Aalto University
School of Engineering

Business Finland Co-Innovation Project

TwinFlow: Identification, Tracking and Tracing for Indoor Logistics

Hari Prasanth S.M., Jaakko Peltokorpi, Risto Ojala

Department of Energy and Mechanical Engineering, Aalto University

Identification and Tracking Solutions for Manufacturing Environments

Make-to-order (MTO) environment faces deviations from the plan, emphasizing the need for constant situational awareness of materials and other assets. Information (data) must be shared between different parties. This requires a traceability system enabling physical parts to be differentiated and linked to their respective data (identification) and keeping a record of identifications (tracking). Based on a literature review [1], Table 1 shows potential technologies.

Table 1. Evaluation of applicability under various conditions (•• suitable, • limited suitability, ◦ not suitable).

		2D barcode	RFID	UWB	Laser marking	Optical authentication
Material	metals	••	•	••	••	••
	plastics	••	••	••	••	••
	ceramics	••	••	••	••	••
Surface	limited	◦	•	•	••	••
Object value	low	◦	◦	◦	◦	••
Line feeding	piecewise	••	••	••	••	•
	bulk	•	••	••	•	•
Process conditions	challenging	•	•	•	•	•

Case: Sheet metal manufacturing

Challenge: Sorting and grouping sheet metal parts for subsequent processes is inefficient without identifiers.

Goal: To identify and mark sheet metal parts to enhance operational efficiency.

Potential solution (Figure 1): 2D barcodes are laser-engraved onto valuable and large sheet metal parts. The codes are read by a matrix camera or handheld scanner in subsequent processes. Less valuable, smaller, and randomly stacked sheet metal parts can be identified using optical authentication

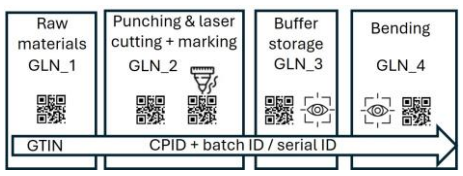

Figure 1. Sheet metal manufacturing

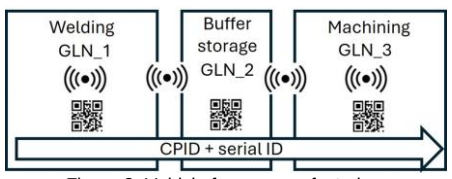

Figure 2. Vehicle frame manufacturing

Case: Vehicle frame manufacturing

Challenge: Vehicle frame components lack identifiers for automatic data capture and real-time situational awareness.

Goal: To identify and track vehicle frames to monitor their status against the plan and enable proactive decision-making.

Potential solution (Figure 2): Combining plastic 2D barcode labels with RFID tags. The tags are removed during challenging process conditions and reattached, using magnets, once the production step is completed. Additionally, an RFID gate at the entrance of a buffer zone would indicate that the product is waiting for the subsequent production step.

TwinFlow

Detection and Tracking of Industrial Objects using Computer Vision

Computer vision enhances real-time monitoring and automation in industrial settings, but traditional object detection methods require extensive labeled datasets, making it difficult to recognize new objects. This challenge is significant in industries where specialized objects frequently appear. Few-shot learning offers a promising solution by enabling models to detect objects with minimal data. However, existing models perform poorly on industrial datasets, highlighting the need for improvements. Our research aims to refine foundation models for better industrial object detection with limited training data.

Preliminary Experiments: Autodistill framework [2]

This experiment revealed their limited ability to adapt to industrial objects, struggling to distinguish between similar items (Figure 2). This underscores the need for further research and custom enhancements to improve detection performance

Figure 2. The model misclassifies all tools as hammer.

On-going development

Recent work explored NIDS-Net[3] (Figure 3), leveraging foundation models for few-shot detection. This utilizes models like DINOv2 and SAM to detect and segment objects with minimal labeled data. The insights from this approach could aid in developing more effective few-shot detection models for industrial object recognition.

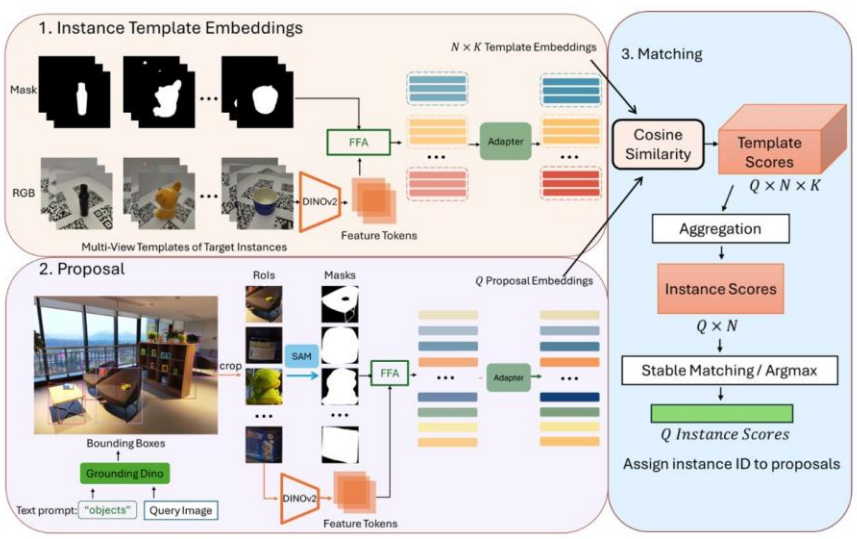

Figure 3. NIDS-Net framework.

References

1. Peltokorpi, J. (2024, November). "Who Saw It Last, and Where? Materials Identification and Tracking for Efficient Production and Intralogistics." In Asia-Pacific Industrial Engineering and Management Systems Conference.
2. Autodistill, GitHub. Link: https://github.com/autodistill/autodistill
3. Lu, Yangxiao, et al. "Adapting Pre-Trained Vision Models for Novel Instance Detection and Segmentation." *arXiv preprint arXiv:2405.17859* (2024).