

# Machine Learning-Based UAV Sensor Deployment for Under-Structure Environments

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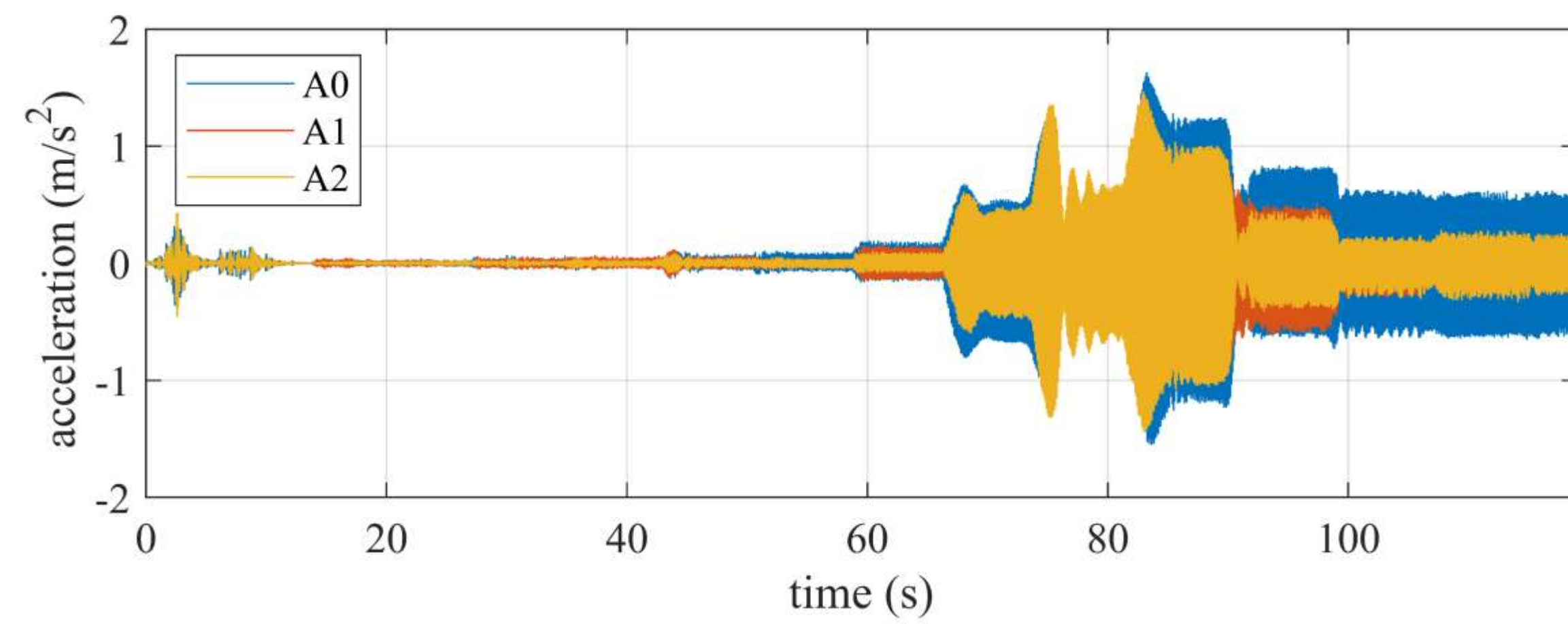


## UAV Deployable Sensors

- Sensors mount to the underside of structures using electro-permanent magnets, which can adjust the presence of their external magnetic field via electric currents.
- Radio frequency, magnet/accelerometer, and memory modules are linked to a microcontroller housed in a protective frame to send and receive acceleration data over time.
- Acceleration data is correlated with bridge deformations (strain).



Deployable sensor package layout.



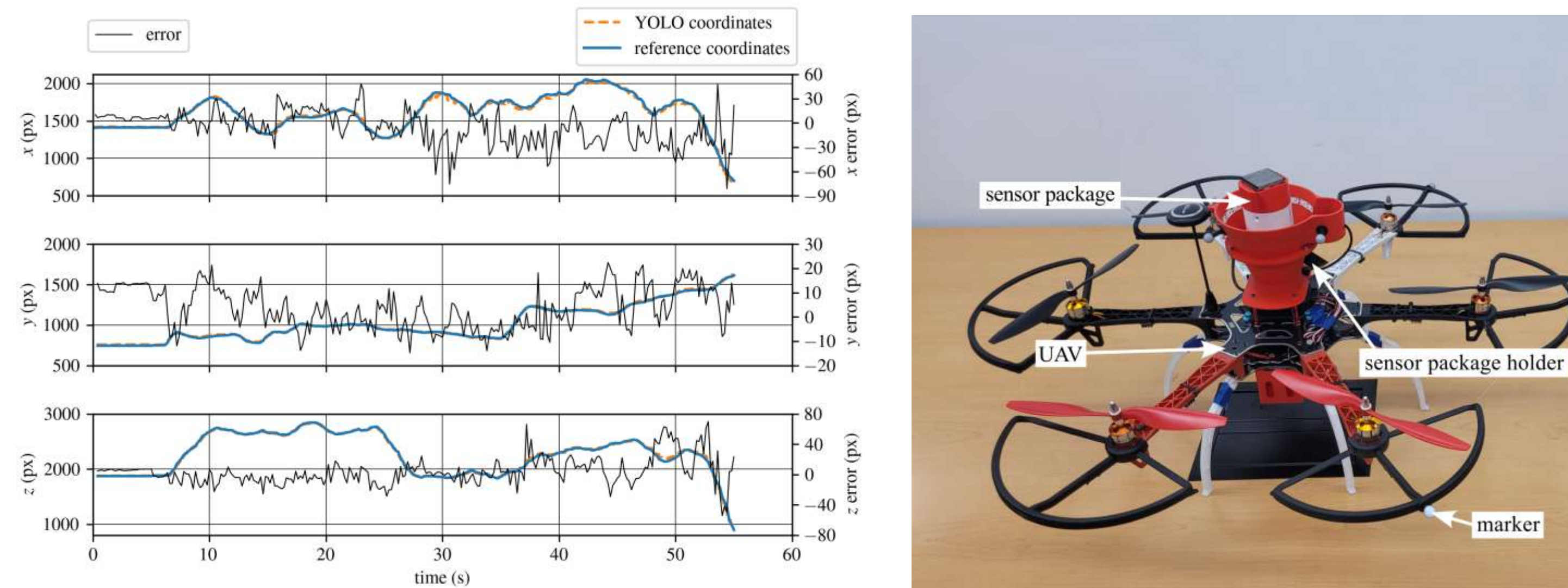
Accelerometer data over time under a pedestrian bridge.



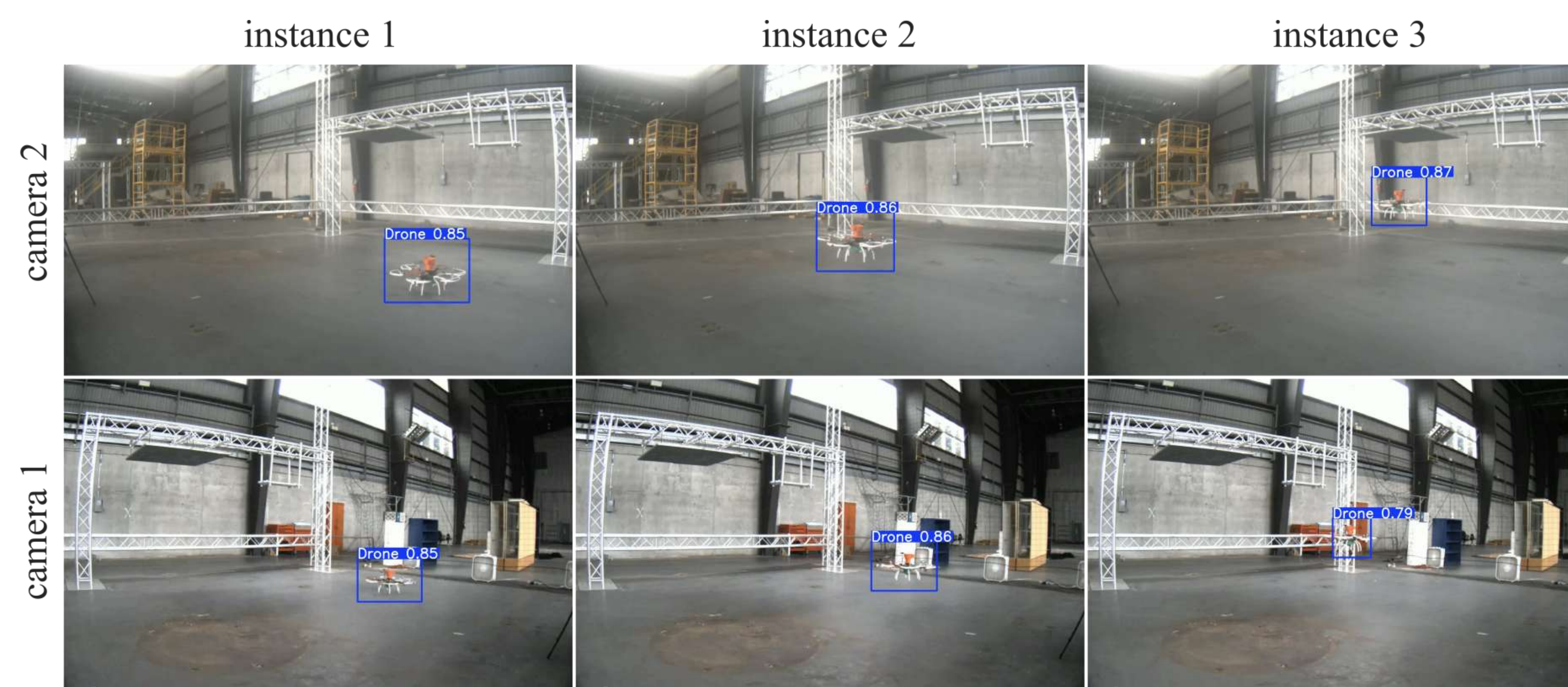
EMP engaged and attached to underside of pedestrian bridge.

## Stereo Camera Object Tracking

- Object tracking algorithms (YOLO) use two cameras with a 90-degree field of view (FOV) intersection.
- Training is done on a custom UAV to allow camera-based tracking of UAV coordinate location.
- Coordinate location is compared to reference coordinates, which are labeled through manual frame-by-frame analysis of camera video output from the set of two cameras.
- Stereo camera system allows for effective tracking of a UAV during sensor docking flights, where a deployable sensor package is magnetically attached to the underside of a structure.



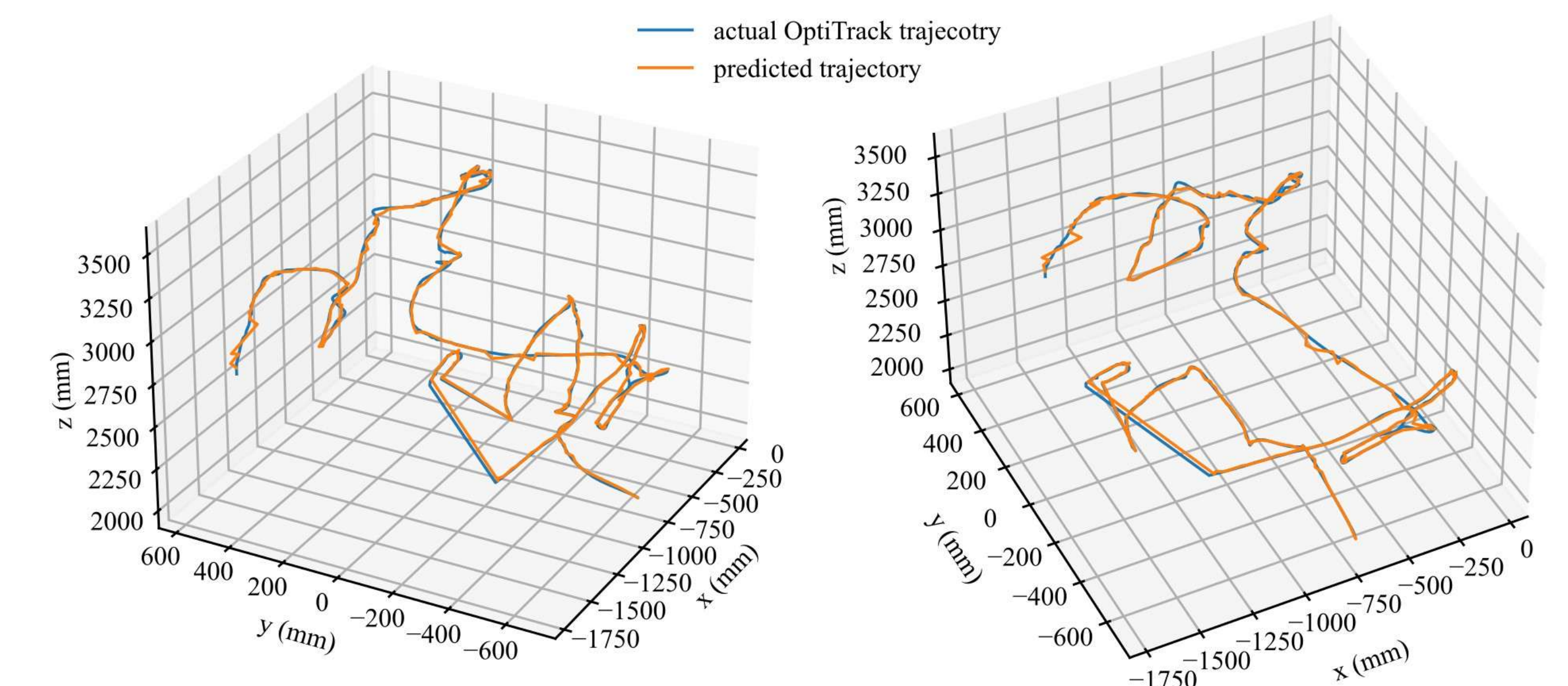
Technical aspects of the object detection system, showing: (a) comparison between YOLO and reference coordinates, and; (b) EPM-enabled sensor deployment mechanism on the UAV.



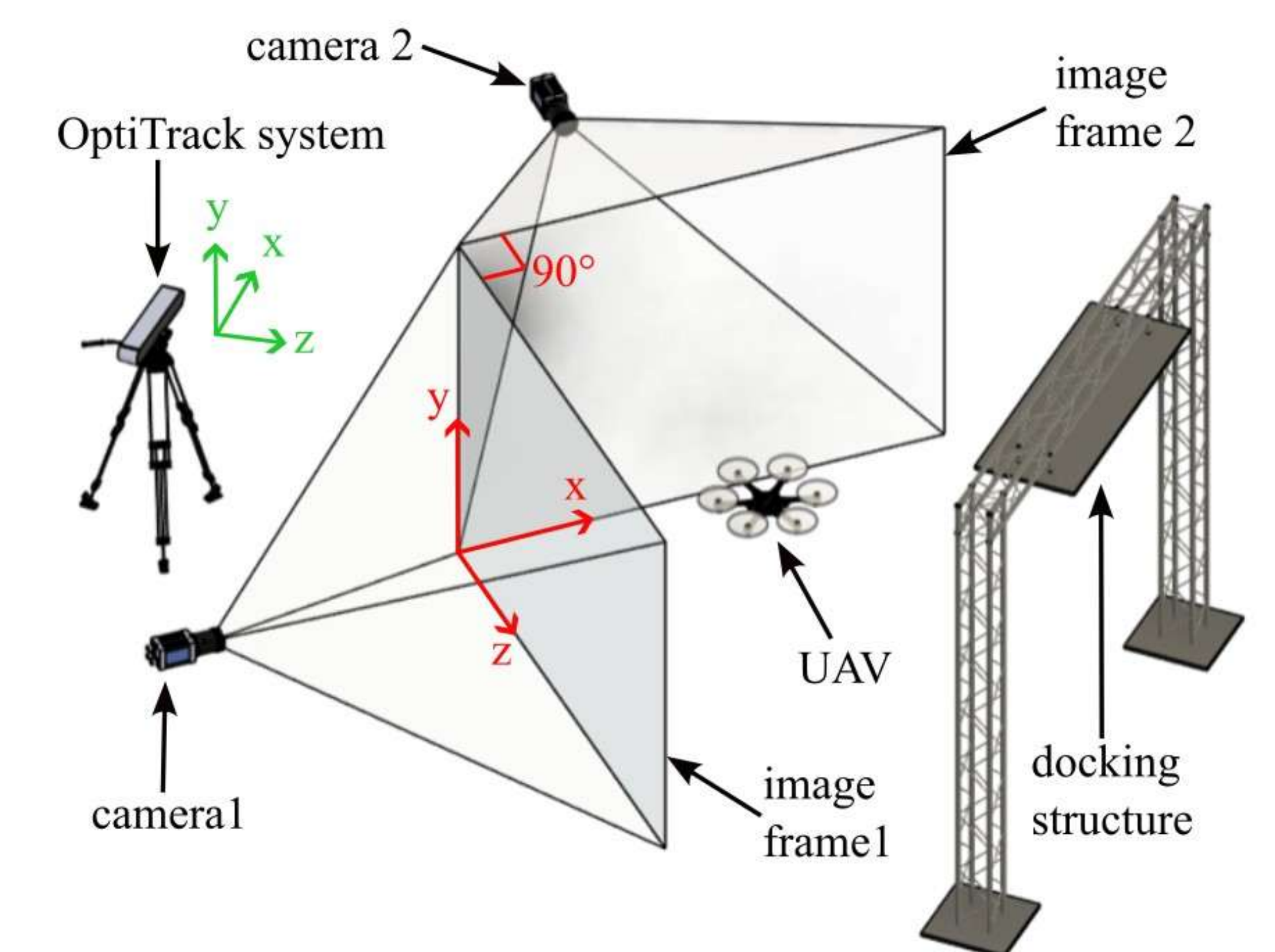
Stereo camera output with YOLO bounding boxes on a sample UAV sensor docking flight.

## Machine-learning Localization

- Machine learning-based object detection algorithms output coordinates that are relative to the camera frame.
- FOV intersection can be difficult to quantify, thus an additional machine-learning algorithm can be trained to convert relative coordinates to spatial coordinates.
- IR-based object tracking systems, which use IR reflective markers, serve as reference coordinates in the training of this algorithm.



Comparison of predicted and true UAV trajectory across different FOV.



IR-based object tracking system running in parallel with YOLO-based stereo camera vision.