Sensor-based, automated monitoring of fully mechanised harvesting processes – including options for automated process control

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Agenda

1. CAN bus data & iFOS
2. Monitoring of forest operations
3. Control aspects for forest operations
4. Conclusions

5. Questions
1. CAN bus & iFOS

1.1. (Very short) background about the CAN bus

The **controller area network (CAN) bus** is used for sending communication messages on
- engine- and
- machine status, in any heavy duty machinery, also in forestry machines.

There is a widely accepted data standard, which is “SAE J1939”.

The list of variables / parameters available over the CAN bus is quite long, typical elements are

- Engine status (engine-stop, engine-start, engine-idling, working engine speed control, engine revolutions, ...)
- Engine oil status (level, temperature, pressure, ...)
- Engine coolant (level, temperature, ...)
- Fuel indicators (consumption, engine trip fuel, temperature, ...)
- Ambient conditions (barometric pressure, cab temp., engine air inlet temp., ...)
- ...

CAN-Frame in base format with electrical levels without stuffbits

1. CAN bus & iFOS

1.2. integrated Forestry Operations Software (iFOS)

Machine parameters via CAN-Bus

Vehicle bus SAE J1939

GPS [Smartphone!]
Other sensors

Other hardware, such as: eScales [Ponsse LoadOptimizer], CTI [Pösges & Tigges]

Link to other software, such as: polterluchs, TimeControl
1. CAN bus & iFOS

1.2. Integrated Forestry Operations Software (iFOS)

Machine, used for testing:
Skidder HSM 805 HD

Enriching CAN bus information by adding
1. Extra sensors (slope indicator, rear blade force indicator, ...)
2. Including messages from driver: status messages
3. Including messages on machine level by CMC (central machine controller)

3. Report messages, as provided by skidder

<table>
<thead>
<tr>
<th>Electric generator on</th>
<th>0x1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water in filter</td>
<td>0x2</td>
</tr>
<tr>
<td>Parkbrake</td>
<td>0x4</td>
</tr>
<tr>
<td>Active brake</td>
<td>0x8</td>
</tr>
<tr>
<td>Hydraulic oil level low</td>
<td>0x10</td>
</tr>
<tr>
<td>Hydraulic oil too hot</td>
<td>0x20</td>
</tr>
<tr>
<td>Cooling water too hot</td>
<td>0x40</td>
</tr>
<tr>
<td>Hydraulic reservoir pressure low</td>
<td>0x80</td>
</tr>
<tr>
<td>Preheating</td>
<td>0x100</td>
</tr>
<tr>
<td>Water in filter</td>
<td>0x200</td>
</tr>
<tr>
<td>Allwheel drive on</td>
<td>0x400</td>
</tr>
<tr>
<td>Boom on</td>
<td>0x800</td>
</tr>
</tbody>
</table>

2.: Messages as provided by operator

<table>
<thead>
<tr>
<th>Activity</th>
<th>ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport</td>
<td>0x1</td>
</tr>
<tr>
<td>Work</td>
<td>0x2</td>
</tr>
<tr>
<td>Repair</td>
<td>0x4</td>
</tr>
<tr>
<td>Break</td>
<td>0x8</td>
</tr>
<tr>
<td>Service</td>
<td>...</td>
</tr>
</tbody>
</table>
2. Monitoring of forest operations

2.1. integrated Forestry Operations Software (iFOS)

1. What to monitor?
   - Engine
   - Machine
   - External sensors (GPS)
   - Produced elements (assortments)

2. Make this monitoring information available independent of:
   - Position and
   - Time

   by sending the describing data *instantly* to onto a GeoDatabase server

3. Thus a flexible data display is possible:
   - Values over time
   - Values pinned onto a map
   - ...

   iFOS offers first, basic display options.
2. Monitoring of forest operations

2.2. Examples from iFOS (screen shots) 1/5

Status: grapple / boom active
2. Monitoring of forest operations

2.2. Examples from iFOS (screen shots)  2/5

Status: forces on rear blade
2. Monitoring of forest operations

2.2. Examples from iFOS (screen shots) 3/5
2. Monitoring of forest operations

2.2. Examples from iFOS (screen shots)
2. Monitoring of forest operations

2.2. Examples from iFOS (screen shots)
2. Monitoring of forest operations

2.3. Simplified data flow for blending engine- / machine- / operational data
3. Control aspects for forest operations

3.1. What are the variables to be controlled at the operational level?

**Product quantities & characteristics:**
more or less fixed and driven by other parameters

**Resources, describing the technical production:**
- input of energy;
- output of emissions (exhaust fumes, CO₂, ...);
  at this time no control feasible

**Time:**
important resource, steering actor for the sequence of actions
3. Control aspects for forest operations

3.1. Produced quantities over time

![Graph showing produced quantities over time with expected corridor]
3. Control aspects for forest operations

3.1. Produced quantities over time

![Graph showing produced quantities over time with planning points and alerting boundaries for two consecutive operations.](image-url)

- **Planning point 1:** Start operation 1
- **Planning point 2:** End of operation 1 = start of operation 2

- Anticipated, planned endpoint: operation 1
- 2 consecutive operations: No 1 and 2 without any time overlap

**Operation 1**
- Alerting boundary [delay]
- Alerting boundary [speedup]

**Operation 2**
- Alerting boundary [delay]
- Alerting boundary [speedup]
3. Control aspects for forest operations

3.1. Produced quantities over time

![Graph showing produced quantities over time with annotations for alerting boundaries and predicted delay.]

- 50% time overlap for Operation 1 and 2
- Automatically adjusted, endpoint for operation 2 after alert level in point A was triggered and confirmed

- Predicted Delay
4. Conclusions

4.1. The CAN bus offers valuable information for describing the engine / machine status, thus production.

4.2. In particular, by merging and enriching, the CAN bus data by further information elements, a detailed, automatic description of production is possible.

4.3. By sending such production data instantly to a database server, a space independent life monitoring of forest operations is possible.

4.1. Even an automatic, time oriented process control is possible.
THANK YOU FOR YOUR ATTENTION!

QUESTIONS ?