TrimBot2020: an outdoor robot for automatic gardening

50th International Symposium on Robotics, 20-21 June 2018, Munich
TrimBot2020 project

“to prototype the first outdoor robot for automatic bush trimming and rose cutting”
TrimBot2020 objectives and components

Prototype the first outdoor garden trimming robot

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

Robot components

- Mobile platform (base)
- Kinova Jaco robotic arm with clipper
- Multiple camera system
Challenges

Dynamic environment
  Weather and seasonal changes
  Variable lighting conditions

Navigation over diverse terrains
  Detection of slopes and drivable surfaces

Plant shape representation
  Where to cut and how much?
  Target vs. observed shape

Accuracy of trimming
  Bend, flex, wind
  Visual servoing to bushes
Mobile platform

Based on Bosch Indego lawn mower
  + Retractable stabilizers
Carries control computers
  Pokini Mini PC
  2x RazorBlade notebooks
Camera system + IMU
Robotic arm with trimming tools
Custom trimming tools

Bush trimmer
- Counter-rotating blades
- Omni-directional cutting
- Visual servo to desired surface

Rose cutter
- Pruning of rose bushes
- Cut stems at defined locations
Robotic arm control

Stereo camera on the arm for bush shape fitting to 3D data
Cutter path planning and visual servoing (open loop). Multiple cutting sites around bush
Closed-loop visual servoing (future work)
Camera sensors

5 pairs of stereo cameras (WVGA)
360° field of view
FPGA synchronization @10Hz
On-board stereo @10Hz
Localization and Mapping

- Visual SLAM for 6DOF pose estimation based on local features
- 10 cameras are modeled as a generalized camera
- @5Hz
3D sensing of the environment

Passive sensors only

Stereo pairs
- 5 pairs for navigation (FPGA)
- 1 pair for visual servoing (DispNet)

Dynamic reconstruction
- Optical flow (FlowNet 2.0) – tracking of branch movements
Scene Understanding

Image segmentation

Image intrinsics decomposition
Navigation

- Rough user drawn sketch map
  - Surfaces
  - Bushes
  - Obstacles, slopes
- Indicate the target bush to trim and obstacles to avoid
- Integrated-visual representation (on going/future work)
Test gardens: Wageningen and Renningen
Workshops, Challenges, Exhibitor’s booths

3D Reconstruction meets Semantics (3DRMS) workshop

1\textsuperscript{st} edition @ICCV 2017, Venice

2\textsuperscript{nd} edition @ECCV 2018, 9\textsuperscript{th} September 2018, Munich

Challenge on combining 3D and semantic information in complex scenes

http://trimbot2020.webhosting.rug.nl/events/3drms/
https://gitlab.inf.ed.ac.uk/3DRMS/Challenge2018

Paper submission (full papers and extended abstract) deadline – July 10\textsuperscript{th}

Challenge deadline – August 31\textsuperscript{st}

Upcoming

EU project exhibitor’s booth at IROS 2018 (1-5 October, Madrid)
Data sets

Real data recorded in the garden
Camera streams (with pixel-wise gt)
3D Point clouds (semantically annotated)
https://gitlab.inf.ed.ac.uk/3DRMS/Challenge2017
(Place recognition benchmark coming soon)

Synthetic data
Rendered from virtual garden
Varied lighting conditions
https://gitlab.inf.ed.ac.uk/3DRMS/Challenge2018
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 – Live camera
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Thank you