

UAV-UGV Collaboration for Sustained Mapping & Navigation



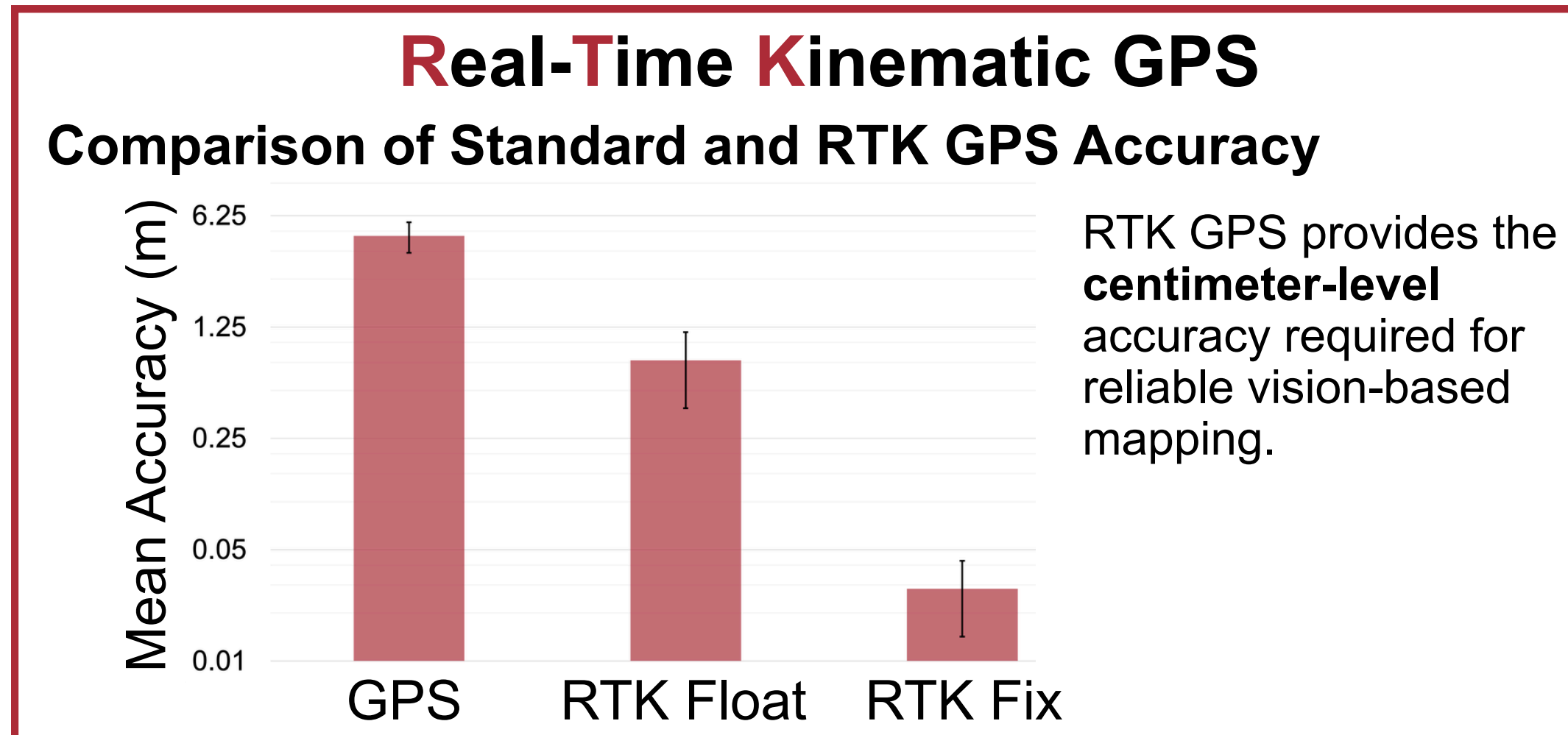
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Abstract: For search-and-rescue operations, UAV-UGV Collaborative Systems can be deployed into an unknown field to be mapped and traversed through to desired endpoints. An **Unmanned Aerial Vehicle (UAV)** assists in **computer-vision** algorithm based map creation through capture of aerial imagery, and the **Unmanned Ground Vehicle (UGV)** utilizes **path planning** algorithms to complete its field traversal task. Repeatability of the collaborative system's function is ensured by **autonomous landing** and **recharging** of the UAV on a UGV-bound charging bed.

Design Challenge

- Deploy, Localize & Map
- Land & Charge
- Navigate & Traverse



Computer Vision and Mapping

- Capture geotagged images with the UAV
- 75% overlap across image set
- Undistort images using calibrated camera model
- Construct a georeferenced orthomosaic with **OpenDroneMap**

Geotagged Dataset → odm_orthophoto.tif

System Architecture

Unmanned Aerial Vehicle (UAV)

- Camera: OpenMV H7 Plus
- ESP32: MAVLink/ESP-NOW
- Charging Circuit: UGV Compatible

Shared Components

- Flight Controller
- RTK GPS Module
- Telemetry Communication: 915MHz Radio

Unmanned Ground Vehicle (UGV)

- Charging Station
- Large Capacity Batteries

Object Detection and Path Generation

- Locate obstacles using **OpenCV**(Computer Vision)
- Create **occupancy grid**, any detection marks cell as blocked
- Plan **A* Path** on downsampled grid
- Simplify navigation with **RDP path**
- Convert to waypoints for rover control via **QGroundControl**

A* Path (Red) | RDP Path (Green)

Results

Demonstrated full system pipeline: Aerial Mapping > Landing > Path Generation > UGV Traversal

- RTK-enabled mapping error of **1.16 meters**
- Total Map Area of **1000m²**
- Orthomosaic construction in **90 seconds**

Axis	RMS Error (m)
X	0.215
Y	0.975
Z	0.725
Total	1.16

Future Work

- Develop **cooperative multi-UAV strategies** for distributed mapping and task allocation
- Increase autonomy** by attaching **on-board compute** to the UGV, reducing the need for a human-operated ground station.

Acknowledgements

We acknowledge and thank our project advisors Dr. Leahy, Dr. Lewin, and Mr. Woodyard for their contribution and support. We are grateful to Worcester Polytechnic Institute, the RBE Department, and Draper for their support.