Detecting Transient Surface Features via Dynamic Landmarking

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Image credit: HiRISE, 2/19/2008
Outline

• Goal: Detect transient surface features
  • Pixel-Based Change Detection
  • Landmark-Based Change Detection
• Features: dark slope streaks, dust devil tracks on Mars
• Current Results
• Next Steps
Transient Surface Features

June 12, 2000

April 12, 2002

Image credit: MOC
Transient Surface Features

New dark slope streaks

Image credit: MOC

June 12, 2000

April 12, 2002
Pixel-Based Change Detection

- Register two images
- Derive mapping from SIFT features
- Detect pixel changes
- Create difference image
- Threshold on difference image
Pixel-Based Change Detection

Image 1

Image 2

Image credit: MOC

Adnan Ansar
Pixel-Based Change Detection

Image 1

Image 2

Image credit: MOC

Adnan Ansar
Pixel-Based Change Detection

Image 1

Image 2

Difference image

Image credit: MOC

Adnan Ansar
Pixel-Based Change Detection

Image 1 - Image 2 = Difference image

Image credit: MOC
Adnan Ansar
Registration Improvements

- Global match
- Local refinement
- Quadratic refinement

False color indicates magnitude of change

Automatic labeling of changed pixels using dynamic threshold

Image credit: MOC
Registration Improvements

Global match

Local refinement

False color indicates magnitude of change

Automatic labeling of changed pixels using dynamic threshold

Image credit: MOC

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Registration Improvements

Global match  Local refinement  Quadratic refinement

False color indicates magnitude of change

Automatic labeling of changed pixels using dynamic threshold

Image credit: MOC
Landmark-Based Change Detection

VS. =
Landmark-Based Change Detection

vs.

=
Landmark-Based Change Detection

VS.

=
Landmark-Based Change Detection

vs.

vs.

=
Landmark-Based Change Detection

VS. VS. =
Landmark-Based Change Detection
Intensity Histograms

HiRISE PSP_003570_1915

$w_1$

$w_2$
Salient Landmark Selection

- How much does a window stand out from its neighbors?
  \[ D_{KL}(w_1 || w_2) = \sum_i w_1(i) \log \frac{w_1(i)}{w_2(i)} \]

- Sort windows by their average KL-divergence salience (across all neighbors)

- **Evaluation:**
  - One-to-one matching of detected landmarks and manual annotations for each feature
  - Thank you to science collaborators!

Early version presented at 2007 Fall American Geophysical Union Meeting
Dark Slope Streaks
Detections given salience threshold

Original

HiRISE PSP_003570_1915
Dark Slope Streaks

Detections given salience threshold

Original

>= 1.89

Match

Manual

HiRISE PSP_003570_1915
Dark Slope Streaks

Detections given salience threshold

Original

>= 1.89

Match

>= 1.45

No match

HiRISE PSP_003570_1915
Dust Devil Tracks

Detections given salience threshold

>= 1.96
>= 0.81
>= 0.28

Dust devil track annotations by Melissa Bunte (ASU)
ROC Curves

- Dark slope streaks easier to detect reliably
- Window size affects results
- Improve on one-to-one mapping?
Landmark Salience

as a function of window size

- Dark slope streaks more salient than dust devil tracks
Next Steps

- **Change Detection**
  - Use mutual information to mark changes
  - Apply landmark detection to difference image

- **Landmark Detection**
  - Improve efficiency, extend to rectangles
  - Integral Histogram computation [Porikli, 2005]

- **Landmark Type Classifier**
  - Ridge, crater, streak, track, gully, etc.
  - Summer student: Julian Panetta (Caltech)

Thank you! Any questions?

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