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The Center for Education and Research in Information Assurance and Security

MIXED-SENSE: A Mixed Reality Sensor Emulation Framework for Test and Evaluation of UAVs Against False Data Injection Attacks

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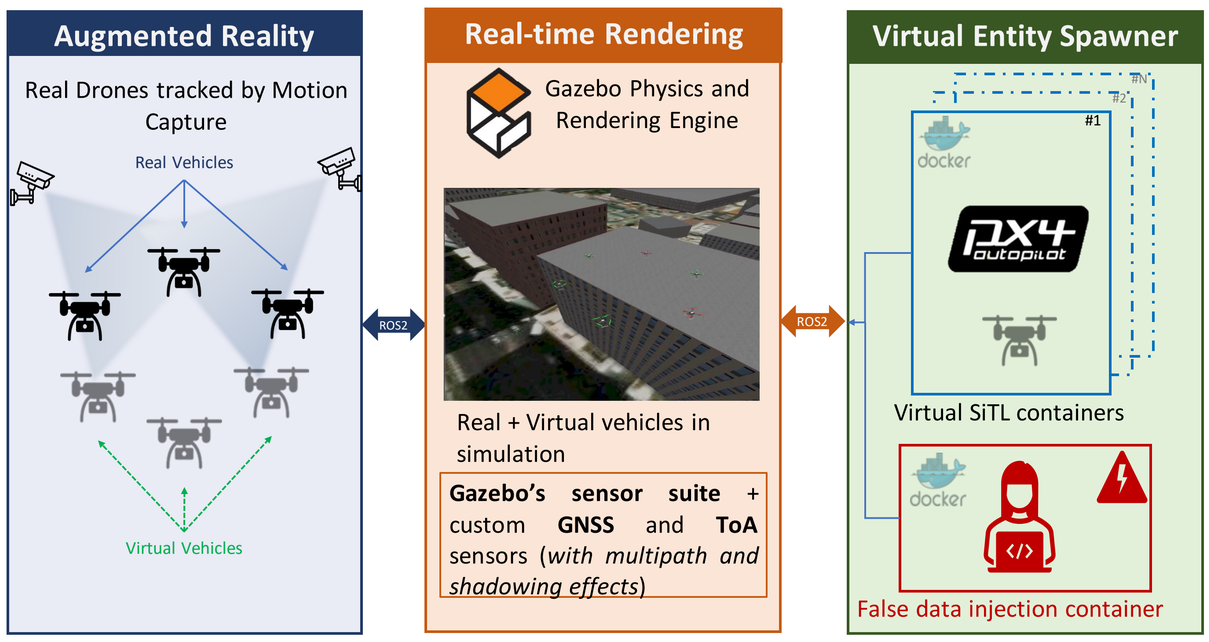
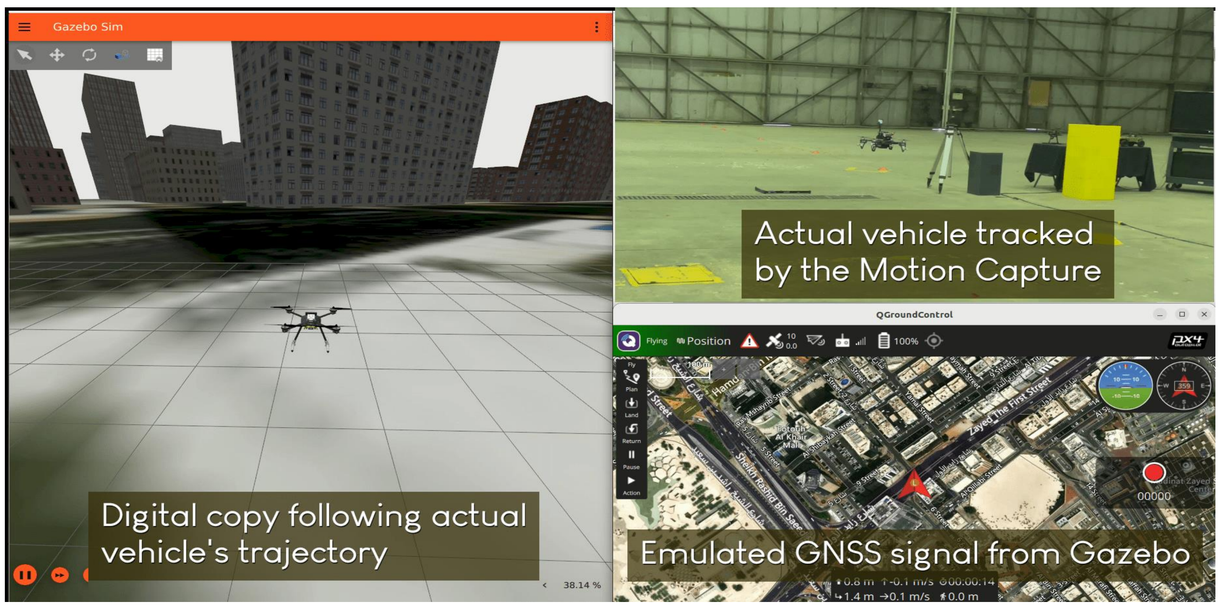
System Architecture



Overview of our proposed framework

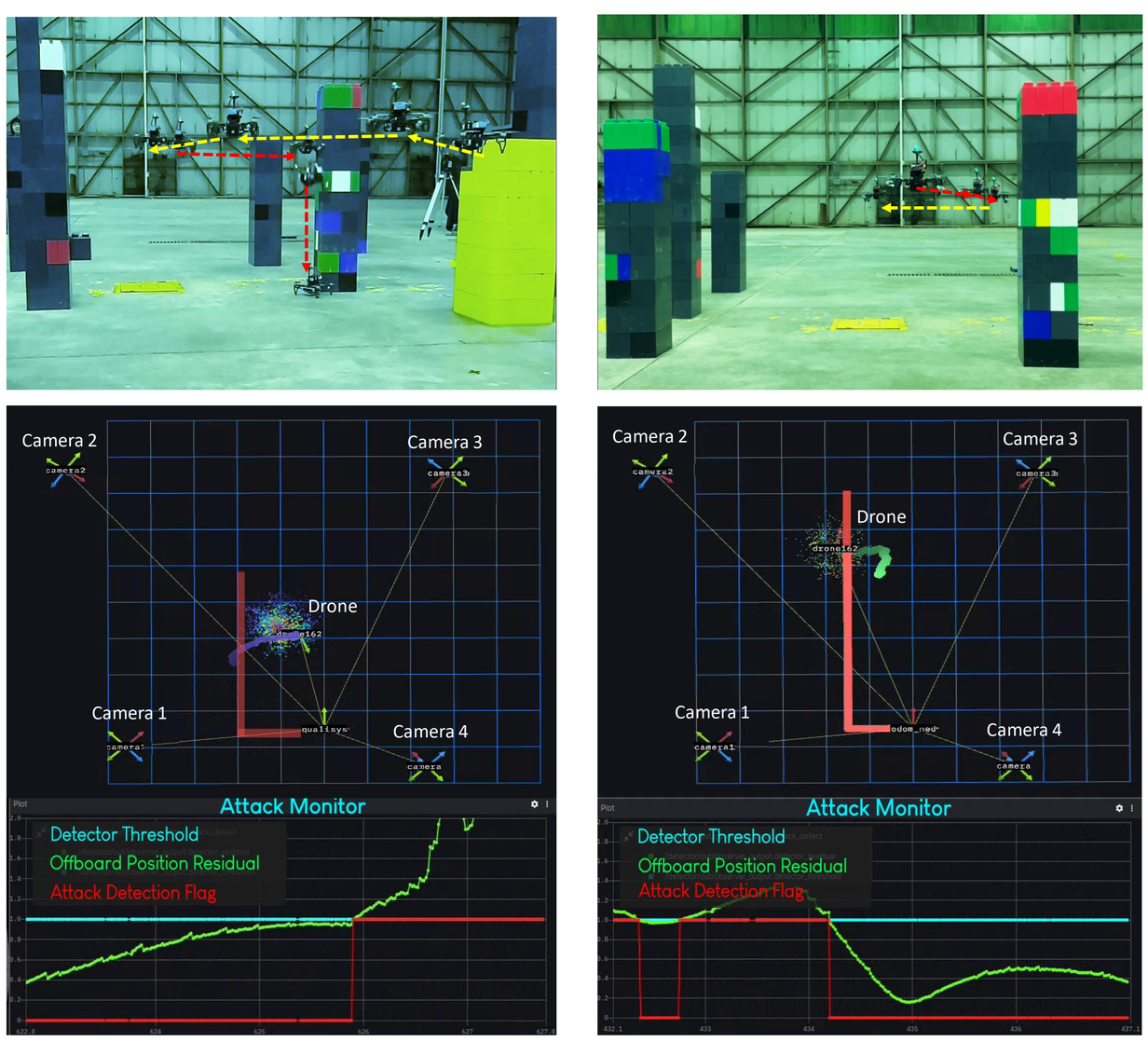
- A **modular** sensor emulation framework leveraging simulations of **Gazebo** and a **Motion Capture system** to emulate **proprioceptive** (e.g., GNSS) and **exteroceptive** (e.g., camera) sensor measurements in real-time
- Faithful recreation of signal characteristics such as **latency** and **noise** in the emulated sensor measurements
- **Vulnerability analysis** comprising natural motion and behavior of the UAVs with virtual sensor measurements and cyberattacks.

Experimental Demonstration



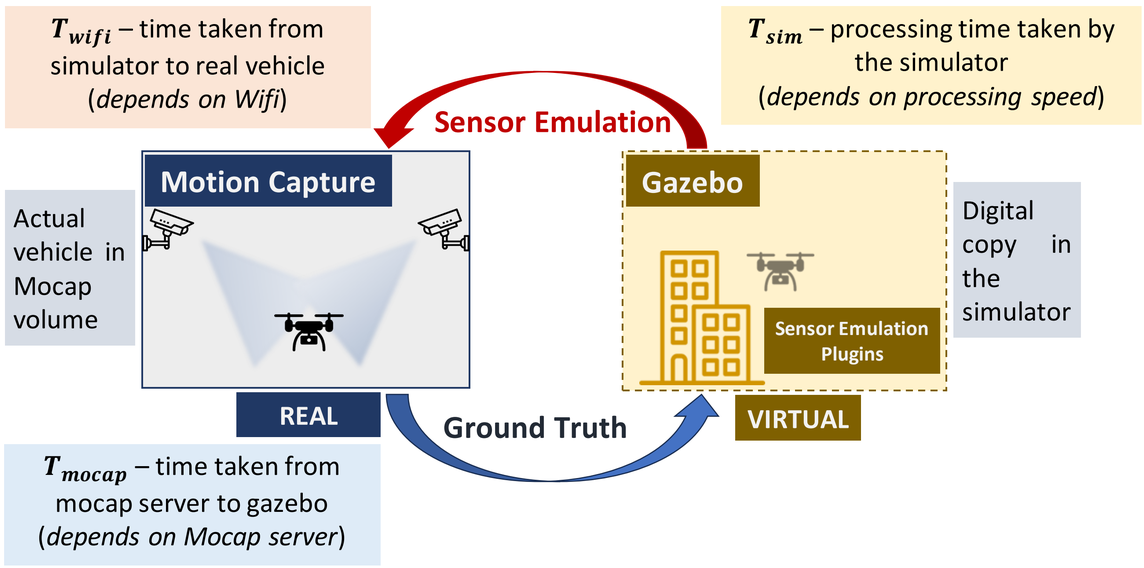
An instance of **Mixed-Reality-in-the-loop (MRiTL)** GNSS sensor emulation

- Emulation of **GNSS replay/meaconing[1]** attacks on an actual vehicle tracked by the Motion Capture system.



Top Down: Particle filter-based UAV detection and tracking used as external measurements for attack detection. **Run-time Monitor**: A linear observer-based detector that combines onboard and external measurements to detect and mitigate attacks.

Latency in Sensor Emulation



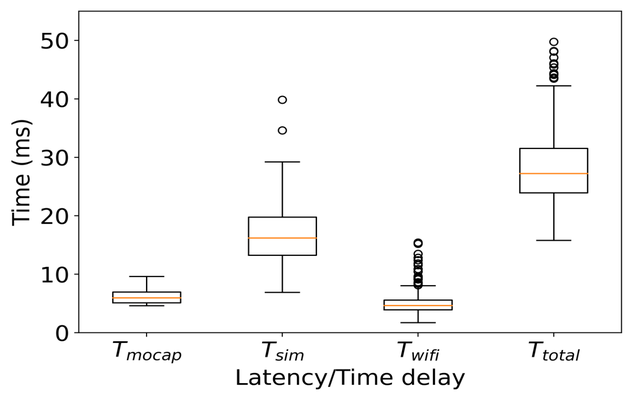
End-to-end time delay from sensing the motion of the real vehicle to publishing the emulated sensor measurements.

Total end-to-end time delay in sensor emulation:

$$T_{total} = T_{mocap} + T_{sim} + T_{wifi}$$

An empirical approach to tuning delays by delaying the emulated signal to match true signal characteristics

$$T_{actual} = T_{total} + T_c$$



Empirical latency in each component and total end-to-end latency in GNSS sensor emulation

References

[1] Pant, K. A., Yang, Z., Goppert, J. M., and Hwang, I. (2023). An Open-Source Gazebo Plugin for GNSS Multipath Signal Emulation in Virtual Urban Canyons. In *AIAA SCITECH 2023 Forum* (p. 2586).

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