



# Artificial Intelligence for Image Analysis

*Professorship Computer Vision & Data Science*

Presentation for Samenwerking Noord

5 July 2023

*Dr. Klaas Dijkstra*



# NHL Stenden



24000  
STUDENTS

APPROX. 15%  
INTERNATIONAL  
STUDENTS



DESIGN  
BASED  
EDUCATION



14  
ACADEMIES  
35  
PROFESSOR-  
SHIPS



MULTI  
CAMPUS  
UNIVERSITY



17  
ASSOCIATE'S  
DEGREES



76  
BACHELOR'S  
DEGREES

90+  
STUDENT  
NATIONALITIES

2250  
ACADEMIC  
STAFF

51  
MINORS

20  
MASTER'S  
DEGREES



# Academy Technology & Innovation

- **RESEARCH** (5 groups)
  - Water Technology
  - Smart Sustainable Manufacturing
  - Computer Vision & Data Science
  - Sustainable Polymers
  - Circular Plastics
- **EDUCATION** (1700 students)
  - Associate, Bachelor and Master degrees
  - Engineering
  - Built environment
  - Life Science & Technology



# Academy ICT-CT

- **RESEARCH**

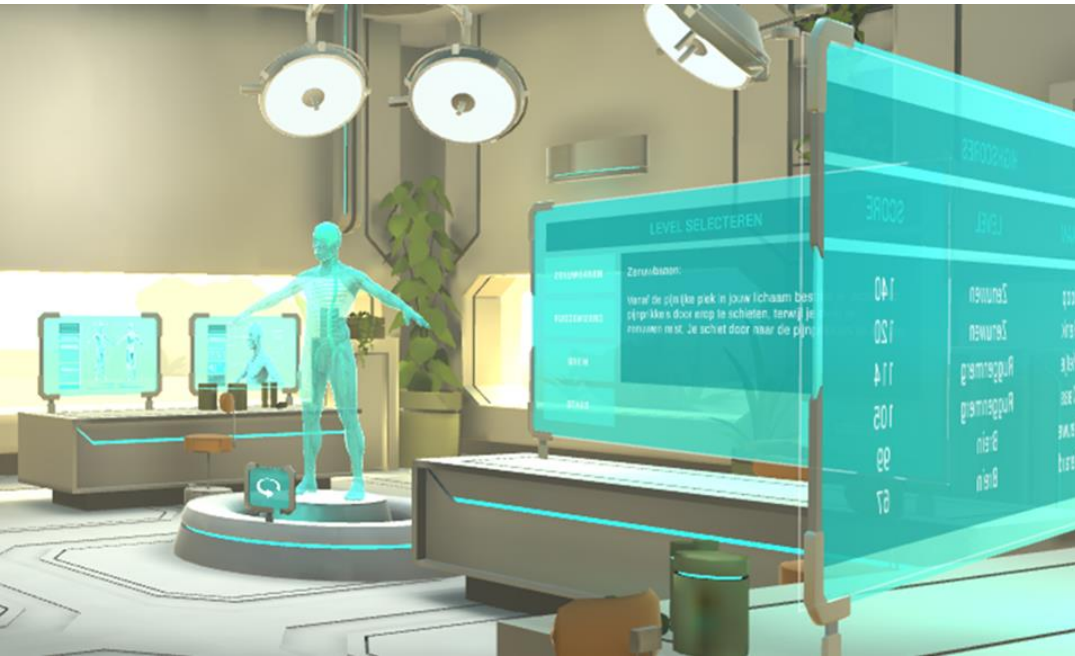
- Maritime Security
- ISA Lab
- Serious Gaming

- **EDUCATION**

- Associate, Bachelor and Master degrees
- HBO ICT
- CMD



# *Design Driven Innovation & Serious Gaming Research Group*



- Established in January 2023;
- Transdisciplinary design research for the challenges of an open, dynamic, complex and networked society;
- Ongoing design research projects in health Innovation, education development, transitions in agriculture and water management, governance, including two PhD-research programmes;
- We conduct research on and with artefacts and boundary objects and serious gaming, these boundary objects can be either analogue or digital in nature;
- We bring innovative and creative perspectives to the design process. We take a human-centred approach, focused on actionable insights and societal impact.

# Maritime IT Security Research Group



- Established September 2021
- Goal is to conduct impactful research into Cyber threats to the Maritime Transportation System (MTS)
- Our scope apart from traditional maritime activities includes inland waters, port facilities and other critical elements of the MTS
- This is achieved by leveraging our skills across disciplines within NHL Stenden in Ethical Hacking, Secure Programming, Serious Gaming, Maritime Technology, Maritime Officer Training, Marine Shipping Innovations and Cyber Safety
- Three major projects Maritime Cyber Incident Database, Ship Honeynet & Maritime Cyber Attack Simulations



- Leeuwarden

- CV&DS Lab

- High Performance GPU cluster
- State-of-the-art vision hardware

- Education

- Minor and Master CV&DS
- Master-Apprentice teaching

- Research

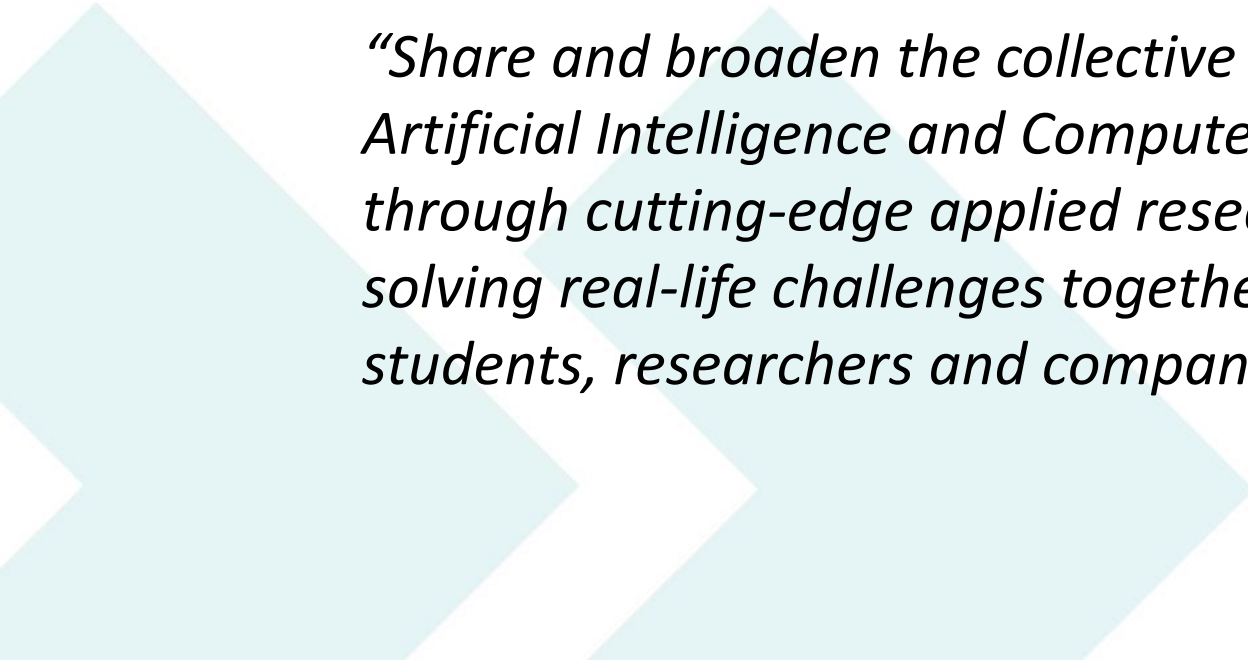
- Team of dedicated research staff
- Feasibility studies for companies
- Applied research projects



Two blue L-shaped lines forming a partial frame on the left side of the slide.

## Our mission is to

*“Share and broaden the collective knowledge on Artificial Intelligence and Computer Vision through cutting-edge applied research by solving real-life challenges together with students, researchers and companies.”*

Large, light blue geometric shapes, including a large arrow pointing right, positioned behind the mission statement text.



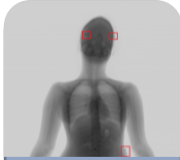
Artificial  
Intelligence

Computer  
Vision

Vision  
Systems



Agriculture and Horticulture



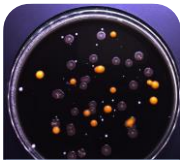
Safety and Security



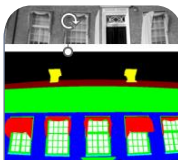
Public space and Tourism



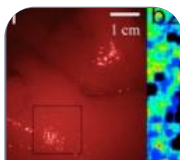
Circular economy



Water and Maritime



Industry and Inspection



Health and Medical

## Artificial Intelligence

- Data shortage
- Explainable A.I.
- Anomaly detection
- Synthetic data

## Computer Vision

- Image acquisition
- Pattern recognition
- Hyperspectral imaging
- Short-wave infrared

## Vision Systems

- Software and optimization
- Prototyping
- Camera, optics, lighting
- Smart data

# State-of-the-art vision hardware

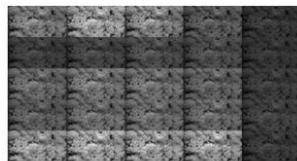
Industrial, NIR, SWIR, LWIR, Hyperspectral, etc.

## Snapshot Mosaic



**XIMEA 4X4-VIS**

- 470-630 nm
- 16 Bands



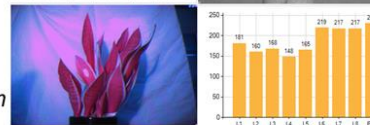
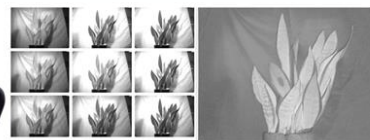
**XIMEA 5X5-NIR**

- 600-1000 nm
- 25 Bands



**SILIOS CMS-V**

- 550-830 nm
- 9 bands



## Linescan Hyperspectral



**Specim FX17**

- 900-1700 nm
- 224 Bands

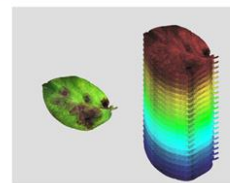


## Liquid Crystal Tunable Filter



**PerkinElmer VariSpec VIS**

- 400-720 nm
- 28 bands



# Your own Virtual Machine

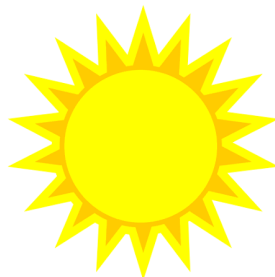
High performance computing cluster



TWIRRE



DEEP  
FRISIAN



SINNE



TOMKE  
&  
ROMKE

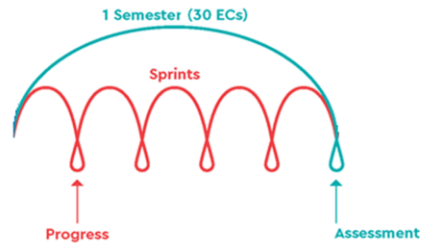


SYKLOAN

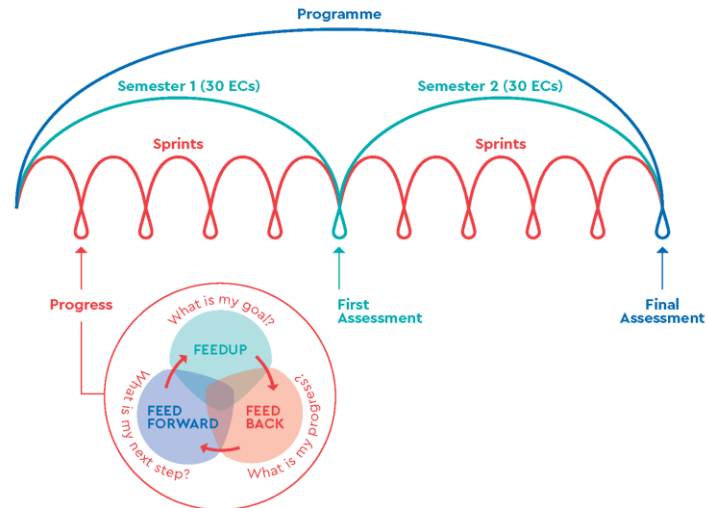


# Specialization

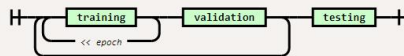
## Minor (Bachelor)



## Master (Master of Science)



# Learn

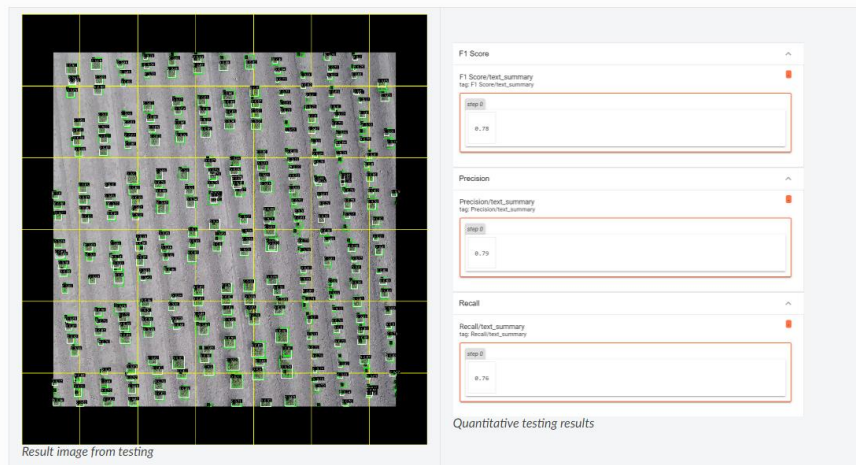


First the network is trained and each 10th epoch the results are validated on a separate set. The model with the lowest loss on the validation set is saved to yolov5.pth (early stopping). The training and validation loss are shown in a tensorboard session. During validation one of the processed tiles for each minibatch is shown in tensorboard and after a few epochs. In our training session this looked like this <sup>2</sup>:



One of the validation tiles shown in the tensorboard

The testing pipeline loads the model and estimated bounding boxes on the full image. The testing pipeline outputs the metrics Precision, Recall and F1-Score. The results are shown in a tensorboard session. In our run the results looked like this:



*“Teach a system to detect and count potato plants in drone images, using deep learning.”*



# Final products



To the effect of dataset order in multiple object tracking

Moustafa Elahagy

Supervisors: Klaas Dijkstra & Lucas Ramos

**Abstract**—In this paper, we explore the effect of domain adaptation and catastrophic forgetting in conjunction with multiple object tracking and its application of two-wheeler tracking to see if using different orders of datasets during training matters. We employ a Siamese Multiple Object Tracker (SiameseMOT) and train it using different permutations on two public datasets (Multiple Object Tracking (MOT) and Specialized Cyclists Dataset (SCD)) and a proprietary dataset (Traffic Intersection Dataset (TID)). We ran experiments on the datasets using different permutations to test the performance when trained on a single dataset, combining datasets and sequence training. We also qualitatively tested the generalizability of the best model in dusk/light footage. Training exclusively on the TID dataset results in the highest IDF1 score, and combining datasets results in a lower IDF1 score compared to when training exclusively on TID. Catastrophic forgetting occurs when training the model with datasets in different orders, when swapping orders of datasets leads to a reduction of about 30% in performance. We have shown that the order of datasets during training plays an important role when adapting datasets from different domains. The best model shows promising results when testing the generalizability on data from different conditions. The qualitative results of the best model on crossing a red light detection show the possibilities of using tracking-by-detection models for other traffic safety indicators.

**Index Terms**—multiple object tracking, traffic analysis, siamese network, object detection, incremental learning, catastrophic forgetting

## 1 INTRODUCTION

According to the global status report on road safety published by the World Health Organisation (WHO), approximately 1.3 million people die each year as a result of road traffic accidents. On average, a cyclist dies every 12 minutes and 30 seconds somewhere in the world.

Traffic Safety Specialists are in charge of analyzing traffic footage to identify risk situations and identify possible areas for improvements, while, traffic psychologists analyze the behavior of road users identifying dangerous behavior. Moreover, expert knowledge is required during the analysis. This analysis is time-consuming since it requires the specialist to watch footage that corresponds to long periods of time; therefore, conclusions are often drawn based on the analysis of shorter video fragments. Such approaches can lead to biased results and a distorted vision of a certain traffic region's overall problems. Traffic analysis using Deep Learning could assist in identifying and measuring hazardous situations in traffic, reducing the time necessary for analysis and being less biased. Deep learning technology has seen major advances in recent years, with detection algorithms including Faster R-CNN [1], SIFTNet [2] and YOLO [3, 4]. Given the advancements in object detection, these models have been applied to multiple

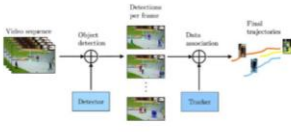


Fig. 1. Tracking-by-detection paradigm. First the object is detected and then the detections are associated across frames to form tracks.

trajectories by estimating object motion. Despite the recent advances in MOT, many challenges remain: 1) the tracker has to deal with multiple objects that need to be tracked from the moment they appear to the moment they disappear from the scene, 2) frequent object

## Automatic quantification of traffic safety with multiple object tracking using deep learning

Moustafa Elahagy  
Supervisors: Klaas Dijkstra & Lucas Ramos

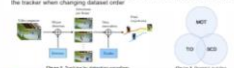
Winner 2022

### Abstract

We train an object tracker using different experimental setups when we use single, combined and sequence training. We test the use of the dataset order during training on the three datasets based on IDF1 score. The best model is the one trained on TID, followed by the combination of TID and SCD, and then SCD. Training on SCD results in the lowest performance, and the combination of TID and SCD results in the highest performance.

### Introduction

- Approximately 1.3 million die each year as a result of road traffic accidents [1].
- Current traffic safety evaluation requires expert knowledge analyzing all footage and requires watching a time-consuming task. Therefore, conclusions are often drawn based on the analysis of shorter video fragments.
- Crossing a red light is an important traffic safety indicator.
- Advances in object detection have been widely used in object tracking, commonly referred as tracking-by-detection.
- We test the effect of domain adaptation by running experiments using single and combined dataset using public datasets (MOT17 and SCD) and TID dataset.
- We test and measure the effect of catastrophic forgetting by applying sequence training where a model is trained on one dataset and then trained on another dataset.
- We explore the effect of training orders to see how it influences the performance of the tracker when changing dataset order.



### Materials and Methods

**Network**—SiameseMOT2 that uses Faster R-CNN for object detection and Euclidean Distance Matching that explicitly learns a matching function between the same instances in sequential frames.



### Experiments and Results

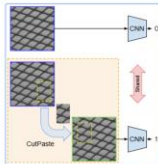
- Tracker and dataset generalization.**
    - The best IDF1 score (62.3%) is achieved by training on the TID dataset.
    - The best result of the sequence experiment is when first training MOT -> TID.
    - The importance of dataset order when training is quantified as shown when training SCD -> MOT -> TID resulting in an IDF1 score of 81.0% and inverting the order of the MOT and TID results in an IDF1 score of 57.8%.
- | Order             | IDF1 | AUC  |
|-------------------|------|------|
| MOT               | 57.8 | 0.73 |
| SCD               | 27.0 | 0.06 |
| TID               | 62.3 | 0.80 |
| MOT+TID           | 52.0 | 0.69 |
| MOT+SCD           | 45.2 | 0.65 |
| MOT+TID+SCD       | 56.5 | 0.75 |
| SCD+TID           | 62.3 | 0.80 |
| SCD+MOT           | 40.2 | 0.58 |
| TID+SCD           | 33.5 | 0.33 |
| TID+MOT           | 55.5 | 0.65 |
| TID+MOT+SCD       | 46.4 | 0.61 |
| MOT -> TID        | 57.8 | 0.73 |
| MOT -> SCD        | 27.0 | 0.06 |
| MOT -> TID -> SCD | 81.0 | 0.86 |
| MOT -> SCD -> TID | 56.5 | 0.75 |
| MOT -> TID -> SCD | 57.8 | 0.73 |
| SCD -> MOT        | 57.8 | 0.73 |
| SCD -> TID        | 62.3 | 0.80 |
| SCD -> MOT -> TID | 62.3 | 0.80 |
| TID -> SCD        | 33.5 | 0.33 |
| TID -> MOT        | 57.8 | 0.73 |
| TID -> SCD -> MOT | 57.8 | 0.73 |
- Tracker evaluation with red light detection.**
    - The best model (single SCD) is used and results in long tracks allowing for the tracker to track objects past the traffic light which in conjunction with traffic light state allows for crossing red light detection.

## Poster on the Computer Vision & Data Science symposium

## CutPaste framework Self-supervised representation learning for anomaly detection [2]

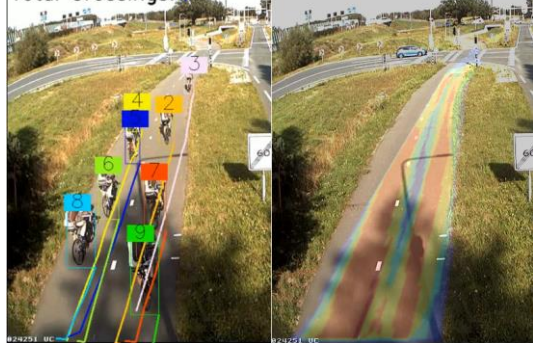
### Dataset

- Fixed tiling with
- Each tile gets a class
  - Anomaly or not
- Training: normal
- Validation & testing: all tiles



## Presentation on the Computer Vision & Data Science symposium

### Traffic Light: Red Total Crossings: 1

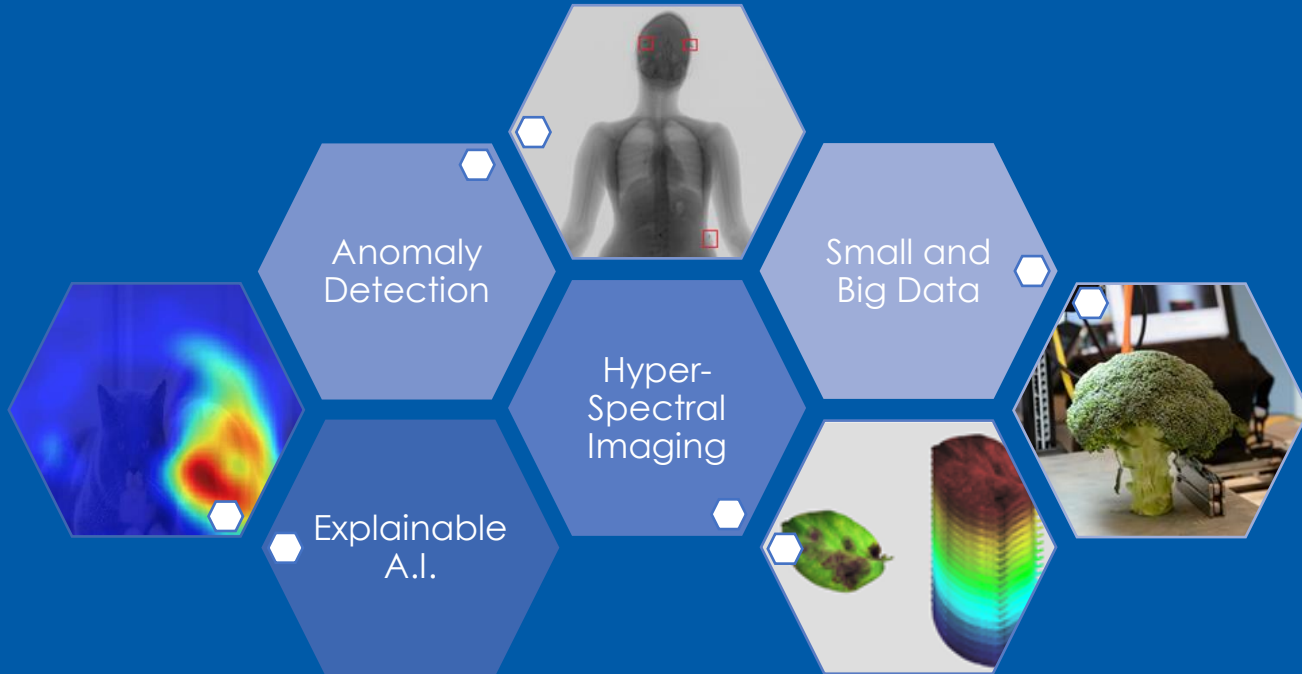


## Proof of Concept

## Paper

# Project examples

Main strategic topics in A.I. for Image Analysis





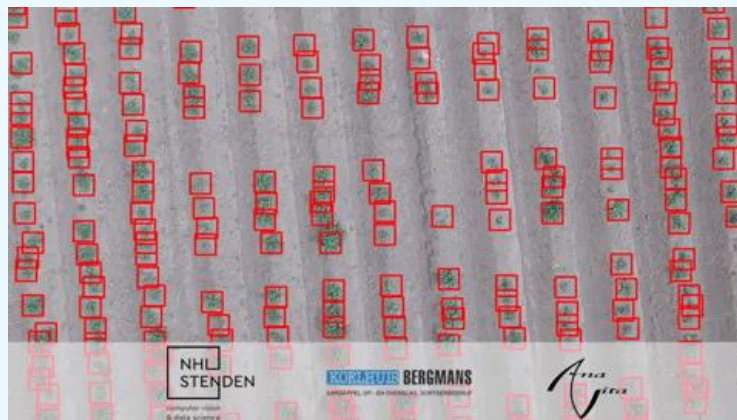
# Counting potato plants

Crop-growth monitoring  
with commodity drones



CentroidNet: A Deep Neural Network for Joint  
Object Localization and Counting

K. Dijkstra, J. van de Loosdrecht, L.R.B. Schomaker and M.A. Wiering



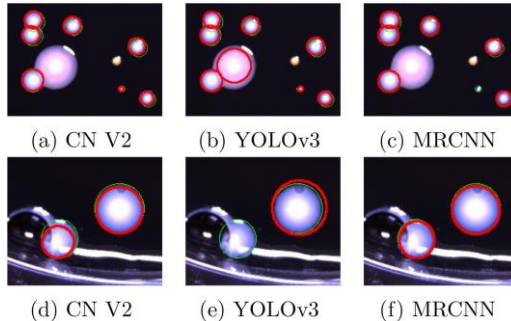
Model	Score
CentroidNet	90.4%
RetinaNet	89.4%
YoloV2	88.8%



# Counting bacterial colonies

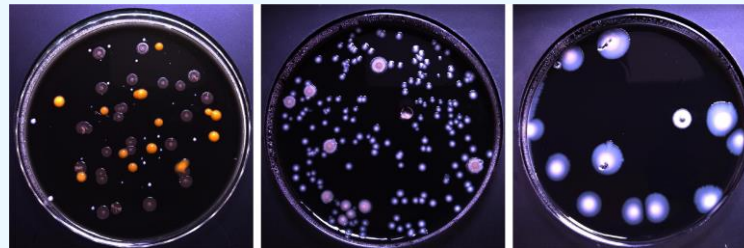
Legionella suspect  
determination

Vitens



CentroidNetV2: A hybrid deep neural network for small-object segmentation and counting

K. Dijkstra, A.W. Atsma, J. van de Loosdrecht, L.R.B. Schomaker and M.A. Wiering



Model	Score
CentroidNetV2	<b>92.6%</b>
FRCNN	92.2%
YoloV3	92.3%



# Identification of point sources



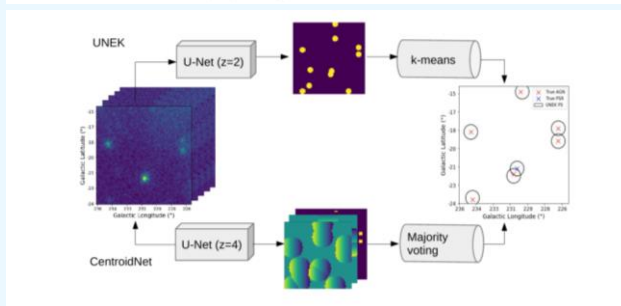
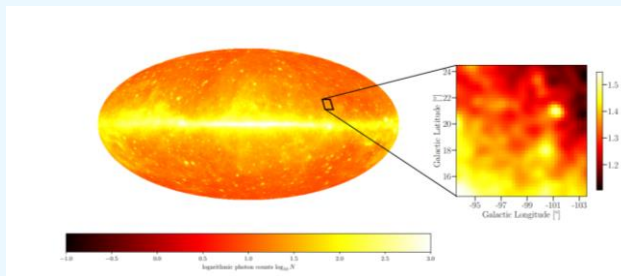
Radboud University



Nikhef

## Identification of point sources in gamma rays using U-shaped convolutional neural networks and a data challenge

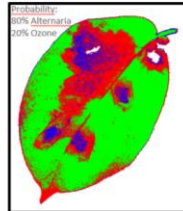
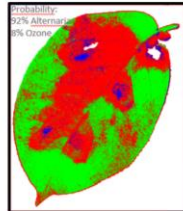
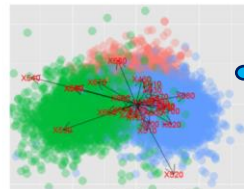
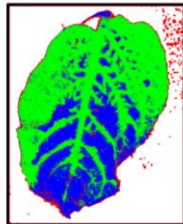
Sascha Caron, Klaas Dijkstra, Christopher Eckner, Luc Hendriks, Guðlaugur Jóhannesson, Boris Panes, Roberto Ruiz de Austri, Gabrijela Zaharijas



# Disease recognition

## Hyperspectral frequency selection for the classification of vegetation diseases

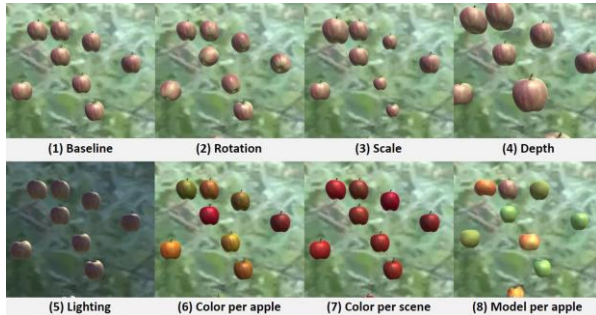
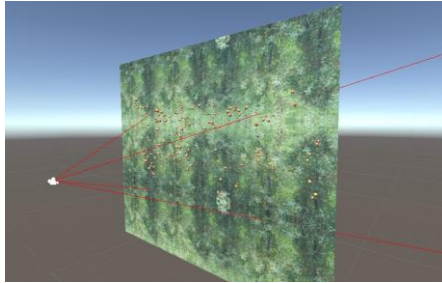
K. Dijkstra, J. van de Loosdrecht, L.R.B. Schomaker and M.A. Wiering



Potato disease classification



# Detect apples using synthetic data



Training

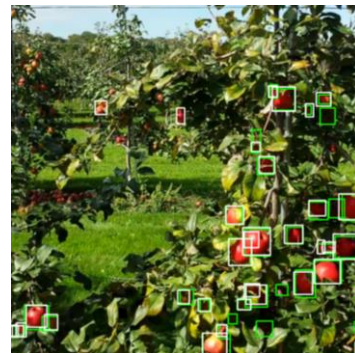


Detection



# Detect apples using synthetic data

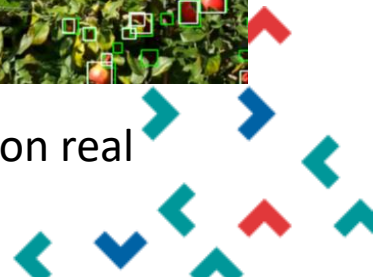
An image says more than a thousand words



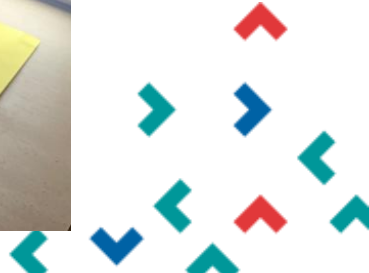
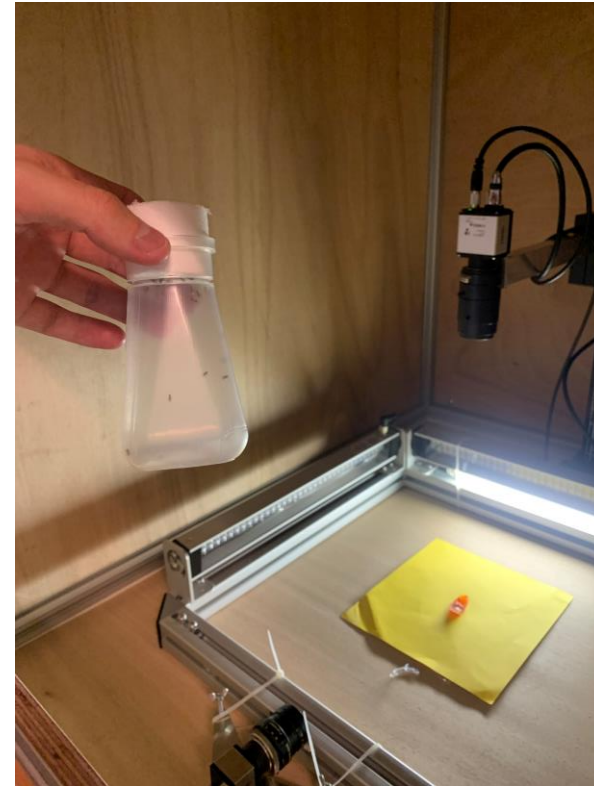
Condition on real

Train on fake

Test on real



# In-flight detection of Aphids in potato fields



# Collaboration examples

