Electronic Tow Bar
Automating Agricultural Machines

Research Project EDAUG
Dipl.-Ing. B. Jahnke
Vector Congress, 26.11.2014
Contents

- Driver Assistance in Agricultural Machines
- Electronic Tow Bar Project - EDAUG
- Adressing Safety and Usability
- Prototype Development
- Summary
Automation Drivers
Driver Assistance in Agricultural Machines

Why automating agricultural machinery?

Target Functions
- Resource efficiency
- Crop maximization
- Crop quality optimization
- Time efficiency

Tasks
- Steering
- Velocity
- Implement controls (PTO, Hitch, Hydraulics)
- Drive train management
- Fleet management
- Documentation

Technical Support
- Driver Assistance
- Ergonomics
- Comfort Cab

Work Conditions
- Dreary tasks
- Long work time
- Uneven, rough terrain

www.fendt.com
Boundary Conditions for Automation
Driver Assistance in Agricultural Machines

- Process:
  - Complex growth and crop models → nutrition, density, treatments,…
  - Changing Conditions within short ranges and time period → Soil, Crop, Weather,…

- Technical:
  - GNSS availability
  - GSM/GPRS mobile web access

- Law and Standards:
  - No road traffic regulations
  - ISO 25119 (equivalent ISO 26262)

- Machine Design:
  - Power split transmissions
  - Power shift transmissions
  - Electro-hydraulic steering
  - Speed up to 60km/h
  - ISOBUS standard for automation applications
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EDAUG Project
Electronic Tow Bar Project - EDAUG

agricultural machines, market insights and and safety competence

GNSS, navigation and geo-information systems

04/2011
07/2014

project management, control systems of mobile machines, environment perception

Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz

Bundesanstalt für Landwirtschaft und Ernährung
The Concept
Electronic Tow Bar Project - EDAUG

Electronic Tow Bar system for agricultural machinery using sensor based obstacle detection and geo-information

- Connected:
  - On-site web access to a customized geo-information server

- Intelligent:
  - Dynamic path planning based on obstacle coordinates

- Safe:
  - Permanent parameter monitoring
  - Obstacle detection enabling autonomous safety stop
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Safety Concept
Adressing Safety and Usability

Operational
- No safety critical faults or errors

Safety Stop
- Low GNSS signal quality
- Sensor based obstacle detection
- Manually uncoupled

Emergency Stop
- V/V collision risk
- Data Communication loss
- Severe system faults

Safety Targets:
- Human beings (ISO 25119)
- Environment
- Machines
State Machine
Adressing Safety and Usability

Operational Safety Stop Emergency Stop

Master
Assignment assigned

Safety Stop emergency

Docking alarm

Slave

Turn-Over

Evasion

Parallel Driving

Turn-Over

Tracking

Ignore

Emergency Stop

reset

[parallel = 1] [track = 1] [ignore = 1] [evade = 1]
Obstacle Detection
Adressing Safety and Usability

Sensor based obstacle detection

- Speed dependent Safety-Zone:
  - \( r_{min} = 5m \)
  - \( r = t_{brake} \cdot v \)
  - \( t_{brake} = 3s \)
  - \( v_{max} = \frac{20km}{h} \)
  - \( w = w_{implement} + 3m \)

- Long-Range-Surveillance:
  - Remote obstacle detection
  - Purpose: avoidance path calculation
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System Architecture
Prototype Development

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System Architecture
Prototype Development

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Software Development and Testing

Prototype Development

- Model Based Code Development
  - Matlab/Simulink
  - dSPACE rapid prototyping platform

- Remaining Bus Simulation
  - Vector CANoe for state machine validation
  - including CAN and RS232 RF

- Bus Monitoring and Diagnosis
  - CAN and Ethernet
  - VN5610 and CANoe
Sensor Setup
Prototype Development

Driveaway and Close Range:

4 x Mesa SR4500 3D-cameras
- 2 x front mount/2 x side mount
- Difference image segmentation for $v = 0\ \text{km/h}$
- Iterative TLS Grid segmentation algorithm for $v > 0\ \text{km/h}$
- Range 0…5 m
Sensor Setup
Prototype Development

Long Distance Obstacle Detection

2 x Sick LMS511- LIDAR
- 1 x fixed horizontal mount, Range: max 80m
- 1 x active 3D-fixture, Range: 5…15m
  - speed dependent elevation control
  - lateral slope compensation → active 3D-fixture

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Obstacle Management and Operator Interaction
Prototype Development

Slave

Master

EDAS Speed

Safety Zone Dimension

UFS-Obstacle

Mapping Tracking

Shape Compression

Obstacle list

Path planning

Protocol Synchronization

Protocol

Obstacle Visualization

Driver Decision

Decision Evaluation

Path visualization

Field boundary

Obstacle ID

evade

ignore

edaugMAP

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Geo-Information Server
Prototype Development

- **GI-Server for Electronic Tow Bar Systems:**
  - Concentration of GI from open source and commercial GI web-clients
  - Standardization of coordinate system
  - Relevant GI are:
    - Static obstacles like water, tree, power poles,…
    - Field boundaries for current platoon position

- **EDAUG-Client:**
  - Connectivity to EDAUG platoons
  - Request of local GI-set

- **Platoon:**
  - Download of obstacles and field boundaries
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Summary

- EDAUG Tow Bar System features a complex Cyber Physical System using web-based data onsite in a real time environment.

- Environment perception and mapping supports driver to optimize usability.

- Collision avoidance has not been designed as safety function with regard to ISO 25119 → The responsibility remains with the operator.

- Management of information and operator interaction has been met as core problem to design a single operator multi vehicle platoon.
Thanks for your attention!

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