The future of hemp breeding: Artificial intelligence for detection of off-type and escape plants in seed production

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Industrial hemp R&D at InnoTech Alberta

Over 20 years of experience with hemp research

- "Gene to Final Product" research program involving industrial hemp for fibre, grain, cannabinoids
- Multidisciplinary research team (breeders, agronomists, plant pathologists, biochemists, engineers)
- A one-of-a-kind decortication facility serving clients since 2011
- Breeding a monoecious fibre type variety

Diecious vs. monoecious hemp varieties

In the natural state hemp is a dioecious plant

Dioecious variety at flowering

Dioecious variety at seed setting

Monoecious (hermaphrodite) variety at flowering

Monoecious varieties require maintenance breeding and selection to retain their status

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Hemp inspections: easy vs. not-so-easy

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Inspection of hemp seed production field is costly and time consuming

Logistically difficult

- Isolation distances 3 mi. means fields can be scattered on the landscape=more driving
  - Limits number of fields/day that can be inspected
- Monoecious varieties & feminized hemp require two inspections
  - Doubles the workload

Physically challenging

- A need for six counts of 10,000 plants for each inspected field
- Tall and very tall plants
- Typically, high stand density making inspections tough

Takes about 2.5 hours per field per inspection

- Plus, driving time, data entry, analysis, etc.

Accuracy

- Inspectors can only sample (do not take into consideration **ALL** plants)

How to make life of crop inspectors easier?

Versatile teams at InnoTech Alberta have experience in solving industry problems with the use of:

- **artificial intelligence**
- **machine learning**
- **vision recognition**

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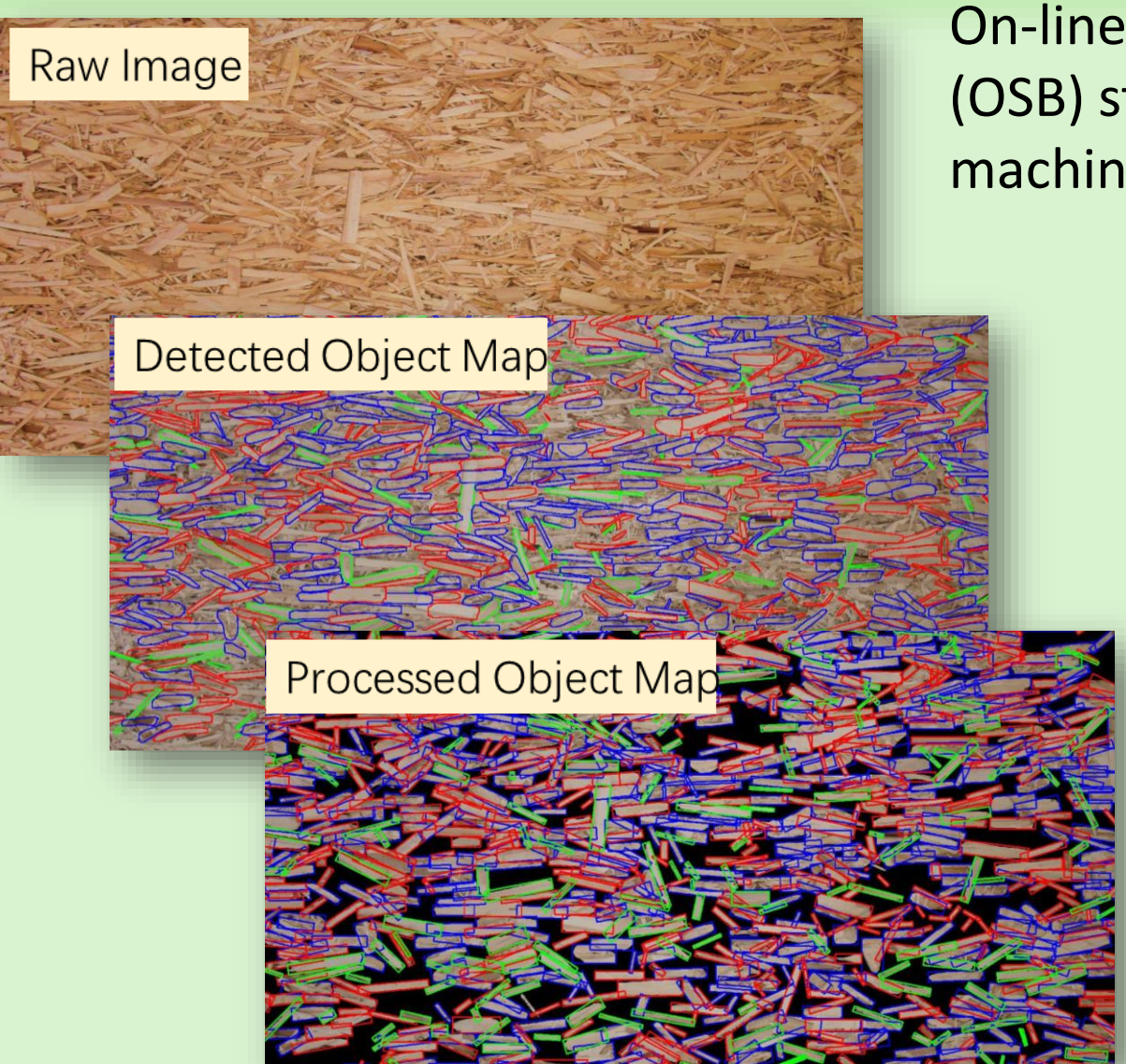
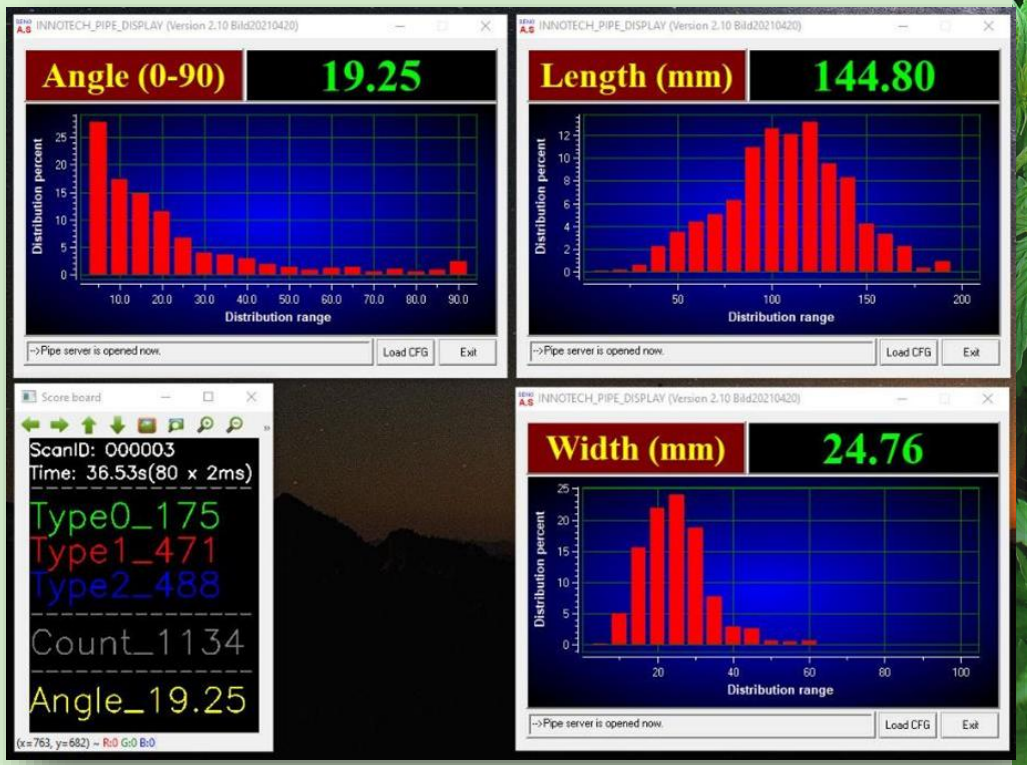
Machine vision capability – forest products



On-line measurement for oriented strand board (OSB) strand alignment and geometry using AI machine deep learning approach (Mask R-CNN)

Strand Orientation and Geometry Results



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Machine-vision application –
plant pathology projects

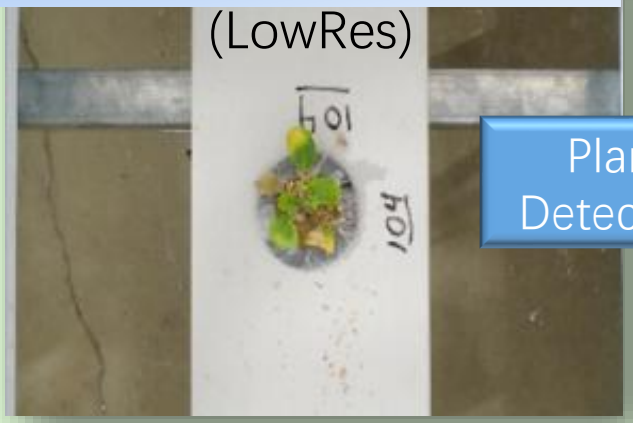
AI-based phenotyping of Verticillium stripe of canola

- Indoor camera gantry system for capturing disease development in inoculated canola plants
- Predicting resistance or susceptibility to Verticillium stripe disease
  - Models trained to emulate human ground truth data (human ratings) of know susceptible resistant control plants

Machine Vision Capability – from raw image to numerical score

Step 1
Plant
Detection

Plant Raw Image
(LowRes)



Plant
Detection

Plant Map (LowRes)

Plant Health
Data Retrieval

Plant Image (HiRes)

Step 2
Plant Health
Classification

AI Model Input HiRes
Image

AI Plant Health
Classification

AI Model Plant Health
Classification Results

plant type: 1; score: 0.99852425

best rating: 7; score: 0.9873115

weighted rating: 7.449561

-->rating 1 :7, score: 0.9873115

-->rating 2 :8, score: 0.8063694

Best rating: 7; Score: 0.98731

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Combining AI-powered vision recognition system with drones

- Drones (UAV):
  - DJI Mavic 3
  - DJI Matrice 210 V2 equipped with a DJI Zenmuse X5S camera

- Pilots:
  - Three licensed pilots

Transport Canada / Transports Canada

Pilot certificate

Small Remotely Piloted Aircraft System (RPAS), Visual line-of-sight (VLOS)

The individual indicated below may exercise their privileges to fly a drone subject to the rules and regulations listed below and set out under the Canadian Aviation Regulations (CAR).

Issued to:
Sharla M Eldridge
5821 52 Street
Vegreville, AB T9C 1J2

Date issued (YYYY-MM-DD):
2022-04-07

☑ Basic operations
☐ Advanced operations
☐ Flight reviewer rating

Certificate number:
PC2209702634

Transport Canada account number:
TC2209629788

What problems of hemp inspections would drone + AI solve?

- Less time at each site = more sites/day
  - Drive to field, deploy drone, drive to next field
  - Time per field: **3-5 minutes per acre**
  - Accuracy – **every plant** in the field is accounted for
- Record keeping and analysis automated
  - Collected imagery uploaded to secure server
    - Possible to do this from the field, depending on cell coverage
  - Custom algorithms generate plant counts, area measurements, etc. and populate a table, maps, graphics
  - Analysis takes minutes
    - If data uploaded to server from the field, this would allow time for additional flights if there are problems with the data or the field
  - Drone flight planning can be done in the office using available satellite imagery and can be saved to repeat surveys multiple times

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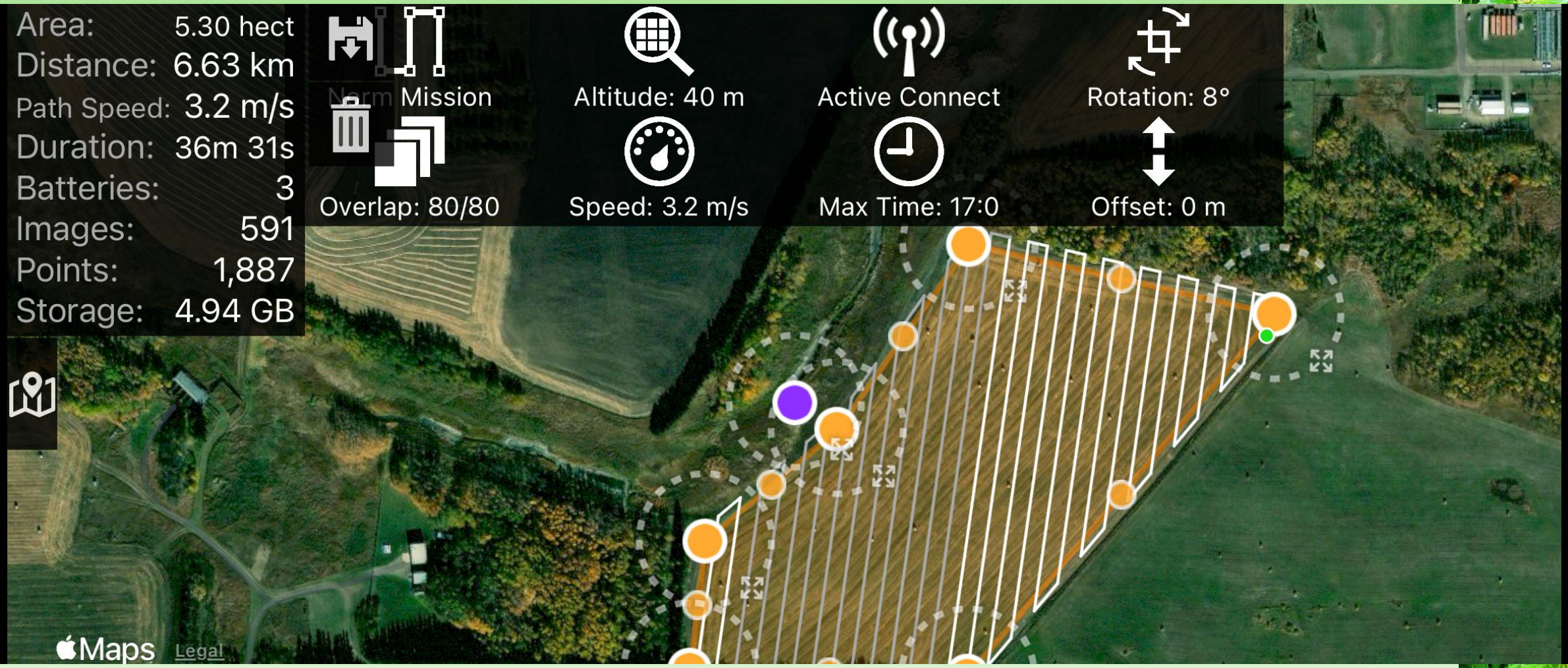
Drone survey flight planning



- Area: 13 acres
- Flight time: 36 mins & 31 sec

- Once drone flight is programmed it can be flown repeatedly without further planning

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July 8
July 13
July 21
Aug 4
Aug 10
Sep 2

Zoomed in on individual plots – Aug. 4 image

InnoTech plots were used for ground-truthing

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Some flight parameters in the 2024 growing season

- Flights occurred on July 13, 18, 23, and 31
- Flight altitude - 15 m (the lowest permitted by the flight planner software)
- The images were taken with 80% front and side overlap and included a 1.5 m margin around the trial area
- Ground Sample Distance (GSD) was approximately **0.34 cm/pixel**

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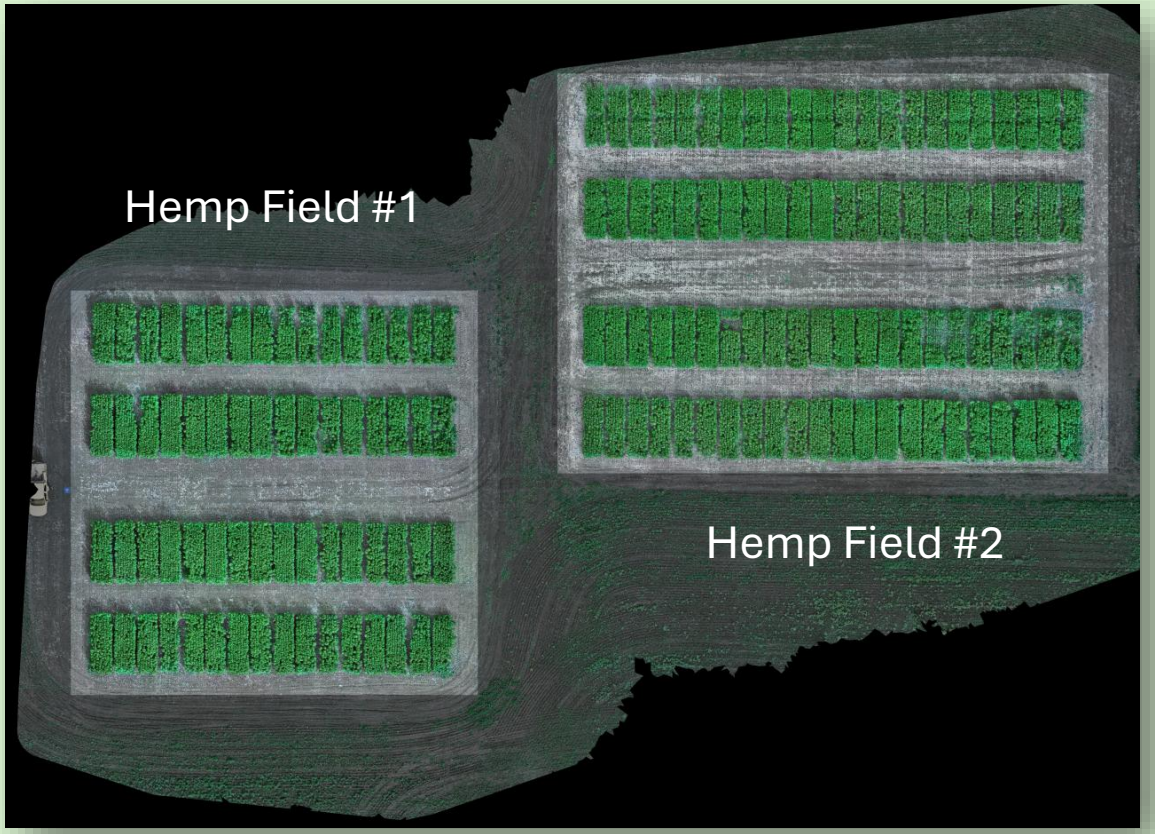
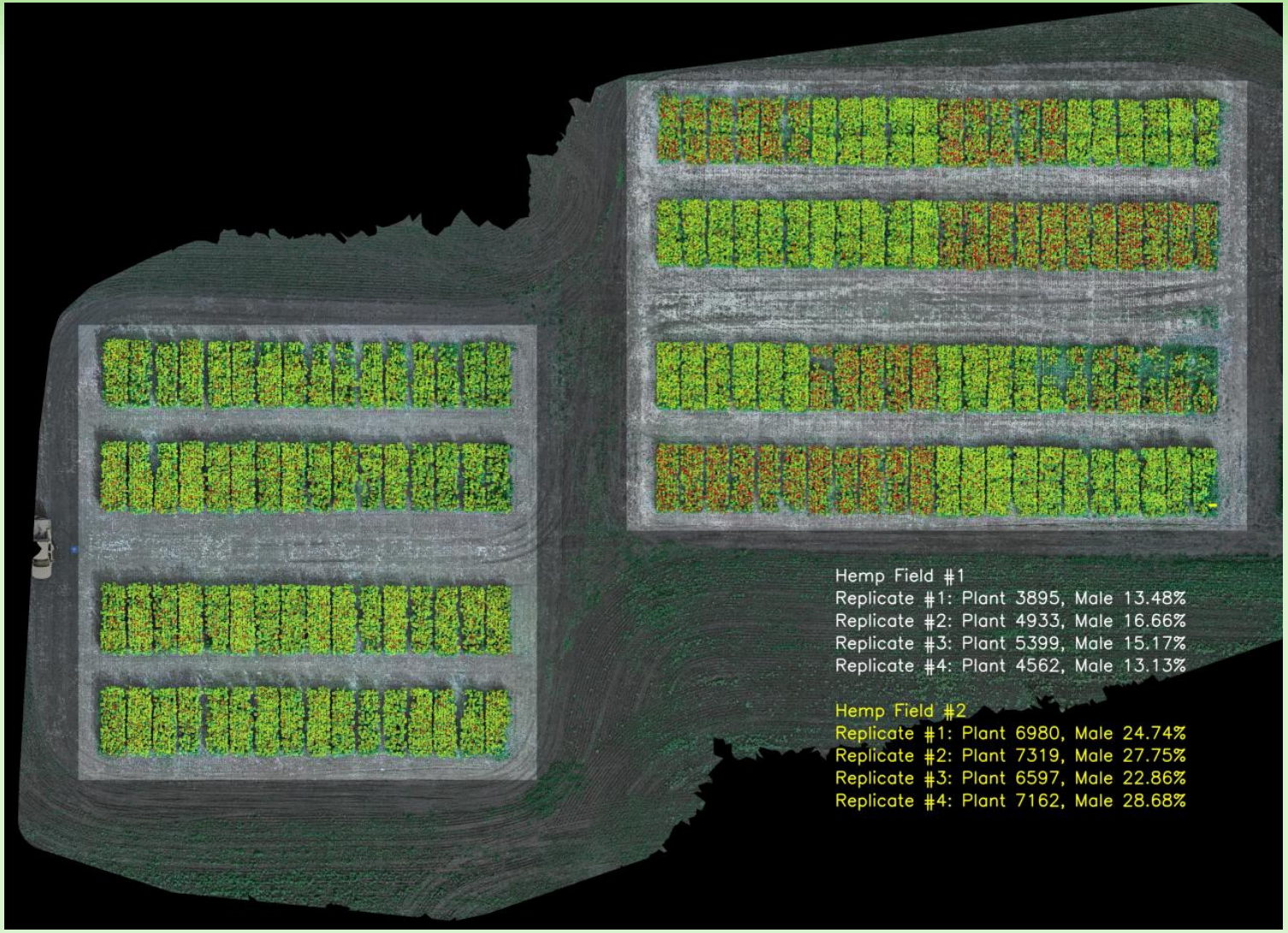
Progress made in 2025

- 12 flights during flowering
- Ground truthing (counting of male plants) was done after each flight
- Two monoecious (Silesia, Anka) and one dioecious (Katani) were involved
- Calibrated reflectance panel (CRP) was used to generate consistent data across the different flight timings
- DJI Mavic 3 Multispectral (3M) captured images from Red, Green, Blue, RedEdge, and NIR wavelengths



Ongoing work:
Plant count and classification



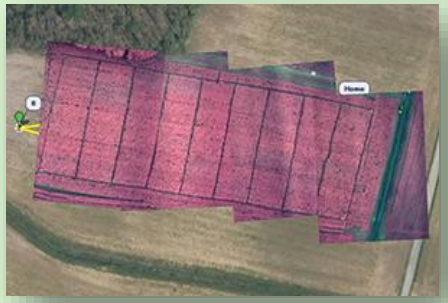
Development of an in-house smart hemp vision recognition system consisting of:

- a stitching module
- a machine learning model training module
- a user interface

Using an automated male detection system, in practice

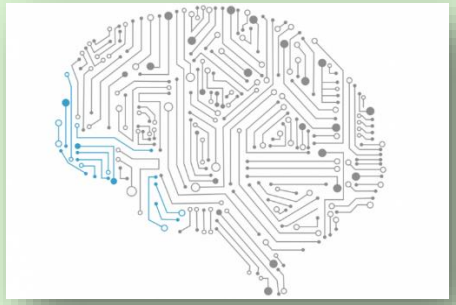
Image capture

- flights can be preplanned and automated
- flight paths are repeatable
- upload images to server



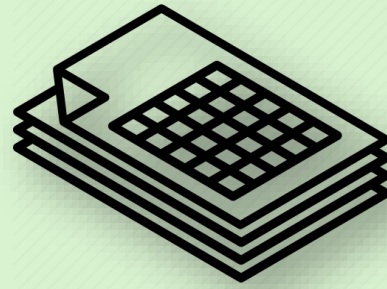
Automated pre-processing

- georectification
- trimming
- image correction
- mosaicking



Implement ♂ detection model

- runs on server
- no human interaction required



Analytics

- aggregate data in desired format
- deploy to user
- user downloads from server

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Applications for hemp regulatory compliance

- Since hemp is a **regulated crop**, involuntary seed dispersion of seeds by birds to the areas adjacent to hemp production fields poses severe **regulatory infringements**
- Our technology assists with identification (and subsequent removal) of **volunteer hemp plants** in the fields grown to different, non-regulated crops, which is in best interest of the landowners who can be confronted by law enforcement officers due to illegal activities (i.e. growing of non-licenced hemp or cannabis)

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How to confuse machine learning?

Blueberry cupcake vs. chihuahua ☺

https://blog.cloudsight.ai

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Food for thought

The only way to keep AI from taking your job is to...

use AI to do your job better

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