TrimBot2020: The First Outdoor Garden Trimming Robot

EU Horizon 2020 Project Overview

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Outline

TrimBot2020 Project Objectives

Prototype the first outdoor garden trimming robot

- Research the underlying robotics and vision
- Navigate over varying terrain
- Approach hedges, boxwood topiary, rose bushes
- Trim them to ideal shape

Robot components

- Mobile platform (base)
- Robotic arm with clipper (Kinova Jaco 6 DOF)
- Multiple camera system (10 base + 4 arm)

TrimBot2020 Project Consortium

Project period: 2016 - 2019.

Coordinator: Bob Fisher, University of Edinburgh

Challenges in Robotic Gardening

- Dynamic environment
  - Weather and seasonal changes
  - Variable lighting conditions
- Navigation over terrain
  - Detection of slopes
  - Drivable surface types
- Plant shape representation
  - Where to cut and how much?
  - Target vs. observed shape
- Accuracy of trimming
  - Bend, flex, wind
  - Visual servoing to bushes

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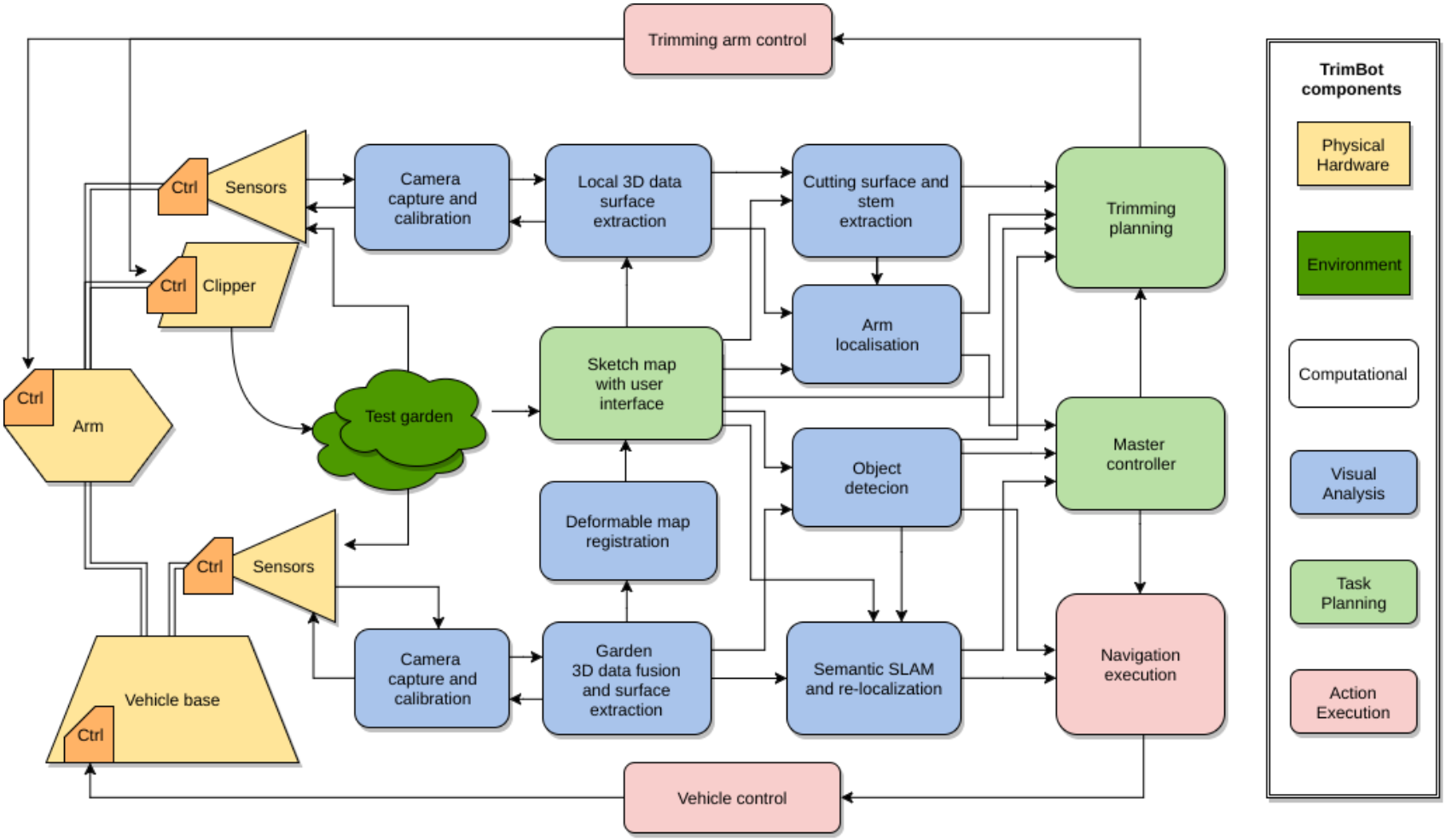
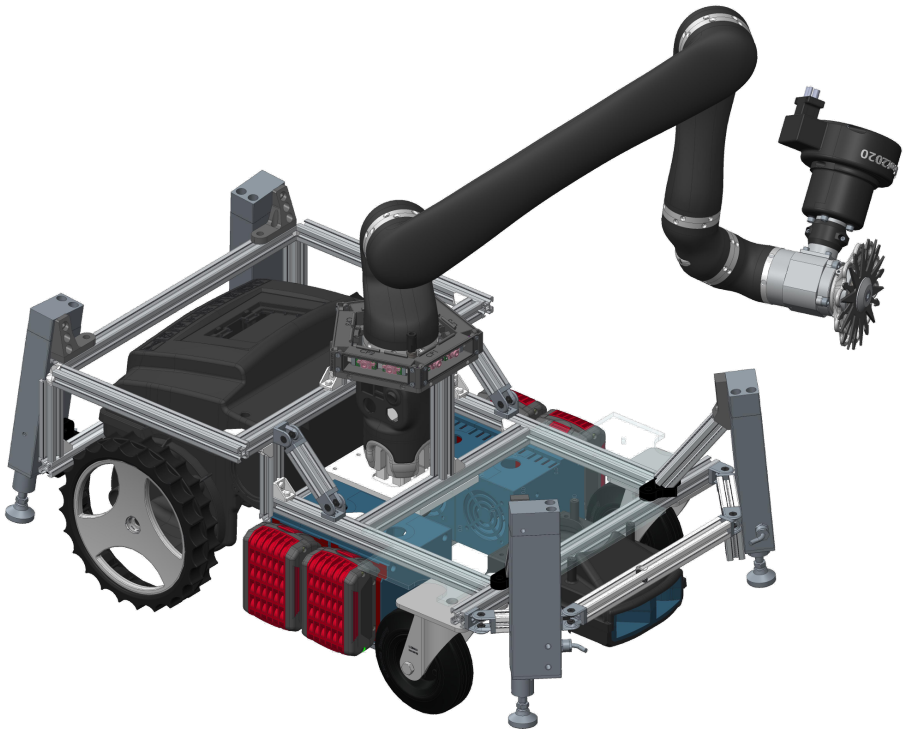
TrimBot System Components



Mobile Platform

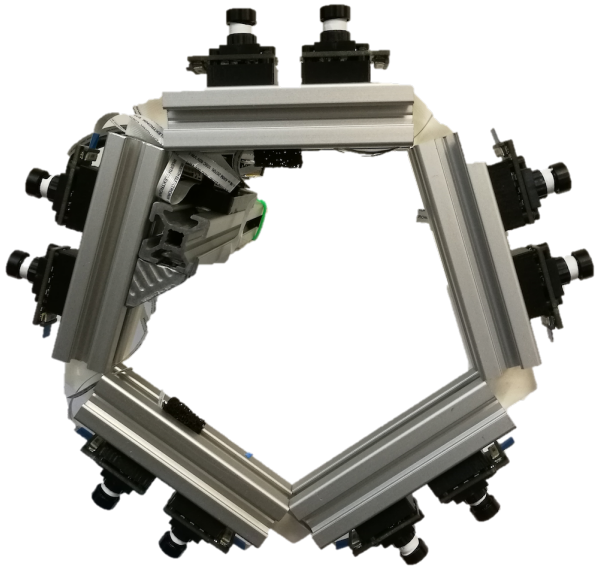
- Modified lawnmower base
  - Bosch Indego
- Retractable stabilizers
- Provides power supply
- Carries control computers
  - Pokini Mini PC
  - 2x RazorBlade notebooks
- Camera system + IMU
- Mounted arm with trimming tools



Final platform concept

Camera System

- Pentagonal rig
  - 5 x 2 cameras (WVGA)
  - 360 degrees view
- FPGA control board (ETHZ)
  - Synchronization @ 10 fps
  - On-board stereo @ 10 fps



Interchangeable Trimming Actuators

Bush trimmer

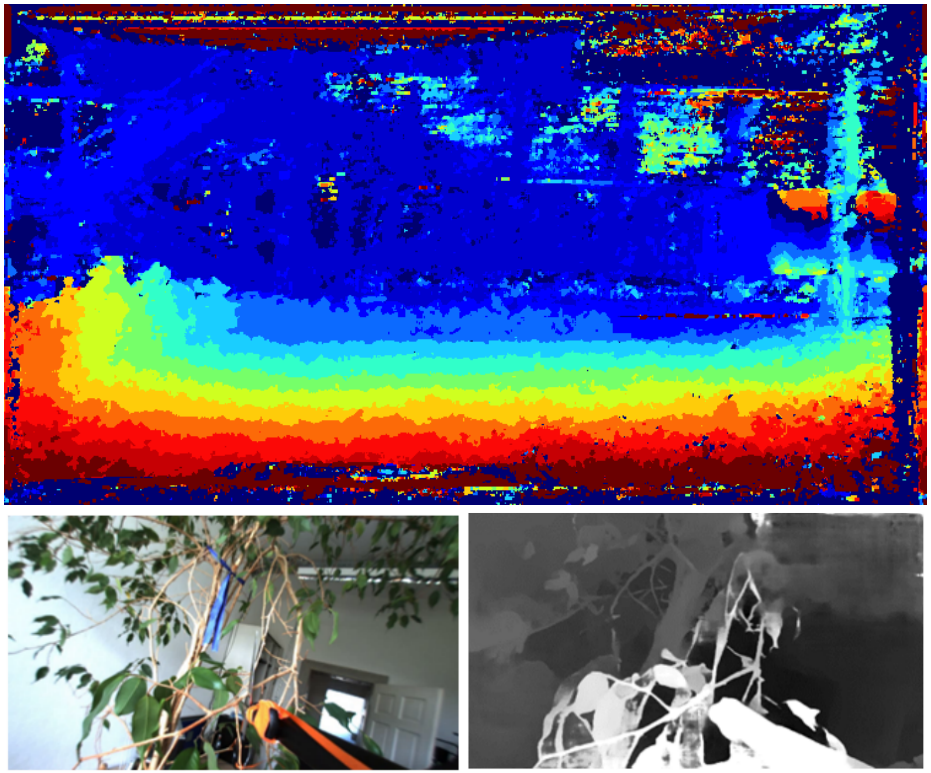
- Counter-rotating blades
- Omni-directional cutting
- Custom design
- Visual servo to desired surface

Rose clipper

- Pruning of rose bushes
- Cut stems at defined locations
- Adapted Bosch product

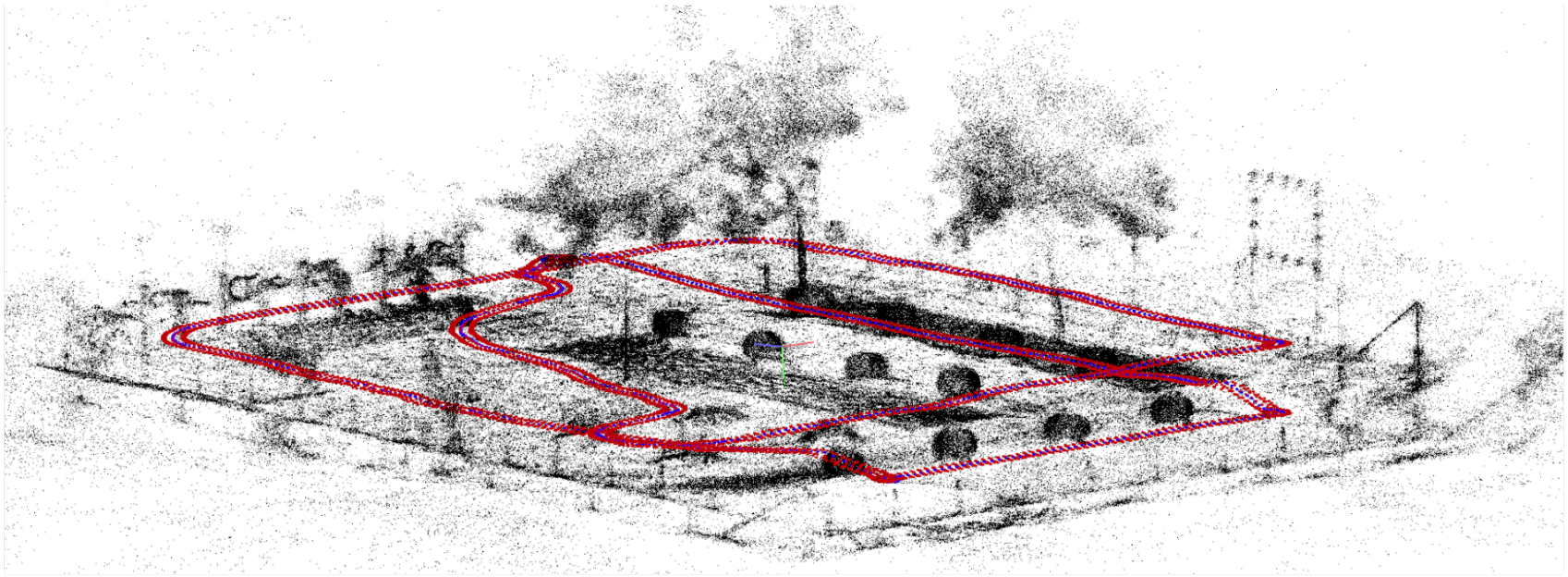
3D Sensing of Environment

- Passive sensors only
- Cameras + IMU
- Depth from 5 pairs
  - Stereo matching
  - FPGA, *DispNet*
- Dynamic motion
  - Optical flow
  - *FlowNet2*



Localisation and Mapping

- Feature based Structure from Motion
- Visual SLAM for 6 DOF pose estimation @ 5 Hz



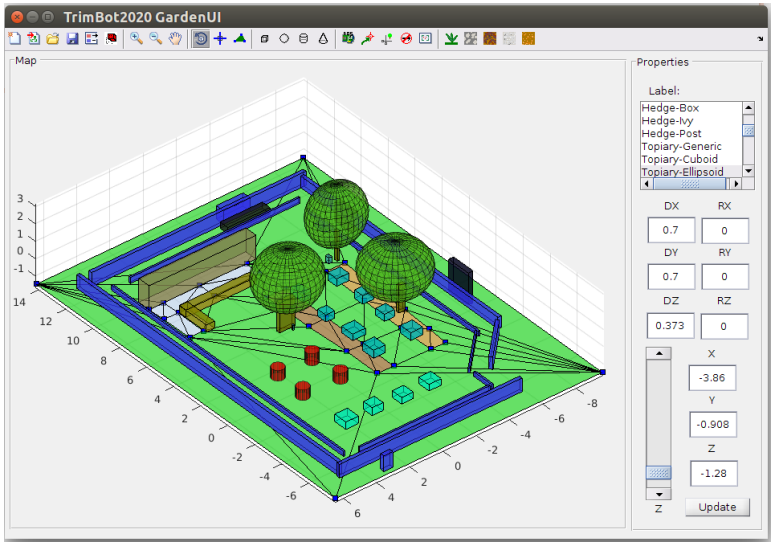
Scene Understanding

- Semantic segmentation
- Intrinsic image decomposition
- Deep networks employed

Input RGB | Albedo GT | Our Albedo Prediction | Shading GT | Our Shading Prediction

Vehicle Navigation

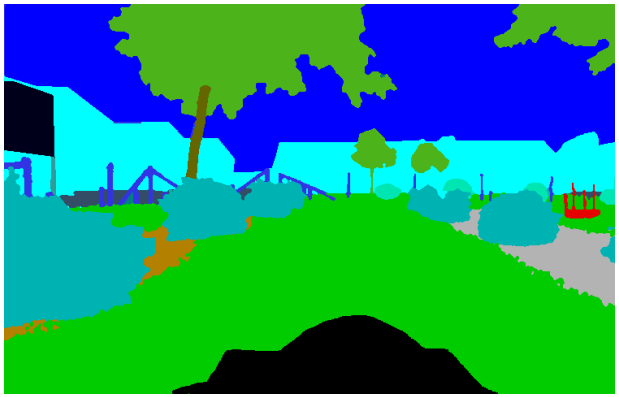
- User drawn sketch map
  - Intended bush shape
  - Surface types
  - Slopes, obstacles
- Indicate bushes to trim
- Obstacle avoidance



Trimming Control

- Arm mounted camera pair
- Bush shape fitting to 3D data
- Multiple cutting sites around bush
- Cutter path planning
- Visual servoing

Garden Datasets

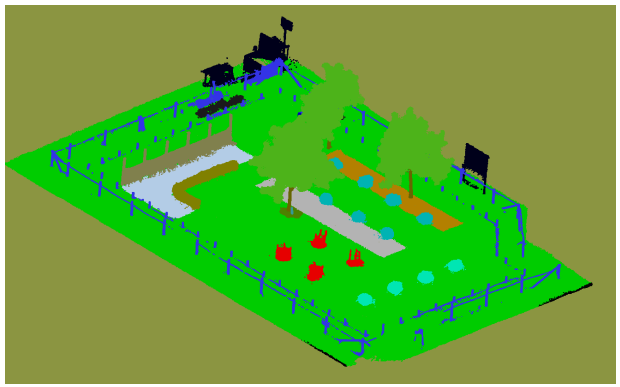


Real data captured in test garden

- Camera streams and positions
- 3D point clouds
- Semantic annotation of both

Synthetic images and scenes

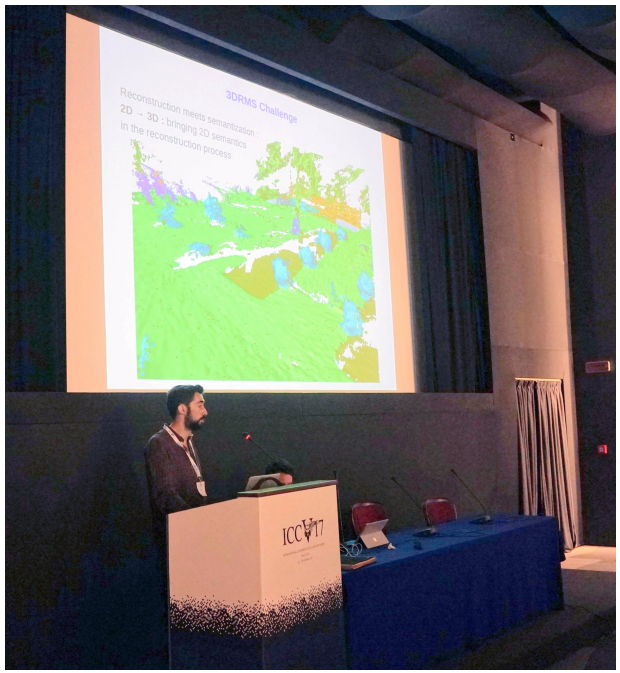
- Rendered from virtual garden
- Varied lighting conditions
- Release TBA



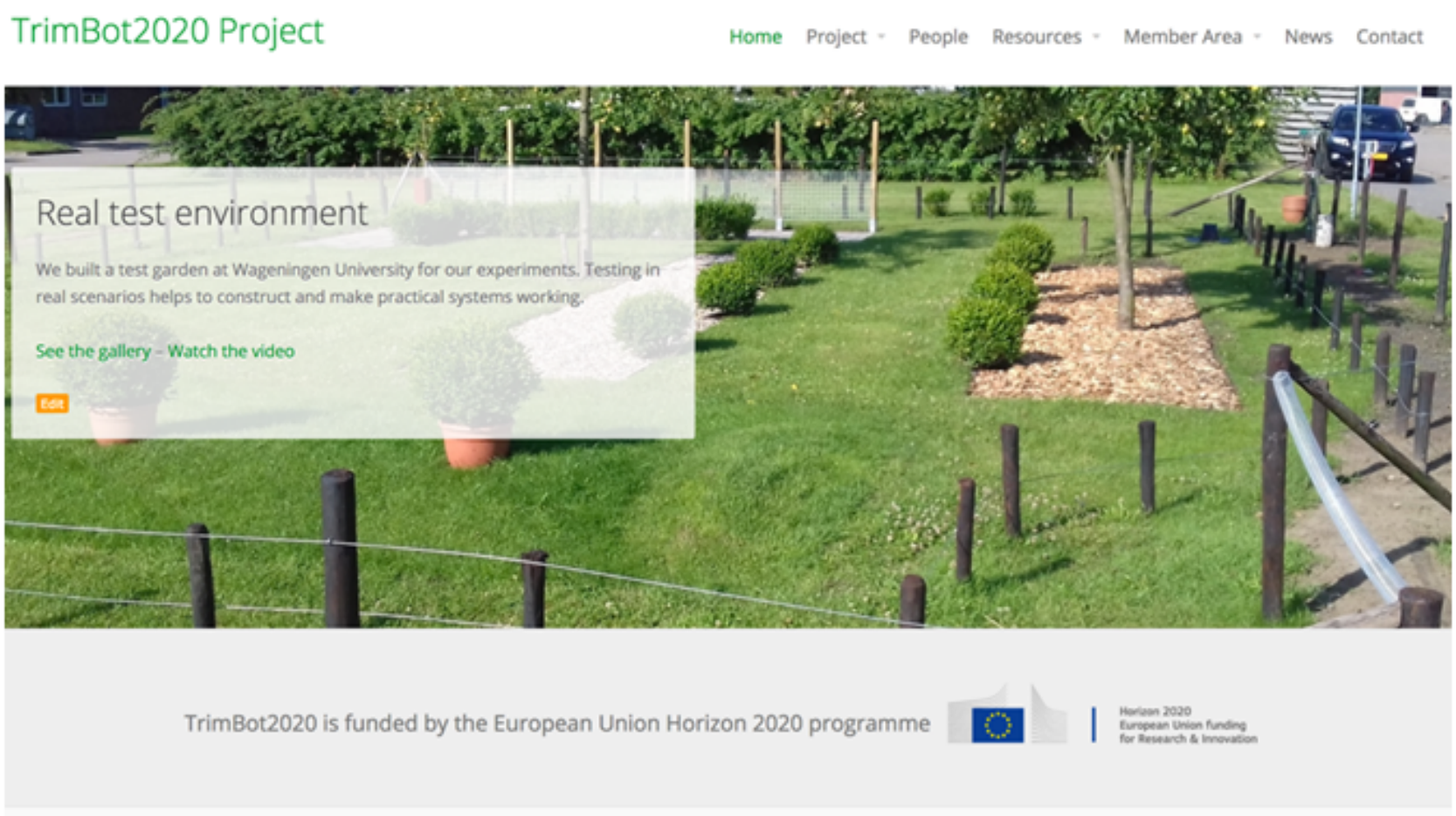
- `https://gitlab.inf.ed.ac.uk/3DRMS/Challenge2017`

Workshops

- 3D Reconstruction Meets Semantics (3DRMS)
  - `http://trimbot2020.webhosting.rug.nl/events/3drms/`
- Main topics covered
  - Semantic 3D reconstruction and SLAM
  - Learning for 3D vision
  - Fusion of geometric and semantic maps
- ICCV October 2017
  - Challenge on real data
- ECCV September 2018 (?)
  - Challenge on synthetic data
  - Submission summer 2018



Webpage



http://trimbot2020.org