KU LEUVEN

Deep learning-based mapping of tree density and species diversity in Flemish forests

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Scope and goals

GEO.INFORMED

Remote sensing and deep learning for environmental policy support

- Goal
  - Develop remote sensing product to determine tree density
- Why?
  - Scale up the current ground-based field sampling method, both in temporal and spatial manner
  - Ground-based: only every 10y
- How?
  - Using freely available remote sensing data (aerial images, satellite)
  - Using computer vision/AI-based methods

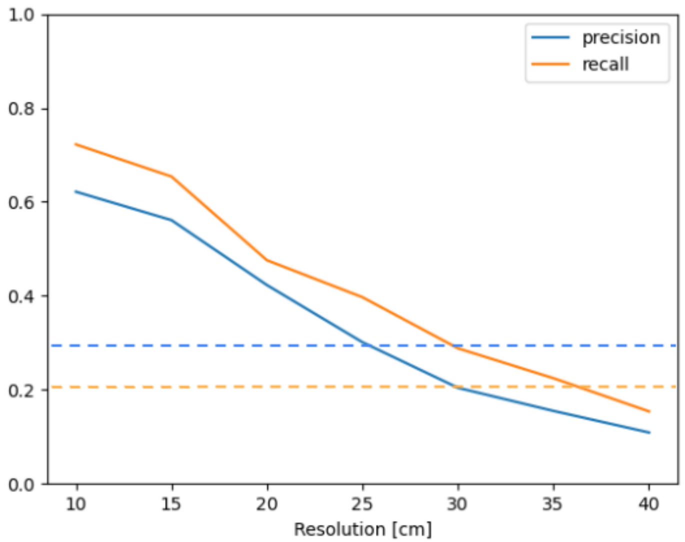
Materials and methods: high resolution imagery

- Freely available remote sensed data: ~~satellite~~ or aerial imagery?

  - Individual tree count (or density) drives the need for high resolution input data
  - Georeferenced imagery from geopunt of the whole Flanders is available
    - @ 25cm and 40cm resolution

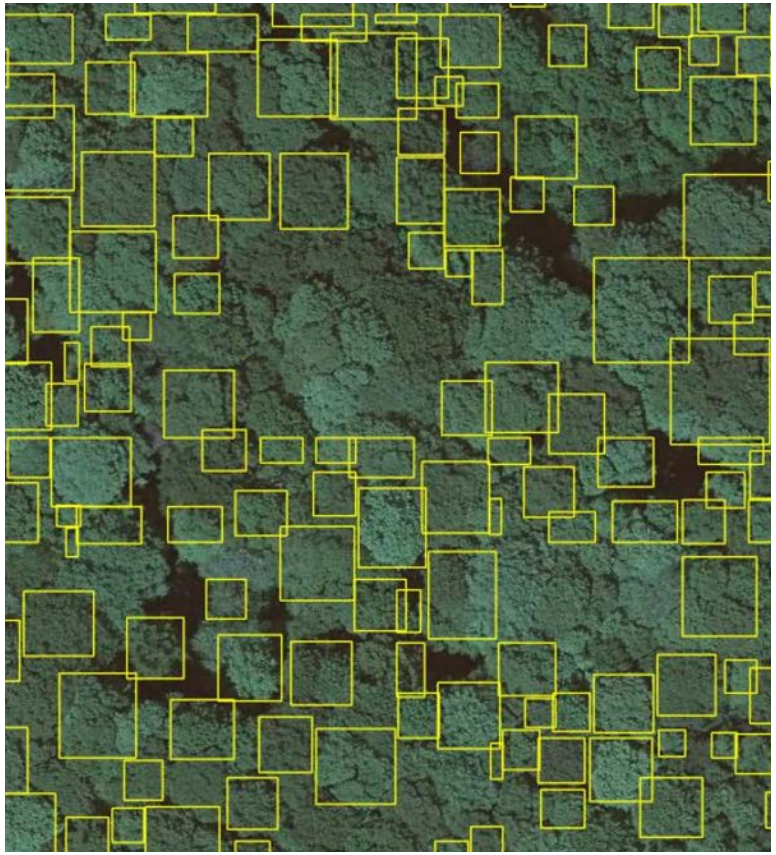
Materials and methods: state of the art

- Weinstein et. al: DeepForest python package[1]
  - Object detection (RetinaNet)
  - Trained on USA UAV data (10cm resolution)
    → **Not scale invariant** to our data of 25cm res.



Deepforest (pretrained)

Benchmark (random)

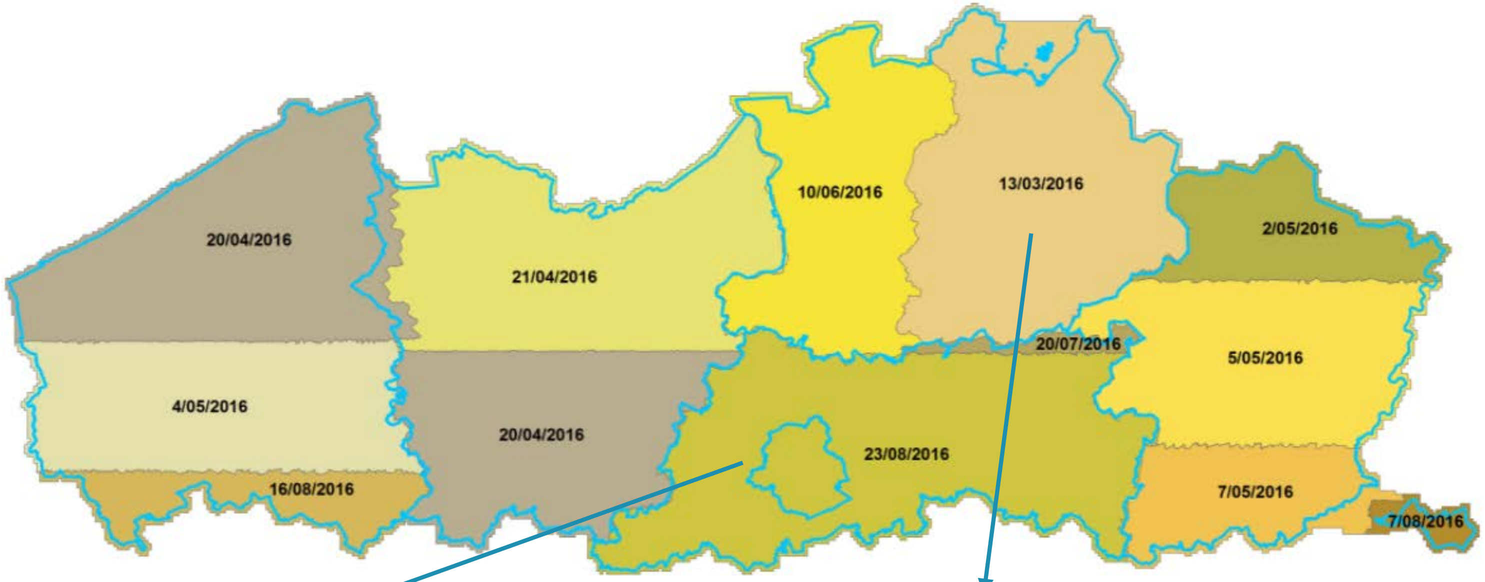


[1] Weinstein, B.G.; Marconi, S.; Bohlman, S.; Zare, A.; White, E. Individual Tree-Crown Detection in RGB Imagery Using Semi-Supervised Deep Learning Neural Networks. Remote Sens. 2019, 11, 1309

Challenges: data is heterogenous from a temporal perspective

- Flight missions can be spread over multiple months

  ➔ **phenology** could be very different
  ➔ we avoid data from feb-mar to reduce the data complexity

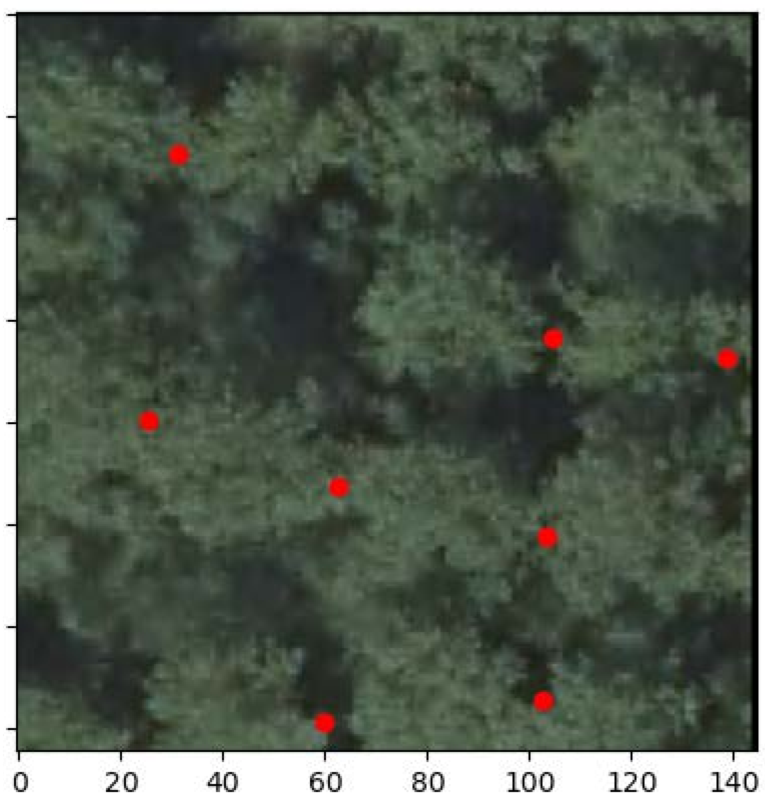


Challenges: data is heterogenous from a species and density perspective

- Broadleaf vs conifers
- Large vs small tree crowns
- Dense vs sparse forests

Data quality challenges with reference data (in situ)[2] vs aerial imagery

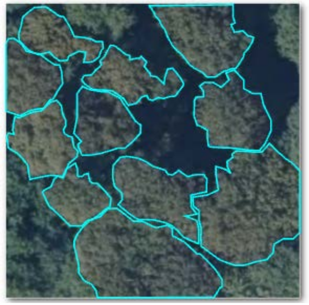
- No true orthophoto → **relief displacement** linear with height of trees (40cm/m-height)



[2] Flemish Forest Inventory (Agentschap Natuur en Bos), https://www.natuurenbos.be/beleid-wetgeving/natuurbeheer/bosinventaris/wat-de-bosinventaris

What is the computer vision task to solve?

Localization and count are difficult, since we do not teach the network what a tree is



count ← **localization (centroids)** ⇄ **object detection (bouding boxes)** ⇄ **segmentation (crown delineation)**

localization (centroids):
- In situ measured
- Hand annotated

object detection (bouding boxes):
- Derived from centroids
- Hand annotated

segmentation (crown delineation):
- Hand annotated

Difficult: very “noisy” reference (see relief displacement)

Possible if in the future in situ measured centroids are of high quality(vs aerial image)

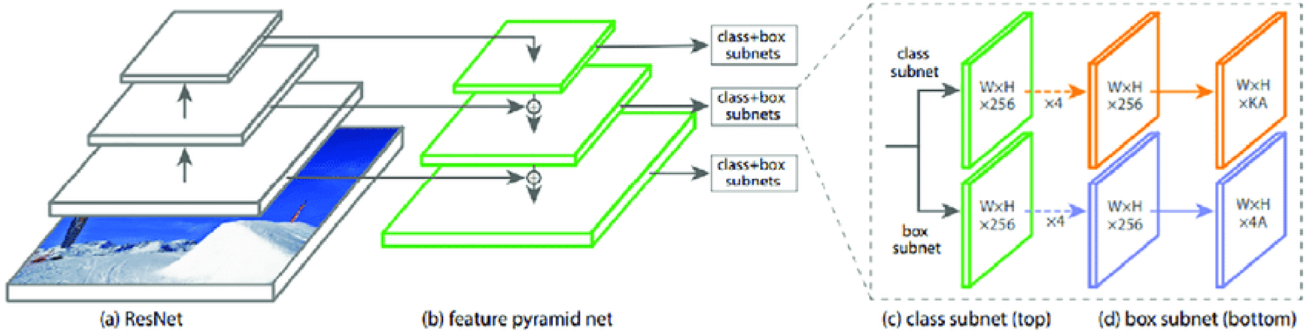
BUT: estimating tree diameter is extra noise factor

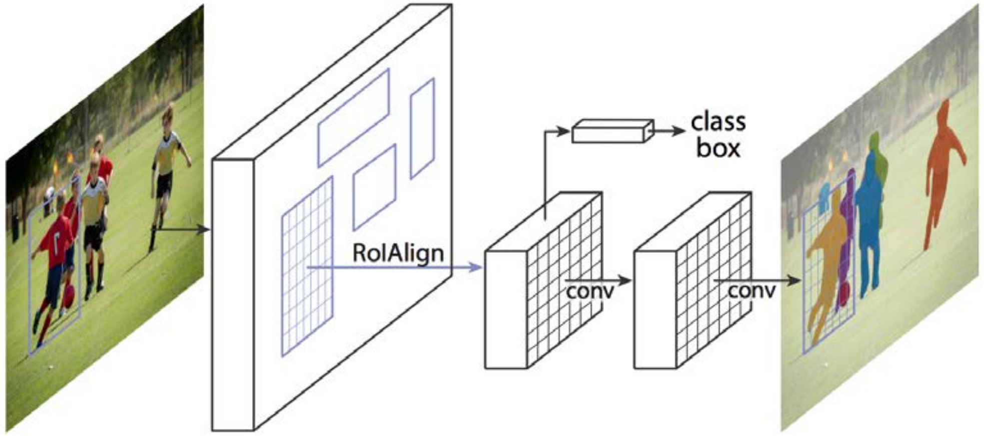
Hand annotating turns out also to be challenging

Non obvious zones to
hand annotate

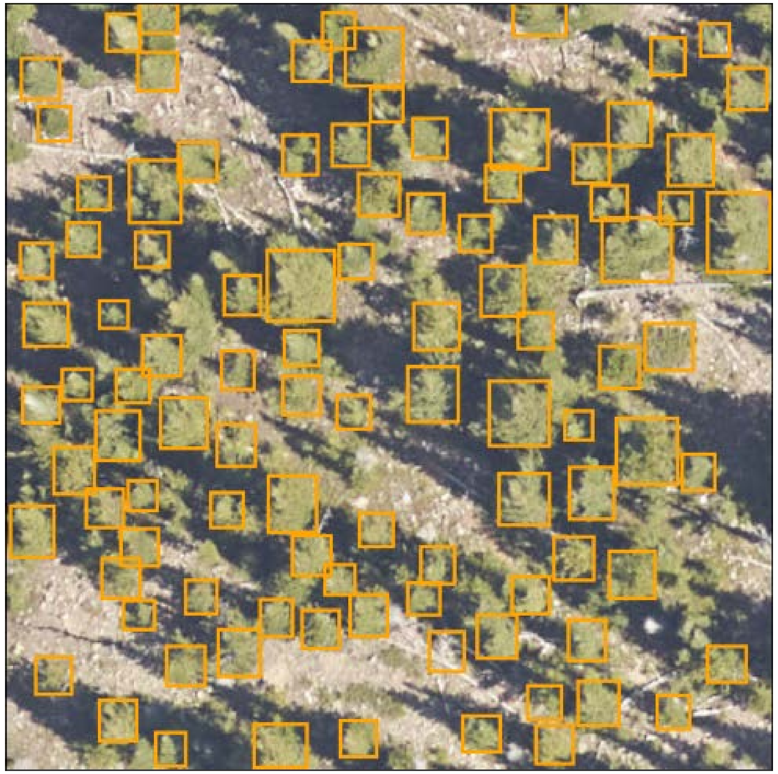
AI models for object detection and segmentation

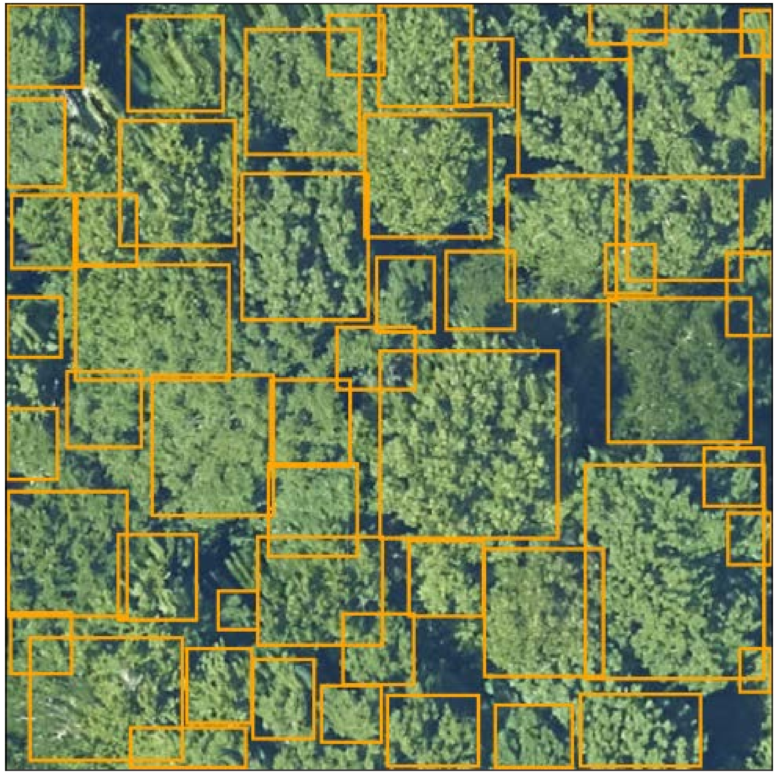
- RetinaNet
- Faster R-CNN
- Mask R-CNN





RetinaNet on USA data (trained on USA data)





RetinaNet on Flanders data (trained on USA data)