Towards Agri-KITTI: a 4D Dataset for Phenotyping and Simultaneous Localization and Mapping in Agricultural Applications

Riccardo Polvara †, Sergi Molina †, Konstantinos Tsiolis*, Alexios Papadimitriou*, Ioannis Mariolis*, Dimitrios Giakoumis*, Dimitrios Tzovaras*, Grzegorz Cielniak †, Marc Hanheide †

† Lincoln Centre for Autonomous Systems, University of Lincoln, UK

*Centre for Research & Technology Hellas, Thessaloniki, Greece

University of Lincoln

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GOAL

To deploy an autonomous mobile robot in a vineyard at specific time intervals and to record sensor data.

- Long-term robust deployment of the robot in the wild navigating on a topological map.
- Building Agri-KITTI, a long-term database of robot sensor data spanning across various seasons.
- Adopting the database as benchmark for SLAM algorithm in agricultural environment.

INTRODUCTION

- Agricultural environments, such as vineyards, offers many challenges for autonomously and safely deploy robots at work.
- E.g., plants changing appearance can lead to a degradation of the localization module, with the robot drifting from its course [1]
- Existing SLAM methods are developed and tested mainly in urban or indoor environment which are consistent across time [2].

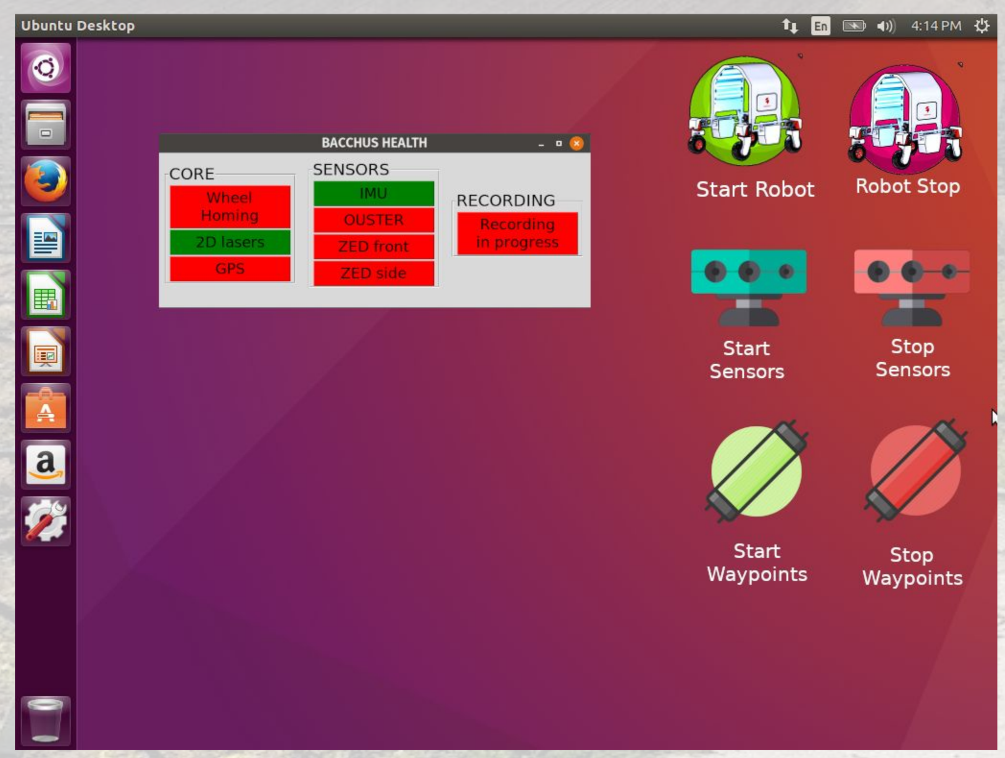
CONTRIBUTION

- To establish a robust and reproducible navigation strategy for data recording by using a robot in a vineyard.
- To define an efficient data recording and storing pipeline.
- Building and releasing to the research community a 4D dataset useful for developing and testing SLAM applications in the agriculture domain.

METHODOLOGY

In order to build a 4D dataset, we aim at recording data in Ktima Gerovassiliou, a vineyard located not far from Thessaloniki (Greece), every two weeks.

To this scope, we equipped the Thorvald robot (Saga Robotics) with a complete sensor suite consisting of RTK-GPS (Trimble BX992), 2 RGBD cameras (Stereolabs ZED2), one 16-beam 3D LIDAR (OUSTER OS1-16), IMU (RSX-UM7) and two 4-beam 2D LIDARs (SICK MRS1000) located at opposite corner of the robot itself. Dedicated desktop icons and a UI have been designed, while a touch monitor is mounted on the robot facilitating the deployment of the robot.



The robot traverses autonomously a human-designed path along the edges connecting nodes of a topological map.

Data are recorded and organized into a MongoDB database by using *topic_store* (TS)[3]. Unlike ROS rosbags, TS adds flexibility by serialising all messages into a data hierarchy that's easily searchable with database queries and allows for remote storage. The user simply needs to define a *scenario* file listing all the topics to record and the hierarchy to adopt.

```
context: "kg_recording_march"

storage:
  method: "database"
  config: "default"

data: {
  2d_lidar: {
    laser: "/scan",
    cloud: "/merged_cloud",
  },
  camera1: {
    color: {
      image: "/front/zed_node/rgb/image_rect_color/compressed",
      intrinsics: "/front/zed_node/rgb/camera_info",
    },
    aligned_depth_to_color: {
      image: "/depth_republish/compressedDepth",
      intrinsics: "/front/zed_node/depth/camera_info",
    },
    imu: {
      data: "/front/zed_node/imu/data",
      mag: "/front/zed_node/imu/mag",
    },
    odom: "/front/zed_node/odom",
    pose: "/front/zed_node/pose",
  },
  camera2: {
    color: {
      image: "/side/zed_node/rgb/image_rect_color/compressed",
      intrinsics: "/side/zed_node/rgb/camera_info",
    },
    aligned_depth_to_color: {
      image: "/depth_republish_2/compressedDepth",
      intrinsics: "/side/zed_node/depth/camera_info",
    },
    imu: {
      data: "/side/zed_node/imu/data",
      mag: "/side/zed_node/imu/mag",
    },
    odom: "/side/zed_node/odom",
    pose: "/side/zed_node/pose",
  },
  gps: {
    readings: "/gps/filtered",
    fix: "/gps/fix",
    error: "/health/gps/error_std",
    yaw: "/yaw",
  },
  imu: {
    data: "/imu/data",
    mag: "/imu/mag",
    rpy: "/imu/rpy",
  },
  motor: "/motor_controller_data",
  odometry: {
    raw: "/odometry/base_raw",
    gps: "/odometry/gps",
  },
  ouster: {
    points: "/os_cloud_node/points",
    imu: "/os_cloud_node/imu",
    packets : "/os_node/imu_packets"
  },
  robot_pose: "/robot_pose",
  topomap: {
    current_node: "/current_node",
    closest_node: "/closest_node",
  },
  tf: {
    tree: "/tf",
    static: "/tf_static",
  },
}
collection:
  method: "event"
  watch_topic: "/front/zed_node/rgb/image_rect_color/compressed"
```

OUTCOME

Data are stored and indexed in a MongoDB database, which can be queried and inspected .


```
_id: ObjectId("623b098e4fdd9bd95115f1b5")
⌄ 2d_lidar: Object
  › laser: Object
  › cloud: Object
⌄ camera1: Object
  › color: Object
  › aligned_depth_to_…: Object
  › imu: Object
  › odom: Object
  › pose: Object
⌄ camera2: Object
  › color: Object
  › aligned_depth_to_…: Object
  › imu: Object
  › odom: Object
  › pose: Object
⌄ gps: Object
  › readings: Object
  › fix: Object
  › error: Object
⌄ imu: Object
  › data: Object
  › mag: Object
  › rpy: Object
⌄ motor: Object
  › header: Object
  › controller_data: Array
  › _ros_meta: Object
  › _connection_header: Object
⌄ odometry: Object
  › raw: Object
  › gps: Object
⌄ ouster: Object
  › points: Object
  › imu: Object
  › packets: Object
⌄ robot_pose: Object
  › position: Object
  › orientation: Object
  › _ros_meta: Object
  › _connection_header: Object
⌄ topomap: Object
  › current_node: Object
  › closest_node: Object
⌄ tf: Object
  › tree: Object
  › static: Object
› _ts_meta: Object
```


FUTURE PERSPECTIVE

- Continue to record data until the harvesting season so to capture the entire crops' growth.
- Releasing the dataset to the community.
- Defining a new benchmark for SLAM in agriculture domain, where features are less stable than in an urban scenario.
- Thanks to its temporal aspect, Agri-KITTI can also be used for phenotyping and crop mapping.

CONCLUSION

- We propose the creation of Agri-KITTI, a new dataset for benchmarking SLAM application in agricultural domain.
- We are planning to record 4D sensor data from March until late September in a Greek vineyard.

REFERENCES

1. Hroob, I., et al.. (2021). Benchmark of visual and 3D lidar SLAM systems in simulation environment for vineyards. In Annual Conference Towards Autonomous Robotic Systems (pp. 168-177). Springer, Cham.
2. Labbé, M., & Michaud, F. (2019). RTAB-Map as an open-source lidar and visual simultaneous localization and mapping library for large-scale and long-term online operation. Journal of Field Robotics, 36(2), 416-446.
3. https://github.com/RaymondKirk/topic_store

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CONTACT

Email to: rpolvara@lincoln.ac.uk