Day-24

1. Introduction

To find whether it is possible to achieve sub-meter precision, specifically a 3x3 feet (~1 meter) error margin, when detecting objects from high-altitude between 1 to 10 kilometers above the ground using image processing, without the use of a laser rangefinder. The solution relies on modern aerial surveying techniques, photogrammetry, and precise GNSS systems.

2. Key Techniques to Achieve High Precision Without Laser Rangefinder

2.1 RTK/PPK GNSS System

Real-Time Kinematic (RTK) and Post Processed Kinematic (PPK) GNSS systems are capable of achieving centimeter level accuracy in our horizontal and vertical measurements. RTK and PPK are exceptionally useful systems since they can completely replace laser based distance measuring tools because they obtain the vertical measurements that will allow us to accurately map.

2.2 Ground Control Points (GCPs)

Ground Control Points (GCP) are permanent, known coordinate marks that are surveyed to sub-centimeter accuracy using RTK/PPK equipment. The GCP's are used as reference points to anchor the image processing steps that are programmed into the software and can improve accuracy to the repeating standards of RTK or PPK positional accuracy.

2.3 Photogrammetry and Structure from Motion (SfM)

Photogrammetry, or structure from motion (SfM), are techniques that allow us to properly reconstruct a 3D model using overlapping oriented images taken at various locations. The photogrammetry or SfM software allows robust measurements of distances and positional locations of objects other than with laser measurements.

2.4 IMU Integration

The inertial measurement unit (IMU), tracks the full motion of the camera system including the pitch, roll and yaw. As part of the IMU function it provides the ability for the corrections to be classified and vary according to IMU body movements and enables positional accuracy.

2.5 Orthorectification

Orthorectification is the decision-making part of correcting distortions that are associated with tilt in the camera and the position of the terrain so that all of the pixels, in the map, correspond appropriately to ground coordinates.

3. Detailed Workflow

Step 1: Equipment Setup

- High-resolution camera (minimum 50-150 MP) with long focal length lens.
- RTK/PPK GNSS system with centimeter-level accuracy.
- IMU for tracking camera orientation.
- Multiple GCPs surveyed to centimeter precision.

Step 2: Flight Planning

- Prefer low altitude (1-3 km) when possible.
- Ensure 70-80% image overlap.
- Maintain stable flight paths.

Step 3: Image Acquisition

- Capture high-resolution, overlapping images.
- Ensure all GCPs are visible in multiple frames.

Step 4: Post-Processing

- Use photogrammetry software (Pix4D, Agisoft Metashape, DroneDeploy).
- Integrate GCPs for georeferencing.
- Apply camera calibration and bundle adjustment.
- Orthorectify images to correct geometric distortions.

Step 5: Accuracy Assessment

- Validate using Root Mean Square Error (RMSE) reports.
- Sub-meter RMSE indicates successful precision achievement.

4. Advantages and Limitations

4.1 Advantages

- Eliminates the need for expensive laser rangefinders.
- Uses widely available GPS and camera systems.
- High-precision mapping achievable with proper setup.

4.2 Limitations

- Requires accurate GNSS systems and GCP placement.
- Relies on complex photogrammetric processing.
- Less effective in poor weather or low-visibility conditions.

6. References

Pix4D Documentation: https://support.pix4d.com/hc/en-us/articles/202557459

Agisoft Metashape GCP Guidelines: https://www.agisoft.com

Trimble Geospatial: https://geospatial.trimble.com/en

DroneDeploy Mapping Accuracy Guide: https://help.dronedeploy.com/hc/en-us

UAV Photogrammetry for Precision Agriculture, DOI: https://doi.org/10.3390/rs9010096

ASPRS Positional Accuracy Standards: https://www.asprs.org/