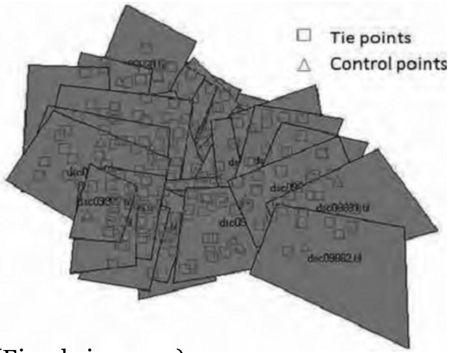
- Planning and execution of response action
- Role of geospatial information
- Disaster Mapping

Natural Disaster Mapping Requirements

- Real time/Rapid processing
- High Temporal Resolution
- High Detail/Spatial Resolution
- Automated Processes

UAV Trajectory Challenges

- Flight
  - Instability (Wind and thermals)



(Eisenbeiss 2009)

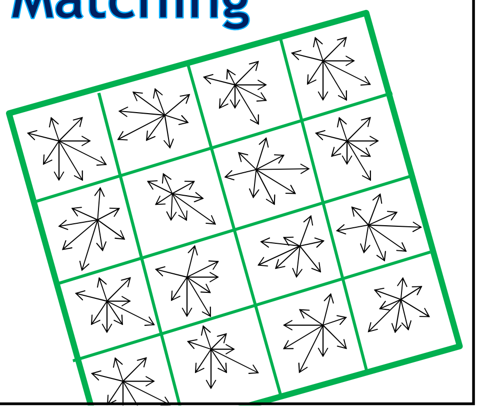
UAV Imagery Challenges

- Images
  - Large scale differences
  - Illumination changes
  - Occlusions
  - Convergent images
  - Larger number of high resolution images

Sample UAV Images

MAVinci Unamnned Aerial Systems (www.mavinci.eu)

SIFT Based Feature Extraction And Matching



Traditional matching

- Correlation Based Template Matching
  - Computationally expensive
  - Sensitive to variance
- Feature Based Matching
  - More robust
  - Sparse features

SIFT

- Scale Invariant Feature Transform
- Localized scale invariant features
- Invariant to scale, rotations and partially invariant to illumination changes and camera perspectives
- Image pyramid approach

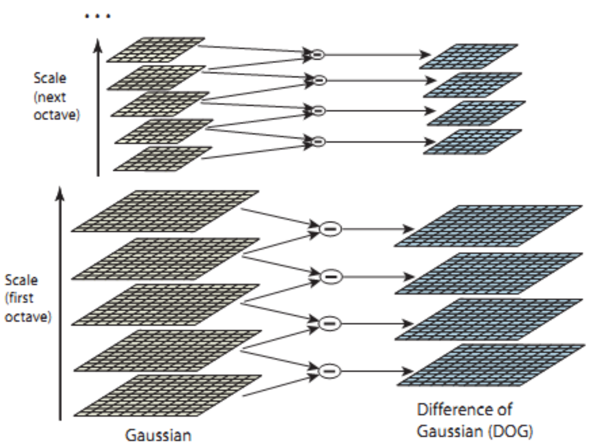
Scale Space Extrema Detection

- Detect features invariant of scale
- Construction of scale space L(x,y,σ)

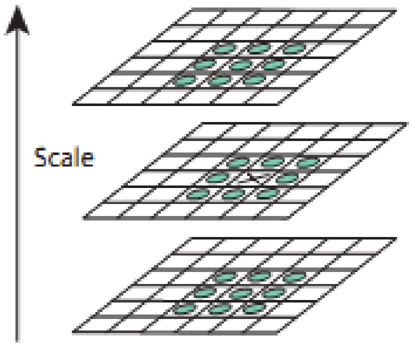
$$L(x, y, \sigma) = G(x, y, \sigma) * I(x, y), \qquad (1)$$

where $*$ is the convolution operation in x and y , and

$$G(x, y, \sigma) = \frac{1}{2\pi\sigma^2} e^{-(x^2+y^2)/2\sigma^2} \qquad (2)$$

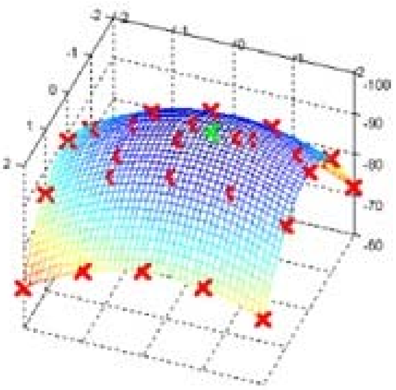


Local Extrema Detection



Keypoint Localization

- Candidates fitted to a detailed model to determine their scale and location
- The Taylor expansion is used to determine the interpolated location of the keypoints
- Edge and Low contrast point reduction



Orientation Assignment

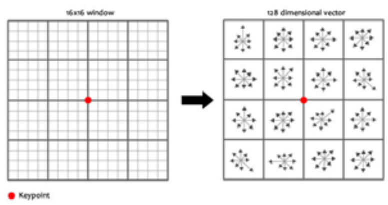
- Consistent orientation at each keypoint
- L(x,y) at the selected scale, the gradient magnitude, m(x,y), and orientation, θ(x,y), are calculated

$$m(x,y) = \sqrt{(L(x+1,y) - L(x-1,y))^2 + (L(x,y+1) - L(x,y-1))^2}$$

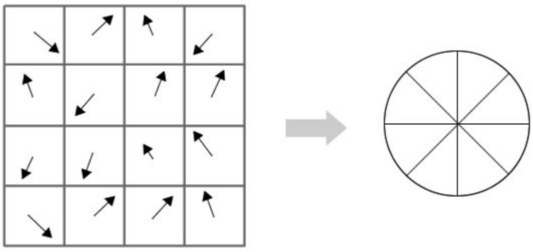
$$\theta(x,y) = \tan^{-1}((L(x,y+1) - L(x,y-1))/(L(x+1,y) - L(x-1,y)))$$

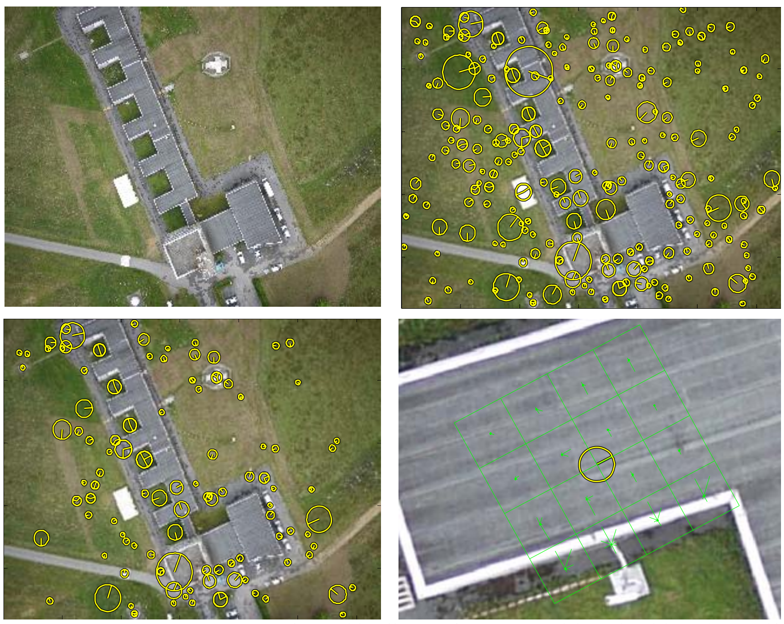
Keypoint Description

- Parameters are then assigned to a distinctive feature descriptor
- Local image gradients at selected scale
- Gradients are then distributed into orientation histograms composed of 8 bins over a 4x4 region



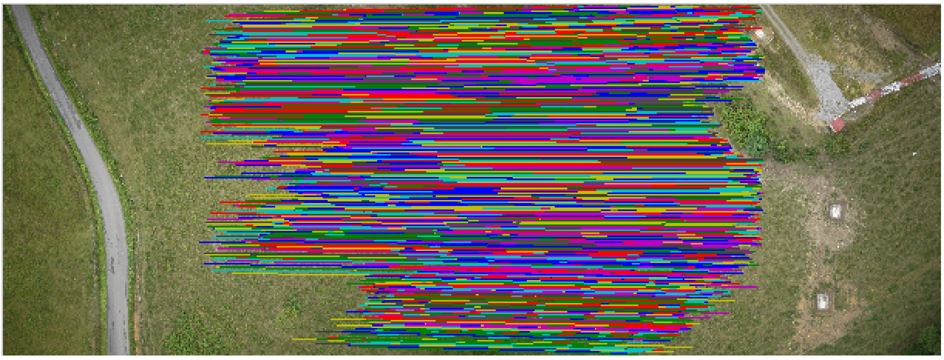
- Transformation to 128 element vector
- Normalized to reduce the effects of illumination variance



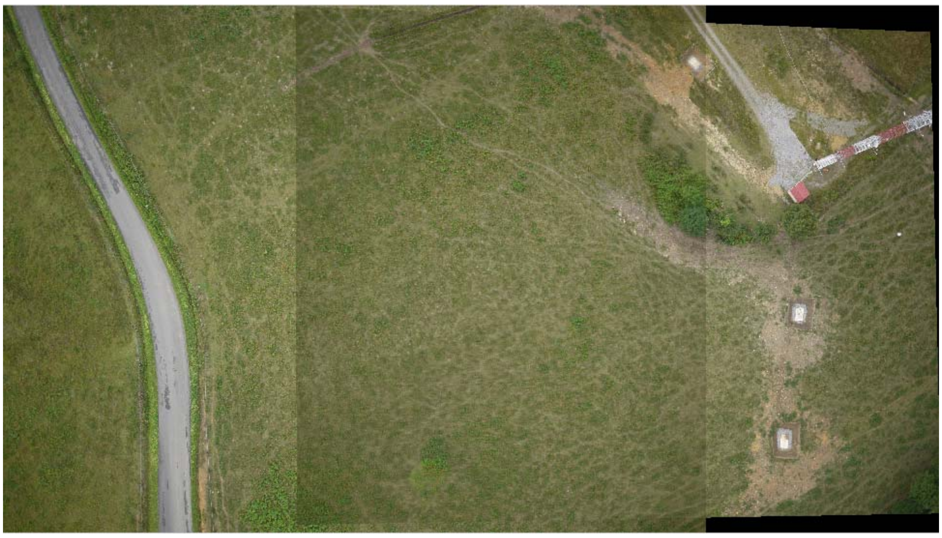


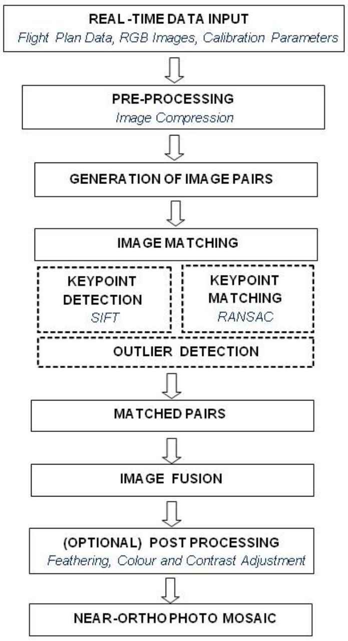
VLFeat: An Open and Portable Library of Computer Vision Algorithms (www.vlfeat.org)

Sample Processing



VLFeat: An Open and Portable Library of Computer Vision Algorithms (www.vlfeat.org)





Proposed Workflow

The workflow will be implemented and subsequent experiments will be performed using UAV imagery.

Further expansion of the workflow will include the measurement of control points and the bundle adjustment process required to generate numerical products such as DSM or DEM.

Conclusion

- Rapid Processing
- Computer Vision techniques
- Future Work

References

- Al-Tahir, R., Arthur, M., and Davis, D. 2011. Low Cost Aerial Mapping Alternatives for Natural Disasters in the Caribbean, FIG *Working Week 2011, Bridging the Gap between Cultures*, Marrakech, Morocco.
- Barazzetti, L., Remondino, F., Scaioni, M., Brumana, R. 2010. Fully Automatic Uav Image-Based Sensor Orientation, in *Proc. ISPRS Commission I Mid-Term Symposium 'Image Data Acquisition - Sensors & Platforms'*, vol. 12.
- Bay, H., Tuytelaars, T., and Van Gool, L. 2008. SURF: Speeded Up Robust Features, *Computer Vision and Understanding (CVIU)*, 110 (3):346-359.
- Beis, J. and Lowe, D. 1997. Shape Indexing Using Approximate Nearest-Neighbour Search in High-Dimensional Spaces, in *Proc. Conference on Computer Vision and Pattern Recognition*, 1000-1006.
- Bendea, H., Boccardo, P., Dequal, S., Giulio Tonolo, F., Marenchino, D. and Piras, M. 2008. Low Cost Uav For Post-Disaster Assessment, *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*. Vol. XXXVII. Part B8. Beijing, 1373-1380.
- Eisenbeiß, H. 2009. *UAV Photogrammetry*, PhD Thesis, Institut für Geodäsie und Photogrammetrie, Eidgenössische Technische Hochschule Zürich, Zurich.
- Hough, P.V.C. 1962. Method and means for recognizing complex patterns. U.S. Patent 3069654
- Jena, S. 2003. The Emerging paradigm of Local Governance, Disaster Management and Role of Local Institutions in India, Edited by T. M. Joseph. Local Governance in *India: ideas, challenges and strategies*. Thodupuzha, India: Concept Publishing Company, 536.
- Lindeberg, T. 1994. "Scale-space theory: A Basic Tool for Analysing Structures at Different Scales", *Journal of Applied Statistics*, 21(2): 224–270.
- Lowe, D. 1999. Object Recognition from Local Scale-Invariant Features' in ICCV'99, 1150-1157.
- Lowe, D. 2004. Distinctive Image Features from Scale-Invariant Keypoints, *International Journal of Computer Vision*, 60 (2):91-110.
- UAV International, Unmanned Aircraft Systems: The Global Perspective (2010-2011 Yearbook), P. van Blyenburgh (editor), Blyenburgh & Co. France.
- Witkin, A. 1983. Scale-space filtering. *In International Joint Conference on Artificial Intelligence*, Karlsruhe, Germany, 1019-1022.

Acknowledgements

- MAVinci Unamnned Aerial Systems (www.mavinci.eu)
- VLFeat: An Open and Portable Library of Computer Vision Algorithms (www.vlfeat.org)
- Dr. Cathy-Ann Radix
- Mr. Akash Pooransingh
- Dr. Bheshem Ramlal
- UWI Campus Research Grant