Remote Sensing for Transportation Organizations

University of Colorado
Prof. William Emery

Overview

- Deliverables Review
- Progress Report - Surface Quality Extraction
  - Two-case Study
  - Large-Area Statistics Study
- Upcoming Project - LU/LC Classification
  - Large-area Land-Use/Land-Cover classification
  - Inventory extraction
  - Direction for project
- New capabilities – RoadTracker
  - Overview
  - Interest?
- Conclusions

Deliverables Review

Up To Date/In Progress

Year 1
1. UTD - Quarterly and final reports to DOT and collaboration partners on project progress.
2. UTD - Publish website to host project plans, updates, and help educate the larger user community.
3. UTD - Conduct kick-off and semiyearly collaboration meeting to include feedback from advisory panel and review/revise upcoming project plans accordingly.
4. UTD - Measure ability to produce six-class product over different regions (model portability) using literature based data space normalization methods.
5. IP - Develop aerial data correlation of surface quality metrics with in-situ data.

Year 2
1. IP - Conduct correlation study of satellite based surface quality metric with aerial observations and in-situ measurements.
2. IP - Strategy to reduce manual work load in classification systems (based on model portability studies) to facilitate large area deployment of land-cover model.
3. IP - Implement into high performance computing (HPC) platform supervised or semi-supervised method for training land-cover models.
4. IP - Implement into HPC platform image scoring code to utilize models developed from the semi-supervised training system.
5. UTD - Submit technical papers to reputable journal and/or conference proceeding on the subjects of:
    a. Regional model portability
    b. Paved surface quality aerial and satellite metrics

Progress Report

Current Progress - Surface Quality Extraction

1. Representative Study Sample
   --Two-case tests of road-surface image metrics

2. Statistical Study
   --Large area statistical sampling

3. New Data Sets and Data Manipulation
   --Recent Colorado Springs in-situ measurements

Two-Case Study

- Series of image metric experiments on two sample road segments
    - 1 with low fatigue (171 sq ft)
    - 1 with high fatigue (6567 sq ft)
- Resampled to three resolutions:
    - Aerial (30 cm) --- future WV3 resolution
    - WorldView-2 (50 cm)
    - QuickBird (60 cm)
- Image metrics
    - 1st order w/ 3x3 window:
        - Data Range, Mean, Variance, Entropy, Skewness
    - 2nd order w/ 3x3 window w/ 1x1 offset:
        - Mean, Variance, Homogeneity, Contrast, Dissimilarity, Entropy, 2nd Moment, Correlation
    - Image entropy w/ 3x3, 5x5, and 7x7 window

Image Chips
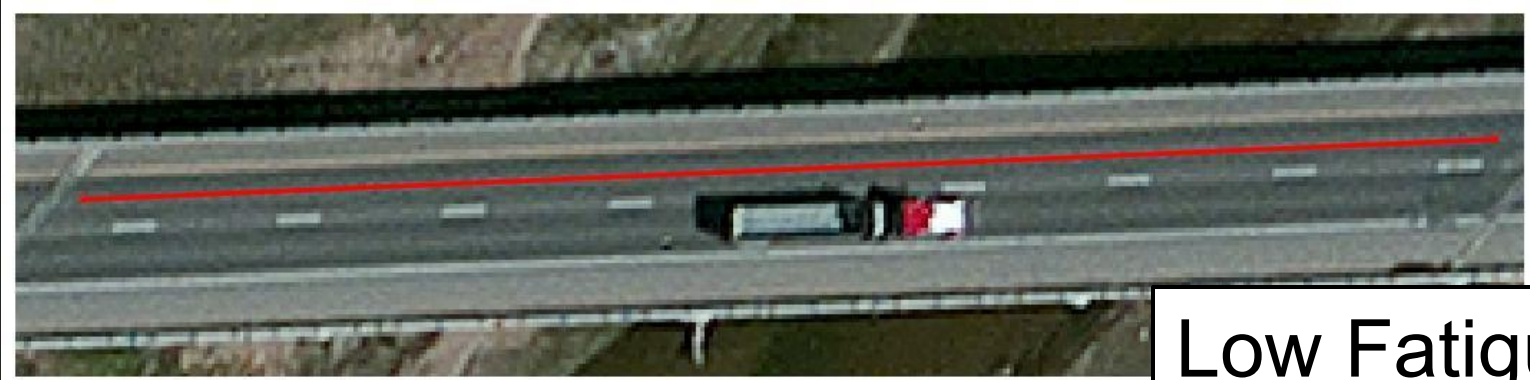
Low Fatigue
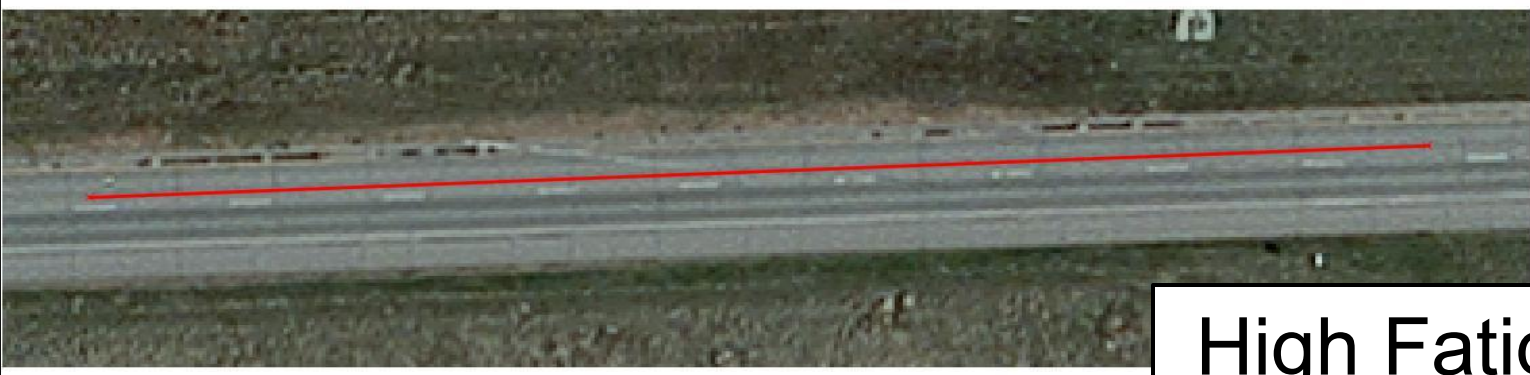
High Fatigue

Image Chips - Aerial Panchromatic

Low Fatigue
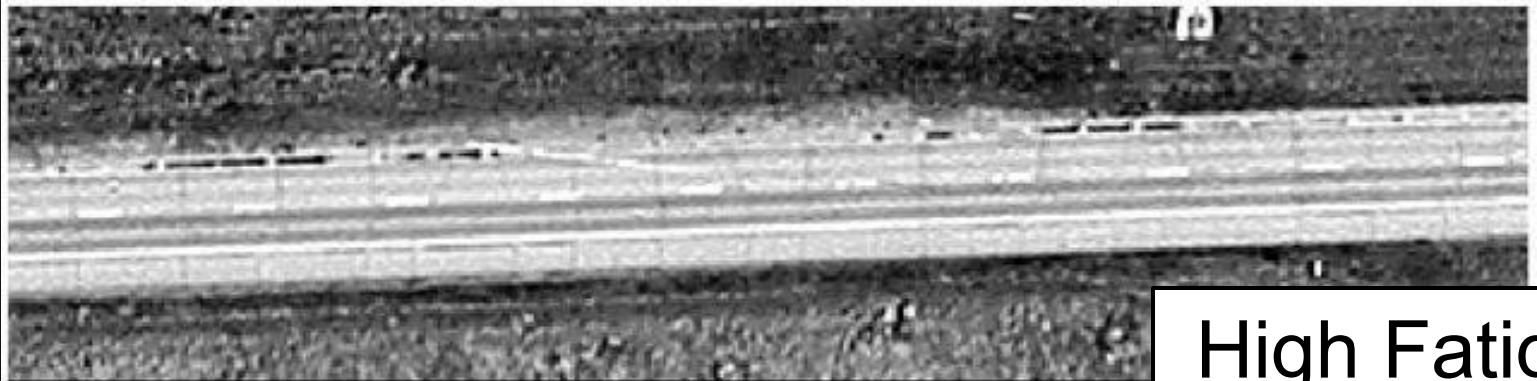
High Fatigue

Image Chips - WorldView-2 Panchromatic
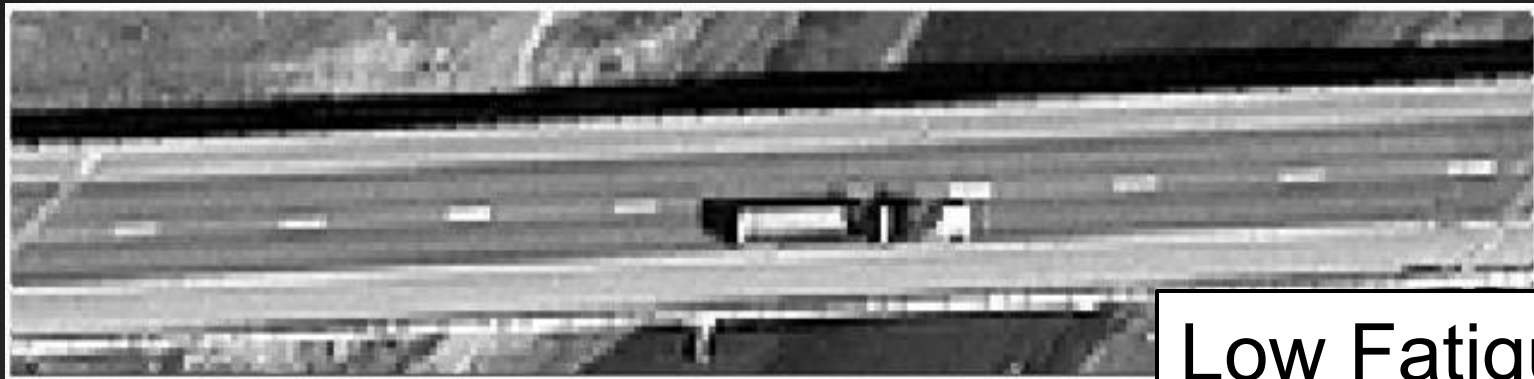
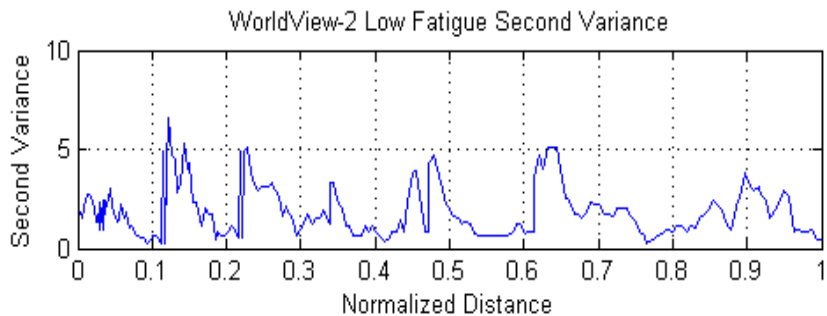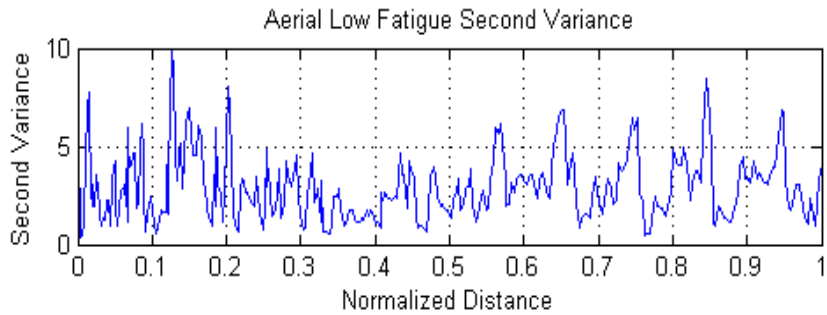
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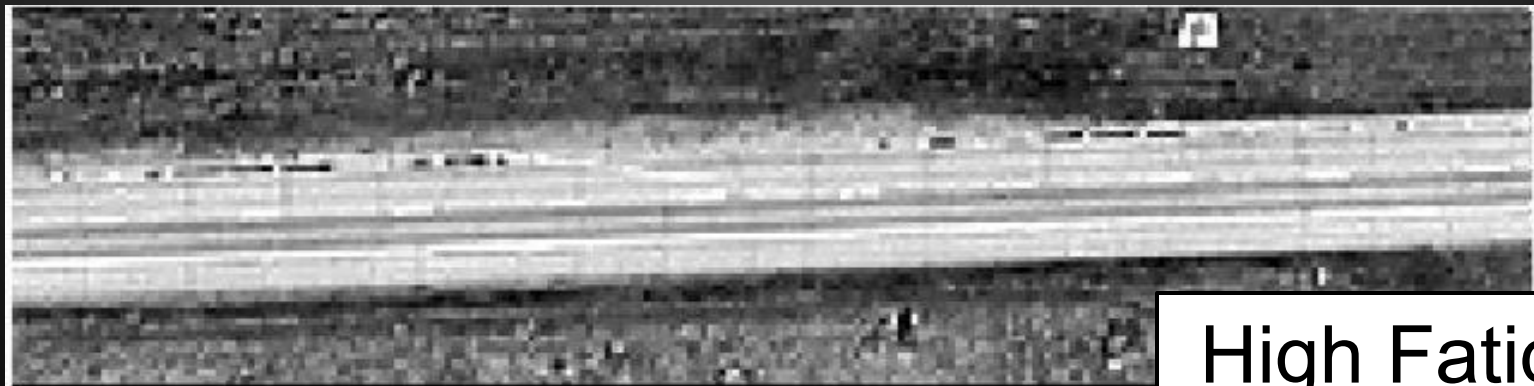
High Fatigue

Image Chips - Quickbird Panchromatic
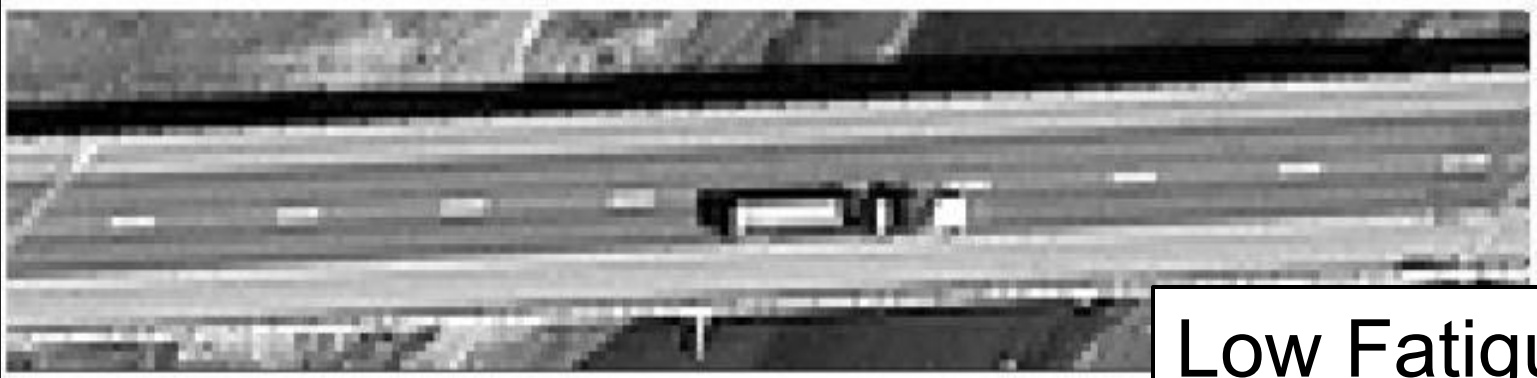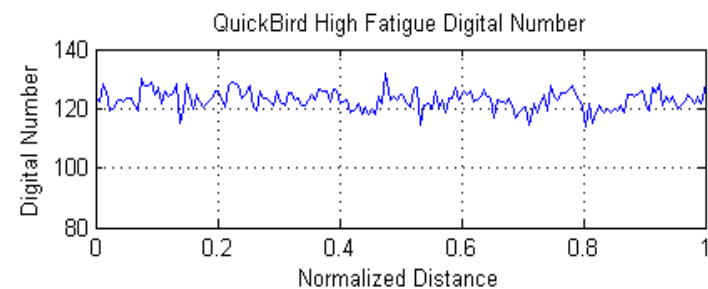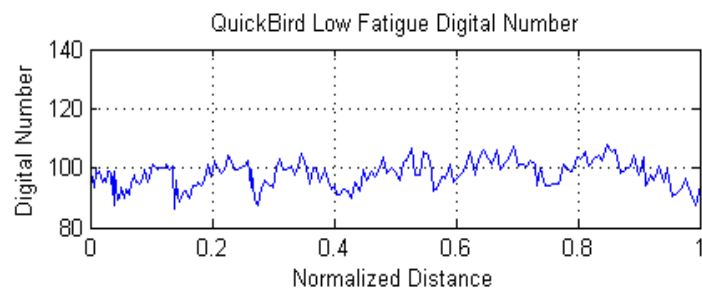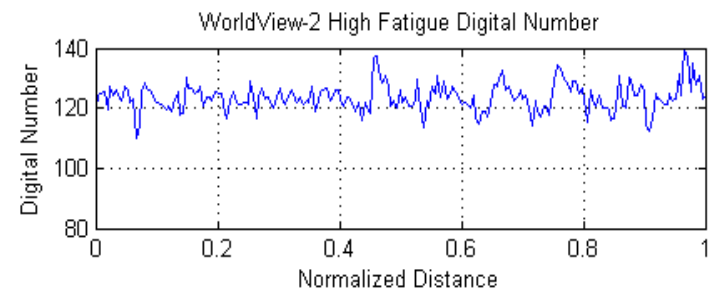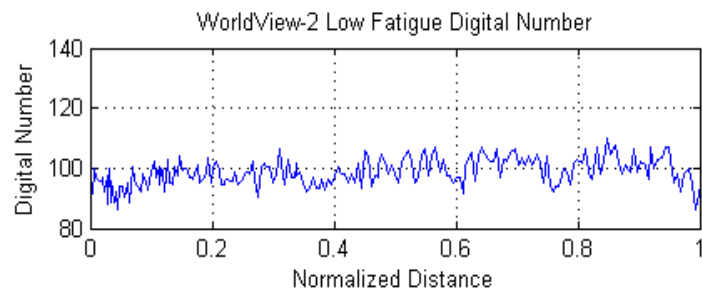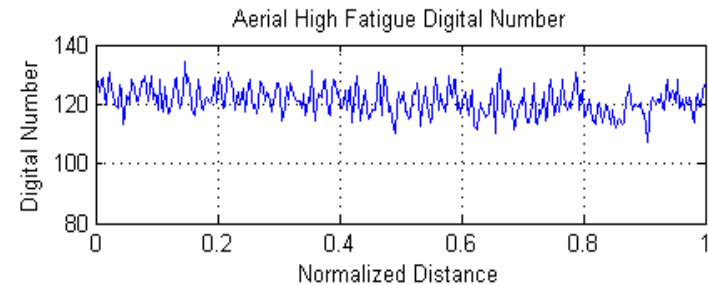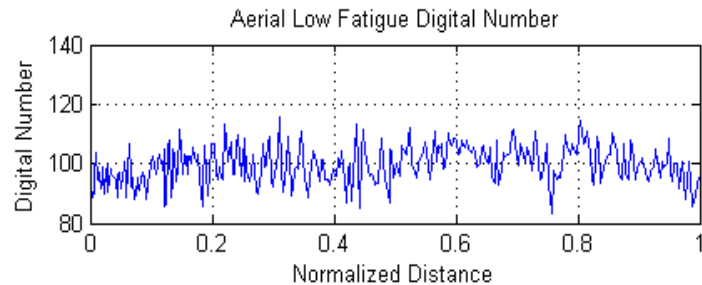

Low Fatigue
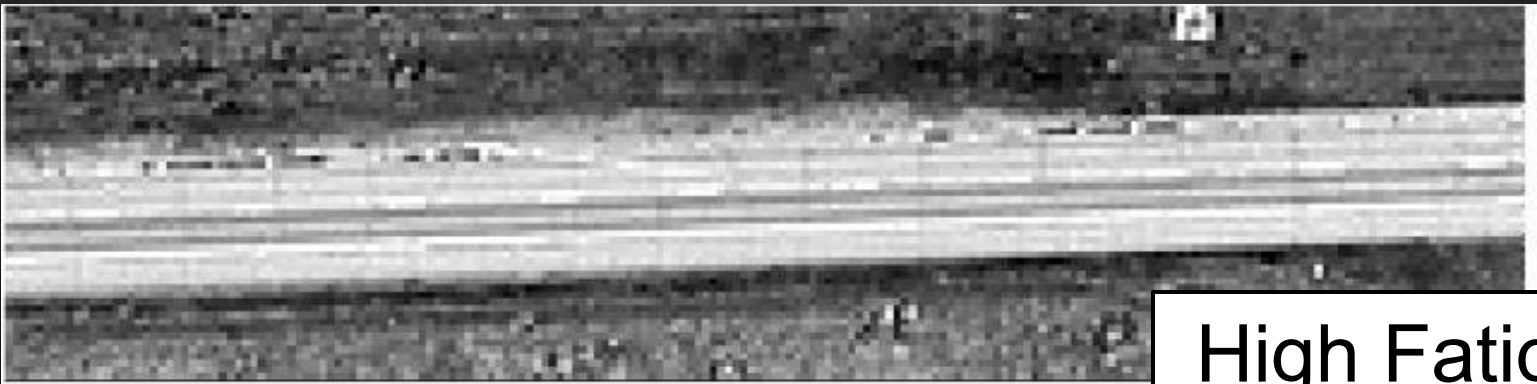
High Fatigue

Resolution Data Dependence (1)
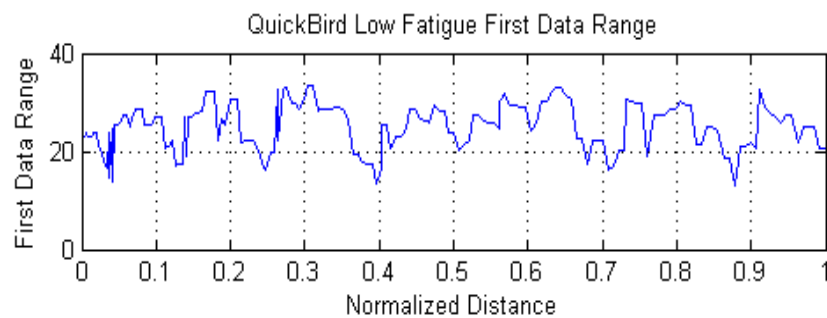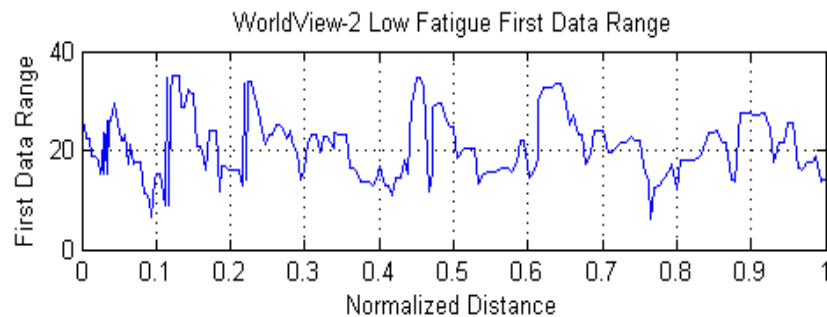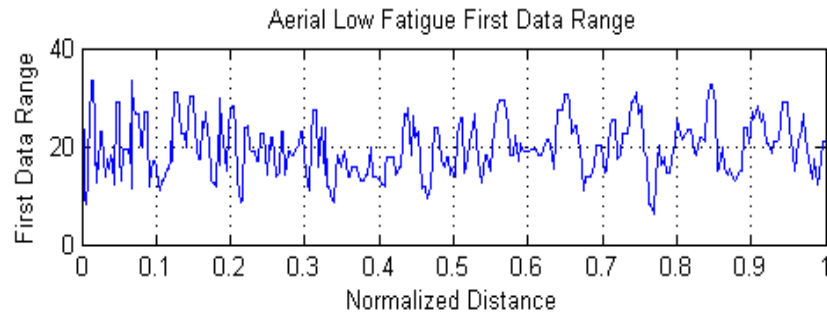
Resolution Data Dependence (2)
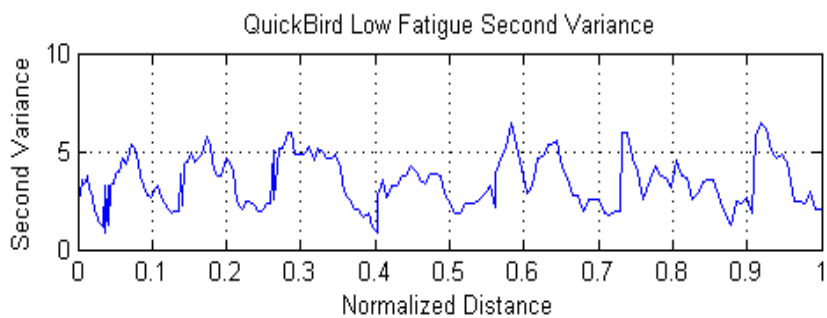
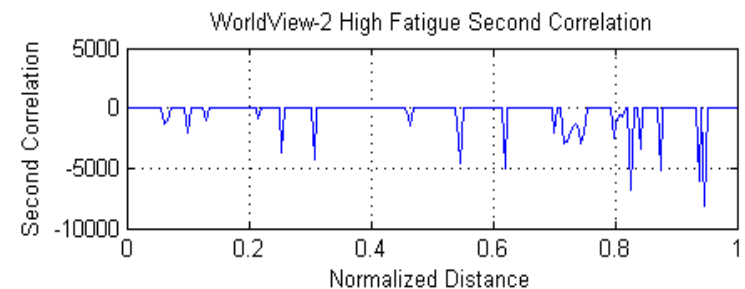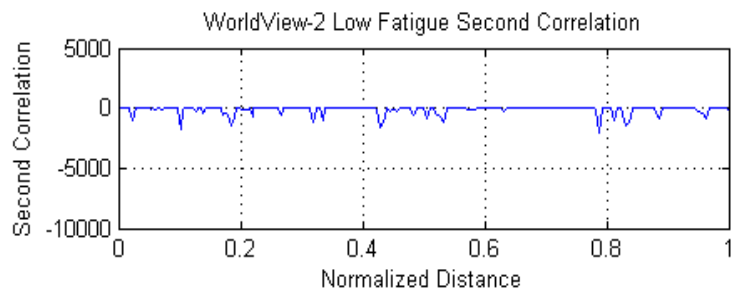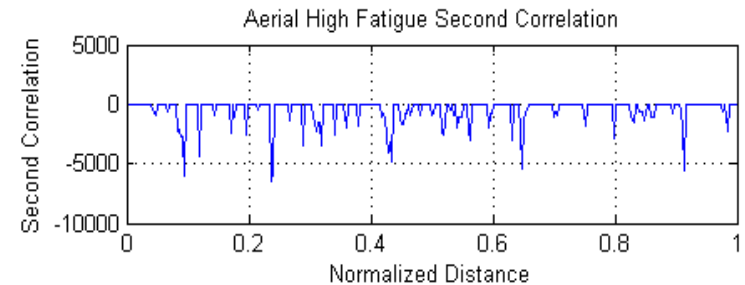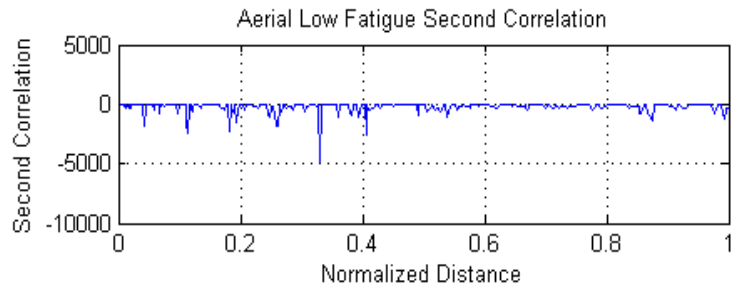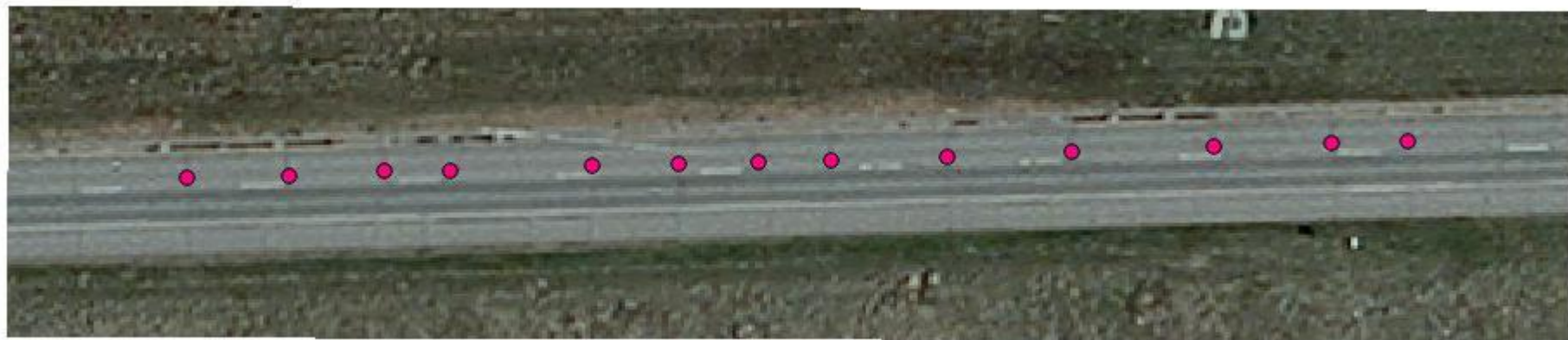# Results - DN (and texture means)

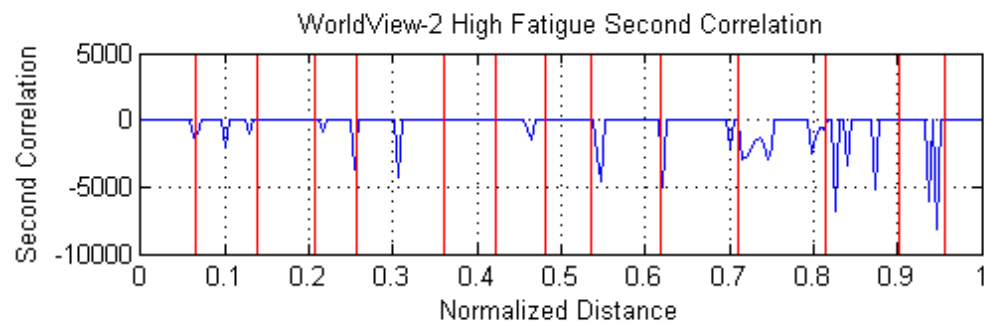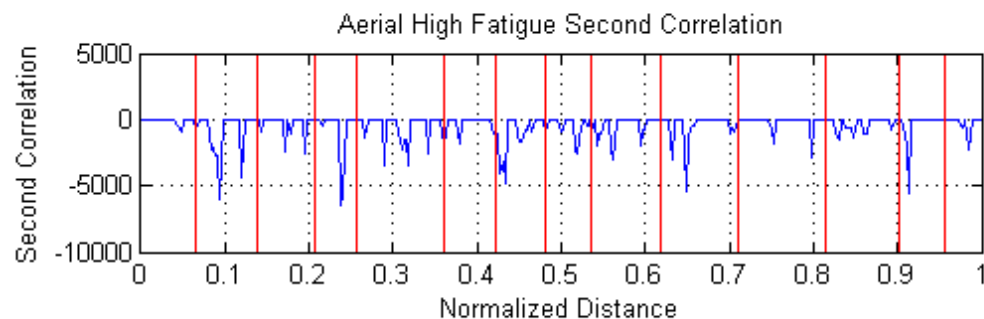- Probably not a good generalized indicator
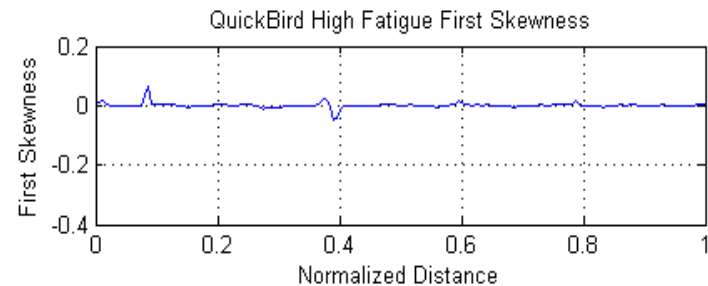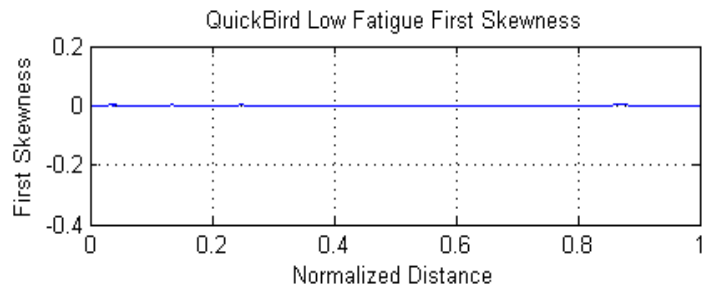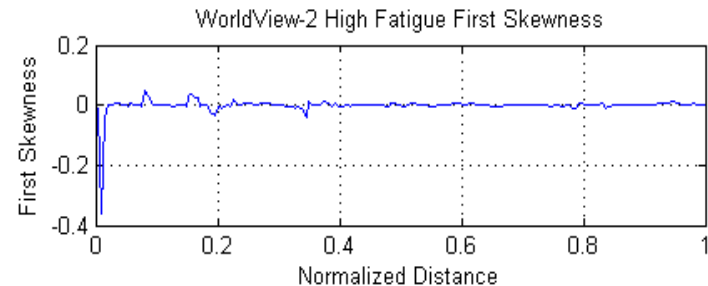
Results - Second Order Correlation
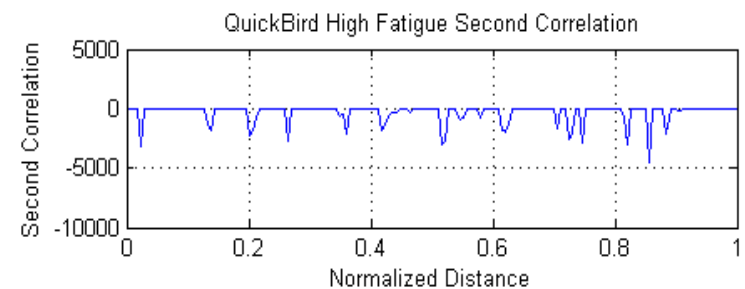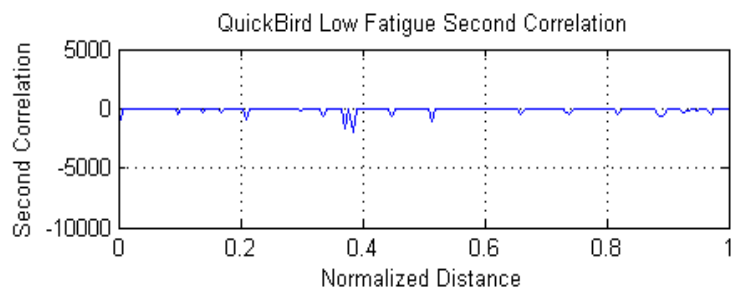
Qualitatively a measure of transverse cracking

Results - Manaul Cracking Validation

Results - First Order Skewness
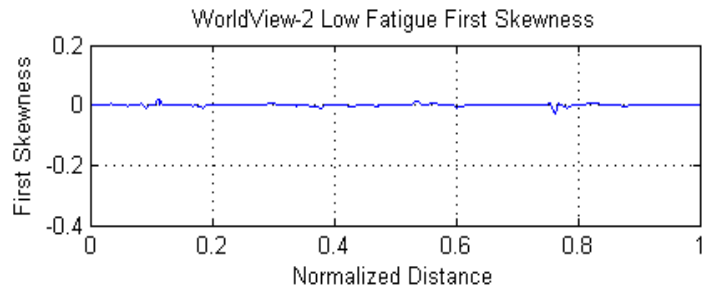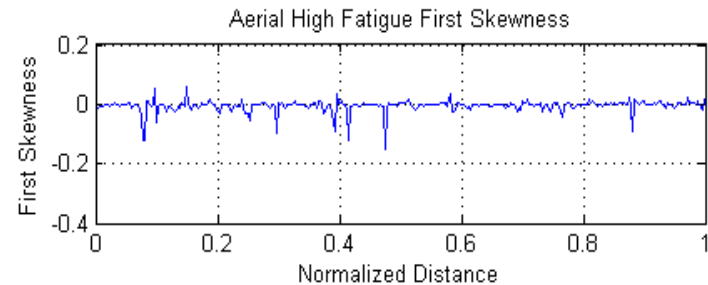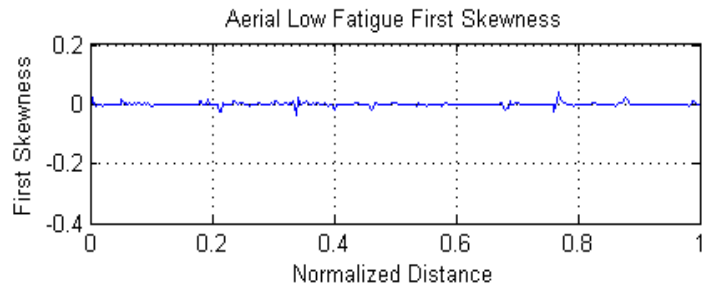
- Qualitatively a measure of roughness

Summary - Two-Case Study

- Some clear signals are indicated in the two-case study
  - DN
    - probably not a good generalized indicator
    - correlate with pavement types to measure degradation?
    - possibly include multispectral information
  - Skewness
- Unknown how these signals generalize to arbitrary images/surface samples.
- Therefore, we developed the ability to look at larger data sets...

Large Scale Workflow
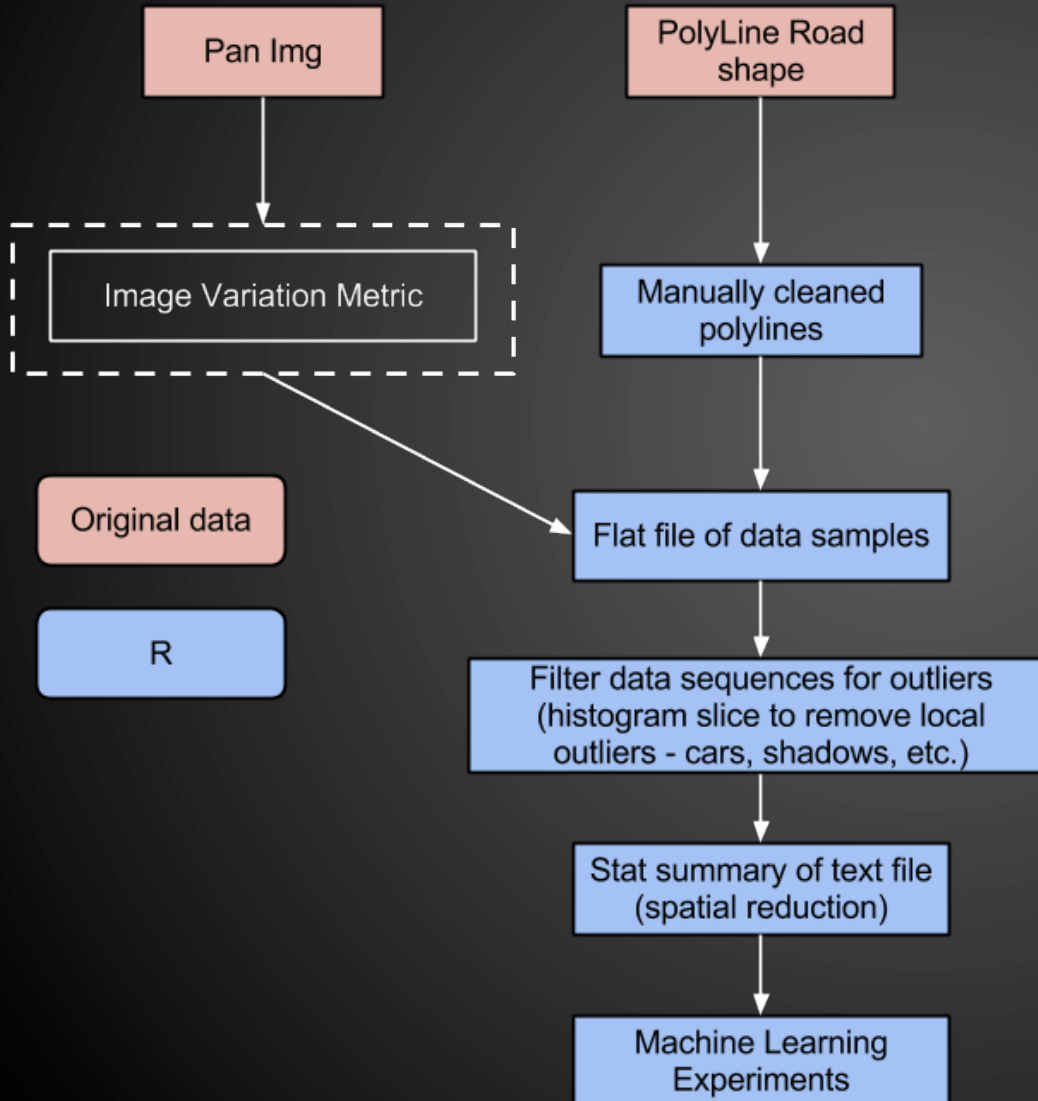
- Single program
- Large area extraction
- Correlation with ground truth

Preliminary Large Area Results

- Colorado Springs:
  - 2007 In-situ measurements
  - Quickbird 60 cm from late summer
  - Two experiments with texture metrics:
    - IRI classification
    - IRI regression
- Larimer County
  - 2011 CDOT in-situ measurements to polylines
  - WorldView-2 (eight band) 50 cm
  - Aerial (RGB) 30 cm
  - One experiment each with DN statistics:
    - Regressed IRI values
  - Rutting and Fatigure Area also available

Colorado Springs Extraction
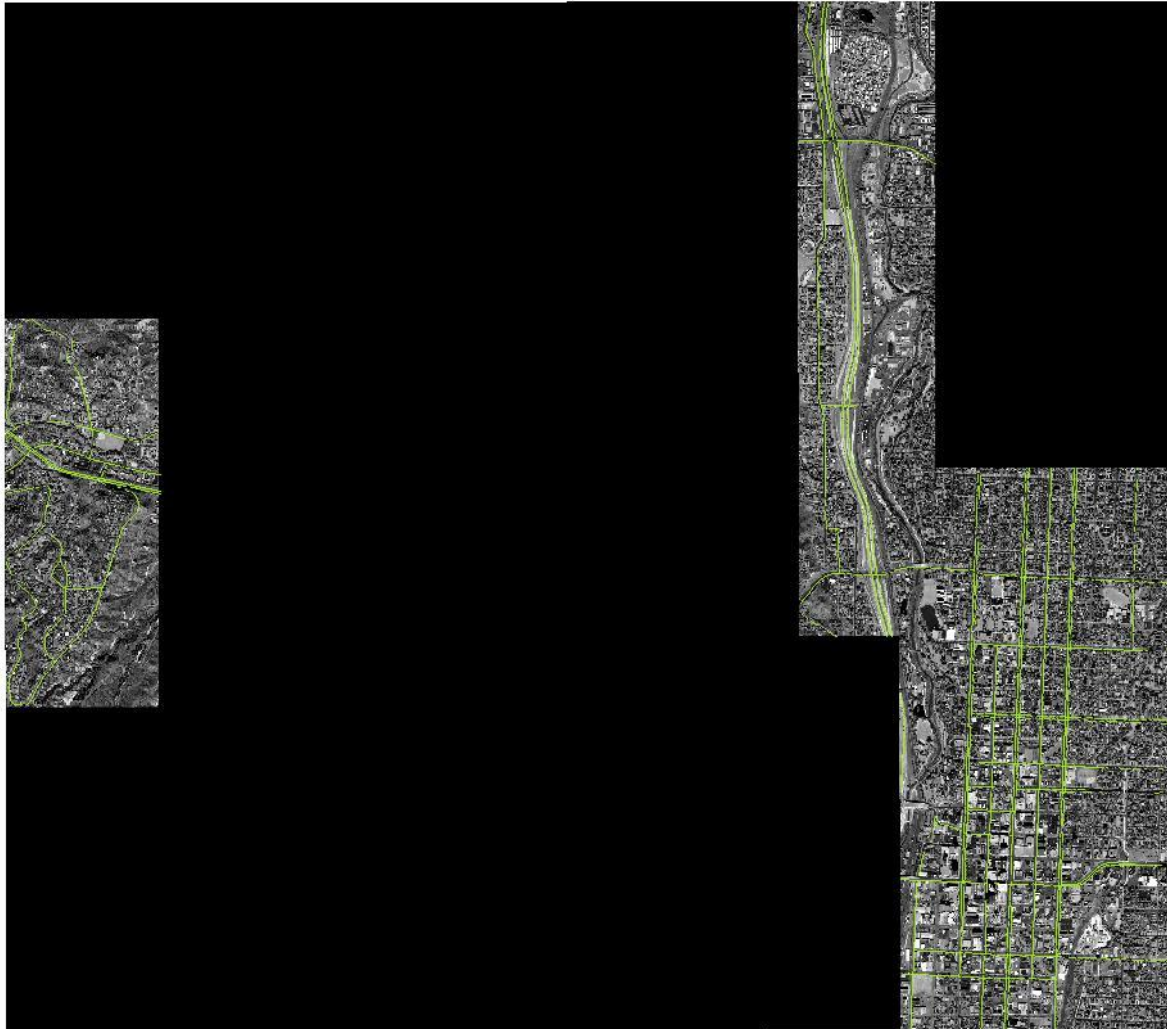
CSprings IRI Modeling
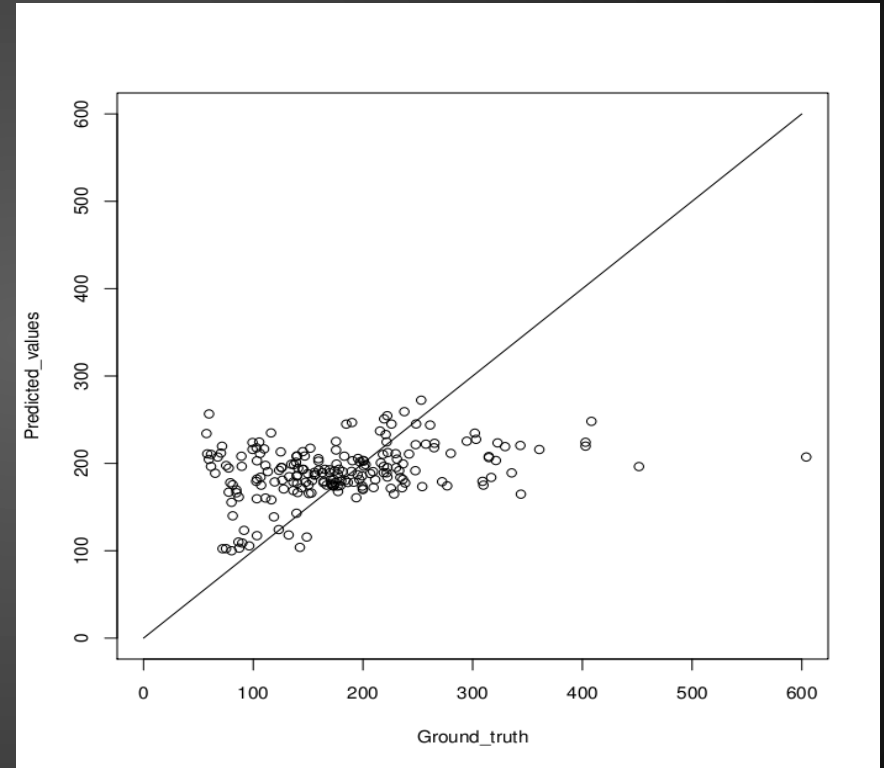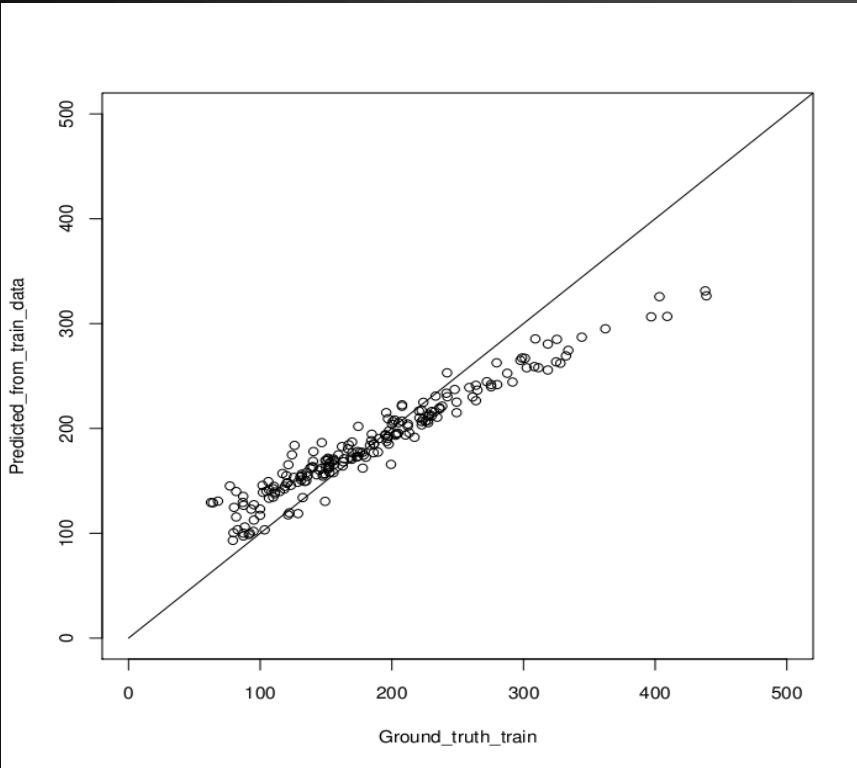
1st & 2nd order texture

Quickbird 60 cm

Training data predicted RMSE (IRI) = 8

Validation predicted RMSE (IRI) = 157

Larimer County Extraction

Larimer IRI Modeling
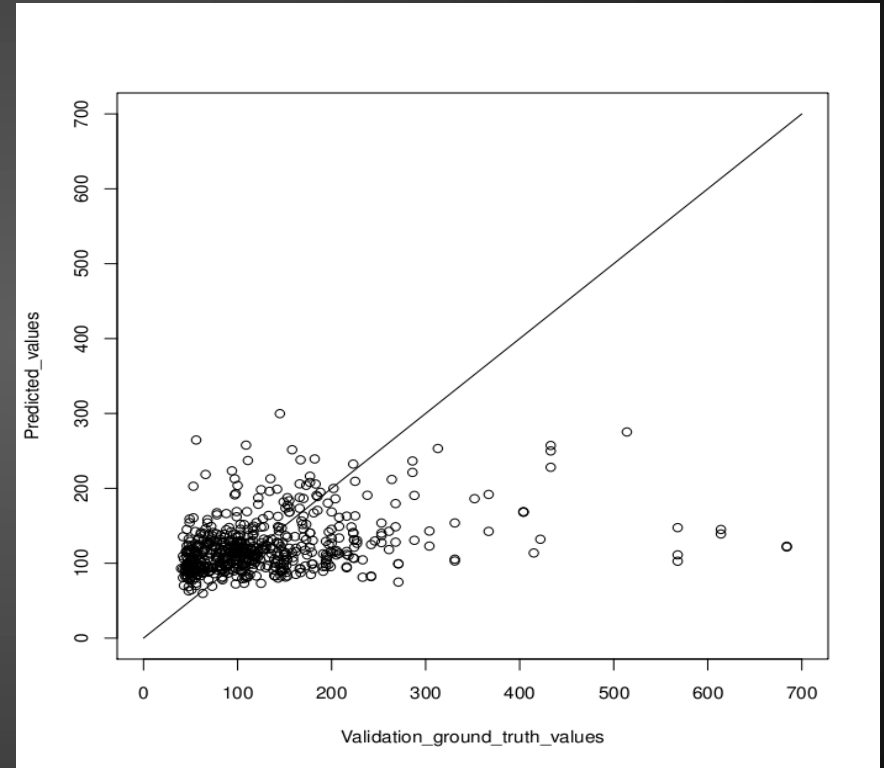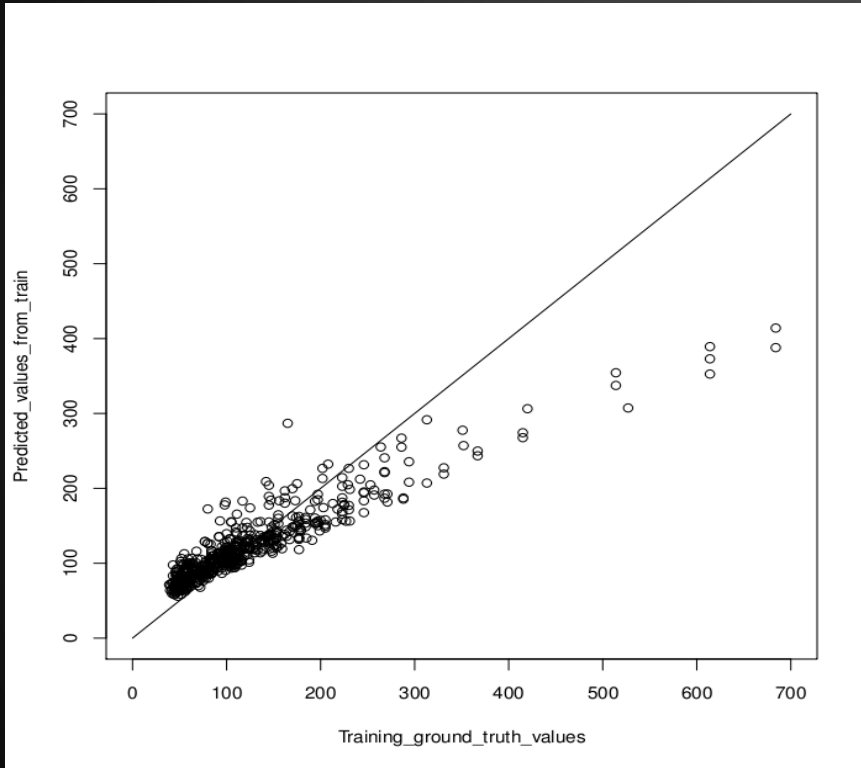
DN statistics
WorldView-2 50 cm

train predicted rmse (IRI) = 17.8
val predicted rmse (IRI) = 164.4

CSprings - Coincident Data Collection

- Fall 2012
  - Low sun angle
  - minimal foliage obstruction
- Coincident WorldView-2 and in-situ van measurements

CSprings 2012 - Distressed Polygons

CSprings 2012 - IRI/Rutting

Upcoming Project Work...

Large-Area Classification

- Four WorldView-2 strips
- >8000 km2
- 17 Land Cover Classes
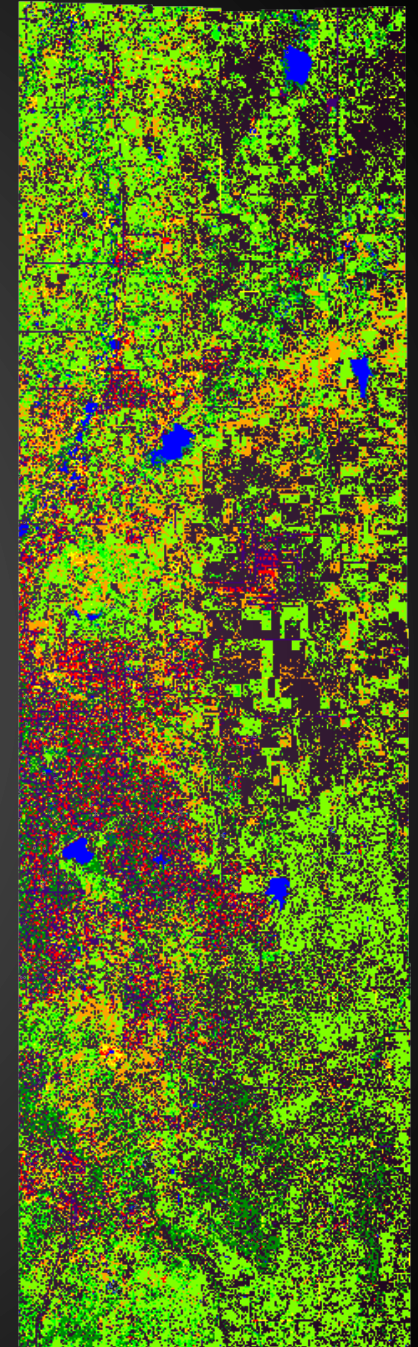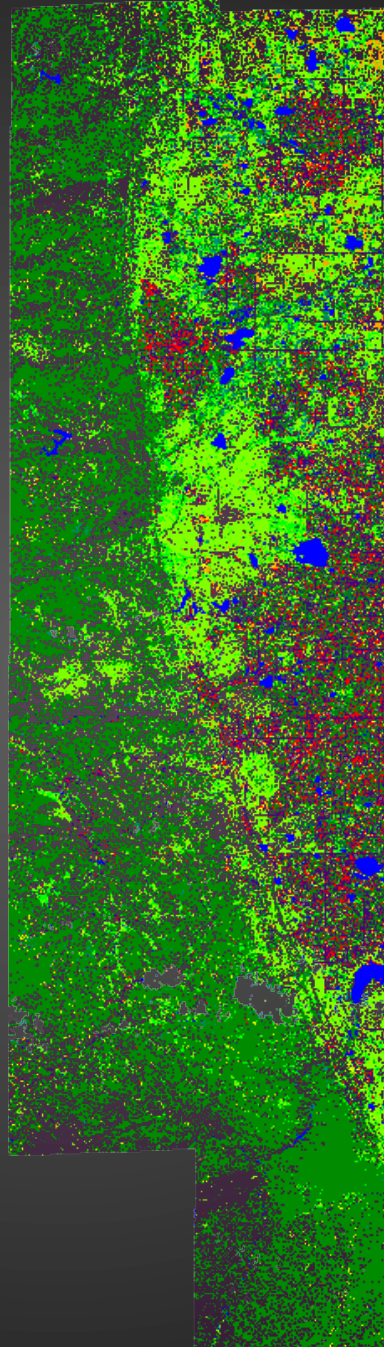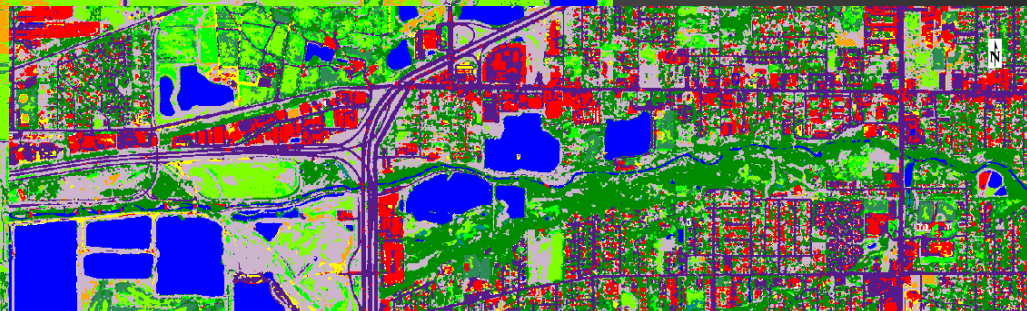
- Future collect from Fort Collins to Colorado Springs?
- Classes of interest?

Classification Examples
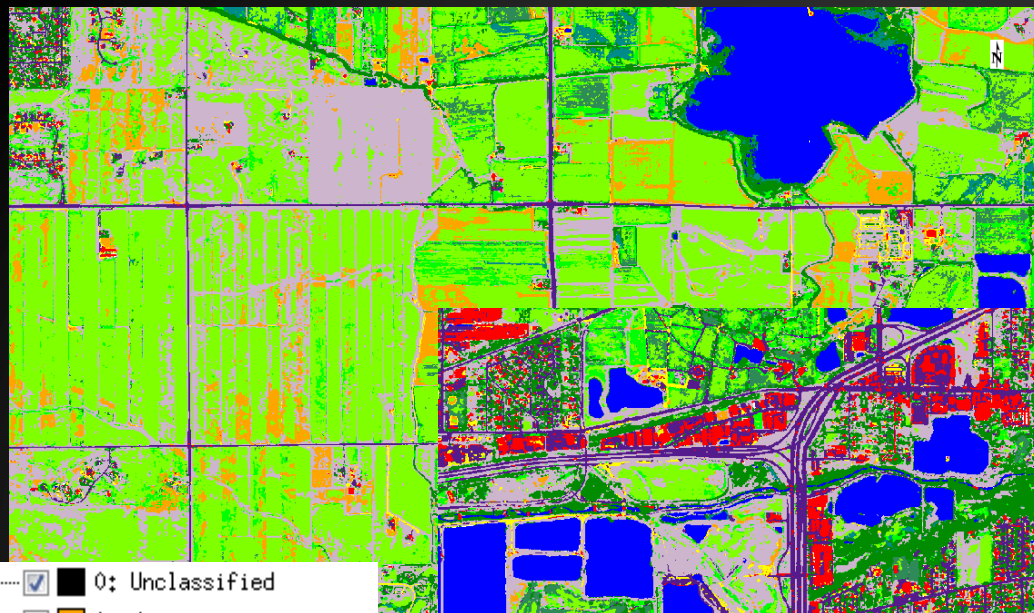
☑ ⬛	0: Unclassified
☑ 🟧	1: drygrass
☑ 🟩	2: shrub
☑ 🟩	3: crop_LightBrownField
☑ 🟦	4: pool
☑ ⬜	5: cloud
☑ 🟦	6: water2
☑ 🟩	7: tree
☑ 🟩	8: crop_GreenField
☑ 🟥	9: roof
☑ 🟦	10: water
☑ 🟨	11: sand
☑ 🟦	12: wetland
☑ 🟩	13: crop_DarkBrownField
☑ ⬛	14: NA
☑ ⬜	15: barren
☑ ⬛	16: shadow
☑ 🟩	17: grass
☑ 🟪	18: road
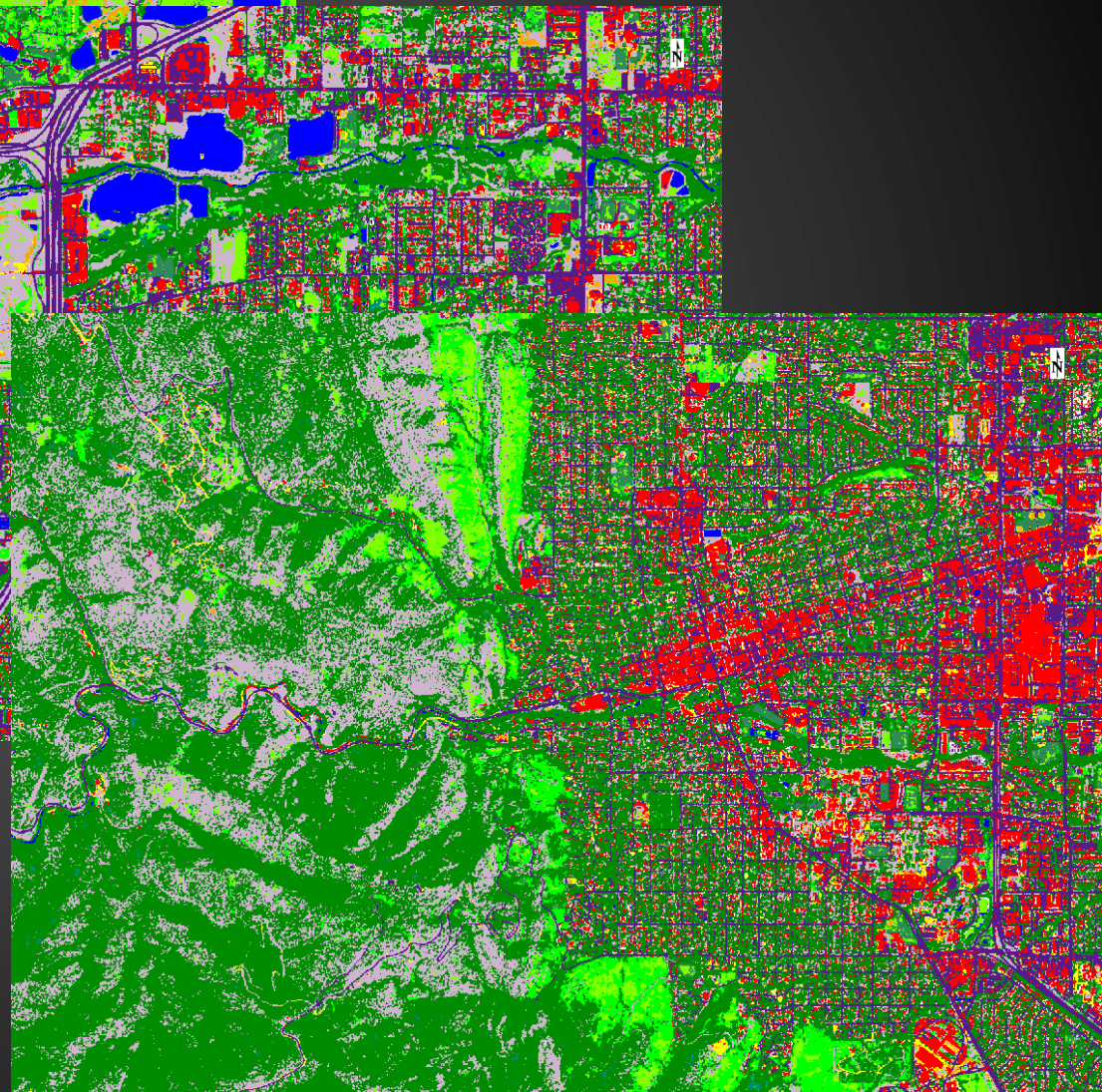
Municipality Class Information
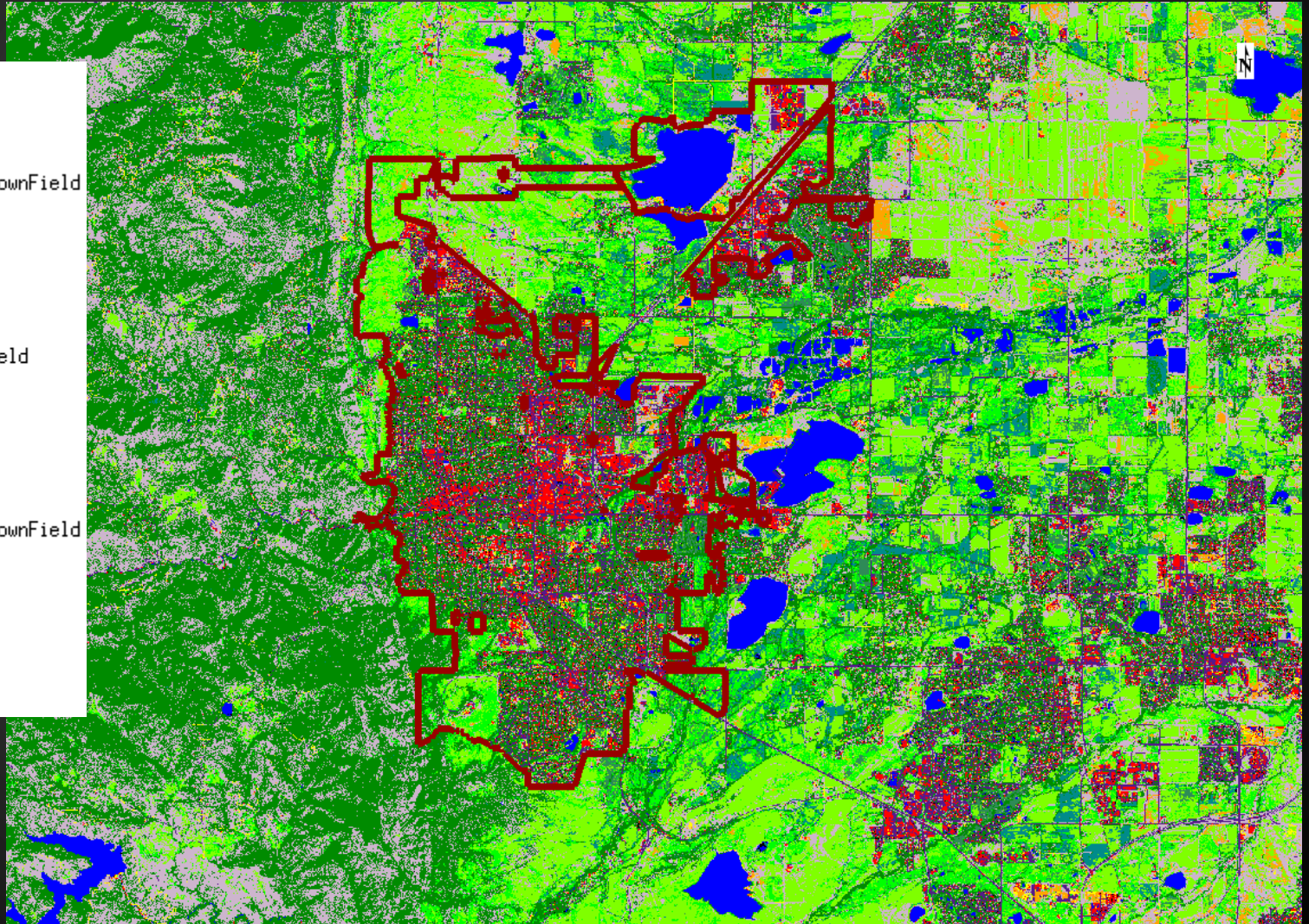
Arbitrary Area Land-Cover Classification
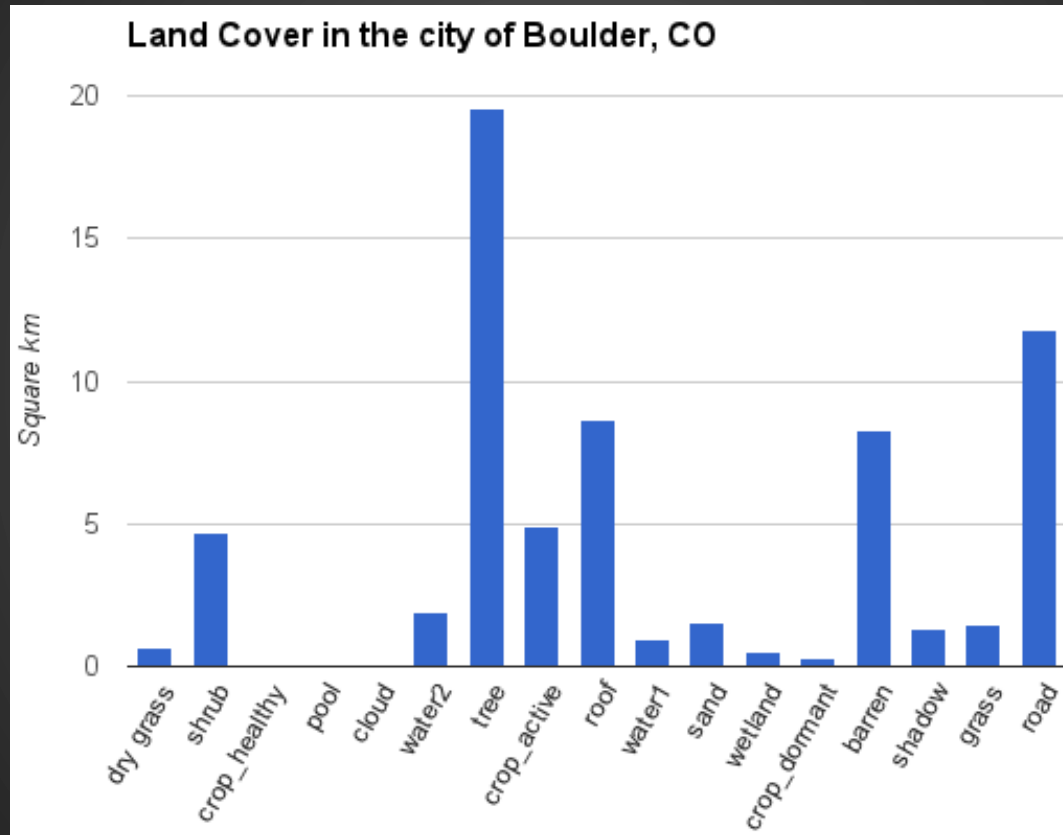
- Extract large-area surface coverage
- Current research into identifying parking lots

Direction on Upcoming Classification Work?

- Planned front range WorldView-2 collection
- What classification experiments would be most useful?
  - Extraction/delineation of dirt roads
  - Estimation of municipality responsible pavement
  - Monitoring of remote sites vegetation recovery

**Possible Areas of Interest...
RoadTracker® for ArcGIS®**

RoadTracker® History

IRT (Interactive RoadTracker®)
  Interactive extraction tool for linear features
    Internal R&D project since 1998
    Version 1.0 commercialized in 2008
    Version 2.0 released in 2009

VUPT (Vector Update)
  Automatically registers and updates outdated vectors to new imagery

ART (Automated RoadTracker®)
  Fully automated linear feature extractor
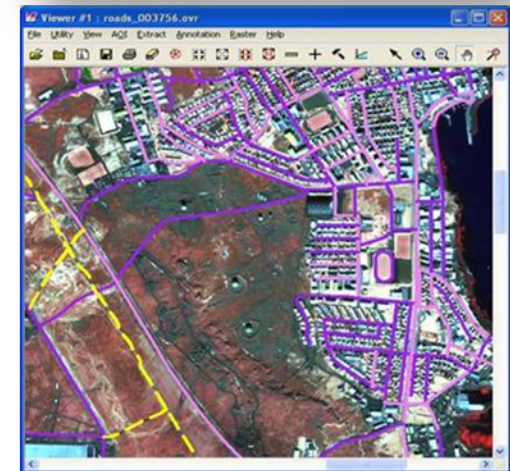
GIRT (RoadTracker® For ARCMap)
  ArcGIS plug-in
    Combines IRT, ART, and VUPT in a single integrated environment
    Initial release in 2011
    Used by NGA and SOFPREP

RoadTracker® screenshots

Semi-Automatic Extraction

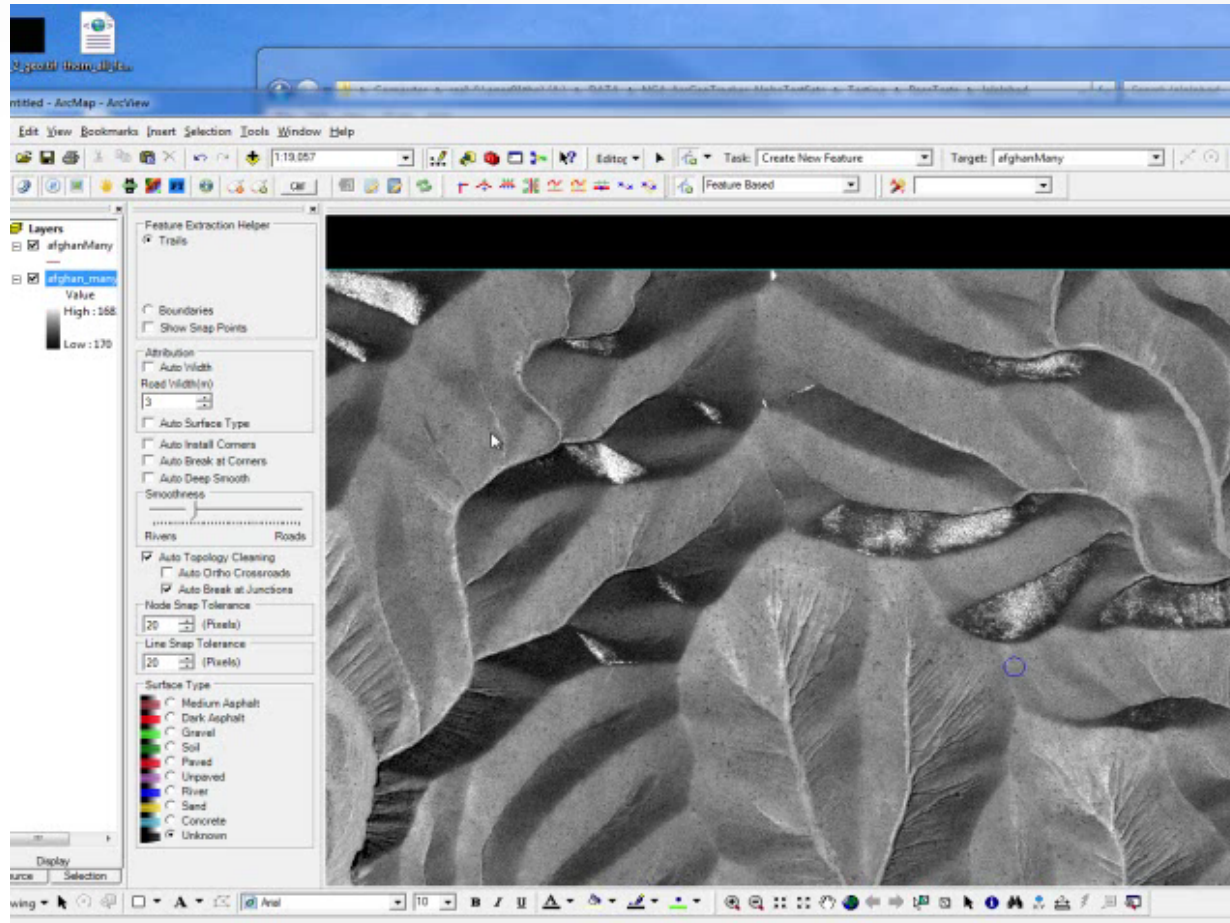**Note the automatic attribution of different ribbon widths**

Trail Extraction

Semi-automatic extraction

Mountain Crests and Ravines

Boundary Extraction

Semi-automatic extraction

(Red) crosshairs indicate lock on raw feature signal

Smart Editing with Auto Topology Cleaning

N-Point Detour editing operation

In combination with Auto Topology Cleaning (which causes snapping of crossroads to main road)

Vector Update

Before

(Blue) Imprecise river extraction

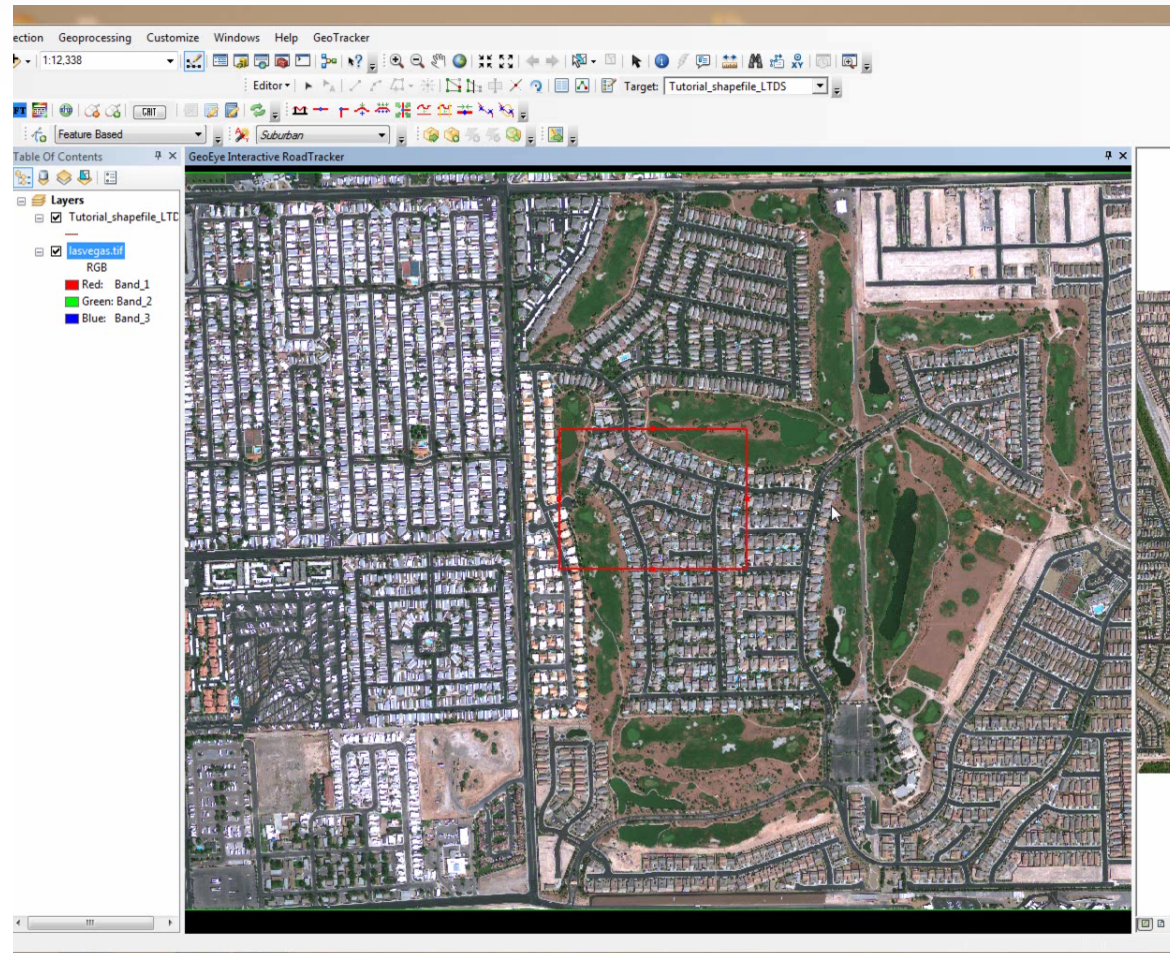(Yellow) Imprecise trail extraction

Vector Update operation

After

(Blue) Precise river extraction

(Yellow) Precise trail extraction

Fully-Automated Extraction

RoadTracker® Performance

- Tested by internal and outside cartographers
    - 2x efficiency improvement over manual extraction
        - All supported image types
        - Roads
        - Paths and trails
    - As much as 85% reduction of mouse clicks required
    - Less fatigue experienced by cartographers

Thank you!