Introduction to the HTP course

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Schedule

Workflow **(3 credits)**		
Class	Date	Lectures (Wednesdays, from campus) 9:30 -12:30 am
1	Jan 24	Introduction to HTP; Radiation properties and remote sensing
2	Jan 31	Image properties and acquisition; Image matrix practice on R (HW 1)
3	Feb 7	Indices and tools (HW 2)
4	Feb 21	Metashape: orthomosaic, DEM, and cloud points; Shapefiles on R (HW 3)
5	Feb 28	Raster, index, counts, areas, and plant height on R (HW 4)
6	Mar 6	Envirotyping (theory) and Practice on R (HW 5)
7	Mar 20	Data mining and modeling (Theory)
8	April 3	Pre-processing images (theory and practice on R and VGG image annotator) (HW 6)
9	April 10	Data mining and modeling – Practice on R (HW 7)
10	April 24	Journal Club

Classes   Moodle
Scripts and data   https://github.com/rfn-qtl
Evaluation
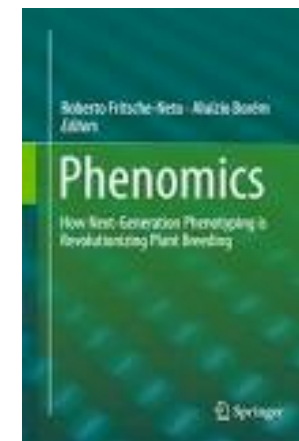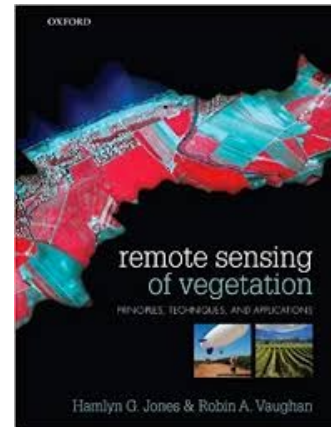**Homeworks**   Moodle
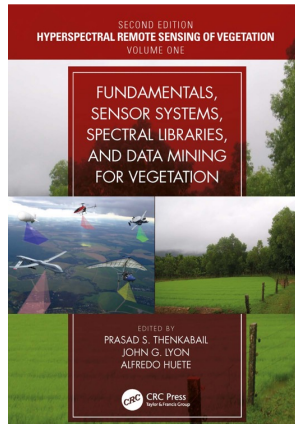**Journal Club**   4 papers in the end of the course

Main bibliography and material

- **Books**

- **Softwares**
- **QGIS -** https://www.qgis.org/en/site/
- **Metashape -** https://www.agisoft.com/
- **R -** https://cran.r-project.org/
- **Rstudio -** https://posit.co/download/rstudio-desktop/

- **See and install the packages one week in advance based on the script in the next slide**

R packages and material

- Create a folder on your PC and inside it download the materials

- Download the datasets a week before (26 Gb of data!!!):

- Also, install R (version 4.2.3), then, these packages running this code:

- install.packages("imager", "raster", "devtools", "magick", "foreach", "doParallel", "sp", "tidyr", "data.table", "rlas", "lidR", "spdep", "pak", "BiocManager", "devtools", "superheat", "caret", "caretEnsemble", "h2o", "Cairo", "reticulate", "keras", "tensorflow", "abind", "ggplot2", "terra", "sf")

- BiocManager::install("EBImage")

- pak::pkg_install("TiagoOlivoto/pliman")

- https://cran.r-project.org/src/contrib/Archive/rgdal/rgdal_1.6-7.tar.gz (install manually this package)

- devtools::install_github("andersst91/UAStools")

- devtools::install_github("rfn-qtl/SoilType")

- devtools::install_github('allogamous/EnvRtype', force=TRUE)

- Install Tensorflow via https://tensorflow.rstudio.com/install/

- For Mac users follow: https://medium.com/gft-engineering/macbook-m1-tensorflow-on-jupyter-notebooks-6171e1f48060

Plant breeding as a solution

- It is the genetic improvement of plants for human benefit
- Two sources of information - Genotype and Phenotype
- Connect genotype to phenotype - heritability
- Understand the underlying genetics of traits
- Improve the rate of genetic gain
- Develop cultivars more efficiently
- It necessitates very large sample (population) sizes
- Improve the probability of selecting favorable recombinants
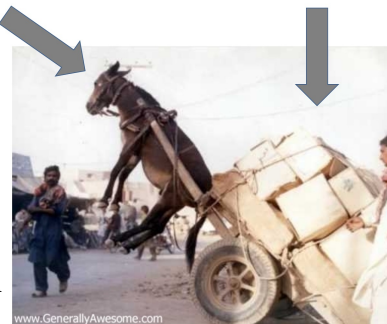- Challenge: collecting phenotypic data on large populations

Phenotyping vs. genotyping

$$y = Zm + \varepsilon$$

Past   **Present**

Past   **Present**

Phenotypic data   Genomic/genotypic data
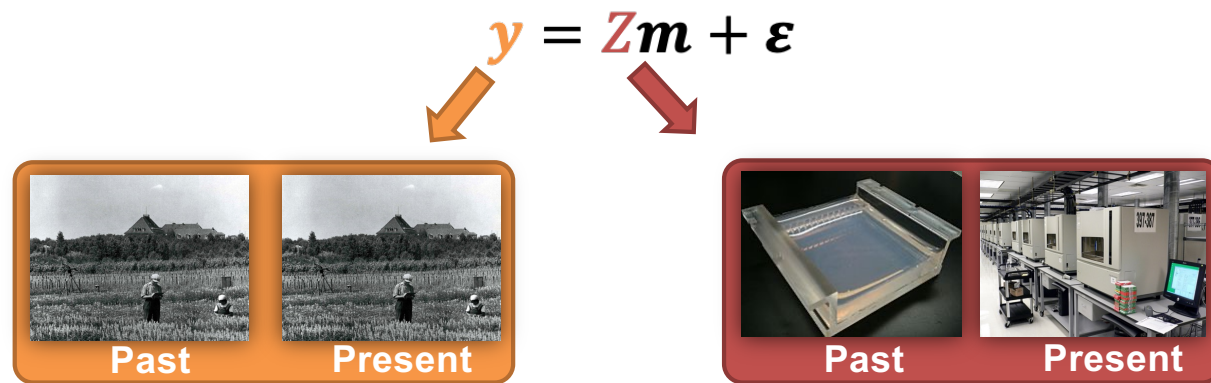
Phenomics (HTP)

Current challenges:

1. **Validation of methods**
2. **Optimization of information**

Plant Phenotyping

- **Classic**
- **Time intensive**
- **Limited amount of data collected**
- **Small population sizes - single time point data - Quality?**
- **Trait bias - visually scored**
- **Expensive?**

- **High-Throughput (HTP)**
- **Efficient**
- **Massive amount of data collected - Large population sizes**
- **Multiple time point data**
- **Latent traits – machine scored**
- **Lower cost?**

Bottleneck

- How do we increase VG, accuracy, and response to selection?
- How can we accurately evaluate thousands of genotypes?

- **Effect on Breeder's equation**

$$RS = \frac{i.r.Vg}{T}$$

- Reduce phenotyping costs

- **Challenges**: build the structure, algorithms, and pipelines

Applications

Corn Stand RGB

Machine	Manual
2.25 seconds per plot	5.75 seconds per plot
Requires 1 person	Requires 9 people

Machine Average	Manual Average
2%	5.6%
Range 0% - 5% on plot basis	Range 0% - 26% on plot basis

Source: Gore (2017)

Light Detection And Ranging (LIDAR) phenotyping of defoliated cotton plants
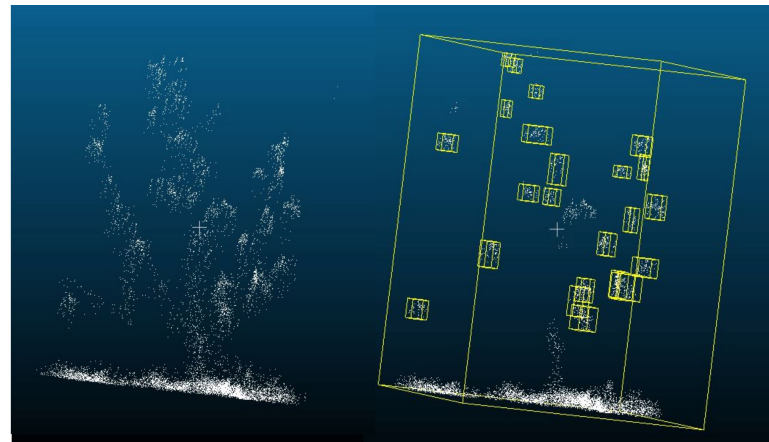
HTP is an interdisciplinary field

- **Computing languages**
- **Artificial intelligence**
- **Physiology**
- **Crop development**
- **Quantitative genetics**
- **Remote sensing**
- **Image and spectral wavebands**
- **GPS or GNSS**
- **http://thetruesize.com/**