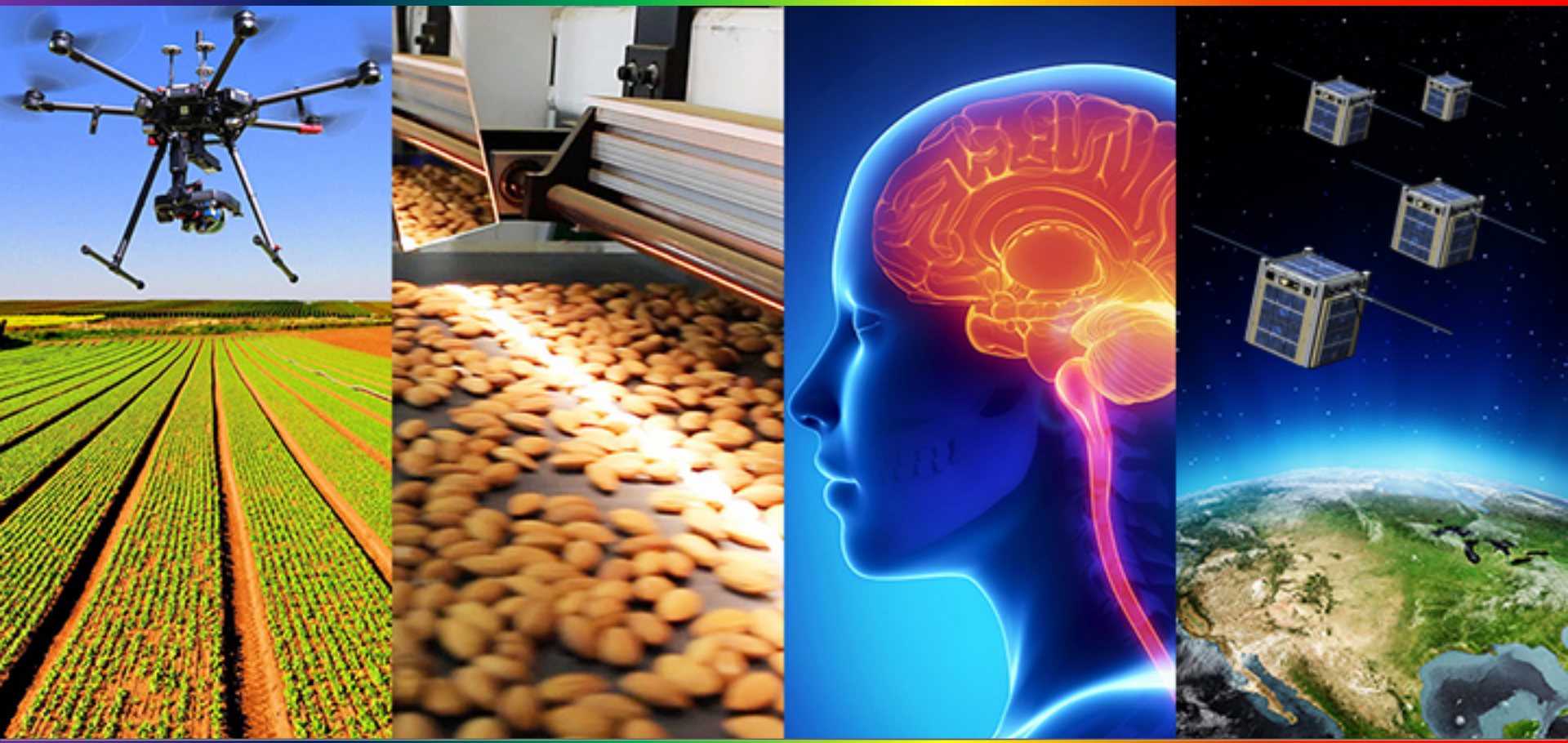


Identification of *Jacobs Cross Cabbage* within Kitchen Herbs Parsley and Thistle

Christian Felsheim

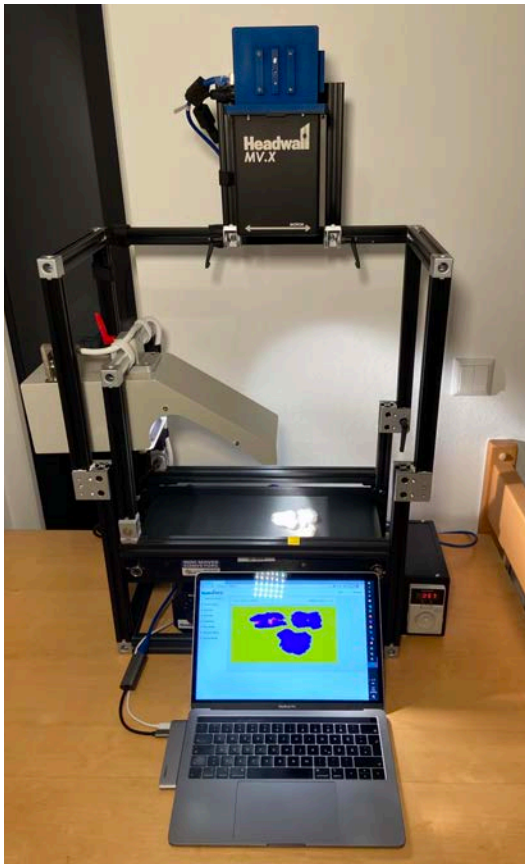
Headwall

Challenge

Jacobs Cross Cabbage (Jacobaea vulgaris) is a very common flower that is native to northern Eurasia. The flower contains liver toxic Pyrrolizidine alkaloids which makes it an unwanted plant for farmers who need to separate it out from harvested kitchen herbs such as parsley.

Current tests are intended to identify dried *Jacobs Cross Cabbage* online within dried samples of parsley and thistle using a *Headwall MV.X* VNIR Hyperspectral System running *perClass Mira Runtime* software on the processors embedded in the *MV.X* system.

Test Setup



- MV.X Hyperspectral Imaging System
  VNIR : 400 – 1000nm, 16mm lens
- Headwall lab kit halogen light
- Mini conveyor belt
- perClass Mira Analysis and Runtime Software
- Dried samples of Jacobs Cross Cabbage, Parsley and Thistle

Process

Preparation

Record Training Data (inline)

Program MV.X

Download Raw Data

Upload Classification Model

Create Classification Model (offline)

Operation

Cloud

Inline Classification and Grating

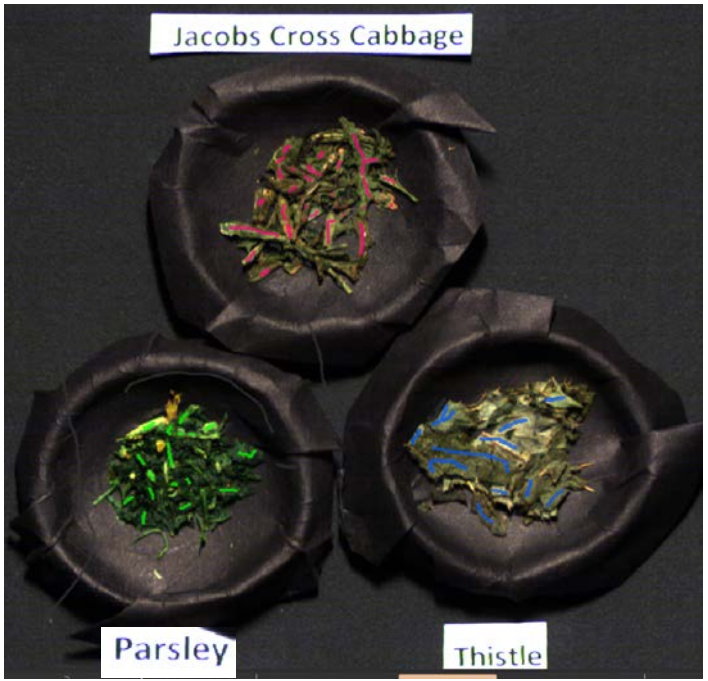
Actionable Results

Continued Performance Control and Optimization through WebInterface (remote)

Ethernet Connection

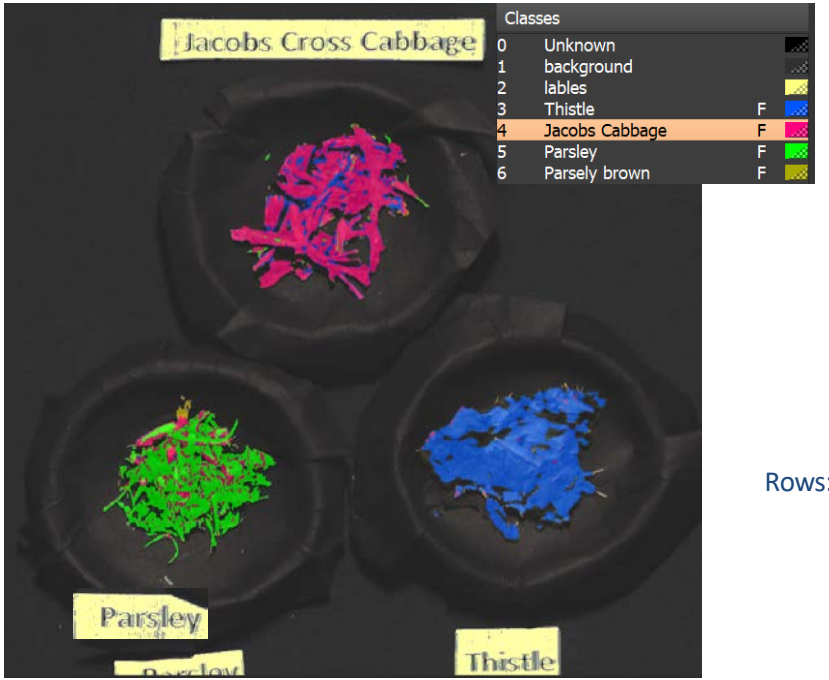
Model Build in *perClass Mira* Analysis Software

RGB Image



Labelled RGB Image

Classification and Confusion Matrix



Classified Result

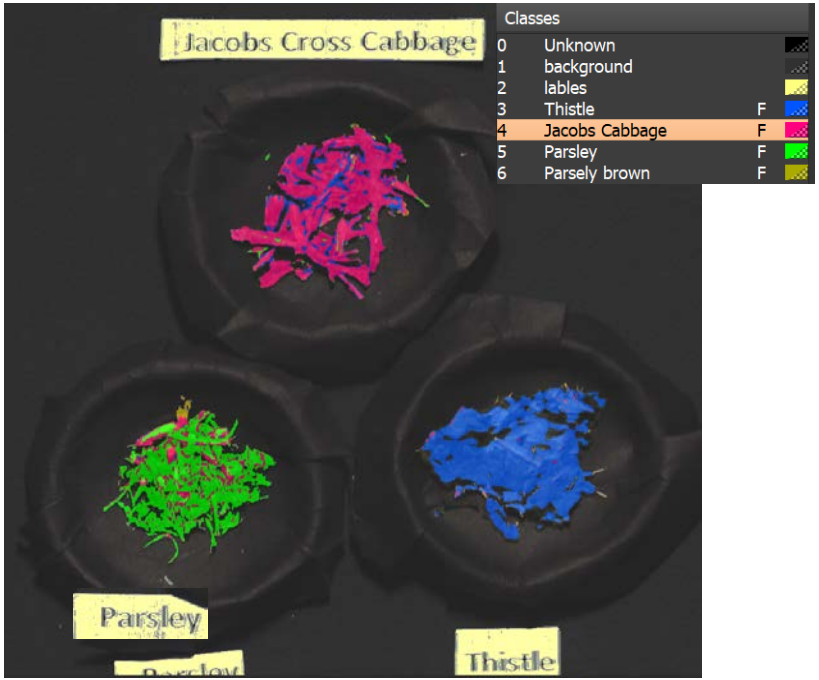
Columns: Decisions

	1 backgro	2 lables	3 Thistle	4 Jacobs	5 Parsley	6 Parsely	Class error
1: backgro	0.998	0.000	0.001	0.000	0.001	0.000	0.002
2: lables	0.000	1.000	0.000	0.000	0.000	0.000	0.000
3: Thistle	0.030	0.000	0.970	0.000	0.000	0.000	0.030
4: Jacobs (	0.000	0.000	0.103	0.873	0.016	0.009	0.127
5: Parsley	0.029	0.000	0.001	0.016	0.954	0.000	0.046
6: Parsely	0.015	0.000	0.000	0.103 <=0.566	0.000	0.882	0.118
Precision	0.98	1.00	0.90	0.98	0.96	0.90	0.054 Mean error

Rows: True data

Confusion Matrix provides measure for correct classification

Optimization for Not-Missing *Jacobs Cross Cabbage* (JCC)



Classified Result

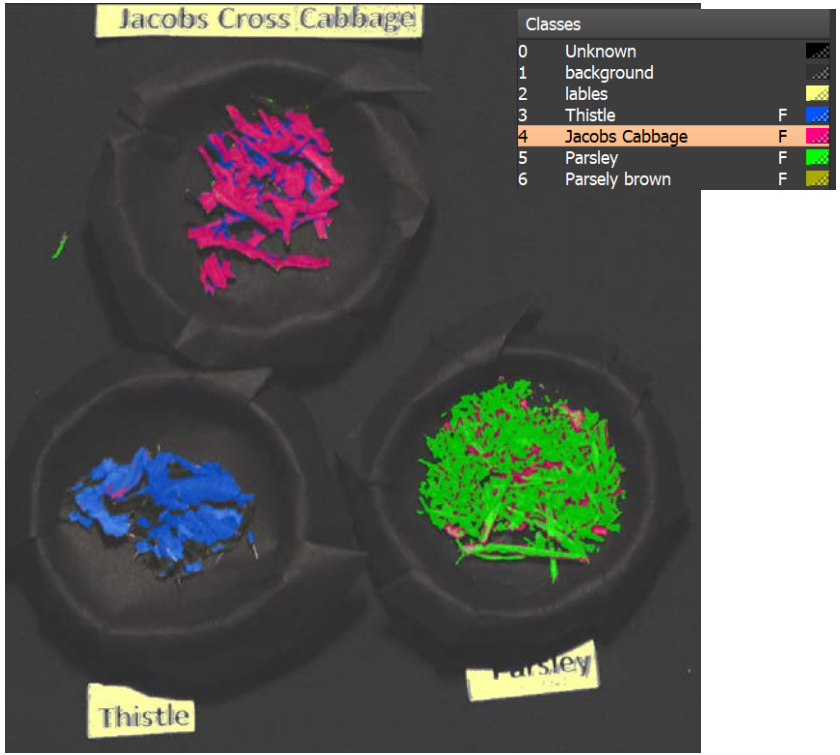
	1 backgro	2 lables	3 Thistle	4 Jacobs	5 Parsley	6 Parsely	Class error
1: backgro	0.996	0.000	0.000	0.001	0.003	0.000	0.004
2: lables	0.000	1.000	0.000	0.000	0.000	0.000	0.000
3: Thistle	0.047	0.000	0.887	0.066	0.000	0.000	0.113
4: Jacobs C	0.000	0.000	0.004	0.987	0.007	0.001	0.013
5: Parsley	0.010	0.000	0.000	0.045	0.945	0.000	0.055
6: Parsely	0.010	0.000	0.000	0.446	0.000	0.544	0.456
Precision	0.97	1.00	0.99	0.88	0.97	0.97	0.107

Jacobs cross Cabbage

Brown parsley leaves

Confusion Matrix Constraint set for likelihood of missing JCC about 1%
=> Accepted increase in false hit for JCC in brown parsley leaves

Test of Classification Model with 2nd Probe



	1 backgro	2 lables	3 Thistle	4 Jacobs	5 Parsley	6 Parsely	Class error
1: backgrou	1.000	0.000	0.000	0.000	0.000	0.000	0.000
2: lables	0.000	1.000	0.000	0.000	0.000	0.000	0.000
3: Thistle	0.089	0.000	0.819	0.092	0.000	0.000	0.181
4: Jacobs C	0.000	0.000	0.001	0.998	0.001	0.000	0.002
5: Parsley	0.001	0.000	0.000	0.010	0.989	0.000	0.011
6: Parsely b	0.286	0.000	0.095	0.202	0.000	0.417	0.583
Precision	0.98	1.00	0.99	0.90	1.00	1.00	0.130

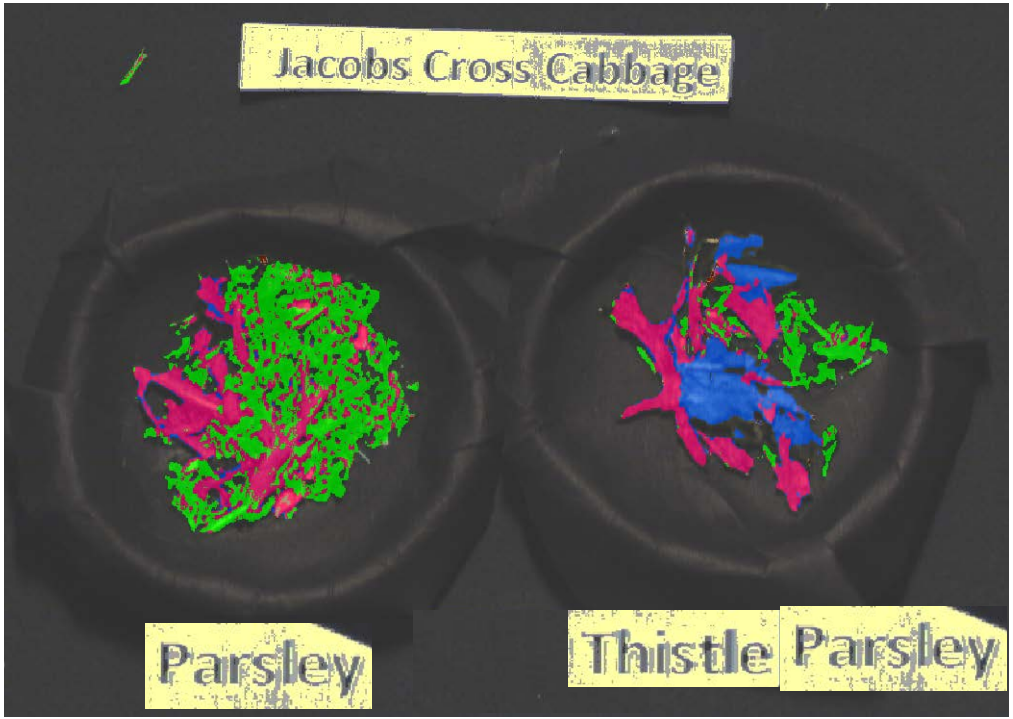
Mean class error

Jacobs cross Cabbage

Brown parsley leaves

- Miss rate for Jacobs Cross Cabbage << 1%
- False positive for Jacobs Cross Cabbage within brown parsley leaves 20%

Test using Mixed Probes



Conclusions

- Though dried material is inhomogeneous (lower and upper leave sides, stem and leaves included), herbs can be differentiated at about **5% precision** level
- ***Jacobs Cross Cabbage*** *(JCC)* detection: At the expense on increased *false positive rate* on brown parsely leaves detection model can be optizimed to reduce ***miss rates*** **for JCC to about 1% level**
- Model to be optimized for speed

MV.X Data Sheet

Wavelength Range	400 – 1000 nm
Spatial Pixel	1020
Spectral Bands	340
Spectral Sampling	1.75 nm/pixel
Spectral FWHM	6 nm
System F/#	f/2.5
Optical Design	Abberation-corrected concentric
Field of View	*Angular*
24mm lens	14.2°
16mm lens	21.16°
Bit Depth	12 bit
Sensor Technology	CMOS
Memeroy Storage	8GB RAM, 128GB SSD
Integrated Prcessors	GPU, CPU

Interfaces	Gen<I>Cam MQTT RS232/422* 5V TTL*
Ports	RJ45 (GigE) x2 D-Sub 26 pin (GPIO)
Software	WebInterface, on-board classification module available
Memeroy Storage	8GB RAM, 128GB SSD
Input Voltage	12-30V DC
Max Power Consumption	< 42 W
Dimensions (LxWxH)	255 x 136 x 136 mm
Weight incl. 24mm lens	3 kg
IP Rating	IP66 / IP67
Operating Temperature	0 – 50°C
Storage Temperature	-10 – 60°C

* in development

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