Assisted thinning operations using Artificial Intelligence and Augmented Reality

García-Pascual, Borja

Prof. Kärhä, K. & Acuna, M.

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NATURAL RESOURCES
INSTITUTE FINLAND

UNIVERSITY OF
EASTERN FINLAND

borja.garciapascual@luke.fi

borja.garcia.pascual@uef.fi

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1. Introduction

- Tendency to overcut:
  - Operators can't know how many trees remain
- Operators can't see broken treetops
- They consider many factors during long periods of time
- **Harvesting is mentally taxing**

Source: Kelli Martinelli (2016).

1. Introduction

- Tree marking improves productivity:
  - Bigger impact on novel workers
  - Levels novel and experienced
- Tree marking improves thinning quality
  - Less overcutting
- **Huge cost of tree marking**

Source: Olga Anourina (n.d.).

1. Introduction

- New technologies can replace marking:
    - Remote Sensing (RS)
    - Artificial Intelligence (AI)
    - Augmented Reality (AR)
- Huge interest:
    - UNITE & Sintetic, IlmoStar…
    - Ponsse, Metsähallitus..

2. Objectives

1

Describe and lo[...] each tree in the forest automatically

2

[...] selection

3

[...] productivity of assisted harvesting operations

4

[...]ssess stress levels of workers during assisted harvesting operation

Make harvesting operations better, faster, and safer

3. Materials and methods

Trial design

- Three types of plots:
    1. No assistance for the operator
    2. Trees selected by forester and marked
    3. Trees selected by algorithm and marked
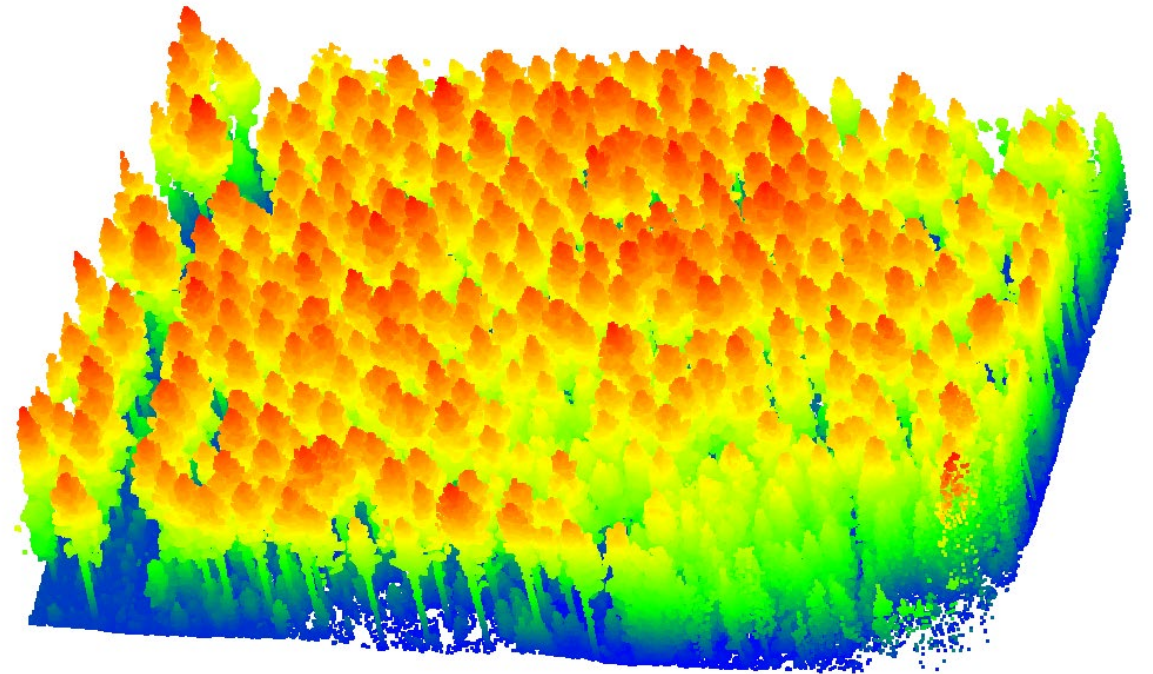
- Homogeneous Finnish forest conditions

Source: Deschutes Collaborative Forest Project (2015).
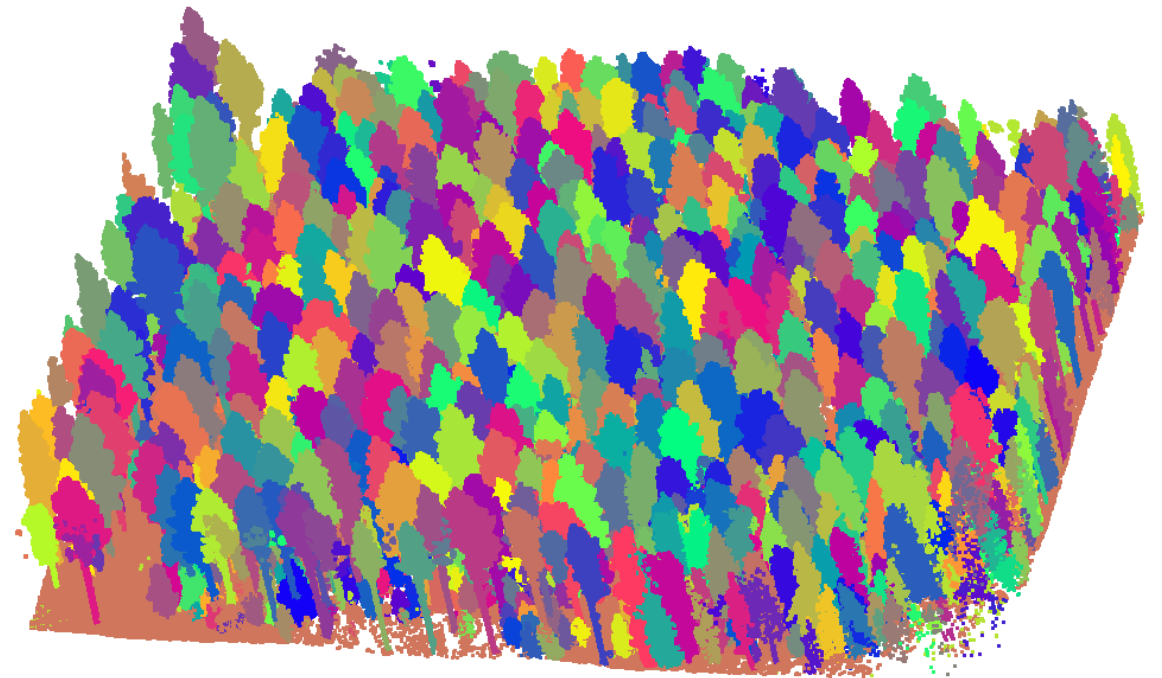
3. Materials and methods

Trial design

- Plots of approx. 20x100m

- LiDAR and RGB scan of the forest before harvest (MLS and ALS)

- Measure trees manually:
    - DBH, height, tree species…

- Detect and select trees automatically

3. Materials and methods
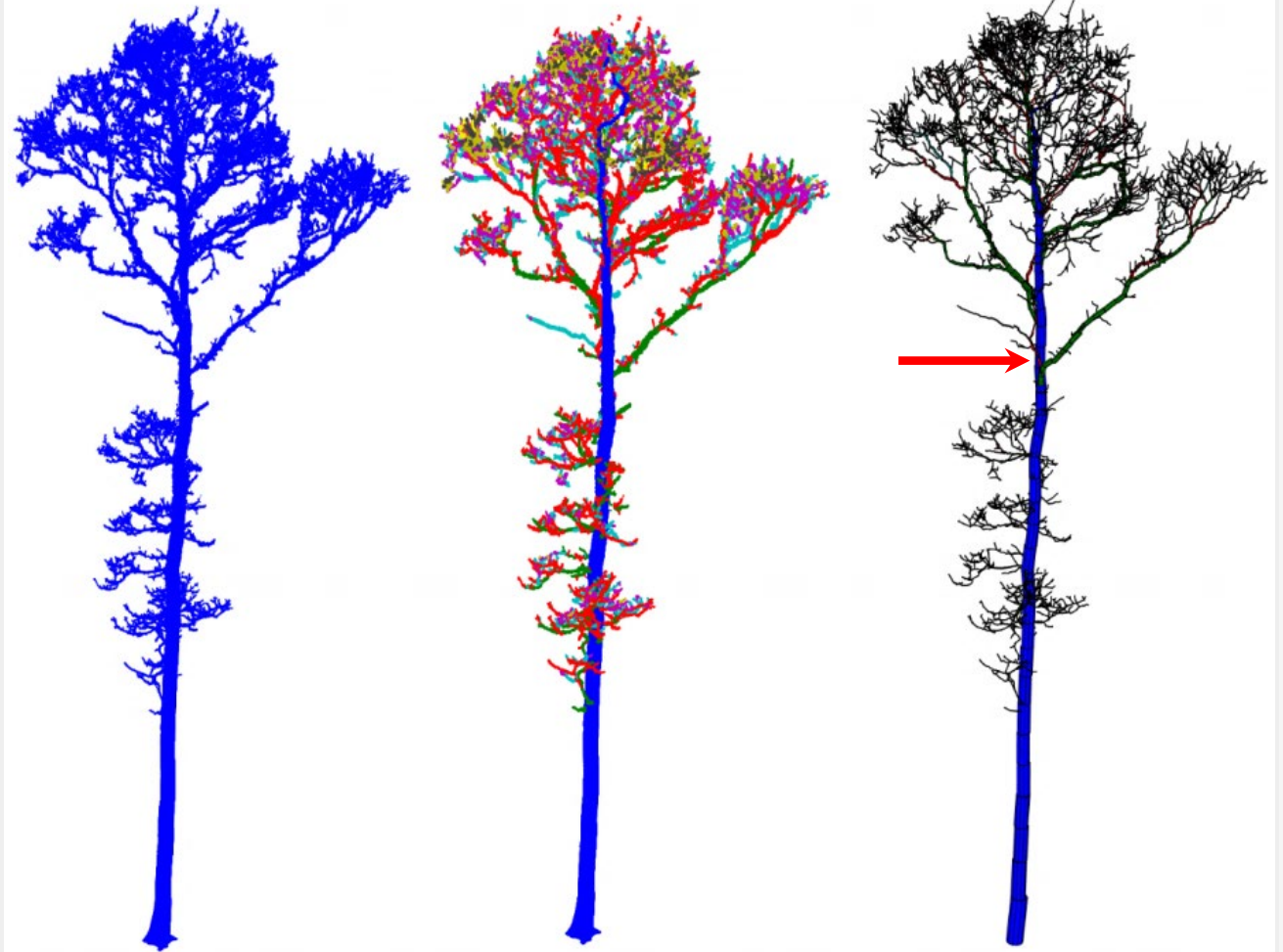
Tree detection

- Detect trees from dense LiDAR point cloud
  - SegmentAnyTree
  - 3DForest
  - TLS2Trees
  - ...
- Correct misclassified blobs of data
- Database of geolocated trees

3. Materials and methods

Tree description

- QSM models → Branch height
- Best fit circle
  - At breast heigh → DBH
  - At different heights → Volume
  - → Curvature

Source: Tampere Inverse problems group (n.d.).

3. Materials and methods

Tree description

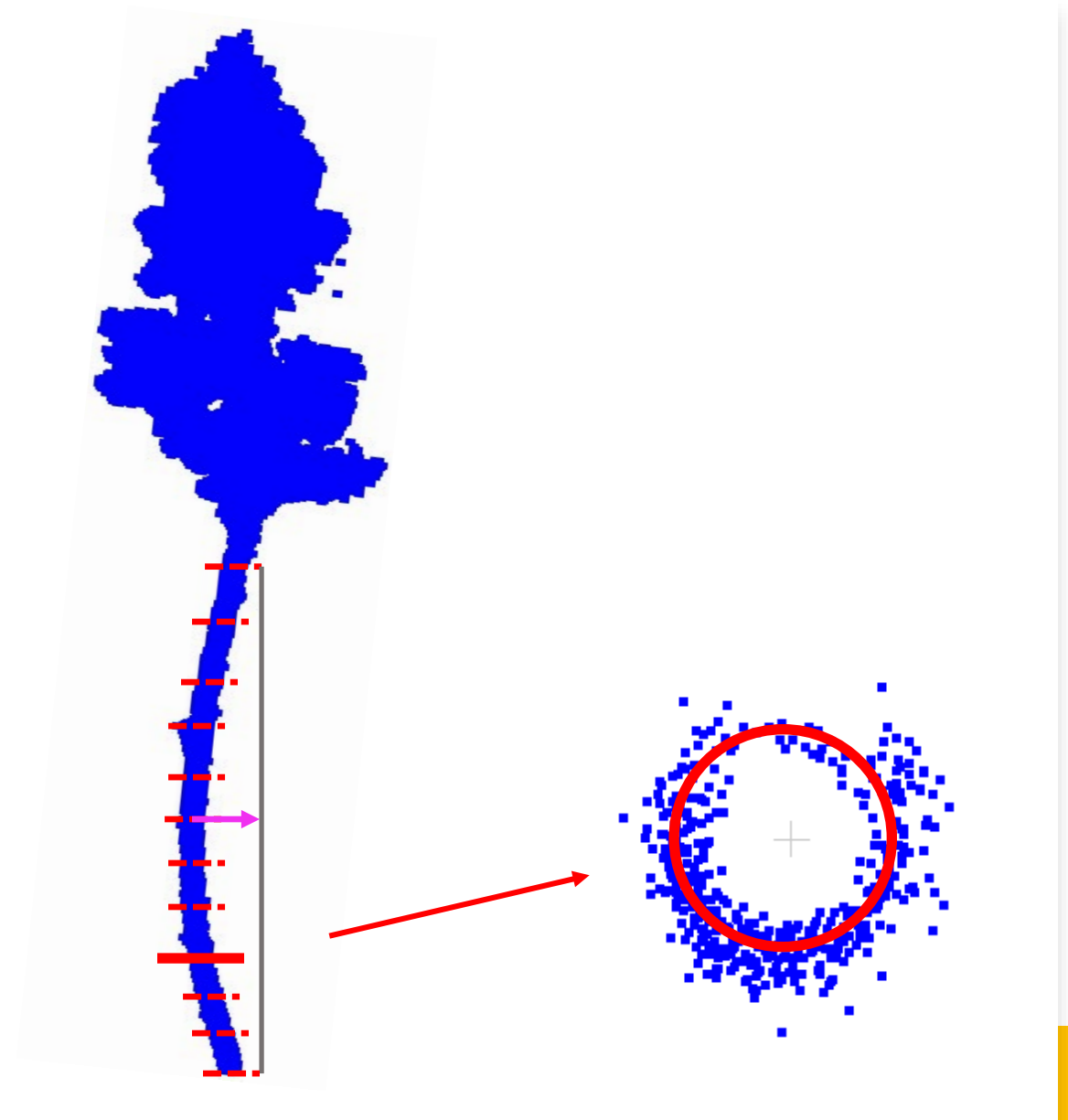- QSM models ⟶ Branch height

- Best fit circle

  - At breast heigh ⟶ DBH

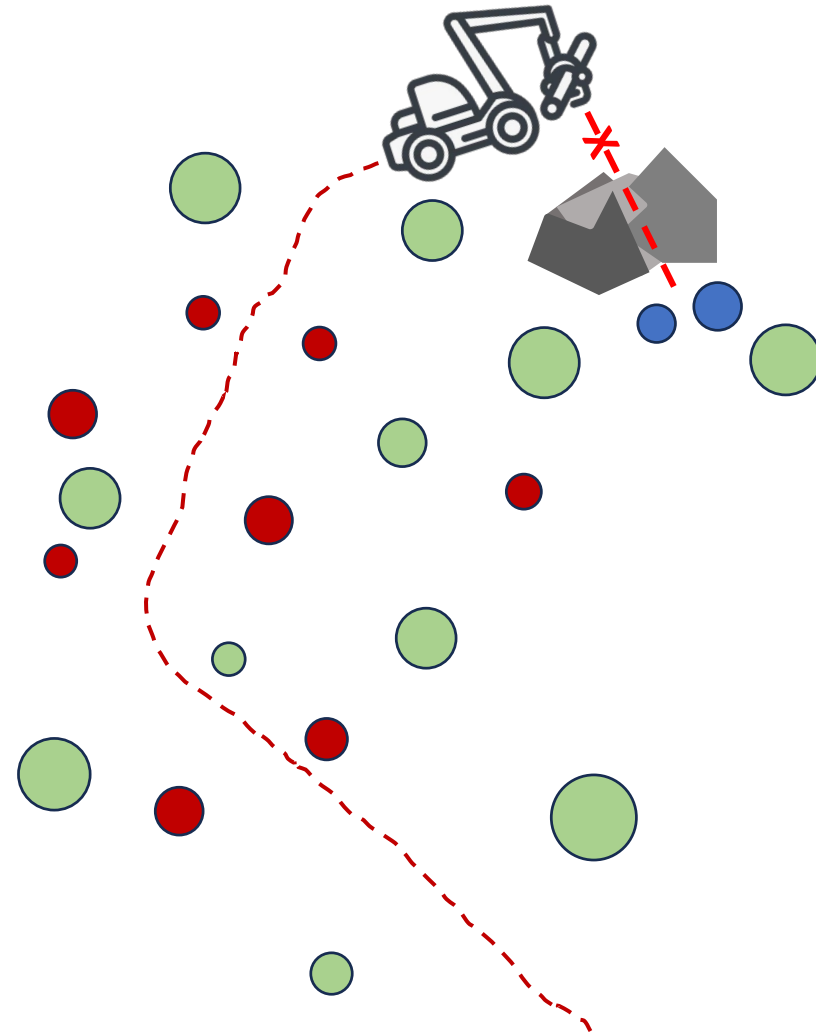 - At different heights ⟶ Volume
  - ⟶ Curvature

3. Materials and methods

Tree selection

- Optimization algorithm that accounts for:
  - Tree characteristics
  - Desired tree density
  - Ecological parameters
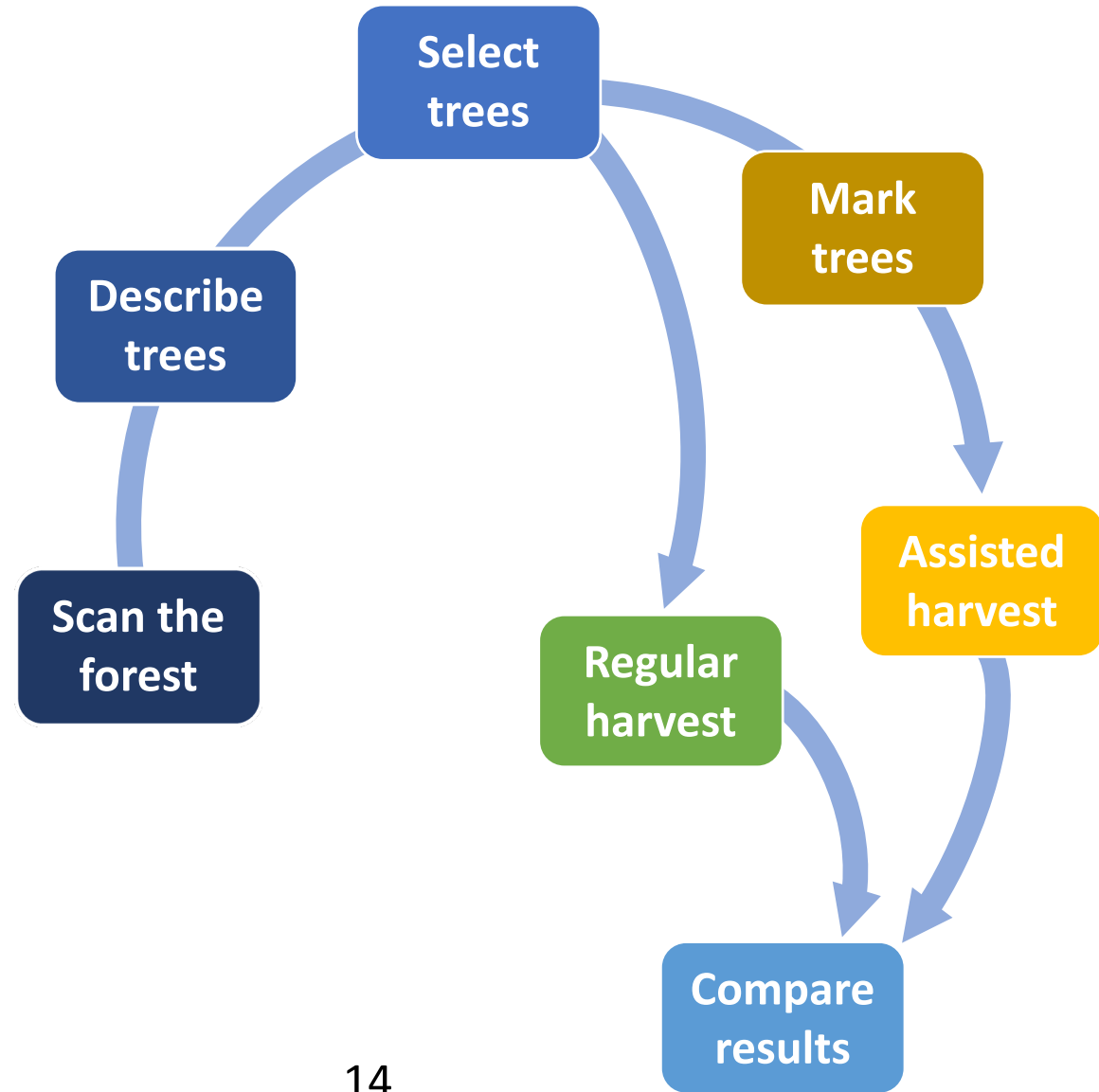 - Harvester accessibility

3. Materials and methods

Eye tracking

- Track eye movement of workers during harvest

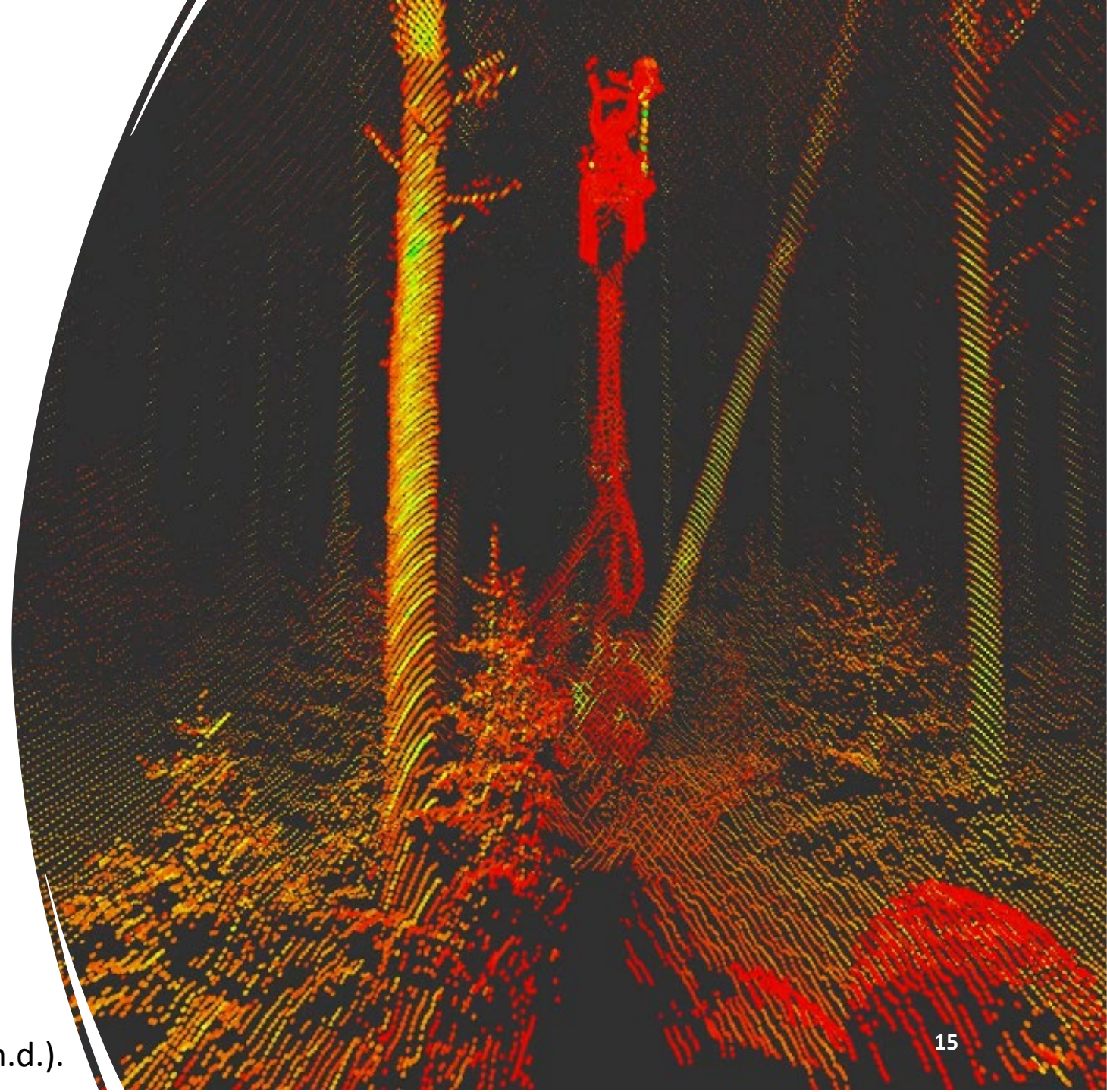- Estimate stress levels and tiredness

- Compare between plots

3. Experimental design

Select trees

Mark trees

Describe trees

Assisted harvest

Scan the forest

Regular harvest

Compare results

4. What's next?

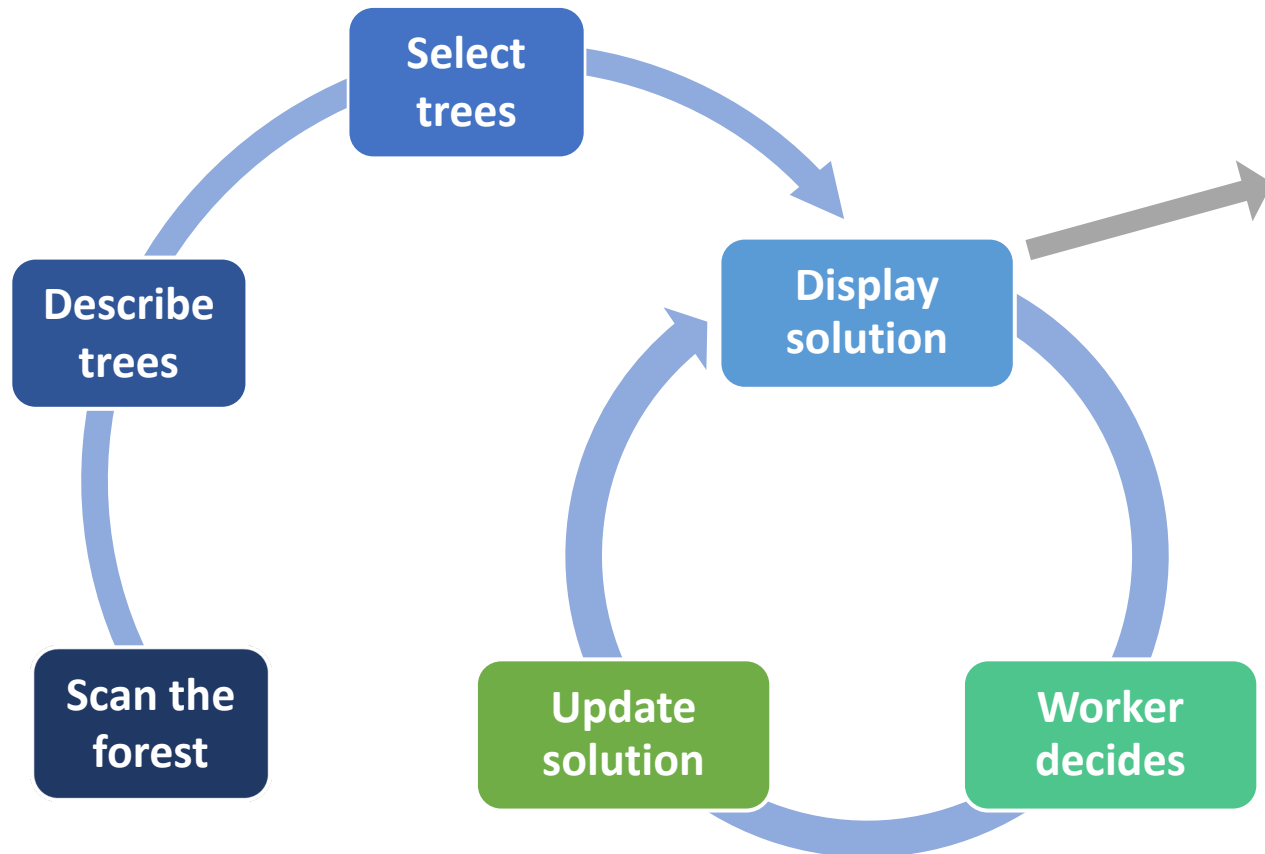## Tree matching

- LiDAR on top of harvester

- Locate machine using SLAM

- Detect trees in real time

- Match them with database of trees

Source: Finnish Geospatial Research Institute (n.d.).

4. What's next?

AR & human in the loop

Select trees

Describe trees

Scan the forest

Display solution

Update solution

Worker decides

DBH: 22 cm
Height: 16 m

DBH: 26 cm
Height: 18 m

DBH: 15 cm
Height: 12 m

Source: modified from John Deere (n.d.).

5. Conclusion

- Move to closed-loop machine-human systems

  - More productive

  - More ergonomic

  - More sustainable

- Decreasing price of Remote Sensing

- Robotics advancing fast

Will robots scan the forest?

Source: Kalle Kärhä (n.d.).

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