

29/01/24

Demonstrating Visual-Inertial A&OD & On-Orbit Edge Computing

Progress summary

94 days before May 1st

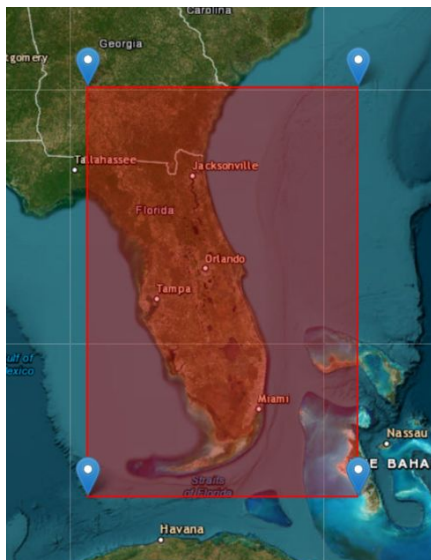
- Dark room testbed
 - Developed first iteration of dark-room test bed for V1 prototype
 - Completed single-camera calibration
 - Workstation and Jetson set-up
- Vision
 - Dataset pipeline changes & automated saliency-based landmark annotation
- Implemented all perturbations, sensor, and magnetorquer models in simulation
- Working prototype for A&OD (Batch optimization)
- Team changes: 1 out, 3 in
 - Task allocation and schedule updates

Vision

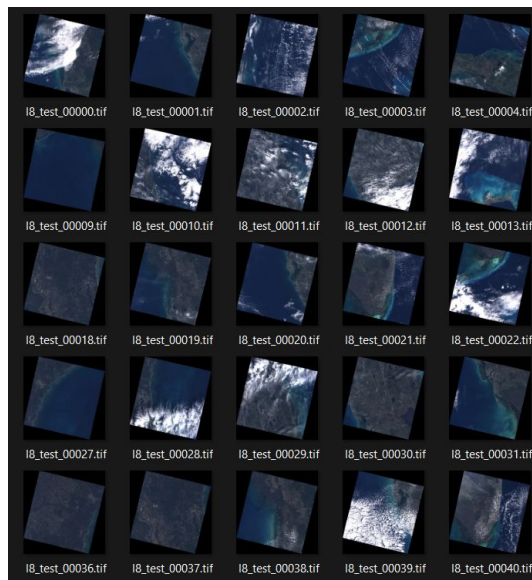
- New training plan for RC+LD structure
- Dataset Pipeline Design changes:
 - Data Access: USGS M2M API -> Google Earth Engine (more data)
 - Region Annotation: World Referencing System -> Military Grid System (for non-landsat images)
 - Preprocessing: Training image GSD 30m -> GSD 150mm (Camera lens 16mm -> 3.2mm for bigger FOV)
- Military Grid System based dataset download
- Automated saliency-based landmark annotation
- Small dataset for training & testing for V1
- **Next Steps**
 - Fully automated dataset pipeline on Workstation
 - Training RC net and LD net for V1
 - Refine landmark annotation (used less accurate code due to workstation fan issue)

V1 Dataset Prep

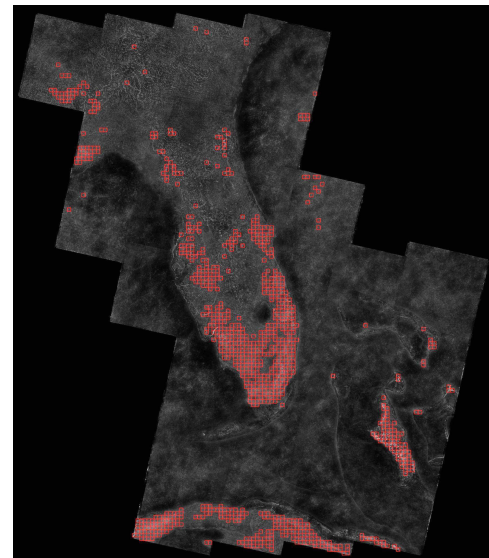
One Region: R17



~500 images GDS 150m



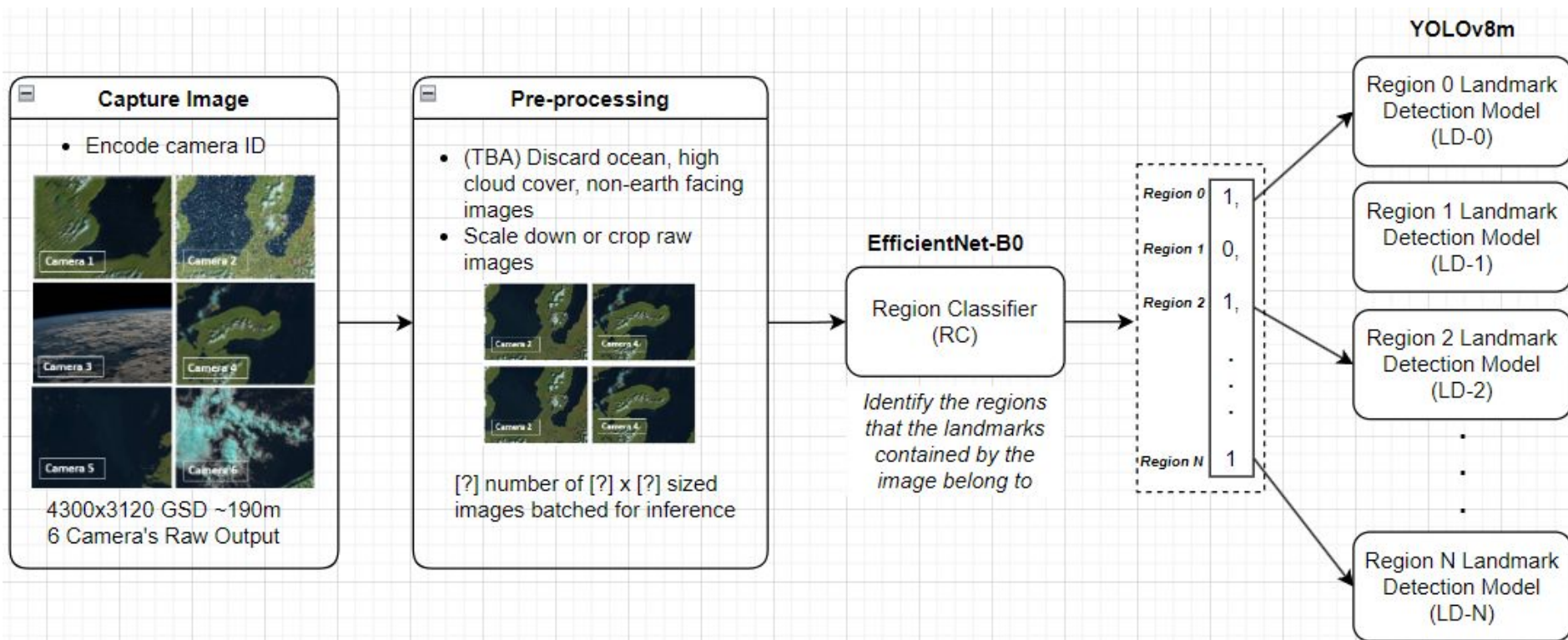
Top 1000 salient landmarks



Labeled with real lat/lon:

Top-Left Longitude,Top-Left Latitude,Bottom-Right Longitude,Bottom-Right Latitude
 -79.489400090212,25.80369695391825,-79.44429409111412,25.751627180421764
 -82.10554803788904,24.60609216349909,-82.06044203879117,24.554022390002604
 -82.33107803337845,24.501952616506117,-82.28597203428056,24.449882843009632
 -82.24086603518268,24.554022390002604,-82.1957600360848,24.501952616506117
 -79.17365809652684,25.543348086435824,-79.12855209742895,25.49127831293934
 -79.12855209742895,25.49127831293934,-79.08344609833108,25.439208539442852
 -82.28597203428056,24.501952616506117,-82.24086603518268,24.449882843009632
 -82.28597203428056,24.554022390002604,-82.24086603518268,24.501952616506117
 -82.15065403698692,24.60609216349909,-82.10554803788904,24.554022390002604
 -79.39918809201623,26.27232491538662,-79.35408209291836,26.22025514189013
 -79.57961208840776,24.345743296016664,-79.53450608930987,24.293673522520177
 -82.1957600360848,24.554022390002604,-82.15065403698692,24.501952616506117
 -82.33107803337845,24.501952616506117,-82.28597203428056,24.449882843009632

New Inference/Training Plan

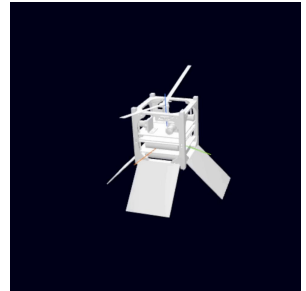


Simulation

Developing simulator to test and validate detumbling, A&OD, and FSW algorithms and support Software-in-the-loop (SIL) testing.

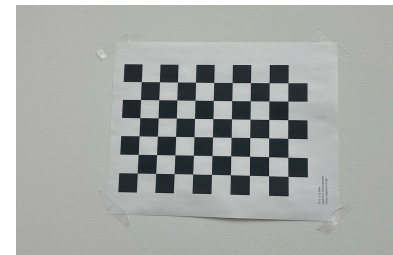
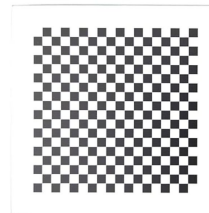
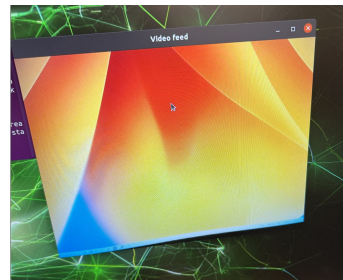
Progress

- Incorporated atmospheric drag and third body effects in orbital perturbations.
- Added sensor model for gyro, magnetometer, sun sensor and GPS.
- Implemented magnetorquer model.
- Implemented B-cross control along with unit tests.



Dark room testbed

- Initial setup for V1 pipeline testing in dark-room environment along with associated hardware
- Progress
 - Camera position and parameters adjustments for field-of-view on projector
 - Camera interface software
 - Single-camera calibration pipeline and generated camera intrinsic and extrinsic matrices and distortion parameters
- Next steps
 - Calibrate all 6 cameras, w/ chessboard
 - Research towards multi-camera calibration (mock-up Cubesat)
 - Research and experiments (?): match images captured from screen to actual image in dataset
 - Report testbed errors
 - Start V2 dark room design



Testbed hardware / FSW - next steps

- Initial discussion w/ Comms for telemetry and command
- Jetson <-> PyCubed intercommunication driver requirements w/ Avionics
- Next steps
 - Dark room test bed
 - Metrics data logging (latency, power, cpu, gpu, ..) on Jetson for V1
 - PyCubed board (acquired one for GNC usage)
 - Set-up basic I/O w/ simulation for Software-in-the-loop testing
 - Learn Pycubed stack and implement basic flight software
 - Inference V1
 - Test inference pipeline on V1 testbed (Jetson)

Team schedule status

| A | B | C | D | E | F | G |
|----------------|--|---------------------------|--|---------------------------------------|--------|--------|
| Flight Version | Version name | Module | Tasks | Assignment | 22 Jan | 29 Jan |
| V1 | Nadir-only Payload Pipeline Validation | Single-camera calibration | Camera interface (Jetson) | Atharv Pulapaka | | |
| | | | Calibration software pipeline 1 camera | Tianxin Li | | |
| | | | Calibrate 6 cameras (id them) and store parameters | Tianxin Li | | |
| | | | Multi-calibration research | Tianxin Li | | |
| | | Dataset | Image pre-processing & img storage pipeline | Atharv Pulapaka | | |
| | | | Body vector transfo + landmark retrieval | Atharv Pulapaka | | |
| | | | Set-up workstation | Sachit Goyal | | |
| | | | Download dataset on workstation + annotate | Eddie Li Jash Shah | | |
| | | Training system | Saliency-based annotation automation | Eddie Li | | |
| | | | TIF -> lat-long to ECI landmark database | Atharv Pulapaka | | |
| | | | Training plan | Eddie Li | | |
| | | | Train RC net (all regions) | Jash Shah | | |
| | | Inference | Train LD net (1 region) | Haochen Zhang Eddie Li | | |
| | | | Implement inference pipeline (Jetson) | Haochen Zhang | | |
| | | | Integrate w/ camera interface | Haochen Zhang Atharv Pulapaka | | |
| | | | Test RC & LD pipeline on Jetson | Haochen Zhang Eddie Li | | |
| | | Batch optimization | Conversion to body vector + landmark retrieval from the database | Atharv Pulapaka | | |
| | | | Prototype optimization | Ibrahima Sory Sow | | |
| | | | Simulation validation + test on Jetson | Ibrahima Sory Sow | | |
| | | | Integration test w/ inference | Ibrahima Sory Sow | | |
| | | Simulation | Perturbations and sensor models | Elakhya Nedumaran Atharv Pulapaka | | |
| | | | Vision measurement model | Atharv Pulapaka Ibrahima Sory Sow | | |
| | | MCM (Magnetic Control) | Initial Bross Monte-Carlo | Elakhya Nedumaran | | |
| | | | FSW version ready for SIL | Elakhya Nedumaran | | |
| | | Test-bed | Install dark room set-up (covers, tent, whatever) | Luyi Tang | | |
| | | | Get screen | Luyi Tang | | |
| | | | Camera mount | Luyi Tang | | |
| | | | Research & experiments - image matching | Luyi Tang | | |
| | | PyC | Report testbed errors | Luyi Tang | | |
| | | | V2 darkroom design | Luyi Tang Ibrahima Sory Sow Luyi Tang | | |
| | | | Metrics data logging (latency, power, cpu, gpu, ..) | Sachit Goyal | | |
| | | | Familiarize w/ current PocketQube board | Sachit Goyal | | |
| | | | Set-up basic I/O w/ simulation (SIL prep) | Sachit Goyal | | |
| | | | Intercommunication design dev (PyC <-> Jetson) | Sachit Goyal | | |

Next steps

- Finalize V1 prototype integration and testing before this Friday
 - Test of the entire pipeline in the dark room from pixel to A&O estimates
 - Report preliminary results
 - Pixel errors for landmark detection
 - A&O accuracy
 - Testbed source of errors
- V2 refinement based on learnings