National perspectives on big data from forest machines: Finland

Tapio Räsänen
Metsäteho Oy

NB-NORD workshop on Big data from forest machines

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Vision: Efficient Wood Supply 2025

“Efficient and precise wood supply improves the competitiveness of the forest industry and guarantees its growth and regeneration potential.”

Development goal 2025

Wood supply produces added value to the value chain while being 30% more cost-efficient than today.
Focus areas of R&D 2018 - 2025

Forest data ecosystems and decision support tools
Management of sustainability
Work safety, well-being and working skills
Resource and energy efficiency
Transport systems
Efficiency of wood production

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Forest Big Data vision – more precise and cost-effective wood supply through improved data and advanced decision support systems

Web-based wood market, Decision Support Systems

Planning & control of wood flow, DSS

Reference data & updating


Topography, terrain wetness index, soil type, rainfall, road conditions.
Use of forest machine data expands

- Non-touching wood measurement
- Dynamic control of bucking and stem banks
- Wood quality data repositories and quality models
- Guiding tools for machine operators
  - automatic bucking
  - control of harvesting head
  - robot control
- Applications to operational planning of harvesting
  - optimization of forwarding
  - planning of strip road network
- Management of logging company and operations
- Remote control of machines
- Training of operators (simulators)
- Feedback of soil trafficability classification
- Wood measurement
  - commercial measurement
  - control of measurement
- Follow-up of work productivity
  - machines and operators
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  - machines and operators
- Wood measurement
  - commercial measurement
  - control of measurement
- Reference data for forest inventory systems (e.g., remote sensing)
- Service for measurement and work quality monitoring and feedback
- Measurement of internal wood quality properties
- Tree maps
- Production of condition data (trafficability, weather data etc.)
- Automatic self-control of logging quality
- Update of forest resource information
- Non-touching wood measurement
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Recommendation for common forest machine data use principles (1)

• A joint recommendation for common forest machine data use principles has been prepared and published in Finland in 2017

• The purpose of the recommendation is
  – to clarify the rules of ownership and use of data
  – to promote the construction of applications and services based on forest machine information for the purposes of sector parties.

• Use of forest machine information most often calls for agreements between the owner and the user of the information, agreeing in detail on the production and use of data.

• The recommendation has been drawn up taking into account the requirements of competition legislation, and the purpose is not to harmonise agreement practices.

• Along with data ownership and use rights it takes into account the new requirements of the EU data protection regulation (GDPR).
  – separate training material of GDPR has been prepared and published 05/2018
Recommendation for common forest machine data use principles (2)

• Forest machine data ownerships and use rights
  A. Full ownership of data
     - shared ownership is possible only in some cases
  B. Free right to use the data, but no right to deliver it to third parties
  C. Restricted right to use the data for specified purposes
     - may require removal of part of the data, anonymization or processing of the data into a new format

• Data ownerships and use rights are specified by
  - type of data
    - StanForD 2010 file type groups
    - unstandardized / machine-specific files
    - potential new data types
  - machine type
    - harvesters
    - forwarders
    - machines for silvicultural operations
  - parties involved
    - business parties: service buyers (forest companies and others) and service providers (logging companies, contractors)
    - machine manufacturers
    - third parties: IT providers, Finnish Forest Centre, research organizations, forestry schools etc.
Some examples of R&D projects
Advanced and dynamic bucking
- is developed in ValueForce service by Trimble Forestry

Forest company IT system

Harvester production data (stem banks)

Classification of production data → harvesting object types

Measurement and x-ray data of logs from the sawmills → wood quality databases

Simulation of cross cutting

Dynamic control of cross cutting

Calculation of simulation tree sets

Management of cross cutting instructions (pin files with cutting parameters etc.)

Analyses and reports of simulation results

Comparison of cross cutting alternatives

Forest resource data
- grid-based stand and tree stock attributes
- estimates of single trees

Planning of harvesting operations and wood deliveries
- harvesting objects
- orders
- delivery destinations
- storages
- resources

Forest company IT system hpr
Method to Generate Stand Delineation Based on Harvester Locations

Data collection by harvester and pre-processing of stm / hpr-files

Importing data to GIS - software and performing coordinate transformations

Separation of strip roads, which lead to the stand.

Creating basic patterns based on Delanay triangulation and buffering

Creating final stands delineations and calculating the area of the stand.

Timo Melkas & Kirsi Riekki, Metsäteho 2017
Harvester data as reference data in forest inventories

• Utilization of tree data measured by the harvesters in the forest inventory systems based on laser scanning and satellite images has been developed and studied in the project
  – Arbonaut Oy
  – VTT (Technical Research Centre of Finland)

• Aim is to make the forest resource inventories more cost-efficient and to improve their quality

• Harvester sample plots could be used
  – to complete regular field measurements
  – to add varied wood quality parameters in the reference data

• Results have shown so far that
  – use of the harvester sample plots improves the estimates of all stock attributes slightly at least with the main tree species
  – however, location accuracy of the plots is critical

Source: Hakkuukoneen paikannetulla hakkualaitteella kerätyn puutiedon hyödyntäminen lentolaserkeilaukseen perustuvan puustotulkitun aputietona. Atte Saukkola, Pro gradu thesis, University of Helsinki
Harvester tree maps

Goals
• Tool for the harvester operator to follow thinning density
  – partly automated selection of trees
  – semi-automated boom movements
  – control and report of thinning density
• To produce a map of remaining trees after the thinning
  – to be used in GIS systems

Technology
• Laser scanners or digital camera
  + GNSS + measuring system

Challenges
• Precise location of the trees
• Detection of trees
• Image processing time
• Costs vs. benefits

Source: EffFibre-project (Timo Melkas / Metsäteho, Mikko Miettinen / Argone Oy and Ponsse Oyj)
Goals
• Improvement in diameter and length measurement accuracy
• Automatic calibration of the measuring system
• Utilization of image data in automated bucking
  ‒ models for predicting internal wood quality attributes (branches)

Challenges
• Camera concept and mounting to the machine
  ‒ inside or outside the harvester head?
  ‒ varying and uneven lightning
  ‒ disturbing materials: bark pieces, dust, snow ...
  ‒ mechanical strain
• Image processing time and complexity
• Costs

New method has been developed and studied in Aalto University (Jakke Kulovesi and Arto Visala)
• Calibrated stereo cameras
  ‒ 3D measuring
• Modeling and estimation of cylinder surface
• Bayesian method: combination of observed and model data
• Good results with pine and birch, spruce seems to be more difficult

Source: Heikki Hyyti, Aalto University
Source: MetrixPro project

Non-touching harvester measurement
Harvester CAN-bus data for site trafficability mapping

• Harvester motion resistance can be measured using the data in harvester CAN-bus aiming at site trafficability map for the forwarder, which follows the harvester and is heavier, for route planning:
  – At steady speed on level ground engine power via transmission is expended on overcoming motion resistance
  – Motion resistance is mainly dependent on wheel sinkage
  – Wheel sinkage is dependent on soil strength vs. loading

• Expended power monitored from CAN-bus
  – Pressure and flow of transmission hydraulics or transmission power deduced from engine power
  – Power losses in mechanical transmission components must be estimated
  – True ground speed needed for power to force calculus
  – Further corrections:
    • Acceleration
    • Inclination
  – Dimensionless output:
    \[
    \text{coefficient of motion resistance} = \frac{\text{motion resistance}}{\text{vehicle weight}}
    \]

• CAN-bus mapping benefits:
  – Assessing trafficability by measuring
  – Comprehensive and continuous assessing
  – Low-cost of assessment

Source: Jari Ala-Iломäki, Luke, Efforte project
Vision for operational harvesting planning tools
- focus in soil trafficability, risk of terrain damages and productivity of forwarding

Pixel-based stock data

Static soil trafficability classification

Strip road network planning service

CAN-bus data
Production data (.hpr)
Tracking data

Forwarding optimization and guidance tools

Models of soil bearing capacity and soil damage risk & route optimization models

Topography, soil types, ditches, roads, borders

Dynamic and adaptive soil moisture index (based on weather attributes), soil frost, snow, ...

Key biotopes, waterside buffers, protection and sensitive areas, ...

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Towards automatic work quality measurement in harvesting

**Thinning intensity**
- Laser

**Strip road density**
- GNSS tracking

**Rut depth**
- Time-of-flight imaging or laser

**Tree damages**
- Camera

Picture: Lari Melander, Technical University of Tampere

Picture: Jyry Eronen, University of Eastern Finland

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Aim is to develop new methods to self control of logging quality
• Camera and laser scanning technology combined with CAN bus data of forest machines and production data
• Systems to detect automatically damages to terrain and standing trees caused by harvesters and forwarders
  • depth of tracks
  • stem bark injuries and damages to roots

Vision: real-time application on cloud services, which
• receives the image
• detects and identifies damages
• calculates total amount of damages
• creates a report
"Contractor’s Data Bank"
A service provided by Trimble Forestry in collaboration with Trade Association of Finnish Forestry and Earthmoving Contractors

Mom- and drf-files from forest machines → cloud service

Reports for the contractor through a web-based application
- key figures about productivity and profitability
- machines and operators
- comparative figures to other logging companies in the service on average
Next generation’s Forest Data Ecosystem

What has been done and what is still needed?

Application development

Utilization concepts (POC)

Data management and analysing (methods)

Data transfer and fusion (methods)

Data acquisition and modelling (methods)

Legislation and rules

Vision and targets

LogForce, WoodForce, ValueForce, Kuutio.fi, Forest Hub, site trafficability maps, ...

KAOS, site trafficability, “Ajourakone”, dynamic forest planning

Harvester data and wood quality data warehouses, forest road data platform (pilots)

StanForD, papiNet, Forest Data Standard, SMK-data interfaces, Forest Data Platform, Forest JSON

stem distribution and wood quality, forest resource updating, operational conditions (soil and roads), work quality

Forest Information Act, recommendations for forest machine and timber truck data

Forest Big Data, Metsätieto 2020

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