Digital Analytics and Robotics for Sustainable Forestry

CL4-2021-DIGITAL-EMERGING-01

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DELIVERABLE 6.2

Report demonstrating achievement of systems up to mid-project review

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1   Introduction

In this report, we present the results achieved with hardware and software systems integrated and deployed in the Stein am Rhein forest in July 2024.

2   Automonous Harvesting (ETH,PreFor)

2.1   Chassis Balancing

2.2   Long Distance Autonomous Driving

The harvester was able to travel autonomously for XX kilometer

2.3   Forest Scan and Global Navigation Mapping

The map provided by ... was used to ...

2.4   Local Navigation and Collision Avoidance

2.5   Map Based Tree Grasping

2.6   Full Map-Based Single Cut

2.7   Future Work

Explain here what will be done to make the map-based detection based.

3   Autonomous Forest Inventory with Legged Robots (UOXF)

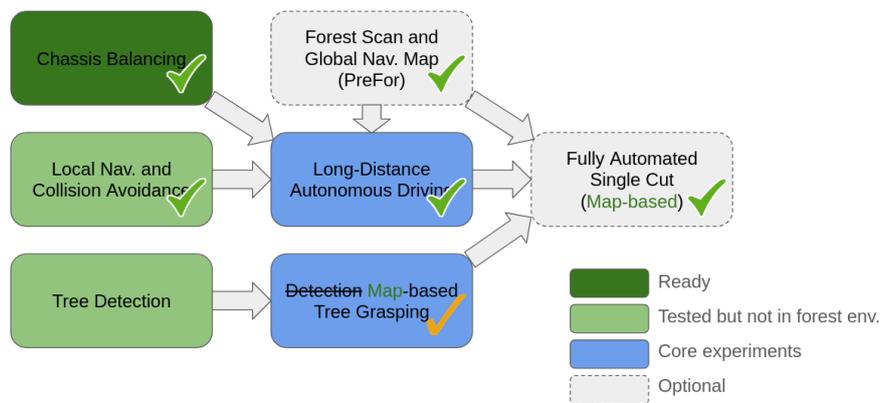# 4   Autonomous Under-Canopy Flight (TUM)

Figure 1: Harvester tests demonstrated in field

4.1 TUM stack

4.1.1 Tightly couple Depth-Visual-Inertial SLAM and Large-Scale Volumetric Occupancy Mapping

Describe the SLAM system and how it can leverage any depth information (LiDAR, depth from RGBD cameras or learnt depth) to perform SLAM and how this info is reused as factors of the state-estimator.

4.1.2 Scalable Autonomous Drone Flight in the Forest with Visual-Inertial SLAM and Dense Submaps Built without LiDAR

Given that we have already presented our state-estimator and ho volumetric submaps are being used, explain how our path planner works, the concept of trajectory anchoring and how it enables to do safe planning upon loop-closures.

4.1.3 Efficient Submap-based Autonomous MAV Exploration using Visual-Inertial SLAM Configurable for LiDARs or Depth Cameras

Now that we have presented our basic planning and autonomy stack, we can move forward to explain how these are used for exploration.

4.1.4 Real world experiments in Stein am Rhein

After explaining the whole autonomy stack, we can then showcase some results of both the Leica drone and the SRL drone and the type of maps we obtain. We can also showcase the difference of using and not using submap alignment.

4.1.5 SOLVR: Submap Oriented LiDAR-Visual Re-Localisation

Afterwards, we explain how are submap strategy can be beneficial to perform cross-modal relocalization. Showcase some dataset results and then explain how this will be used to perform multi-session missions.

4.2 NTNU stack

5 Marsupial Configuration Safe flight (NTNU)

5.1 Multi-platform tests

Marsupial, visual- and lidar-based navigation on GPU drone.

5.2 Successful Missions

- marsupial guidance via waypoints
- neural CBF safety on drone
- neural MPC controller, up to 2.5m/s

5.3   Data to Process

navigation bags and marsupial joint states. LiDAR data acquisition for partners: UOXF, WSL, needs to be shared.

5.4   Real World Lessons from the Field

sparse vs. dense forest, safety vs. scalability, whole-marsupial integration, autonomous landing goals...

6   Decision Support System (WSL,PreFor)

6.1   Forest Parameter Collection

Comprehensive field inventory including tree positions, DBH measurements, and species identification conducted on M1 plot using Leica RTC360.

6.2   Multi-Source Data Integration

For the Intersection Plot. Integration status of partner contributions:

- Integrated: UOXF, Leica, PreFor, WSL datasets

- Pending integration: NTNU, ETHZ inputs

6.3   Validation Methods

RTK GNSS cross-validation planned for 4-hectare plot (M1) for position accuracy verification.

7   Open Dataset (BONN)

7.1   DigiForests: A Longitudinal LiDAR Dataset for Forestry Robotics

Dataset Features:

- Novel Forestry Dataset via robotic LiDAR

- Longitudinal: three seasons

- Backpack / Aerial scans

- Semantic Labeling

- Semantic Benchmark in 4D

- Reference Inventory from WSL

7.2   Future Directions: Dataset v2.0

more rigorous ground truth, other semantic-SLAM benchmarks, etc.