New development of automation for agricultural machinery.

Computer Vision
- a versatile technology in automation of agriculture machinery.

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Agenda

- Introduction
- Mechanisation & Automation
- Computer vision
  - Concepts of 2D & 3D vision
  - Applications
  - Challenges
  - Benefits
  - Conclusion
- Future directions
Mechanisation & Automation
Bigger and bigger

Jaguar 60 SF (1973)    Jaguar 980 (2008)

- 12 rows header (9m)
- 830 HP
- Width: 3.1m Height: 3.8m
- Weight ≈ 15 ton
Mechanisation & Automation
More and more automation

More automation e.g.
- Better precision
- Improved quality
- Higher uptime
- Increased yield

...leading to overall improved efficiency.

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Mechanisation & Automation
Automation concept – we call it EASY

- Auto Steering solutions …
- Tracking and diagnostics…
- Farm management software …
- Task Management …
- Advanced sensors …
- …

- And Computer Vision
  - the focus in my presentation today.
Computer Vision – Applications (3D)
CLAAS AutoFill
Computer Vision
Concept of 2D colour vision

- 2D Computer Vision (colour)
  - Image capturing
  - Image processing
    - Segmentation - based on pixel colour - into soil and plants
    - Apply knowledge about structure, size, shape, etc to discriminate plants - as crop or weed
  - Feature extraction
    - Location of the crop row
    - Location of the individual plant
    - Provide a confidence measure
  - Tracking

Colour image:  
Segmented image:
Computer Vision
Concept of 3D vision

- **Image capturing**
  - 2 image sensors
  - Fixed baseline (b)
  - Focal length (f)

- **Image processing**
  - Disparity image (dl – dr)
  - Subtraction of ground level
  - Shape based matching

- **Feature extraction**
  - Location of object

- **Tracking**
Computer Vision
Concept & Hardware

- Computer Vision
  - Image capturing
  - Image processing
  - Feature extraction
  - Feature tracking

- Hardware designed to meet high environmental standards
  - Temp. range -40 to +85 °C
  - Water & dust proof
  - Vibration resistant

1999
- 1 colour sensor
- 1 microprocessor
- 2D technology
- CAN Bus

2005
- 2 colour sensors
- 2 microprocessor
- 3D technology
- CAN Bus & USB

2010
- 3 sensors
- Colour & B/W
- Multiple Microprocessors
- 2D & 3D technology
- CAN Bus, Ethernet, Video
Computer Vision
Summary

- a touch-less sensor in a compact and robust design
  - providing combinations of colour and black & white lenses
  - with very powerful image processing capabilities
  - and external interfaces like CAN bus, ethernet, and analogue video

- with embedded software providing a detailed scene interpretation by
  - extracting features based on colour, size, shape, etc (2D)
  - measuring the spatial structure (3D)
  - using 2D and 3D techniques independently or in combination
  - high accuracy and minimal latency
Computer Vision – Applications (2D)
Inter-row cultivation

- Conventional inter-row cultivation
- Major European manufactures provide camera-guided cultivation systems:
  - Tim-Thyregod (DK)
  - Carre (FR)
  - Stekete (NL)
- Position of the crop rows
- Active implement steering
- For large cultivators, camera guiding is requested by customers
Computer Vision – Applications (2D)
Inter-row & Inter-plant cultivation

- Robocrop InRow, Garford Machinery Equipment Ltd (GB)
- Position of the individual plants
Computer Vision – Applications (3D)
CLAAS CAMPilot

Swath

Row crops

Tramlines

Ridges
VINESCOUT

- Clemens manufactures machinery and equipment for vineyards
- Navigation system based on 3D vision guiding the tractor along the narrow paths of vineyards
Computer Vision
Challenges in both 2D & 3D – Growth cycle and conditions

- From small green dots to a green “carpet”
- High yield – low yield
- Vegetation level
Computer Vision
Challenges in both 2D & 3D – Illumination and shadows

- Sunrise to sunset
- Artificial light at night time

- From clear sunlight to overcast and with drifting clouds
- Driving direction both causing counter light and back light

- Shadows from
  - trees in the windbreaks
  - implement or tractor
  - the camera itself


**Computer Vision**

Challenges mainly 2D – weed structure and weed pressure

- Weed structure:
  - Random
  - “Row structured”

- Weed pressure:
  - Low
  - Medium
  - High
Computer Vision

Benefits

- Higher efficiency in the mechanical weed control as tools can work closer to the plants
- Mechanical weed control operations can be performed at higher speed
- Automate labour intensive weed control operations like inter-plant cultivation and spot spraying
- Less driver fatigue and reduced stress
- Driver can focus on optimizing machine settings
Computer Vision

Conclusion

- Computer vision is a versatile technology because:
  - it is *touch less and compact* - thus flexible with respect to mounting position
  - it provides a *detailed scene interpretation* by combining 2D and 3D techniques
  - it outputs the *actual* position of features relative to the camera position – thus providing true local information
Thank you for your attention.