HBC.2022.0062

VLAIO TETRA

Machine Vision for Quality Control

(MV4QC)

Tussentijdse vergadering II

Met de steun van VLAIO

Agendapunten

- Status project
- Toelichting cases
- Toelichting demonstratoren

Met de steun van VLAIO

Status project

WP1

- Rapport WP1 geschreven – laatste versie op de website
- Bedrijfsbezoeken afgerond

WP2

- Rapport WP2 geschreven – laatste versie op de website
- Summerschool in de maak

WP3

- Rapport WP3 (Interactieve Python Scripts) geschreven – laatste versie op de website
- Seminarie georganiseerd op 15 februari 2023

WP4

- Alle zes de cases in uitvoering – cases met masterstudenten lopen af in juni
- Eerste demonstrator afgewerkt (Momenteel te zien op Hannover Messe) – tweede demonstrator in initieel ontwerp

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Status project - leverbaarheden

- ✓ L1.1 Startvergadering (12/10/2022)
- ✓ L1.2 Rapport die de aanwezige kennis, noden, mogelijke toepassingen, en vijf geselecteerde cases beschrijft (Rapport WP1)
- ✓ L2.1 Rapport die de bestaande technieken bundelt (Rapport WP2)
- ❑ L2.2 Seminarie over de gebundelde technieken (Summerschool)
- ✓ L3.1 Rapport die de praktische kennis bundelt (Rapport WP3)
- ✓ L3.2 Seminarie over de praktische kennis (15/02/2023)
- ❑ L4.1 Vijf uitgewerkte use-cases
- ✓ L4.2 Inschakelen van studenten voor het uitwerken van de use-cases en demonstratoren
- ❑ L4.3 Rapport over de vijf uitgewerkte use-cases
- ❑ L4.4 Twee ontwikkelde demonstratoren (1/2 afgerond)
- ❑ L4.5 Workshop rond de demonstratoren
- ❑ L5.1 Economische evaluatie en haalbaarheidsstudie
- ❑ L5.2 Rapport over de economische evaluatie en haalbaarheidsstudie
- ✓ L6.1 Cursusmateriaal dat zal ingezet worden binnen het vak ‘Machinevisie’ en Manama ‘AI for Business and Industry’
- ❑ L6.2 Finale begeleidingsgroep vergadering
- ❑ L6.3 Webinar voor doelgroep
- ✓ L6.4 Website

Met de steun van VLAIO

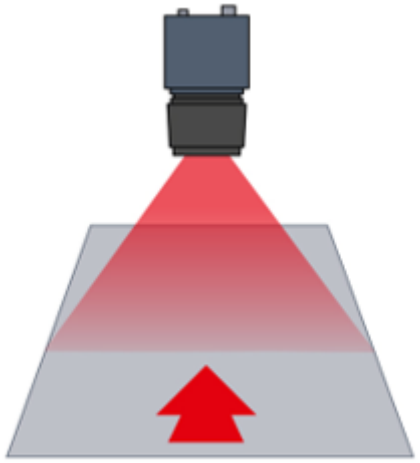
Toelichting cases

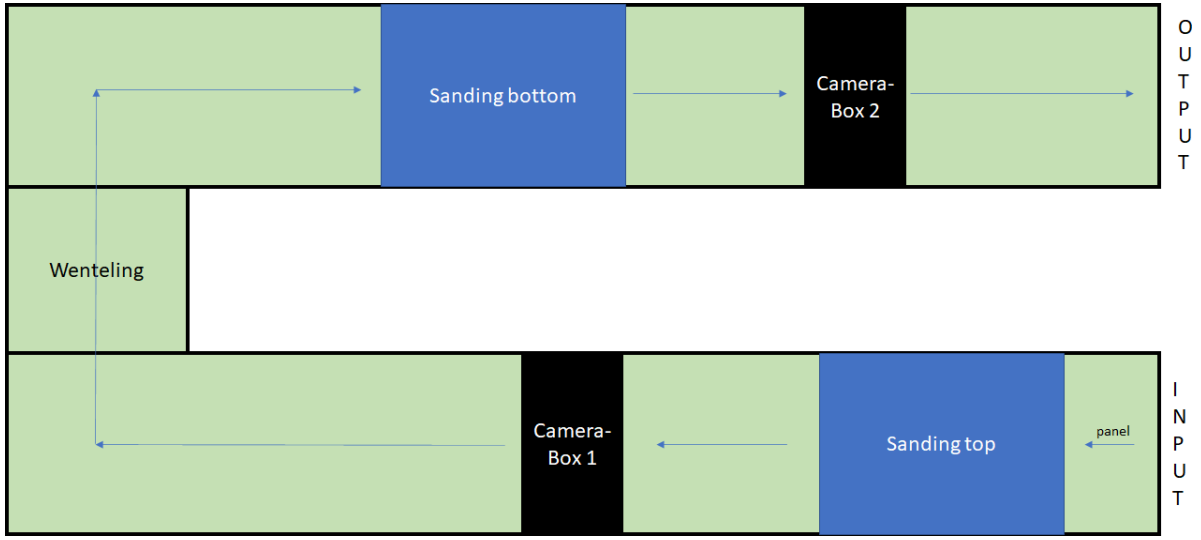
Met de steun van VLAIO

Case 1 - Detection of surface damage on flat sheets

Quality control setup:

- 2 camera boxes (both sides)
- Line scan cameras

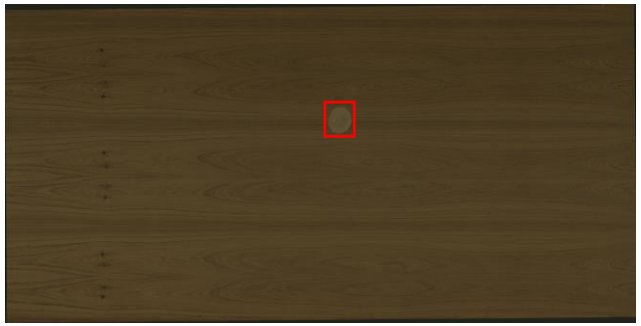




Case 1 - Detection of surface damage on flat sheets

Available data:

- Annotated pictures with boundary boxes
- Pictures with different types of wood
- Challenges
  - Large
  - Irregular sizes
  - Limited dataset (130 pictures)
  - Representation

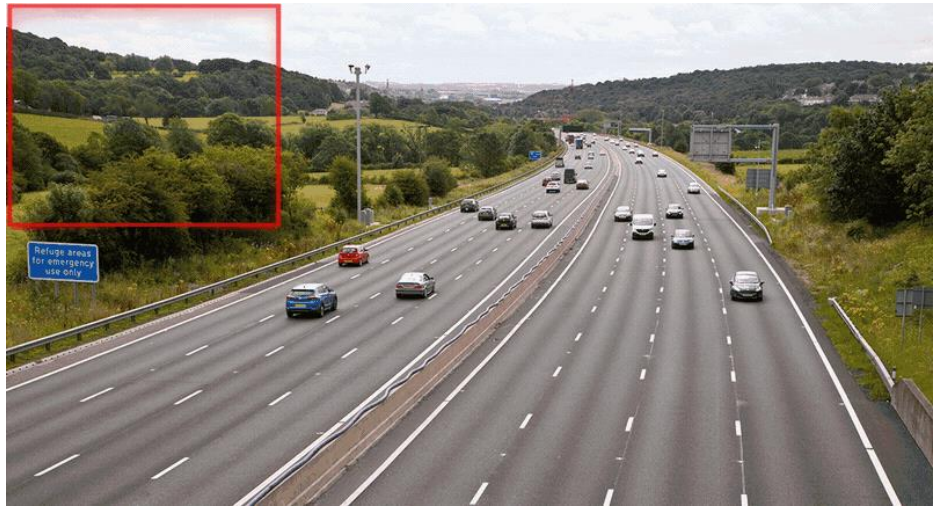


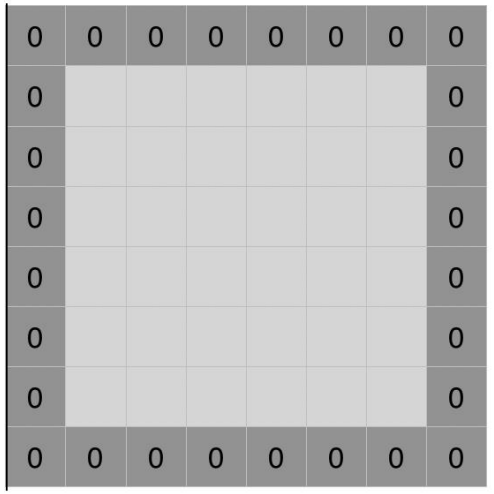
Met de steun van VLAIO

Case 1 - Detection of surface damage on flat sheets

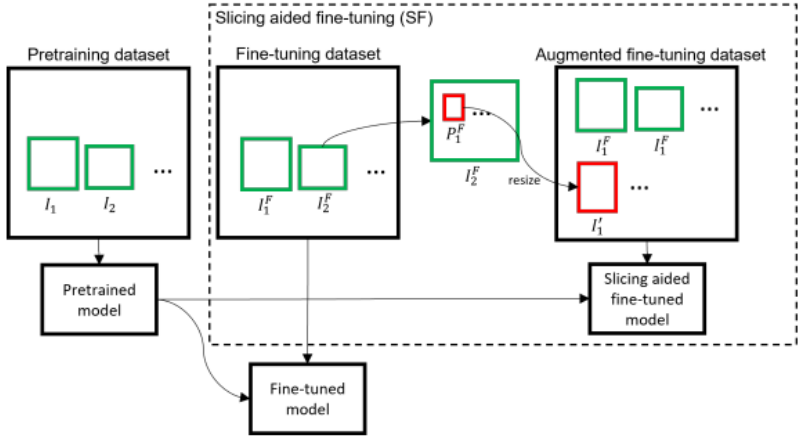
Literature:

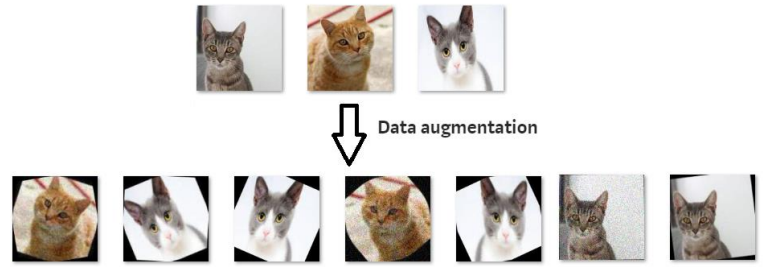
- Patching
- Transformations
- Augmentation





Zero-padding added to image



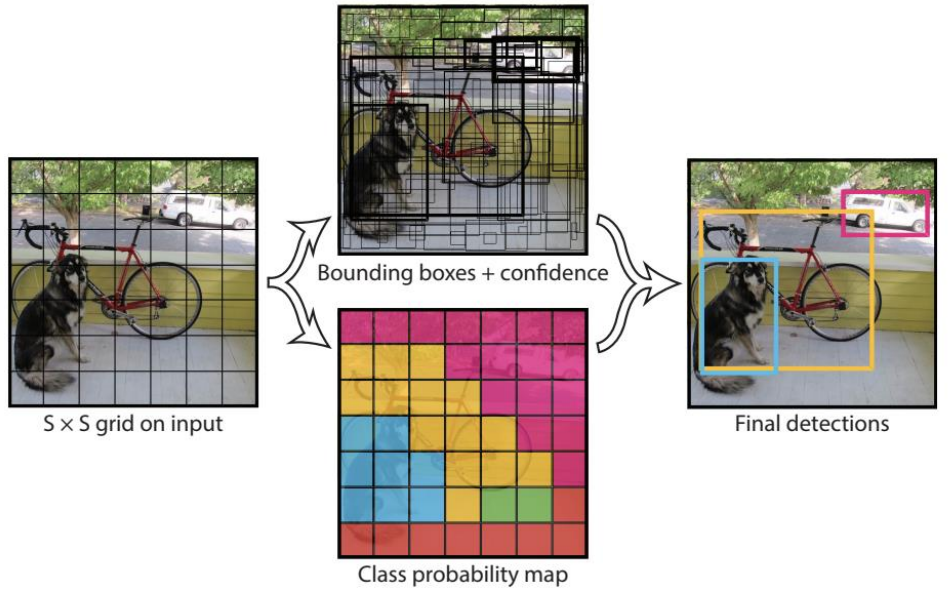


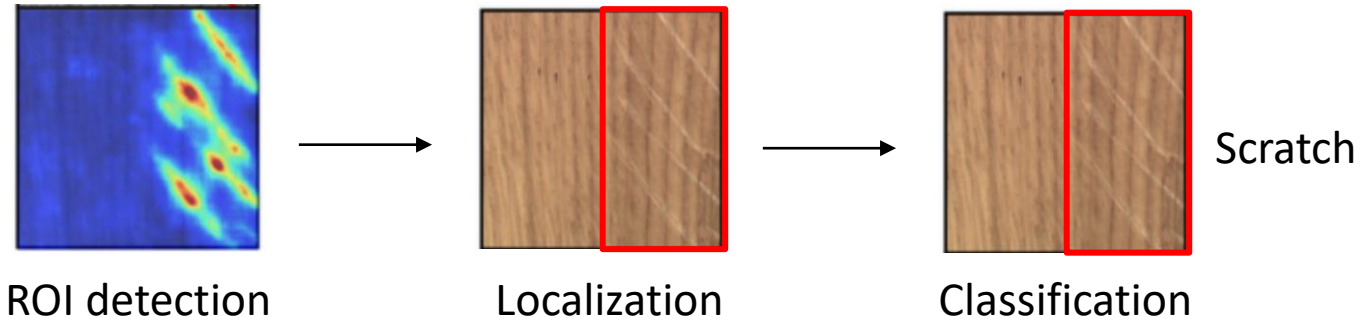
Met de steun van VLAIO

Case 1 - Detection of surface damage on flat sheets

Networks:

- Single-stage using YOLO
  - Faster processing
  - Less accurate
- Two-stage
  - More accurate (in general)
  - Slower processing



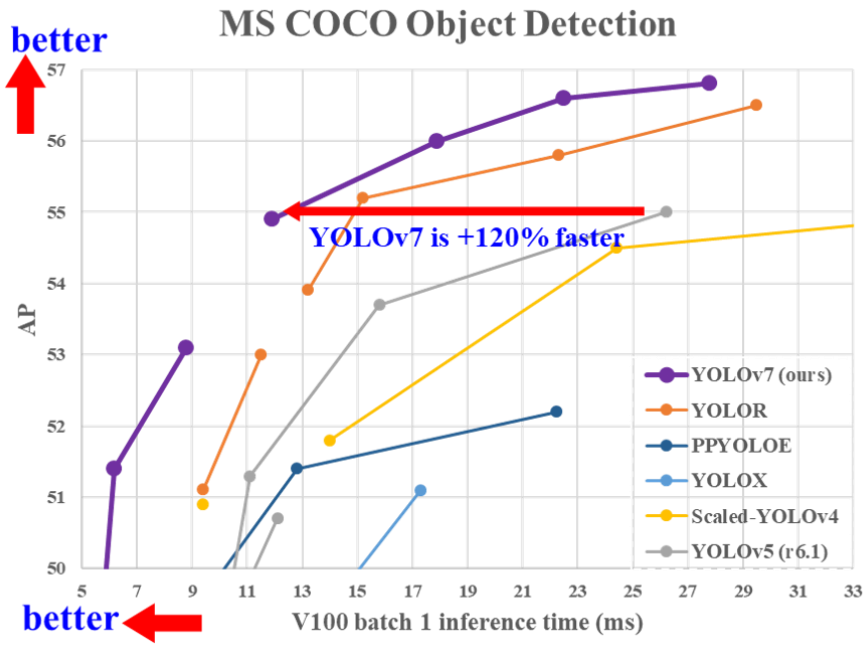


Met de steun van VLAIO

Case 1 - Detection of surface damage on flat sheets

Near future work:

- Implement patching and augmentation
- Training YOLO

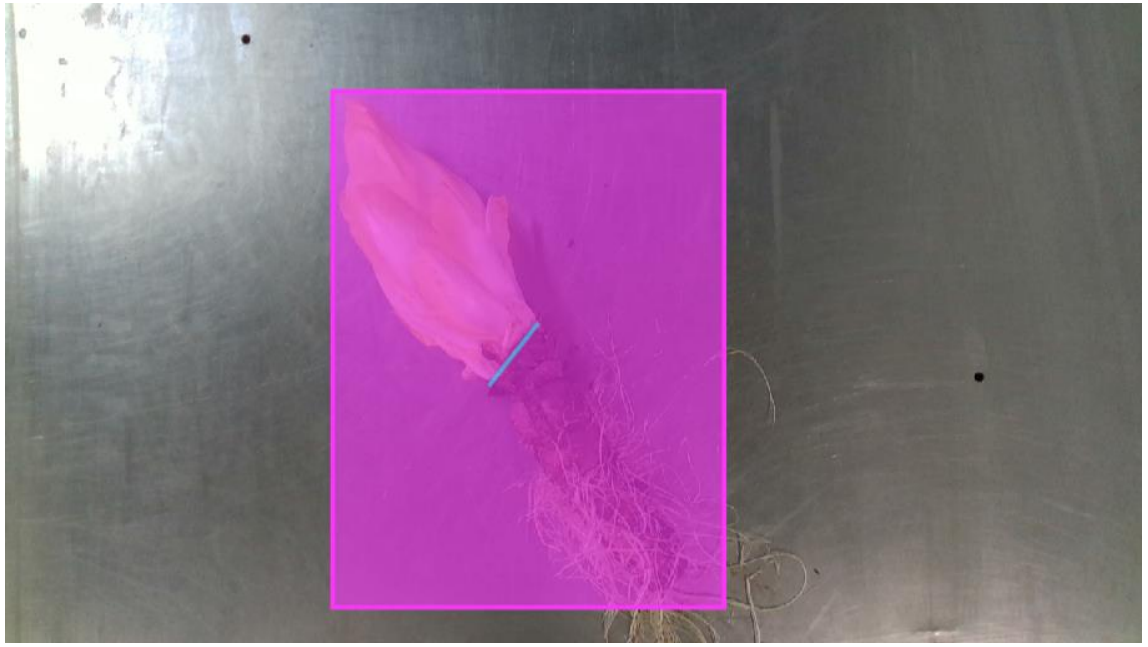


Met de steun van VLAIO

Case 2 - Detection of the optimal cut line for chicory

Three models will be trained:

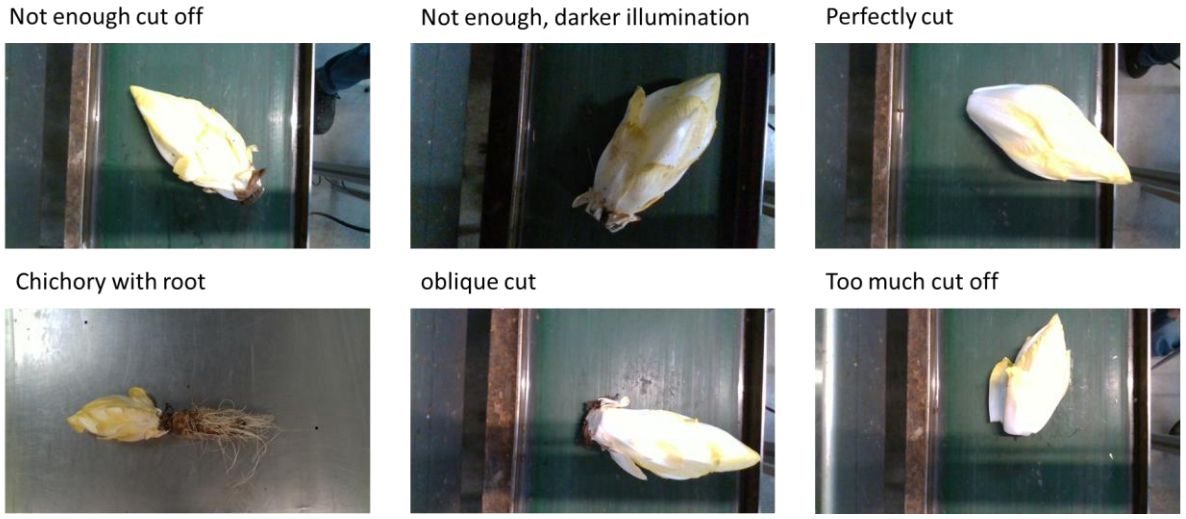
- Chichory detection
- Classification good / bad
- Cutting line detection

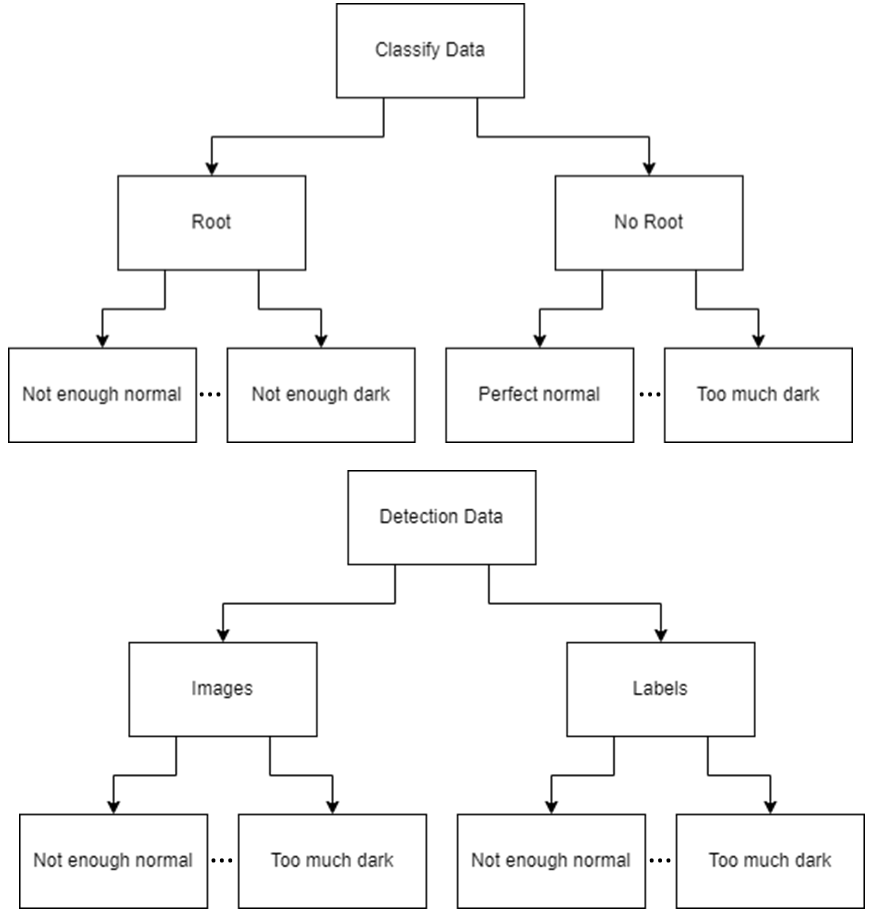


Met de steun van VLAIO

Case 2 - Detection of the optimal cut line for chicory

Available data





Met de steun van VLAIO

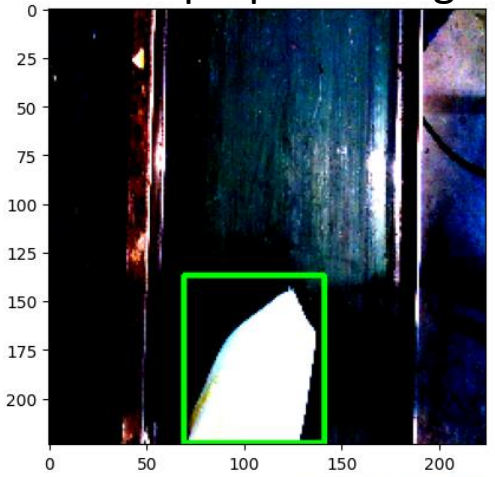
Case 2 - Detection of the optimal cut line for chicory

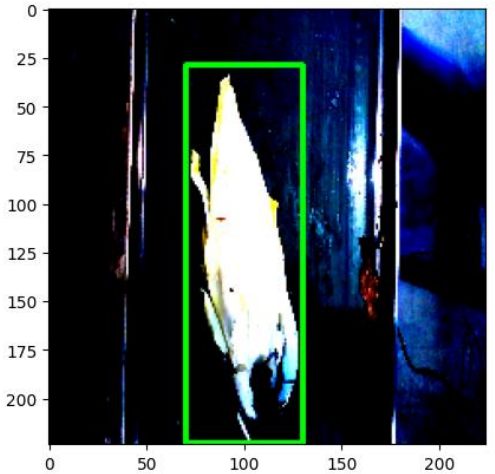
Preprocessing steps:

- Change format to tensor
- Pixel values in float
- Resize to (244,244)
- Normalize the image
- Bounding boxes must be resized as well

Original image

After preprocessing

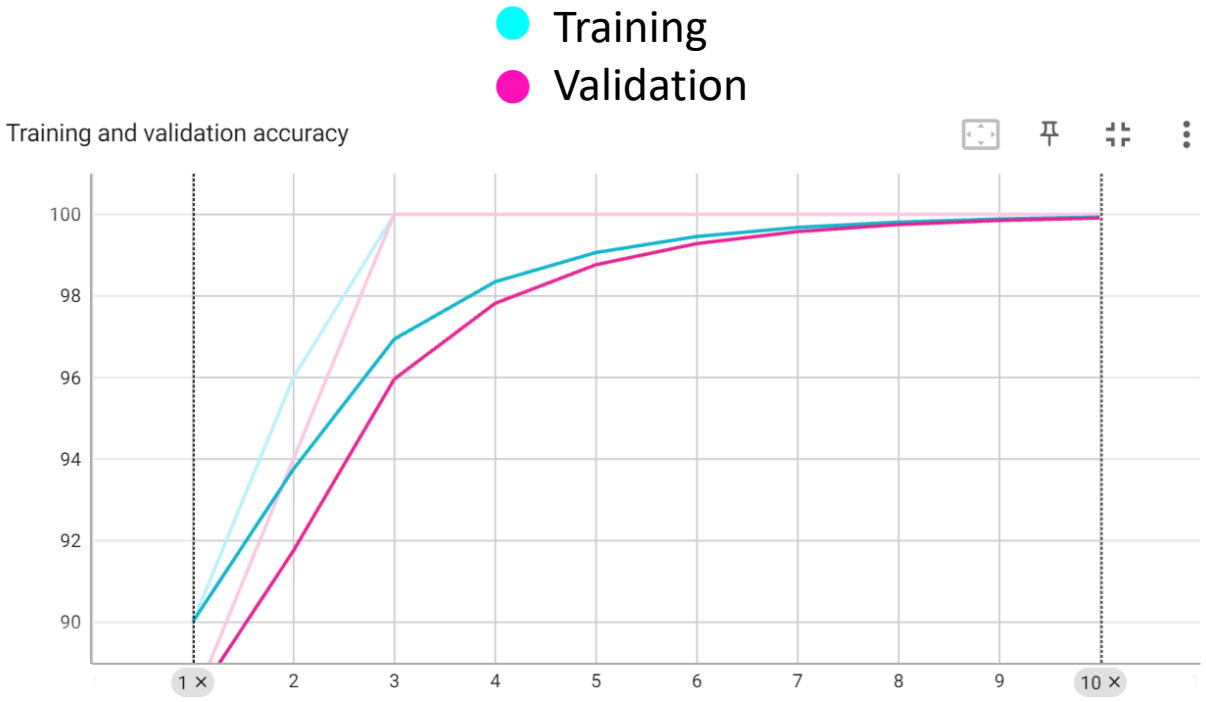




Met de steun van VLAIO

Case 2 - Detection of the optimal cut line for chicory

Classification - Training with 10 epochs - Batch size of 64 - Learning rate of 0.001

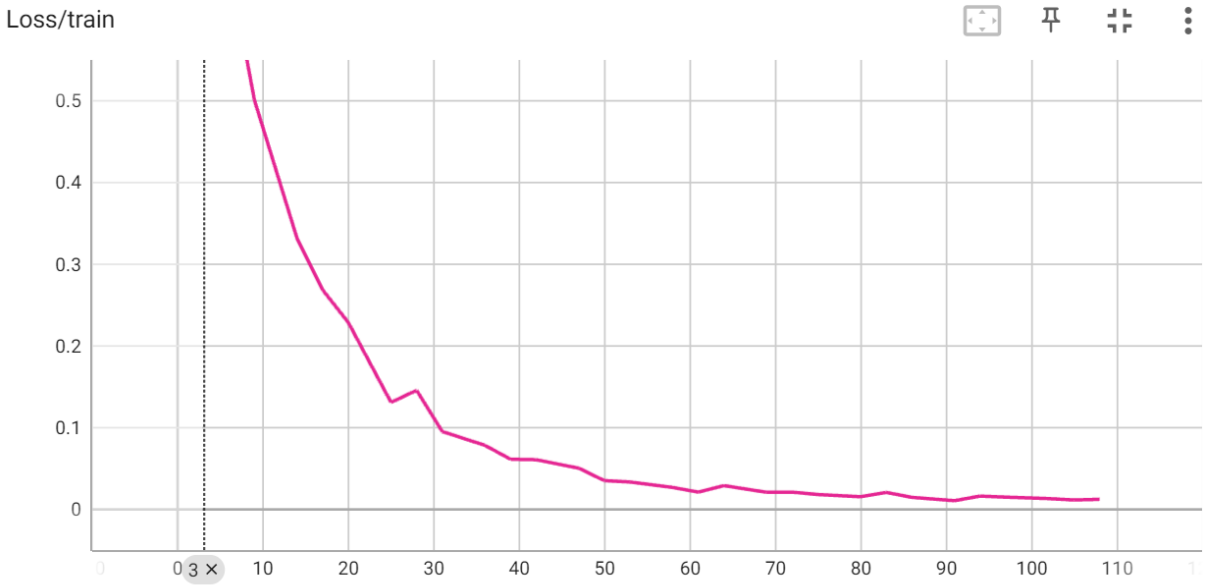


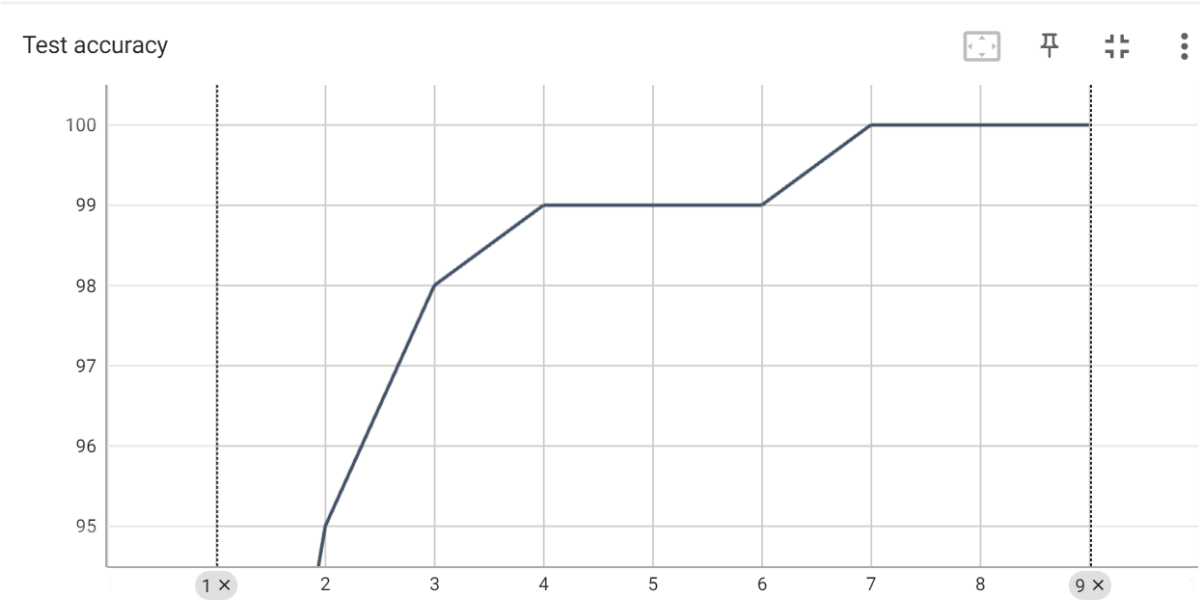
Actual class \ Predicted	Root	No Root
Root	50 (98%)	0 (0%)
No Root	1 (2%)	96 (100%)

Met de steun van VLAIO

Case 2 - Detection of the optimal cut line for chicory

Classification - Training with 10 epochs - Batch size of 64 - Learning rate of 0.001

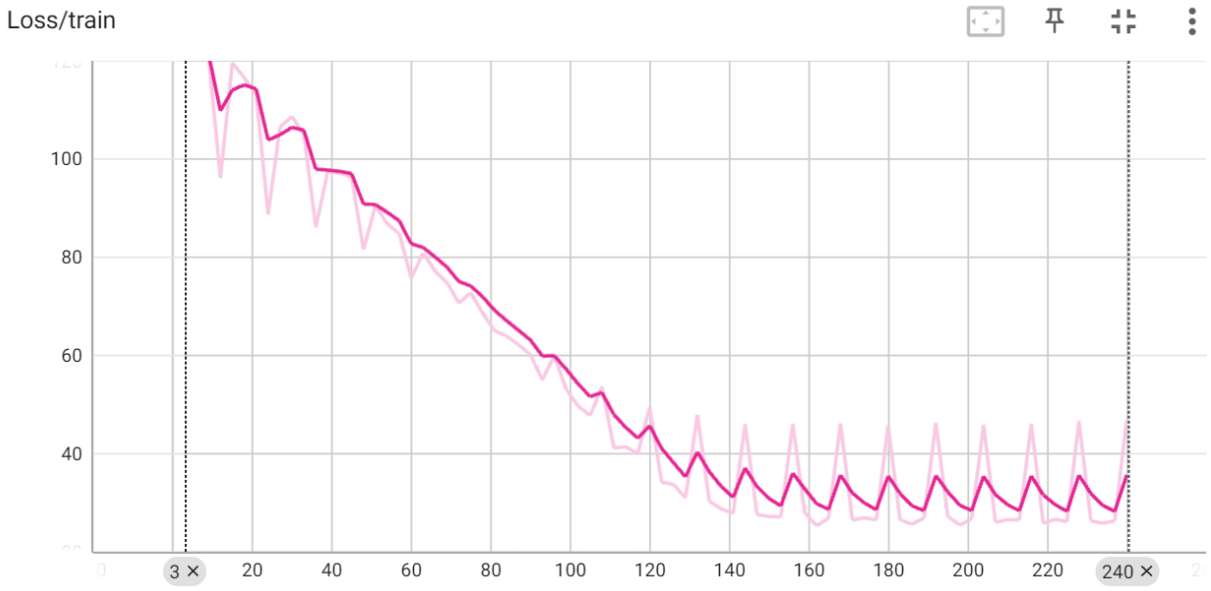


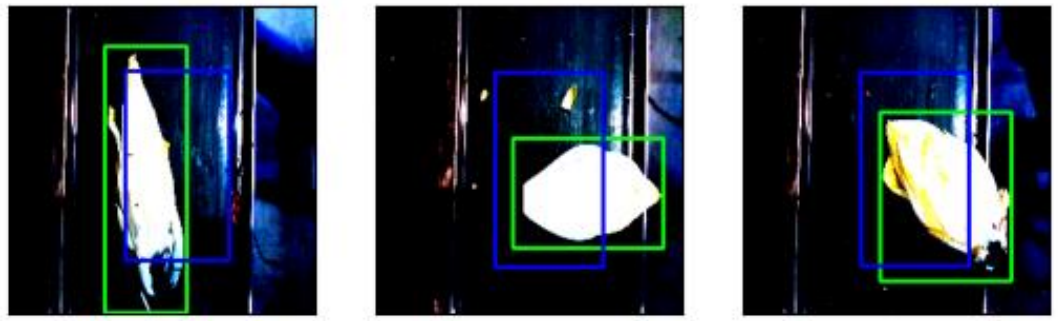


Met de steun van VLAIO

Case 2 - Detection of the optimal cut line for chicory

Detection - Training with 20 epochs - Batch size of 64 - Learning rate of 0.001

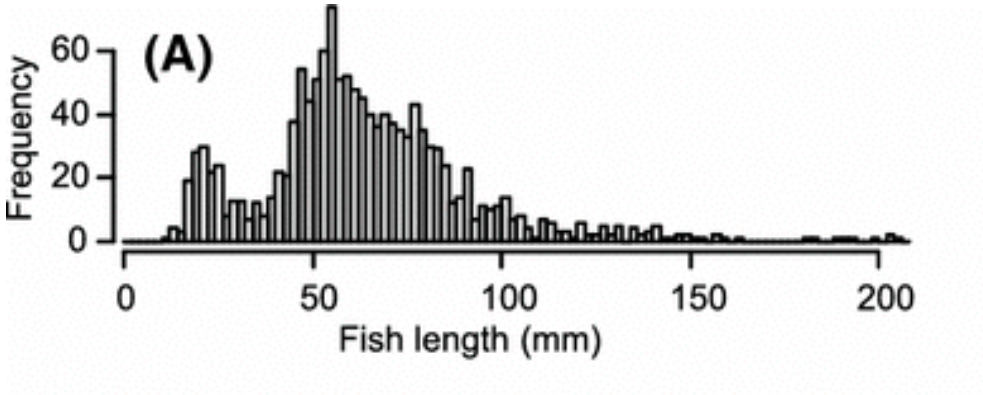


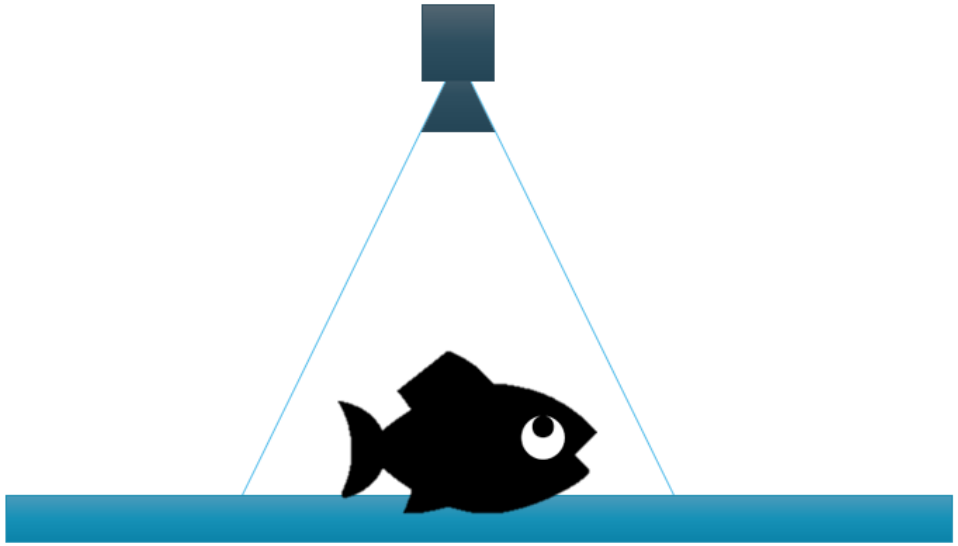


Met de steun van VLAIO

Case 3 - Inline determination of the length distribution of fish by category

- Instituut voor Landbouw-, Visserij- en Voedingsonderzoek
- Ecologisch project
- Spreiding lengte vissen per soort





Met de steun van VLAIO

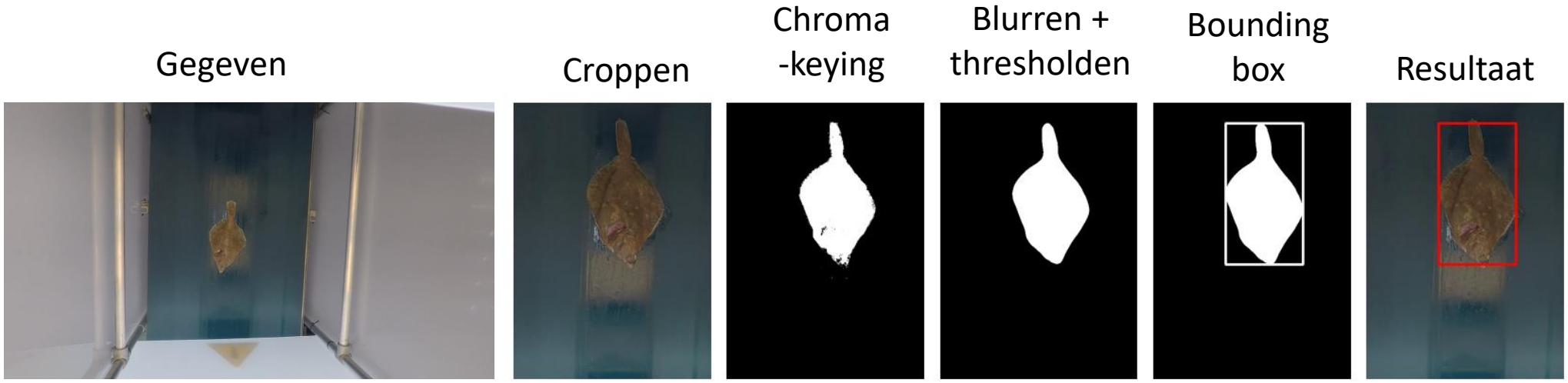
Case 3 - Inline determination of the length distribution of fish by category

Video van lopende band

⇒ Enkel vis detecteren

⇒ YOLO trainingslabel

YOLO FORMAT
<class>, <centerx>, <centery>, <bbwidth>, <bbheight>

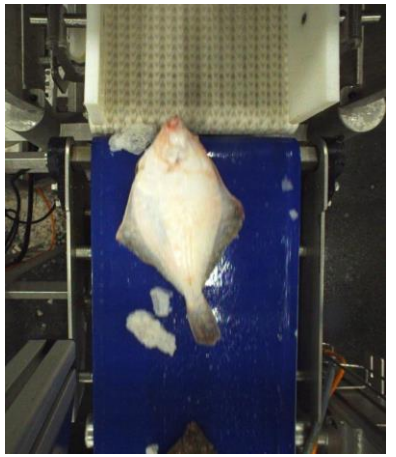


Case 3 - Inline determination of the length distribution of fish by category

Classificatie en bounding box

- ⇒ Met labelbox
- ⇒ 15 soorten
- ⇒ .json file
- ⇒ Yolo traininglabel

YOLO FORMAT
<class>, <centerx>, <centery>, <bbwidth>, <bbheight>



Met de steun van VLAIO

Case 3 - Inline determination of the length distribution of fish by category

Deel YOLO

- Pakket github
- Snelle training
- Hoge nauwkeurigheid

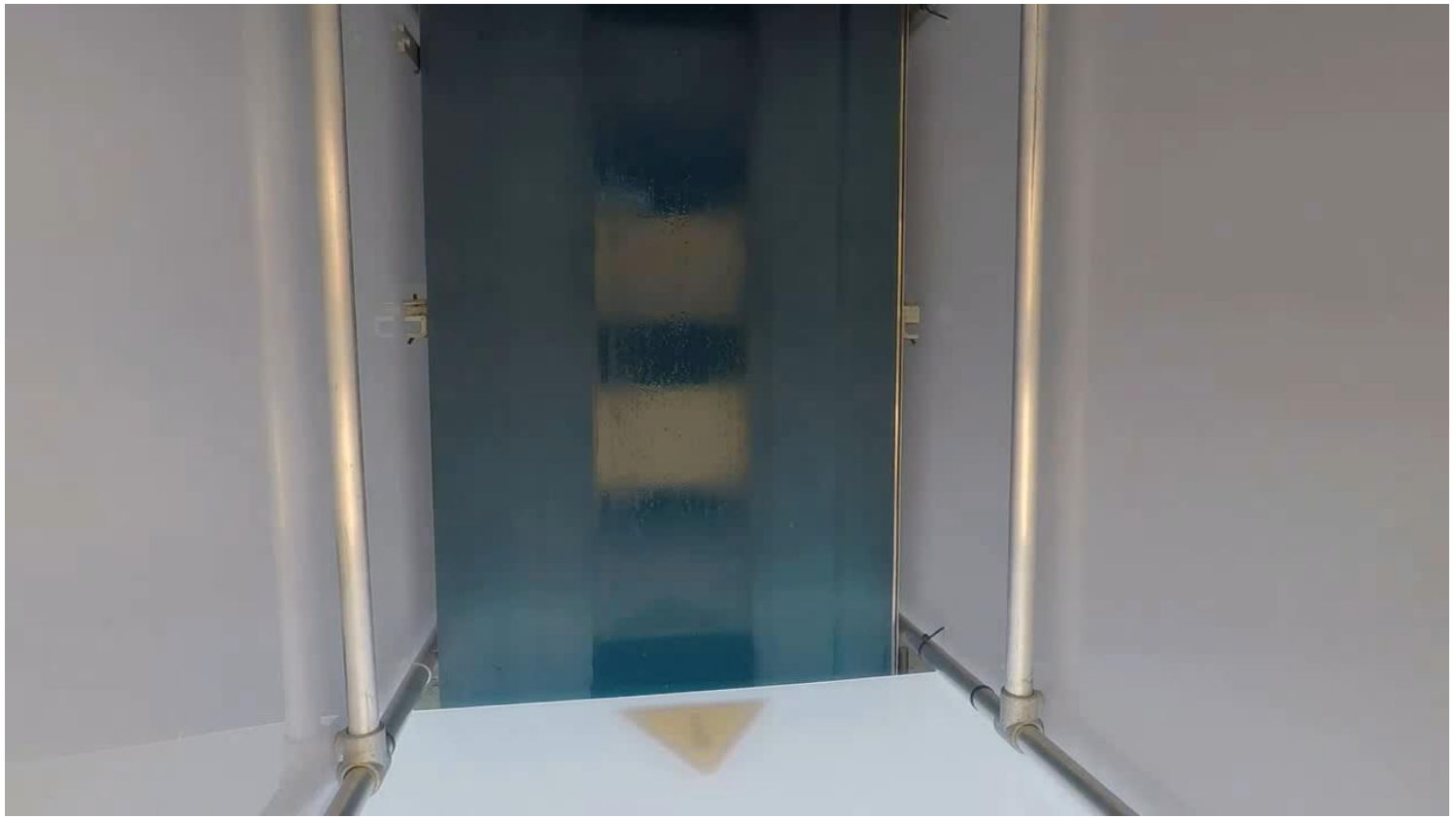
Deel Resnet

- Academischer
- Elke parameter tweaken
- Tragere training

Met de steun van VLAIO

Case 3 - Inline determination of the length distribution of fish by category

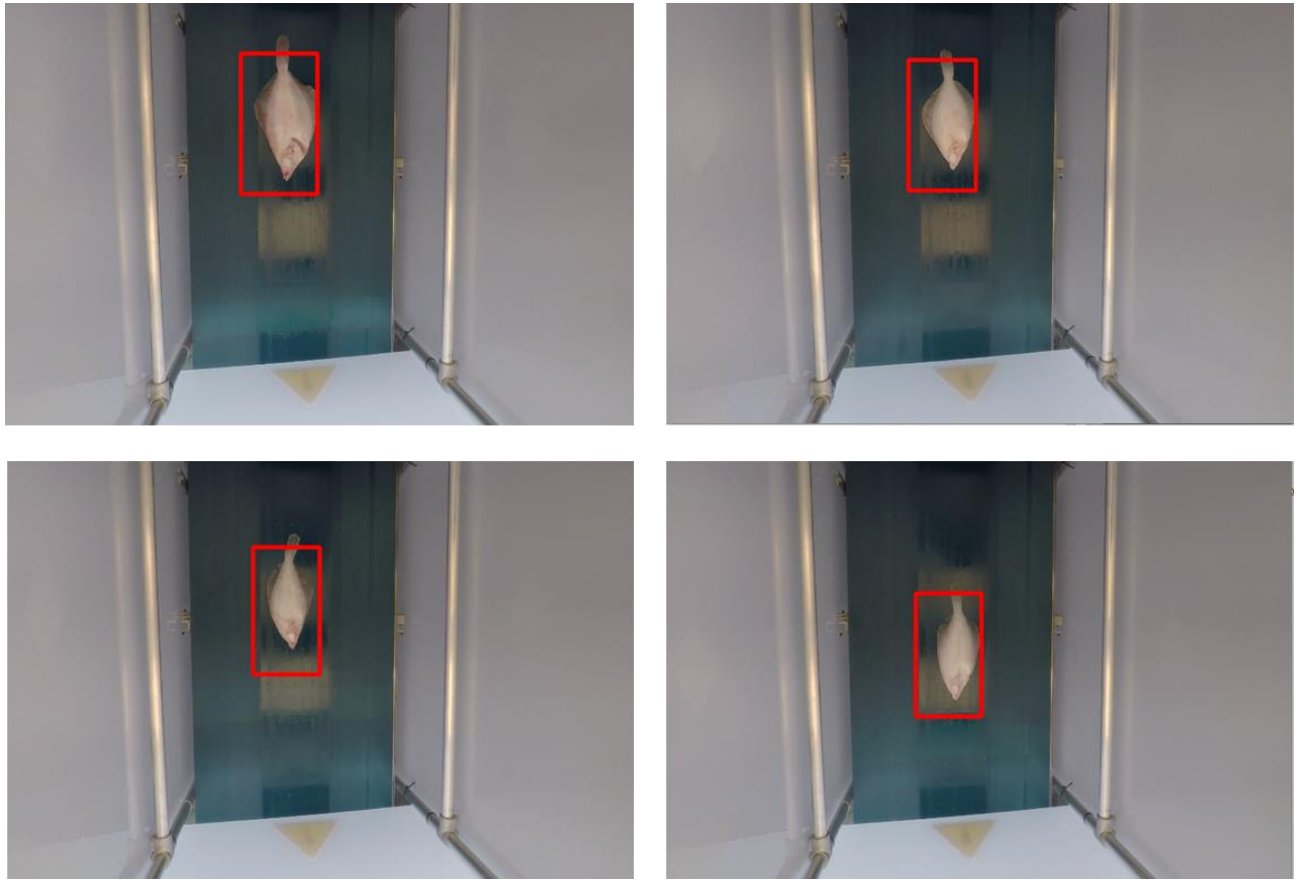
Resultaat YOLO



Met de steun van VLAIO

Case 3 - Inline determination of the length distribution of fish by category

Resultaat ResNet



Met de steun van VLAIO

Case 3 - Inline determination of the length distribution of fish by category

Trainingstijd (GPU)

- # Epochs
- Resolutie trainingsdata
- Learning rate
- Batch size

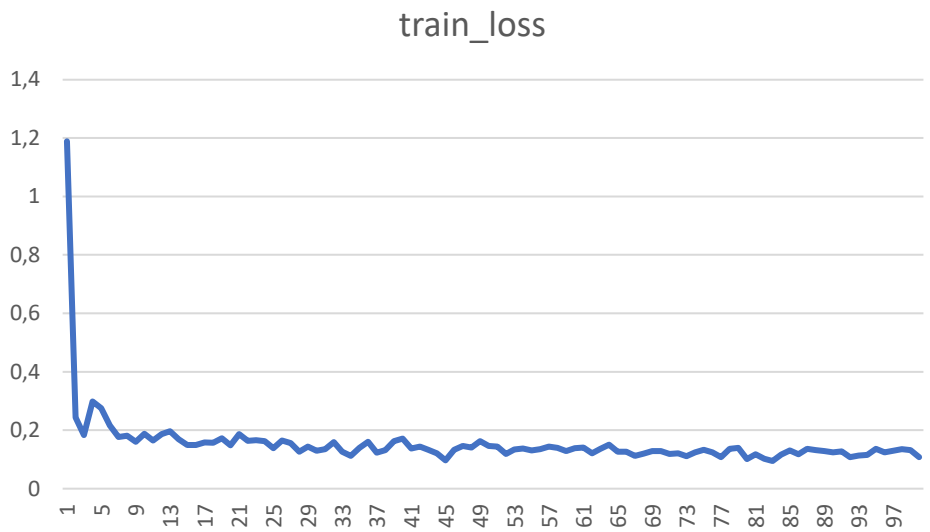
- Data augmentation
- Andere optimizers
  - Adam
  - SGD → momentum

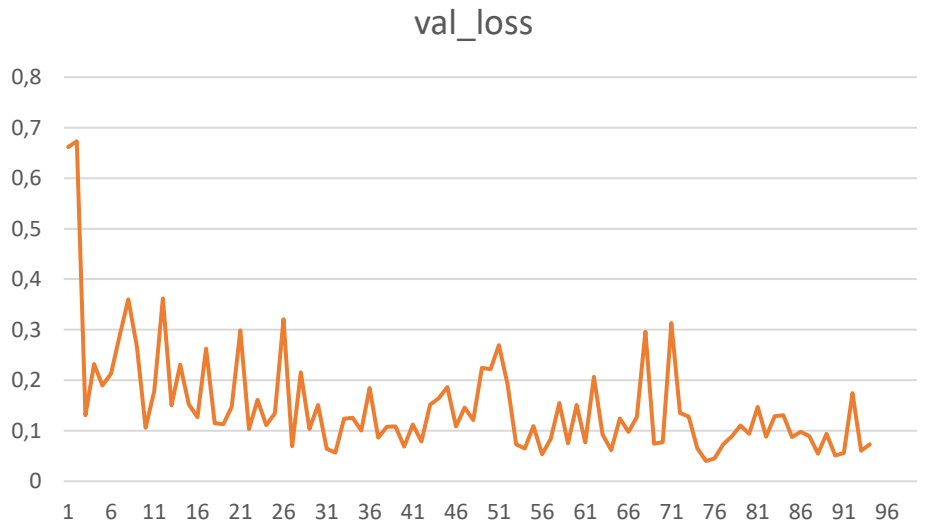
Batch size * Opslag per foto = Opslag GPU

Met de steun van VLAIO

Case 3 - Inline determination of the length distribution of fish by category

Trainingsresultaten





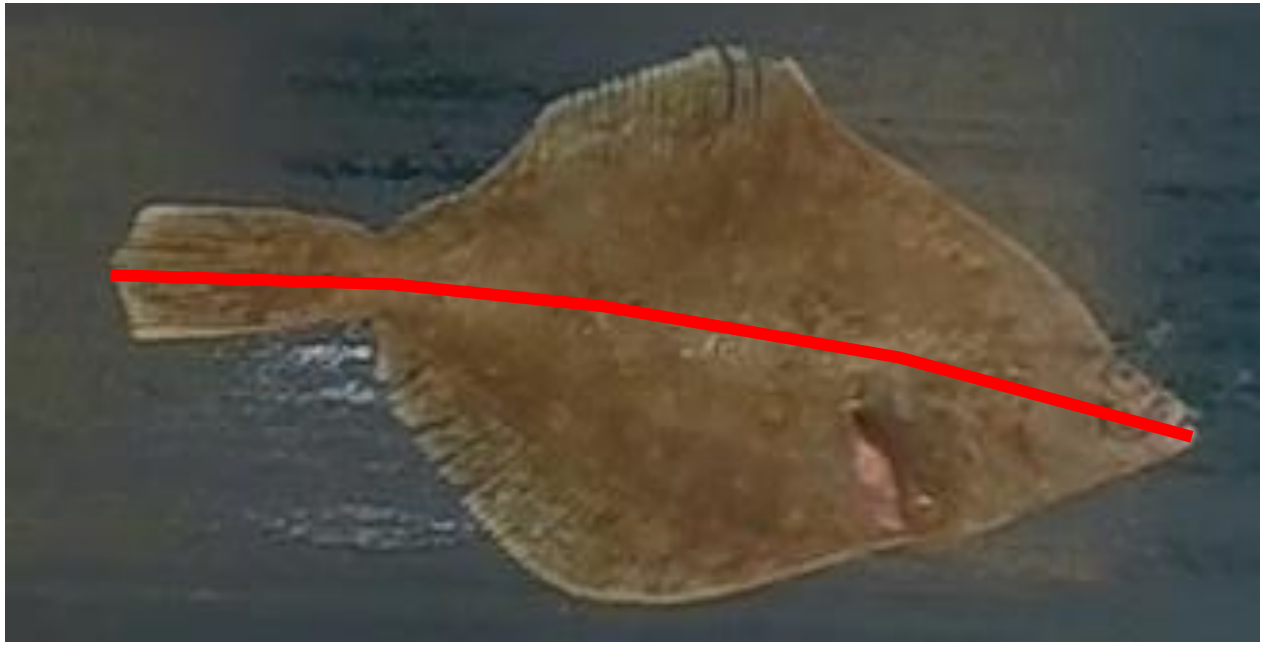
Ook accuracy (nog te weinig soorten)

Met de steun van VLAIO

Case 3 - Inline determination of the length distribution of fish by category

Spline detection

- Lengte bepaling
- AI of klassieke machine visie
- Beter dan enkel bounding box
- Makkelijker door bounding box



Met de steun van VLAIO

Case 4 - Determination of the proper functioning of a LED display

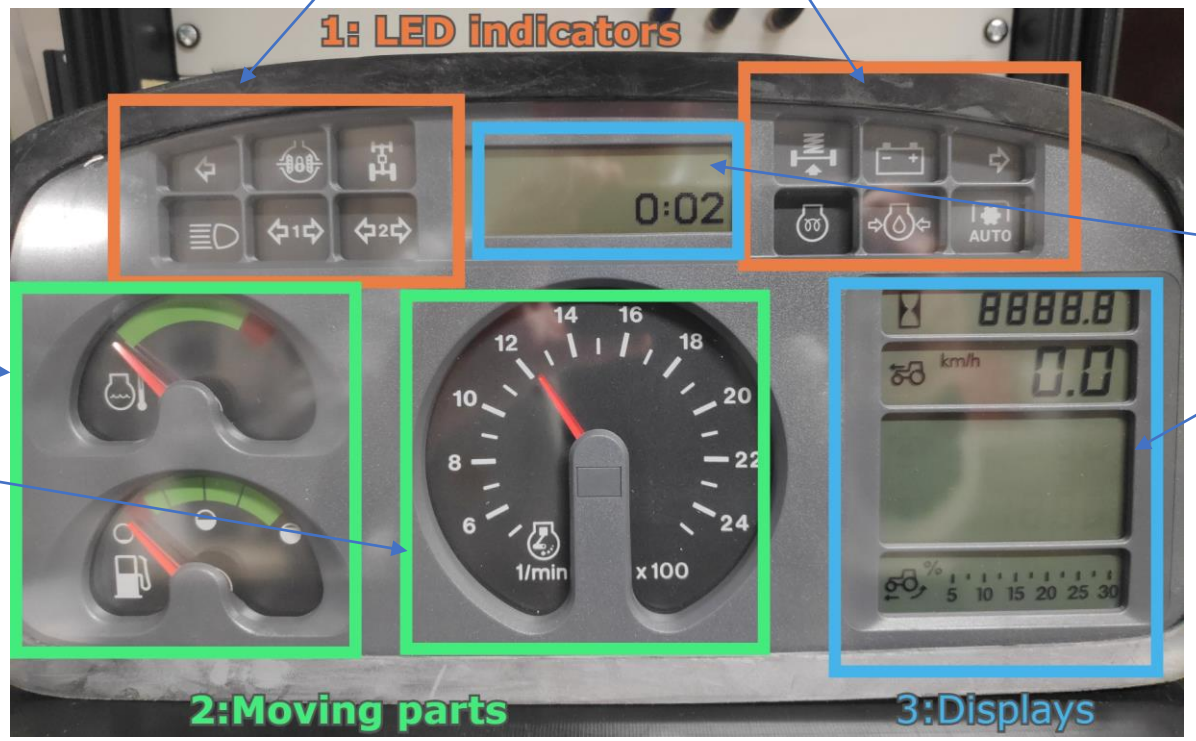
- Problem
- Methodology
- Results
- Industrial proposal
- Proposed flowchart
- Questions?

Met de steun van VLAIO

Case origin

Parts of the Display

```
test_is_led_on(img, filter)
```




```
get_angle_180_gauge(img)
get_angle_360_gauge(img)
```

```
inspect_displays()
```


Met de steun van VLAIO

Methodology

Met de steun van VLAIO

Setup

Traditional Computer Vision → No AI model

→ Only using OpenCv functions

- Template matching
- HSV filtering
- Canny edge detection
- HoughCircles
- HoughLines

Met de steun van VLAIO

Data

No AI model → Dataset different

→ Problems?

- Lighting
- Reflection
- position

Calibration

Goal? Find components on display

On  find the 

```
res = cv2.matchTemplate(img, template, method)
```

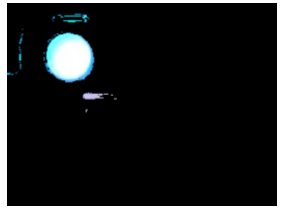
Save locations for later use

Met de steun van VLAIO

Evaluation of LED

1: Take the component

2: Use HSV filter → Only want the color of the LED



3: Find the circle → Circular light source is probably the LED

Met de steun van VLAIO

Evaluation of Gauge

1: Take the component → Pointer indicates value

2: Use HSV filter → Only want the pointer

3:Find the middle line → Use edge lines + validation line

4:Get the angle of the middle line → Convert it to a value

Met de steun van VLAIO

Evaluation of Gauge: Speedometer?

99% the same as the previous

Get edge lines

Draw line

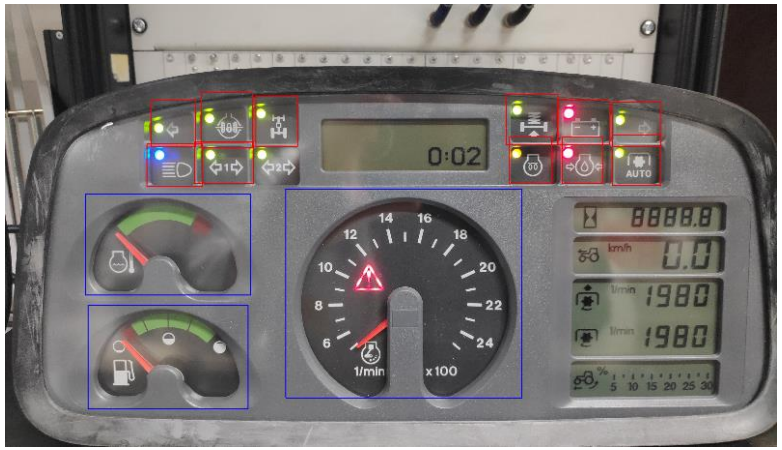
Find Pointer line

Results

Met de steun van VLAIO

Calibration example

Calibration script → Finds and saves component data



But:

- Visual confirmation needed
- Lighting problem!
- Display must be static!

Met de steun van VLAIO

Evaluation example

Evaluation script

Iterate and do check

```
Testing LED: direction_indicator_right
Status led on:  off
It was supposed to be:  off
Testing:  {'name': 'speed', 'coords': [1475, 1483, 2699, 2564]}
Testing GAUGE
0
Testing:  {'name': 'fuel_gauge', 'coords': [450, 2084, 1280, 2621]}
Testing GAUGE
```

But:

- How do we create the expectation?
- How do we give feedback?
- How do we integrate it?

Met de steun van VLAIO

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Industrial proposal

With support of Beckhoff

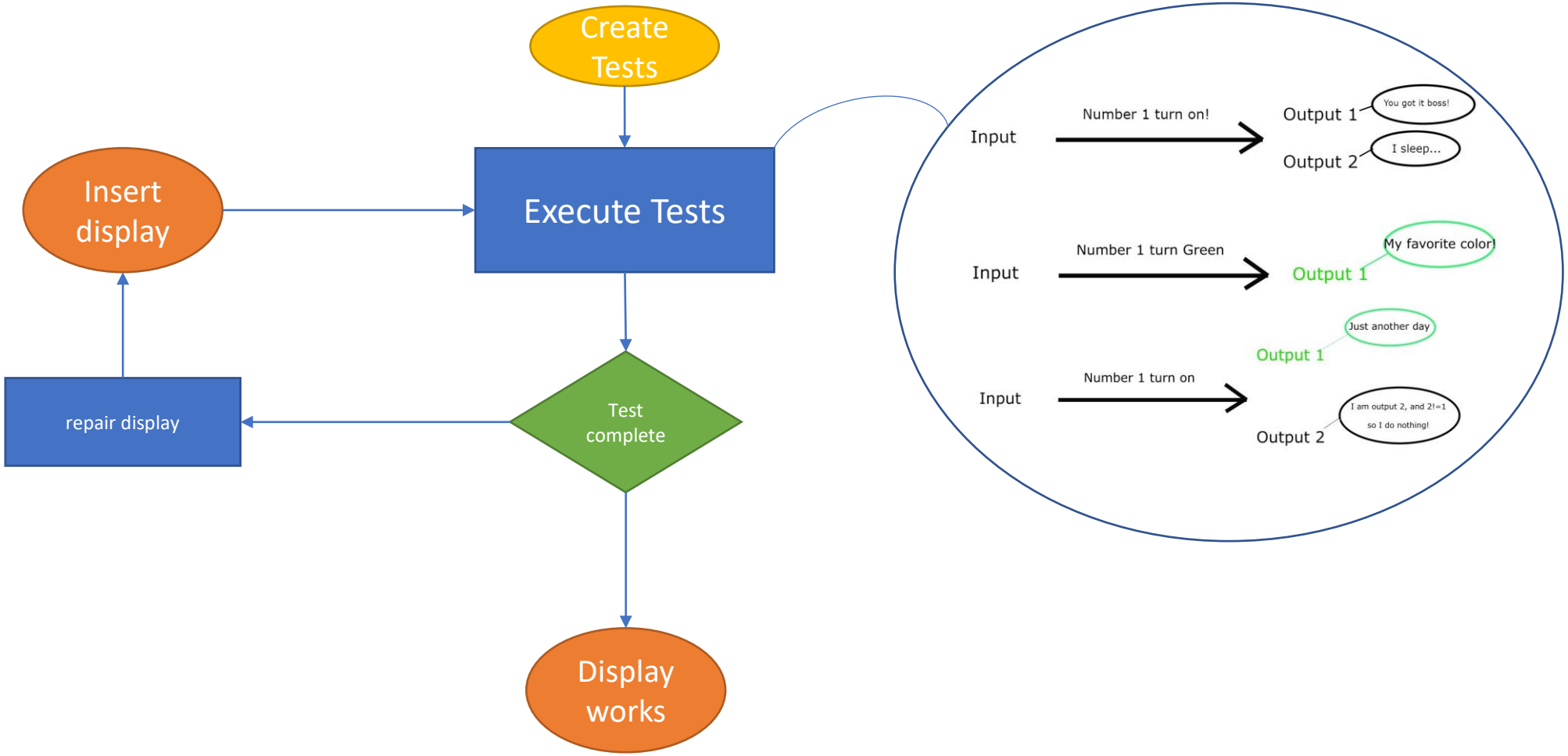
Met de steun van VLAIO

Robust system based on commercial hardware

- Hardware proposal used for initial testing by Beckhoff
  - Beckhoff CX2043
    - Industrial PC
    - CanOpen Master
      - Using different protocol
      - Direct communication with Module
  - Camera
    - **VCS2001-0200** Area scan camera, 2.5 Gbit/s, Sony IMX392, color, 2.3 MP
      - Kleur nodig: verschillende LED kleuren
      - Resolutie : hoge resolutie is niet noodzakelijk (features regio 1mm)
  - Lens:
    - **VOS2000-1218** Lens, image circle 11 mm, pixel size up to 2.0 µm, f = 12 mm, f/1.8
    - Combinatie met werkhoogte van 500 mm

Met de steun van VLAIO

Proposed flowchart



Met de steun van VLAIO

Case 5 - Inline determination of the fat absorption of donuts after frying





Doughmix	Extrusion en cutting	Proofing	Frying	Cooling
Flour, water, sugar, yeast, fat and donut mix and rework		Water ↑ Flour ↑	Fat ↑ Water ↓	Fat distribution uniformity ↓

Fat absorption (FA) = $\frac{F - P}{F} \times 100\ \%$

Met:

P Proofed dough weight

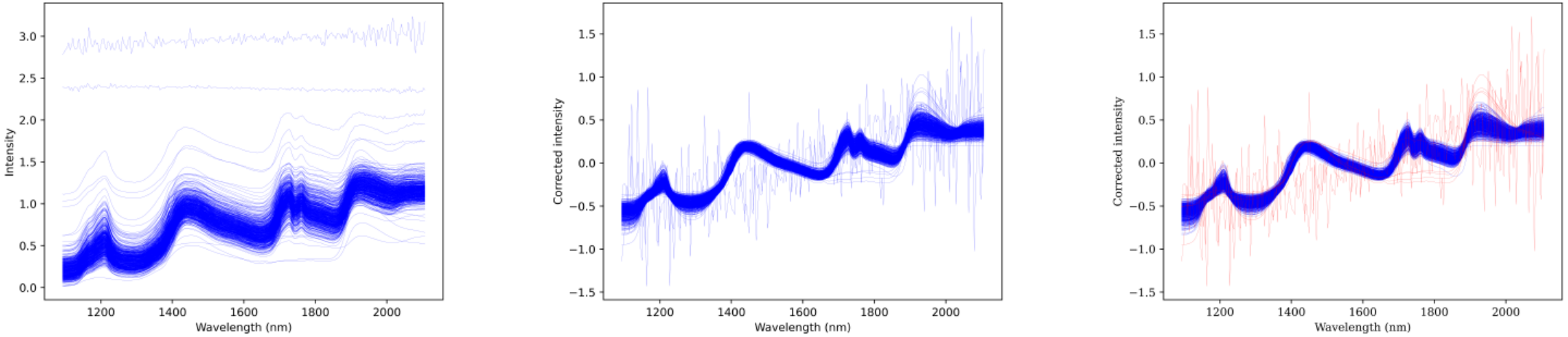
F Fried donut weight

Case 5 - Data capture

- 10 Februari 2023
- **Covicon** voorziet de PAS-H-B01 probe met bijhorende NIR proces spectrometer.
- Opmeten van invloed van proofing, frying and cooling in meerdere stappen bij Vandemoortele R&D
- Vandemoortele bepaald referentie waardes via een chemische analyse

Met de steun van VLAIO

Case 5 – Data pre-processing



(a) (b) (c)

Fig. 1: The raw data (1a) is preprocessed by MSC-correction (1b) and outlier (red) filtering (1c)

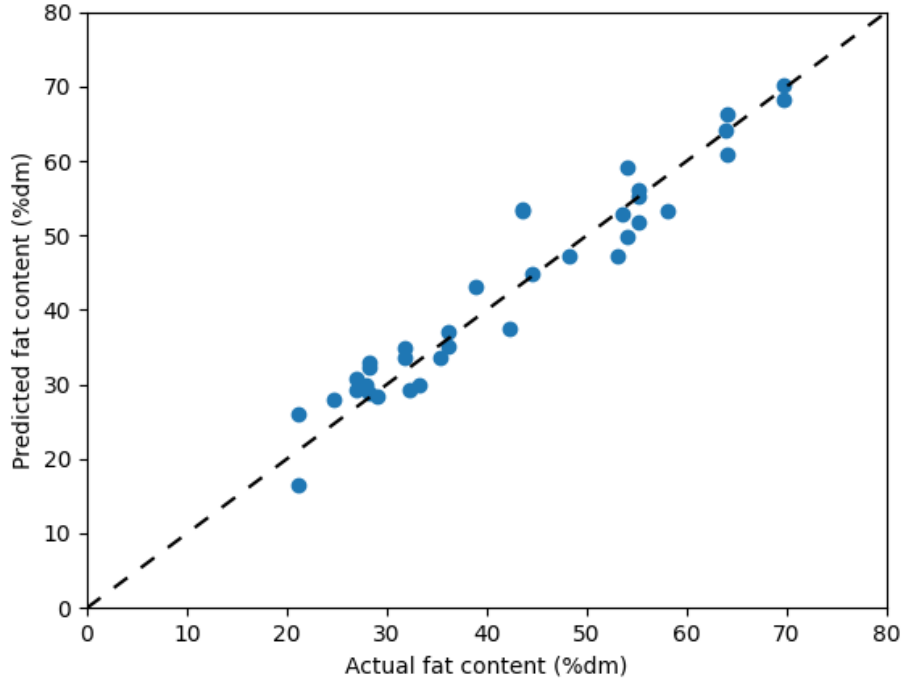
Met de steun van VLAIO

Case 5 - Fat & Moisture prediction

Huidige methode (Weibull-Stoldt)
RMSECV = 1.44

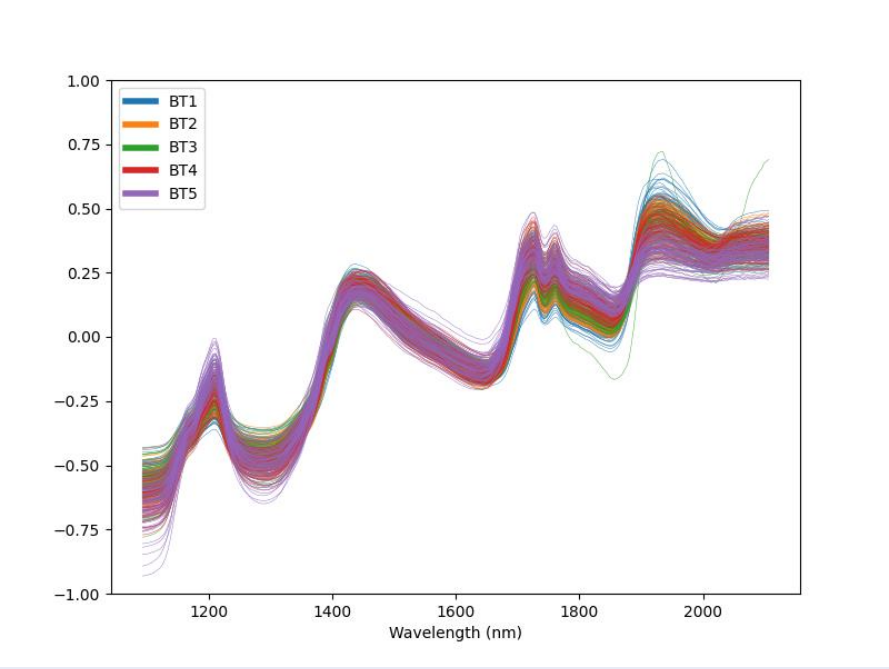
Hyperspectrale analyse
RMSECV = 4.2

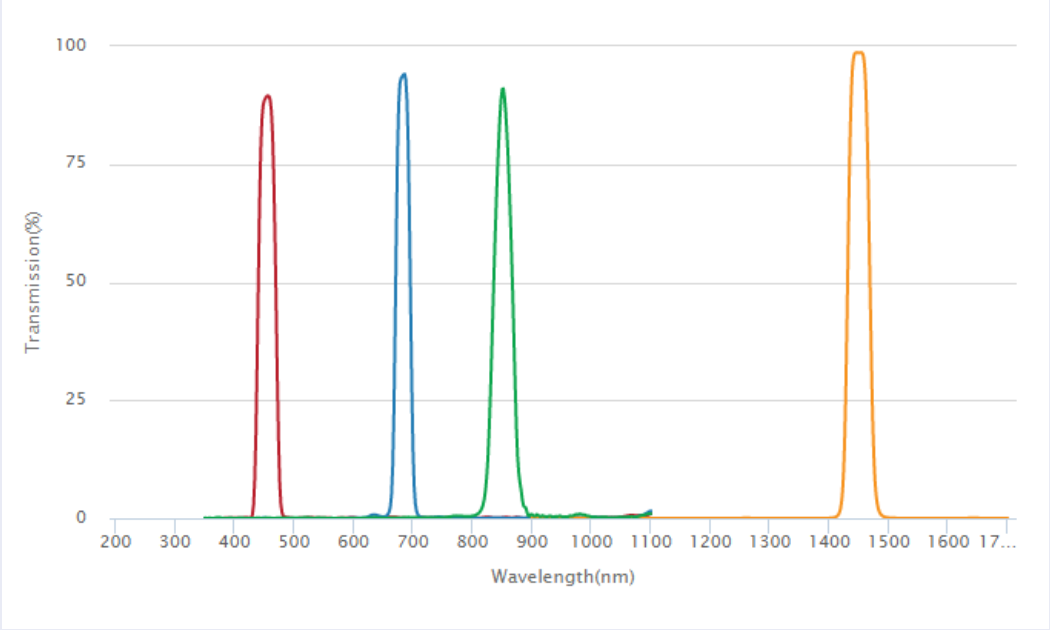
Label	Model (preprocessing)	Number of features	Cross-validation		Prediction	
			Rc^2	RMSECV(%)	Rc^2	RMSEP(%)
Fat	PLSR (SNV + SD)	81	0.89	4.20	0.92	3.8
	LS-SVM (SNV)	79	0.68	7.32	0.75	7.14
Moisture	PLSR (SNV + SD)	60	0.88	1.83	0.92	1.61
	LS-SVM (SNV)	63	0.68	2.96	0.83	2.39



Case 5 – Next steps

Hyperspectraal	Multispectraal
81 Banden van 8 nm	Meerdere commercieel beschikbare filters





Met de steun van VLAIO

Case 5 – Next steps

- Valideren van resultaten voor potentiële implementatie

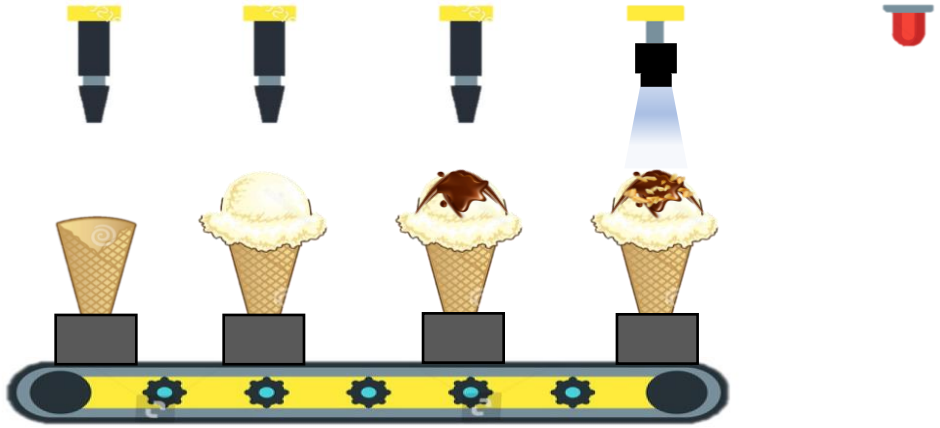
- Mogelijkheden overleggen met **integratoren** voor opstellen van testopstelling + kostenschatting

Met de steun van VLAIO

Case 6 - Detection of a sufficient presence of nuts and sauce on Cornetto's

- Quality control based on the topping present (sauce, nuts, curls, …) on Cornetto's

- Production process:



Met de steun van VLAIO

Case 6 – Literature Study

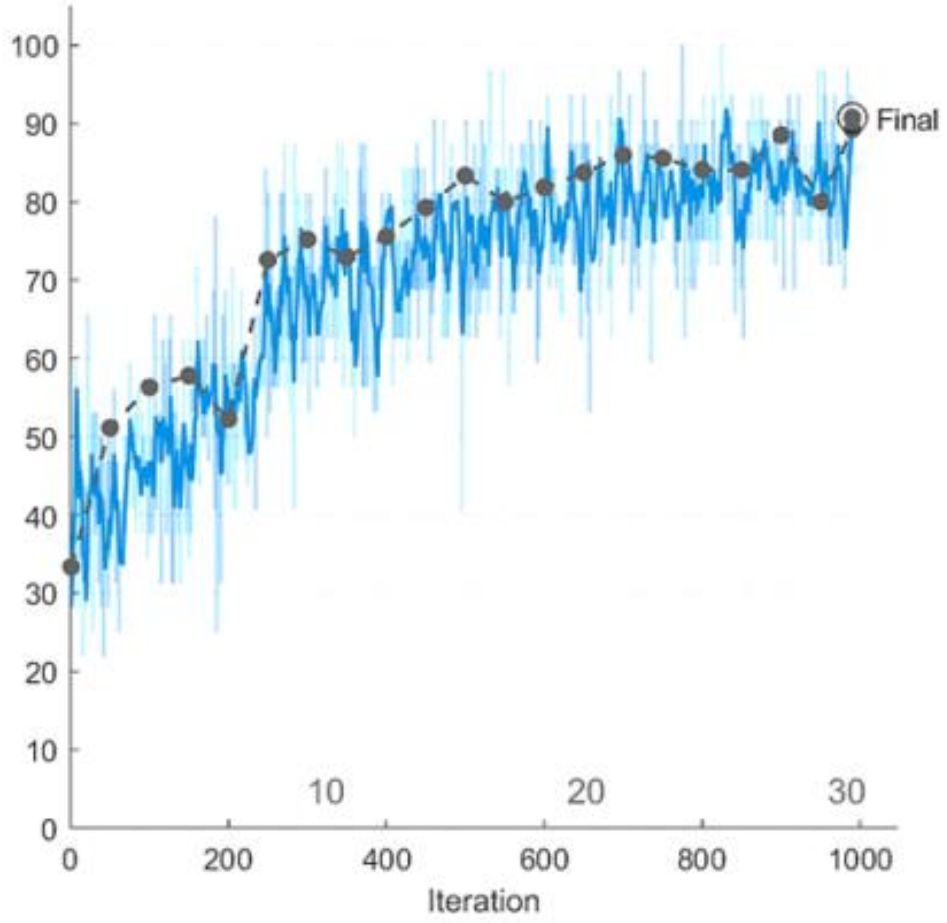
- Quality classification of Copra
- Pre-processing:

Bel Colubio C., Denorte V. P. and Panga R., "Quality Classification of Copra Using Convolutional Neural Network", IEEE

Case 6 – Literature Study

Model training:

- 1080 images (80% train, 20% val)
- 30 epochs
- Validation accuracy: 90.74%

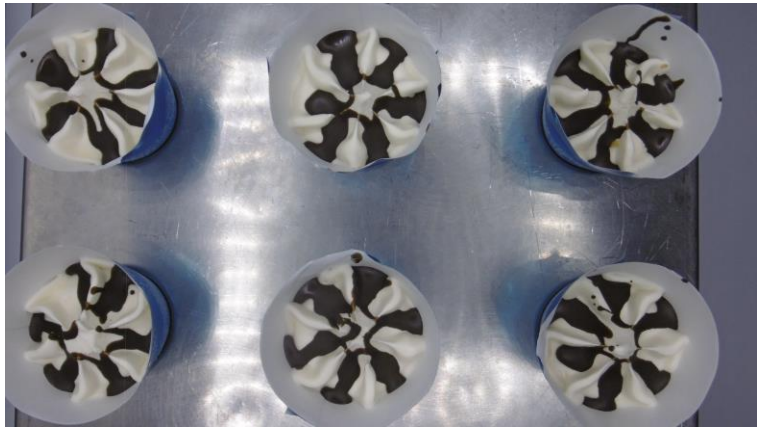


Bel Colubio C., Denorte V. P. and Panga R., "Quality Classification of Copra Using Convolutional Neural Network", IEEE

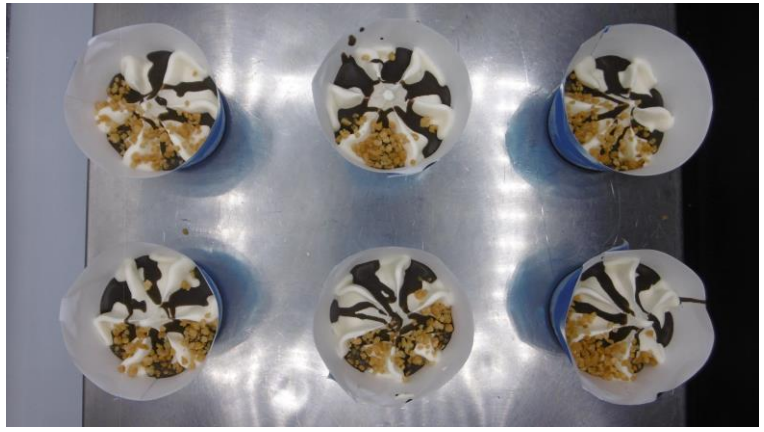
Met de steun van VLAIO

Case 6 – Data Capturing

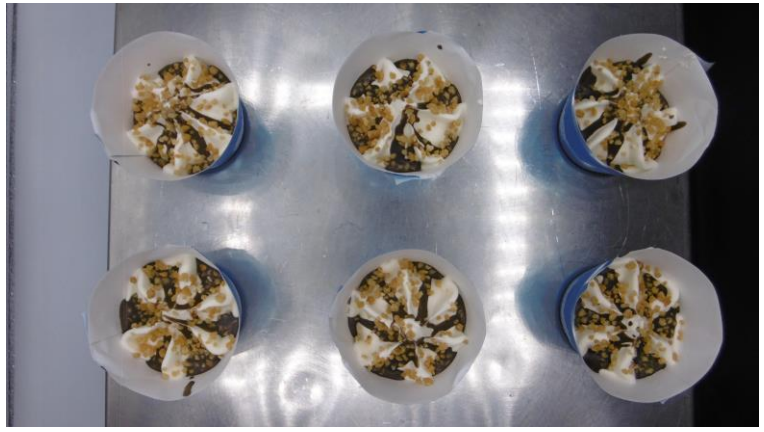
Handmade Cornetto’s with different gradations of defects



No nuts



Half coverage of the nuts

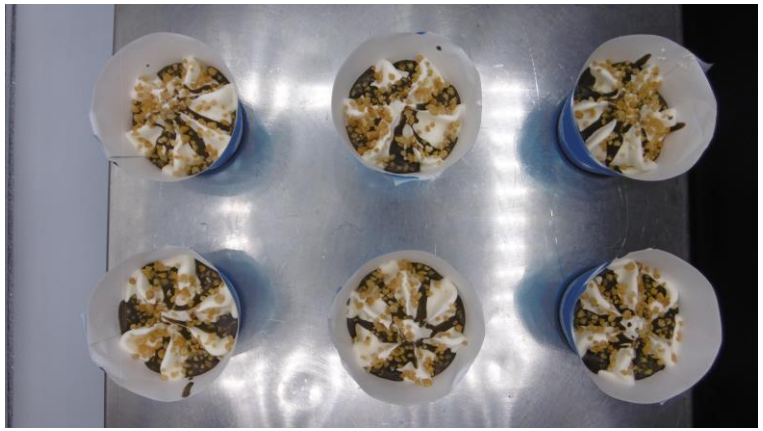


Full coverage of the nuts

Met de steun van VLAIO

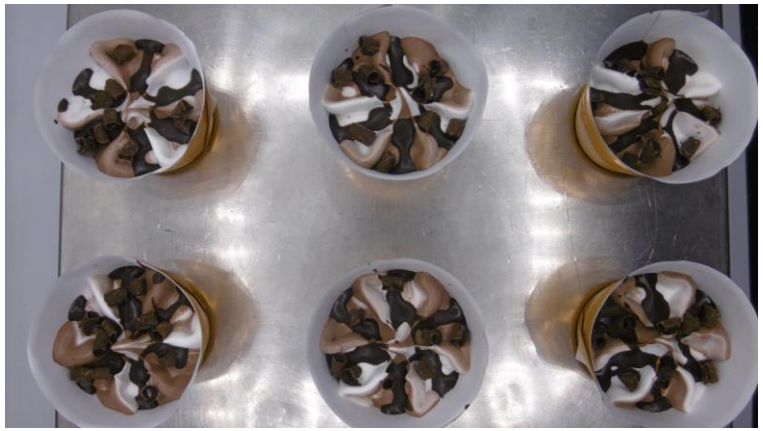
Case 6 – Data Capturing

3 different variants labelled by quality control technicians



2g sauce + 2g nuts → OK

4g sauce → OK



2g sauce + 1,5g curls → OK

Met de steun van VLAIO

Case 6 – Data Pre-processing

3 different variants:

1. Vanilla variant: 14 images with 6 Cornetto's
   - ➢ 84 samples: 60 ☑ en 24 ☒

2. Strawberry variant: 14 images with 6 Cornetto's
   - ➢ 84 samples: 60 ☑ en 24 ☒

3. Chocolate variant: 13 images with 6 Cornetto's
   - ➢ 78 samples: 54 ☑ en 24 ☒

- ➢ Imbalanced datasets

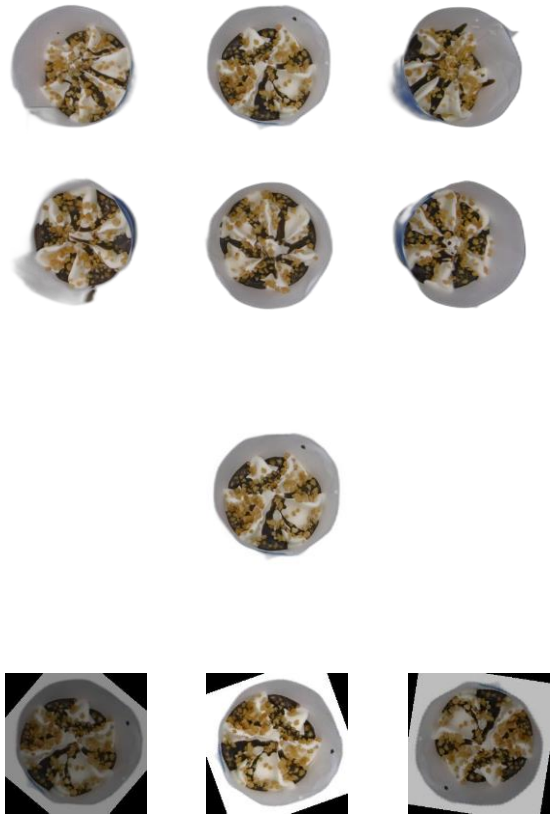
Met de steun van VLAIO

Case 6 – Data Pre-processing

1. Background removal

2. Manual cropping

3. Data augmentation



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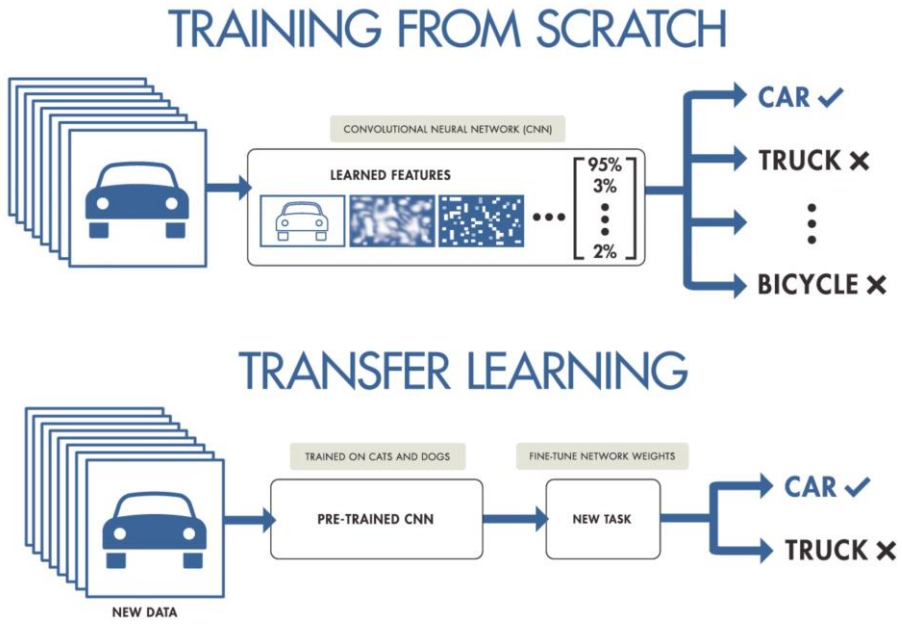
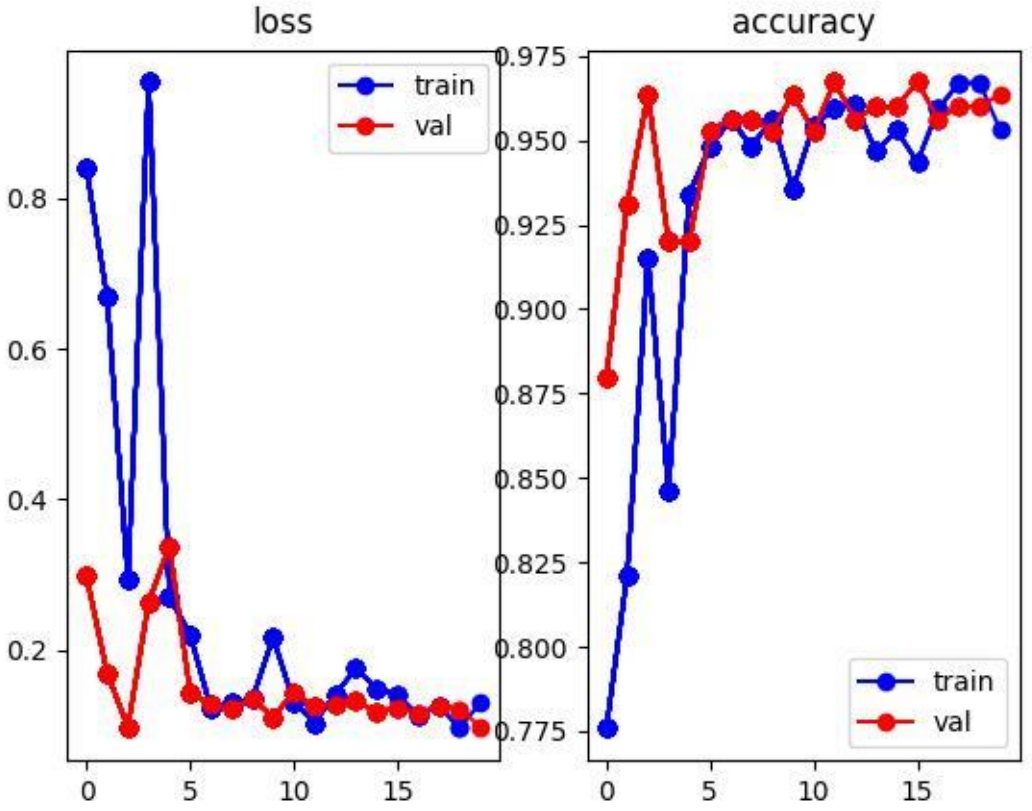
Case 6 – Model Training

- Binary classification of the Vanilla variant
- ResNet model → transfer learning
- 638 images in training set
- 275 images in validation set

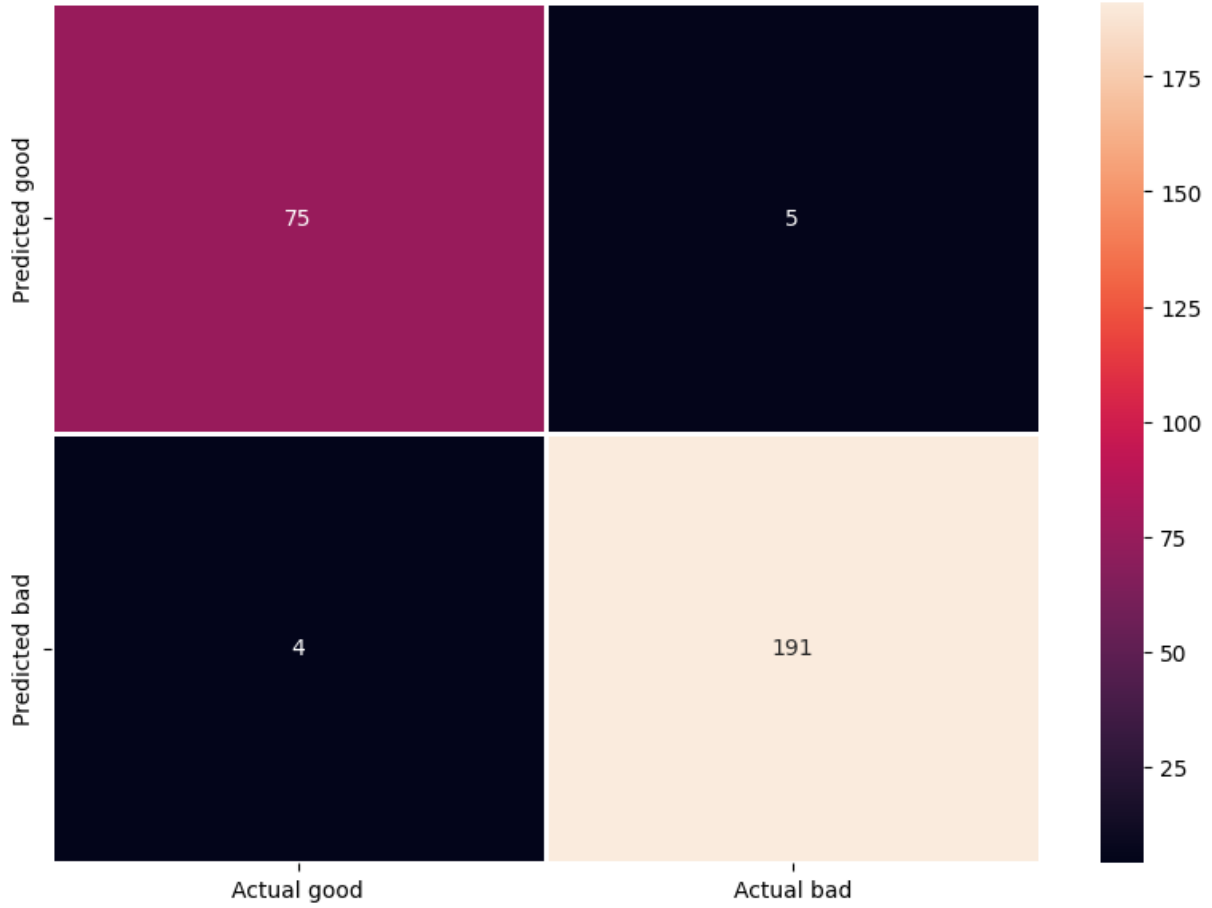


Met de steun van VLAIO

Case 6 – Model Evaluation



Case 6 – Model Evaluation



Met de steun van VLAIO

Case 6 – Next steps

- Binary classification:
  - A separate model for the other variants
  - One model for all the variants

- Multi-label classification:
  - A separate model for the other variants
  - One model for all the variants

- Capturing data from the production line

Met de steun van VLAIO

Toelichting demonstratoren

Met de steun van VLAIO

Demonstrator

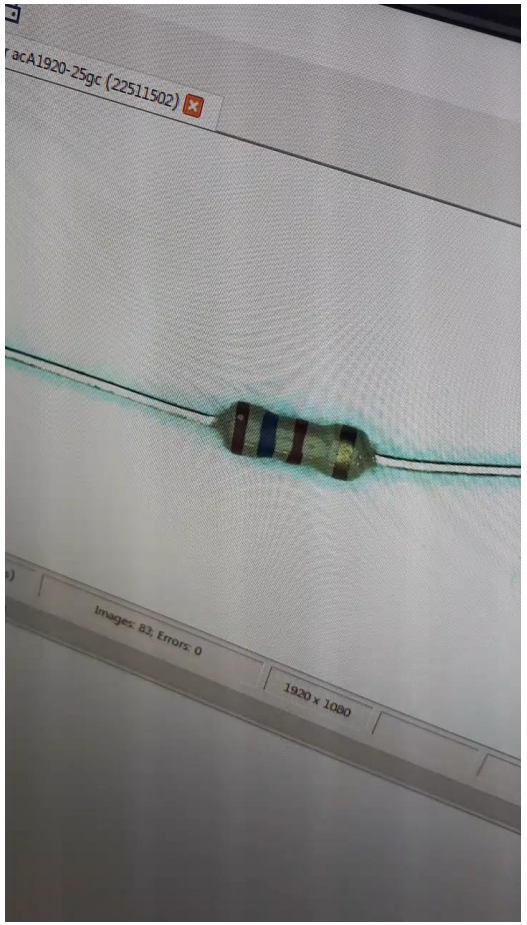
Circulaire setup gemaakt in functie van Hannover Messe 2023

	Demo 1	Demo 2	Demo 3	Demo 4
Beschrijving	Detectie van de 3D coördinaten van een bal	Detectie van de snijhoek van een zaagblad	Detectie van de waarde van een weerstand	Classificatie van schade op houten plaatjes
Applicatie	3D applicatie	Meet applicatie	Kleur applicatie	Classificatie
Techniek	Stereo visie	Lijn / cirkel detectie	Machine Learning	Deep Learning
Camera	RealSense D415	Omron Mono	IDS Color	RealSense D415
Belichting	/	Back light	Dome light	Bar light
Lens	Fixed focus	Telecentrisch	Fixed focus	Fixed focus

➔ Variatie aan technieken, camera's, lenzen, en belichting

Met de steun van VLAIO

Demonstrator



Met de steun van VLAIO

Volgende vergadering

- Midden Juli
- Bedrijf?
- Doodle wordt eerstdaags uitgestuurd.

Met de steun van VLAIO

Website

https://www.mv4qc.be

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