



Spatial Information Solutions (SIS) Map Accuracy Tools (MAT)

2008 Civil Commercial Imagery
Evaluation Workshop

Dr. Charles G. O'Hara
March 25-27, 2008

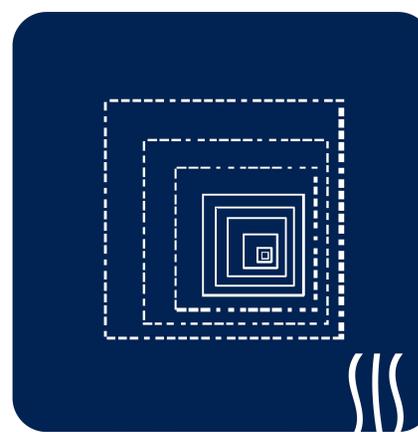
Evaluating the Accuracy and Characteristics of Commercial Image Data for Map Modernization and Maintenance Using Map Accuracy Tools



accuracy analyst



change analyst



sharpening & compression analyst



linear analyst



MSU Mapping Project

Partners and Research Results Deliver Software Technology Applications



MSU and partners investigated map accuracy, modernization, and maintenance technologies and identified:

- Needs for end-user solutions and
- Areas of opportunity for new software.

The MSU team developed designs and working software for needed tools which:

- Enable non-experts to complete complex tasks,
- Provide quantitative solutions,
- Provide qualitative insight, and
- Explain errors and uncertainties.

SIS was formed as a MSU spin off company to speed tech transfer of map enhancement software.

Spatial Data Maintenance Technologies

Exploiting High-Resolution Satellite Image Data, Multi-Temporal Data Sets, and Change Detection and Feature Extraction Methods for Spatial Data Maintenance

High-Resolution Satellite Image Data

Multitemporal Data Sets

Change Detection and Feature Extraction Methods

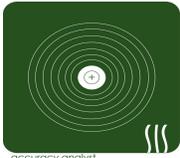
Mississippi State UNIVERSITY

GRI



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Map Accuracy Tools



accuracy analyst

- **Accuracy Analyst** – Quantifies the horizontal accuracy of high-resolution satellite or aerial images and characterizes the statistical and spatial distribution of errors. Visuals provide understanding and explain uncertainty and error distribution.



change analyst

- **Change Analyst** – Utilizes bi-temporal images and hybrid change analysis. Enhanced interfaces to change statistics provide threshold refinement. Hybrid change analysis enables use of multiple change products, customized weighting, and filtering to identify change features of interest.



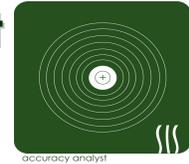
sharpening & compression analyst

- **Compression Analyst** – Evaluates sharpening and compression options and provides quantitative insight about information loss as well as qualitative ability to preview visual quality of image outputs at various compression setting. Delivers output in interoperable JPEG2000 format.



linear analyst

- **Linear Analyst** – Enables quantification of absolute and relative errors and inconsistencies in map data. Horizontal accuracy and correspondence analysis provide useful performance and quality metrics.



Horizontal Accuracy

Horizontal Analyst automates circular error probability distribution analysis (CE90 and CE95) and provides graphics that explain complexities of image error via plots of the statistical and spatial distribution of error and uncertainty.

The National Map Accuracy Standard (NMAS) specifies that the 90% or 95% of spatial errors of well-defined points in an image or map should fall within a certain radial distance R. This radial distance is interpreted as the map accuracy or CE90 or CE95.

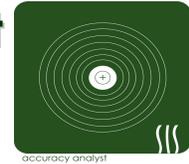
The circular error probability distribution function P(R) given by the function:

$$P(R) = 1 - e^{-\frac{R^2}{2\sigma_c^2}}$$



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Accuracy Analyst



Horizontal Accuracy

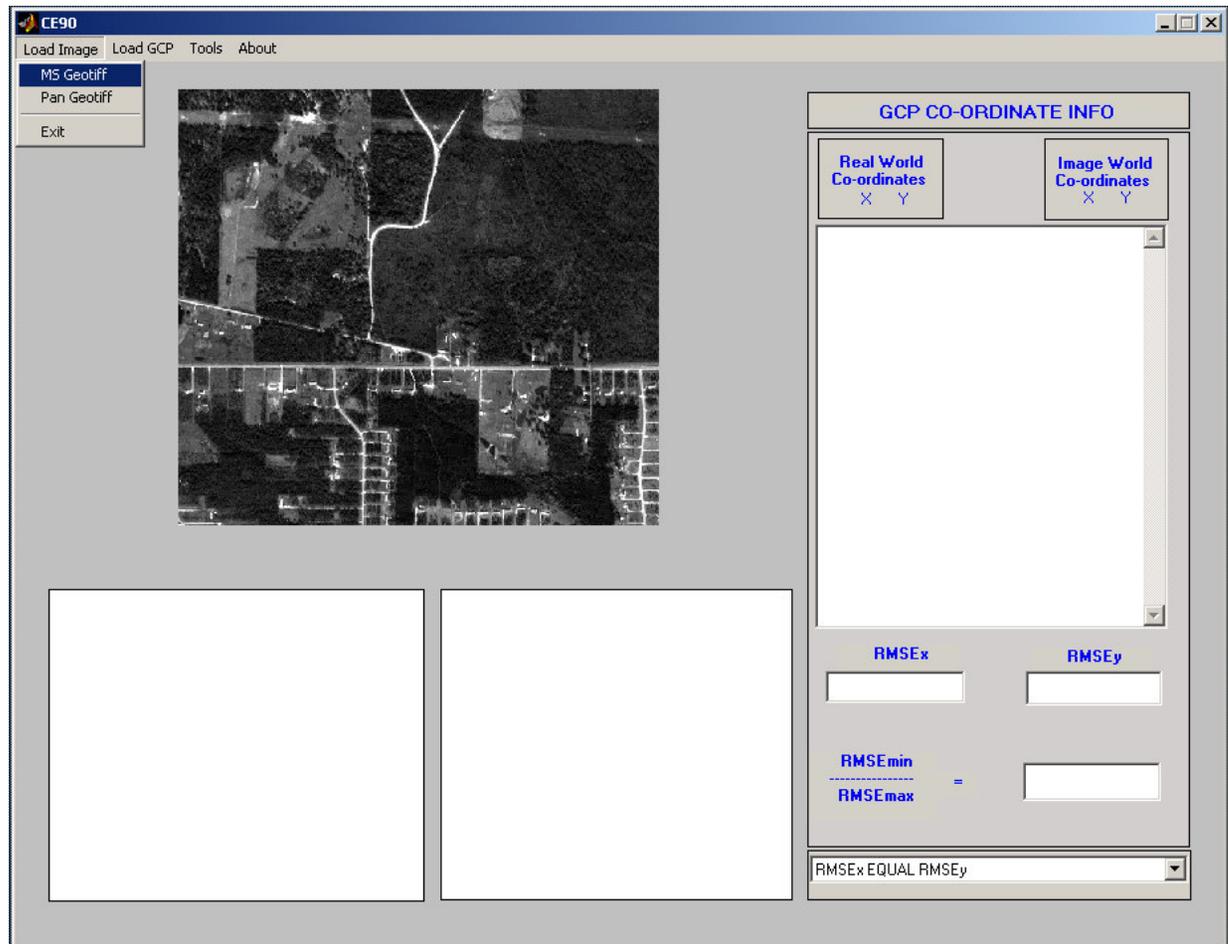
Procedure

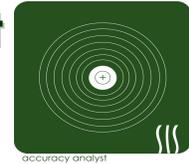
- Collect GPS ground control points (GCPs),
- Select image for analysts,
- Load GCPs
- Select Corresponding locations in image, and
- View Results:

Circular error results

Radial Errors Offset Plot

Vector Errors Offset Plot





Horizontal Accuracy

Analysis

After adding GPS ground control points (GCPs), and selecting an image for analysts, matching locations are found in the image. Matches are found in the image to enable calculation errors in x & y (RMSE_x & RMSE_y).

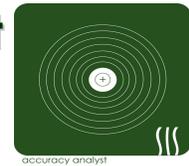
The ratio of errors in x & y enable the selection of the proper equations for determining the circular error probability.

The screenshot shows the Accuracy Analyst software interface. The main window displays a satellite image with several green markers representing Ground Control Points (GCPs). A white line is overlaid on the image, likely representing a path or boundary. The interface includes a menu bar with options like 'Load Image', 'Load GCP', 'Tools', and 'About'. Below the map, there are two empty white boxes. On the right side, there is a 'GCP CO-ORDINATE INFO' panel containing a table of coordinates and calculated error metrics.

GCP CO-ORDINATE INFO			
Real World Co-ordinates		Image World Co-ordinates	
X	Y	X	Y
330015.40	3382681.20	330010.40	3382681.20
330191.30	3381854.50	330195.70	3381854.50
330596.40	3382078.80	330599.40	3382078.80
330471.20	3382674.30	330474.60	3382674.30
330849.30	3381772.90	330845.40	3381772.90
331231.10	3382671.30	331233.70	3382671.30
331495.40	3382890.20	331499.40	3382890.20
331562.40	3382679.20	331568.40	3382679.20

RMSE_x	RMSE_y
4.16668	0.895824
RMSE_{min}	RMSE_{max}
	0.214997

RMSE_{min}/RMSE_{max} BETWEEN 0.2 - 0.6

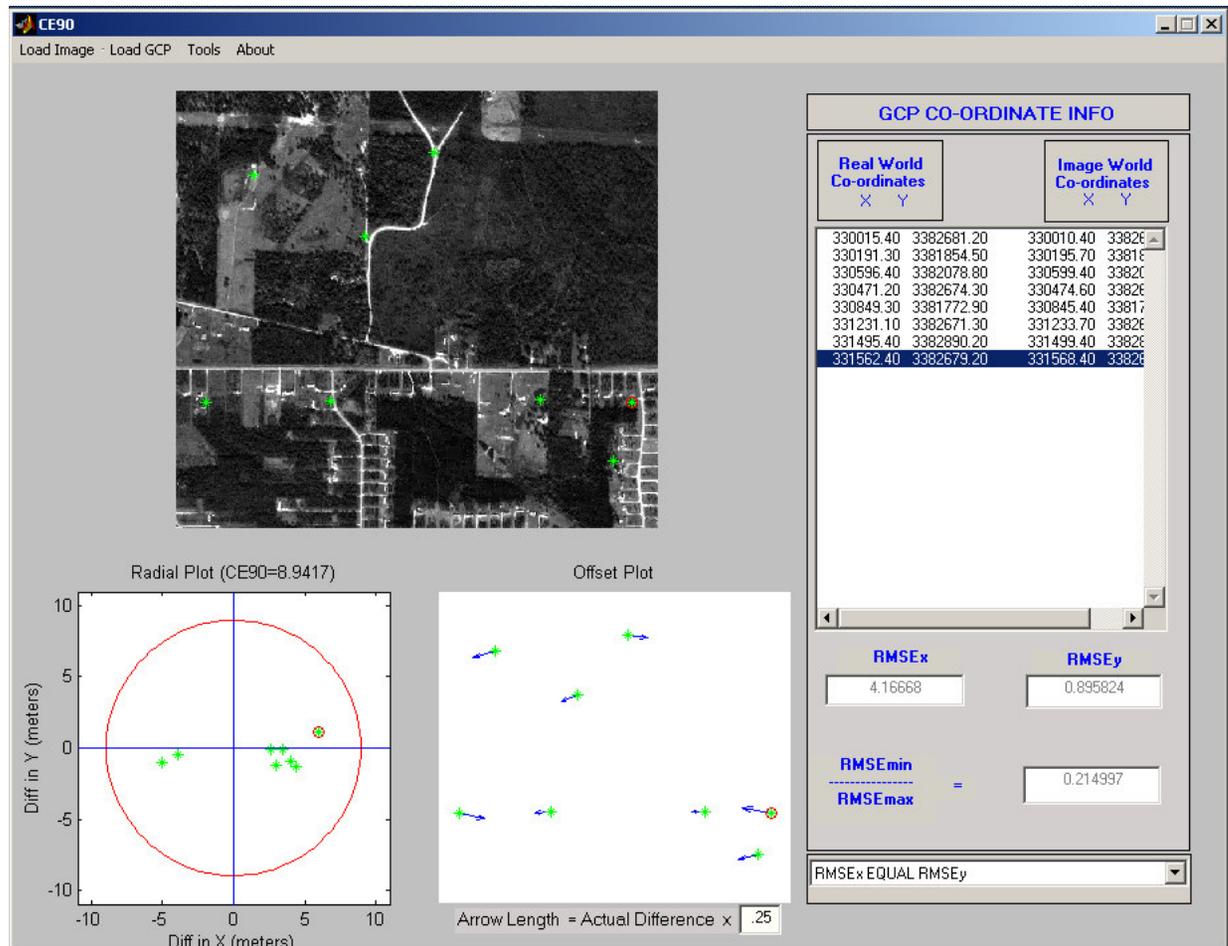


Horizontal Accuracy

Explore Error

Error probability is calculated and error plots are generated. The radial plot shows error for each point as offset from a circular origin. The offset plot shows offset direction and magnitude.

Selecting points in the coordinate interface highlights the location of the point on the map and in each plot providing insight as to the error in the image at that location.





Hybrid Change

Modern mapping applications require accurately mapped and up-to-date features. Temporal images and effective methods of change detection enable directed updates and efficient maintenance.

Multi-temporal precision orthorectified QuickBird image data were used to evaluate change detection methods.



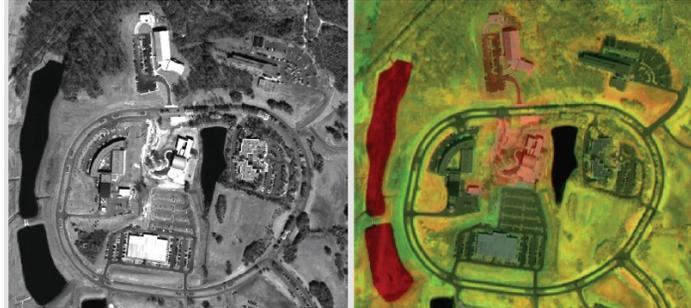


Hybrid Change

Temporal image data provide input to visual inspection of change and effective extraction of change features of interest for map updates. Change Analysts provides multiple methods of creating and combining change products with optimal thresholds and customizable hybrid change products.



Multispectral Image , Feb 2002 Multispectral Image , Mar 2004

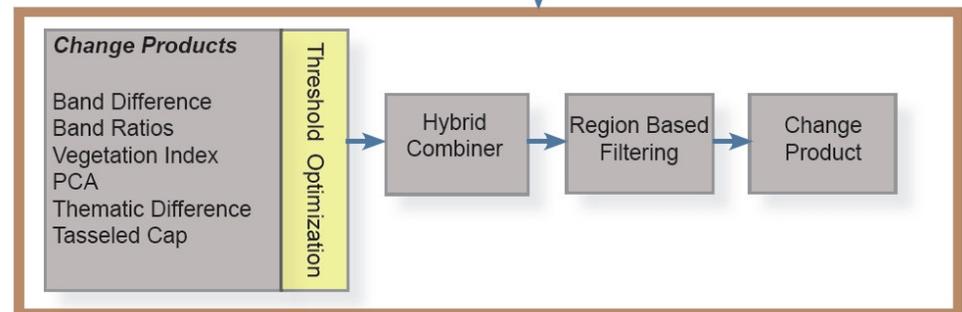


Panchromatic Image, Mar 2004 Change Visualization using write function memory insertion

Traditional Remote Sensing Analysis



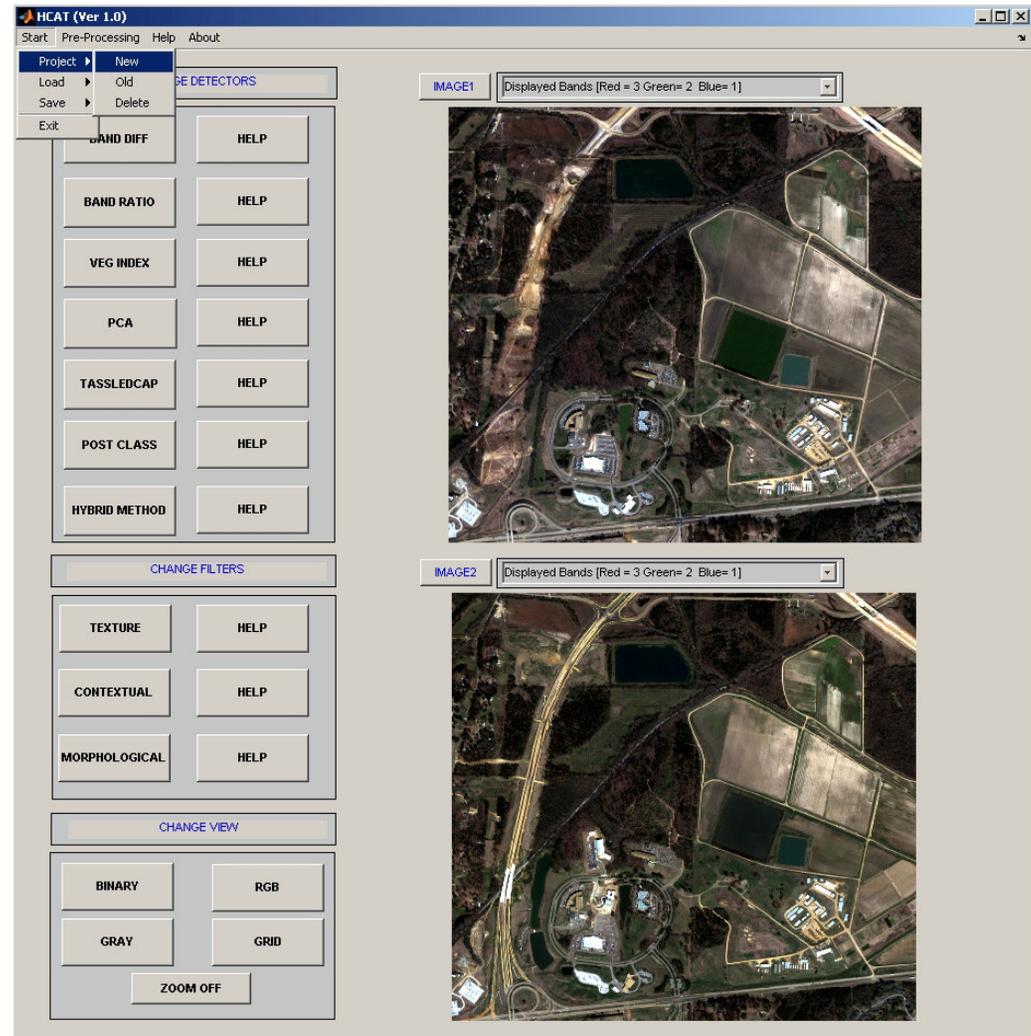
Change Analyst





Hybrid Change

- A Change Analyst project is initiated.
- Temporal images are selected for analysis.
- Change products are generated as desired:
 - Band Differences
 - Ratios
 - Vegetation Indices
 - Post - Classification Change
 - Others
- Thresholds are optimized for change products.
- Change is detected using hybrid combination and voting.
- Filtering removes undesired changes such as small objects that are vehicle sized.





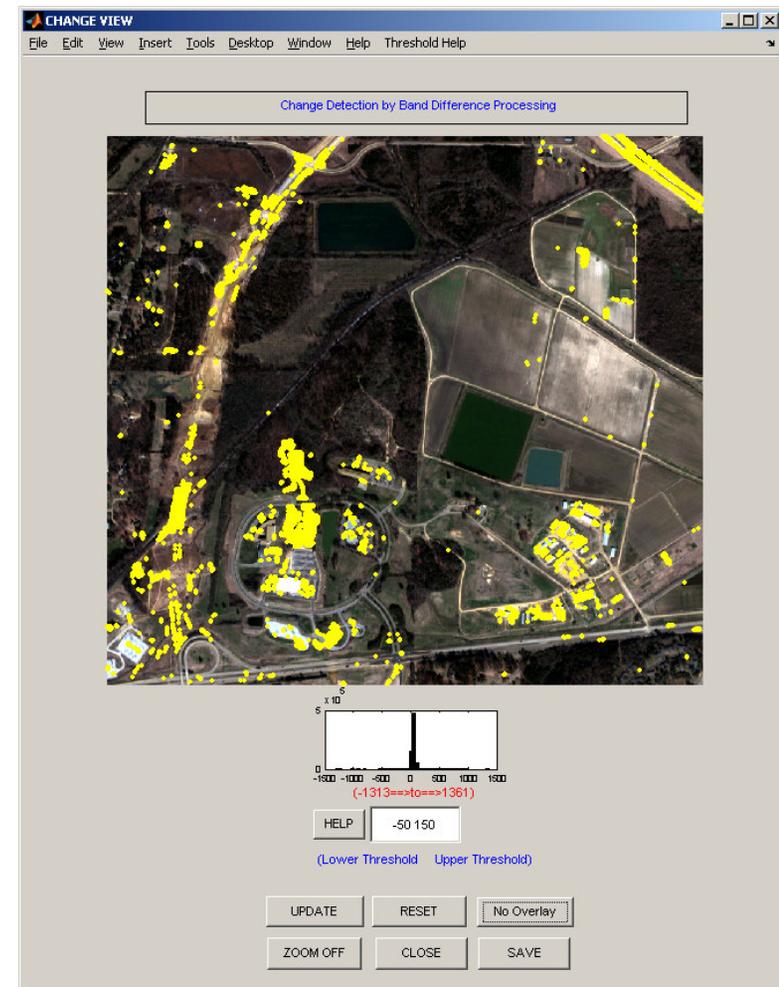
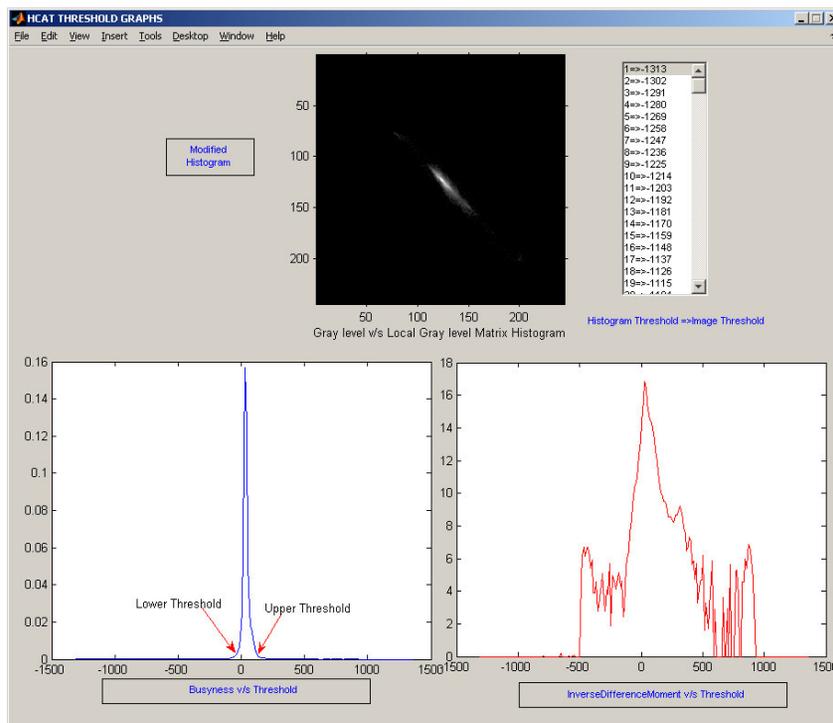
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Change Analyst



Hybrid Change

Thresholds: For each change product, tools are available to explore the distribution of change and refine change or no-change thresholds.

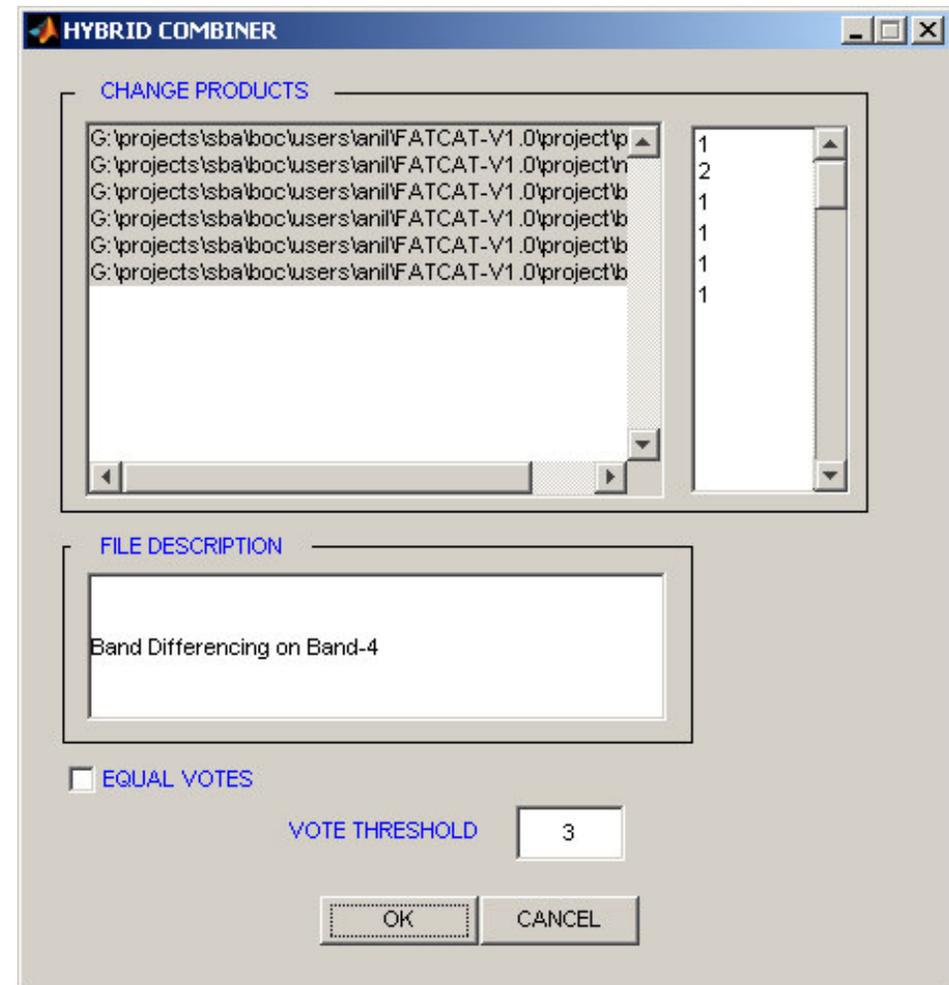


SIS Map Accuracy Tools



Hybrid Change

- **Plural change products are generated**
- **Hybrid analysis combines the change products and allows “weights” to be applied to individual products.**
- **Voting threshold sets required value for change or no-change areas.**





Hybrid Change

Change analysis may be used to efficiently map areas of change and enable rapid and effective update of map information.

- Changed Land Cover
 - NEW CLEARED
 - NEW URBAN
 - NEW WATER BODIES
- Land Cover
 - CLEARED T2
 - SHADOWS AND EDGES
 - URBAN T2
 - VEGETATION T2
 - WATER T2



SIS Map Accuracy Tools

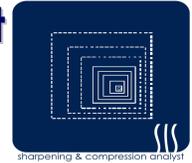


Image Compression

Image compression for useful and interoperable output requires geo-location encoding methods that meet application requirements and compression application settings that preserve the ability to use compressed image data to identify features and preserve uses that meet operational requirements.

Compression Analyst provides:

- **JPEG2000 Image Output**
- **Multiple encoding methods for geo-location data**
- **Visual inspection of subsets at varying compression settings**
- **Quantification and graphical output of performance and information loss at different compression settings.**

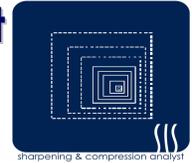


Image Compression

- **QuickBird Image**
- **2.4 m resolution**
- **1024 x 1024 pixels**
- **Memphis, TN**
- **Four bands**
 - **Band 1: Blue**
 - **Band 2: Green**
 - **Band 3: Red**
 - **Band 4: NIR**

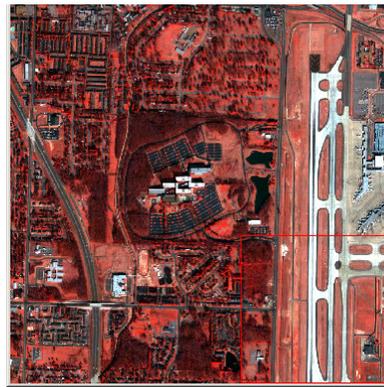


Image Compression

Large area zoomed-out views show little difference due to compression settings



ORIGINAL



1:5



1:10



1:20



1:30



1:50



1:100



1:200



Image Compression

Zooming in shows loss of visual information and reduced ability to identify features of interest due to compression settings



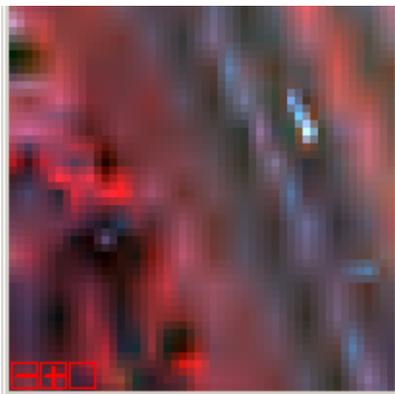
Original



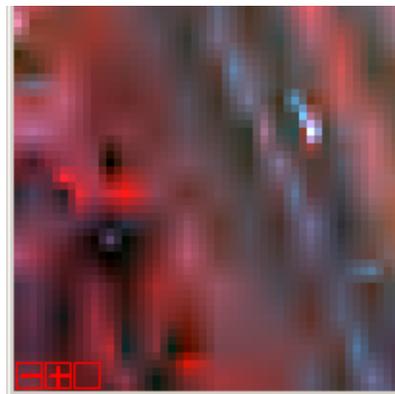
1:10



1:20



1:50



1:150



1:200

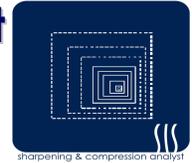


Image Compression

Selected Compression Performance Quality Metrics

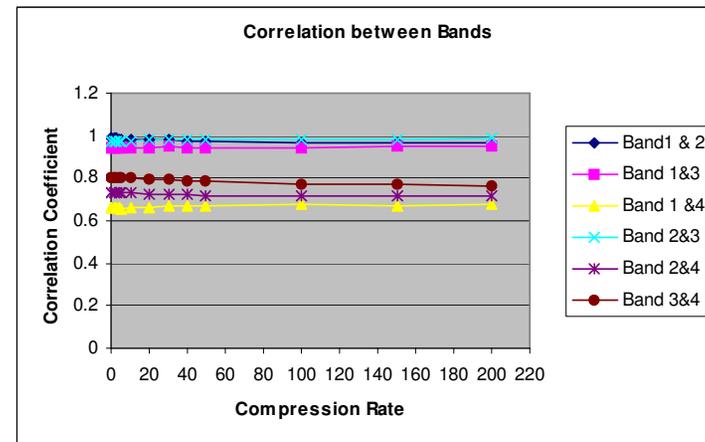
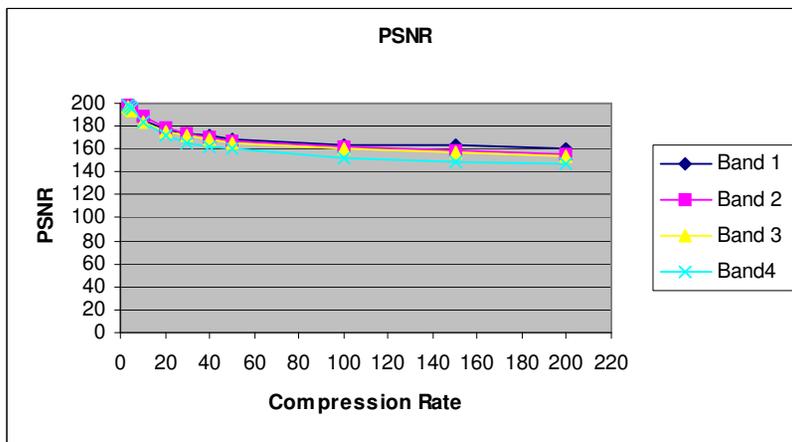
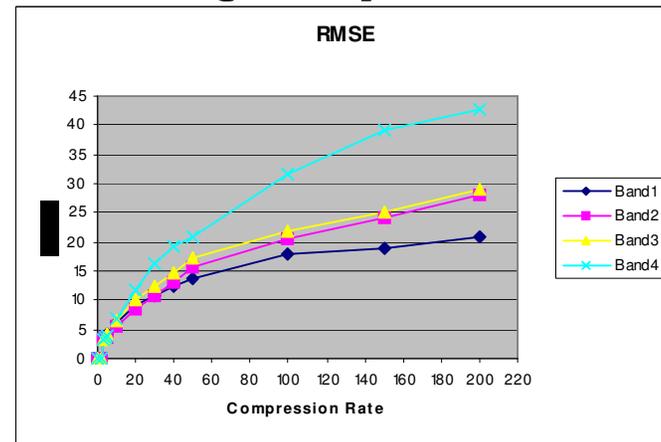
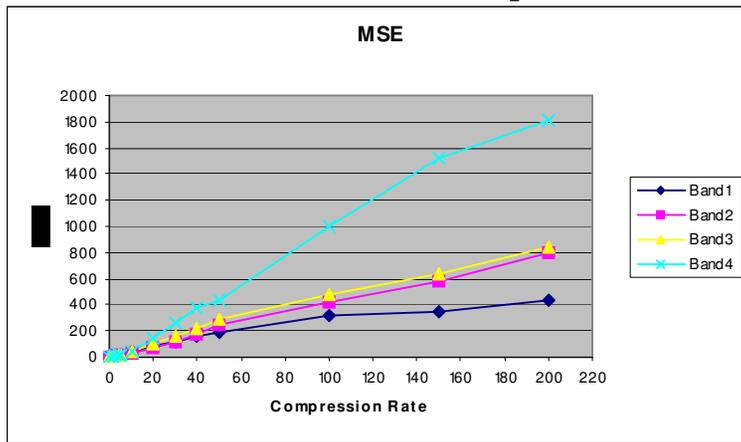




Image Compression

Visual inspection could not determine much difference in images.

Differences are not readily visually observed until compression rates exceed 50 times original.

The quality metrics show that the spectral fidelity of images decreases even for lower compression rates.

MSE and RMSE values increase most in the fourth band of the image.

Correlation coefficients are comparable for all the different rates of compression implying that the changes are relative in each band.

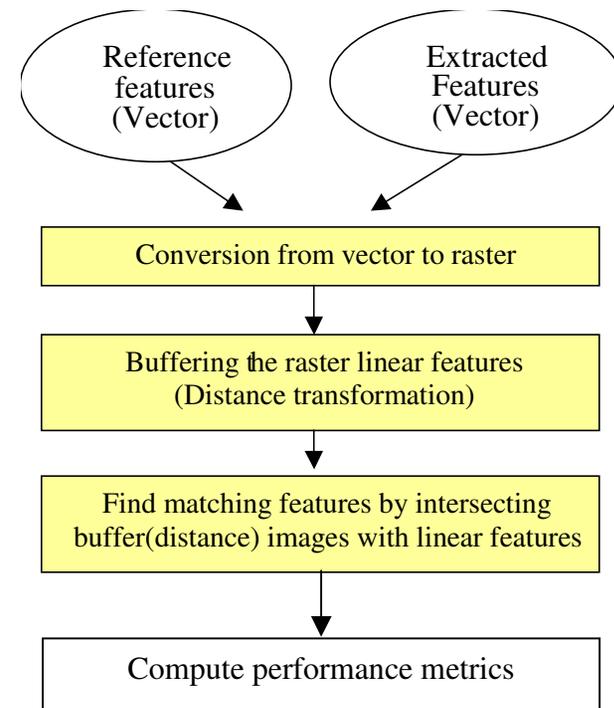


Linear Accuracy

Point- and line-based methods evaluate the geometric quality of linear spatial databases.

Point-based methods present adaptations of traditional methods for absolute and relative accuracy assessment methods using ground truth points (GPS) or a set of points commonly existing between different road datasets.

New line-based methods quantify the geometric quality of datasets by determining correspondences between line segments.



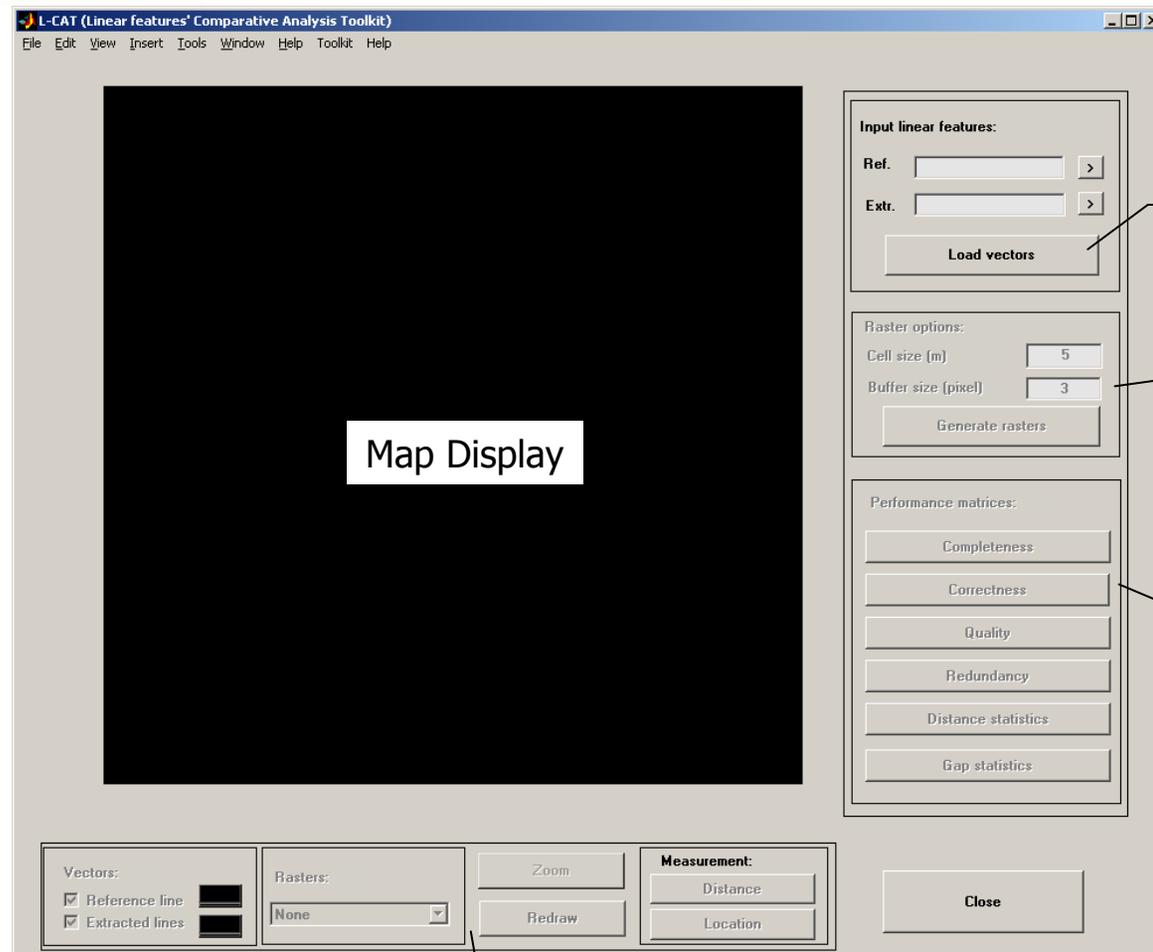


spatial information solutions

Linear Analyst



Linear Accuracy



Map Display

Select input files

Set raster options

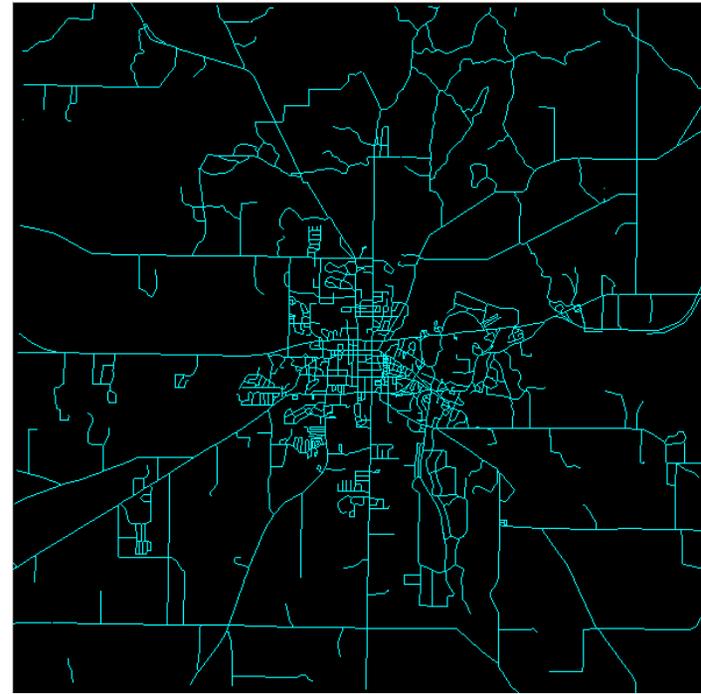
Performance metrics

Display control



Linear Accuracy

- **Objective: Comparison of two existing data sets**
- **Data source: DLG and TIGER Data**
- **Study area: Starkville, MS (16km x 16km)**

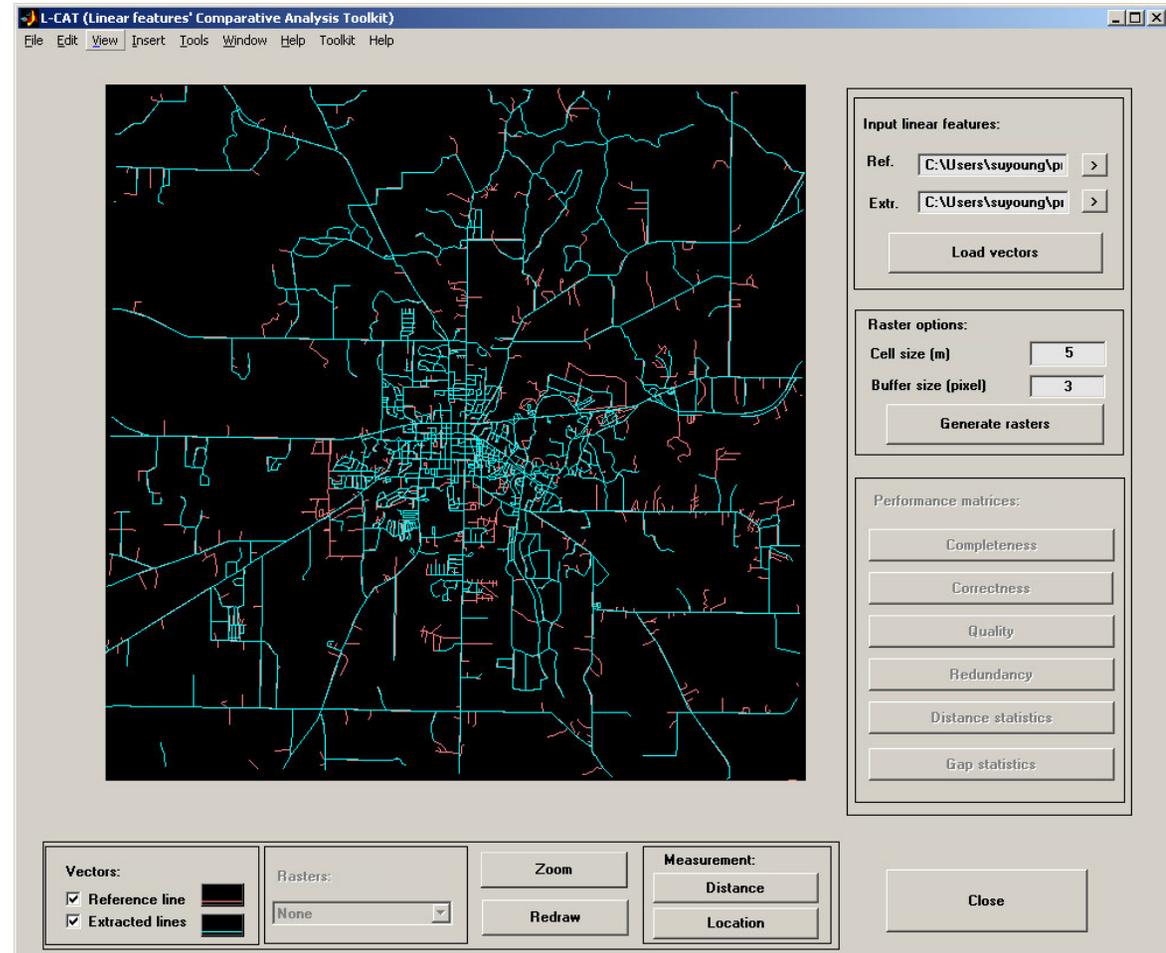




Linear Accuracy

Comparison of existing data sets from legacy sources to examine the nature of errors in the data:

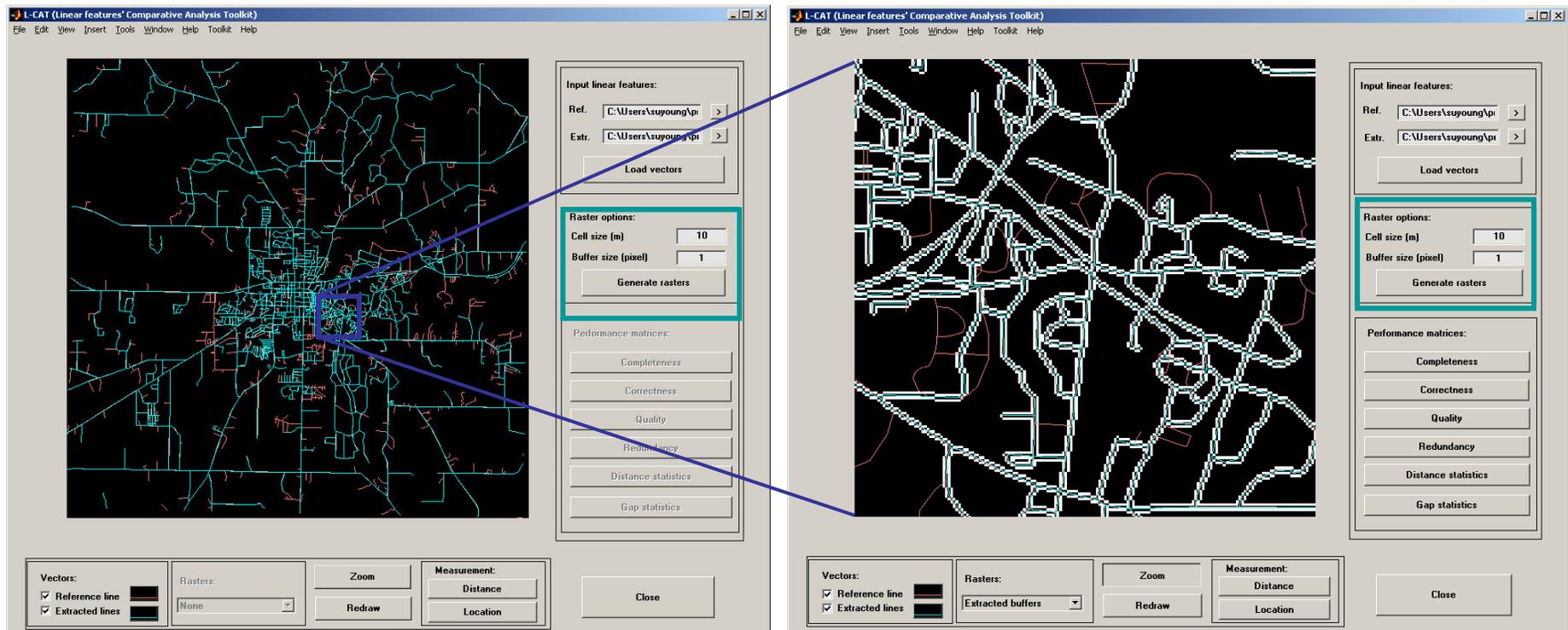
- Omission
- Commission
- Redundancy
- Offset
- Gaps
- Others





Linear Accuracy

A streamlined interface enables stepwise completion of data selection, setting analysis parameters, computing metrics, managing the visual interface, evaluating performance metrics, and generating outputs.



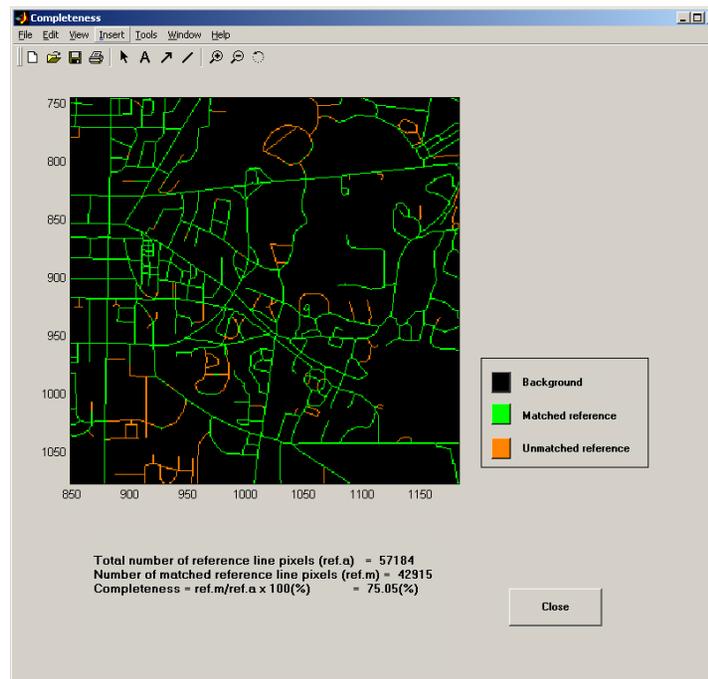
SIS Map Accuracy Tools

Linear Accuracy

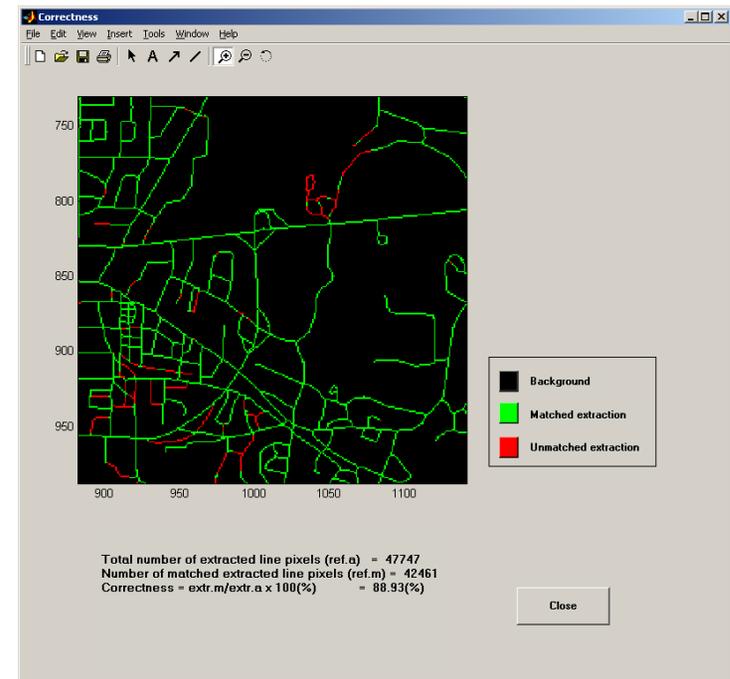
Example Accuracy and Correspondence Performance Metrics

Metrics:

- Completeness
- Correctness
- Quality
- Redundancy
- Distance
- Gaps



$$\begin{aligned}
 & \text{completeness} \\
 &= \frac{\text{length of matched reference}}{\text{length of reference}} \\
 &= \frac{\sum ref.m}{\sum ref}
 \end{aligned}$$



$$\begin{aligned}
 & \text{correctness} \\
 &= \frac{\text{length of matched extraction}}{\text{length of extraction}} \\
 &= \frac{TP}{TP + FP} = \frac{\sum extr.m}{\sum extr}
 \end{aligned}$$



Linear Accuracy

Purposes

- **Ensure data version control.**
- **Detect unintended changes or “creep” in data.**
- **Evaluate data updates and**
 - **Ensure that all old features are still in the updated dataset and match the source reference data**
 - **Ensure that new “extracted” features are part of unmatched extracted.**
 - **Use raster outputs for overlay checking and verification.**
- **Use GPS point locations to evaluate the accuracy of vector datasets.**
- **Evaluate various versions of linear data to determine absolute accuracy and relative quality among data sets.**
- **Determine if vector data meet accuracy requirements or if data geometry must be realigned (migrated) with quality image data.**



spatial information solutions

Map Accuracy Tools

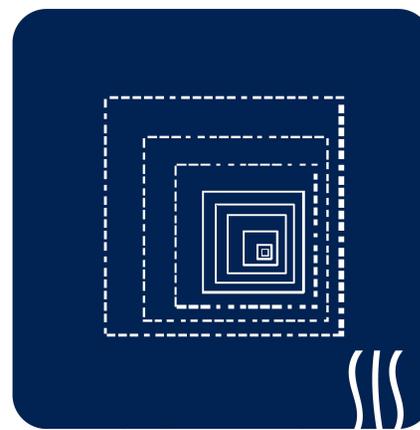
- **Provide basic accuracy analysis capabilities.**
- **Deliver enhanced understanding of map errors as well as the distribution and causes of errors.**
- **Enable apt selection of compression settings for data management.**
- **Enable determination of change in data for efficient map updates.**
- **Enable determination of accuracy of feature data set to determine if data should be geometrically aligned to improved image data.**
- **Fill gaps for map accuracy analysis software for non-experts.**



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