TrimBot2020: The First Outdoor Garden Trimming Robot
EU Horizon 2020 Project Overview

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Outline

1. Introduction
   - Project Objectives
   - Challenges

2. System Components
   - Physical Components
   - Computational Components

3. Resources
   - Datasets
   - Workshops
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

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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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
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)**

- **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
TrimBot2020 Project

Real test environment

We built a test garden at Wageningen University for our experiments. Testing in real scenarios helps to construct and make practical systems working.

See the gallery – Watch the video

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http://trimbot2020.org