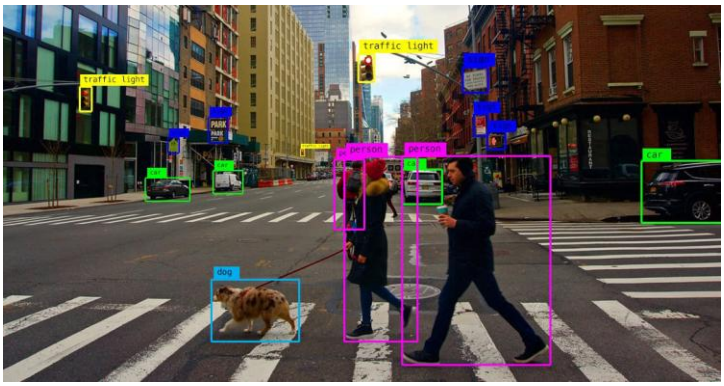
Camera-Based Characterization of GFT Input Streams for Biogas Process Optimization



Example detection and classification using Computer Vision

Twence is a regional waste-processing company in Twente. Every day, large volumes of household waste, including GFT (vegetable, fruit, and garden waste), are collected and processed. In addition to recycling valuable materials, Twence converts organic waste streams into biogas, contributing to the circular economy and the transition toward sustainable energy.

A critical part of this process is the anaerobic digestion system, where pre-processed GFT is broken down to produce methane-rich biogas. The stability and efficiency of this biological process depend heavily on the type and composition of the incoming GFT stream. Seasonal variation (wet winter material, woody spring material, leafy autumn material, high-protein grass in summer) causes significant fluctuations in: methane production, H_2S concentration and overall digester stability.

Twence aims to become a data-driven organization, but one major bottleneck limits further optimization: Operators and analysts currently have no objective, insight into what type of GFT is entering the digester. Given that individual waste items are often not cleanly separable or recognizable, the goal is *not* perfect object classification. Instead, the system should aim to extract useful aggregate features. The question is: *how can we extract the most useful information from the camera that is pointed at the GFT waste to get a better understanding of the structure of the waste that is going in the anaerobic digestion system?*

This lack of ingoing feedstock information makes it difficult to correctly correlate process data, apply machine learning, or reliably predict gas production. To solve this, Twence is exploring the use of camera-based classification of the incoming GFT stream.

You will design and build a prototype system that uses camera technology and computer vision to characterize the GFT stream before it enters the anaerobic digester.

These features can later serve as inputs for Twence's biogas prediction models combined with other features such as temperature, power usage and chemical indicators, enabling data-driven process optimization.

For the entire process you will use the CRISP-DM process which makes sure you work in a structured way (see figure 2).

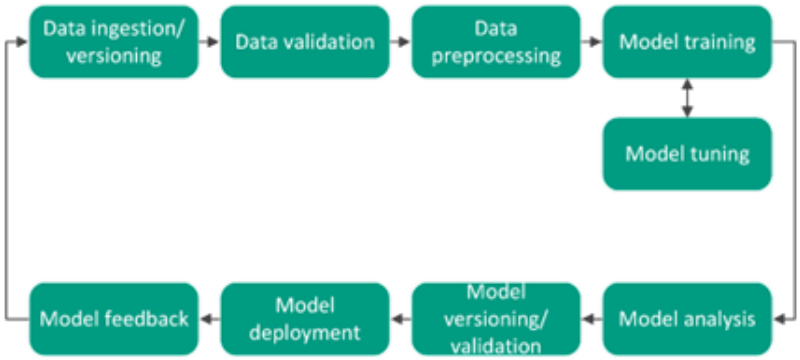


Figure 2: A simplified version, adapted by Deepak Tunuguntla, from a variety of proposed MLOps cycles.

You will work at the Ambient Intelligence Research Group at Saxion, where you will collaborate with data-science professionals and gain practical experience in applied AI.

WORK AND TASK DESCRIPTION:

- Perform a literature study on state-of-the-art computer vision methods for waste classification and difficult to classify waste.
- Analyze the anaerobic digestion process to understand where and how a camera system can be integrated.
- Determine the camera infrastructure that is needed (what type of camera(s) or sensors, what distance, which position, which lighting conditions etc).
- Determine together with the operators and machine learning experts which features are the most valuable to extract from the image.
- Collect a dataset that is useful for training the model.
- Investigate and evaluate suitable machine-learning and deep-learning models.
- Implement a prototype demonstrating the detection and classification pipeline.

PRACTICAL INFORMATION

- **Student profile:** Computer Science / HBO-ICT / AI / Applied Data Science/ Physics
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