

North Carolina

DEPARTMENT OF TRANSPORTATION

Experiences with Non-Metric Cameras

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Experiences with Non-Metric Cameras

- Why now?
 - Received requests from 2 agencies
 - NC DENR
 - NC State Highway Patrol
 - Potential future use of unmanned aerial vehicles

Experiences with Non-Metric Cameras

- NC DENR Request
 - Great Coharie Property
 - Requested images be georeferenced to use in ArcGIS
 - Tools Available
 - Z/I Imaging Photogrammetric Suite
 - Microstation
 - ArcGIS

Experiences with Non-Metric Cameras

- NC DENR Great Coharie Property
 - Imagery obtained in December 2013 using manned fixed wing aircraft
 - Nikon D90 Digital Camera
 - 20 mm focal length
 - 12.3 Megapixel (effective)
 - 4,288 x 2,848 pixels
 - 23.6 mm x 15.8 mm sensor size
 - Unknown pixel size
 - Unknown planned flying height
 - No GPS tags

Experiences with Non-Metric Cameras

- NC DENR Great Coharie Property



Experiences with Non-Metric Cameras



Great Coharie Property
Sampson County



Experiences with Non-Metric Cameras

- NC DENR Great Coharie Property
 - Z/I Imaging Photogrammetric Suite

Requires Camera Definition

- Focal length
- Principal point location
- Pixel element size

Supports Lens Distortion Parameters

- Radial
- Decentering

The image shows a screenshot of a software interface for camera configuration. It is divided into three main sections: Lens Information, Frame Dimensions, and Digital I/O Definition. The Lens Information section includes fields for Focal Length (120 mm), Principal Pt. of Best Symmetry (X: 0, Y: 0 mm), and Principal Pt. of Auto Collimation (X: 0, Y: 0 mm). The Frame Dimensions section shows Frame Size in X (92.16 mm) and Frame Size in Y (185.88 mm). The Digital I/O Definition section includes Scanline Orientation (Row Major, Upper), Number of Lines (13824), Samples Per Line (7680), Line Width (12 um), and Sample Width (12 um).

Section	Parameter	Value	Unit
Lens Information	Focal Length	120	mm
	Principal Pt. of Best Symmetry: X	0	mm
	Principal Pt. of Best Symmetry: Y	0	mm
	Principal Pt. of Auto Collimation: X	0	mm
Frame Dimensions	Frame Size in X	92.16	mm
	Frame Size in Y	185.88	mm
Digital I/O Definition	Scanline Orientation in Camera CS	Row Major, Upper	
	Number of Lines	13824	
	Samples Per Line	7680	
	Line Width	12	um
	Sample Width	12	um

Experiences with Non-Metric Cameras

- NC DENR Great Coharie Property
 - Z/I Imaging Photogrammetric Suite

Requires:

- 60% Forward Overlap
- Initial Camera Position Estimates
- Ground Control Points

**Did not use Z/I Imaging
Photogrammetric Suite**



Experiences with Non-Metric Cameras

- NC DENR Great Coharie Property
 - Microstation
 - 2-D warp on individual images using 2013 statewide orthoimagery
 - ~ 5 to 10 foot fit between images
 - Also delivered 2013 statewide orthoimagery

Experiences with Non-Metric Cameras

- What did we do?
- Googled “Non-metric camera photogrammetry”
- Hits related to Close Range Photogrammetry and 3-D Building Modeling
- Downloaded evaluation copy of Agisoft Photoscan

Experiences with Non-Metric Cameras

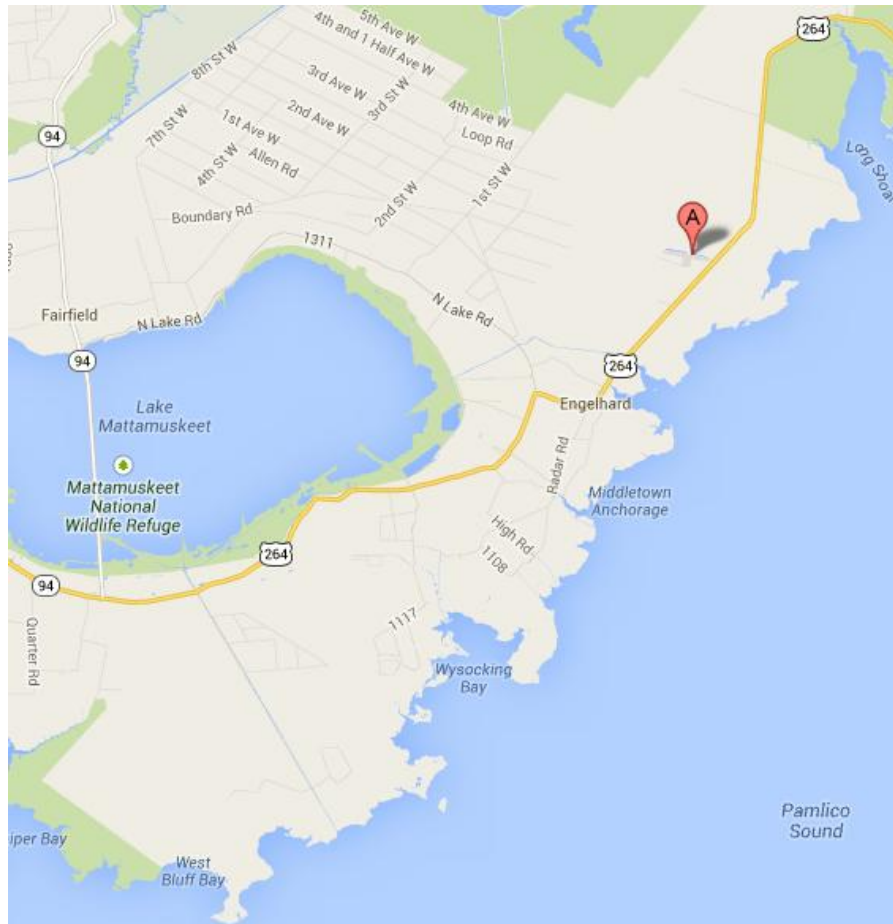
- UAV Imagery from NGAT
 - Gull Rock Test Site (Hyde County Airport)
 - Georeference images and generate an orthophoto and point cloud
 - Tool Used
 - Agisoft PhotoScan

Experiences with Non-Metric Cameras

- Gull Rock Test Site (Hyde County Airport)
 - Imagery obtained in October 2013 using unmanned fixed wing aircraft
 - Bosh Super Swiper
 - GoPro HERO3+ Digital Sensor
 - Individual images extracted from HD Video
 - 2.8 mm focal length
 - 12 Megapixel (effective)
 - 4,000 x 3,000 pixels
 - Unknown pixel size
 - 400 foot above ground planned flying height
 - No GPS tags

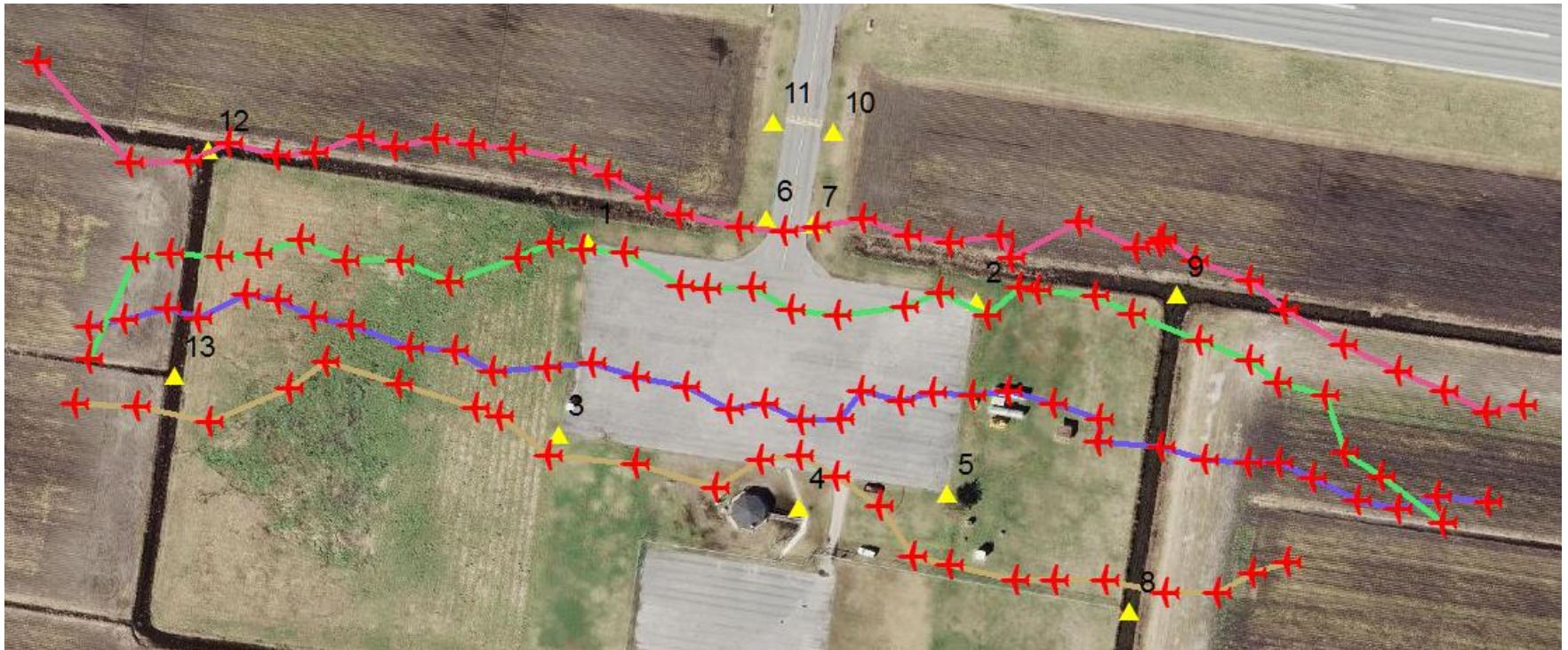
Experiences with Non-Metric Cameras

- Hyde County Airport



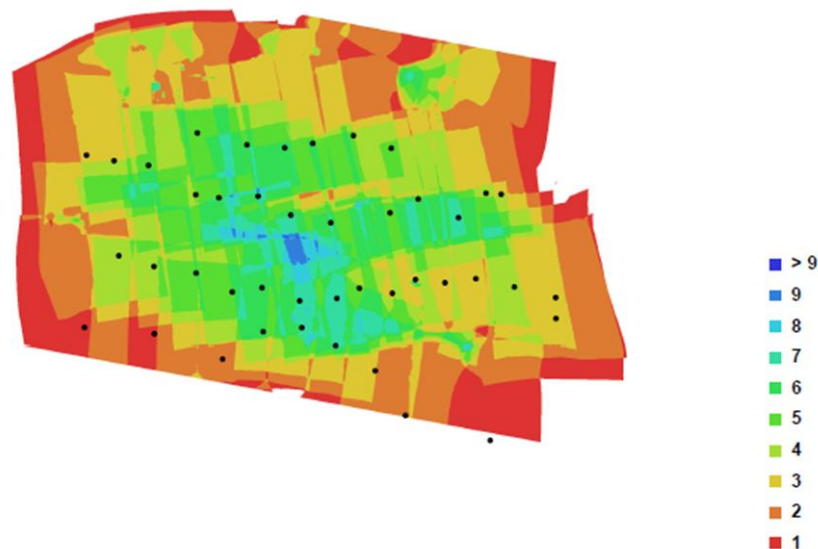
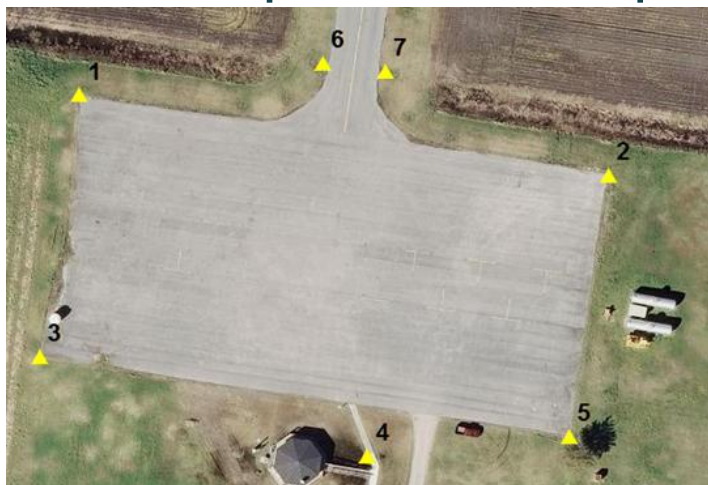
Experiences with Non-Metric Cameras

- Hyde County Airport
 - 4 flight lines, 127 images
 - Variable forward and side overlap
 - No surveyed GCP – use 2012 statewide ortho & LiDAR



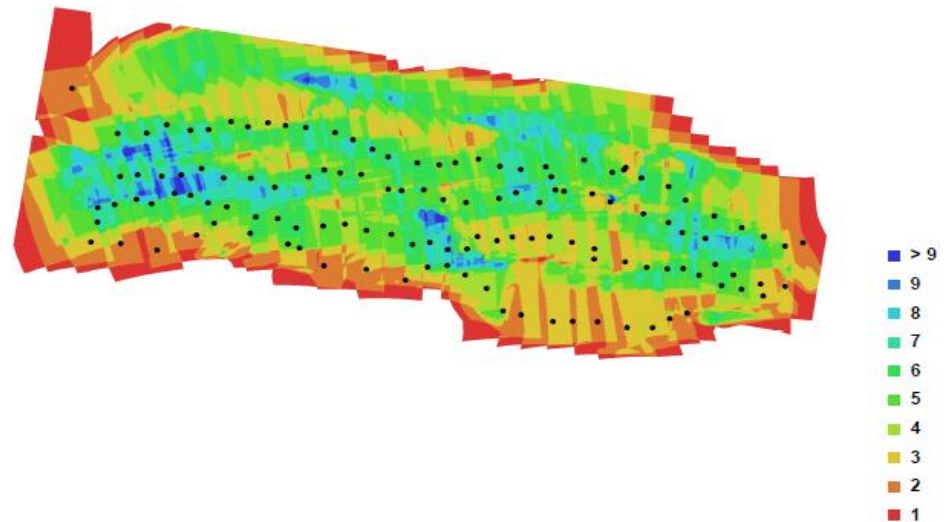
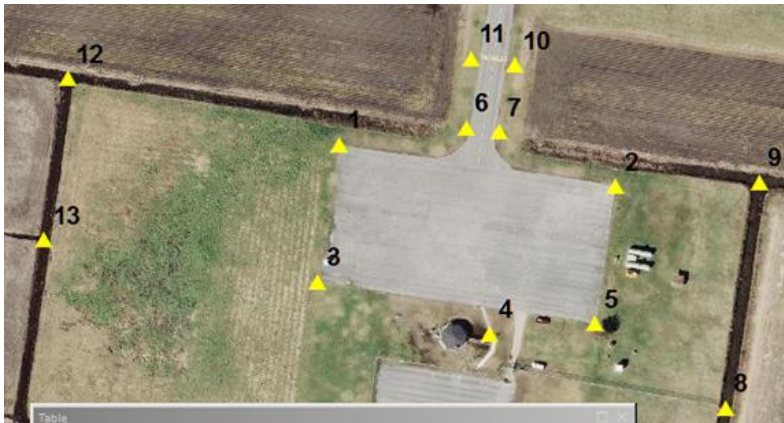
Experiences with Non-Metric Cameras

- Hyde County Airport
 - Initial attempt to “align” all 127 images failed
 - Used a subset of 44 images and 7 GCP for “alignment” which generates a camera calibration for input to subsequent processing



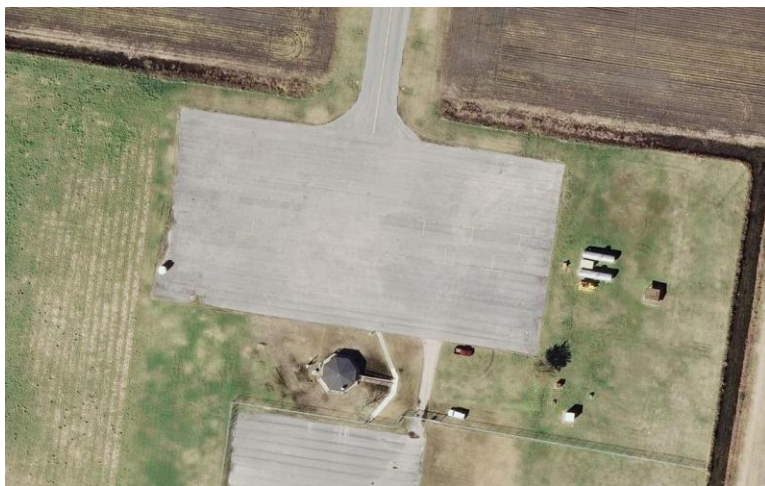
Experiences with Non-Metric Cameras

- Hyde County Airport
 - Second attempt to “align” all 127 images successful
 - Used 11 GCP to generate orthophoto and point cloud



Experiences with Non-Metric Cameras

- Hyde County Airport
 - No accuracy assessment performed due repaving and repainting



2012 statewide orthoimagery



Mosaicked image from
NGAT (not georeferenced)

Experiences with Non-Metric Cameras

- NC State Highway Patrol Imagery
 - South Raleigh: I-440 at Gorman Street
 - Potential higher resolution input for accident reconstruction from multiple images
 - Current 2-D warping approach limited to single image
 - Tool Used
 - Agisoft PhotoScan

Experiences with Non-Metric Cameras

- South Raleigh: I-440 at Gorman Street
 - Imagery obtained in February 2014 using manned helicopter
 - Nikon D3000 Digital Camera
 - 18-55 mm focal length (18mm used for this flight)
 - 10.2 Megapixel (effective)
 - 3,872 x 2,592 pixels
 - 23.6 mm x 15.8 mm sensor size
 - Unknown pixel size
 - 310 foot planned flying height
 - No GPS tags

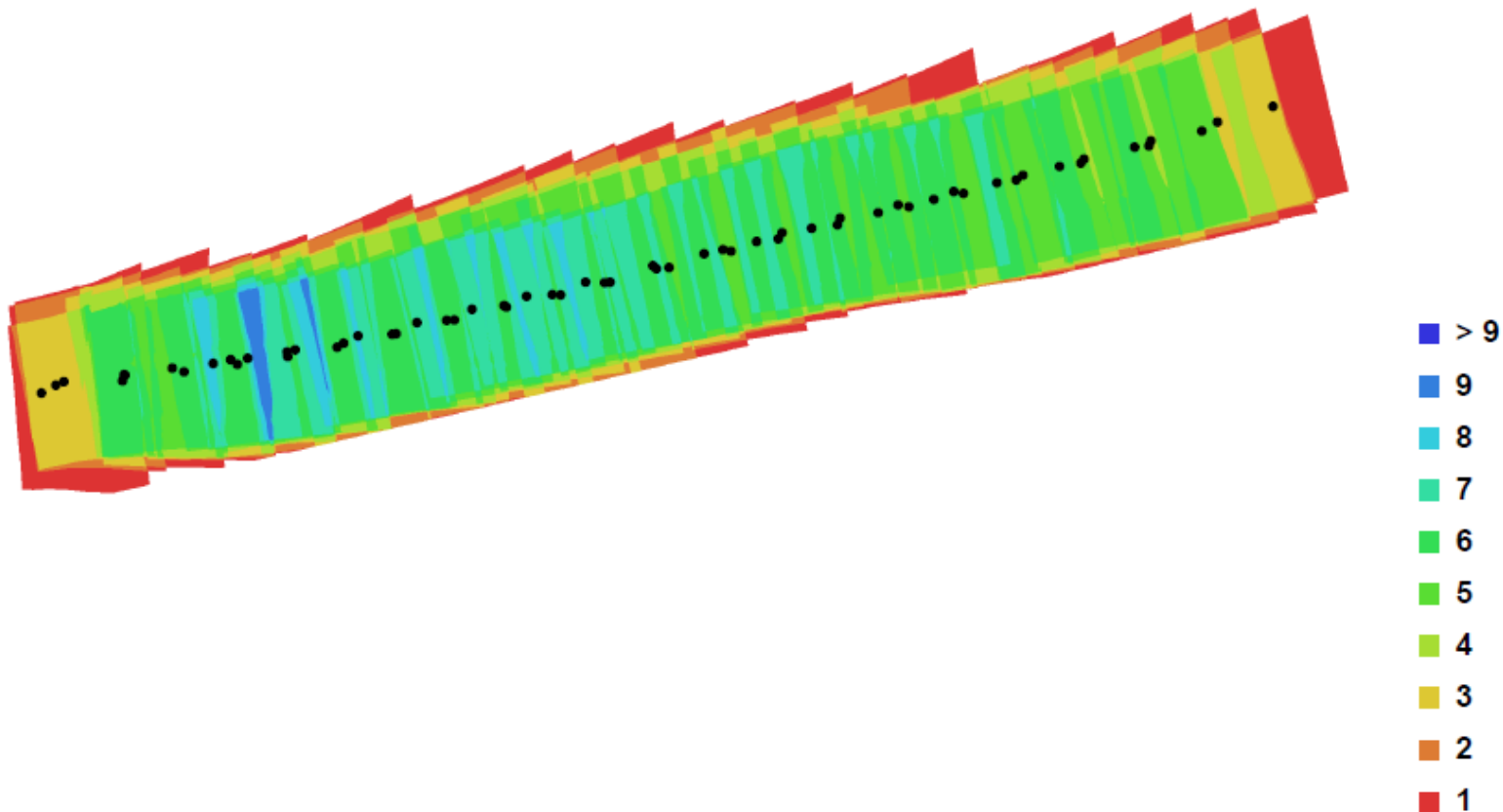
Experiences with Non-Metric Cameras

- South Raleigh: I-440 at Gorman Street
 - 3 flight lines (repeated), 62 images
 - Variable forward and side overlap
 - GCP from project survey & NCDOT low altitude DMC photogrammetry mission



Experiences with Non-Metric Cameras

- South Raleigh: I-440 at Gorman Street
 - Image ray distribution



Experiences with Non-Metric Cameras

- South Raleigh: I-440 at Gorman Street
 - Strips 1-3 orthophoto with control and check point locations



Experiences with Non-Metric Cameras

- South Raleigh: I-440 at Gorman Street
 - Seamline tools not available in Agisoft
 - Note vehicle ghosting

Strips 1-3

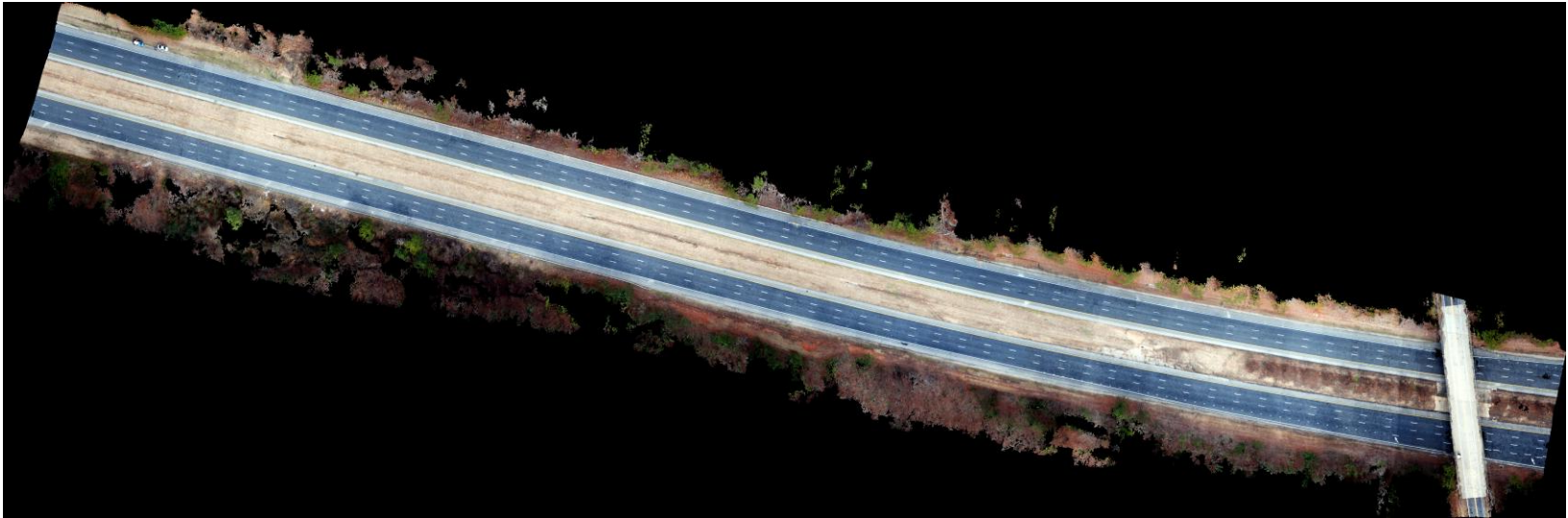


Strip 1



Experiences with Non-Metric Cameras

- South Raleigh: I-440 at Gorman Street
 - Output colorized point cloud to a raster with world file



Experiences with Non-Metric Cameras

- South Raleigh: I-440 at Gorman Street
 - Output colorized point cloud to a raster with world file



Experiences with Non-Metric Cameras

- South Raleigh: I-440 at Gorman Street
 - Accuracy assessment performed on 4 orthophotos
 - Strips 1-3, Strip 1, Strip 2, & Strip 3
 - 35 checkpoints from NCDOT low-altitude photogrammetry mission

Pt ID	Strips 1-3		Strip 1		Strip 2		Strip 3	
	DX	DY	DX	DY	DX	DY	DX	DY
No. Points =	31	31	30	30	30	30	30	30
Min (ft) =	-0.74	-0.96	-0.44	-0.71	-0.20	-0.84	-0.26	-0.75
Max (ft) =	4.71	5.24	4.91	5.33	4.38	5.20	4.81	5.17
Mean (ft) =	2.24	2.12	2.36	2.20	2.29	2.09	2.24	2.11
Std Dev(ft) =	1.64	1.81	1.67	1.85	1.50	1.84	1.56	1.81
RMSE(ft) =	2.76	2.77	2.88	2.86	2.72	2.77	2.71	2.76

Experiences with Non-Metric Cameras

• South Raleigh: I-440 at Gorman Street



- Check points 1-13
- Bounded by control points 205, 207, 17, & 12

Pt ID	Strips 1-3		Strip 1		Strip 2		Strip 3	
	DX	DY	DX	DY	DX	DY	DX	DY
No. Points =	13	13	12	12	12	12	12	12
Min (ft) =	-0.74	-0.96	-0.44	-0.71	-0.20	-0.84	-0.26	-0.71
Max (ft) =	2.47	2.11	2.53	2.12	2.54	2.12	2.60	2.21
Mean (ft) =	0.87	0.76	0.95	0.73	1.06	0.67	0.92	0.71
Std Dev(ft) =	1.05	0.94	1.05	0.94	1.01	0.93	0.97	0.93
RMSE(ft) =	1.33	1.18	1.38	1.16	1.44	1.11	1.31	1.13

Experiences with Non-Metric Cameras

• South Raleigh: I-440 at Gorman Street



- Check points 14-35
- Bounded by control points 217, 12, 1, & 2

Pt ID	Strips 1-3		Strip 1		Strip 2		Strip 3	
	DX	DY	DX	DY	DX	DY	DX	DY
No. Points =	18	18	18	18	18	18	18	18
Min (ft) =	0.57	-0.69	0.12	-0.66	0.62	-0.84	0.39	-0.75
Max (ft) =	4.71	5.24	4.91	5.33	4.38	5.20	4.81	5.17
Mean (ft) =	3.23	3.11	3.30	3.18	3.11	3.04	3.12	3.05
Std Dev(ft) =	1.22	1.66	1.32	1.66	1.18	1.68	1.23	1.64
RMSE(ft) =	3.44	3.50	3.54	3.57	3.31	3.46	3.34	3.44

Experiences with Non-Metric Cameras

- South Raleigh: I-440 at Gorman Street
 - Point cloud views



Experiences with Non-Metric Cameras

- South Raleigh: I-440 at Gorman Street
 - Elevation accuracy assessment performed on point cloud from strips 1-3

Pt ID	Strips 1-3		
	All Pts	Pts 1-13	Pts 14-35
	DZ	DZ	DZ
No. Points =	35	13	22
Min (ft) =	-0.05	-0.05	0.21
Max (ft) =	3.79	1.18	3.79
Mean (ft) =	1.50	0.37	2.17
Std Dev(ft) =	1.27	0.41	1.11
RMSE(ft) =	1.95	0.54	2.43
FVA(ft) =	3.83	1.05	4.76

Experiences with Non-Metric Cameras

- **South Raleigh: I-440 at Gorman Street**
 - Just used the NCDOT GCP (6 points) at the same approximate locations as shown previously
 - Results are for Strips 1-3

Pt ID	Strips 1-3		Strips 1-3		Strips 1-3	
	ALL Checkpoints		Checkpoints 1-13		Checkpoints 14-35	
	DX	DY	DX	DY	DX	DY
No. Points =	30	30	12	12	18	18
Min (ft) =	-1.18	-1.97	-1.18	-0.81	-0.84	-1.97
Max (ft) =	1.47	1.99	1.16	1.99	1.47	1.97
Mean (ft) =	0.07	0.39	-0.05	0.85	0.15	0.08
Std Dev(ft) =	0.94	1.11	1.02	0.79	0.91	1.20
RMSE(ft) =	0.93	1.16	0.97	1.14	0.89	1.17

Experiences with Non-Metric Cameras

- South Raleigh: I-440 at Gorman Street
 - Just used the NCDOT GCP (6 points) at the same approximate locations as shown previously
 - Results are for Strips 1-3

Pt ID	Strips 1-3		
	All Pts	Pts 1-13	Pts 14-35
	DZ	DZ	DZ
No. Points =	35	13	22
Min (ft) =	-2.26	-1.37	-2.26
Max (ft) =	3.65	2.76	3.65
Mean (ft) =	1.29	1.26	1.31
Std Dev(ft) =	1.60	1.32	1.77
RMSE(ft) =	2.04	1.79	2.17
FVA(ft) =	4.00	3.51	4.26

Experiences with Non-Metric Cameras

- What's next?
- Continue to investigate non-metric cameras and associated processing tools
- Continue to evaluate South Raleigh I-440 data set
- Preparing for a controlled test with the NC State Highway Patrol at Raleigh Test Facility
- Stay involved with UAS activities in NC

Experiences with Non-Metric Cameras

Questions

Keith Johnston

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