summary.md

Refine summary.md formatting for clarity in accuracy metrics; adjust column...
Maximilian Johenneken authored 4 days ago

summary.md 5.19 KiB

TEST-20251022-SeedingAccuracy-ArUco-v1 — Executive Summary

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Key Conclusions

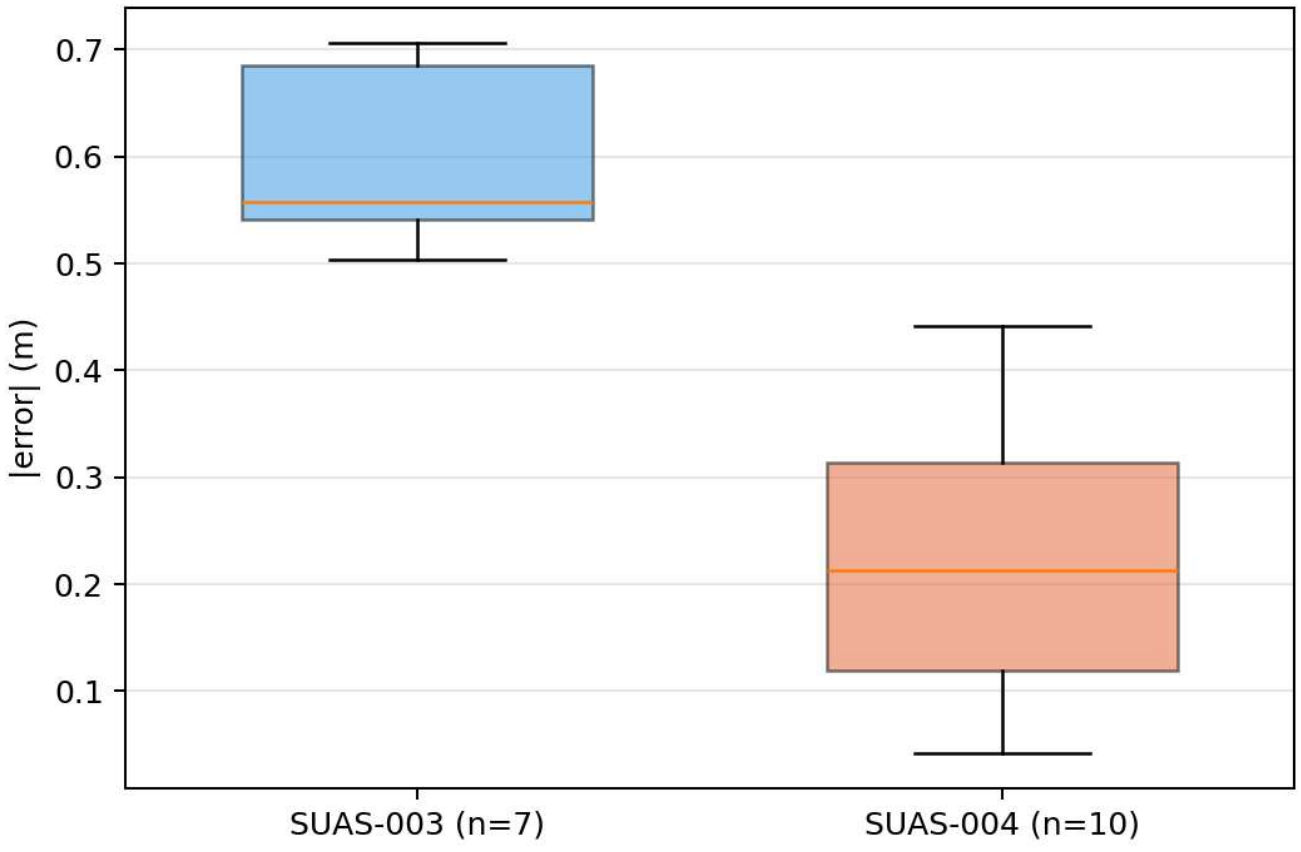
- After configuring GPS receiver offsets (SUAS-004), horizontal deployment accuracy improved markedly:
  - RMSE: 0.251 m (vs 0.608 m in SUAS-003)
  - Bias: 0.08 m East, 0.07 m North (|bias| = 0.103 m)
- The offset reduced systematic error substantially; remaining error is not isotropic. The target plots show larger spread in E than N, likely influenced by wind gusts during testing. Further analysis could correlate error with IMU and horizontal motion across the burst frames.

What We Did (Method, Brief)

- Labeled impact frames and click locations (image pixel) for each trigger.
- Detected ArUco markers and used RTK-measured marker centroids to register images to ground (UTM E/N):
  - Basler→EN: homography if ≥4 markers; full-affine if 3 markers.
  - Cougar bridge for 2-marker Basler frames: Basler→Cougar (ArUco corners) + Cougar→EN (ArUco centers) → composed Basler→EN.
- Computed each landing's E/N and error vector vs target center (`Center`).
- Summarized per-flight accuracy, and produced boxplots and target plots.

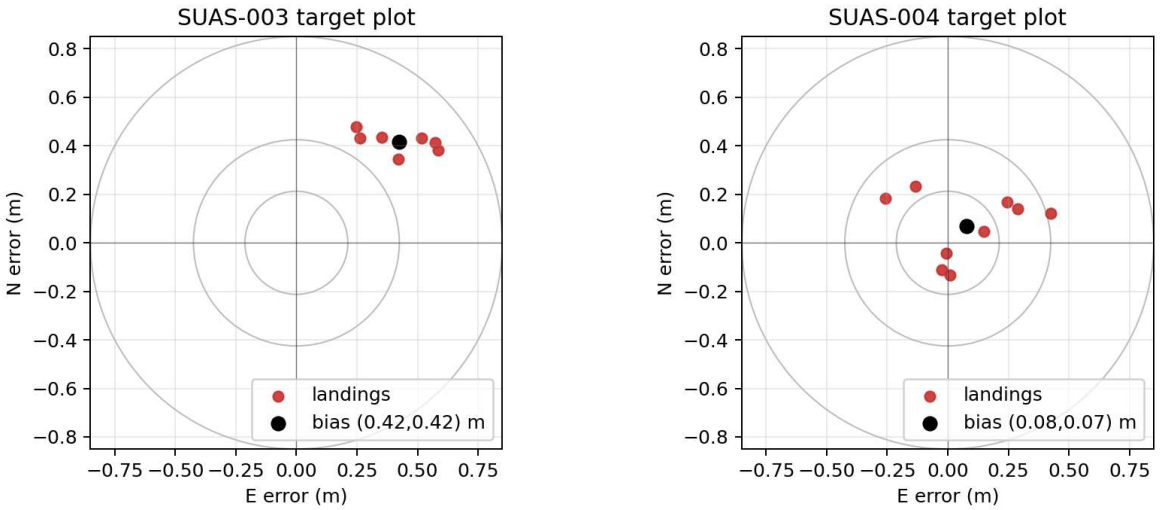
Figures

- Error magnitude (|error|) boxplot:
  - See `results/figures/error_boxplot.png` .

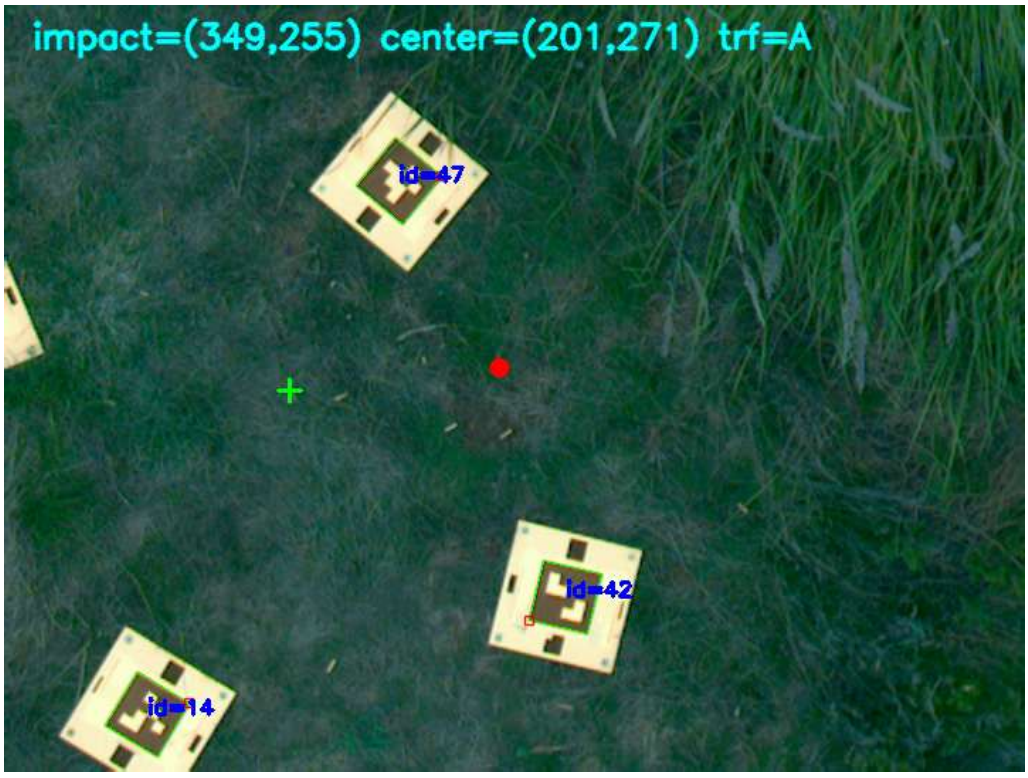


- Target plots (landings in red, bias in black), same axis range both flights:

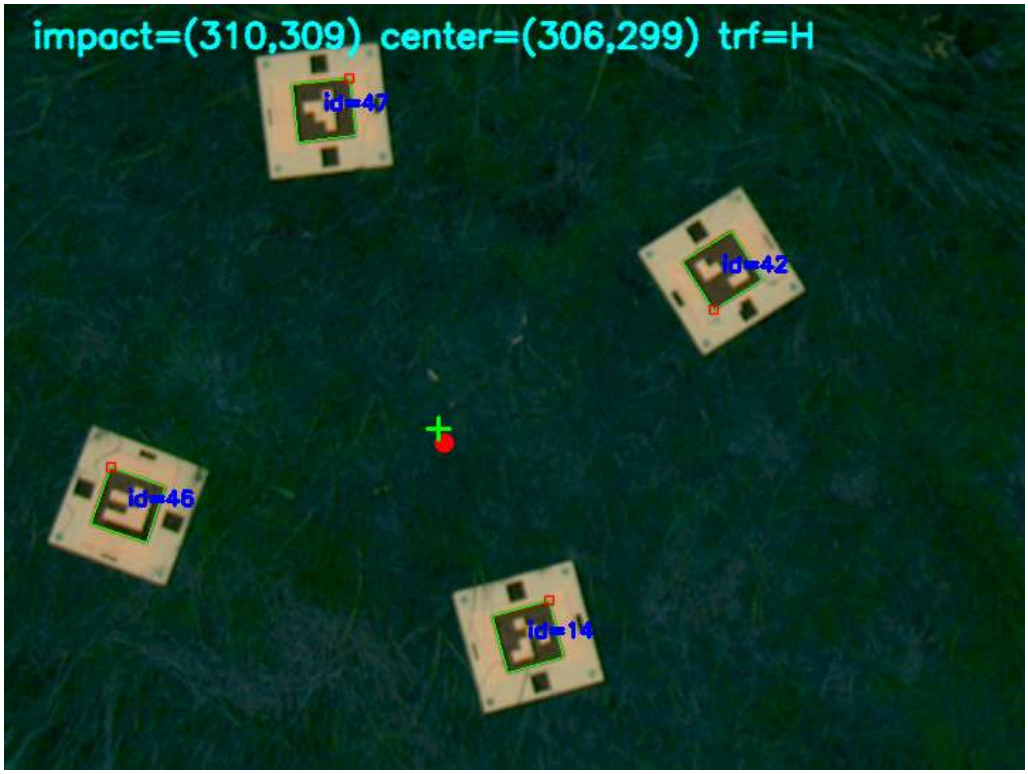
- See `results/figures/target_plots.png`.



- Annotated examples (one per flight):
  - SUAS-003: `results/figures/annotated/rosbag2_2025_08_28-14_07_44_0_trigger_009_frame_040_1756390256269206698.png`



  - SUAS-004: `results/figures/annotated/rosbag2_2025_08_28-15_54_32_0_trigger_006_frame_036_1756396552515914134.png`



Results Tables

Per-Flight Accuracy (from `data/processed/accuracy_summary.csv`)

Flight	n	RMSE (m)	Mean |error| (m)	Bias E (m)	Bias N (m)	|Bias| (m)
SUAS-003	7	0.608	0.603	0.423	0.416	0.593
SUAS-004	10	0.251	0.220	0.077	0.068	0.103

Notes: SUAS-004 shows a dramatic bias reduction (to ~8 cm East, ~7 cm North) and a lower RMSE.

Event Counts and Notes (from `data/processed/landing_points.csv`)

- Total trigger events: 26 (SUAS-003: 11; SUAS-004: 15)
- Valid landings used in accuracy: 17 (SUAS-003: 7; SUAS-004: 10)
- Blanks (no landing annotated/usable): 8
- One event “shattered mid air” (removed from accuracy)

Per flight qualitative outcomes among valid landings:

- SUAS-003 (7 landings): tumbled 7/7; bounced 5/7; shattered noted once within valid outcomes set (“tumbled, shattered, bounced”).
- SUAS-004 (10 landings): tumbled 10/10; bounced 4/10; no mid-air shattered among valid landings (one shattered event occurred but had no landing).

SUAS-004 Landing Errors (per-trigger)

Trigger	error_E (m)	error_N (m)	|error| (m)	Notes
004	0.290	0.141	0.323	tumbled, bounced
005	0.010	-0.133	0.134	tumbled, bounced
006	-0.005	-0.042	0.042	tumbled
007	-0.026	-0.111	0.114	tumbled
008	-0.259	0.185	0.319	tumbled, bounced
009	-0.134	0.232	0.268	tumbled
010	0.073	0.074	0.104	tumbled
011	0.149	0.048	0.157	tumbled, bounced

Trigger	error_E (m)	error_N (m)	|error| (m)	Notes
012	0.246	0.168	0.298	tumbled
013	0.425	0.122	0.442	tumbled

Interpretation: Bias is small (~0.08, 0.07 m), but dispersion is not isotropic. Several events show larger positive E components consistent with an eastward spread.

Procedure (Details)

1. Label impact frame and click pixel location (`analysis/label_impacts.py`).
2. Detect ArUco markers and map to ground using RTK marker centroids:
   - Prefer homography (≥4 markers), full-affine as fallback (3).
   - If Basler has 2 markers, use Cougar bridge (Basler→Cougar via ordered corners; Cougar→EN via centers) and compose.
3. Transform impact pixel to E/N and compute error vs Center; save to `landing_points.csv`.
4. Aggregate by flight to compute RMSE and bias; save to `accuracy_summary.csv`.
5. Visualize |error| distribution (boxplot) and error vectors (target plots); save annotated frames for QA.

Limitations & Next Steps

- Planar homography assumes flat target surface; rolling-shutter ignored.
- Wind gusts may explain higher E variance; future work: correlate errors with IMU and inter-frame motion.
- Consider enforcing homography only (via Cougar) for frames with <4 Basler detections to standardize transforms.