Textural Analysis to Aid Automated Classification of Lunar Craters

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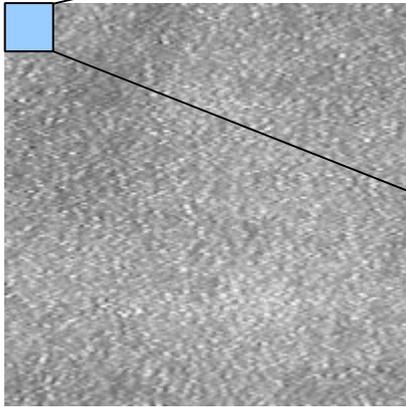- Taxonomy Creation
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Introduction

- "To automatically segment, classify and analyse craters on the Moon"

- Part of a larger project, this talk focusing on textural classification, which include:

  - Segmentation
  - **Classification**
  - **Taxonomy construction**
  - GIS integration

Methodology:
Textural Analysis

- Varma & Zisserman (2003) technique, achieved a classification rate of ~98%

- Each sample has various images of the sample at differing view/illumination angles

- Patches are created (e.g. 3x3, 5x5, 7x7 etc..)

- Randomly select images from each sample to create a model

  - Varma, M. and Zisserman, A. Texture Classification: Are Filter Banks Necessary? Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (2003)
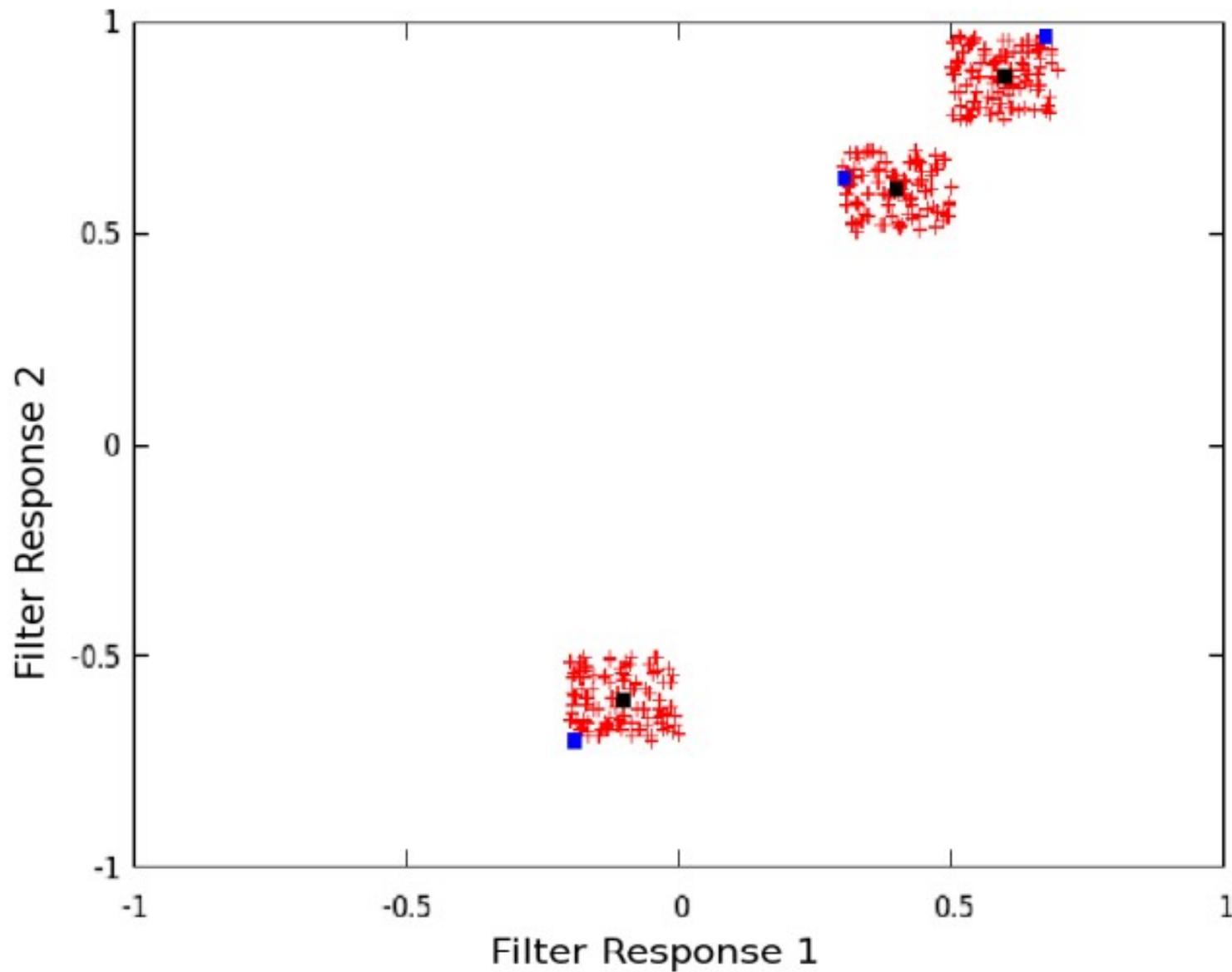
Methodology:
Textural Analysis

Methodology:
Textural Analysis

- Cluster images using K-means to create k number of "Textons"

  - Improvement gain using K-Means++ (Arthur, D., 2007)

- Aggregate the images to create a model

  - e.g. if 10 images are selected from 50 samples, each clustered using k=10. We would have a model containing 500 "Textons"

    – Arthur, D. and Vassilvitskii, S. (2007). "K-means++: the advantages of careful seeding". Proceedings of the eighteenth annual ACM-SIAM symposium on Discrete algorithms. pp. 1027--1035
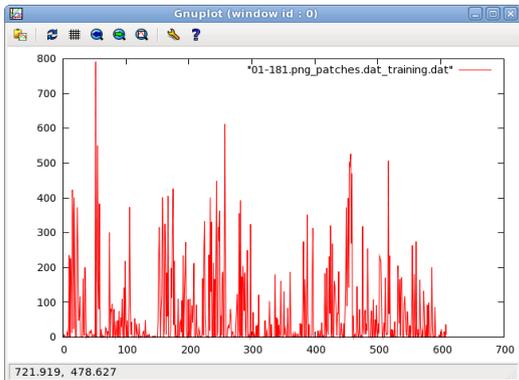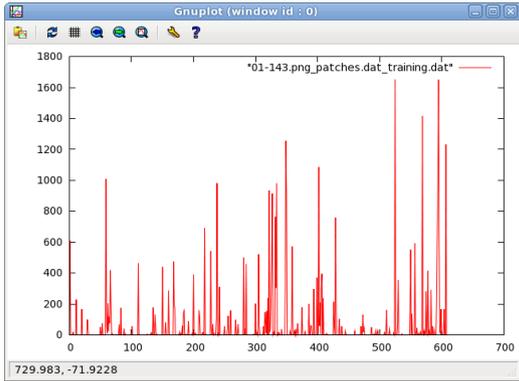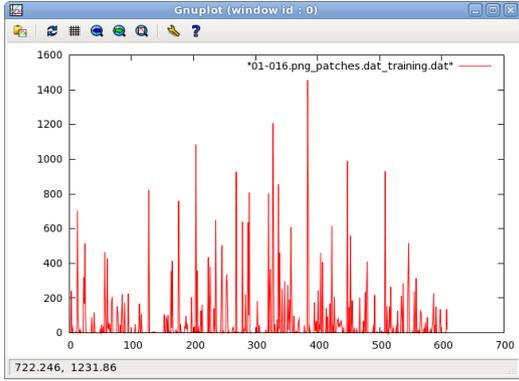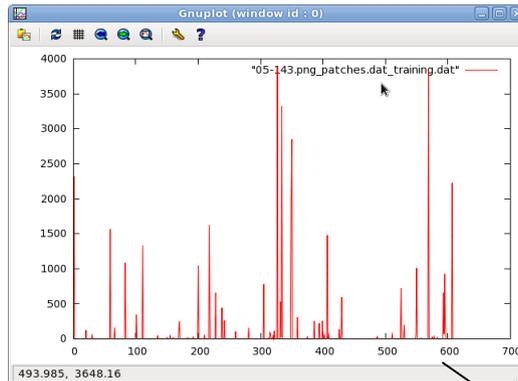
Methodology:
Textural Analysis

Methodology: Textural Analysis

- Create training set
  - Randomly select image
  - Compare each patch to model and align with closest "Texton". This creates a histogram.
- Run the experiment
  - Randomly select novel image
  - Create patches
  - Create histogram using model
  - Compare novel histogram against each training histogram using χ^2

Felt

Leather

Novel Image
(Leather)

X^2

"01-016.png_patches.dat_training.dat"
722.246, 1231.86

"01-143.png_patches.dat_training.dat"
729.983, -71.9228

"01-181.png_patches.dat_training.dat"
721.919, 478.627

"05-143.png_patches.dat_training.dat"
493.985, 3648.16

"05-030.png_patches.dat_training.dat"
719.667, 2366.18

"05-076.png_patches.dat_training.dat"
723.535, 2672.57

"05-155.png_patches.dat_training.dat"
563.624, 3187.45
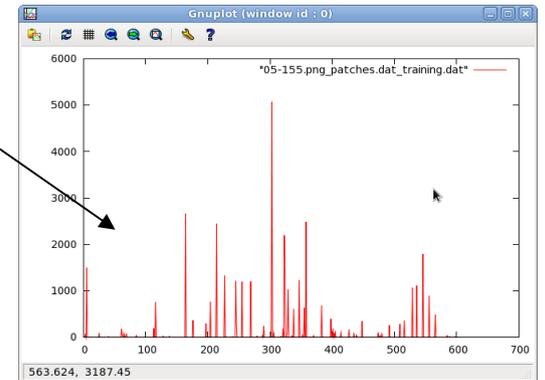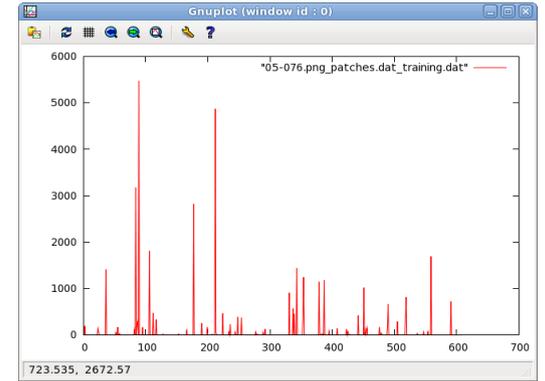
Columbia-Utrecht Reflectance and Texture Database (CUReT)

- 61 different samples

- 205 images per sample

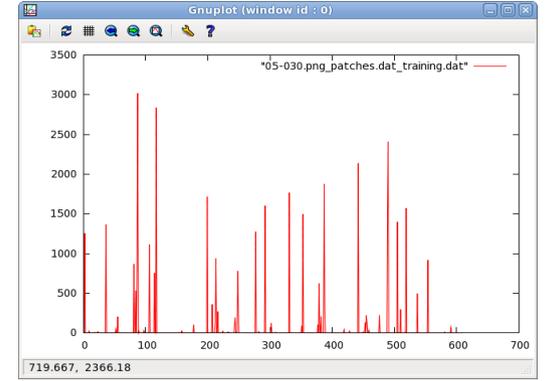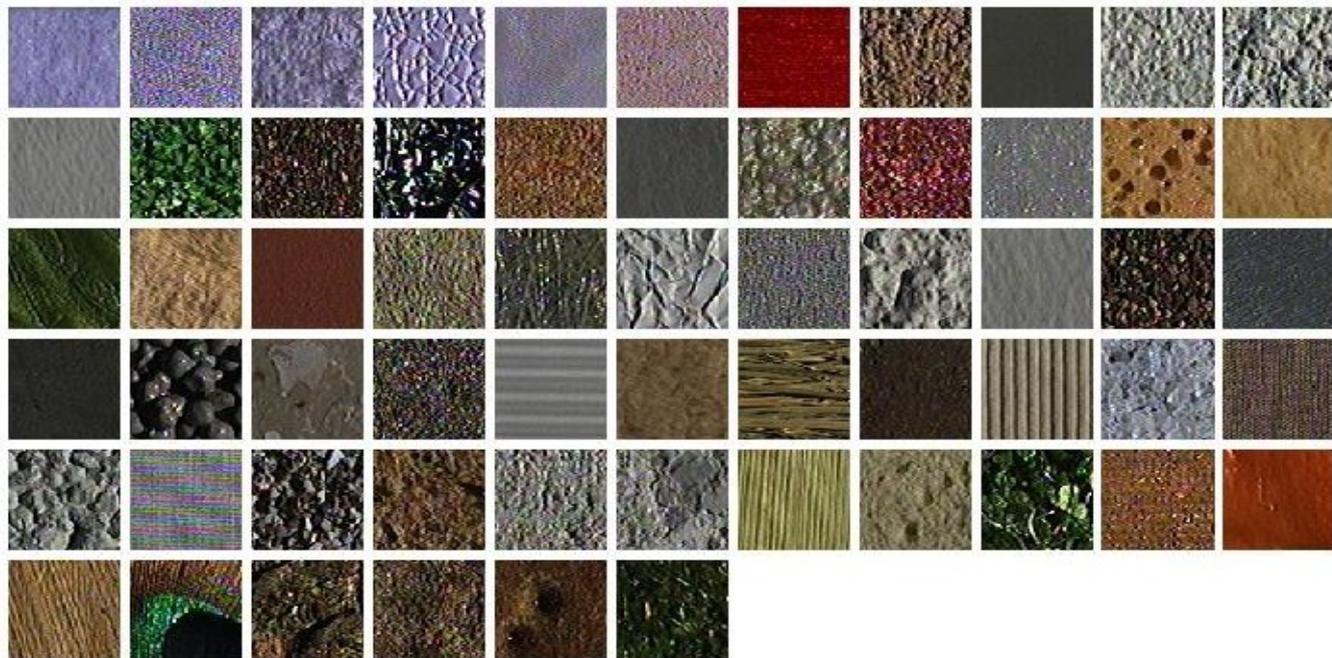- 94 images from each sample with large enough viewable area

- 5734 total images

Textural Analysis:
Number of training sets

- 3x3 patch size

- 10 images per sample for model

- K=10

- 5, 10, 15 and 20 training models

- Run 3 times, 1000 randomly images

- 73.2% classification with 20 training sets
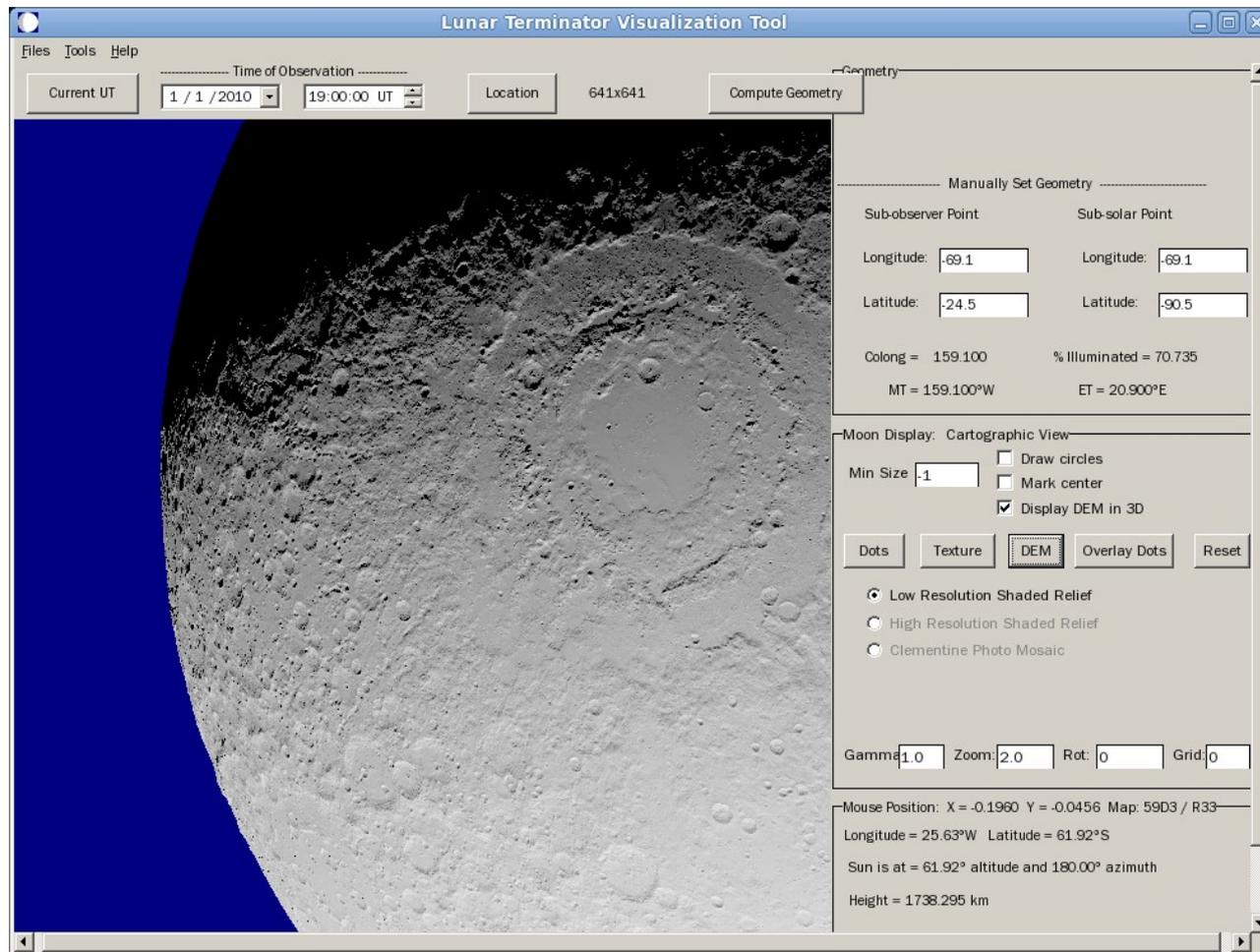
CUReT Database 3x3 Patch
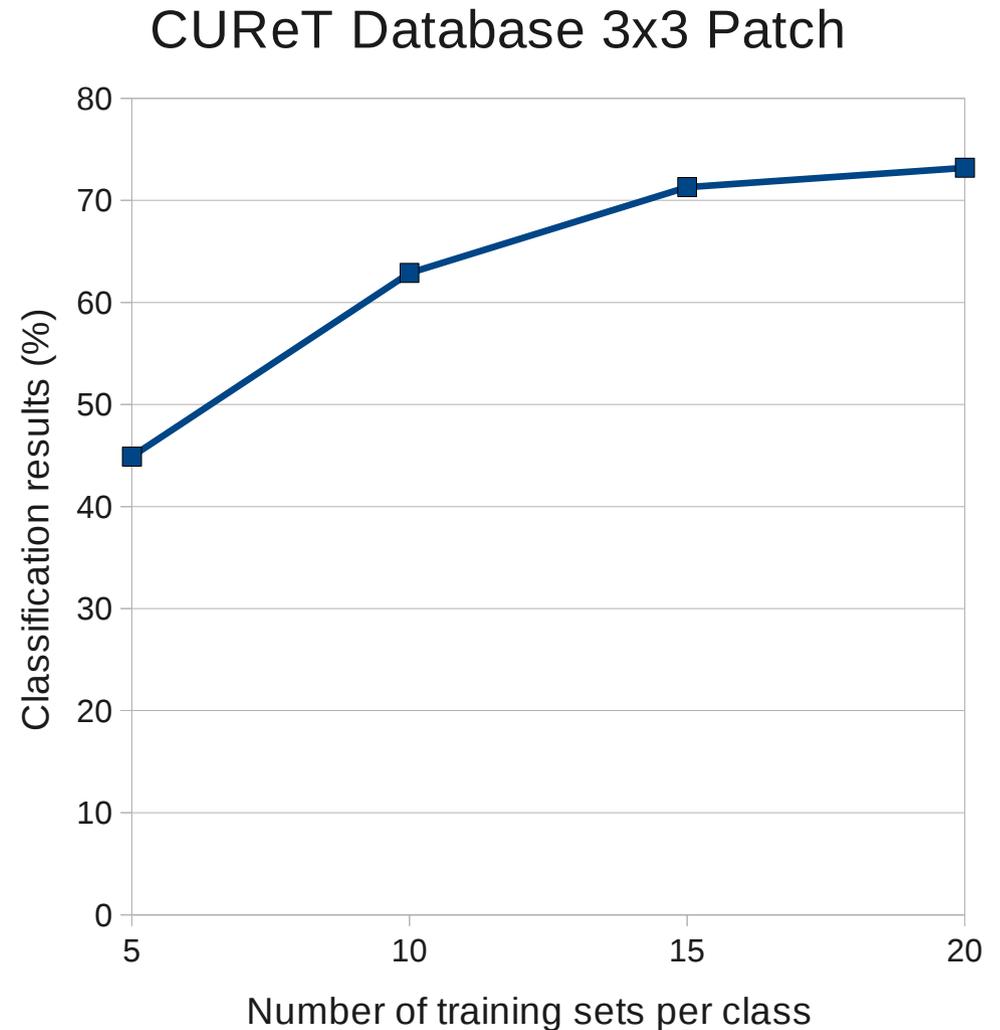
Textural Analysis:
Effect of Patch Size

- 95.8% classification rate using 7x7 patch and 20 training sets per sample

- VZ (2003) attain ~98% when using 46 training sets per sample (half of the 92 images for each sample)
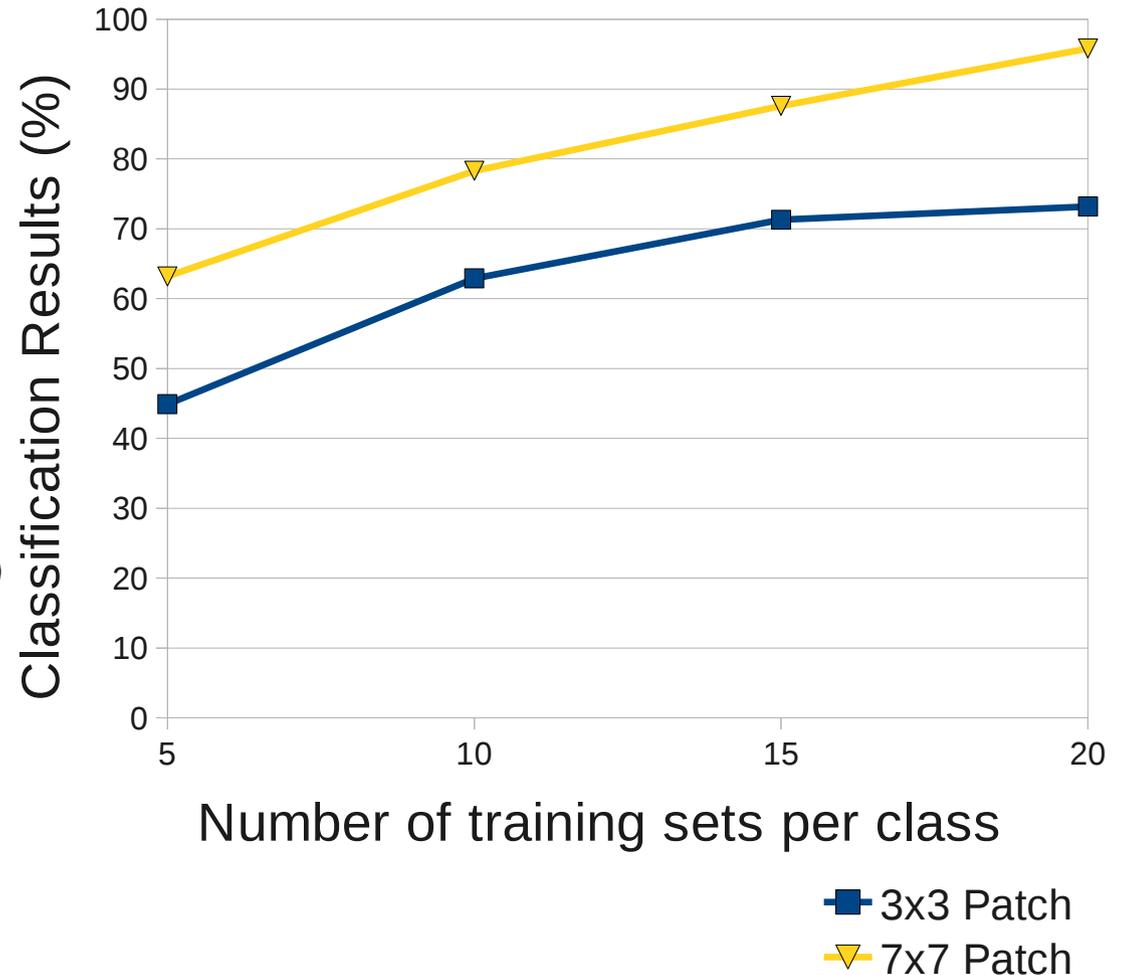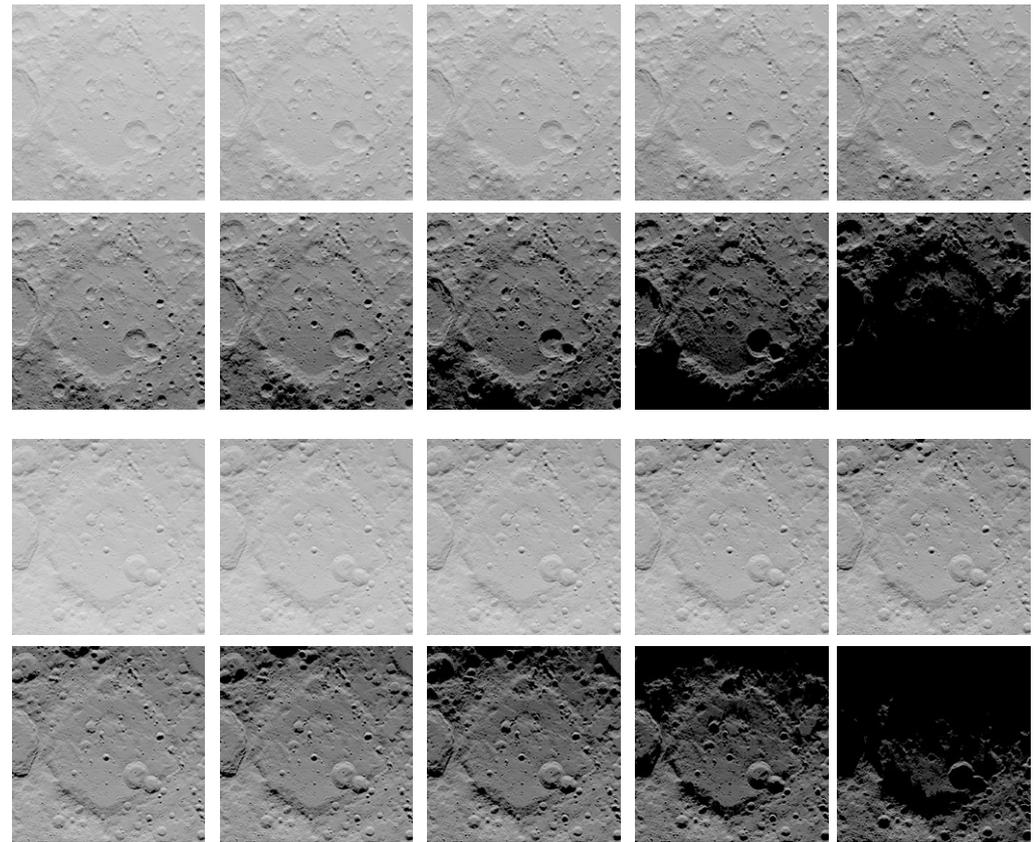
Lunar Terminator Visualisation Tool (LTVT)

http://ltvt.wikispaces.com/

Lunar Terminator Visualization Tool Experiment

- 30 largest craters chosen

- 1 view angle, directly above

- 20 illumination angles

  - 0° Azimuth and 180°

  - 0° - 45° elevation in 5° intervals

- 71.2% classification using 7x7 patch & 10 training sets

Bailly Crater (-66.5lat, -69.1long):
(Top) 0° Azimuth, 0° - 45° elevation in 5° intervals. (Bottom) 180° Azimuth, 0° - 45° elevation in 5° intervals.

Lunar Terminator Visualization Tool Discussion

- Lower classification results compared to CUReT experiment

- Small set of craters

- Limited phase angles

- Created using only LOLA64 DEM and a lunar-lambertian reflectance model
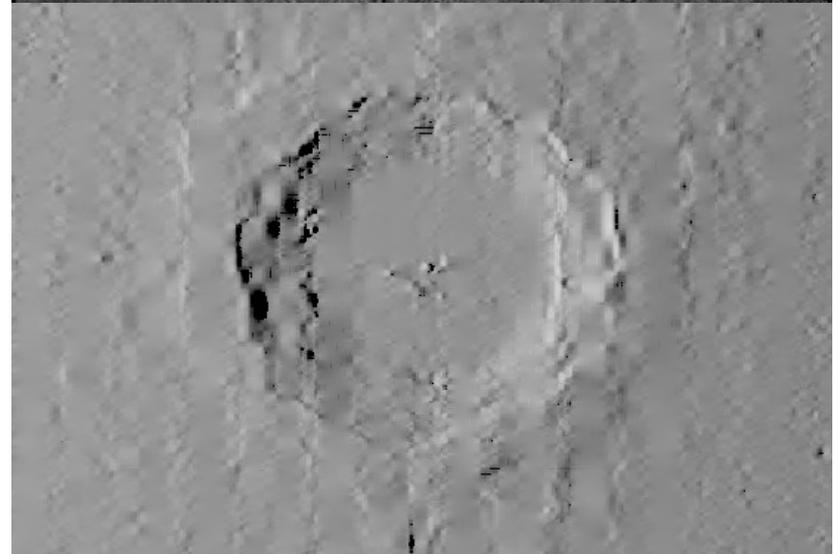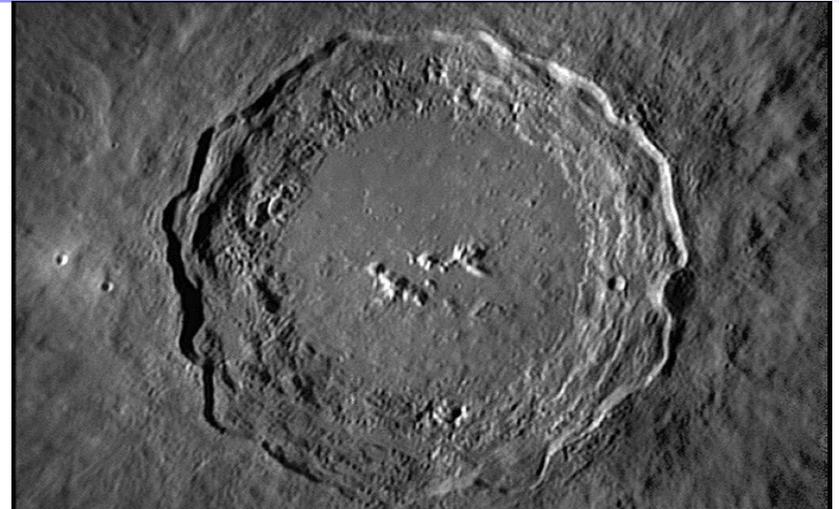
Copernicus crater.
Top: http://www.damianpeach.com/lunar.htm
Bottom: Created using LTVT LOLA64

Taxonomy Creation

- Cluster the similarity of craters rather than using a training set

- Using Earth Movers Distance rather than χ^2 for similarity

- Provides a useful way to navigate large amounts of image data
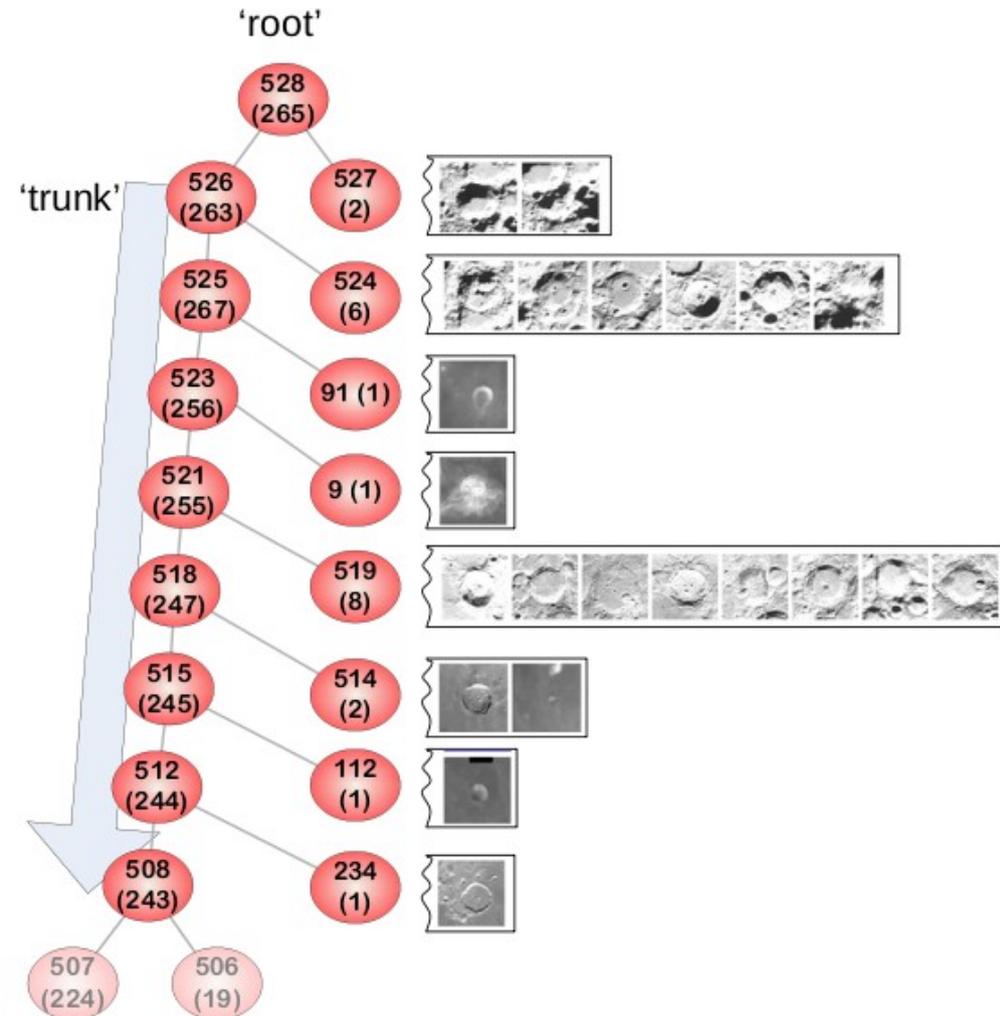
Summary

- Achieved a 95.8% classification of the CUReT database using only 20 training sets

- Currently processing a more comprehensive set of results of the algorithm

- 71.2% LTVT classification using a simple experiment

- Expand LTVT experiment, more craters and multiple phase angles

- Classify LROC images as more phase angles are available

Thank you

Questions?