

# Vision AI in Danfoss

Driving adoption and sharing through our Data Analytics Community

Peter Hindsgaul Bjerre Jensen ([peter.jensen@danfoss.com](mailto:peter.jensen@danfoss.com))

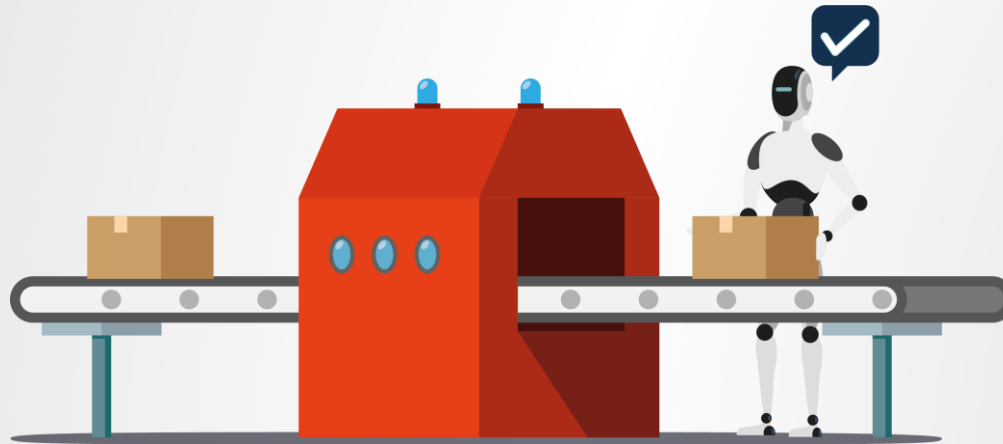
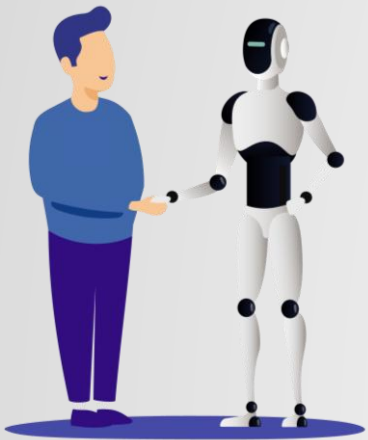
Lead Data Scientist, Applied Data Science, Danfoss Group Digital & IT

Trifork Event, October 24<sup>th</sup>, 2024



# Outline

- Short Intro to Presenter and Danfoss
- Data Analytics Community and Data Science @Danfoss
- Where to Apply AI and Examples of Vision AI in Danfoss
- Feedback, Questions and Answers



# Short Intro to Presenter and Danfoss

# Peter Hindsgaul Bjerre Jensen



- MSc in Chemistry and Applied Mathematics from SDU.
- PhD in Computational Materials Design from DTU Energy.
  
- Lead Data Scientist in Danfoss (hybrid from Kolding, Denmark):
  - Part of Applied Data Science team in Group Digital & IT.
  - Supporting colleagues working with data science, advisory and hands-on.
  - Technology scouting and assessment of offers from consultants and solution providers.
  - Collaborations with external research institutions, e.g. supervising thesis projects.
  - Data Analytics community owner - inspiring colleagues and trigger collaborations and synergies.

# Danfoss Product Portfolio

## Discover Danfoss Products



Expansion valves



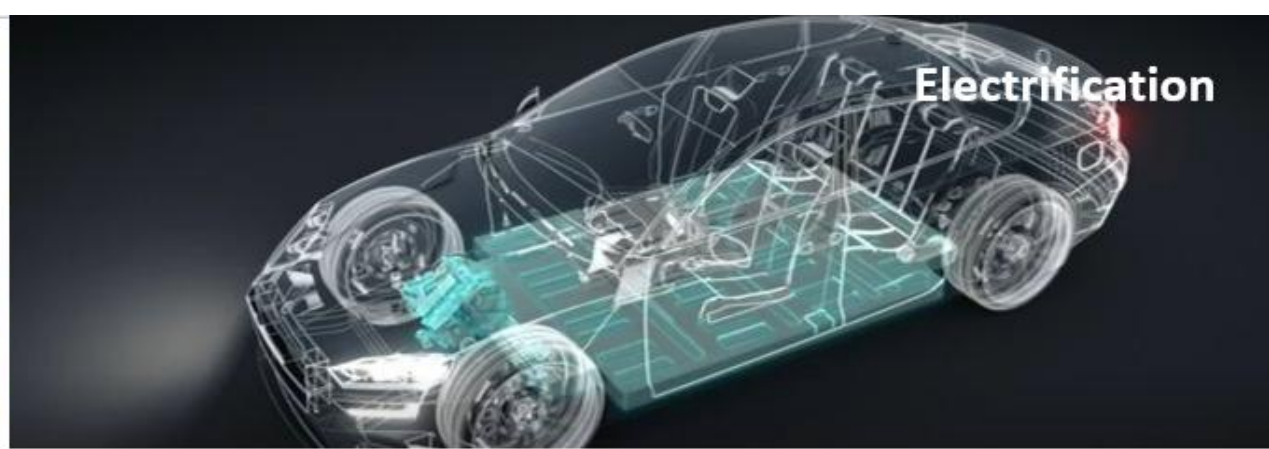
Radiator sensors



Low Voltage Drives

Power Solutions	Climate Solutions for cooling	Climate Solutions for heating	Drives	Other businesses
Autonomy	Compressors	Valves	DrivePro® Lifecycle Services	Emission Monitoring
Cylinders	Valves	Radiator and room thermostats	Low-voltage drives	Fire Safety
Electric converters, motors and systems	Electronic controls	Smart heating	Decentral drives	High Pressure Pumps
Electronic controls	Condensing units	Burner components	System modules	Sensing Solutions
Hoses and fittings	Sensors and transmitters	Energy metering	Enclosed drives	Silicon Power
Hydraulic power units	Switches	Heat exchangers	Power options	
Industrial clutches and brakes	Filters, strainers and oil management	Stations and domestic hot water	Motion control and servo drives	
Motors	Heat exchangers	Electronic controls	Medium-voltage drives	
Hydraulic pumps	Monitoring and services	Hydronic underfloor heating	Gear motors	
Software	Sight glasses	Electric Heating	Soft starters	
Steering	Appliance controls	Differential pressure and flow controllers	Software tools	
+ more products		+ more products		

[Danfoss.com](https://www.danfoss.com) & [Product Store](https://www.danfoss.com/product-store)



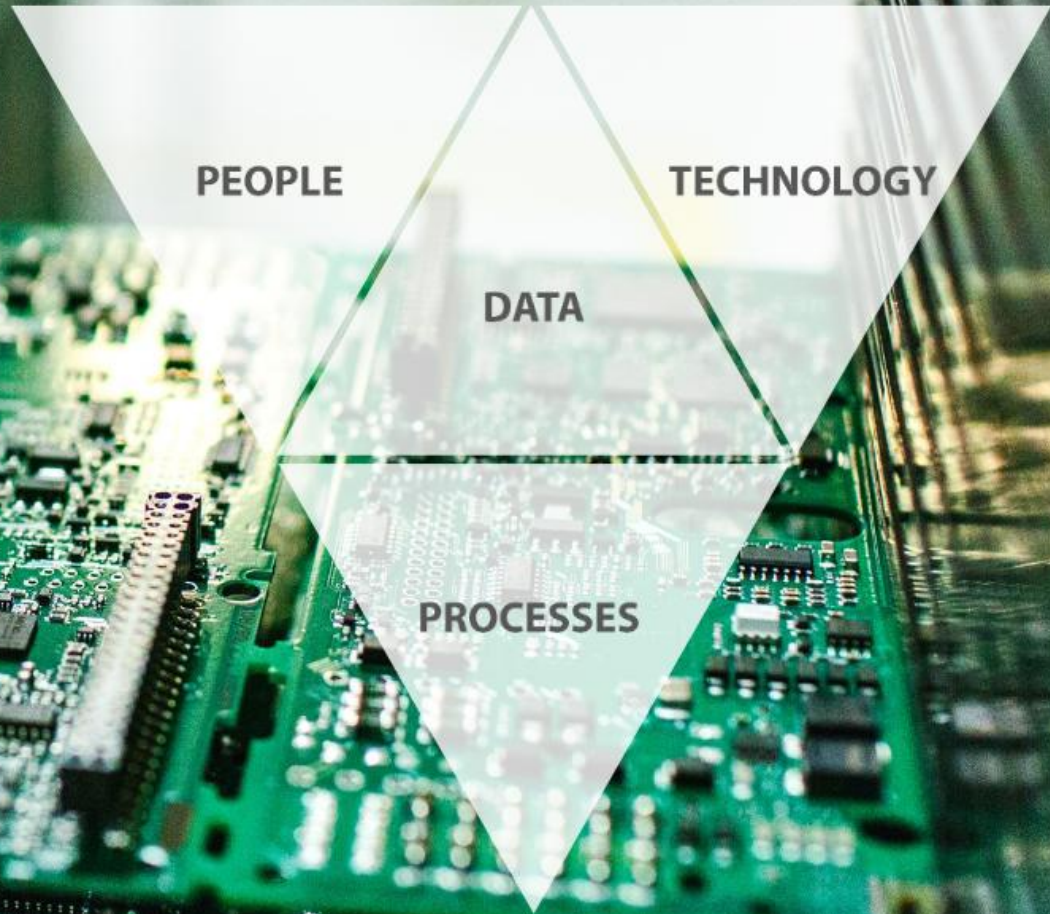
**GLOBAL MEGATRENDS**  
Transforming our world



# Data Science @Danfoss

# Digital impact

Our ability to master a digital transformation to its full potential is an end-to-end focused discipline across the four domains of **people, processes, data, and technology**





# Data Analytics Community

## Background & Introduction

- Originally focusing on Big Data & AI
  - Initially ~20 experts – knowledge sharing
  - Scope broadened in 2018 to applied analytics
  - Open for all colleagues in Danfoss
  - Tech talks in the **Data Analytics Forum**
  - Now **Danfoss' largest community**
- 
- Goal is to **inspire** on data science topics, foster **knowledge sharing** and trigger **collaborations** throughout **Danfoss**



# Data Analytics Community

## Multiple Communication Channels & Styles

The image displays three distinct communication channels:

- LinkedIn Post:** A post from Peter Hindsgaul Bjerre Jensen dated August 21, 2020, discussing an RStudio webinar about the R vs. Python debate. It includes a poll question: "Which data science language do you use?" with options: Python, R, SQL, Scala, MATLAB, and Other (please specify as comment).
- Danfoss Presentation Slide:** Titled "Image Recognition Danfoss Project Examples". It features two main sections: "Smart Troubleshooting (DCS)" and "Autonomous Systems (DPS)". Below these are four project cards:
  - Intelligent Drives:** Description: Drives Condition Monitoring & Predictive Maintenance. Multiple initiatives... Status: Production.
  - Production Optimization:** Description: Ongoing activities to test Thingworx Analytics platform e.g. to monitor rob... Status: Proof of Concept.
  - Production Monitoring:** Description: Multiple projects in RAC, initially focused on Poland. Status: Proof of Concept.
  - Alsense - HVAC monitoring:** Description: Cloud solution from Danfoss Climate Solutions for supermarkets and food... Status: Production.
- Data Analytics Dashboard:** A screenshot of a dashboard with various charts, graphs, and data visualizations, representing the output of data analytics.

# Data Analytics Community Hackathons - Broad & Open vs. Detailed on Invite

Home > News Center > Communication > 2-day Hackathon for a more data-driven organization



**Danfoss**  
227,360 followers  
1yr •

In Danfoss we use hackathons to strengthen our innovation culture and in May we held our biggest event yet together with Microsoft. "The ever-increasing demand for people who can leverage data is not solved only by hiring data experts, but also by improving data skills among existing employees. We have been impressed with Danfoss' active community for data analytics and we see an increasing number of ambitious analytical initiatives in Danfoss" Crillles Jansen, Director of Microsoft solutions.



The participants were from all business segments



2-day Hackathon for

Home > News Center > IT > Danfoss hackathon together with Microsoft



Danfoss hackathon together with Microsoft

# Data Analytics Community

## Early Adoption and Feedback

chat.danfoss.com is LIVE

Happy to announce that [chat.danfoss.com](https://chat.danfoss.com) is now live for all employees  
Thanks for testing the solution, [General](#).

Now the adaptation phase begins!

We encourage you all to help and share the news with your colleagues and assist them in getting used to interacting with the chatbot(s).

If you need training or more information, you can find it here on the AI Hub: [Danfoss AI Chatbot \(sharepoint.com\)](#).

We will be hosting 4 training sessions initially to expedite the adaptation process.

Please still provide us with feedback and ideas.

How should we adopt AI in Danfoss. Give me 5 examples in bullet points.



**Peter Hindsgaul Bjerre Jensen**

How should we adopt AI in Danfoss. Give me 5 examples in bullet points.



**Basic Chat Assistant**

- Implement AI-powered predictive maintenance solutions to optimize the performance of Danfoss equipment and reduce downtime.
- Utilize AI algorithms to analyze large amounts of data collected from sensors and devices, enabling better decision-making and process optimization.
- Develop AI-driven chatbots or virtual assistants to enhance customer support and provide quick and accurate responses to inquiries.
- Apply machine learning algorithms to optimize energy consumption and improve the efficiency of Danfoss products and systems.
- Use AI-powered image recognition technology to automate quality control processes and identify defects in manufacturing.



# Data Science Adoption

## Code, low-code or no-code

- Programming not needed to get started (but some knowledge or interest is good 😊)
- Vendors offers low-code, AutoML and drag & drop interfaces (integrations to e.g. Excel)

### Image Recognition

No/low-code approach

#### PROS

No Need for Programming Experience

Easy Prototyping

No or Limited Starting Costs

Continous Improvement from Vendors ("for free")

Learning by Playing

#### CONS

Less Customizable Solutions

Challenging Deployment

Costly License Fee in Production

Risk of Lower Performance for Specific Domains

Lack of Understanding & Risk of Misinterpretation

The screenshot shows the Lobe.ai interface for image recognition. On the left, there's a sidebar with 'Label' and 'Train' buttons. The main area displays 'All Images' with a 92% accuracy bar, 'Cube' with 100%, and 'Non-cube' with 88%. Below this, it says '92% of your images are predicted correctly, 8% incorrectly.' There are several image thumbnails, some labeled 'Cube' and some 'Incorrect 8%'. A dialog box titled 'Optimizing Model' is overlaid, stating 'Your model has been optimizing for 00:40 s. This can take a while to complete.' On the right, there's a 'View' and 'Import' button. At the bottom, there's a summary table:

Category	Accuracy
All Images	92%
Cube	100%
Non-cube	88%

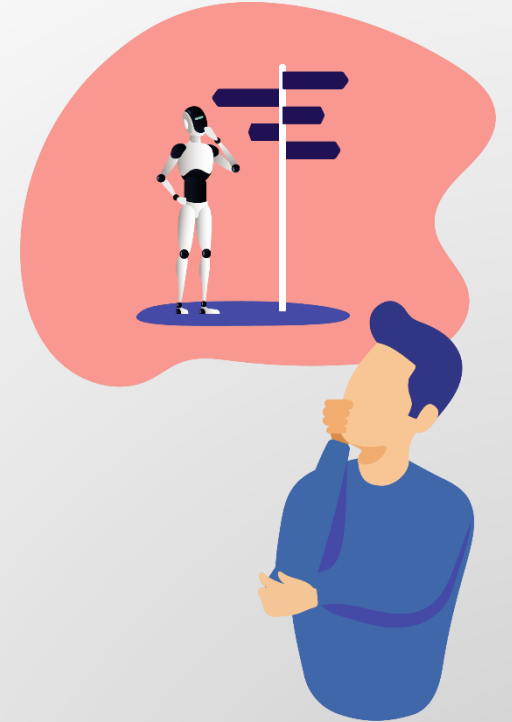
Lobe.ai (2020)

# Where to Apply AI and Examples in Danfoss

# Where to Apply AI?

and where is it applied or an opportunity for Danfoss?

- Everywhere **we have** or **can get data** is an opportunity, for instance:
  - Ideation and support for R&D/Innovation
  - New product development (NPD), e.g. bridging simulation and AI
  - Manufacturing Monitoring and Optimization
  - Supply Chain Optimization and Sales Forecasting
  - HR processes and forecasting
  - Process intelligence and optimization
  - User/Customer Experience (UX/CX) e.g. chatbots & recommendations.
  - Products with improved performance and functionality.
  - Advanced service offerings for products or fleets



# Visual Inspection – Not Always Calling for Advanced AI

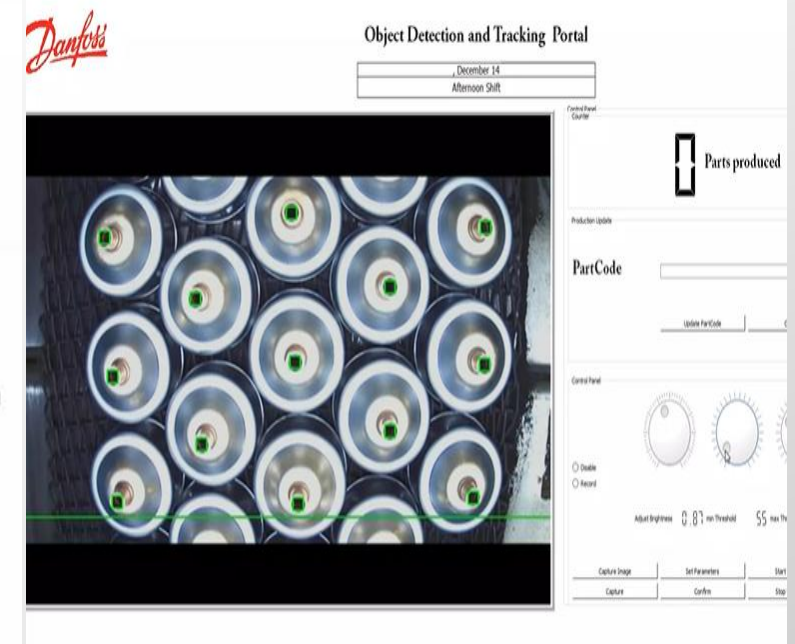
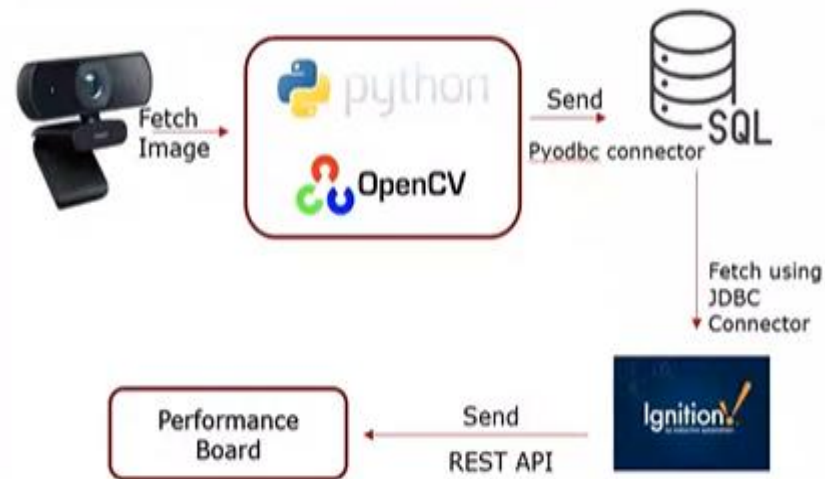
## Counting Filter Drier Cups

### Solutions Explored

- Counting using Photoelectric sensor



### Architecture





# Growing **Autonomy** Through Machine Learning

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Work by Shelley Nation & Systems R&D, Safety and ML Team

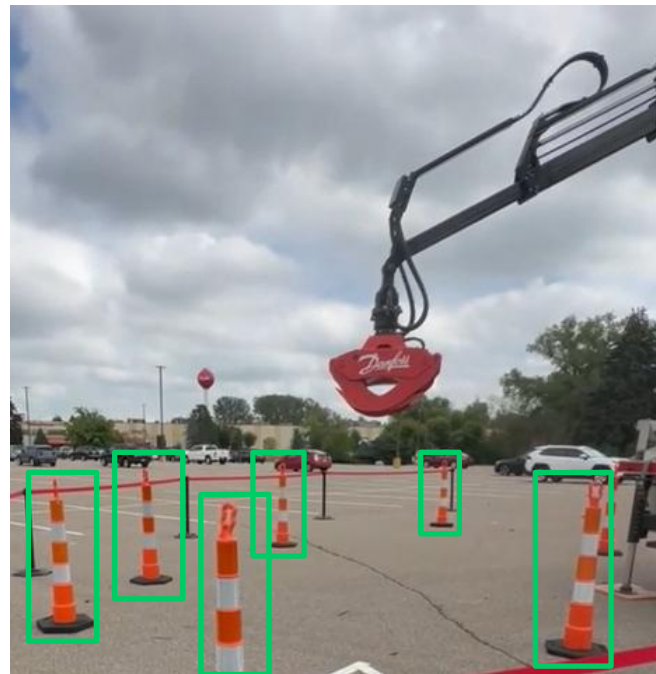
# Machine Learning Makes Sense of the World

## ML-based Solutions Required for Achieving Complex Autonomy

Lane keeping and traffic sign adherence  
*Airport Ground Support*



Position of objects  
*Cranes, Excavators*

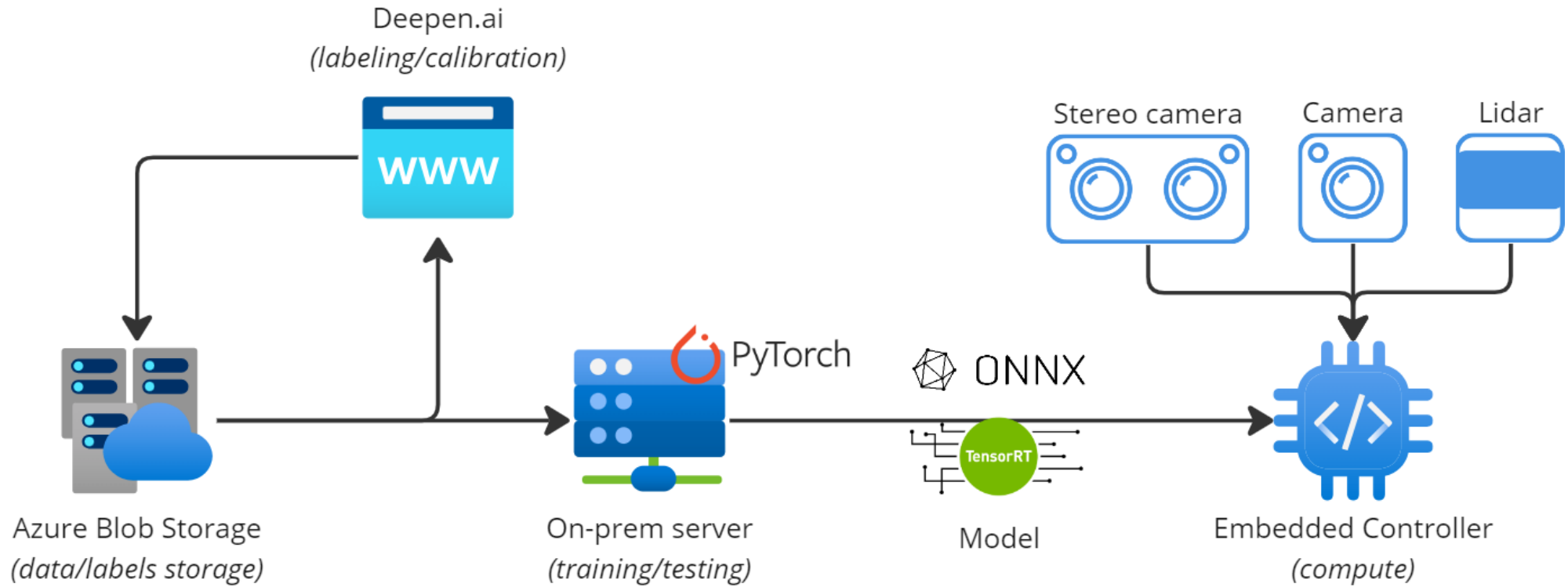


Fruit detection for spraying/harvesting  
*Specialty Ag*



<https://www.danfoss.com/en-us/markets/mobile-hydraulics/dps/autonomous-solutions/>

# Autonomous Development Platform





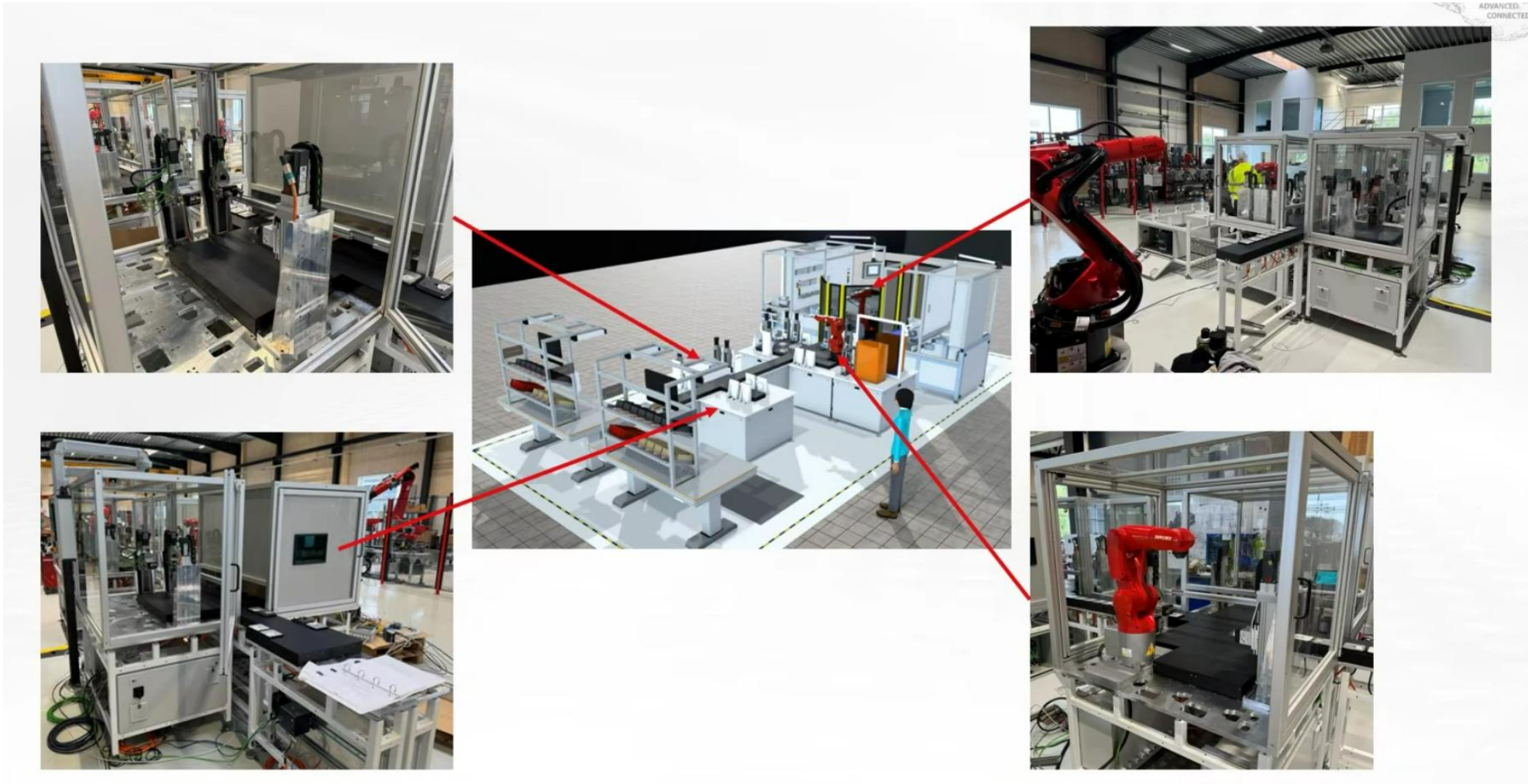
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## Growing **Production Quality** Through Machine Learning

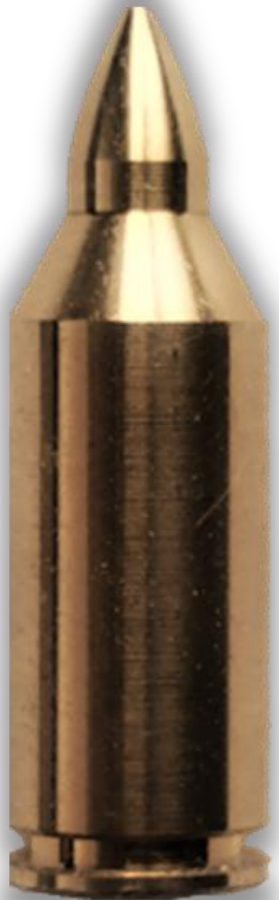
Work by Dominik Windhab from AI & Digital Accelerator in collaboration with the Climate Solutions business segment





# Flexline: Modularizing our Production Lines

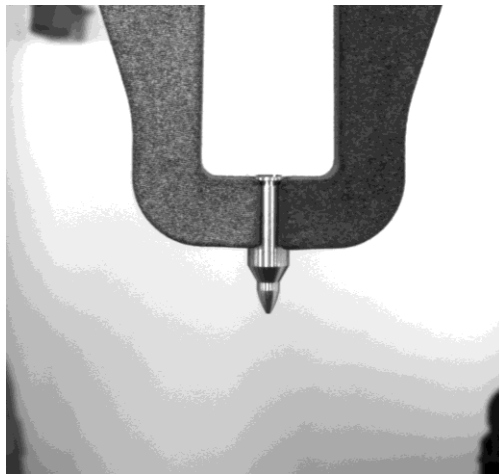


# Use Case 1: Cone Identification

Quality Assurance: Has the correct cone been mounted on the motor?

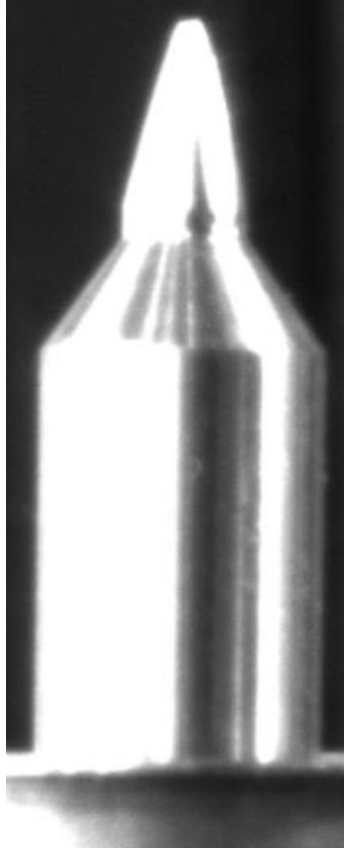
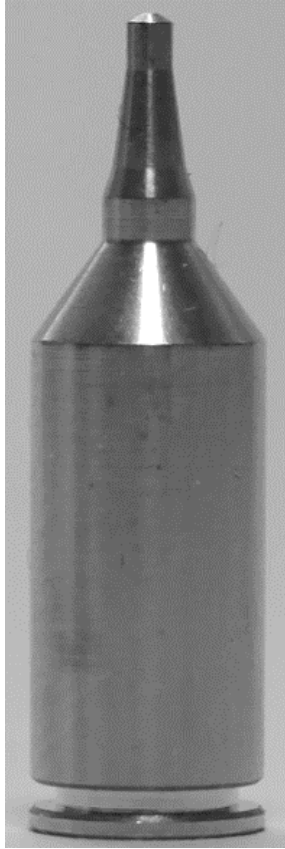
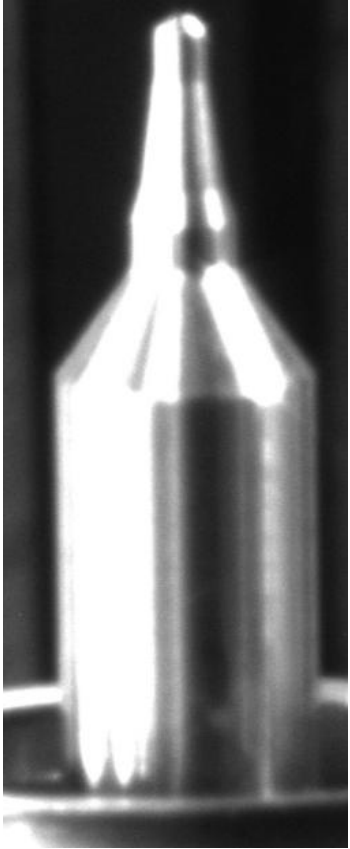


			
034G3541	034G3542	034G3543	034G3544
Valve cone 1.3	Valve cone 1.7	Valve cone 2.0	Valve cone 2.4



# Working with Suboptimal Training Data

Challenged by light and lack of focus



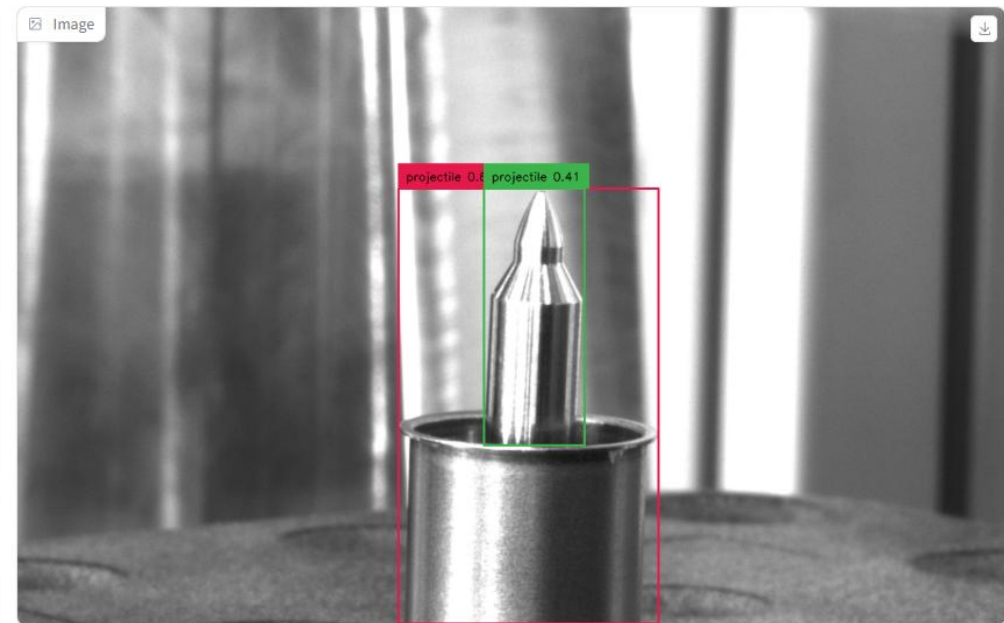
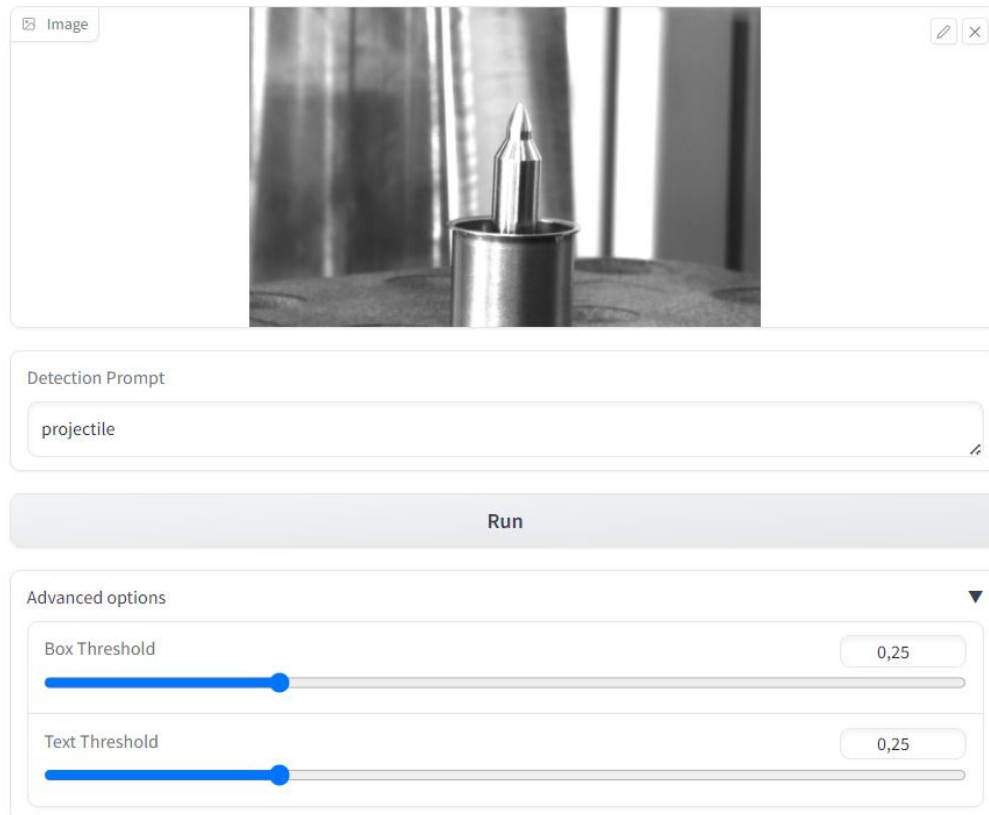
# Projectile or Cone?

## Utilizing Grounding Models for Bounding Boxes

### Grounding DINO

Open-World Detection with [Grounding DINO](#)

Note the model runs on CPU, so it may take a while to run the model.





# Prototyping and Early Feedback with Gradio Apps

Hosted using internal Danfoss AppHub (Databricks apps under exploration)

Cone prediction

valve cone 2.0

valve cone 2.0	96%
valve cone 1.3	4%
valve cone 2.4	0%
valve cone 1.7	0%

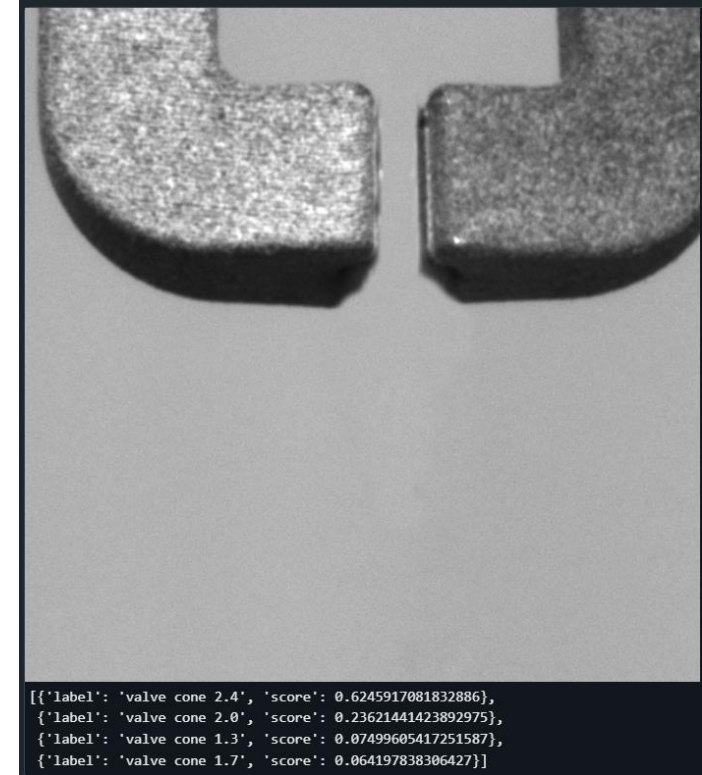
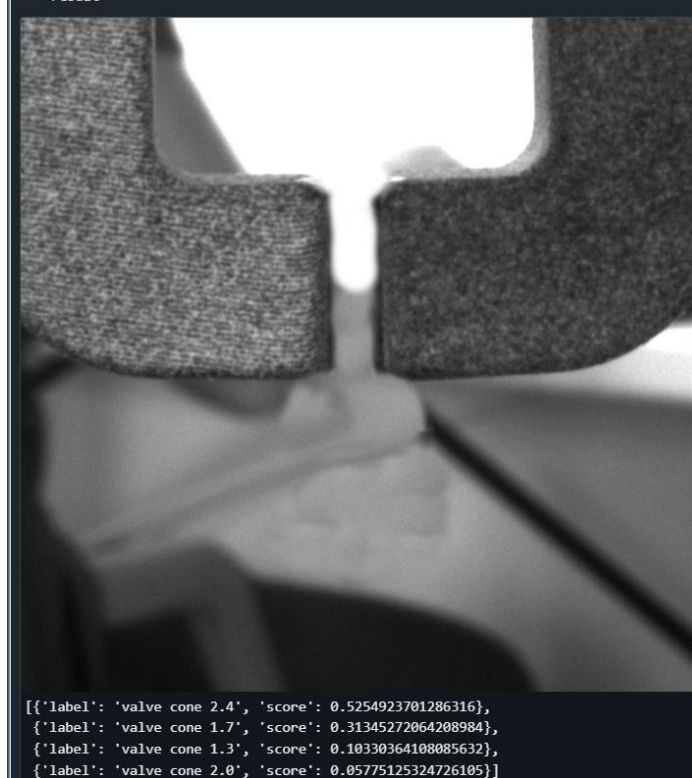
Cone prediction

valve cone 2.0

valve cone 2.0	88%
valve cone 1.3	12%
valve cone 2.4	7%
valve cone 1.7	1%

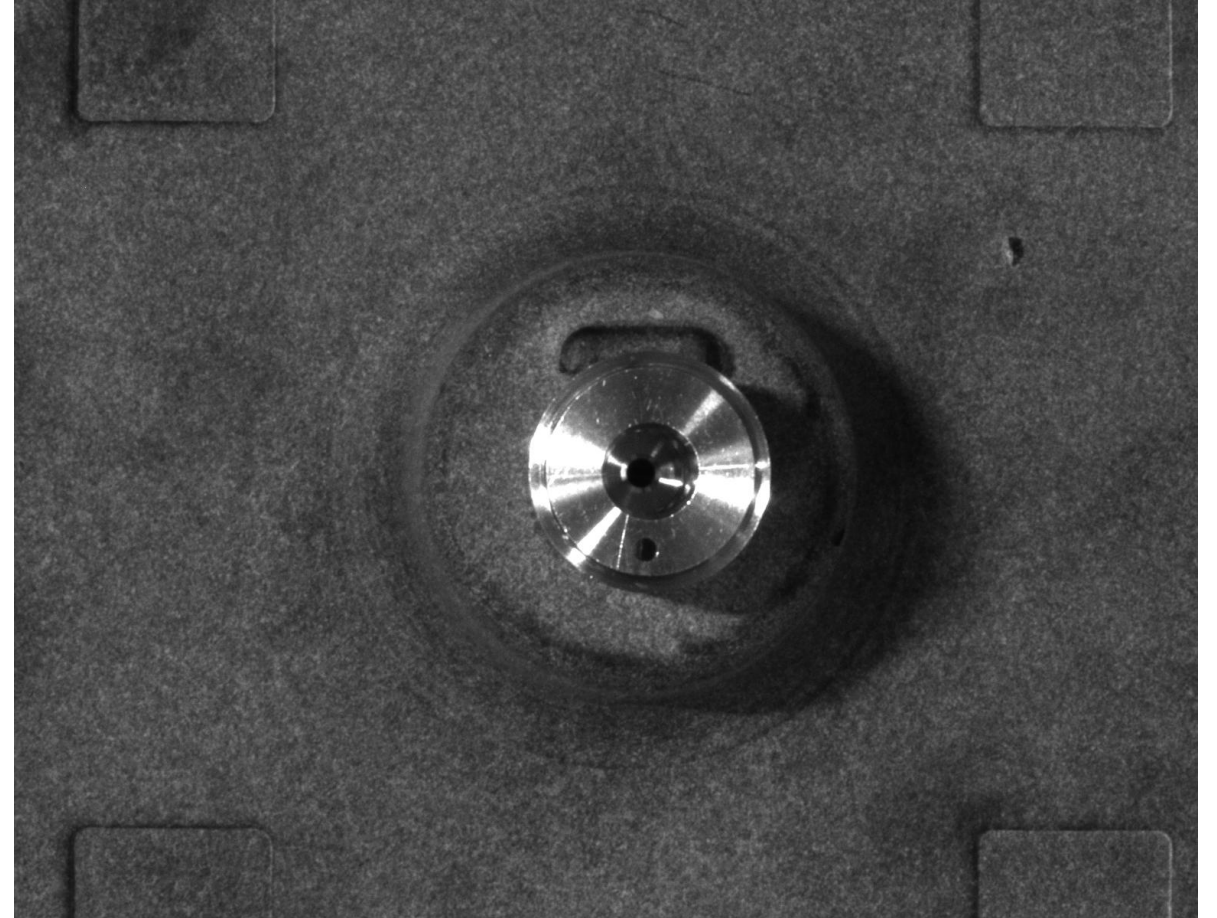
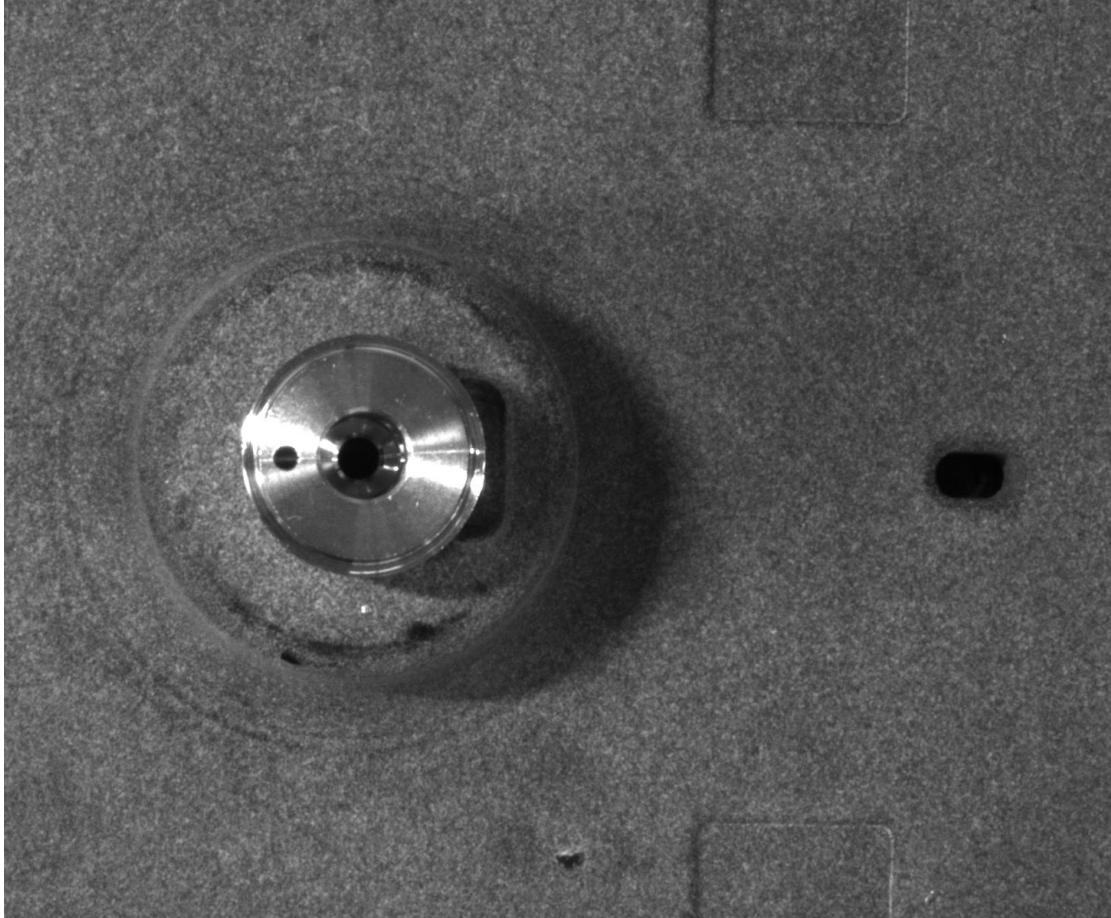
# Testing the Model with Unseen Images

## Model Identifies Cones Everywhere (!)



## Use Case 2: Detect Housing Types

Mainly differentiated by central hole diameter



# Zero-shot Classification for Automated Labeling

## Grounding DINO

Open-World Detection with [Grounding DINO](#)

Note the model runs on CPU, so it may take a while to run the model.



The screenshot displays the Grounding DINO web interface. On the left, there is an input area with an "Image" tab and a placeholder for the input image. Below this is a "Detection Prompt" input field containing the text "circular metal object.". A "Run" button is positioned below the prompt field. At the bottom left, there is an "Advanced options" dropdown menu. On the right, the output image is shown with two bounding boxes: a red one labeled "circular metal object 0.57" and a green one labeled "circular metal object 0.45".

# Housing Location Obtained From Zero-shot Detection

The screenshot displays the Label Studio interface for a project named "Flexline Housing". The left sidebar shows a list of 15 images, each with a checkbox, a small thumbnail, and a content hash. The main image viewer shows a large grayscale image of a housing component. A green bounding box highlights a central circular feature, and a red bounding box highlights a smaller circular feature within it. The interface includes a toolbar with various tools, a file list, and a main image viewer. The bottom right corner has an "Update" button.

checkbox	id	image	content_hash	str
<input type="checkbox"/>			8a324c5db08	
<input type="checkbox"/>	1		3661ae458b01a84cc153a a0c39f0263a	<a href="#">↔</a>
<input type="checkbox"/>	1		371e73792603d73164d0 e9d3472b98d5	<a href="#">↔</a>
<input type="checkbox"/>	1		381d0cbe4705bcf177c92 daa9535d704	<a href="#">↔</a>
<input type="checkbox"/>	1		3843281c9464f21ba670 5ec2a7a355b7	<a href="#">↔</a>
<input type="checkbox"/>	1		3a91cccb3de7512bb28dd 86df3c18319	<a href="#">↔</a>
<input type="checkbox"/>	1		3b195c10dad7e099a42c 199fe58a5e5	<a href="#">↔</a>
<input type="checkbox"/>	1		3ba800c91d9b7b2c3ceb8 5936410ee67	<a href="#">↔</a>
<input type="checkbox"/>	1		3e0166532c9a179457df 7fd3c58b322c	<a href="#">↔</a>
<input type="checkbox"/>	1		3e0533493b168bd226e8 1256f11b9379	<a href="#">↔</a>
<input type="checkbox"/>	1		3f450969864d7efe5e3e5 69d92075946	<a href="#">↔</a>
<input type="checkbox"/>	1		3f90a7d47dfe9c7957f06f a04686739c	<a href="#">↔</a>
<input type="checkbox"/>	1		4070dfe67d703eb8dfa3 8fb02ba0809	<a href="#">↔</a>

# Use Case 3: Detect Rotations

Ensure proper assembly (not yet started)



# Online Ecosystem for Test and Development



## **Databricks data platform and model serving**

Unified analytics platform combining data, code and compute power



## **MLFlow**

Manage the ML lifecycle for experimentation, tracking and reproducibility



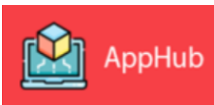
## **Hugging Face**

Tools, libraries, and models for AI applications



## **Label Studio**

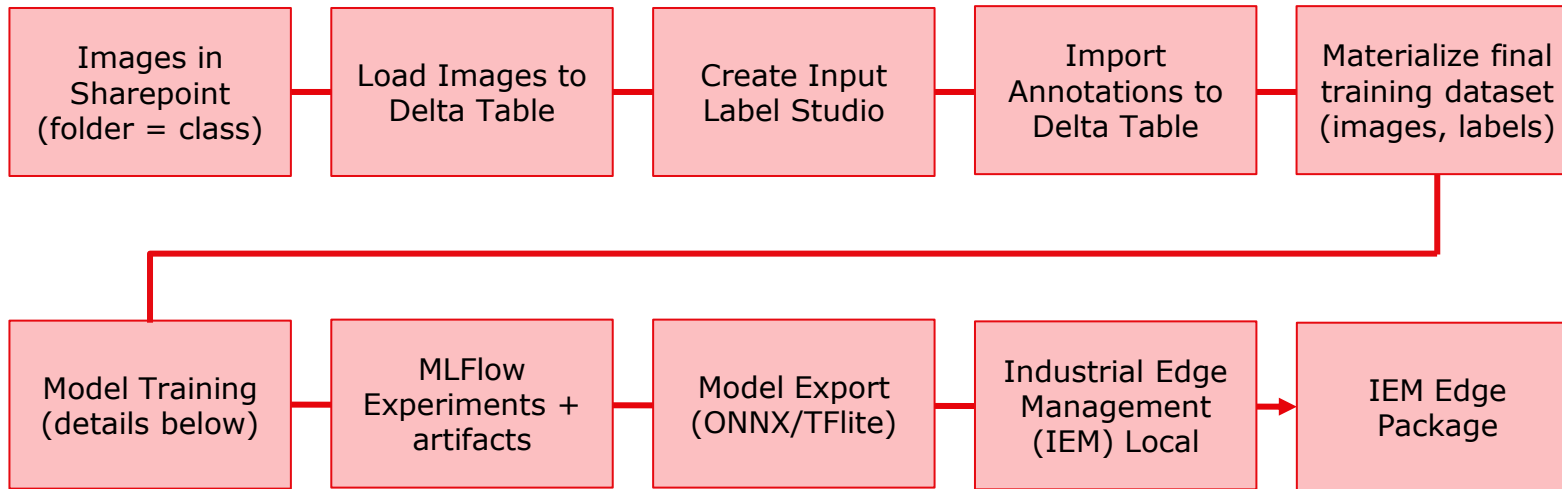
Open source and user-friendly labelling



## **Danfoss AppHub**

Internally developed app hosting platform (we are currently exploring Databricks Apps as well)

# Pipeline from Online Test/Dev to Industrial Production



## Training Experience

Hugging Face Autotrain

Hugging Face in Databricks (manual)

Google Vertex AI

### Hugging Face Autotrain (in Databricks):

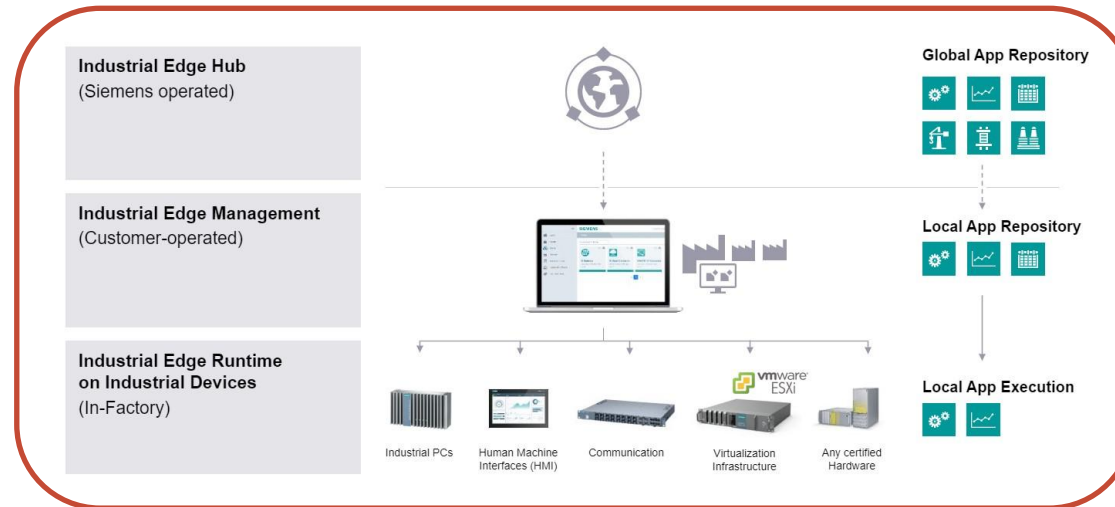
- Worked, but results not good enough

### Hugging Face in Databricks (manual):

- Full control and high accuracy (but req. expertise)

### Google Vertex AI:

- Cloud version worked with good results
- Training for edge model failed with error





# Feedback, Questions and Answers



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