Model-It 2019
6th International Symposium on
MODELING IN HORTICULTURAL SUPPLY CHAIN
Molfetta (Italy) June 9-12, 2019

RECOGNITION OF INLET WET FOOD IN DRYING PROCESS THROUGH A DEEP LEARNING APPROACH

Model-It 2019 – Molfetta (Italy) – June 9-12, 2019

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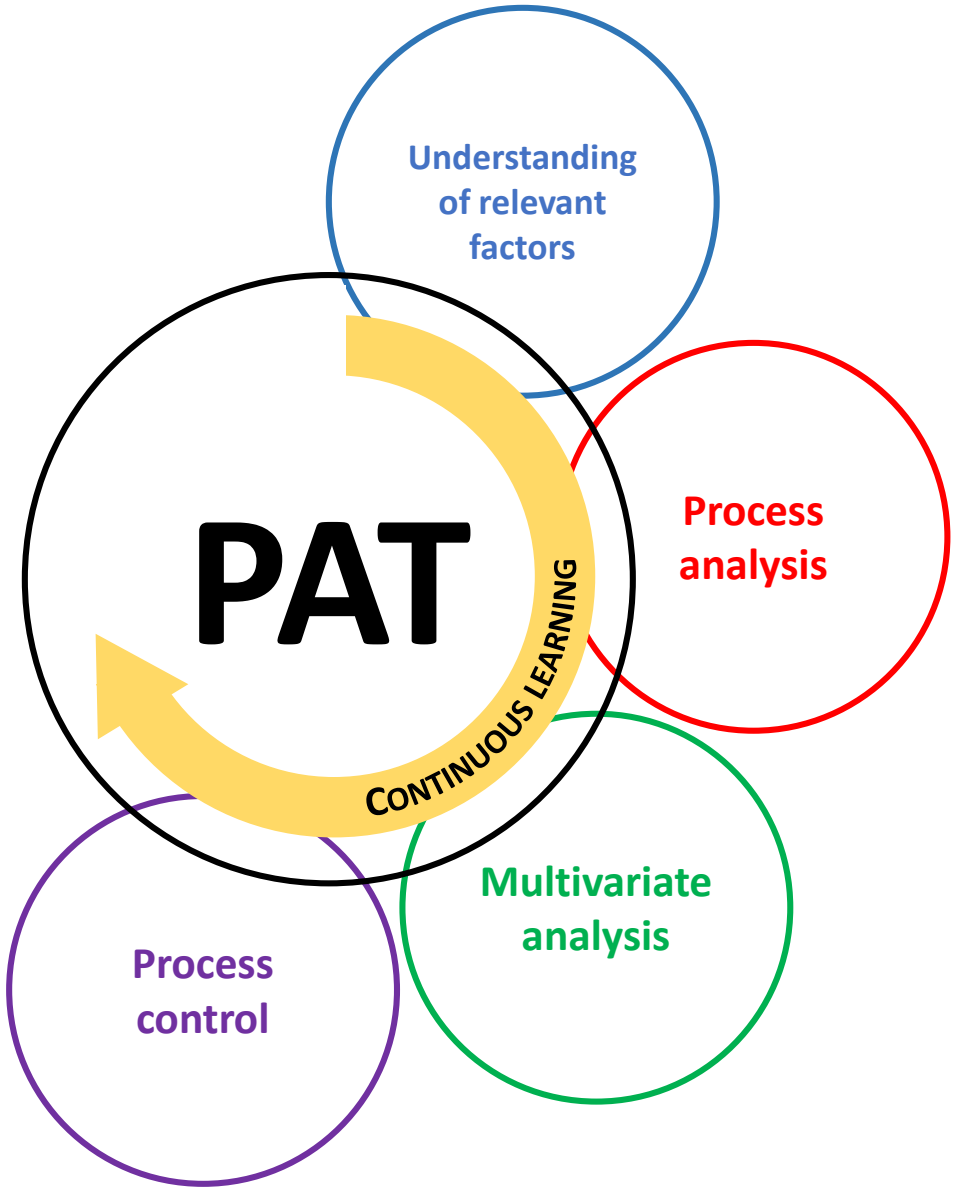
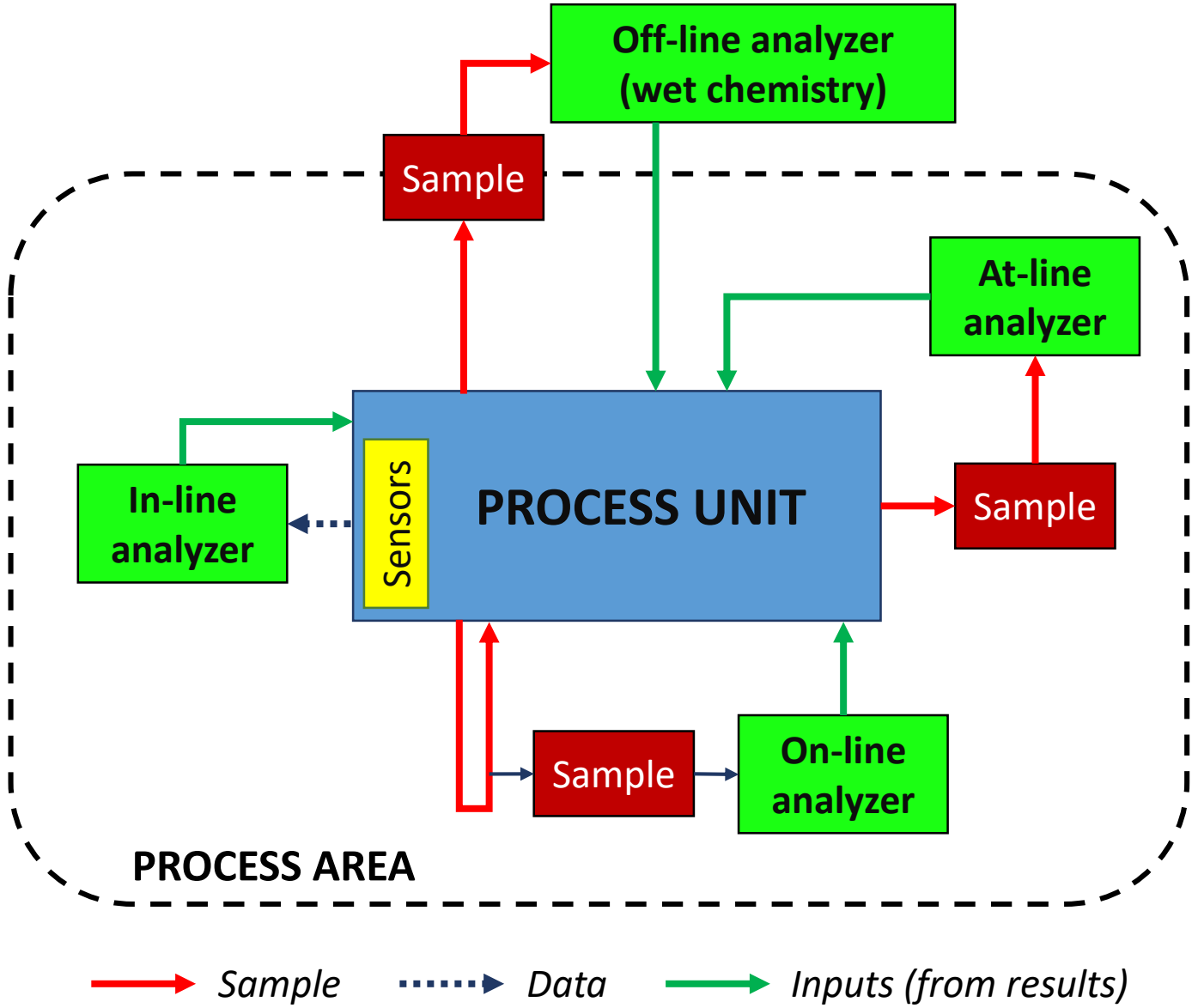
WeDIBAF

WeDAFNE


Understanding of relevant factors
Process analysis
Multivariate analysis
Process control
PAT
CONTINUOUS LEARNING


Off-line analyzer (wet chemistry)
Sample
At-line analyzer
In-line analyzer
Sensors
PROCESS UNIT
Sample
Sample
On-line analyzer
PROCESS AREA
Sample
Data
Inputs (from results)

» Our pilot dryer | *Hardware and software*

Light source

Glass

Trays

INNOTECH Ingenieursgesellschaft mbH

HARDWARE | CMOS camera (it generates data)

- 2/3 inch Sony CMOS Pregius sensor
- 2448×2048 (5 MP), up to 38 fps
- Global shutter
- Trigger and I/O inputs

SOFTWARE | Jupyter (data handling and modeling)

jupyter python R PYTORCH fast.ai OpenCV NVIDIA CUDA

HARDWARE | NVIDIA GPUs (modeling)

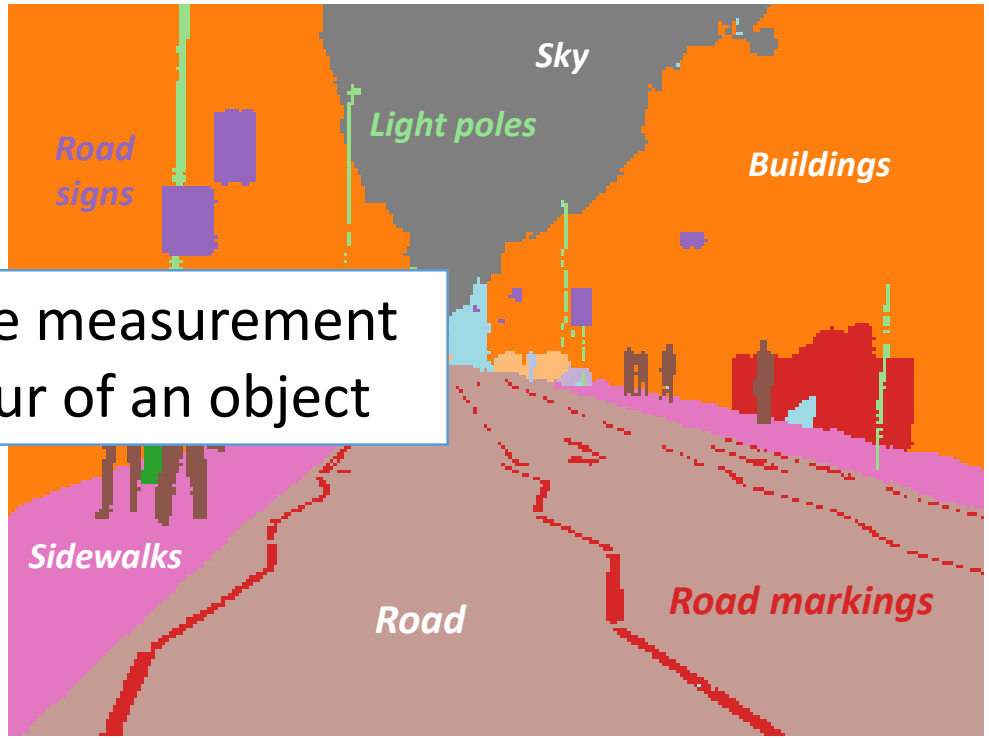
- 4608 CUDA Cores / GPU
- 72 Ray Tracing Cores / GPU
- 576 Tensor Cores / GPU
- 14.2-28.5 TFLOPS / GPU

» What does CV applied to a dryer have to deal with? | The image segmentation problem…

› ***Classical segmentation*** consists in splitting an image into several coherent parts, without any attempt to understand what these parts represent

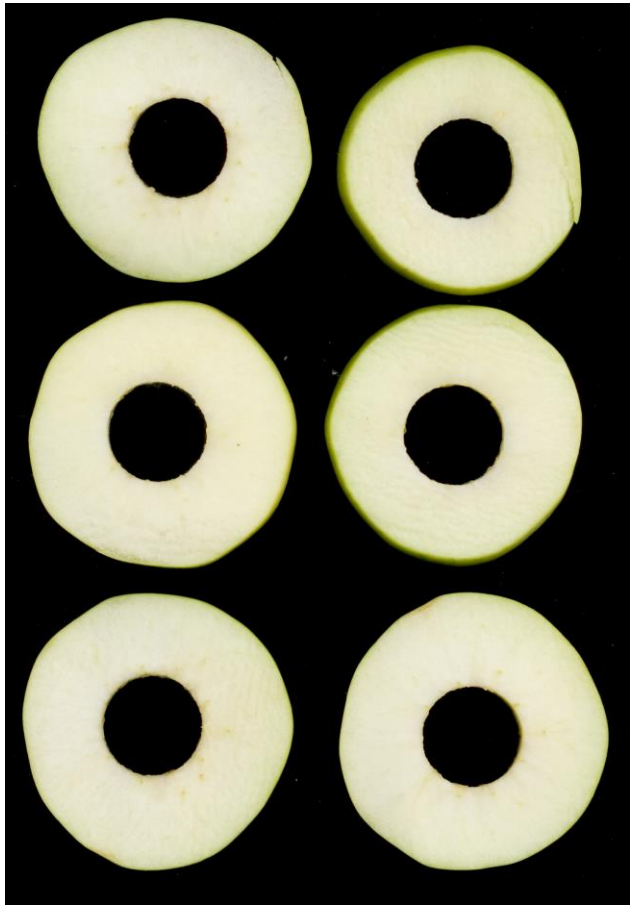
› ***Semantic segmentation*** attempts to partition the image into semantically meaningful parts, and to classify each part into one of the pre-determined classes

Segmentation allows the measurement of shape, size and colour of an object

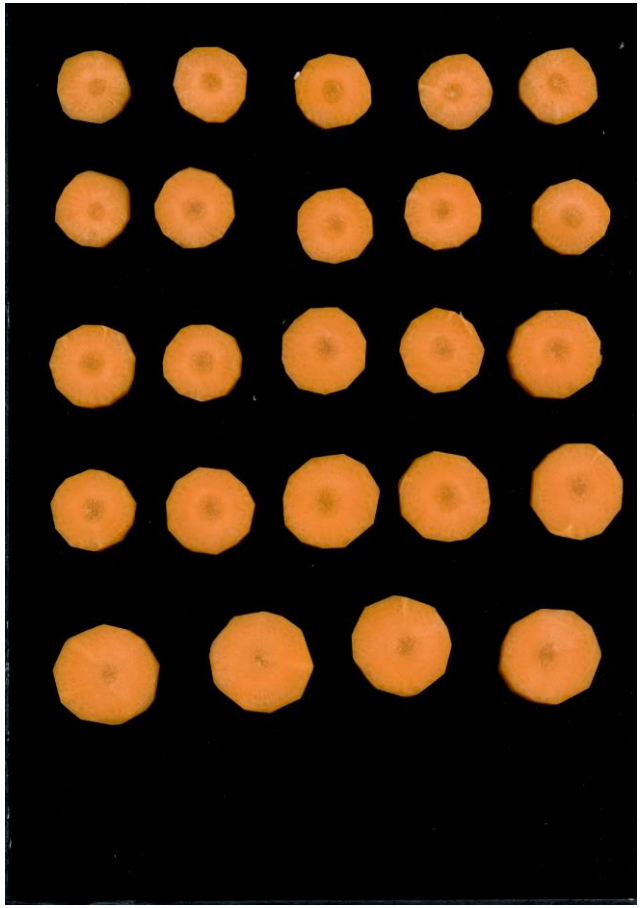


» **What does CV applied to a dryer have to deal with? |** The image recognition problem…

Recognize a product and set the proper process parameters (temperature, air flow and relative humidity)



Apple slices



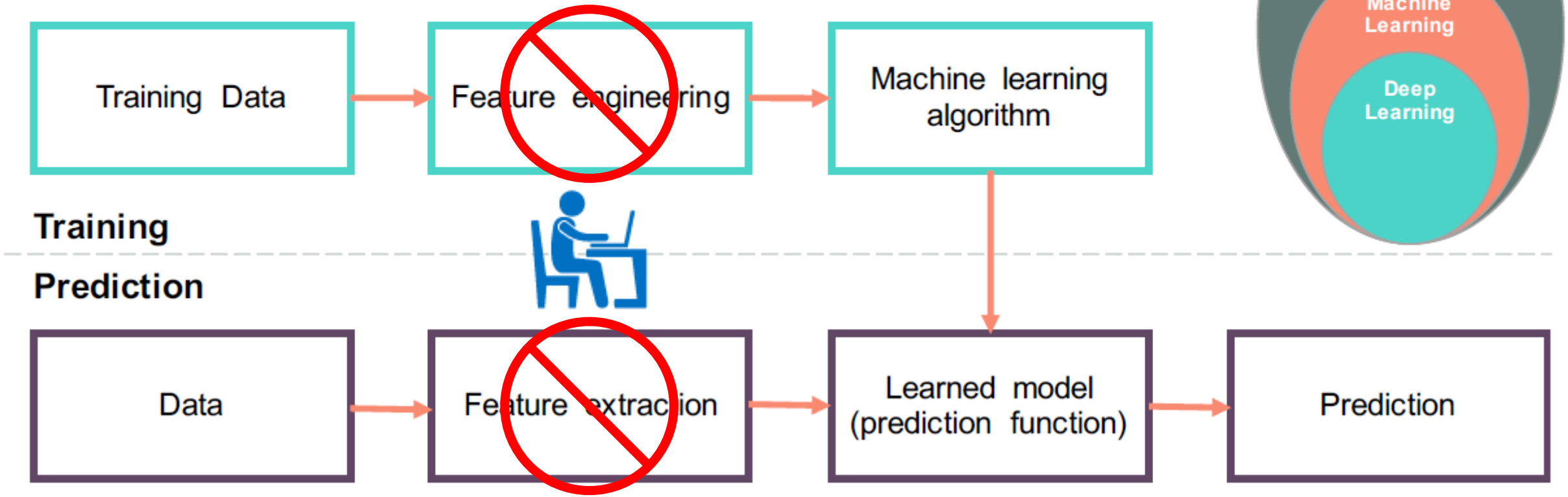
Carrot slices

Cucumber slices

» Artificial Intelligence | *Machine learning vs deep learning*

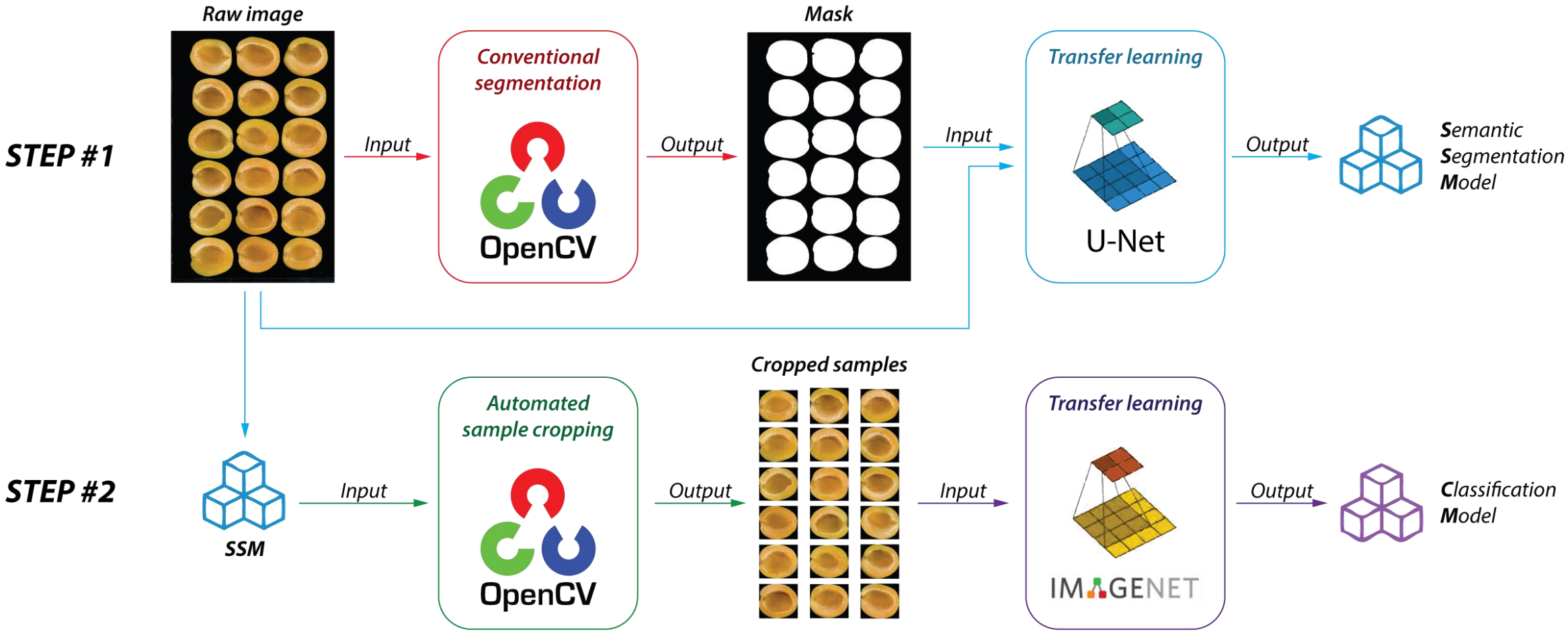
Machine learning requires feature engineering, while deep learning does not require it:

algorithm automatically learns how to perform feature extraction and which features are important for the model



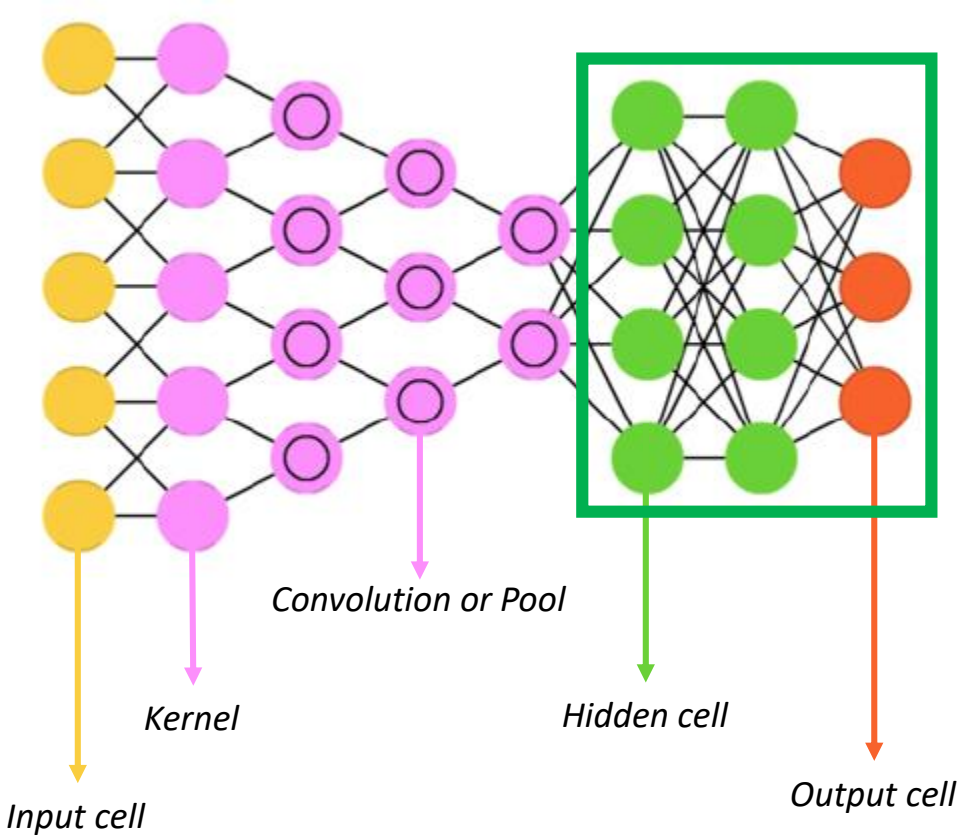
Modified from: Sorin Cheran's presentation titled 'About AI' (2018)

» Our DNN approach | *Semantic segmentation and Image classification*



» How to make the model training much easier | *the transfer learning approach*

Transfer learning is a technique that shortcuts much of this by taking a piece of a model that has already been trained on a related task and reusing it in a new model (source: Google Tensorflow website, 2019)



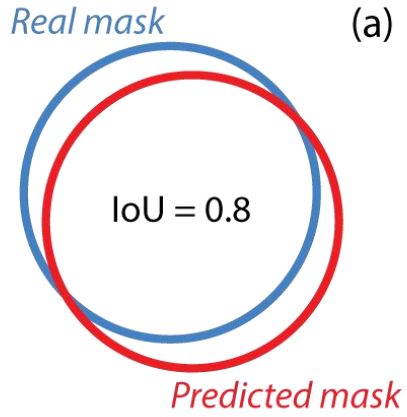
Last layers are the only ones that are retrained

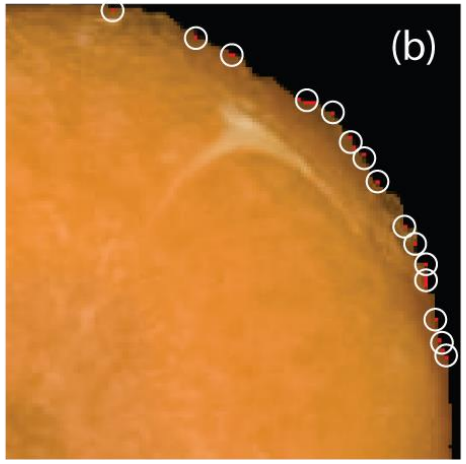
» The dataset | *100+ images per class of product*

1. Apricot
2. Banana
3. Carrot
4. Cucumber
5. Champignon (or white button, mushroom)
6. Cherry
7. Onion
8. Kiwifruit
9. Lime
10. Apple
11. Potato
12. Chilli pepper
13. Pear
14. Peach
15. Red plum
16. Zucchini
17. Cherry tomato
18. San Marzano tomato

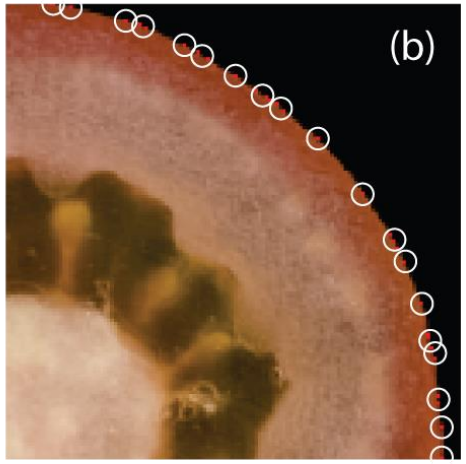
» **Results**| *Semantic segmentation*

Intersection over Union
IoU > 99%

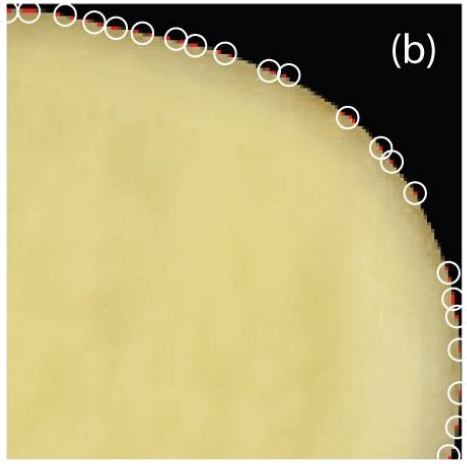




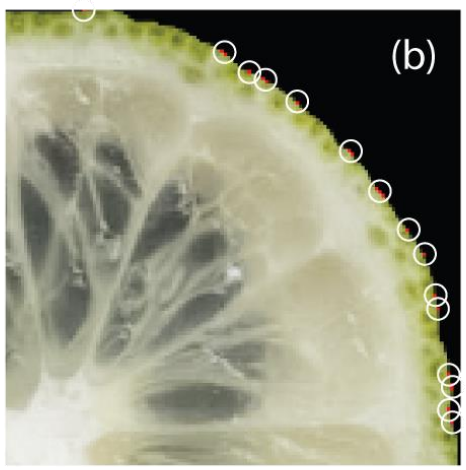
Carrot slice



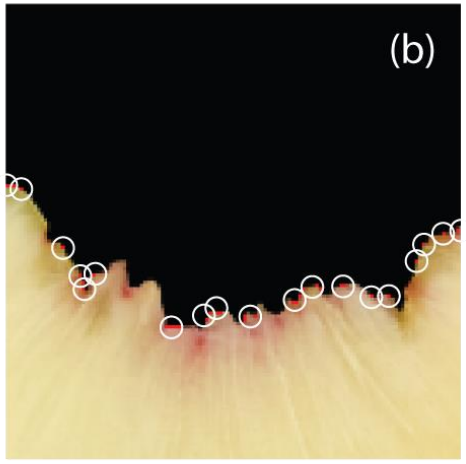
Plum tomato slice



Potato slice



Lime slice

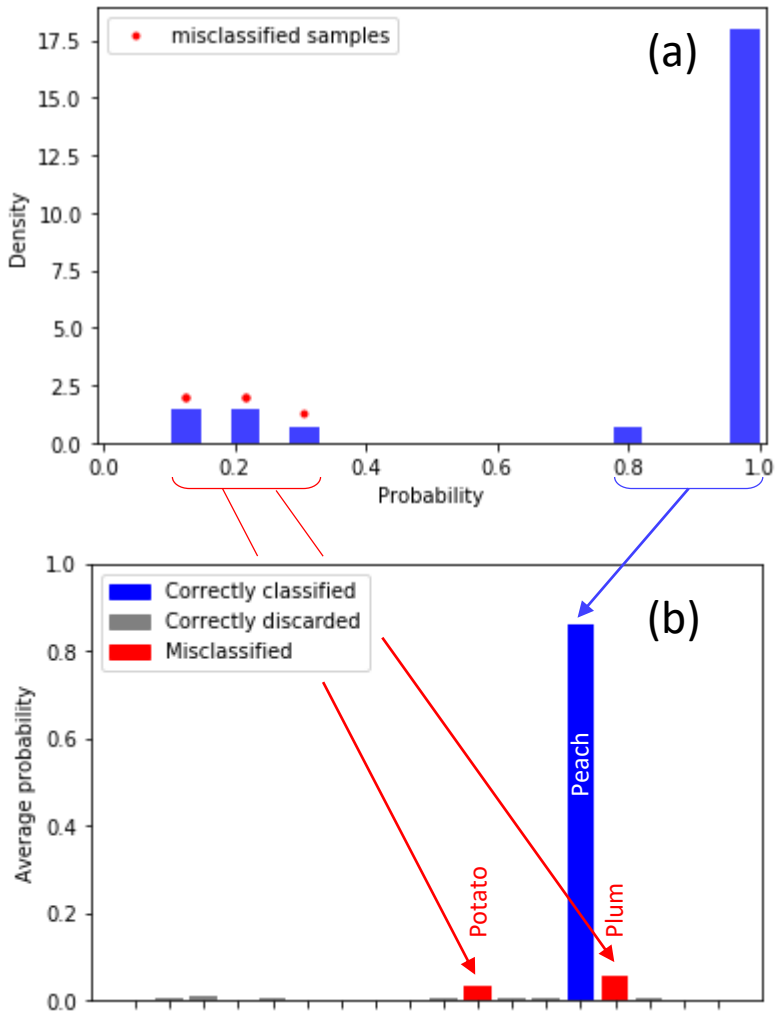


Peach slice

Example of IoU (a) and images of samples with misclassified pixels (b)

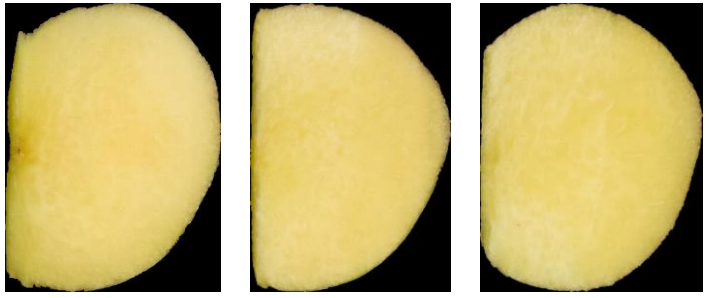
» **Results**| *Product recognition*

Model performance
Accuracy = 0.992



› Peach slices misclassified as red plum slices

› Peach slices misclassified as potato slices

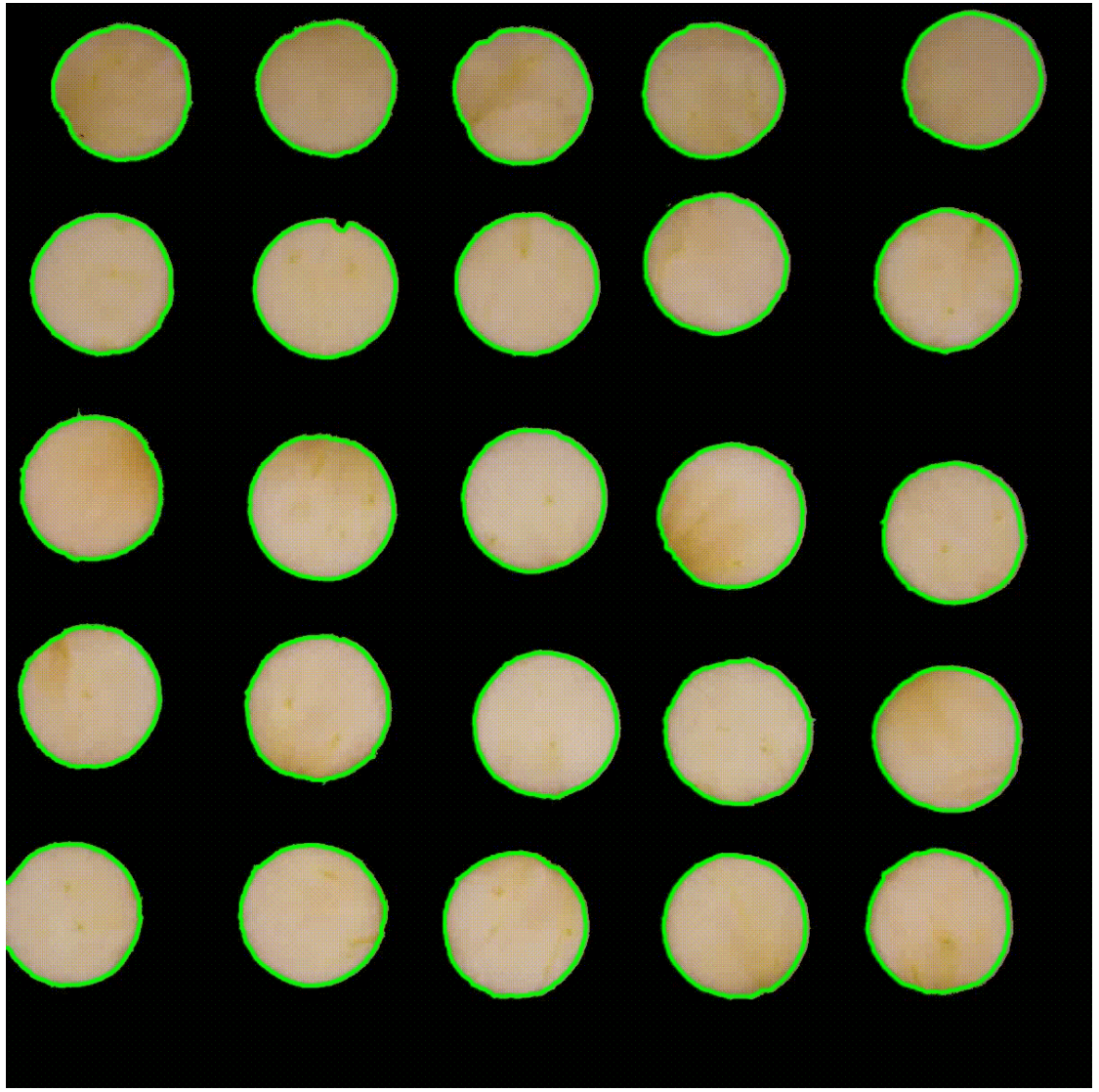


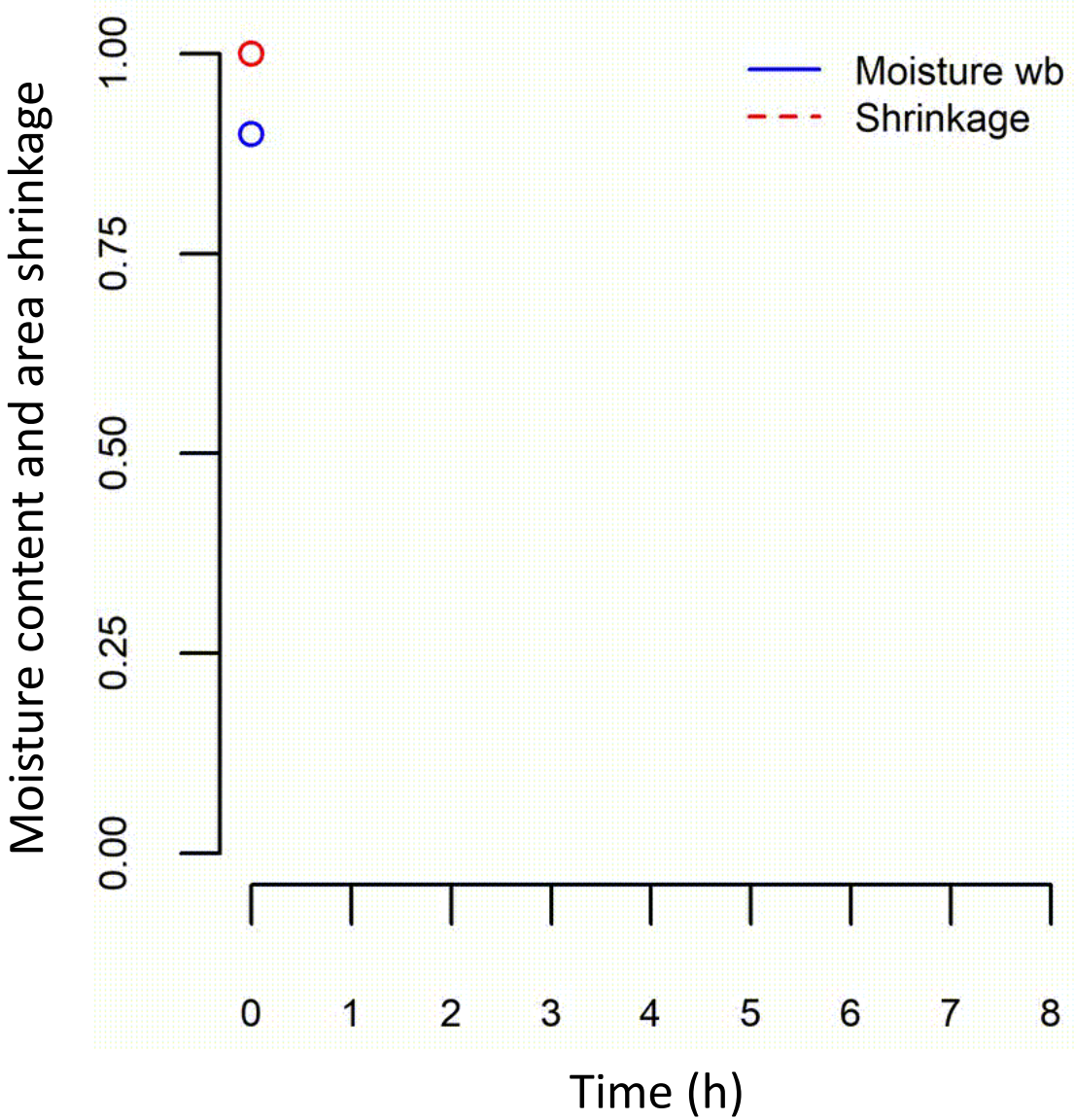
» **Results**| *Training performance: comparison between CPU and GPU*

Model	Learning rate	Epochs	Batch size	Runtime system	Training time (hh:mm:ss)
CM	1E-03	3	64	CPU	00:07:47
				GPU	00:00:26
SSM	5E-05	10	8	CPU	06:44:03
				GPU	00:22:31

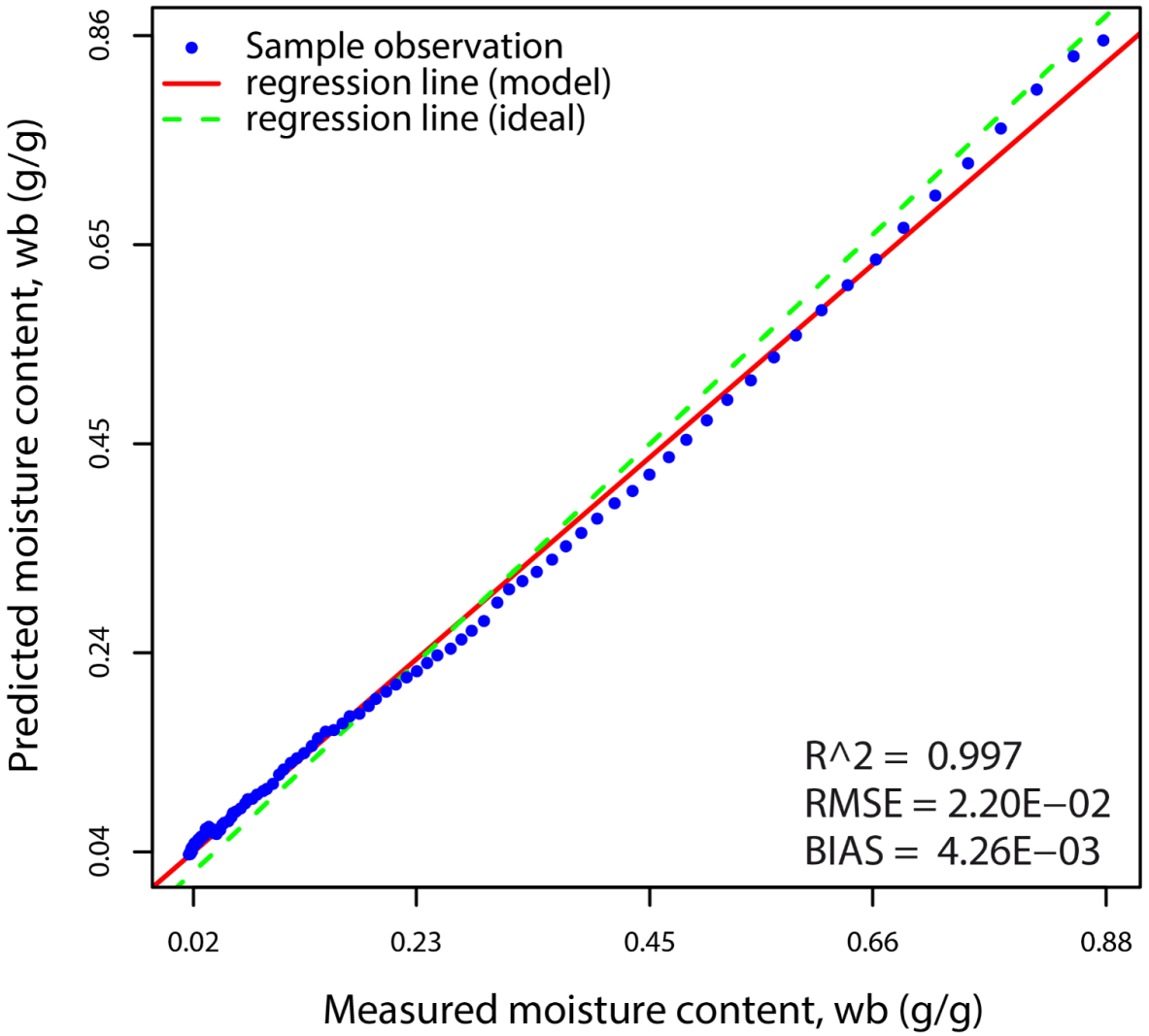
CM: classification model
SSM: semantic segmentation model

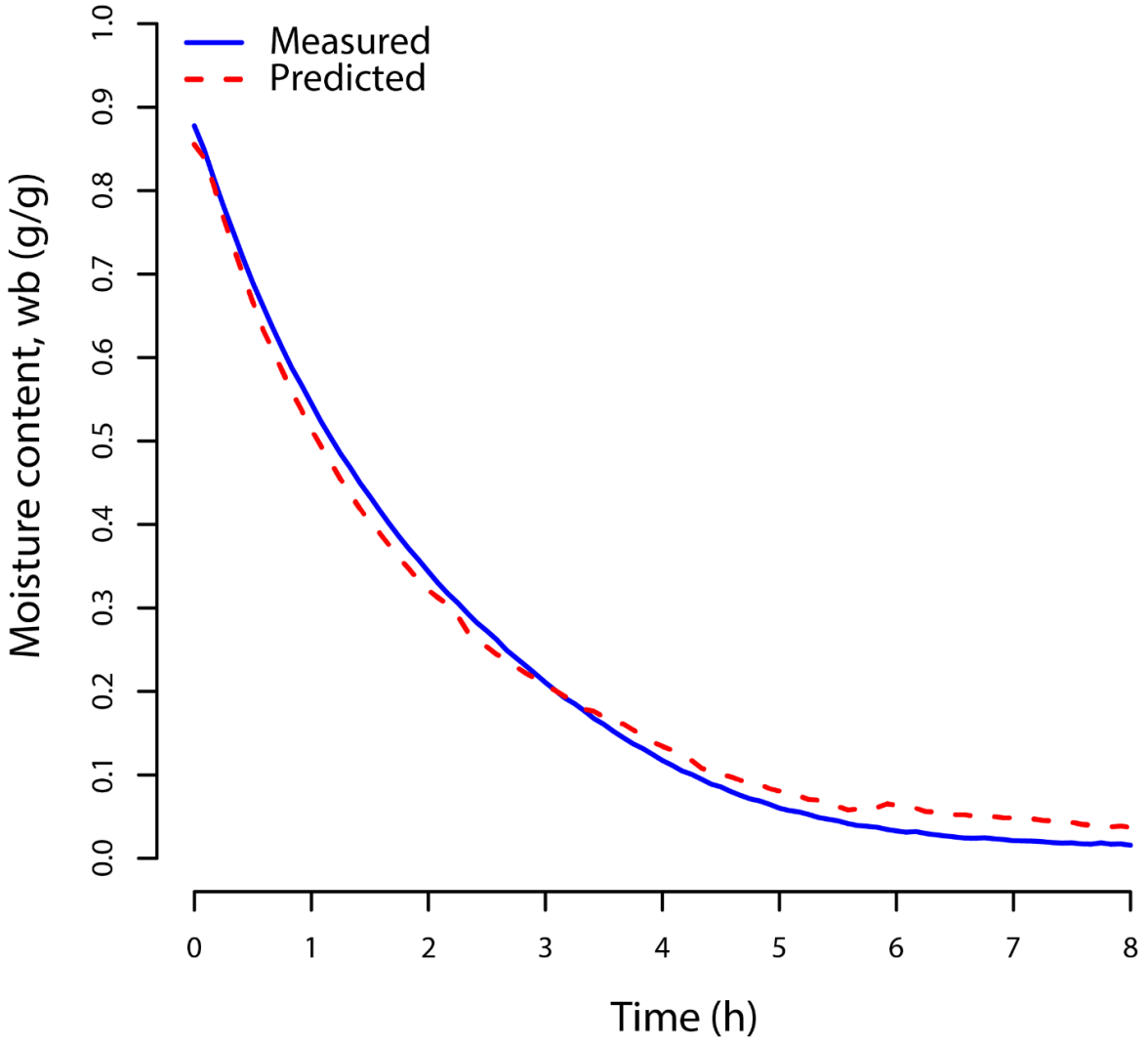
» **Results**| *Shape and size measurements*



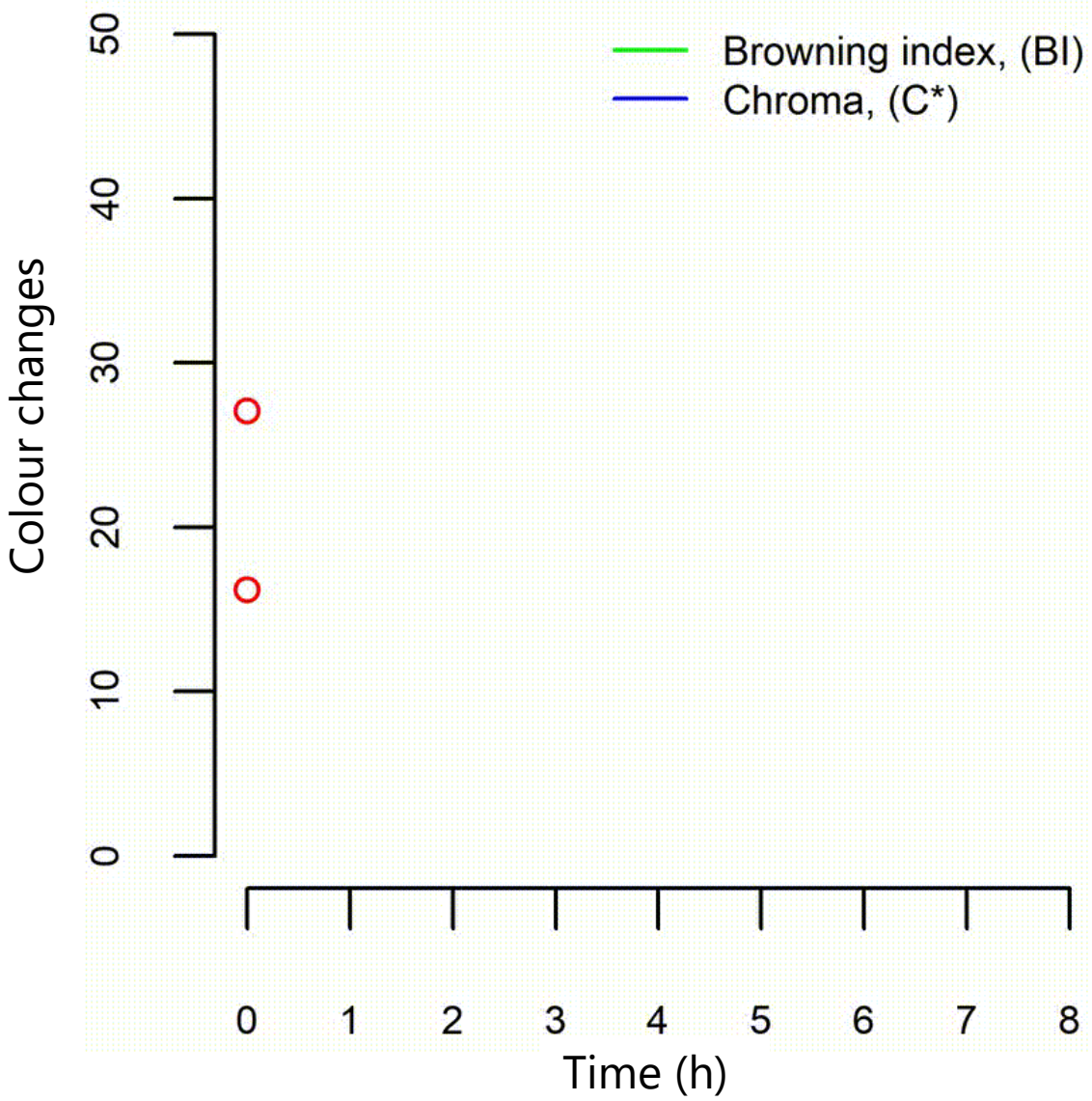


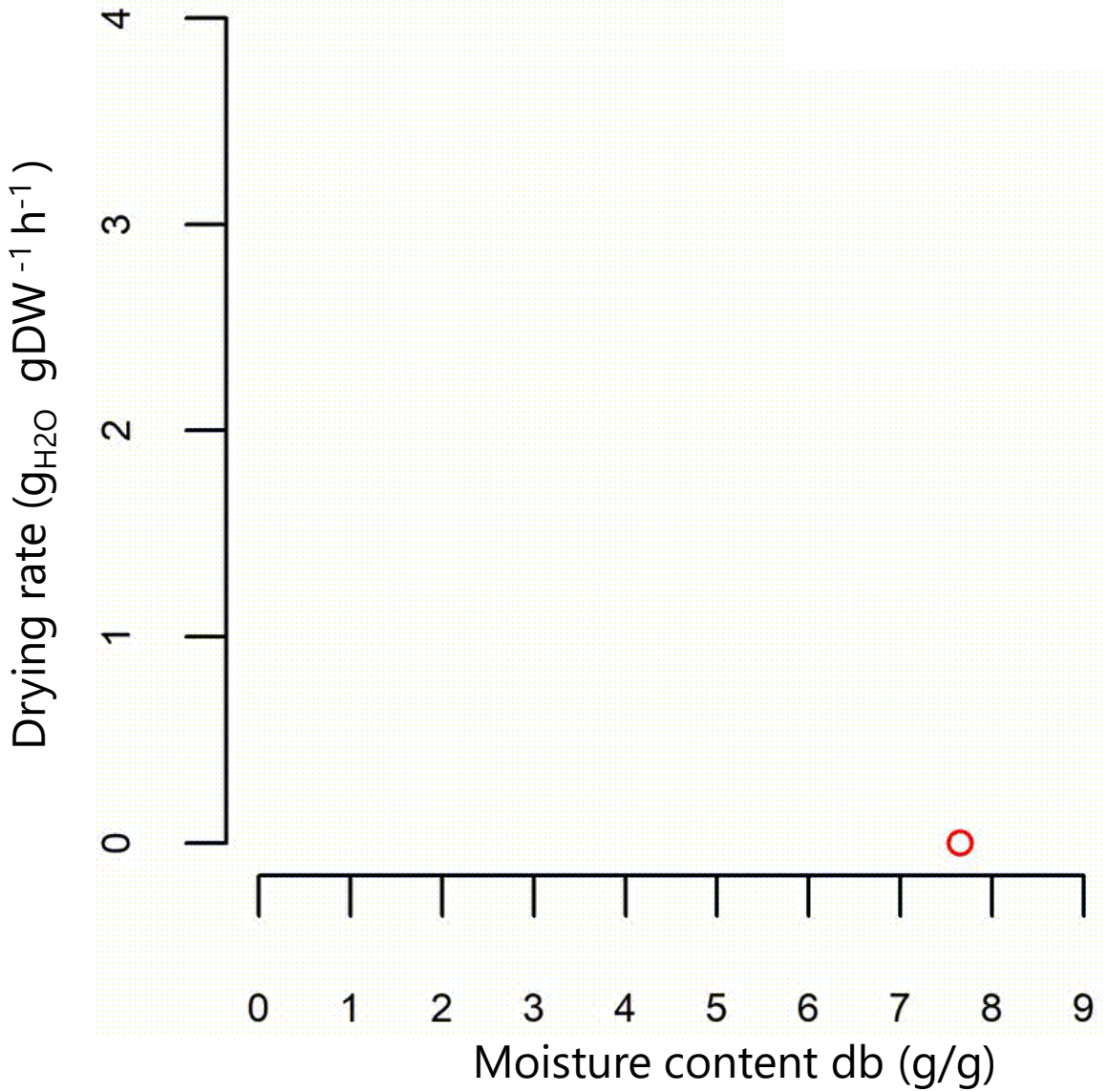
» **Results** | *Prediction of changes in moisture content*





» **Results**| *Changes in colour and trend of the drying rate*





THANK YOU FOR YOUR ATTENTION