Robotic navigation for agricultural environments

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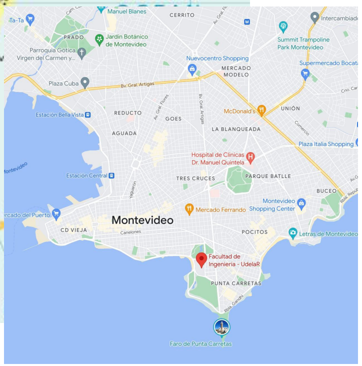

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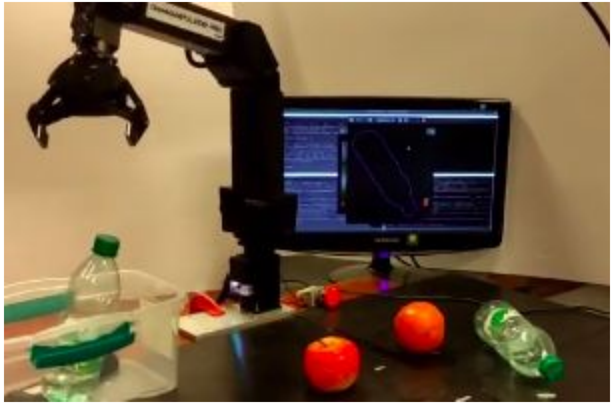
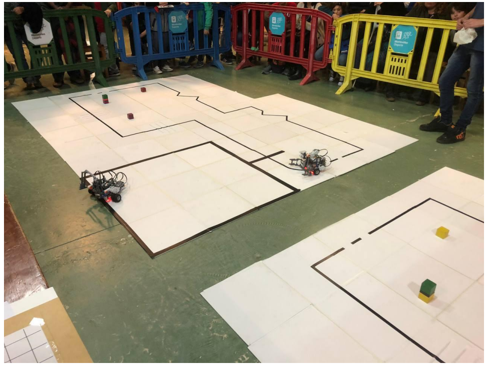
Population:

~3.5 million, around 2 million lives in Montevideo

~ 12 million cows, 3.8 per capita

MINA - Network Management / Artificial Intelligence





MAGRO: A robust robotic navigation system for agricultural environments

- March 2022 - March 2025
- National Agricultural Research Institute (INIA)
- Autonomous robot for different agricultural tasks

Why?

- Improve efficiency and effectiveness
- Reduce the use of chemicals
- Precision agriculture

How?

- Affordable solution
- Robust navigation system
- Estimate the quantity and quality of apple crops

https://youtube.com/shorts/sKVDZcEIFdc?feature=share

Environment

- Significant light variation
- Repeated or insufficient texture
- Uneven terrain
- Large
- Changing
- Windy

Robot

- Jackal from Clearpath (4x4)
- IMU (Inertial Measurement Unit)
- GPS (low accuracy)
- LIDAR Velodyne PUK
- Two ZED 2 from Stereolabs
- Jetson Xavier from NVIDIA

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- Ground Truth: GPS LEICA
  - high accuracy
  - > 10.000 EUR

Some terminology

Simultaneous localization and mapping (SLAM) is the problem of constructing or updating a map of an unknown environment while simultaneously localizing the agent's location.

Odometry uses sensor data to estimate the position over time. This method is sensitive to errors due to the integration of velocity measurements over time.

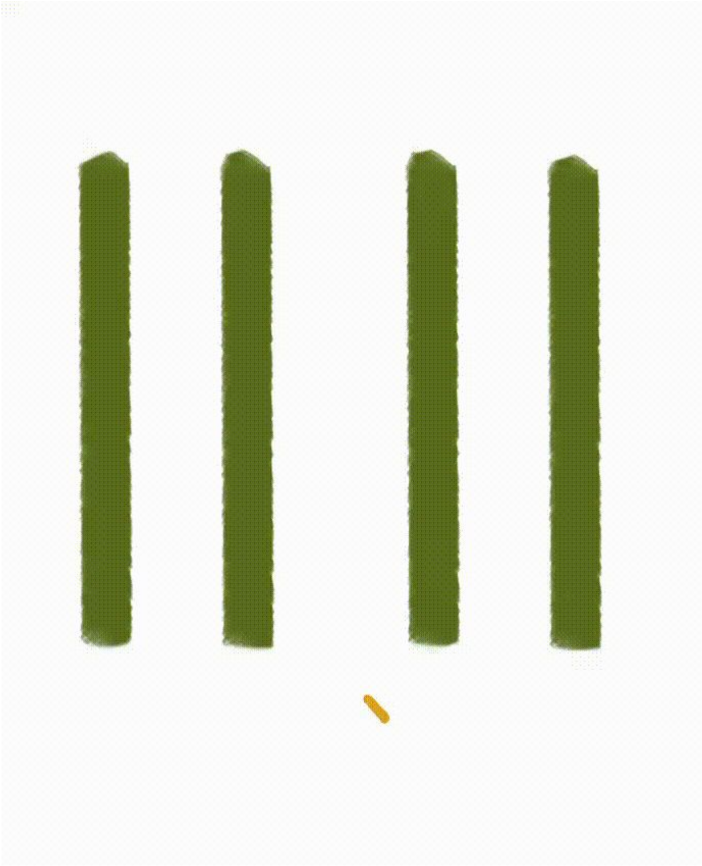
Loop closure is the problem of recognizing a previously-visited location and updating beliefs accordingly.

Datasets

MAGRO dataset

- 9 sequences
- Over a year

https://gitlab.fing.edu.uy/mmarzoa/magro-dataset



Datasets

MAGRO dataset

- 9 sequences
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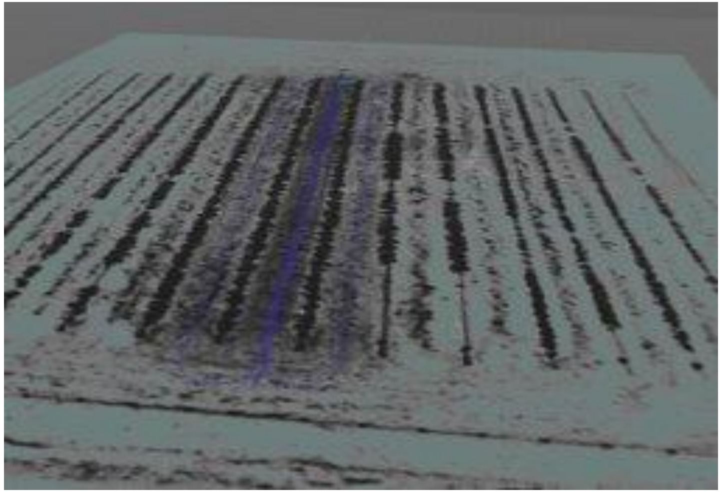

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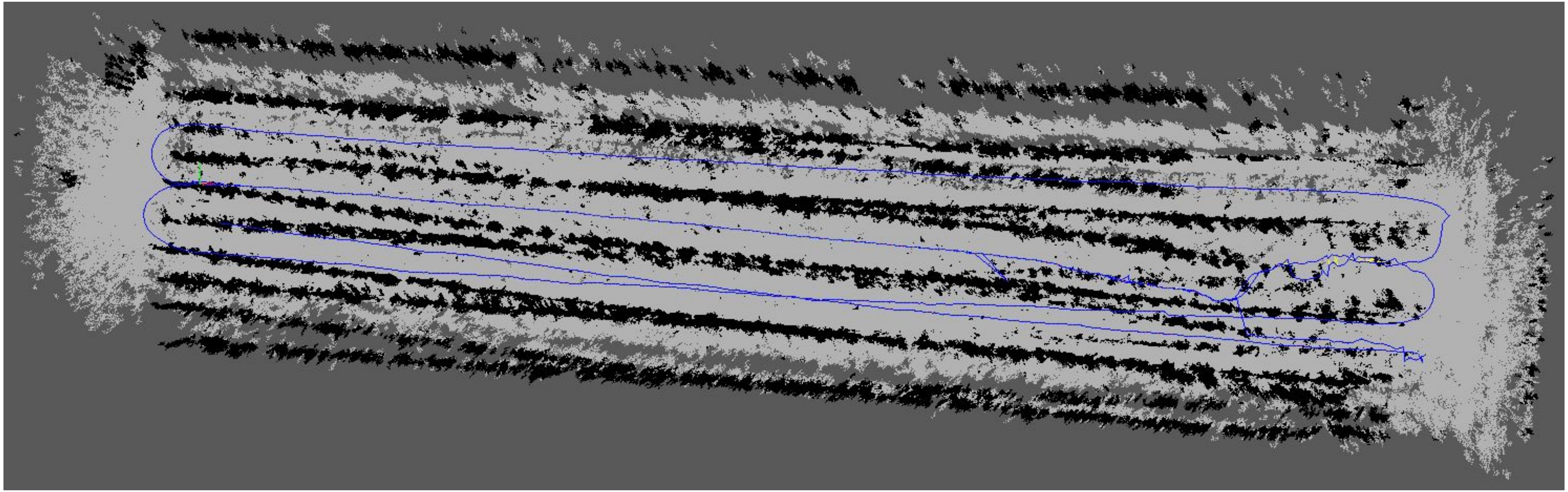
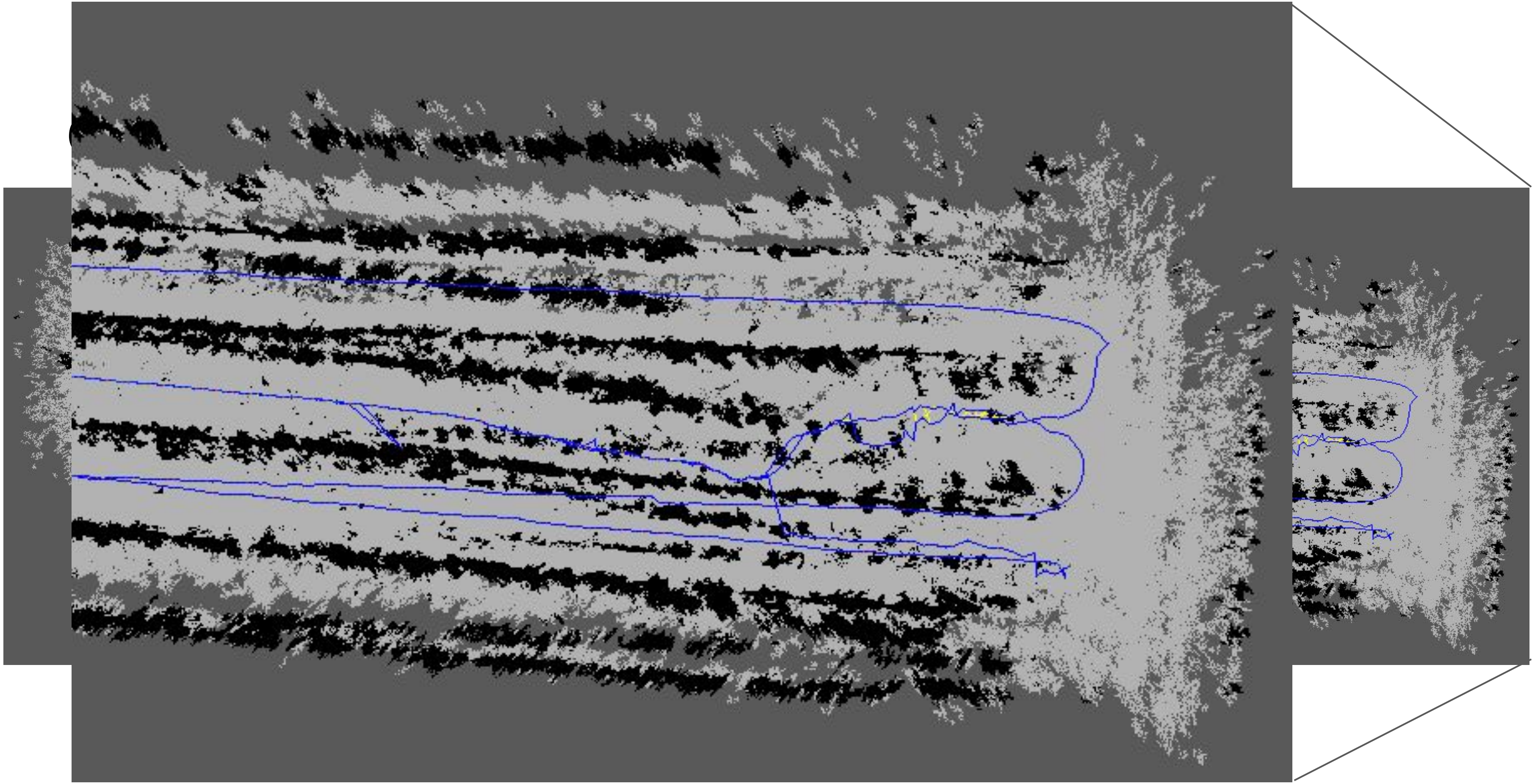
Failure analysis

Output example





Failure analysis

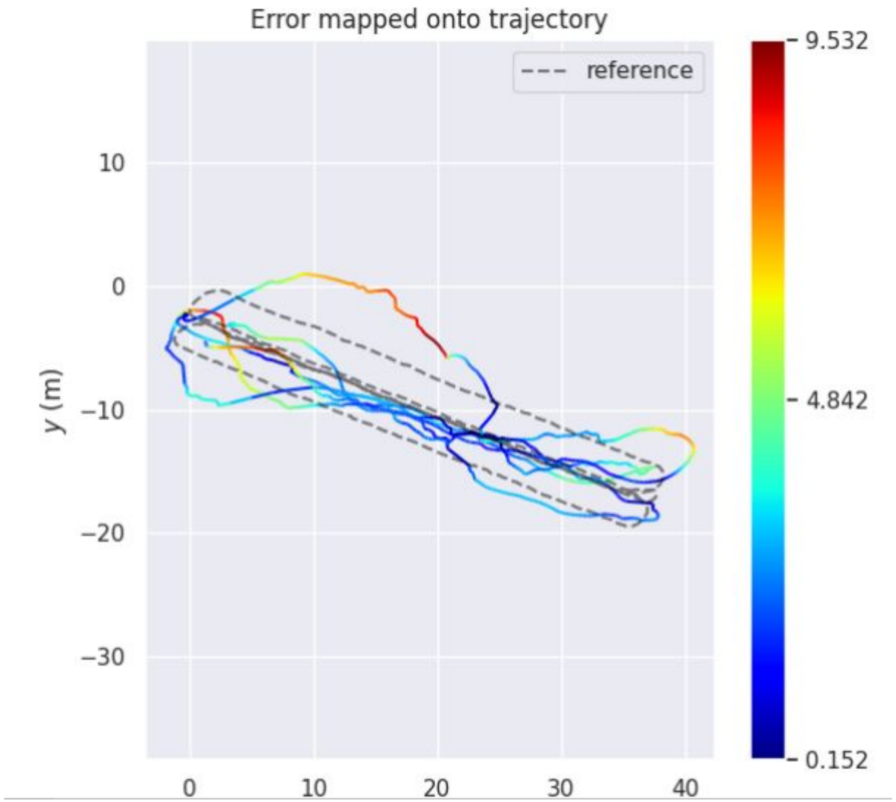
Odometry:

- Wheels
- Visual odometry (front and lateral camera)

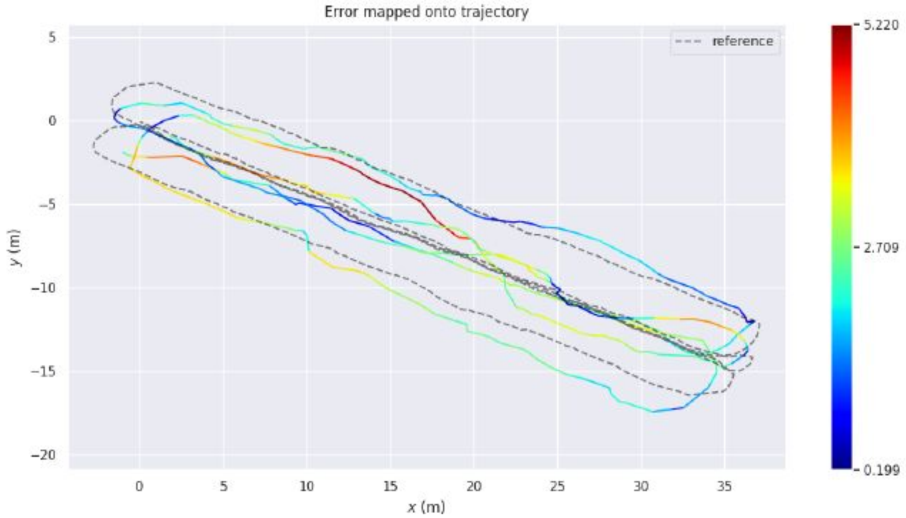
Low quality GPS

GPS

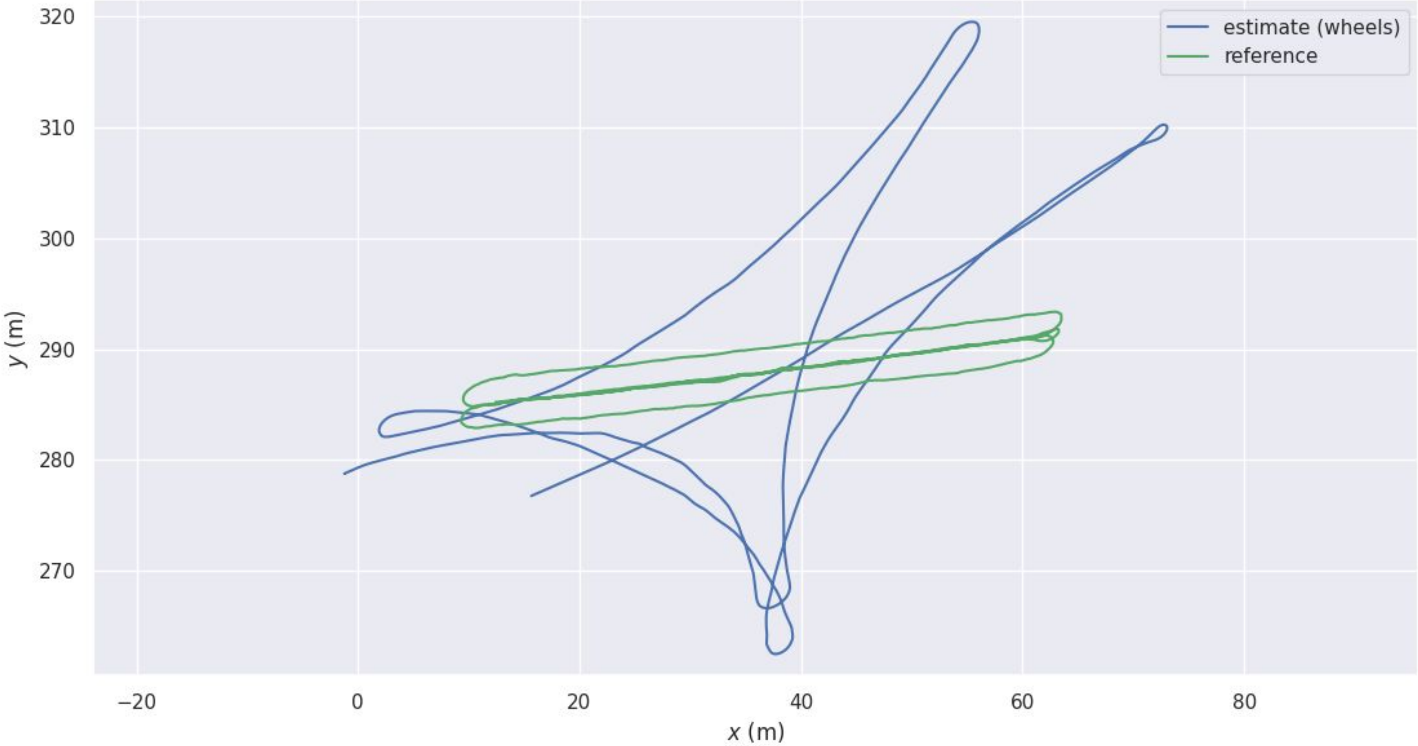

4


Error mapped onto trajectory
reference
10
0
−10
−20
−30
y (m)
0
10
20
30
40
9.532
4.842
0.152

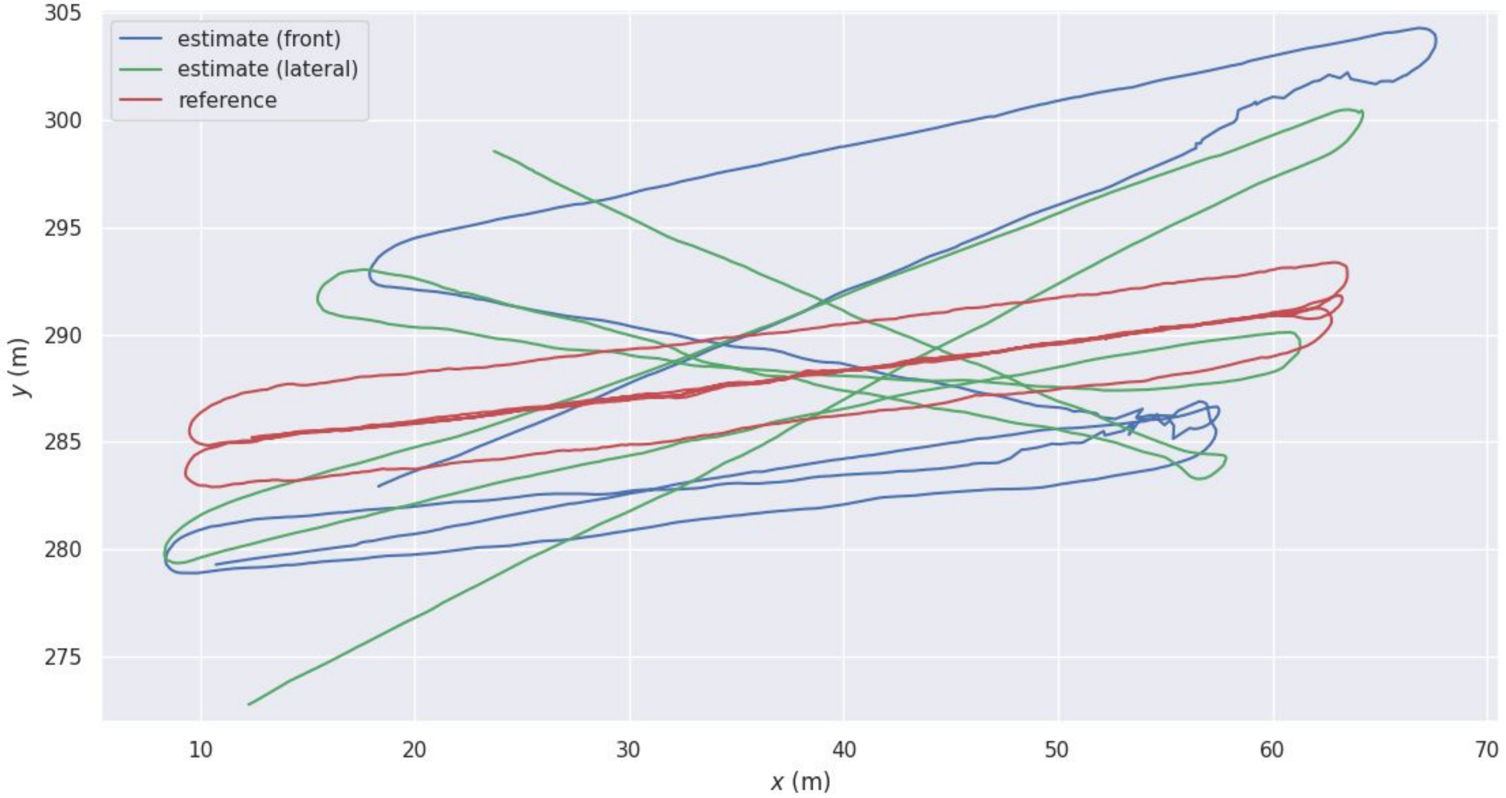
GPS


Error mapped onto trajectory
reference
5
0
−5
−10
−15
−20
y (m)
0
5
10
15
20
25
30
35
x (m)
5.220
2.709
0.199

Wheel odometry

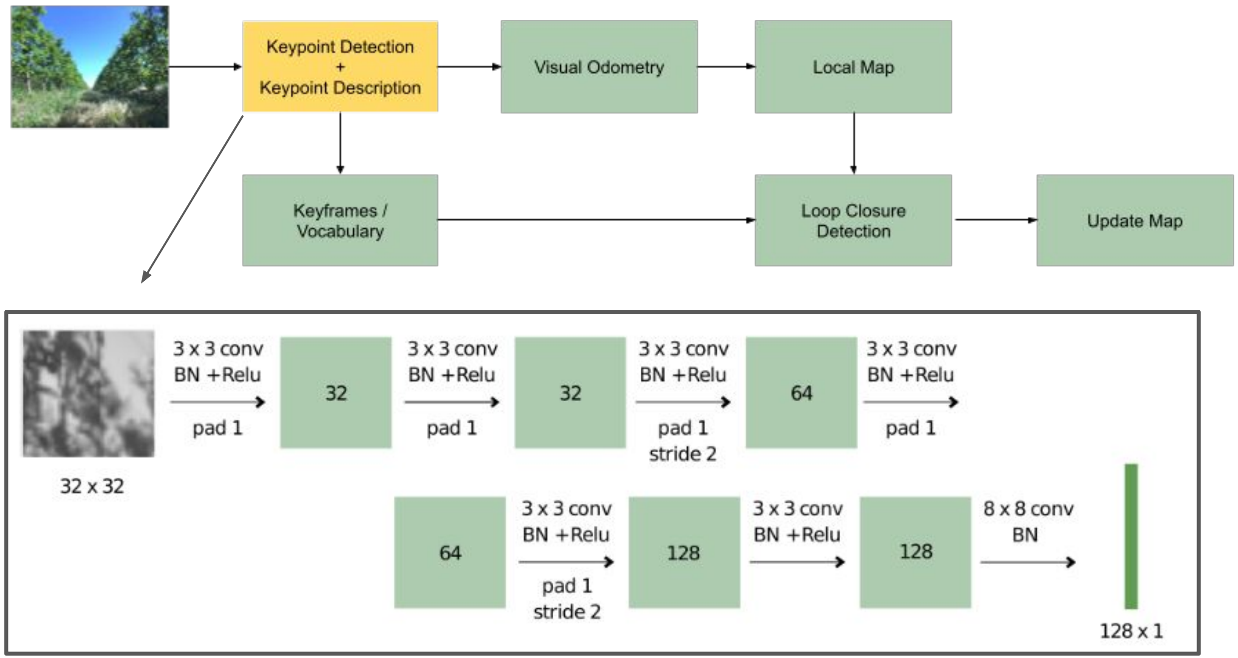


Front and lateral camera odometry



Steps

1. Learning agriculture keypoint descriptors with triplet loss for Visual SLAM



Steps

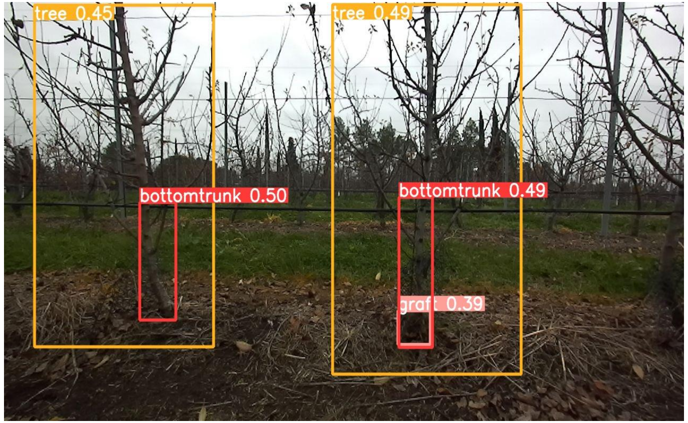
1. Learning agriculture keypoint descriptors with triplet loss for Visual SLAM
2. Identify and count trunks

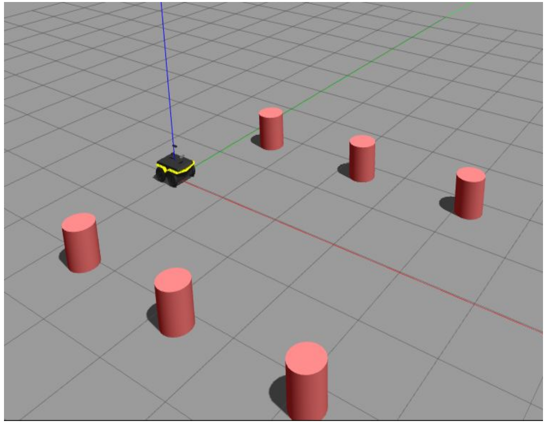
Detect, identify and count trunks

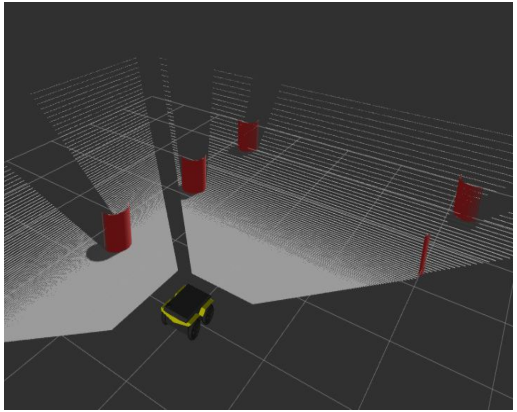
- Trunks are separate from each other the same distance (approx.)
- Detect a trunk and get the position related to the robot
- Use trunks as another odometry
- Identified trunk as a descriptor

https://youtu.be/s1DSRIuQK48

Ongoing work







$$\min_{R_i,t_i,A_j} \overbrace{\sum_{k=1}^{K}\sum_{m=1}^{M} \| a_{km} - (R_m A_k + \vec{t}_m)\|^2}^{\text{troncos}} + \alpha_d \overbrace{\sum_{m=1}^{M-1} \| \vec{\Delta}_m - \vec{o}_d \|^2}^{\text{odometrías}} + \overbrace{\sum_{k=1}^{K-1} \| (A_k - A_{k+1}) - d_s \|^2}^{\text{dist. troncos}}$$

λ

ω_{km} (1 si k se ve desde m)

peso de la odom. d

$\underbrace{(\vec{x}_m - \vec{x}_{m-1})}_{\text{tantos terminos como odom. tenga}}$

¿+ BA en región?

Thanks for your attention!

Questions?

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