

Seed phenotyping and digital seeds NPPN meeting Båstad, Nov. 24, 2022

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Videometer A/S

- Spectral imaging company
- Founded 1999
- Seed phenotyping is app. 60% of revenue
- Products
 - Lab instruments,
 - Turn-key in-line systems, and
 - R&D projects
- 750+ imaging R&D projects since 2000
- In-line 24/7 spectral imaging since 2002
- Based in Copenhagen, Denmark
- Partnerships worldwide







Spectral imaging



LED band-sequential spectral imaging





- LEDs: Stable, durable, large selection, rapidly developing technology
- Up to 20 different high-resolution bands acquired sequentially in 0.5-1.0 seconds
- May be combined with emission filters, backlight, and darkfield illuminant
- Combined reflectance spectral imaging and fluorescence spectral imaging possible!

Spectral Image





Accurate color

assessment and

pigment concentration



N images obtained at N wavelengths

Microbial and plant metabolites

Pigment baseline, moisture, fat, etc.

Spectral image is typically a large data structure of 100 MB to 10 GB



Pure samples 1 and 2 in sRGB



Durum

Common wheat



Pure samples 1 and 2 after nCDA



Primary features for single seeds and grains

Color of seed or any seed part

Spectral indices of seed or any seed part









Multispectral -

(64%)

CONTRACTOR AND A DESCRIPTION OF A DESCRI					
Blob 56	Shape of seed or any seed part				
	Texture of seed or any seed part				
	Size of seed or any seed part				
21 25	Relative size of any seed parts				
	Contour				
	Position and relative position				

Orientation and relative orientation

Secondary features for single seeds and grains







Physical purity class (crop, other crop, inert, weed)

Damage (mechanical, insect, mold)

Germination

Early emergence/priming/preharvest sprouting

Seed health (check for specific pathogens)

Seed treatment (coating, disinfection, pelleting)

Secondary attributes are based on a calibration model and a reference blob collection

Concept: Digital seed phenotyping/testing protocol Image Preparation, Model Format test Sampling Imaging feature presentation calculation report calculation Physical seed sample, Spectral Primary Secondary Test origin data features features image report **Reference data** generation: Virtual testing, **Features** Images outlier detection. Purity class **Reference features** sanity check Species/variety and classes Germination/vigor Seed health Models Other testing modalities Digital signature entities Seed database (digital seeds in cloud)





Example: how does it work on seeds

Seeds are aligned and ordered in database



Seeds sorted by area





Fines can be removed

Seeds sorted by chlorophyll





Videometer throughout the seed/grain chain

- Breeding and genetic resources
 - Screening, phenotyping, ploidy, genebank management (off-type, phenotype query)
- Seed technology
 - Seed coating, seed priming, seed pelleting, seed disinfection, seedborne disease control
- Sowing
 - Germination, vigor, hydration, root and shoot analysis
- Growing
 - Field and greenhouse phenotyping, stressors, resistance
- Harvesting
 - Maturity assessment, preharvest sprouting, combine harvester control
- Trading
 - Product appraisal, logistics, pricing
- Cleaning
 - Physical purity, broken, high value seed sorting, self-adjusting cleaning machines
- Refining and processing
 - Milling, mixing, pelleting, malting



SEED PURITY



Purity analysis of spinach samples





Purity analysis of spinach samples





Second level attributes - Seed classification

Classifier performance on test set with 57115 seeds

Predicted	Cereal	Spinach	Cleavers	Black bindweed	Radish	Rapeseed	Hemp-nettle	Total	Error
Cereal	99.7	0.3	0	0	0	0	0	1.2	0.3
Spinach	0	99.9	0.1	0	0	0	0	75.2	0.1
Cleavers	0	0.4	99.5	0.1	0	0.1	0	7.5	1.5
Black bindweed	0	0.3	0	99.7	0	0	0	10.1	0.4
Radish	0	1.8	0.5	0	97.6	0	0.1	2.6	2.5
Rapeseed	0	0.5	0.9	0	0.4	97.9	0.4	2.3	2.1
Hemp-nettle	0	0.5	0.2	0	0.2	0.9	98.2	0.8	1.8
Total	1.2	75.3	7.5	10.1	2.5	2.2	0.8	57115	
Error	0	0.2	1.6	0.3	0.7	1.2	3.2		0.4



Classification Spinach vs Cleavers

Spinach

Cleavers





VIDEOMETER

Automated Corn Quality Inspection





SEED HEALTH



Heavily Fusarium-infected barley







Microdochium detection



52 "red" kernels analyzed with NGS after spectral imaging

Artificially infected malt

Fusarium Culmorum

Fusarium Avenaceum Fusarium avenaceum/tricinctum

Lewia infectoria Microdochium bolleyi Cladosporium Fusarium poae





Videometer

SEED Germination and Vigor

Hybrid Cabbage (sRGB)





Hybrid cabbage greenness





Maturity of seeds

Hybrid cabbage red fluorescence





(660 nm, >700 nm)

Maturity of seeds

Hybrid cabbage UV fluorescence





(365 nm, >500 nm)

Seed coat cracking, sinapine leakage?

Wheat preharvest sprouting



Collaboration with John Innes Centre





Digital seeds are

Rich representations of seed physico-chemical properties

Purity, damages, contaminants, other seeds, maturity, size and more are evaluated directly on the digital seed

Cloud resources with digital signature compliance

Seed databases are tested and maintained digitally

Digital seeds may link information from other modalities









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Questions?