Multicamera 3D Localization of UAV-based EPM Sensor Package Deployment

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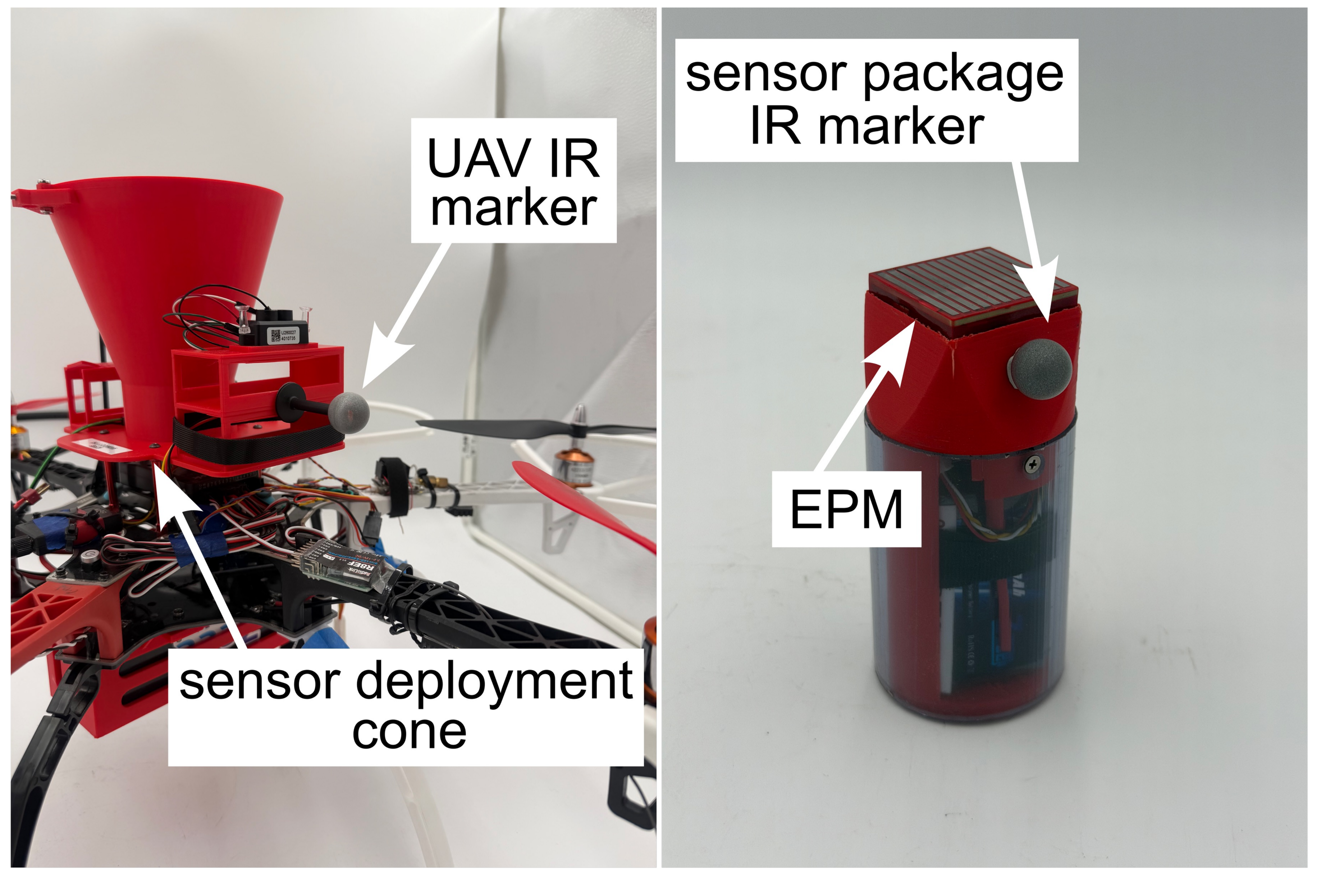
Introduction

- Unmanned aerial vehicles (UAVs) are a leading solution in assessing hazardous environments but can prove difficult in structures with obstructed GPS/compass signals.
- Using machine-learning based external ground cameras has been an explored solution to assist with autonomous UAVs [1].
- There remains the need to assess the accuracy of these solutions, which infrared (IR) tracking systems can provide.

Methods

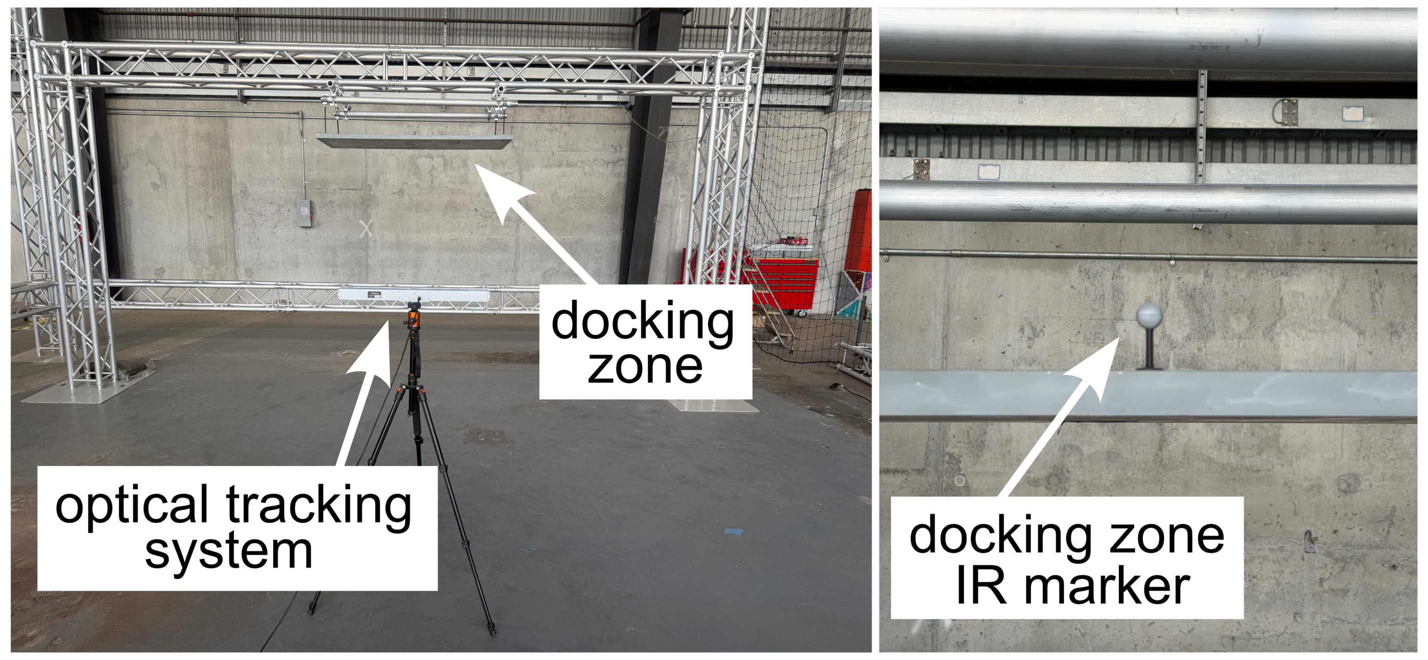
- Markers, which are ~19 mm diameter spheres coated to an extremely IR reflective surface, are attached to all three parts of a UAV docking a magnetic sensor onto a structural surface.
- An IR-trained optical tracking camera is placed approximately 5 meters away from the docking site, with fisheye ground cameras directly below the area [1].
- Flights were conducted where the UAV was flown from ground level with an included magnetic sensor.
- UAV was able to dock the magnetic sensor to the underside of the structure, turn the magnet on, and fly out of the area.
- Optical tracking systems was able to track UAV location using IR markers in comparison to You Only Look Once (YOLO) machine learning-based object tracking [2].



(a) (b)

Figure 1. IR marker placement, showing: (a) UAV IR marker on sensor deployment cone, and; (b) sensor package IR marker near electro-permanent magnet (EPM)

Methods (cont.)



(a) (b)

Figure 2. Test setup, showing: (a) optical tracking system in reference to docking zone, and; (b) docking zone IR marker

Results

- Optical tracking algorithms show close alignment upon visual inspection of UAV flight, with <1% failed detection rates (moments where IR tracking marker was not located).
- Entire process of UAV takeoff/approach to docking zone, magnetic sensor deployment, and flight of UAV away from site was recorded onto the IR tracking mechanism at high frame rates of 120 frames per second.

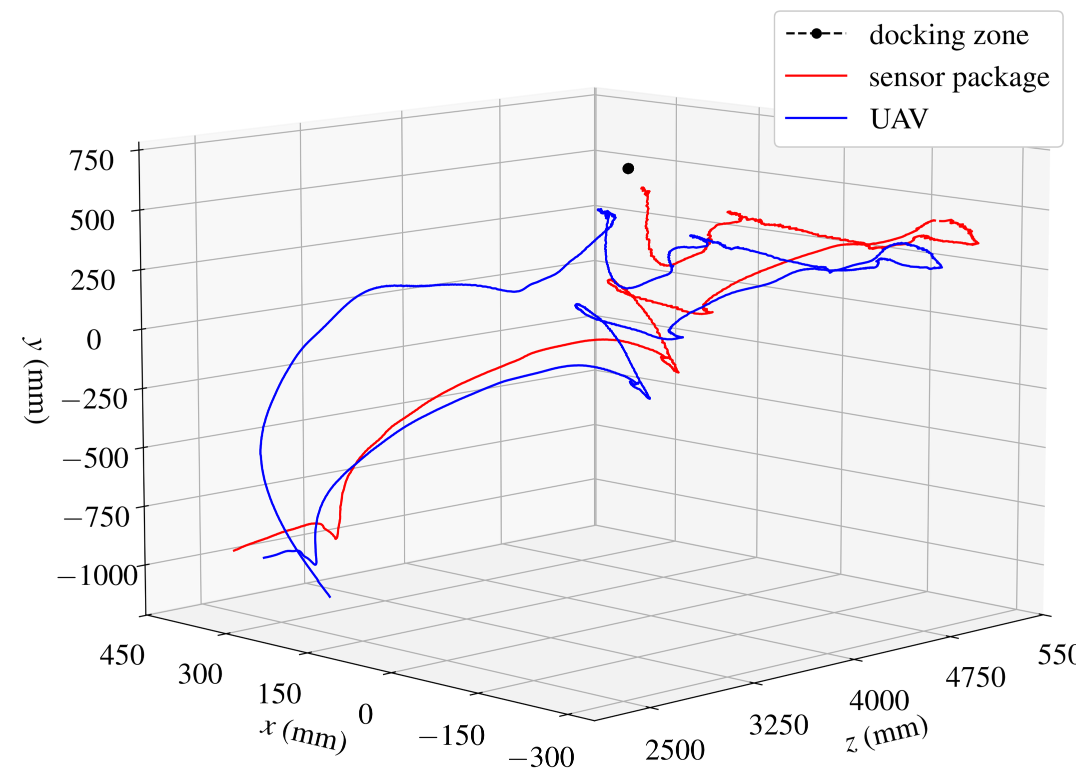


Figure 3. Three-dimensional plot of docking zone, sensor package, and UAV movement (in mm) during the sensor docking process

Results (cont.)

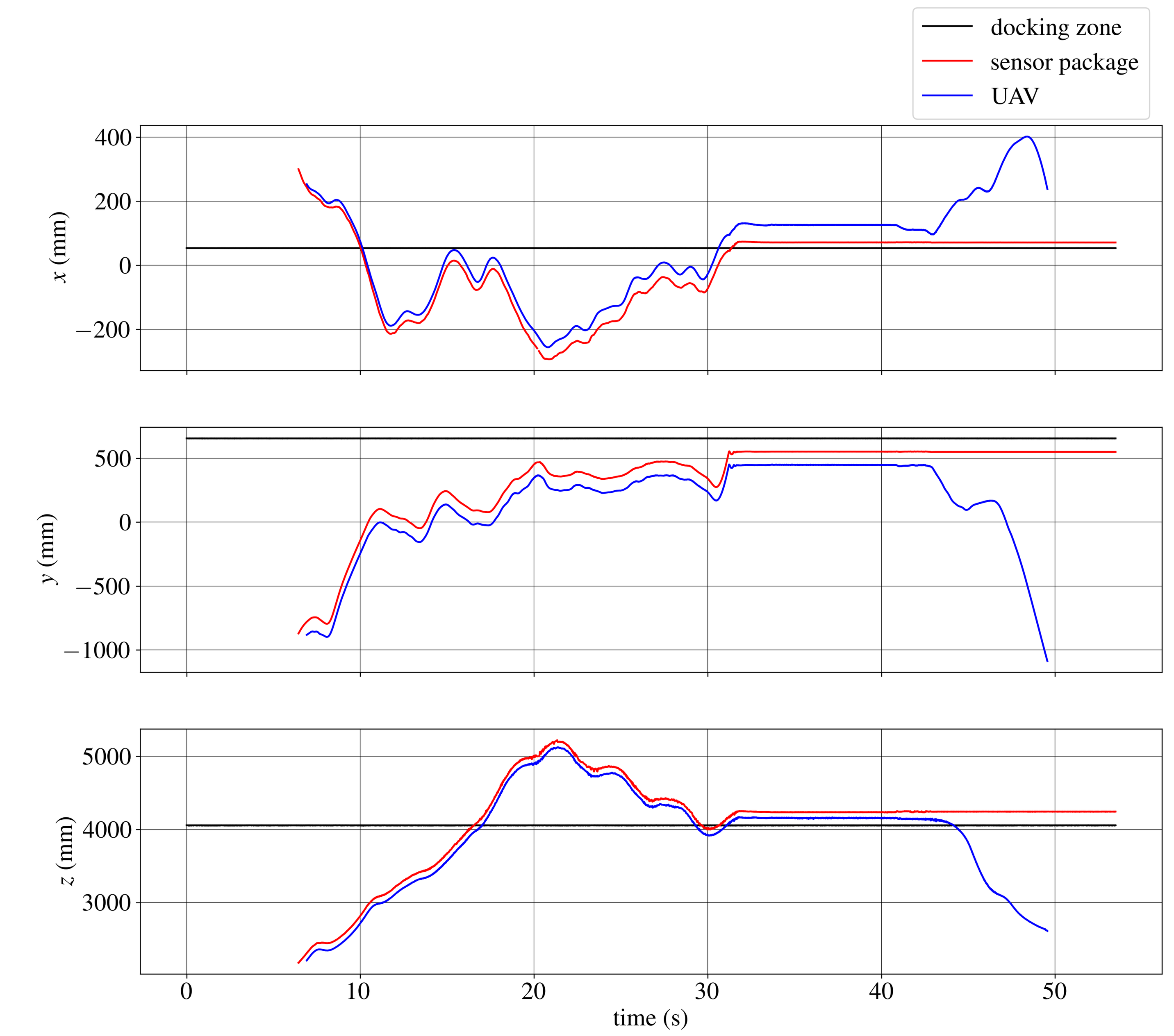


Figure 4. Two-dimensional plots showing docking zone, sensor package, and UAV movement in each Cartesian direction (in mm) over time (in seconds)

Conclusions

- Optical tracking algorithms have shown to be a viable method in tracking UAV flight during sensor deployment
- IR is an effective non-machine learning based approach to tracking objects, even with “distractions” in the form of background reflective objects
- Tracking accuracy is high enough through optical tracking and IR markers to verify the coordinates of YOLO or other machine learning-based object detection

References

[1] Shute N., Khan, A., Satme, J.N., Zheng, M., Adebajo, K., Downey, A.R., and Folsom, M., Vision-Based UAV Localization Using a Fisheye Ground-Camera Network for Sensor Package Deployment in Post-Disaster Structure Inspection,” in [*SPIE Defense and Security*], SPIE (Apr. 2026).

[2] Zheng, M., Khan, A., Satme, J.N., Adebajo, K., Yount, R., and Downey, A. R., “Stereo YOLO UAV Localization and Tracking Enabling Autonomous Sensor Deployment on Critical Infrastructure,” in [*AIAA SCITECH 2026 Forum*], American Institute of Aeronautics and Astronautics (Jan. 2026).

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