Image Quality Evaluation of QuickBird Super Resolution and Revisit of IKONOS

Civil And Commercial Application Project (CCAP)

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NATIONAL GEOSPATIAL-INTELLIGENCE AGENCY
Study Objectives

• Determine the National Imagery Interpretability Rating Scale (NIIRS) for:
  1. Space Imaging IKONOS Revisit
  2. DigitalGlobe QuickBird Super Resolution
Evaluation Process

- Prepare plan
- Define variables
- Collect materials
- Develop evaluation capabilities
- Perform pilot evaluation
- Perform evaluation
- Analyze data
- Prepare briefing
- Publish brief
IKONOS Revisit
Background

• IQ&U assessed IKONOS pan imagery in the fall of 2000
  – 46 chips from 24 images
  – Average GSD: 0.93 meters (36.6 inches)
  – Average NIIRS 4.65

• Data was re-analyzed because new outlier procedures had been established
  – Two IAs were removed as outliers that were not removed in the previous analysis
  – Average NIIRS under this new analysis is 4.49 ± 0.19 (95% confidence)
  – Confidence bounds assumes IAs are random effects as opposed to fixed effects
Objective of Revisit

- To re-assess the quality of IKONOS imagery to determine if there had been a change over time
Experimental Design

- 10 Imagery Analysts
- 22 Images
  - One to five sub-scenes extracted from each image
  - Total of 68 chips
  - GSD from 0.82 (best) to 0.995 meters (32 to 39 inches)
    - Average GSD = 0.89
  - Various OBs (A, C, G, I, N)
- Absolute NIIRS Ratings
Outlier Analysis

- Calculated Bias and RMSE for each IA
  - Remove IAs that exceed thresholds
- Examine individual ratings to identify possible outliers
- Results
  - Two IAs removed from the analysis and one additional rating was identified as an outlier and also removed from the analysis
Average NIIRS by Image Scene
n=22
Average NIIRS for Image Chips
n=68
Average NIIRS by OB

- A - Air
- C - Cultural
- G - GOB
- I - Industrial
- N - NOB

Legend:
- A
- C
- G
- I
- N
Comparison with Previous Evaluation

• Average NIIRS
  – 1\textsuperscript{st} Evaluation (2000): $4.49 \pm 0.187$
  – 2\textsuperscript{nd} Evaluation (2003): $4.30 \pm 0.155$

• Difference not significant at the 0.05 level
Conclusions

- While average NIIRS rating was smaller than previous evaluation, difference not statistically significant
- Conclude that IKONOS panchromatic image quality has not changed between 2001 and 2003
QuickBird Super Resolution
Purpose of Evaluation

- DigitalGlobe developed an algorithm for processing a Super Resolution imagery product
- NGA Commercial Imagery Office requested NGA IQ&U evaluate the Super Resolution product
Background of Original QuickBird Evaluation

- 10 Imagery Analysts (IAs)
- 53 Images
  - 28 Pan (Basic 1B)
  - 10 MSI (Basic 1B)
  - 15 Pan Sharpened MSI (Standard 2A)
  - One to five sub-scenes extracted from each image
- Total of 213 chips
- All images at near-nadir collection geometry
  - Pan and Pan-Sharpened: GSD between 0.62 and 0.7 meters (24.4 – 27.6 inches)
  - MSI: GSD = 2.54 meters (100 inches)
Super Resolution Experimental Design

• 9 IAs
• 8 scenes re-processed two ways
  – Original
  – Super Resolution
• Each IA
  – Absolute NIIRS rated the regular scenes
  – Delta NIIRS rated the original against the Super Resolution product
Average Absolute NIIRS by Image
(IA #4 removed from analysis)

Average NIIRS = 4.57 (±0.10)

95% confidence interval for the Average is ±0.10 NIIRS
Outlier Analysis
Absolute NIIRS

- IA NIIRS ratings examined for outliers by
  - Correlation analysis
  - Bias
    - Needs to be less than 0.45 in absolute value
  - RMSE
    - Needs to be less than 0.75

- Based upon this analysis, IA #4 responses were identified as being different from the remaining IAs and these data were removed from the analysis
Delta NIIRS by Image (IAs #6 and #8 removed)

Average Delta NIIRS = 0.27 ± 0.063

95% confidence interval for the Average is ± 0.063 NIIRS
Average Delta NIIRS by IA (IAs #6 and #8 removed)

IA #6 is only IA to not prefer the super resolution image.
Outlier Analysis
Delta NIIRS

• IA Delta NIIRS ratings examined for outliers by:
  – Average Delta NIIRS
  – Correlation analysis
  – Bias (No threshold established)
  – RMSE (No threshold established)

• Based upon this analysis, IAs #6 and #8 responses were identified as being different from the remaining IAs and these data were removed from the analysis
Conclusions

• All but one IA preferred the Super Resolution product when compared to the original product
• Average Delta NIIRS improvement (after outlier analysis) was 0.27
• Average Delta NIIRS is statistically different from zero at the 0.01 level of significance
QB Super Resolution

Three Gorges

Standard Product

Super Resolution Product
QB Super Resolution

Three Gorges

Standard Product  Super Resolution Product
QB Super Resolution

Baghdad Airport

Original Product  Super Resolution Product
QB Super Resolution

Baghdad Airport1

Original Product  Super Resolution Product
QB Super Resolution

Hainan1

Original Product

Super Resolution Product
QB Super Resolution

Hainan1

Original Product  Super Resolution Product
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