

Efficient Large-Scale Mapping and Path Planning in Forest Environments

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Motivation

- Every year, fires decimate hectares of forest area worldwide, threatening animals and people, along with their livelihood.
- In 2022, more than 20,000 hectares have burned in Portugal, 92% of which forest terrains (an increase of 68% compared to 2021).
- Forest maintenance increases the growth of profitable crops such as pine and eucalyptus.
- Forestry work is expensive, repetitive, dangerous and demanding to humans, making it a prime candidate for automation.

Challenges

- Forests are unstructured with unstable and unpredictable terrain, multiple sources of sensor occlusion, harsh conditions, etc.
- Long-term operation in unstructured environments subject to perpetual change is still an open issue.
- Robotics perception must be robust enough to handle the complexity and dynamics of the forest environment.
- Challenging and potentially expensive to refuel the robot mid-mission.
- Presence of living beings (wildlife), which must be preserved.

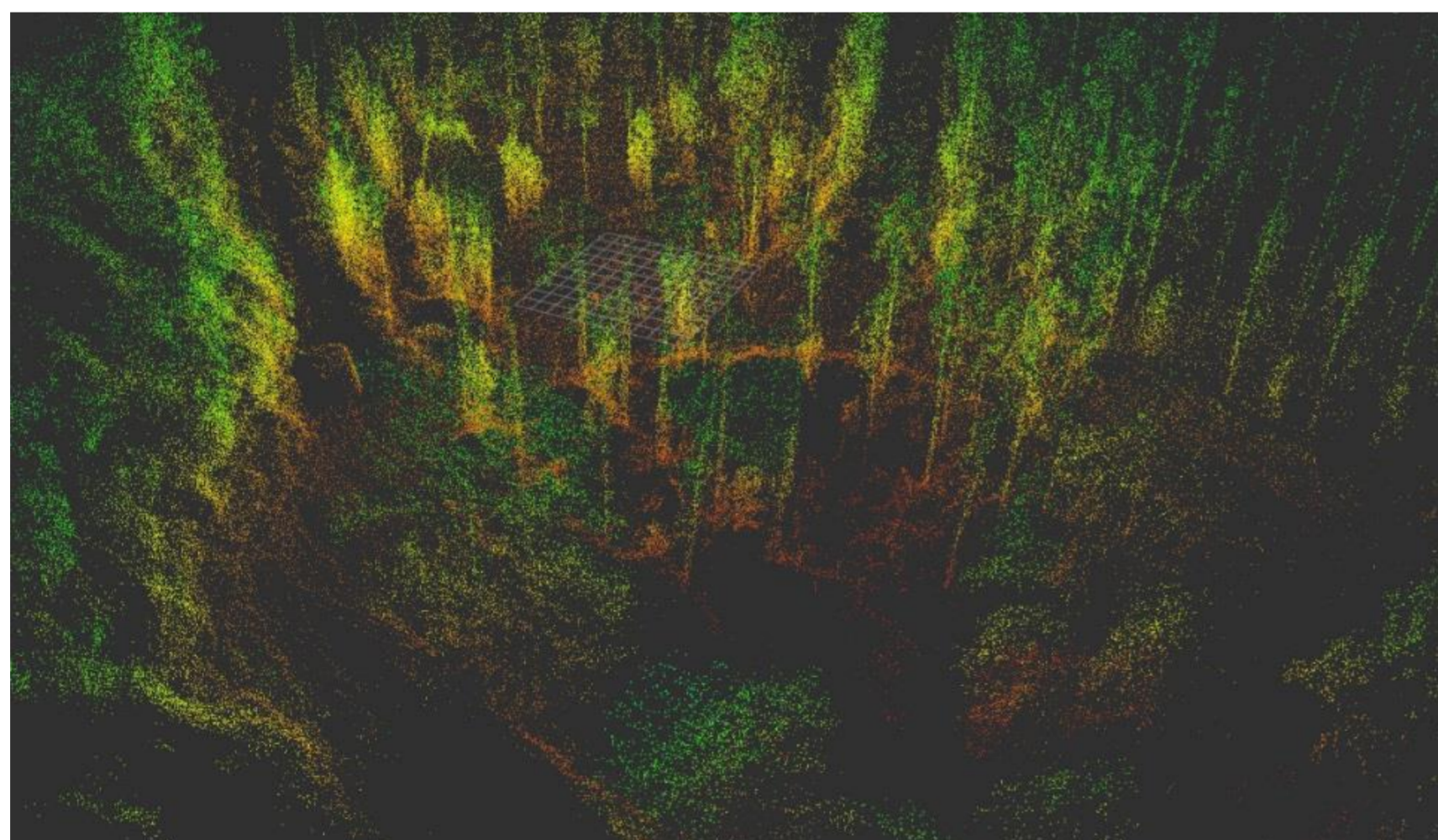


Figure 1: 3D Pointcloud of a forest scenario. A dense spatial representation to deal with.

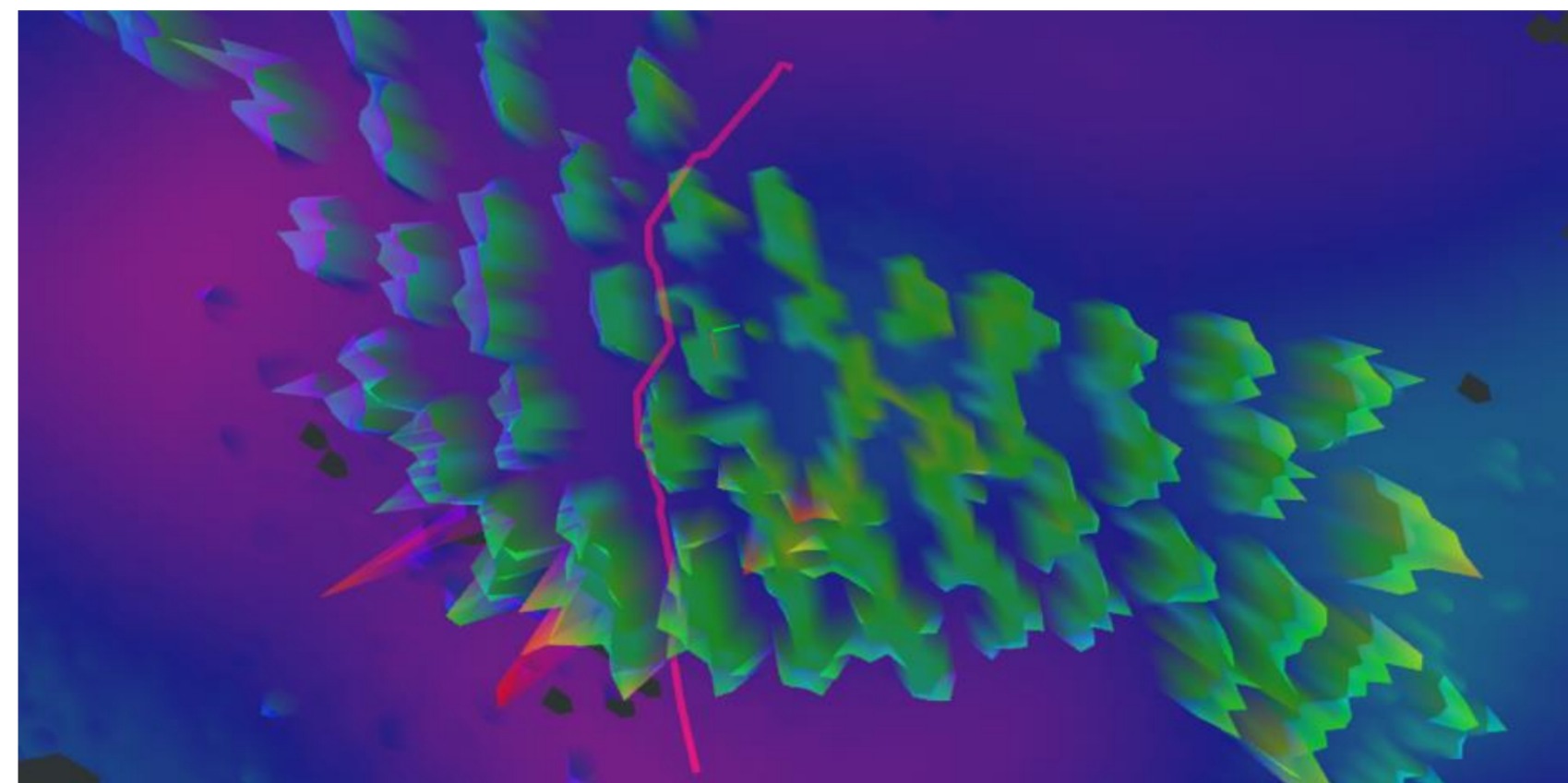


Figure 2: Path planned based on a lighter representation. A 2.5D elevation map.

Objectives

- Develop an efficient large-scale 3D metric mapping approach for complex outdoor scenarios such as forestry applications.
- Propose a solution for probabilistic projection of semantic information using state-of-the-art semantic segmentation techniques onto the proposed metric map to perform efficient 3D metric-semantic mapping in real time.
- Develop an innovative path planning module for robust and safe traversability analysis for autonomous robots under realistic constraints, fed in a first stage by a 3D metric map, and subsequently by an augmented semantic-metric map of the forest environment to outperform current existing techniques.



Figure 3: Heavy-duty UGV used in the SEMFIRE and SafeForest projects in a forest environment.

Work Plan

Project Start: 2022/10/1

TASK	Year 1									Year 2									Year 3																																			
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep																		
Thorough Research of the State of the Art	█																																																					
Establish Existing Research Gaps in Mapping and Path Planning	█																																																					
Development and Implementation of Mapping and Path Planning Techniques	█									█									█																																			
Design Methodologies for Testing and Evaluation	█									█									█																																			
Submit Work to Reputable Scientific Conferences and Journals	█									█									█																																			
Write the Ph.D. Thesis																			█																																			
Milestones	MS1: SotA and Research Gaps									MS2: Metric Mapping Technique									MS3: Path Planning in Metric Map									MS4: Path Planning in Semantic-Metric Map									MS5: Experimental Validation									MS6: Ph.D. Thesis Delivered								