ESTEP 2025 Annual Event
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How decarbonisation, digitisation and circular solutions forge the sustainable European steel future?

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iSteel-Expert

Enhancing Steelmaking Operations through Advanced Computer Vision and Machine Learning

ESTEP — European Steel Technology Platform

DIGIMET

DANIELI AUTOMATION

UNIVERSITÀ DEGLI STUDI DI UDINE — HIC SUNT FUTURA

iSteel-Expert

Remote expert virtual system enhancing human management capabilities and favors preservation, transfer and continuous evolution of knowledge for steelmaking operation

Call: *RFCS-2022*
Instrument: *PDP*
(Pilot and Demonstration Project)
Start date: 01/07/2023
End date: 30/06/2026
Budget: 1.845.686,05
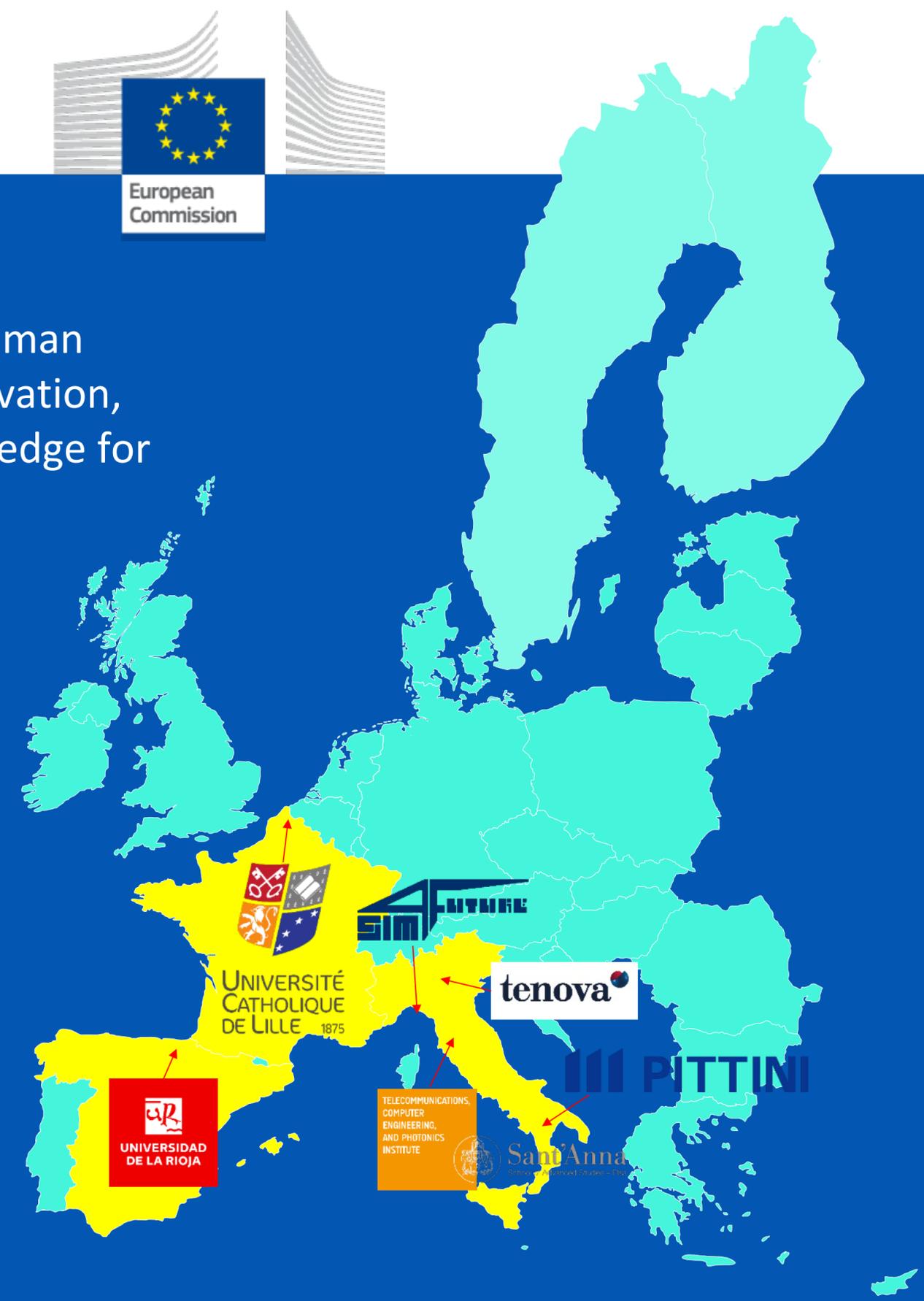
Overview

i-Steel Expert Project

Image generated with AI

Motivations

In the melting area of steelworks **situation awareness** is a key to ensure process reliability, health and safety at the workplace and low environmental impact

The **hemorrhage of highly skilled people** in a sort of 'war of talents' is a serious business threat, which can be faced by creating attractive workplaces and stimulating working conditions

Image generated with AI

Mission

iSteel-Expert implements and demonstrates in industrial environment a **remote expert virtual system** that monitors 24/7 the progress of the process, analyses the information and suggests actions to improve and/or correct steelmaking operations

Image generated with AI

Objectives

- Preserve and evolve company's **know-how**
- Improving **work force management** and safety
- Increase process **efficiency**
- Improve equipment condition and **maintenance**
- Reduce **environmental impact**

Image generated with AI

Training Platform

An **interactive immersive training tool** which, through a knowledge-based approach, favors preservation, transfer and continuous evolution of the company's wealth of knowledge
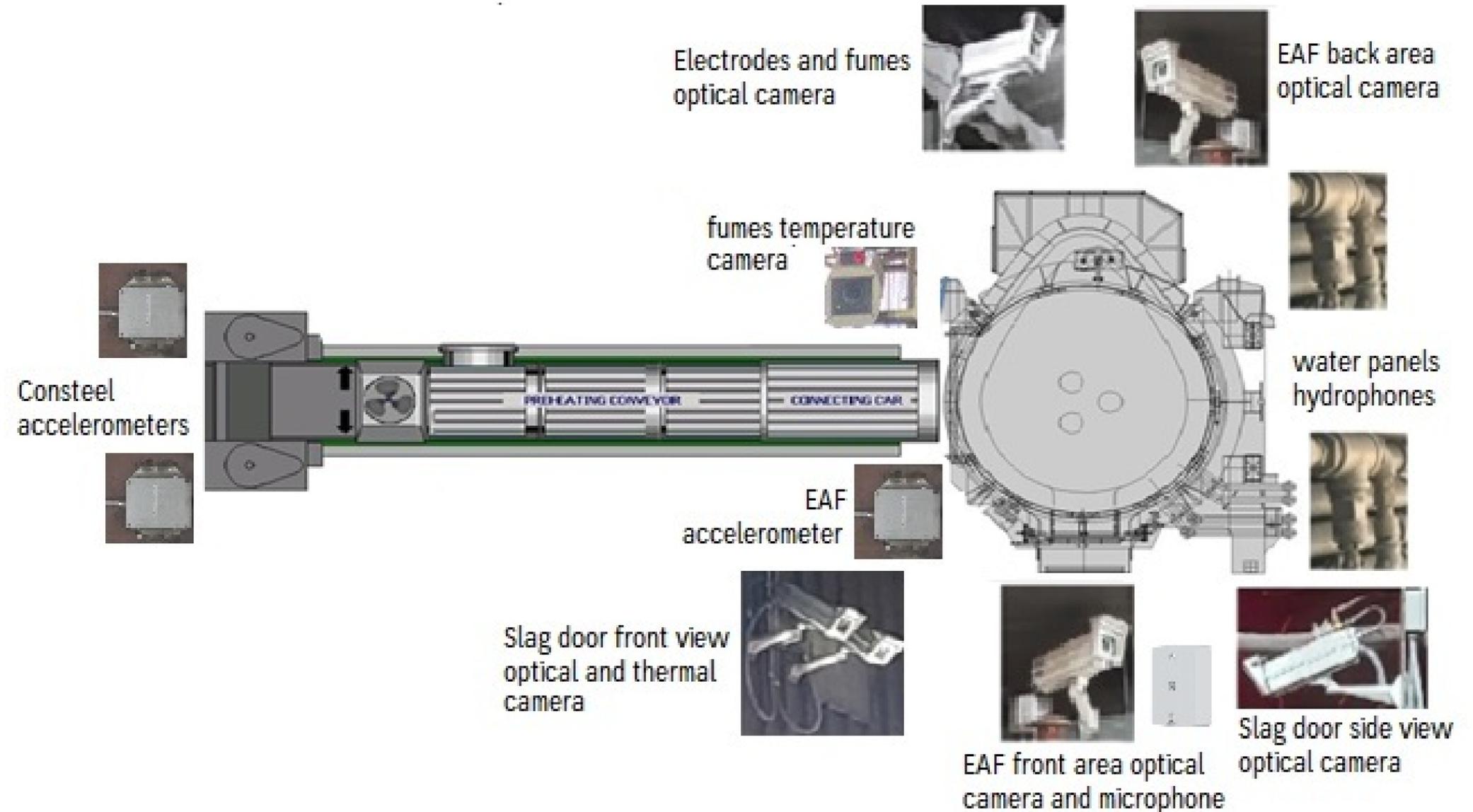
Infrastructure

Sensors
- Cameras
- Microphones
- Accelerometers

Platforms
- Edge Devices
- Cloud
- Dashboards

Machine Learning Models

Object Detection and Image Classification

Image generated with AI

Object Detection

What it is

Object detection identifies *what* objects are in an image and *where* they are, by combining **classification** and **localization**

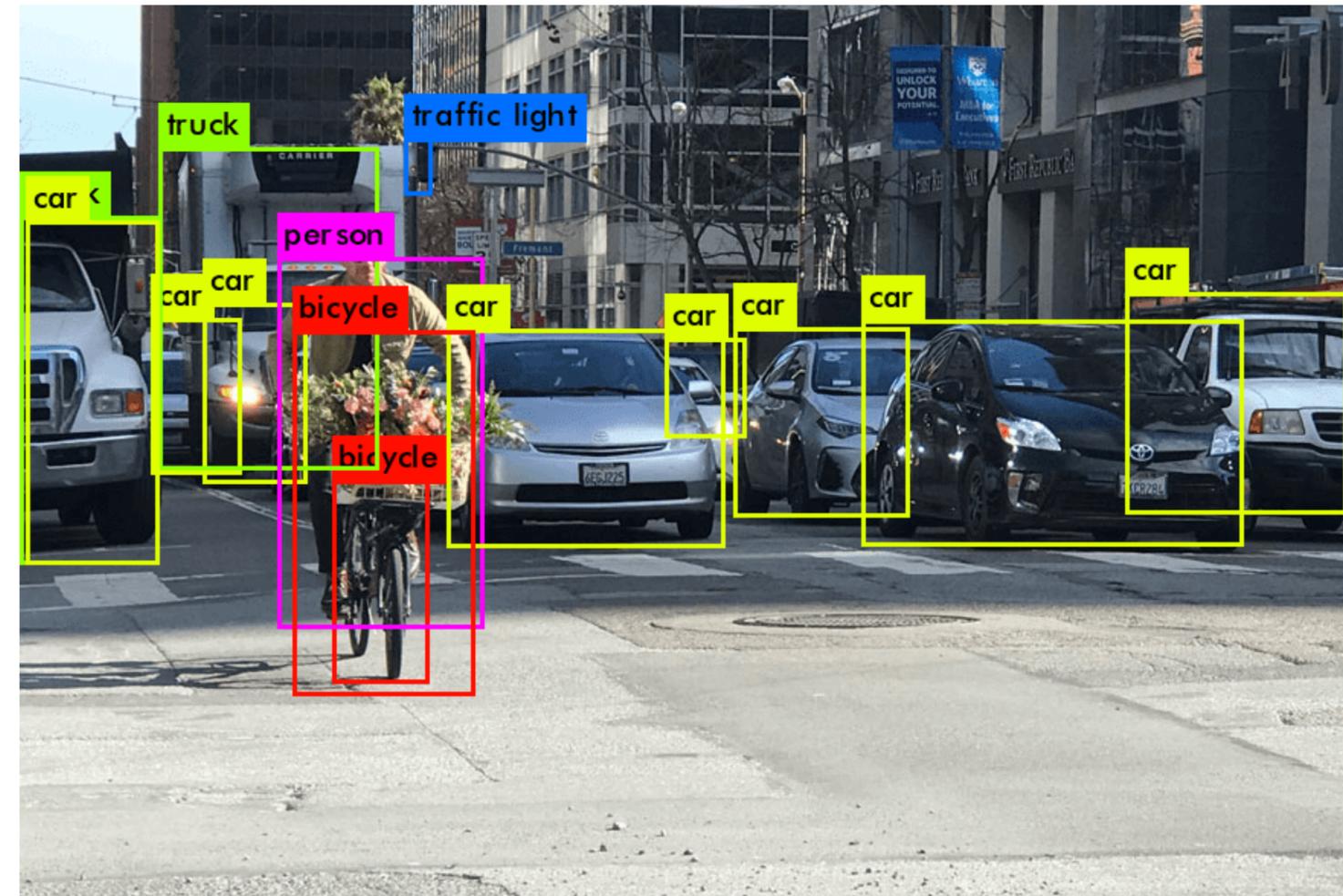Based on convolutional neural networks and transfer learning

How it works

- Use models like **ResNet** trained on **ImageNet** or **YOLO** trained on **COCO** datasets as a backbone
- Attach layers as a detection head to predict object classes and bounding boxes
- Fine-tune model on domain-specific dataset to adapt to new object types while reusing learned visual features

Prediction

- The model outputs class and location of each object in image

Advantages

- Requires fewer labeled images
- Reduces training time and computational cost
- Achieves high accuracy with limited data

Note that pretrained models, like the one above, do not work in industrial environments

Object Detection

Images must be tagged to train the model to recognize the object (people in this case) in the specific setting

Manually tagging images is the most time-consuming activity, but it is also the activity with the biggest impact, if done well
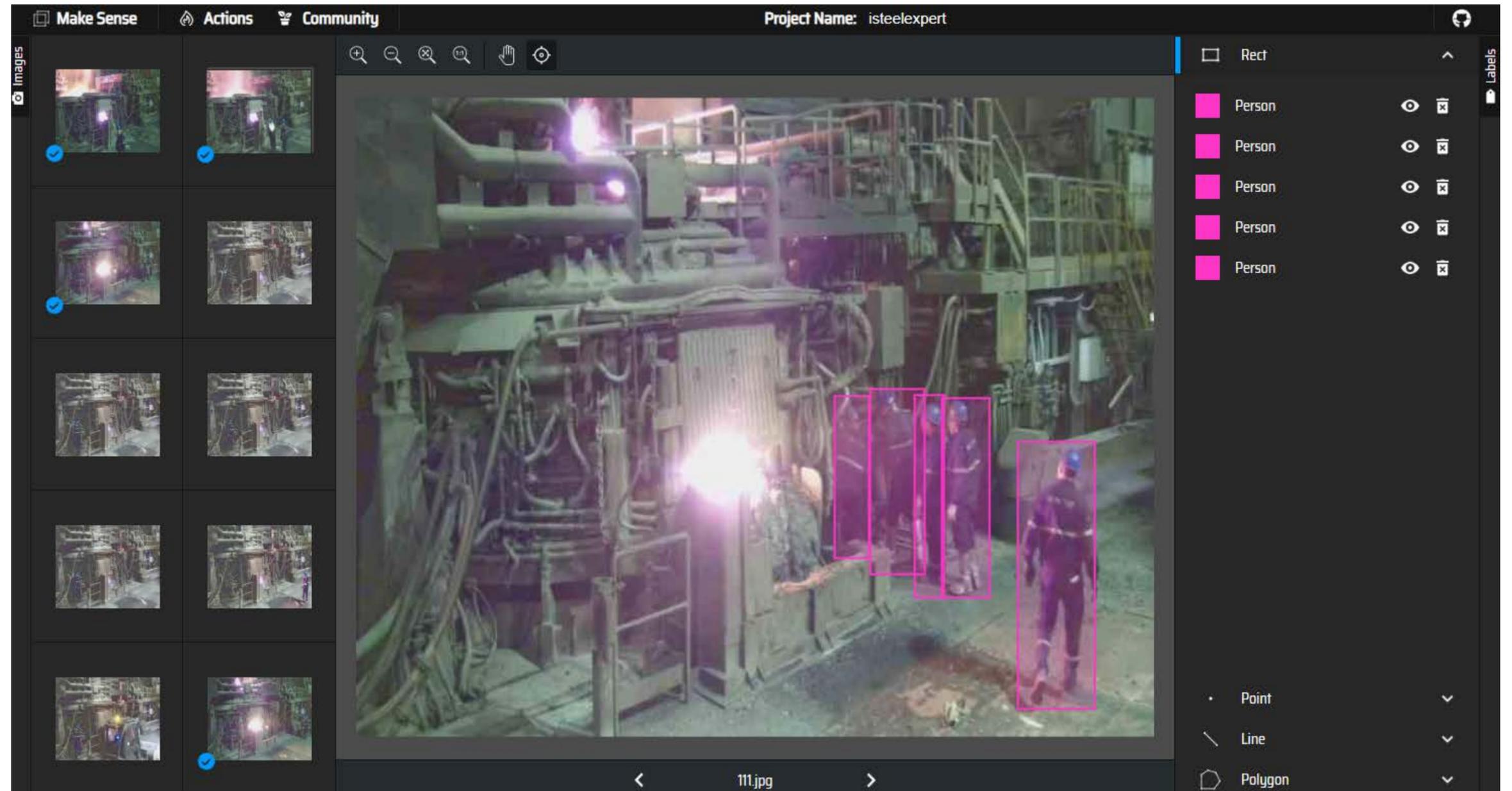
Image Classification

What it is

Image classification assigns a *single label* to an entire image — identifying *what* object or concept it represents

Based on convolutional neural networks and transfer learning

How it works

- Use models like **ResNet** or **EfficienNet** trained on **ImageNet** dataset to extract visual features from images
- Replace the final fully connected (classification) layer with one adapted to your own dataset
- Fine-tune the new layer (and optionally top CNN layers) to learn your specific categories

Prediction

- The model outputs the **most likely class** for each image

Advantages

- Fast convergence and reduced data requirements
- High accuracy even with small datasets
- Reuse of generalized visual representations
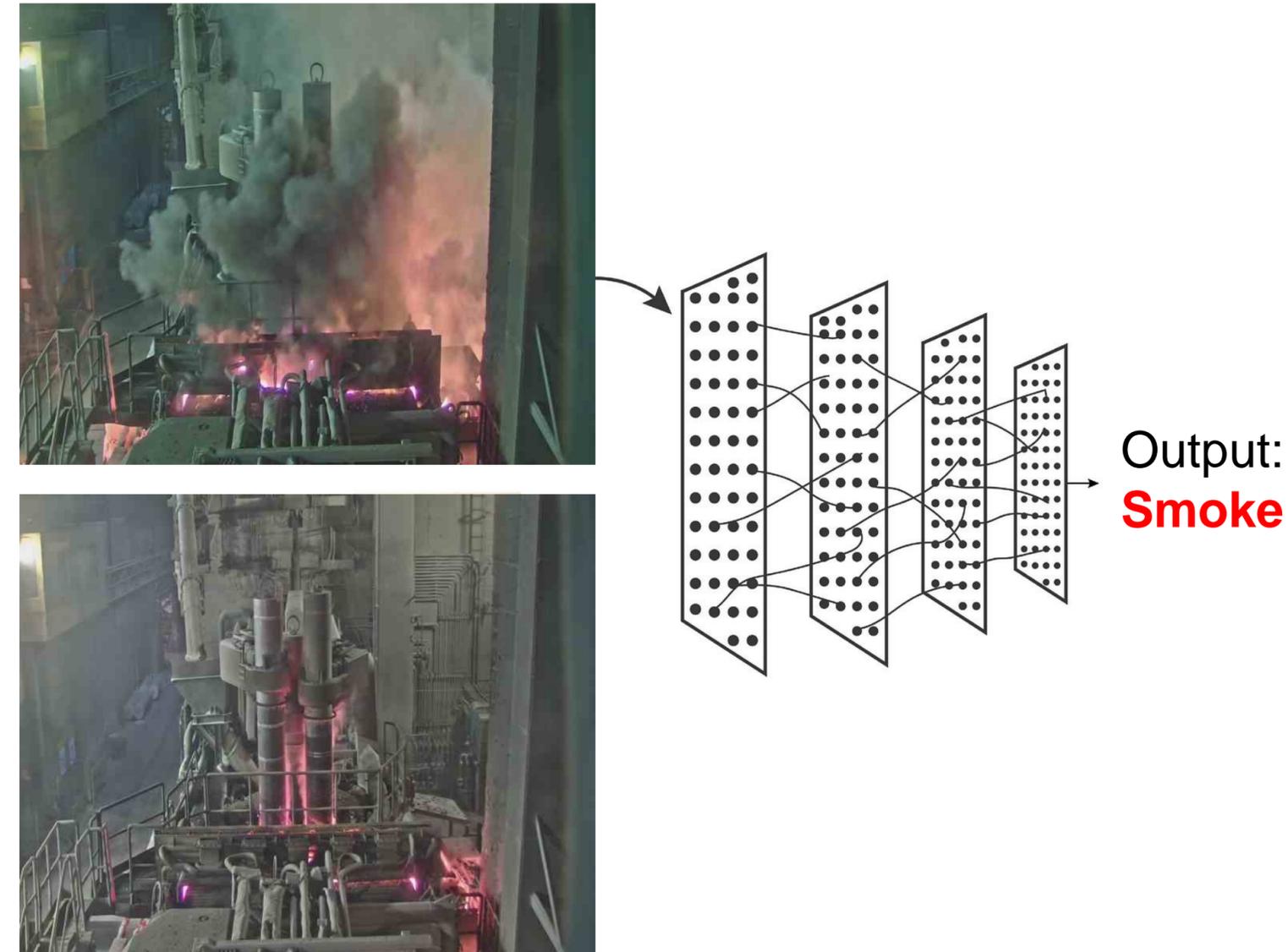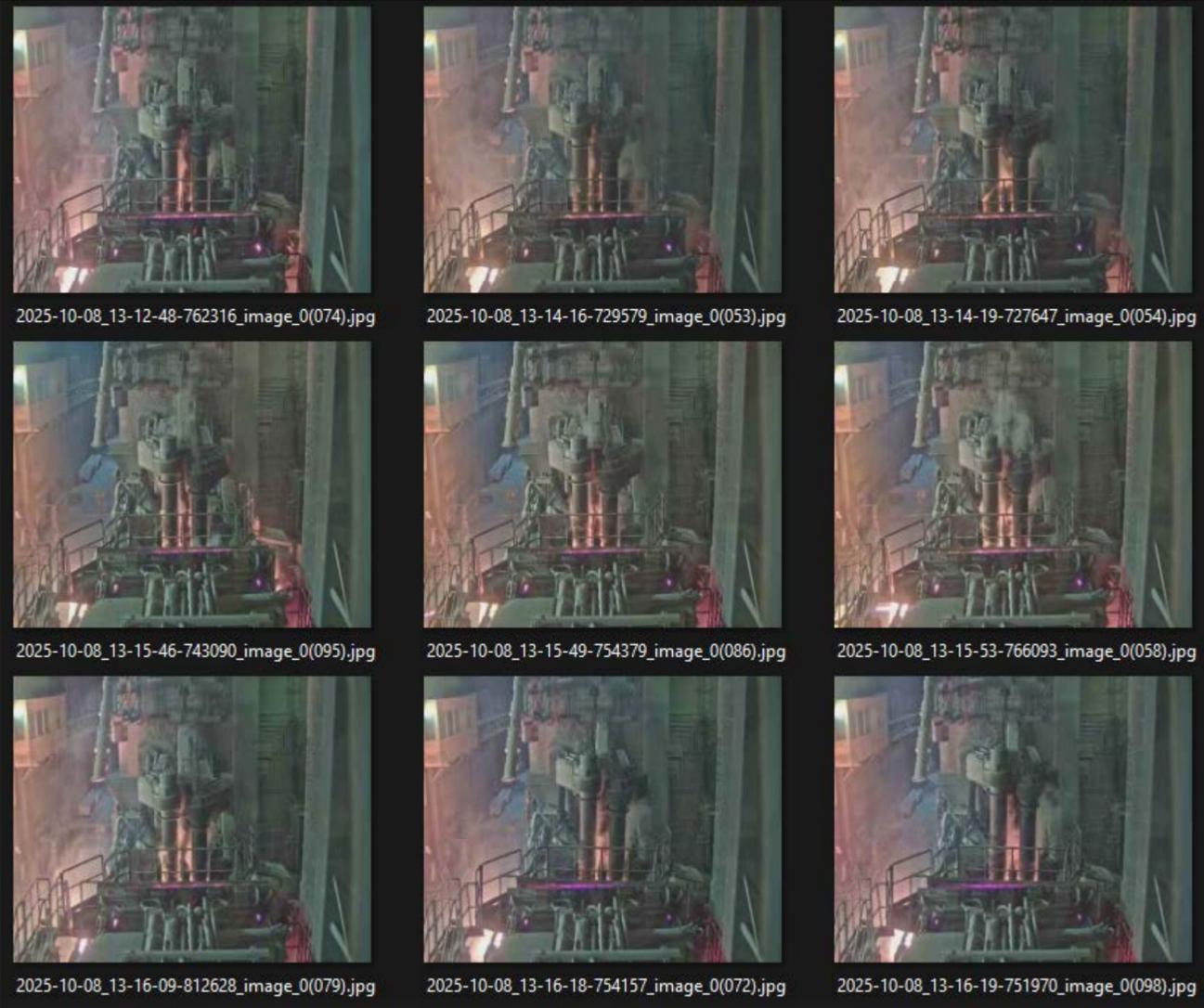

Output: **Smoke**

iSteel-Expert

Image Classification

For image classification it's easier to tag images
Just separate the images with different classes into different folders

No Smoke

Smoke

Smoke Detection

Model analyzes images to detect early signs of fumes or flames around the electrodes and roof

Extracts visual cues to flag potential occurrences of dangerous reactions
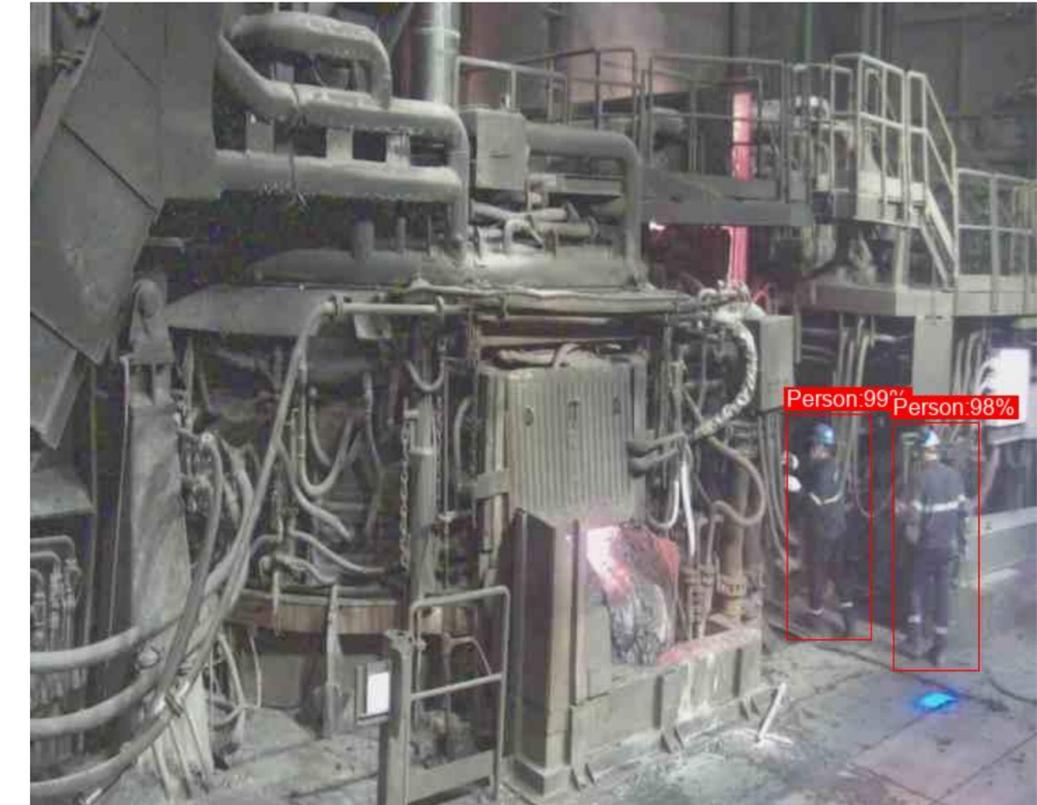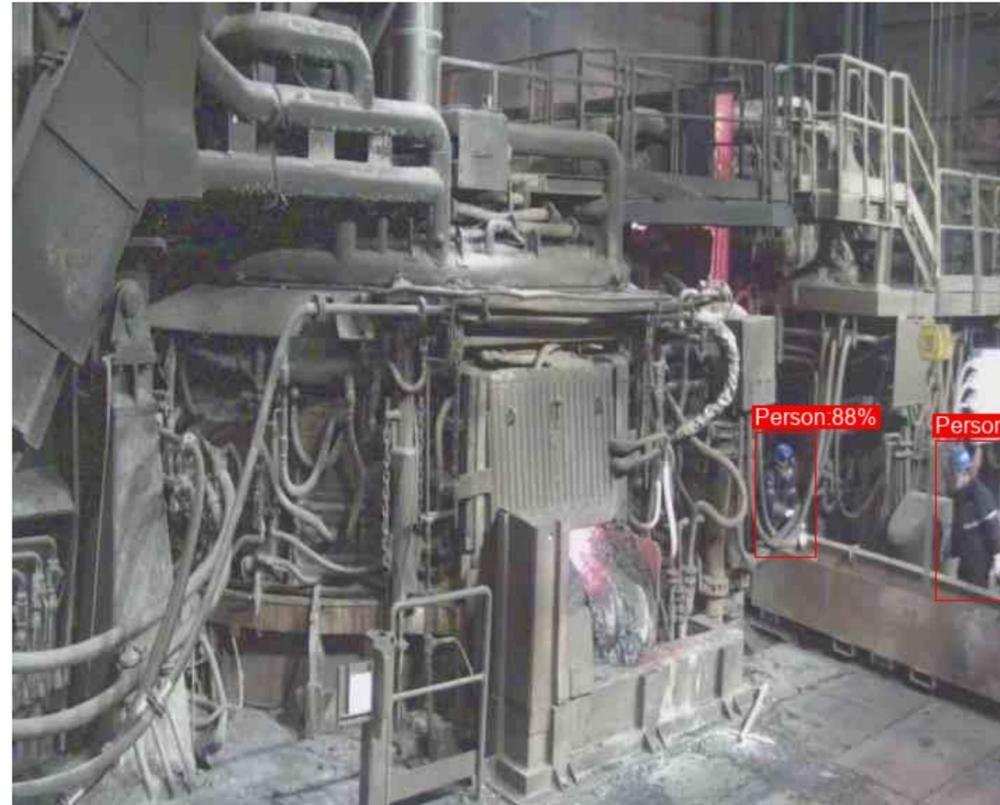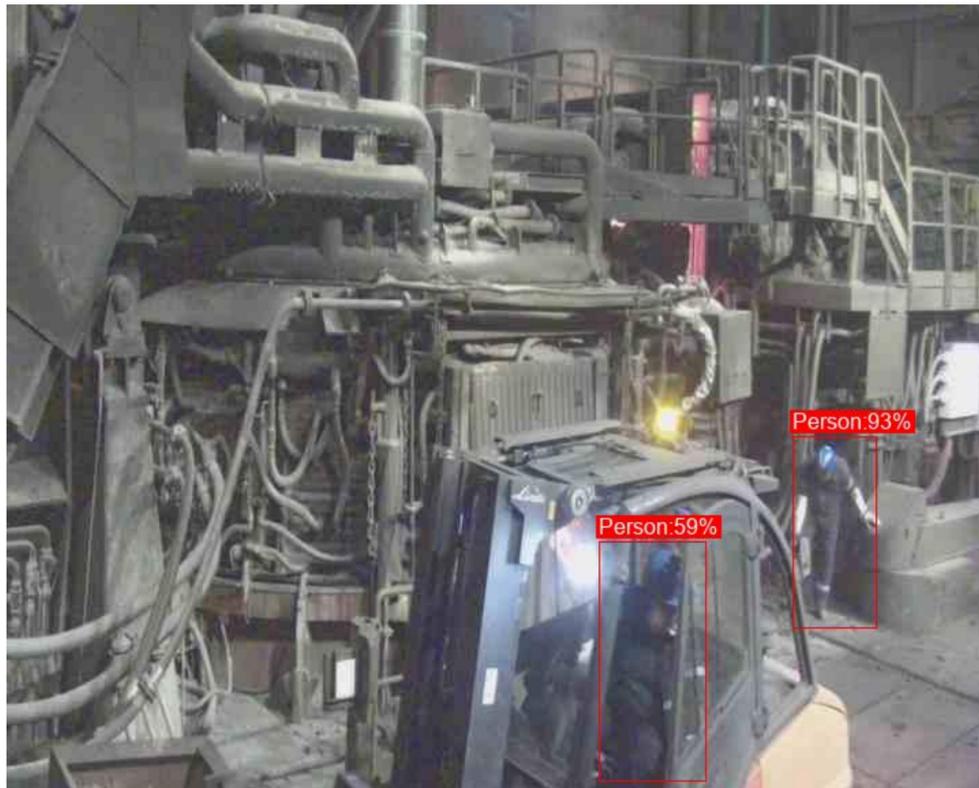
Smoke:

No Smoke:

?

People Detection

The system identifies personnel presence in high-risk zones around the furnace

This ensures that operators are aware of human location relative to hazardous operations, reinforcing safety protocols and minimizing the risk of accidents

Electrode Clamp Speed Estimation

Applying optical flow and frame-to-frame correlation, the system determines the position of the electrode arm and its up-and-down velocity

Movement monitoring provides critical insights into process control, such as abnormal electrode position profile during the heat which requires to adjust the power profile, as well as highlighting potential mechanical or hydraulic degradation of the electrodes control system

Slag Door Status Detection

By analyzing camera feeds near the slag door, the system highlights cases in which the slag door is commanded to close but obstructions prevent it from closing properly

This provides feedback on operator compliance with slag door control and cleanliness practices during the heat
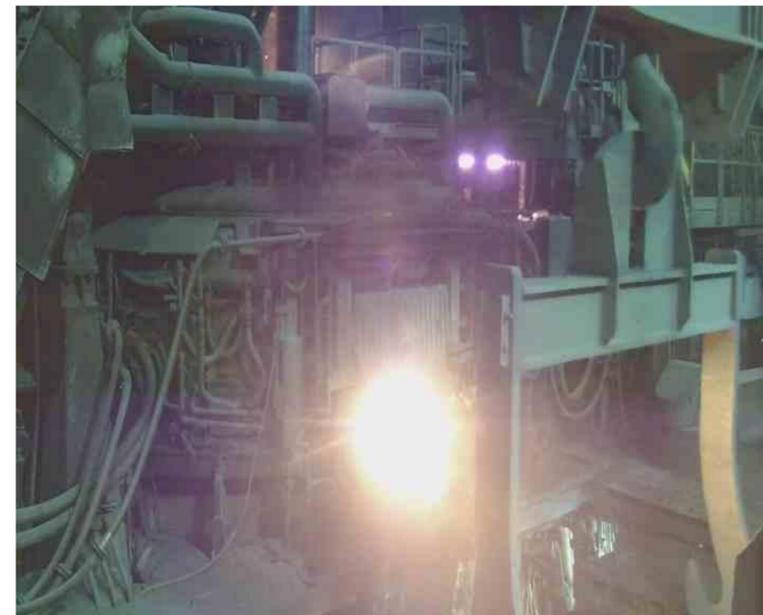
Electrode Tip Evaluation

Leveraging convolutional neural network-based segmentation, the system models and periodically assesses the electrode's tip geometry to recognize

Detecting wear anomalies, such as high side consumption, allows to prompt attention on the control set of both the water cooling and the fume suction, whose right adjustment extends the electrode life

iSteel-Expert Dashboards

User-friendly easy-to-read dashboards have been created in the Cloud to monitor the status and performance of the iSteel-Expert system and its KPIs
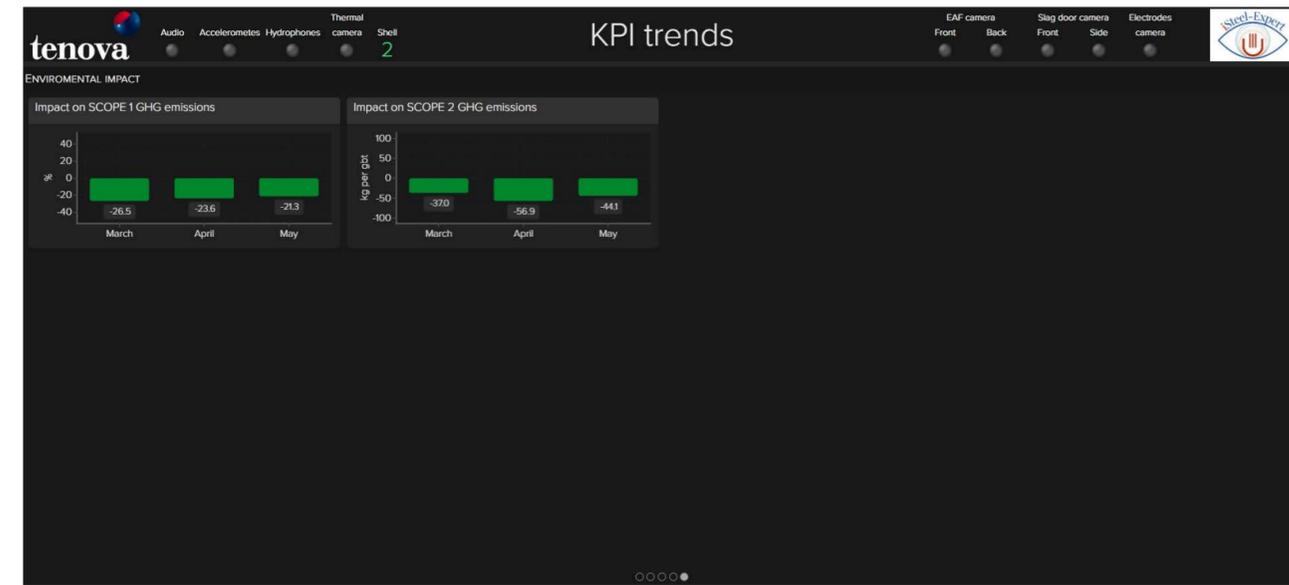
Conclusions

Traditional AI is still very powerful, it's not all about Generative AI

Convolutional Neural Networks (CNNs) are very useful in steel plants

Gathering images in a steel plant is very easy

Training CNNs is relatively easy with current tools and technologies

The biggest challenge is manually tagging images, especially edge cases

Image generated with AI

Image generated with AI

QUESTIONS & ANSWERS

Just for fun...

Who is the painter inspiring each image?