Small UAV Position and Attitude, Raw Sensor, and Aerial Imagery Data Collected over Farm Field with Surveyed Markers

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Data Summary

As part of the AeroAg project at the University of Minnesota, a commercial small Uninhabited Aerial Vehicle (UAV) was flown in a harvested soybean field near St. Peter, Minnesota on the morning of October 22, 2014. The UAV was equipped with a dual-sensor camera (visible RGB and RG-NIR) consisted of taking pictures of the field which had 16 markers laid out in a 4x4 square serving as known ground control points. The markers were surveyed prior to the flight using an RTK-enabled dual-frequency GPS receiver with 1-2 cm accuracy. A time history of the UAV position and attitude are logged, as are the photos taken at known position and orientations, as computed by the UAV navigation system. The flight included sequential passes at both 200 ft and 400 ft altitude (above ground level). The flight was conducted on a windy day, nearing sustained 20 MPH winds. This data set serves to study both challenges and opportunities of UAV-based remote sensing for precision agriculture applications. It is being shared to served as a documented data set for testing new concepts and ideas.

- Location: Field near St. Peter, Minnesota
- Date: October 22, 2014 (morning)
- Wind Conditions: 17.5 MPH (day's average), from 150 deg. direction (see *Data Sheet* folder)
- UAV: Vireo (see *Data Sheet* folder)
- Camera: 10.5 MP Dual Image Sensor Payload (RGB and RG+NIR, see *Data Sheet* folder)

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- Todd Colten and Dann Schoppe (Sentera) - equipment, piloting, and data processing
- Lee Swenson (U of MN - Athletics) - equipment for outdoor testing

Data Files

The names of flights collected and archived:

Folder or File Name	Description
`flight_data.csv`	UAV position, orientation, and sensor measurements (as computed/logged by on-board flight computer)
`ground_control_points_coordinates.csv`	Table of 16 surveyed ground control point locations
`ground_control_points_map.kml`	Mapping of 16 ground control points in Google Earth (associated `.jpg` is snapshot of map)
`uav_groundtrack_map.kml`	UAV ground track plotted in Google Earth, together with points at which pictures logged (associated `.jpg` is snapshot of map)
`Data Sheets`	Data brochures for UAV, imaging sensor, and climate
`images/RGB-original`	Original RGB images logged by UAV during flight. (images are in JPEG format)
`images/NIR-original`	Original RG+NIR images logged by UAV during flight. (images are in JPEG format)
`images/<sensor>-original/jpegs_metadata.csv`	Table of image names, timestamps, and camera pose
`images/<sensor>-original/highrate_gyro.csv`	High-rate gyro measurements co-located with sensor
`images/<sensor>-processed`	Images corrected for dynamics, color, and lens distortions*
`images/NDVI`	NDVI images formed using `NIR-processed`
`images/FalseColor`	False color image separating energy into image channels RGB image channels map to NIR, Red, and Green energy, respectively)
`images/media`	Pictures taken during data collection (People: T. Colten, C. Dernehl, A. Forsman, T. Layh, H. Mokhtarzadeh)
`sample_orthorectified_view.jpg`	Sample orthorectified images (images orthorectified individually and not stitched)

*Proprietary tools were used to apply these corrections and hence the procedure is unspecified.

Camera Matrix

The mathematical mapping between the 3-D world coordinates and the image pixel-coordinates are:

$$x \quad = \quad K\, R_u^c\, R_n^u \left[\, I \mid -\tilde{C} \,\right] X \tag{1}$$

(2)

where each term is described in the table below:

Term	Size	Description
x	3×1	homogeneous representation of 2-D pixel coordinate
X	4×1	homogeneous representation of 3-D world object (expressed in navigation frame, e.g. North-East-Down)
$\tilde{C}$	3×1	3-D camera position in navigation frame
R_n^u	3×3	Rotation from navigation frame (n) to UAV body frame (u)
R_u^c	3×3	Rotation from UAV body frame (u) to camera frame (c)
K	3×3	Mapping from camera frame (c) to pixel frame

The camera calibration matrix K is derived from prior calibration and has the form:

$$K \quad = \quad \begin{bmatrix} \alpha_x & 0 & x_0 \\ 0 & \alpha_y & y_0 \\ 0 & 0 & 1 \end{bmatrix} \tag{3}$$

where $\alpha_x = \alpha_y = 4662.25$ is the focal length length of the camera in terms of pixels and $(x_0, y_0) = (1962.35, 1288.80)$ is the principal point of the camera, again in units of pixels. The pixel size is 1.67×1.67 micrometers, hence the metric units can be derived.

Notes

The following note is in order regarding the RG+NIR imagery logged from the dual sensor camera. Imagery is logged as if it is RGB, however, the following data is in each channel:

- **Red Channel:** NIR and R energy
- **Green Channel:** NIR and G energy
- **Blue Channel:** NIR, R, and G energy

Due to crosstalk between imager channels, the spectral energy in each channel of the `NIR-original` images are not as clear cut as the above list. However, further processing is used to create the `images/FalseColor` imagery, which separates each energy into separate image channels.