

Scene Context Dependency of Pattern Constancy of Time Series Imagery

Glenn Woodell

Daniel J. Jobson

NASA Langley Research Center
Hampton, VA

Zia-ur Rahman

Old Dominion University
Norfolk, VA

SPIE Defense + Security
Orlando, Florida
March 19, 2008

NASA's 2006 Strategic Plan

Given: Increased air traffic

Result: Increased pilot load

Action: Safer aircraft and higher capacity
airspace systems

Flight Decks of the Future

- Sense internal and external hazards
- Evaluate these hazards
- Provide key information to the pilot/aircraft
- Allow for timely and appropriate response by pilot/aircraft

Result: Intelligent Integrated Flight Deck

Intelligent Integrated Flight Deck

- Advanced crew/vehicle interface technologies
- Enable detection of unsafe behaviors
- Fail-safe for changing the operator/automation roles
- Timely detection of external hazards*

External Hazards

Meteorological

Icing conditions
Convective weather
Wind gusts
Turbulence

Airspace constraints/restrictions

Environmental*

Traffic*

Geospatial*

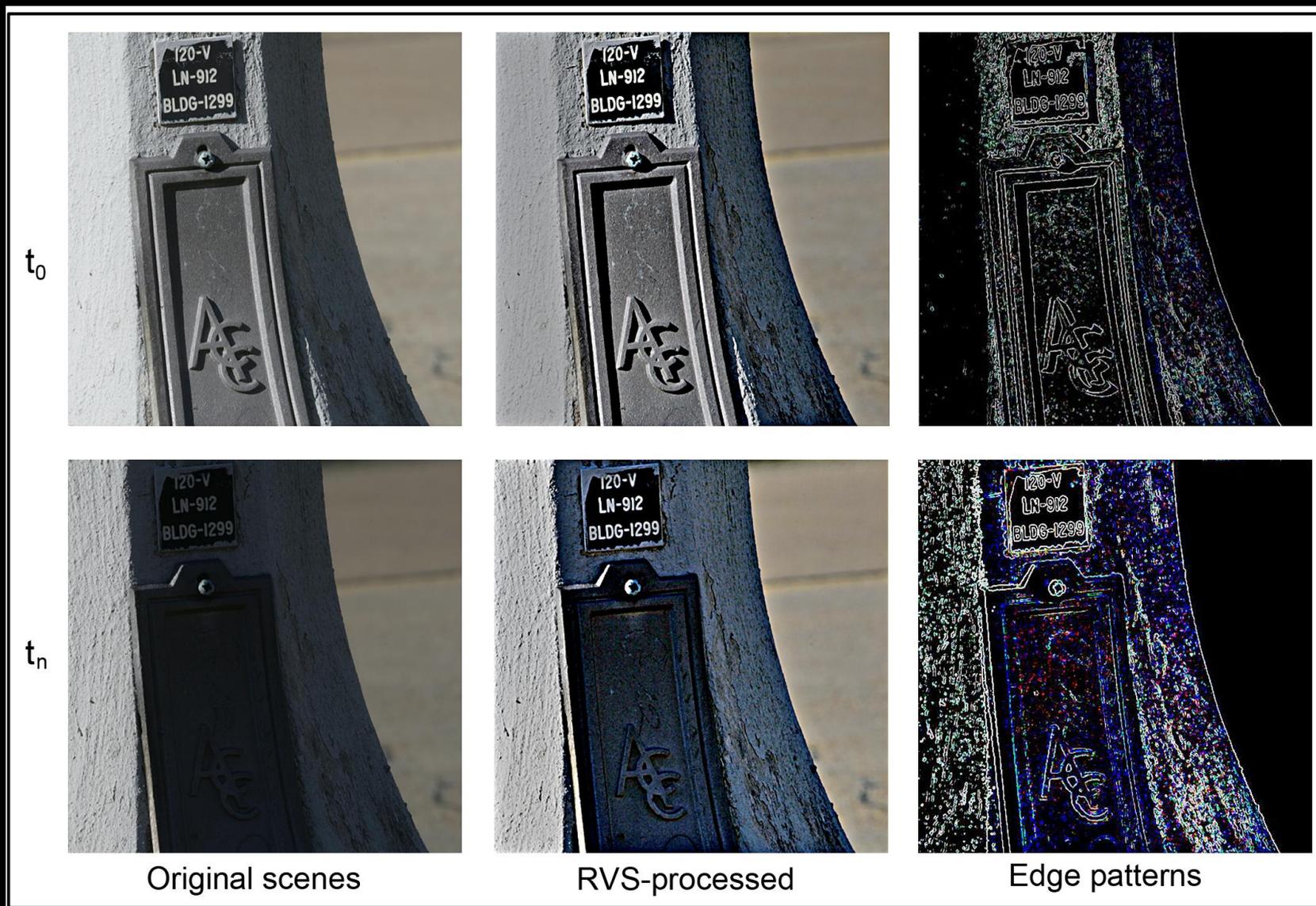
- Terrain
- Man-made obstacles
- Foreign object debris

**Imaging sensors*

How do We Detect Hazards?

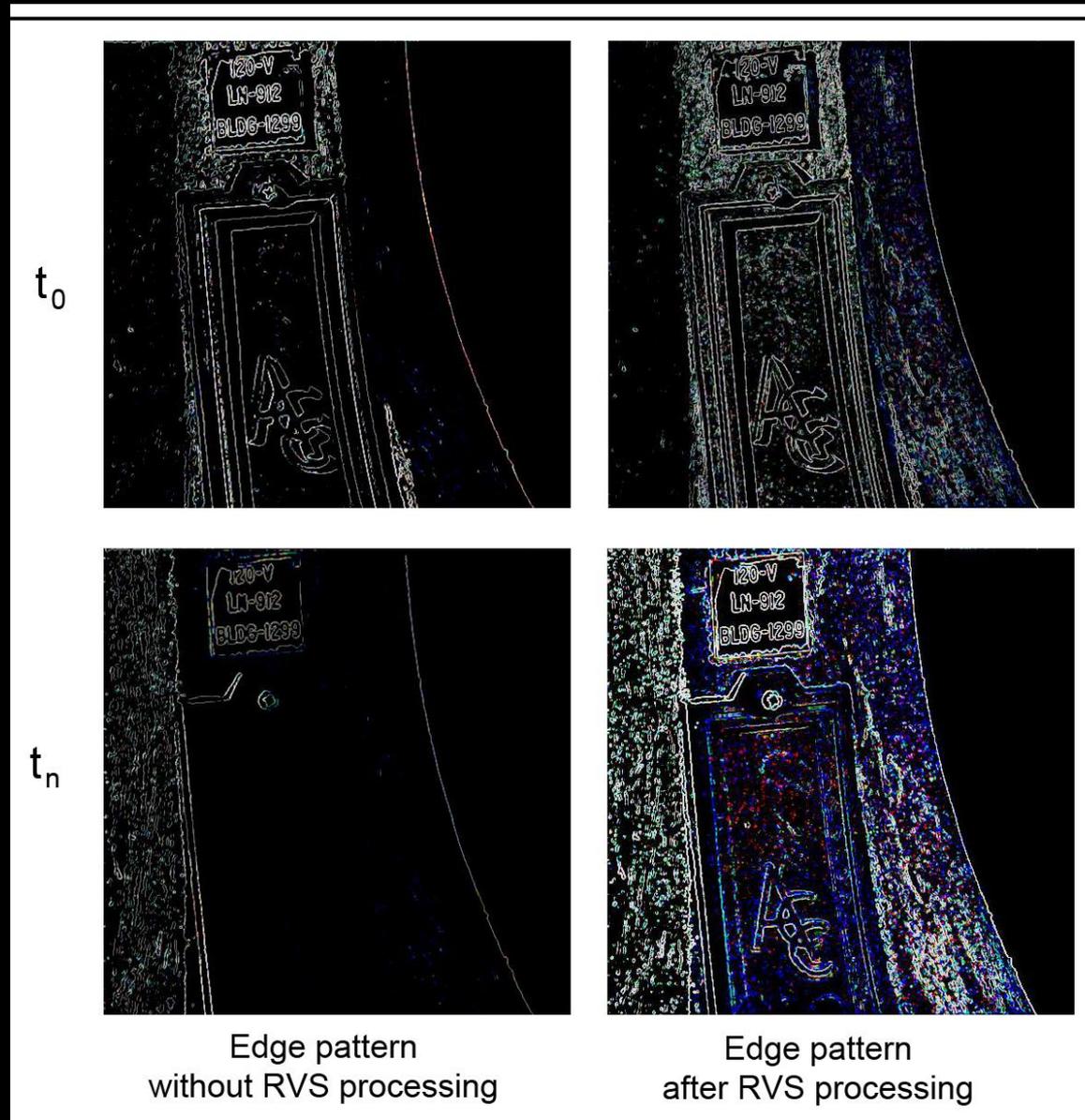
Use edge detection to generate edge patterns
to compare with edge patterns of known scenes

Our Pattern Recognition Process



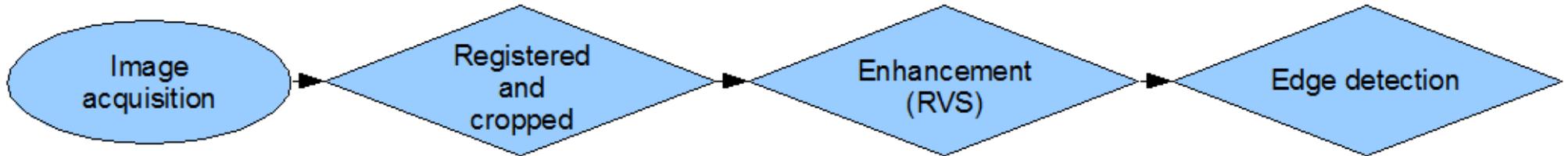
Similar patterns in widely-varying illumination

But is the extra step of enhancement necessary?



Enhancement with Retinex/Visual Servo (RVS)

The Process



Canon
EOS-1Ds Mark II

Photoshop
CS2

Visual Servo

Langley-developed,
zero-crossing,
two-scale

$$\rho_{1,2} = \frac{\frac{1}{M_1 M_2} \sum_{m_1=0}^{M_1-1} \sum_{m_2=0}^{M_2-1} (g_1[m_1, m_2] - \bar{g}_1) (g_2[m_1, m_2] - \bar{g}_2)}{\sigma_1 \sigma_2}$$

Correlation coefficient for MxN images
Calculated only on green channel

What We Noticed

The ability to match a scene under different conditions varied greatly depending the content of the scene, both by scale and local topography*.

*Topography is defined for this work as relief in the scene which produces localized illumination variations.

This is as opposed to a reflectance-only scene in which the lightness values are not due to local shadow effects.

The Test Scenes



Nitrogen storage tank
very little small-scale topography

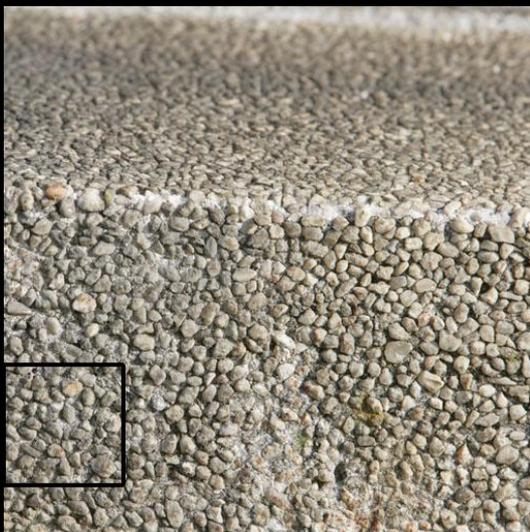
The Test Scenes



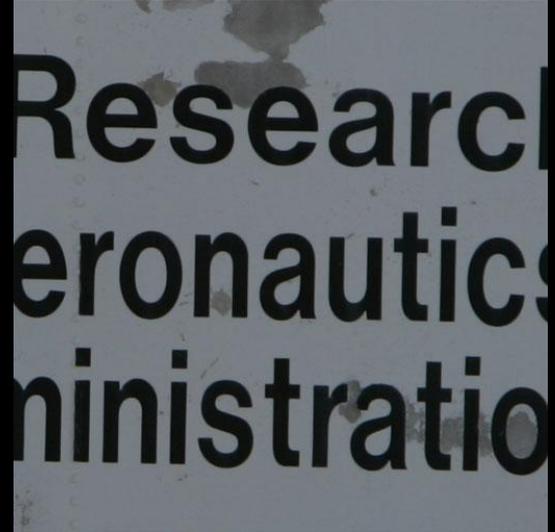
Tree bark
dominated by small-scale topography



Light pole
moderate small-scale topography

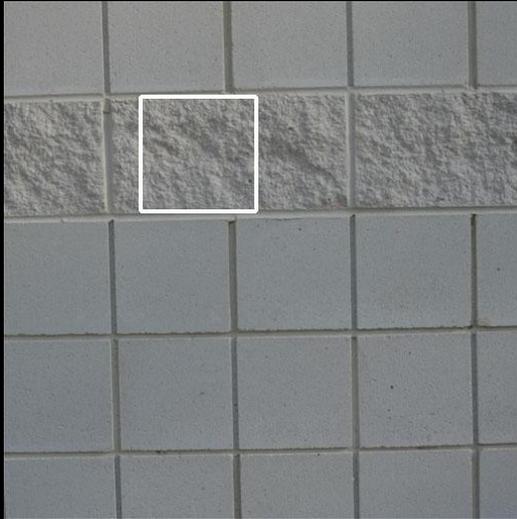


Stone steps
moderate small-scale topography

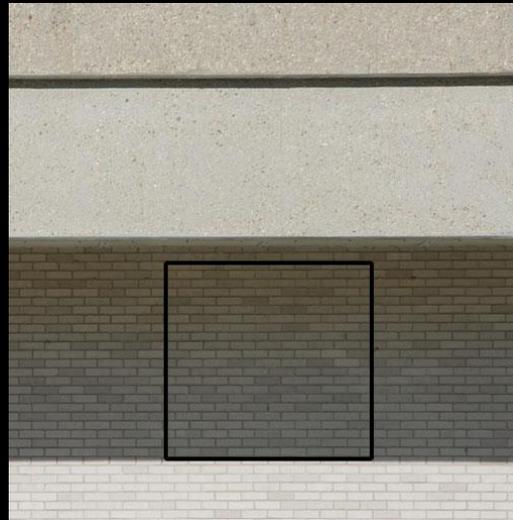


Lettering
dominated by reflectance

Test Scenes

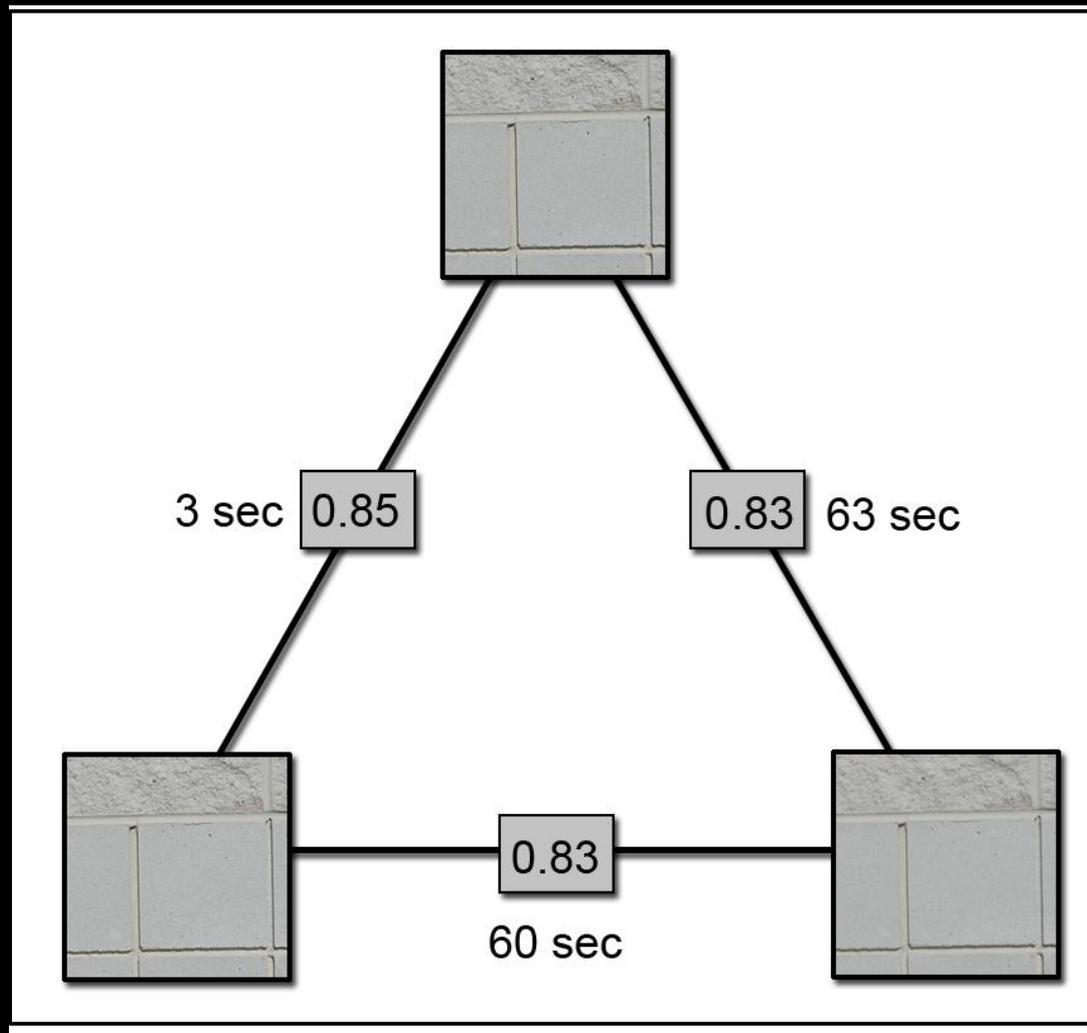


Brick wall
topography only



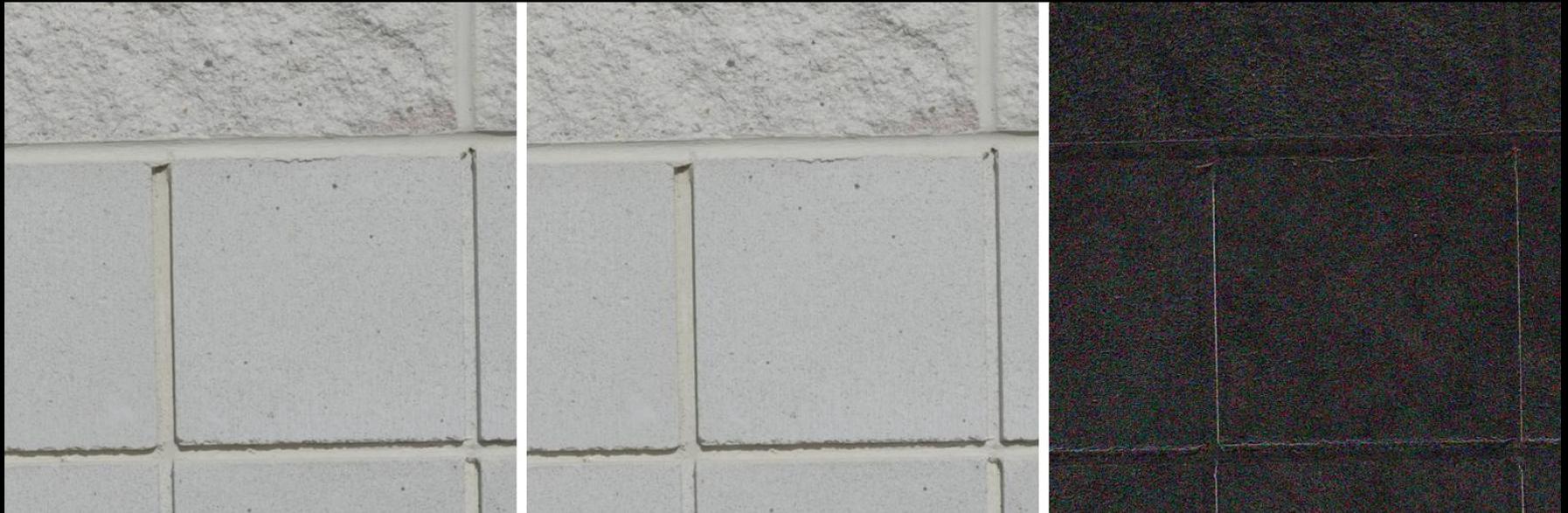
Brick wall
mostly reflectance

Our Best Case



“Match” assumed when correlation coefficient is 0.06 or higher

Good Correlation



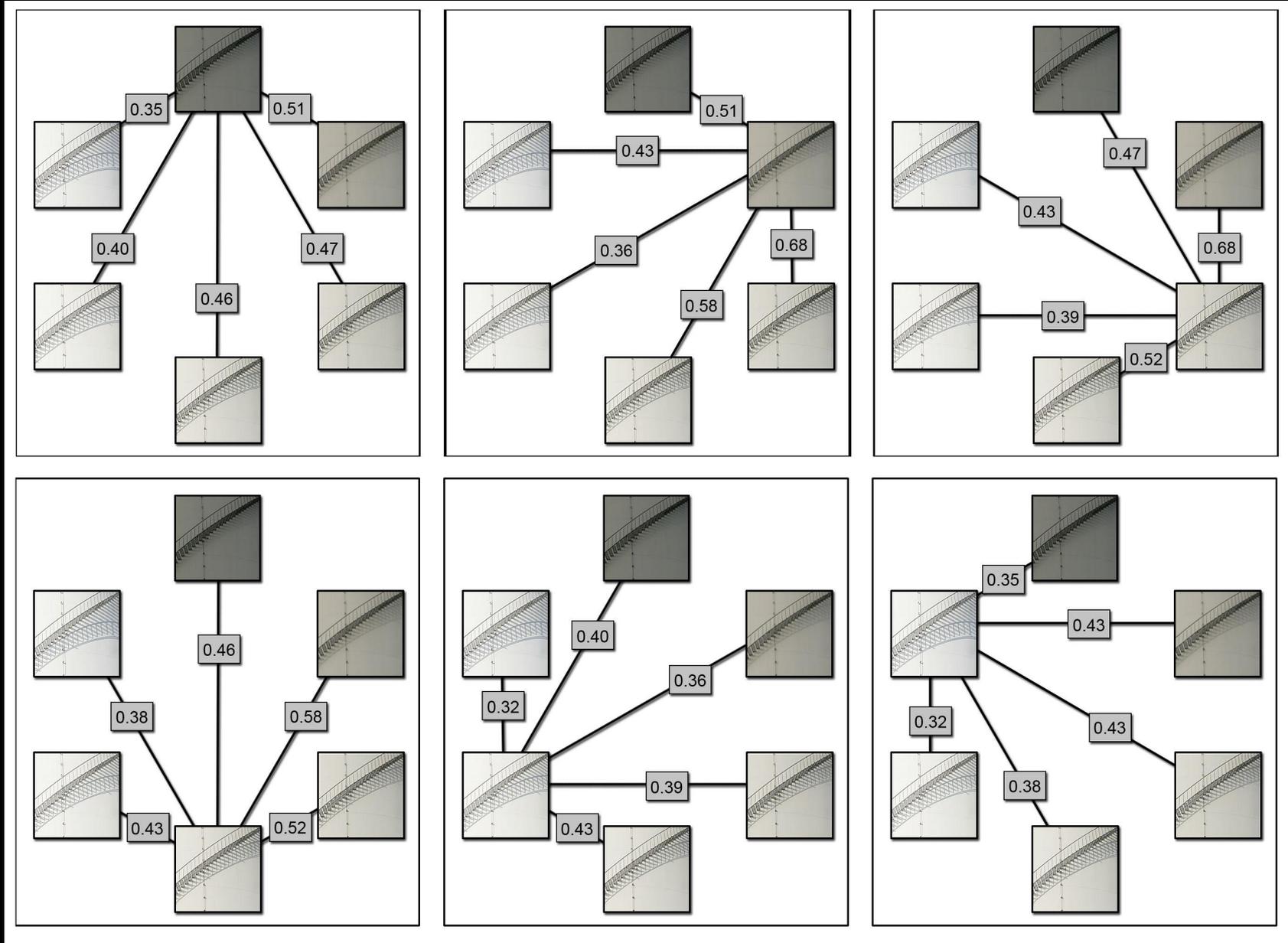
T_0

$t_{0+3\text{sec}}$

Edge pattern of $t_0 - t_{0+3\text{sec}}$

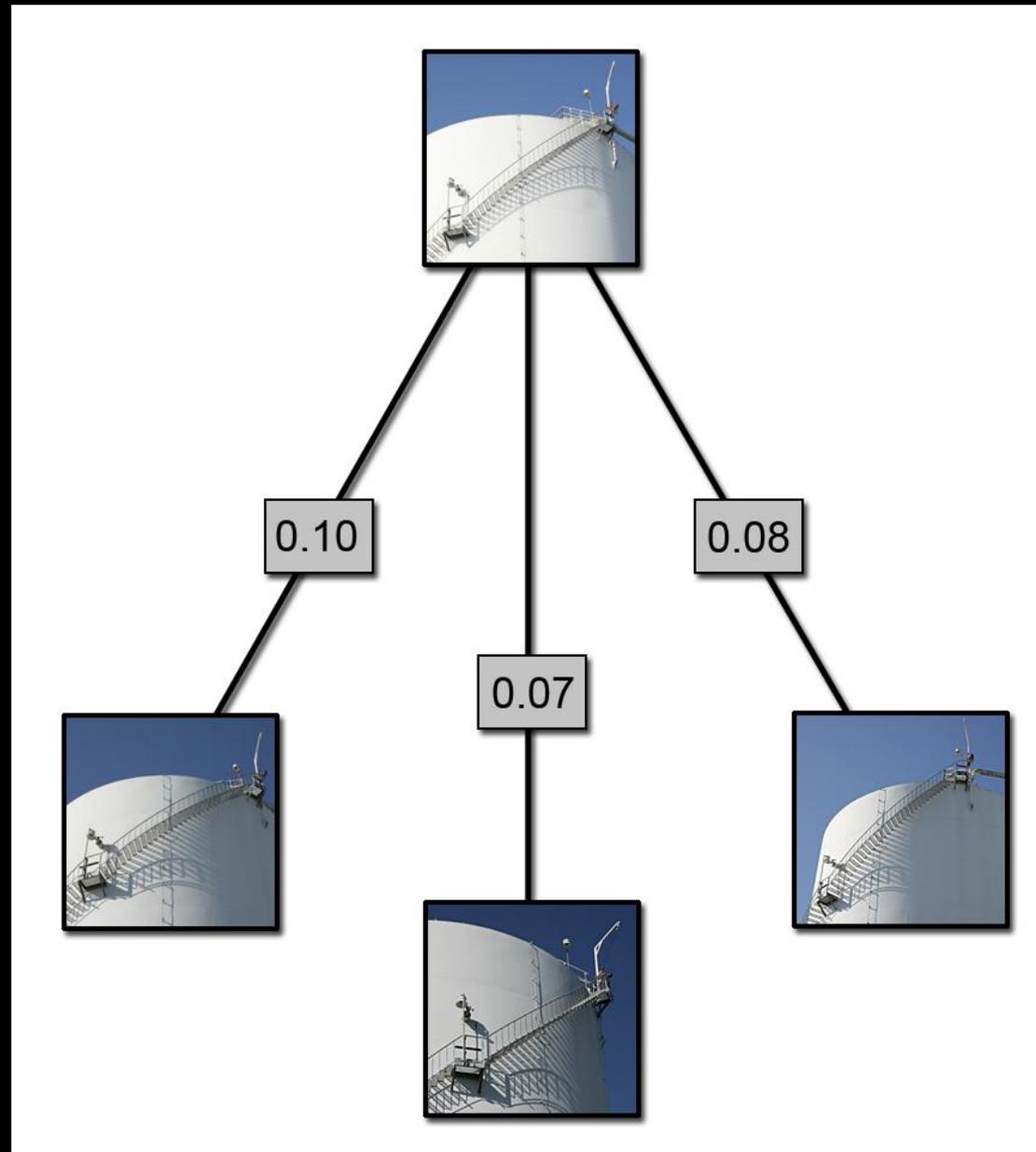
Correlation coefficient = 0.85

The Data



Correlation coefficients calculated between all images of a time series
Mean = 0.45

What About a *Slightly* Different Scene?

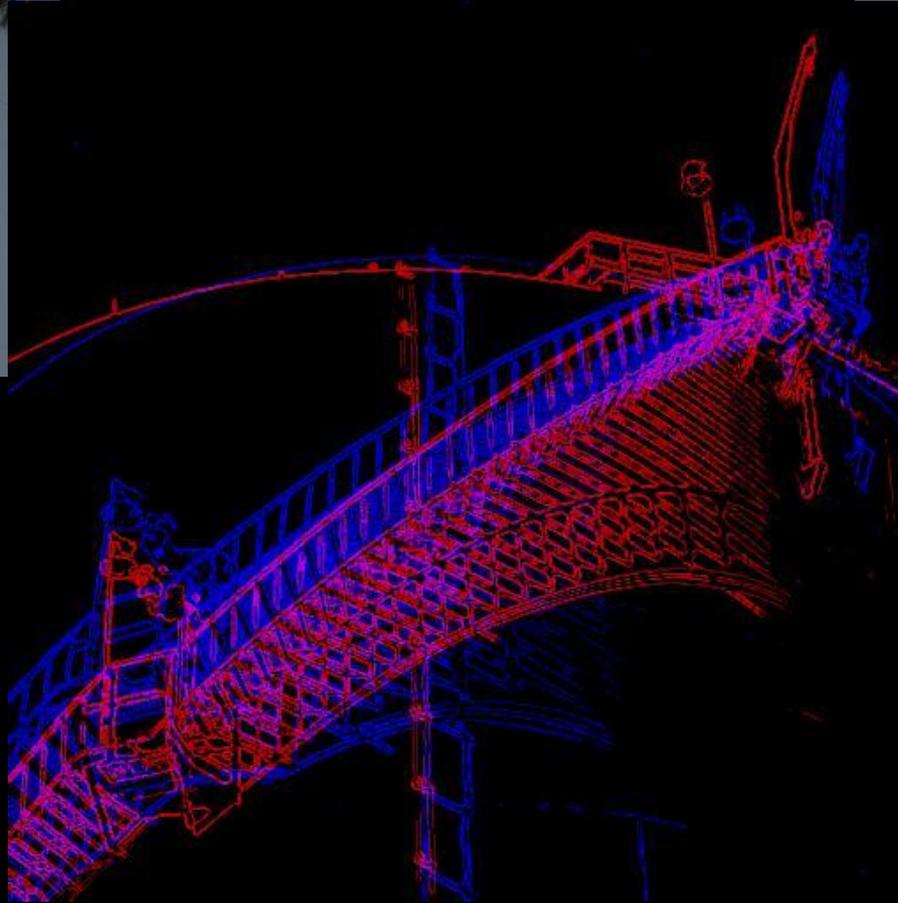


Scene match or not?

Isn't a Score of 0.08 considered a Scene Match?

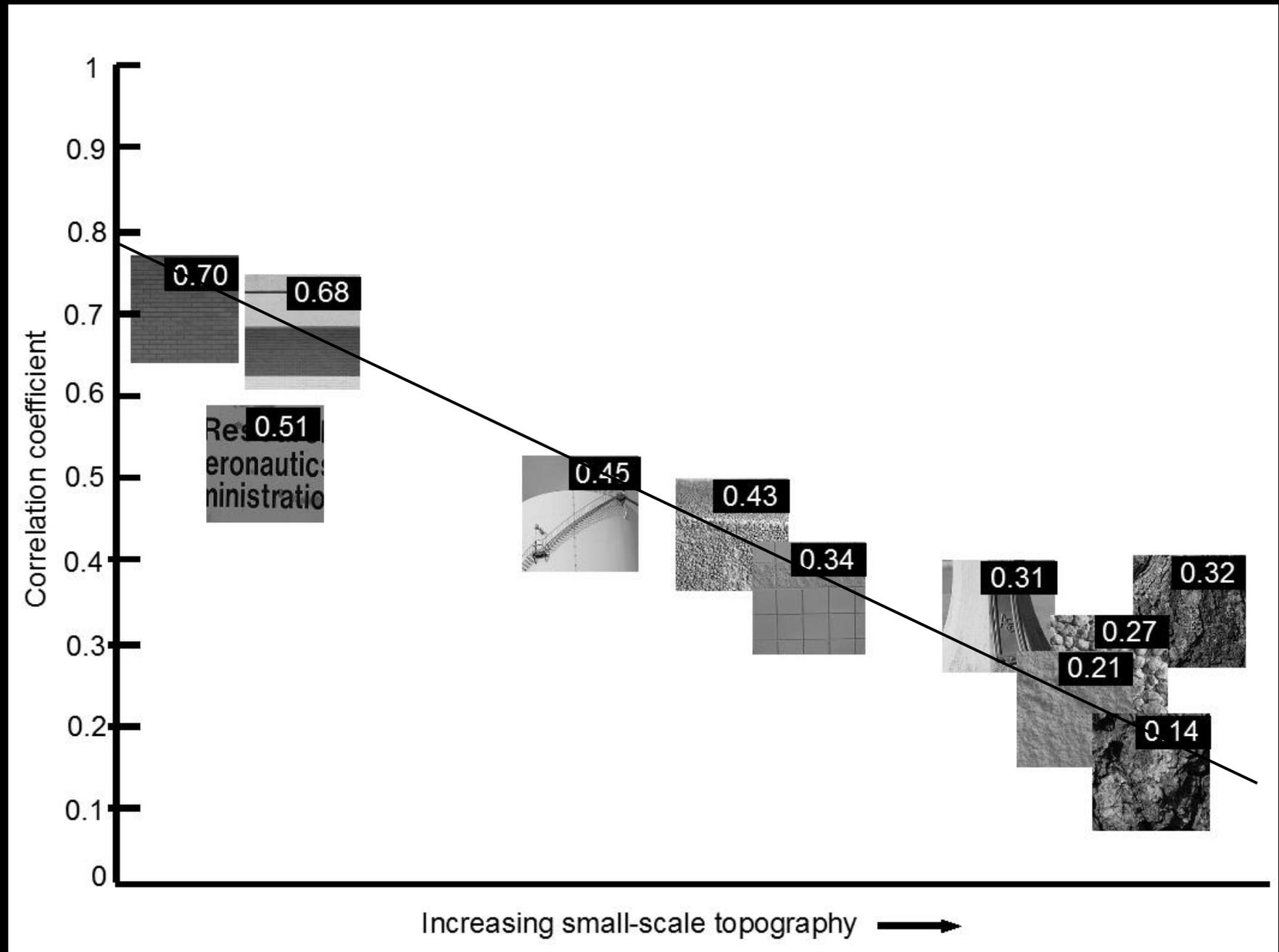


Maybe!



Regular, dense patterns reduce the apparent uniqueness of a scene

The Results



Findings

- Increased small-scale topography produced lower correlation coefficients while scenes with large-scale topography generally showed little to no effect
- Prominence of shadow effects produce more mutable edge data - significant component of the frame edge pattern
- Pattern recognition of terrain hazards (small-scale) is going to be more challenging than runway hazards (large - scale)
- Reliable scene pattern recognition of terrain hazards will likely be limited to range of higher signal-to-noise ratio imaging conditions than runway hazard detection

Future Work

- Limit of scene recognition over differing points of view and differing scales – i.e. automated landing
- Determination of best case correlation possible
- A new edge detection method which handles noise and texture removal, retaining weak features

More Information

The screenshot shows a Mozilla Firefox browser window displaying the website 'Retinex Image Processing at NASA Langley Research Center'. The browser's address bar shows the URL 'http://dragon.larc.nasa.gov'. The website header includes the NASA logo and navigation links: 'Background', 'Team', 'Publications', 'Awards', 'Patents', 'Commercialization', and 'Contact'. The main content area features the title 'Retinex Image Processing' and a sub-header 'From the Imaging Science Effort at NASA Langley Research Center ...making images brighter, sharper, and clearer to look like the world you see.' Below this is a definition of RETINEX: 'RETINEX: 're-tin-ex, 'ret-nex; noun; (pl) retinexes; from Medieval Latin retina and Latin cortic. Edwin Land coined word for his model of human color vision, combining the retina of the eye and the cerebral cortex of the brain. More specifically defined in image processing as a process that automatically provides visual realism to images.' A central image shows a landscape with a large building and a smaller inset image showing a processed version of the same scene. On the left side, there is a sidebar with a table of contents: 'Pattern Constancy Performance', 'News Release', 'Lunar Orbiter Imagery', 'Smoke and Haze Examples', 'Turbidity Examples', 'Wright Brothers Archive', 'Visual Servo', and 'Visual Servo Examples'. Below the sidebar, there are two small images with captions: 'Automated Lunar and Planetary Terrain Analysis' and 'Portable, real-time enhanced vision system'. The bottom of the browser window shows a Windows taskbar with the start button, several open applications, and a system tray with a weather forecast for the week of October 26, 2007, and the time 1:28 PM.

Retinex Image Processing at NASA Langley Research Center - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://dragon.larc.nasa.gov

NASA/Langley Research Center/Electromagnetics and Sensors Research Branch

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Retinex Image Processing

Pattern Constancy Performance
News Release
Lunar Orbiter Imagery
Smoke and Haze Examples
Turbidity Examples
Wright Brothers Archive
Visual Servo
Visual Servo Examples

Retinex Image Processing

From the Imaging Science Effort at NASA Langley Research Center
...making images brighter, sharper, and clearer to look like the world you see.

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Applications to:

- Aerospace
- Safety and Security
- Consumer Science and Technology
- Medical
- Forensic

Automated Lunar and Planetary Terrain Analysis

Portable, real-time enhanced vision system

Last updated: 10/26/2007 09:40:29

Done Radar: Now: Sunny, 48° F Mon: 53° F Tue: 58° F Wed: 61° F Thu: 65° F Fri: 68° F Sat: 59° F

start Dan for Glenn A. Woo... Give babies a chance... Retinex Image Proce... 1:28 PM

<http://dragon.larc.nasa.gov>