TNO innovation for life

Unibot

improving resource efficiency and process automation in greenhouses

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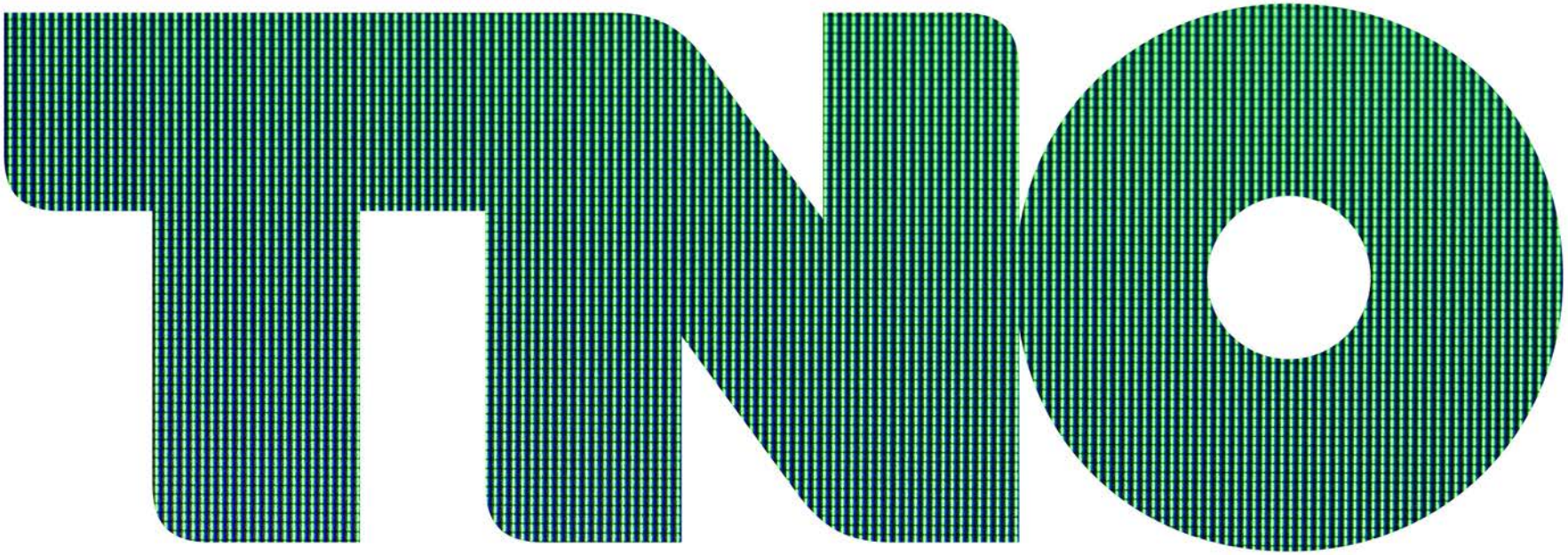

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Introduction

- Increasing mondial population result in the need for resource efficient food production and process automation. Protected horticulture in greenhouses is a good solution, increasing crop production efficiency and reducing inputs like water, nutrients and energy. As a result the area protected horticulture is increasing fast. If we analyse the worldwide expansion of high tech greenhouses there is a mismatch between technology level of the greenhouse installation (water, climate control) and the educational level of the people working in the greenhouse. This proposal focusses on enabling experienced growers with technology to operate greenhouses on a distance.

Introduction (2)

- This proposal will apply as an innovation action within ICT 23B in the robotics call by developing a intelligent greenhouse robotic system to
  - -improve process automation
  - -improve the resource efficiency

Vision

- Many investment projects in high tech big scale greenhouse project in Russia, Middle east, Mexico, Turkey, Spain are not succesful. European suppliers of greenhouse technology sell turn key greenhouse facilities together with limited capacity building for the people operating the greenhouse. Also there's limited experience in operating there greenhouses in the specific climatic conditions. On the long term this will not work because the greenhouses will only work using the "high level green skills" of the grower.
- Our vision is that data acquisition and decision support information should be automated in order to
  - Create circumstances to operate greenhouses on a distance
  - Enable the capacity building of high tech growers worldwide (easy to learn to adapt to local climatic circumstances)

State of the art

- Several high tech greenhouse concepts built world wide
- CROPS project WUR, Research project delivering knowledge to be used for unibot
- Greeneyes project: uniform plant growth and plant health measurement
- SIOM research programme TNO: developing decision support information for design and operation greenhouses worldwide
- Priva uniform robot platform
- Tecnova robotic projects

State of the Art (2)

- VTT: Strawberry harvest platform,
- VTT: Development (including optical design, instrument assembly, measurements) and customer delivery of various spectral imaging instruments realized with PFPI technology. Instrument building and application references from space (ESA), medical (skin cancer detection, glaucoma detection), unmanned aerial vehicles (agriculture, remote sensing), and gas sensing.
- VTT: MEMS FPI development (including optical design, process design and MEMS manufacturing) for selected wavelength range and building of miniaturized gas sensor demonstrators based on the MEMS technology.

Problem

1. When high tech greenhouses are used in other climate zones the “green skills” should be optimized, there isn’t a platform to share experiences, neither a common “green language”
2. Growing in (high tech) greenhouses is labour intensive
3. The circumstances for the labour are hard (temperature, loads, chemicals)
4. Crop handling specific for each variety, and each individual crop has a different shape, hard to automate, resulting in bad business case for automation

Problem (2)

5. Large scale greenhouses result in big crop losses as a result of fast spreading of diseases
6. Sensors to detect diseases, crop performance, climate condition are developing rapidly, but only give information on a specific location
7. Lack of intelligence and flexibility of currently existing robotic systems for greenhouse applications.

Goal

Unibot has the following three step approach: Monitoring, Control, Implementation

MONITORING

1. Develop and test a universal robot platform suitable for autonomous operation (data acquisition) in greenhouses worldwide with various crops like tomato, cucumber, pepper, etc
2. Implement specific state of the art sensors to monitor crop growth and health
3. Develop crop management strategy, coupling data acquisition strategy to decision support information wrt crop health and crop production → where to apply biological treatment, how to optimize production
4. Develop learning strategy fed by experiences worldwide

Goal (2)

- CONTROL

1. Develop actuators for application of biological treatments
2. Develop actuators for typical crop handling, focus on harvesting of tomatoes
3. Develop labour/investment optimization tool to improve the man-machine interaction

Goal (3)

- IMPLEMENTATION
- Implement Unibot in three “Innovation and Demonstration Centres (IDC)”, in different climate zones (Netherlands, Spain, Finland)
- Demonstrate Unibot to groups of end users (specific crops) in the IDC
- Implement the Tomato usecase at an end user (partner in project)

R&D topics

1. **Autonomous moving robot platform.** Develop strategy to operate multiple unibots in a single greenhouse, optimized for the task specific issues (scouting diseases needs other strategy than harvest products)
2. **Man-machine interaction:** divide crop handing tasks in sub tasks and develop a optimal solution where labour and robotics have maximal synergy
3. **Pilot experiments**. Combining technologies to a pilot system and testing in small scale greenhouse, evaluation of design and needs for further development

R&D topics (2)

4. Development of **low cost end harvesting effector** operated by human input for specific tasks in greenhouse (harvest tomato, remote based operator points tomato tot harvested on touch screen). Research topics are man machine interaction, increasing accuracy by environmental feedback (in order to use low cost robot arms)
5. Development of **end effector for precise monitoring crop health** and dosing of chemicals. Research topics are scouting algoritms, dosing techniques, and monitoring strategy.
6. **Monitoring and control of crop production.** Research topics are data acquisition strategy, decision support, learning strategy, model based control, system integration using greenhouse climate model and crop growth model

R&D topics (3)

- **Cognitive multimodal control, navigation, and mission planning for the autonomous robotic system.** Research topics are how to integrate multi-modal information into control, navigation, and mission planning, etc; how to develop efficient vision-based cognitive control algorithms. (University of Stirling involvement)

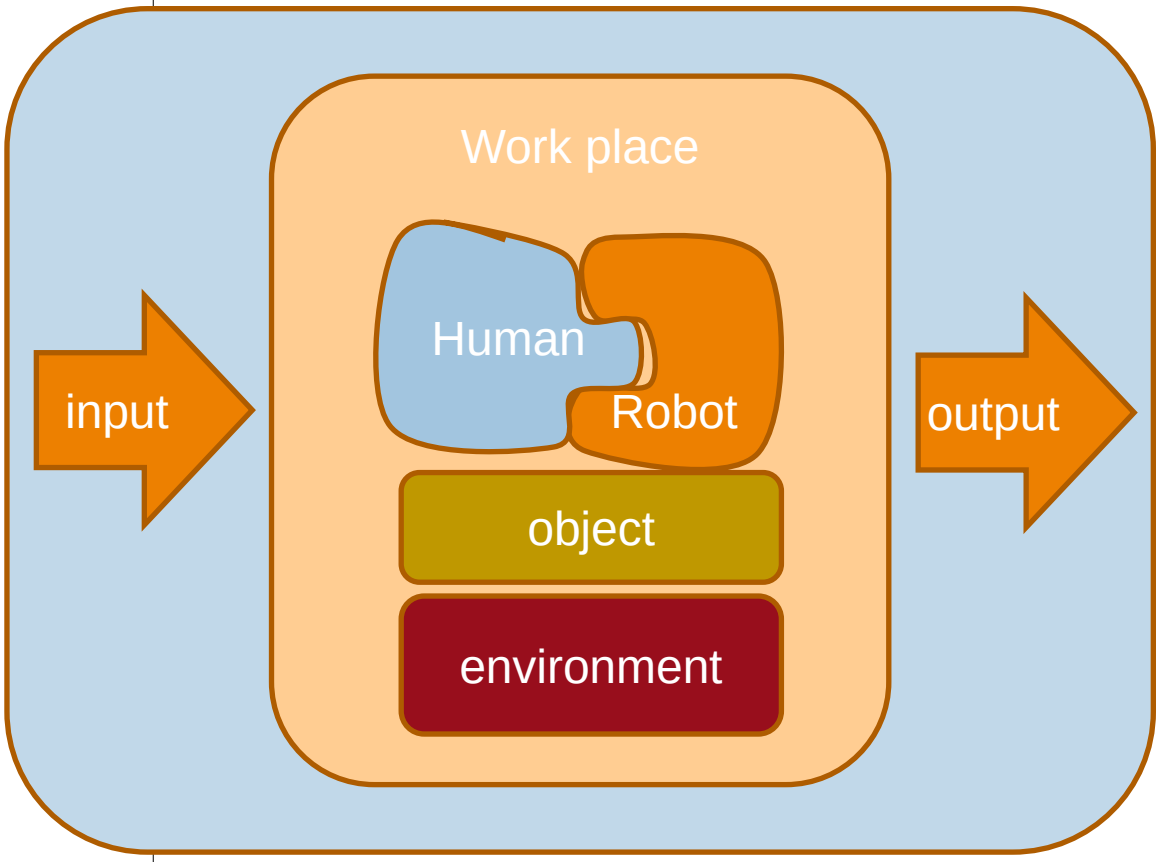
Project partners (to be confirmed and extended)

- TNO (NL, coordinator): man machine interaction, monitoring and control of crop production
- Demokwekerij (NL, SME): Pilot experiments IDC
- Priva (NL) : autonomous moving robotic platform
- Metazet (NL, SME): low cost tomato end harvesting effector
- Tomato grower (NL, SME) usecase tomato
- TU Delft (NL) Pilot experiments IDC
- Koppert (NL) biological treatment strategy
- VTT: (Finland): autonomous moving robot platform, sensor impl.
- Tecnova (Spain): pilot experiments IDC, end user?
- ISOIN (Spain): data acquisition and management (ICT)
- University of Stirling (scotland): implementation of sensors, Cognitive multi-modal control, navigation, and mission planning for the autonomous robotic system

Work Packages

- WP 0 project management
- WP 1 (R&D) man machine interaction (Modelling task division and labour)
- WP 2 (R&D) Sensor development, hyperspectral piezo FPI imaging camera, MEMS FPI gas sensor
- WP 3 (R&D) monitoring and control strategy
- WP 4 development pilots
    - Autonomous platform with integrated sensors
    - Crop health module
    - Tomato end effector
- WP 5 pilot plant and valorisation
- WP 6 Dissemination

In detail: WP 1: Human-Robot interaction/collaboration



human and organisational aspects
Allocation of tasks
Learning and work instructions
Organisation of proces
Organisation of workstations
Human factors

Deliverables

- WP 1: Universal tool for design man-machine interaction
- WP 2: Hyperspectral camera system, miniature gas sensor
- WP 3: Monitoring and control strategy
- WP 4: working pilot of:
  - Autonomous universal inspection platform
  - Tomato harvest module
  - Crop health module
- WP 5: Market place for robotic innovation (IDC robotica)

Budget (to be discussed)

- Maximum project budget seems 3000 kEUR (4 topics in ICT 23B)
- Focus on pilots and demonstrators, limited research
- Knowledge institutes will do research and make knowledge applicable to be implemented in pilots
- 3 R&D packages 25%
- 3 pilot projects 50%
- Management 7%
- Communication / Dissimination 8%

Budget (to be discussed)

WP	Total	TNO	VTT	Stirling	Tecnova	Demo	metazet	Priva	Visser	Koppert	Grower Fin	Grower Sp	Grower NL
0	200	200											
1	100	100											
2	250		200	50									
3	500	250	50	200									
4	1300	200	100		200	100	150	200	150	200			
5	400					100					100	100	100
6	250	100	50		50	50							