LES DIRECTS DE L'EXPERTISE

CE
Process – Manufacturing

=> Focus on the work of the AI subgroup

14/05/2025

INTRODUCING AUTOVI:
A CHALLENGING DATASET FOR VISUAL ANOMALY DETECTION IN MANUFACTURING APPLICATIONS

HTTPS://AUTOVI.UTC.FR/

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TODAY KEY FIGURES

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- **Real-world inspection matters**:
Existing anomaly detection datasets are often synthetic or simulated.

- **AutoVI Dataset => A benchmark for progress:**
Developed by the SIA Working Group and Université de Technologie de Compiègne, AutoVI dataset provides a scientific foundation to evaluate and improve anomaly detection methods for modern manufacturing.

- **Industrial defects are unpredictable and diverse** (texture, structure, logic).
Inspection systems must detect previously unseen anomalies without human supervision => AutoVI, support for applied research and transfer to industry

- **You can access & contribute to AutoVI for free!**

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Outline

- **Context and stakes for industry**
- Public dataset for visual anomaly detection
- AutoVI : a genuine dataset made in real conditions
  - *Inspection tasks of AutoVI and the extensions*
- AutoVI, support for research applications and transfert for industry
- How to contribute to AutoVI?
- Q/A

Context and stakes for industry

- **Global Industrial Context:**
  - Increasing diversity in Manufacturing
  - Increase in "risky" controls
  - Difficulty in "creating" defects without industrial impact
  - Creation of low added value jobs (high cognitive load)

- **AI tools Key Benefits**
  - +30% defect detection, even in multi-reference production
  - -40% operator fatigue from prolonged inspection tasks
  - Shift toward high-value tasks: adjustment, analysis, improvement
  - upskilling: from reactive control to proactive decision-making

Context and stakes for industry

> Industrial Live applications everywhere

Renault Group
Engine Final inspection

Context : Random Fault Detection

Continental

Electronic Card Assembly : small production run

Renault Group
Battery Shop

Context : Connector assembly compliance

> The Hidden Risk: AI Trained on Unrepresentative Data

🧪 In the Lab (POC Phase):

- ✅ Clean, labeled, and stable data under ideal conditions
- ✅ Controlled lighting, product consistency, and known defect types
- ⚠️ Models often trained on *"best case scenarios"*

🏭 On the Production Floor:

- ❌ Real data is noisy, incomplete, and hard to label
- ❌ Frequent changes in lighting, products, variants, and camera settings
- ❌ Models that worked in lab **fail to generalize** in real life

2024 SIA Workgroup
1- Why?
2- Proposal for improvement?

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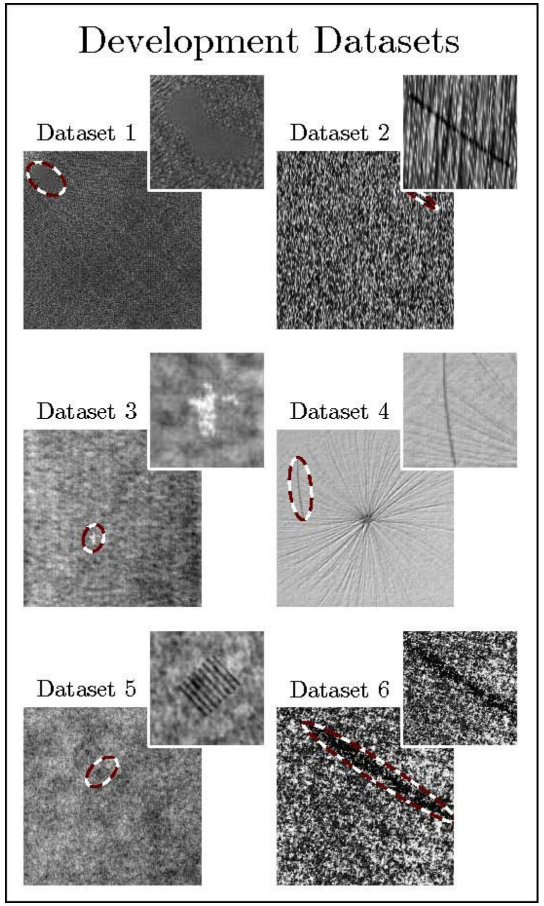
Public dataset for visual anomaly detection

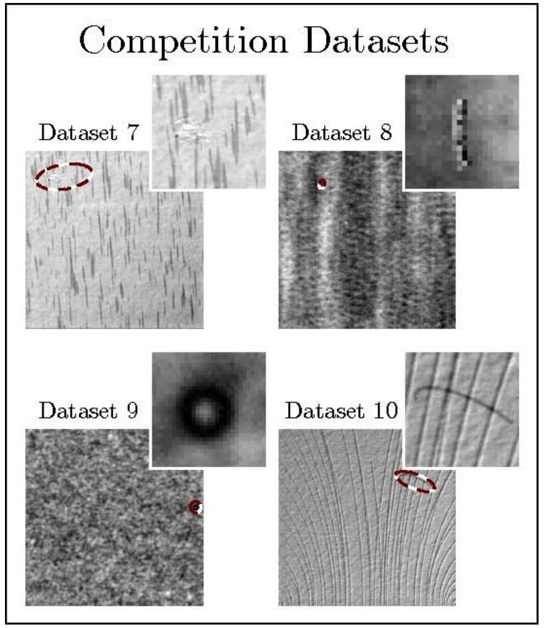
Summary of the main features of the described datasets.

Dataset	N. images	N. defects	N. classes	Shooting conditions	Logical defects
DAGM (Wieler et al., 2007)	16 100	2100	10	Artificial	N
NEU (Song and Yan, 2013)	1800	1800	6	Laboratory	N
Severstal Steel (Severstal, 2019)	12 572	Not given	1	Industrial (steel)	N
MVTec AD (Bergmann et al., 2019)	5354	1258	15	Laboratory	Y[a]
KolektorSDD (Tabernik et al., 2020)	399	52	1	Industrial (plastic)	N
KolektorSDD2 (Božič et al., 2021)	3335	356	1	Industrial (unspecified)	N
MVTec LOCO (Bergmann et al., 2022)	3644	993	5	Laboratory	Y
VisA (Zou et al., 2022)	10 821	1200	12	Laboratory	N

Public dataset for visual anomaly detection

> DAGM
- 2007; 10 classes;
- Dataset artificially generated





Public dataset for visual anomaly detection

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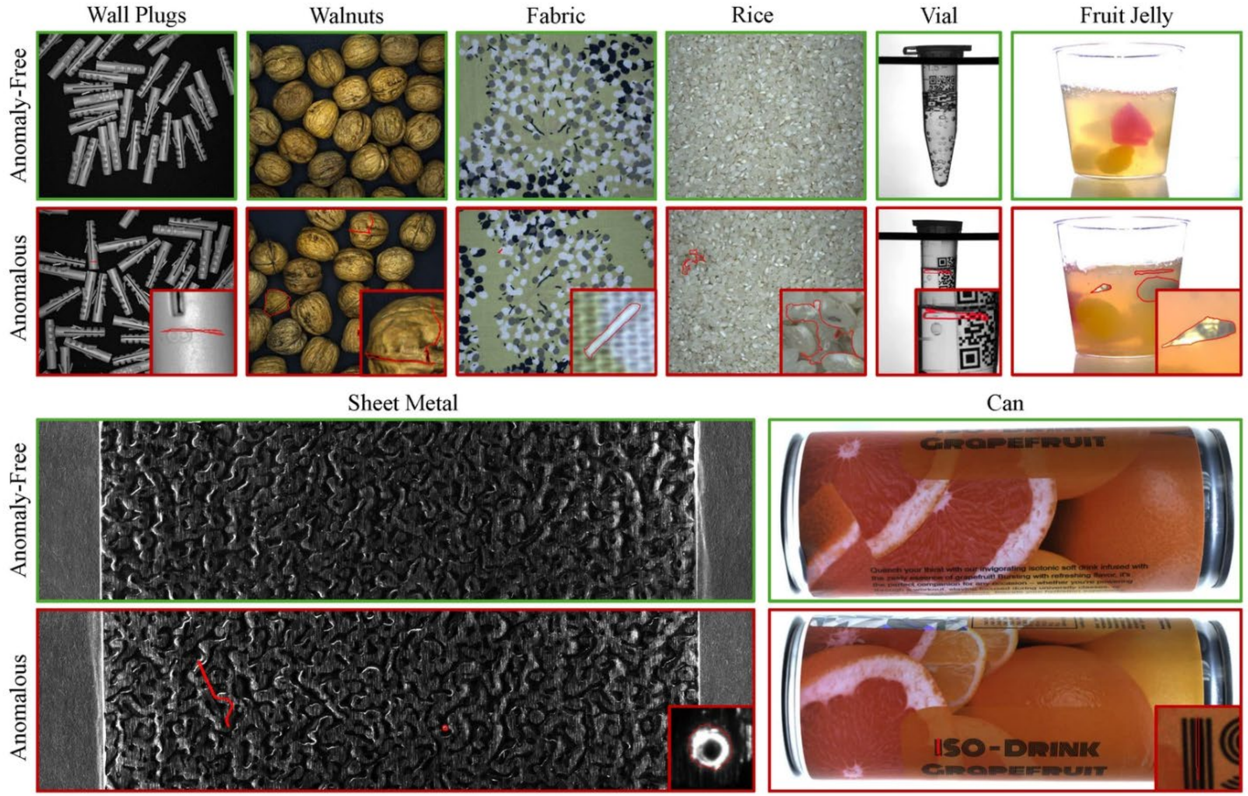
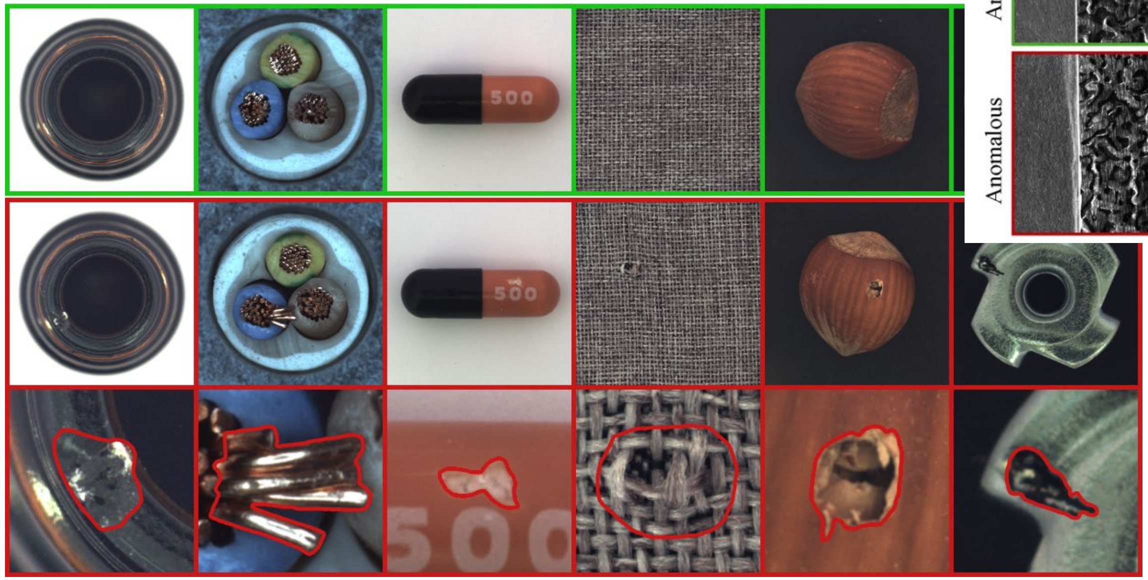
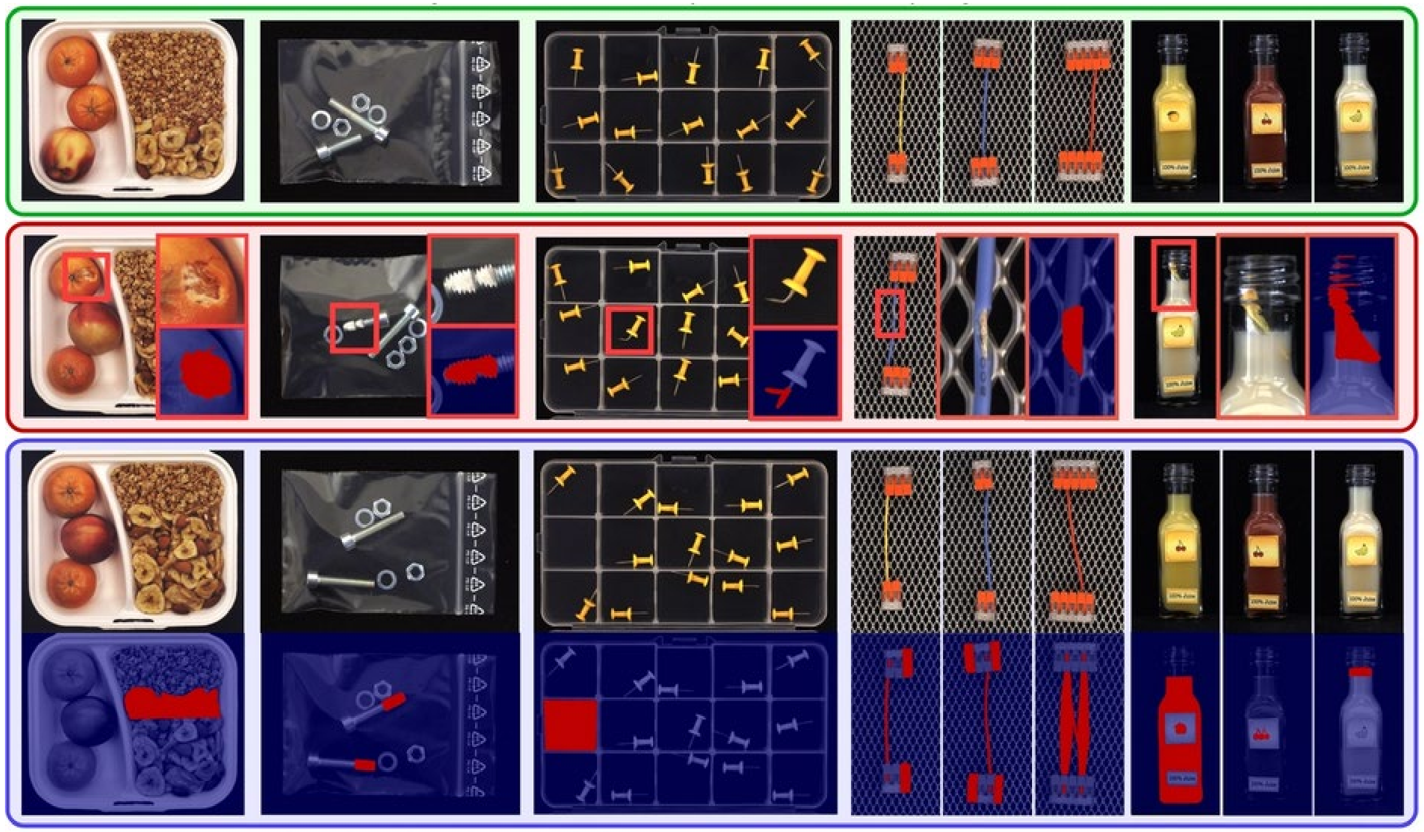
> MVTEC Anomaly Dataset (AD1 et AD2)
  - 2019 et 2025
  - 15 classes + 8 classes
  - Transparent items and variation of lighthing conditions





Public dataset for visual anomaly detection

> MVTEC Loco
  - 2021, 6 classes
  - Logical Defects



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Available public datasets are not sufficiently representative of industrial environments

From a UTC research study published in 2024

MVTEC AD1, AD2 & Loco and VisA (Laboratory shooting conditions) interesting for benchmark (23 classes « aspects » and 6 classes « logicals »)

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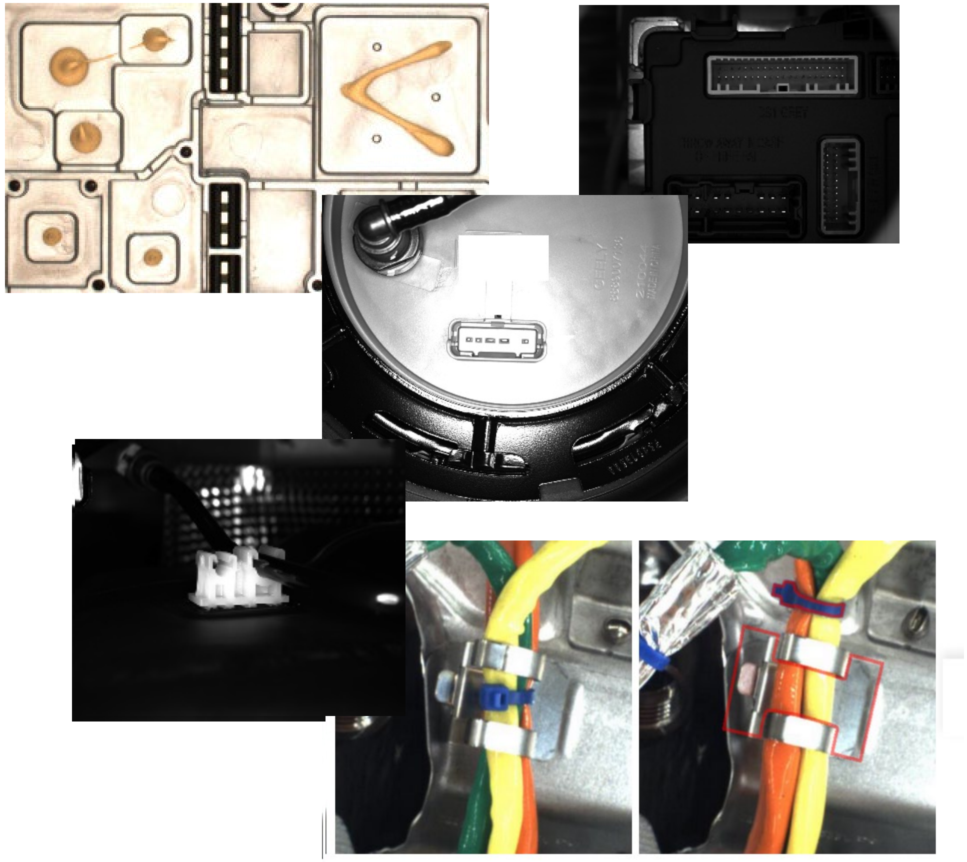
AutoVI : a genuine dataset made in real conditions

> AutoVI : https://autovi.utc.fr

- With the support of SIA partners (Renault Group, Continental, OpMobility etc.)

- Objectives: to increase the transfer of AI technologies to industry, to develop methods that are as close as possible to the real world !



All the images of defects correspond to deliberately built anomalies upstream on the assembly line without any modification of the actual shooting conditions. These anomalies correspond to defects that were recorded in the defect library. This protocol enabled us to collect a large number of different images of defects. Naturally, these defects were corrected after shooting.

AutoVI : [HTTPS://AUTOVI.UTC.FR/](https://autovi.utc.fr/)

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AutoVI   Home   Attribution   Download   Results   Challenge   Acknowledgements   EN|FR

AUTOVI DATASET

The Automotive Visual Inspection Dataset (AutoVI): A Genuine Industrial Production Dataset for Anomaly Detection

ALLIANCE SORBONNE UNIVERSITÉ   utc Recherche Roberval   Renault Group

Continental   OPmobility   SOCIÉTÉ DES INGÉNIEURS DE L'AUTOMOBILE

Modern industrial production lines must be set up with robust defect inspection modules that are able to withstand high product variability. This means that in a context of industrial production, new defects that are not yet known may appear, and must therefore be identified.

On industrial production lines, the typology of potential defects is vast (texture, part failure, logical defects, etc.). Inspection systems must therefore be able to detect non-listed defects, i.e. not-yet-observed defects upon the development of the inspection system. To solve this problem, research and development of unsupervised AI algorithms on real-world data is required.

Renault Group, OPMobility, Continental and the Université de technologie de Compiègne (Roberval and Heudiasyc Laboratories) have jointly developed the Automotive Visual Inspection Dataset (AutoVI), the purpose of which is to be used as a scientific benchmark to compare and develop advanced unsupervised anomaly detection algorithms under real production conditions. The images were acquired on Renault Group's automotive production lines, in a genuine industrial production line environment, with variations in brightness and lighting on constantly moving components. This dataset is representative of actual data acquisition conditions on automotive production lines.

AutoVI : HTTPS://AUTOVI.UTC.FR/

AutoVI Home Attribution Download Results Challenge Acknowledgements EN|FR

Download

The AutoVI dataset consists of six classes corresponding to real inspection scenarios on automotive production lines.

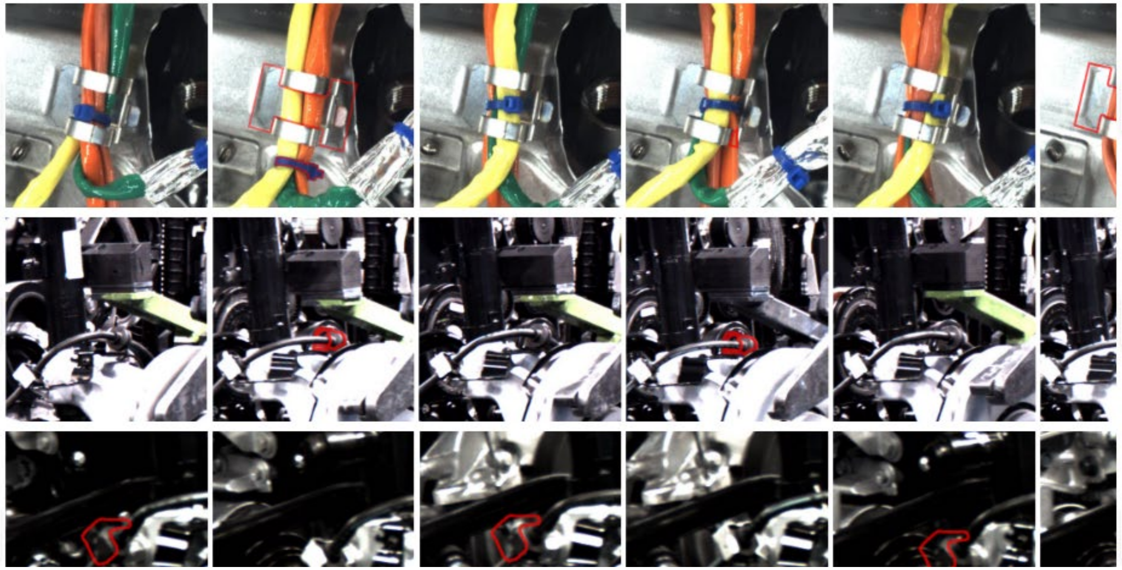
For all classes, the images were taken on our manufacturing plant's production lines. The cameras were set up at varying distances from the object depending on the object photographed and the object's environment, so that they could be installed without blocking the movement of operators around the inspection area. Different lenses have been used for the photographs. The test images show a variety of defects depending on the category of items. Some defects represent a missing part or a misplaced item, such as tank-screw or under-body pipes, while others show defective items (pipe_clip). Some images also show operators that block the inspection area (underbody-pipes)

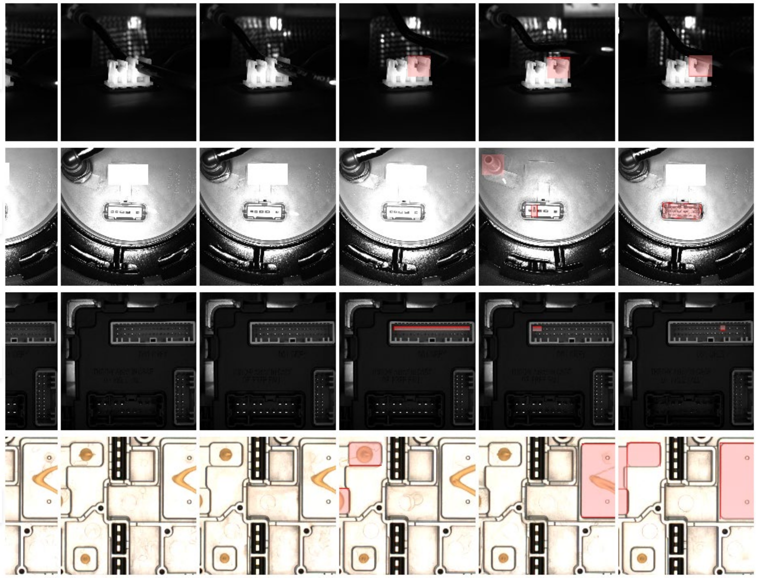
All defects have been created manually and designed to look like real defects. They have all been corrected after the shooting.

Click here to download latest version of the dataset

Click here to access the evaluation script

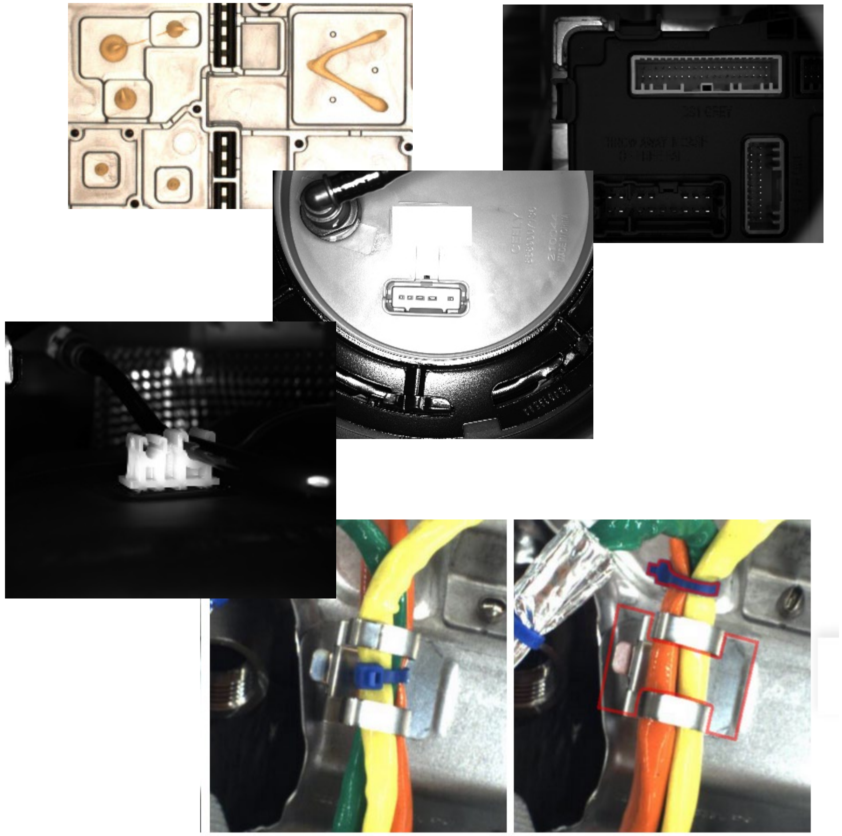
The following shows several images taken from the AutoVI dataset. Segmentation masks were overlayed on the defects when applicable.





Inspection classes of AutoVI and the extensions

Classes	OK / NOK
Engine wiring	570 / 322
Pipe clip	390 / 142
Pipe staple	379 / 117
Tank screw	636 / 95
Underbody pipes	322 / 184
Underbody screw	747 / 18
Cable clamp	329 / 22
Pin connector	342 / 7
Pin pcb	1666 / 5
Thermal paste	986 / 247

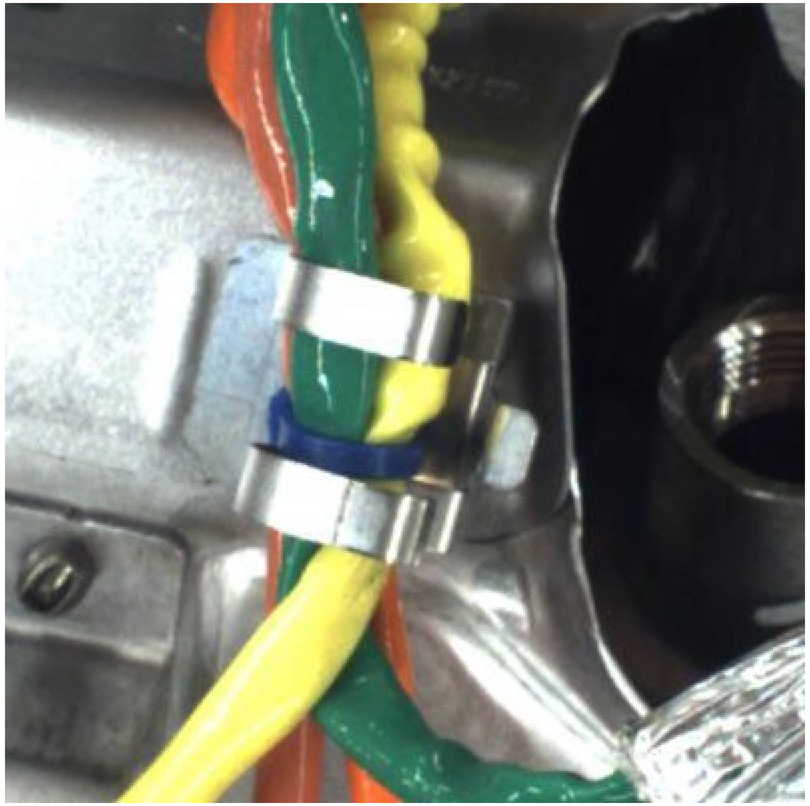


AutoVI : 11 classes & 7184 images !

Inspection classes of AutoVI and the extensions

Engine Wiring

- Logical cable defects.
- Wrong position of the blue hoop, appearance of unknown objects in front of the scene
- Variation in cable position and ring position
- Several types of logical defect (stickers, etc..)

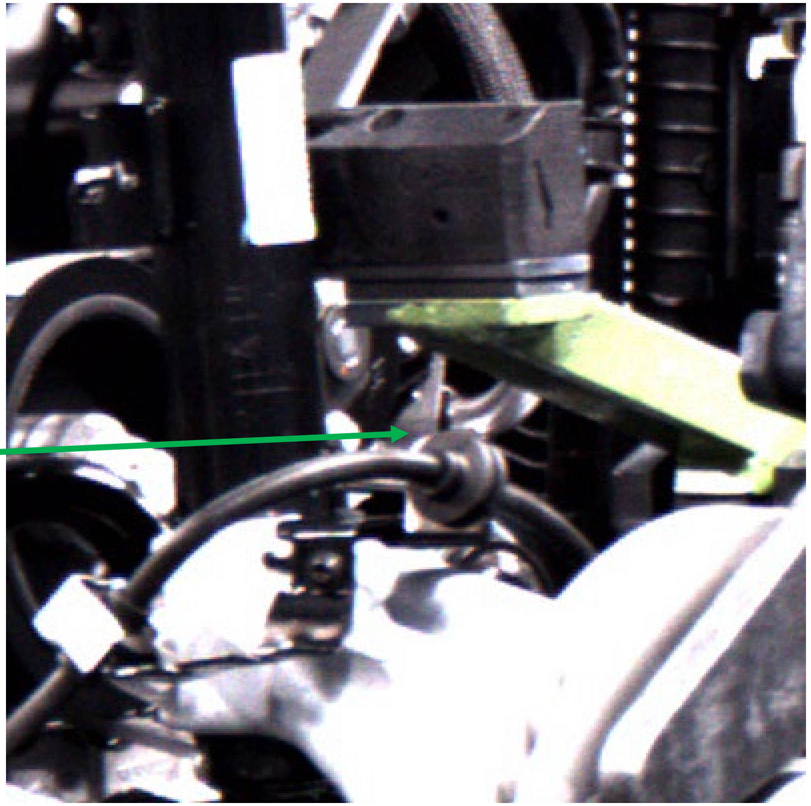


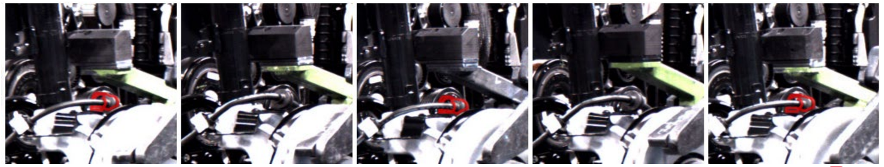
Inspection classes of AutoVI and the extensions

Pipe_clip

> ‘Complex region of interest, variability of the background, different shooting positions, conditions and several reference parts’

> ‘Detecting ot the missing Pipe Clip



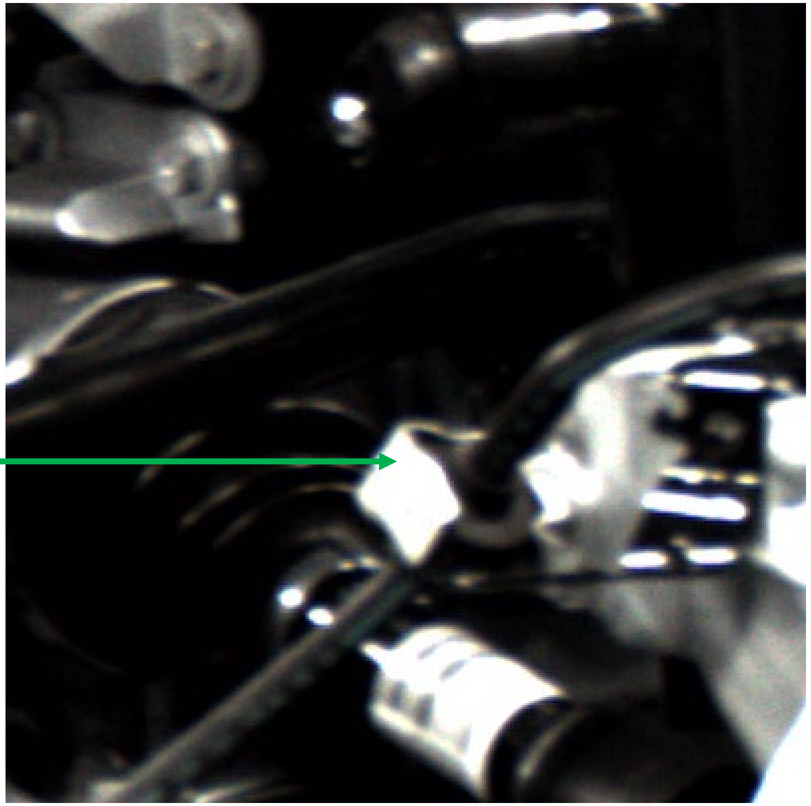


Inspection classes of AutoVI and the extensions

Pipe_staple

> ‘Complex region of interest, variability of the background, different shooting positions, conditions’

> ‘Detecting of the missing Pipe Staple’

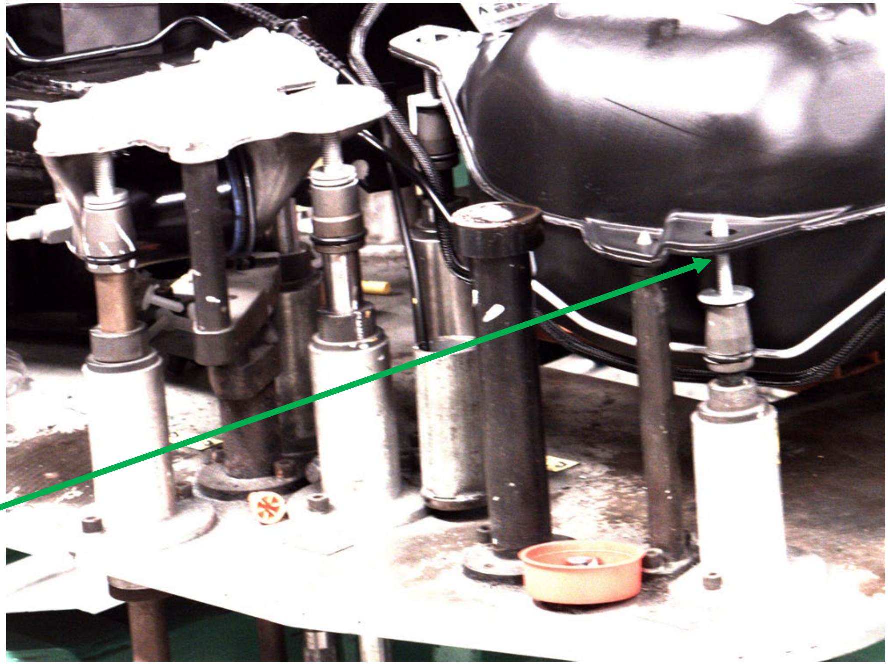


Inspection classes of AutoVI and the extensions

Tank_screw

- Complex region of interest, variability of the background, different shooting positions, conditions’

- ‘Detecting of the missing screws

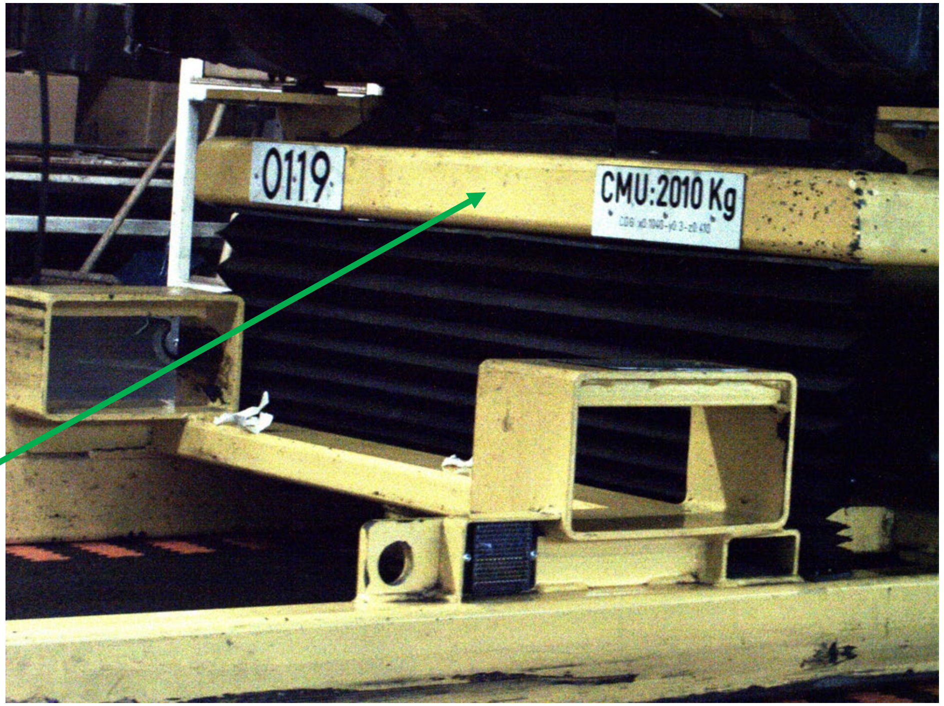


Inspection classes of AutoVI and the extensions

Underbody_pipes

- Moving chassis on a production line, variation of the background, different shooting conditions and positions »

- Cables detection in a front of the chassis

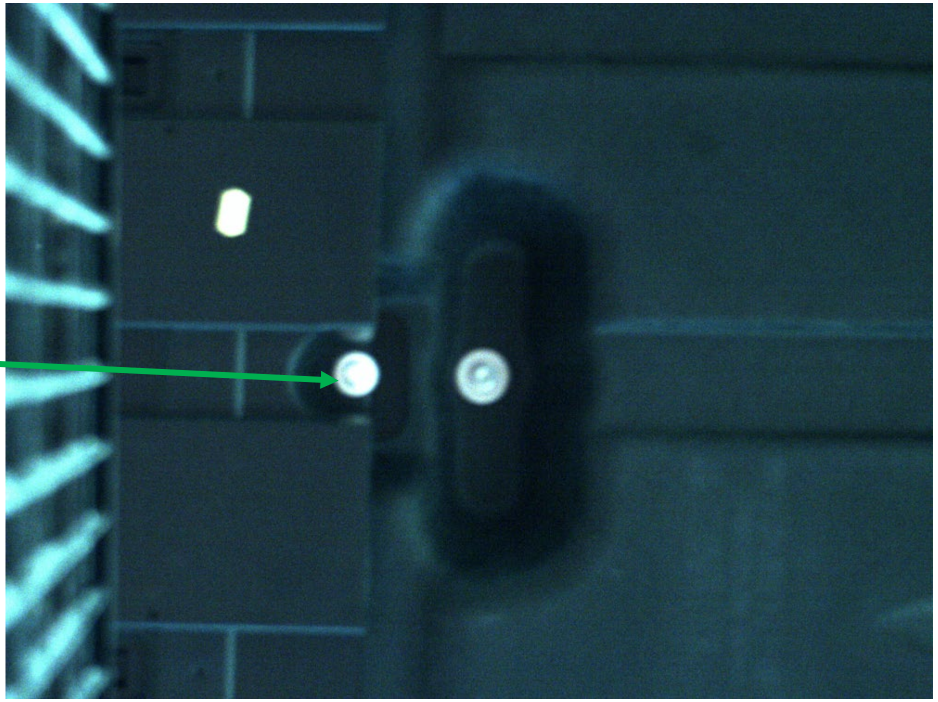


Inspection classes of AutoVI and the extensions

Underbody_pipes

> Different shooting conditions and positions

> Detecting missing screws

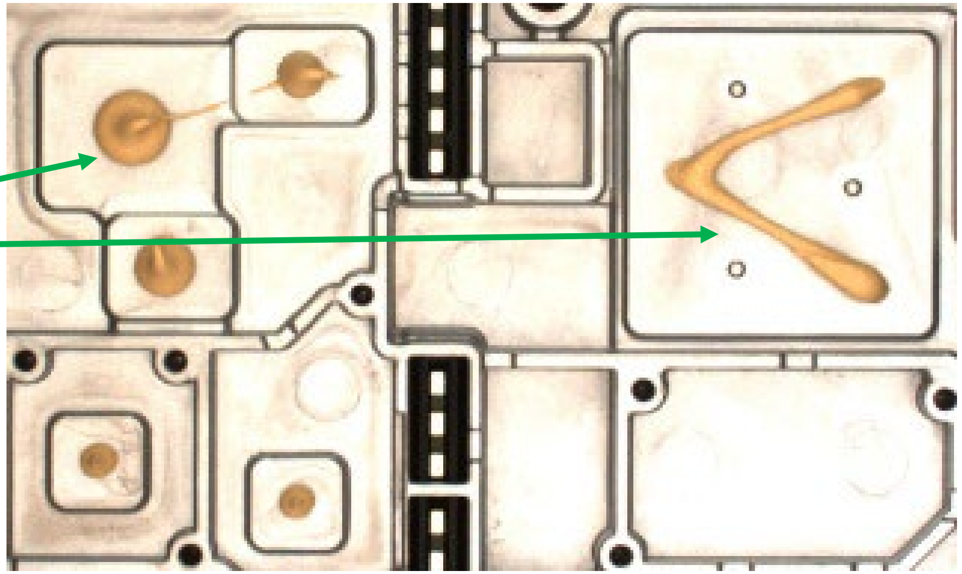


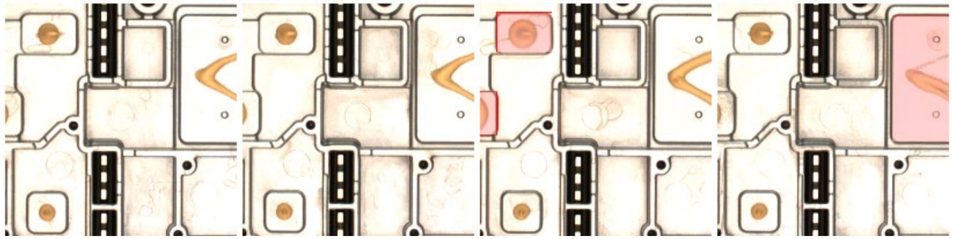
Inspection classes of AutoVI and the extensions

Thermal_paste

> « detection the positions of the thermal paste»

> « multiple region of interest, several types of defects»

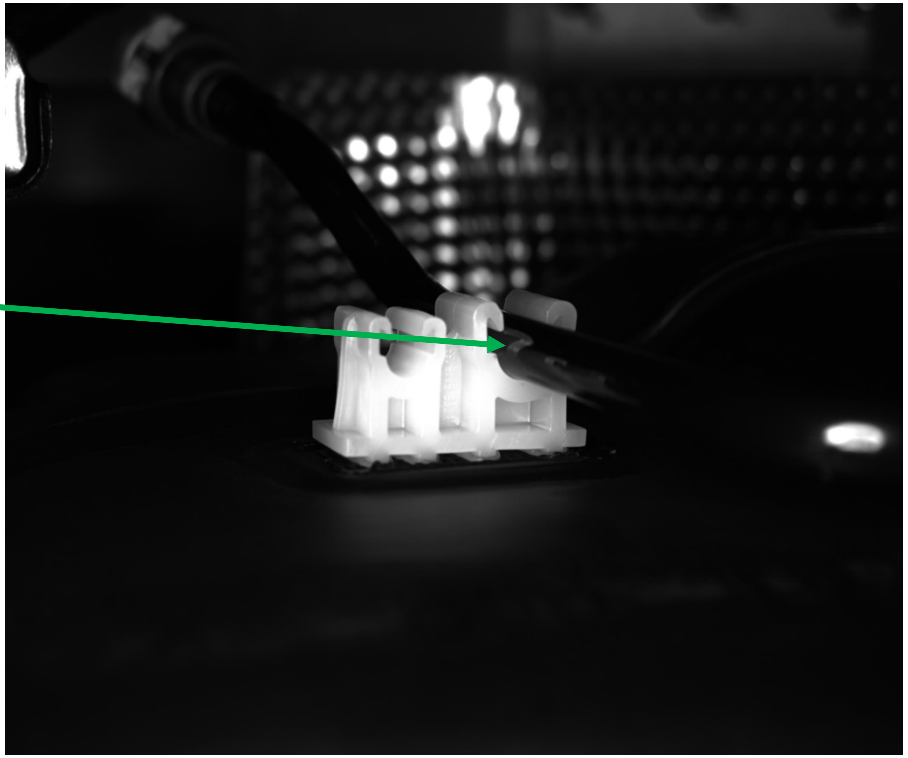




Inspection classes of AutoVI and the extensions

Cable_clamp

> « Cable position has to be detected»

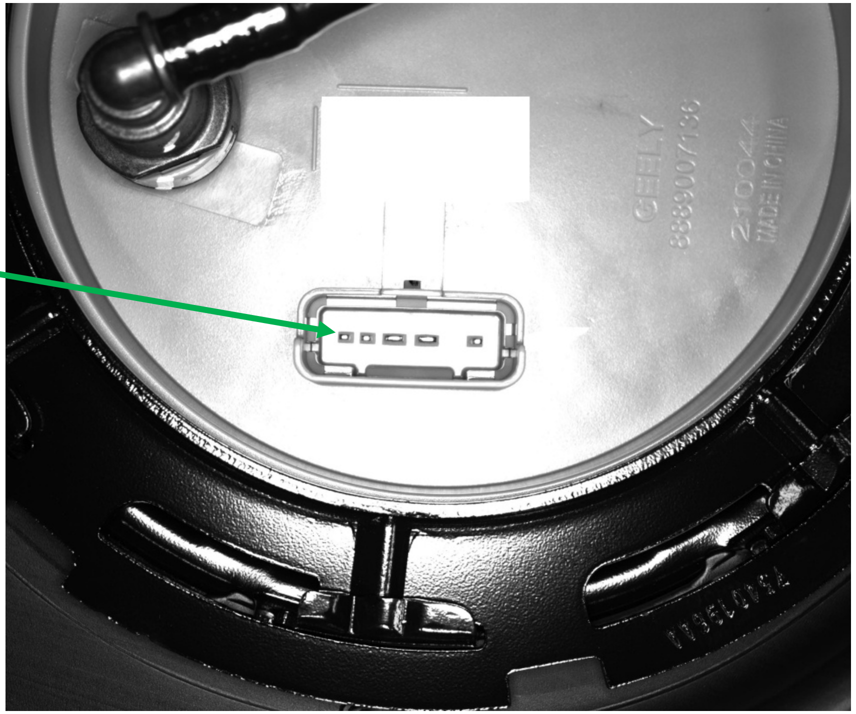


> *Class made for unsupervised methods only*

Inspection classes of AutoVI and the extensions

Pin_connector

- «Detection of the missing pin»

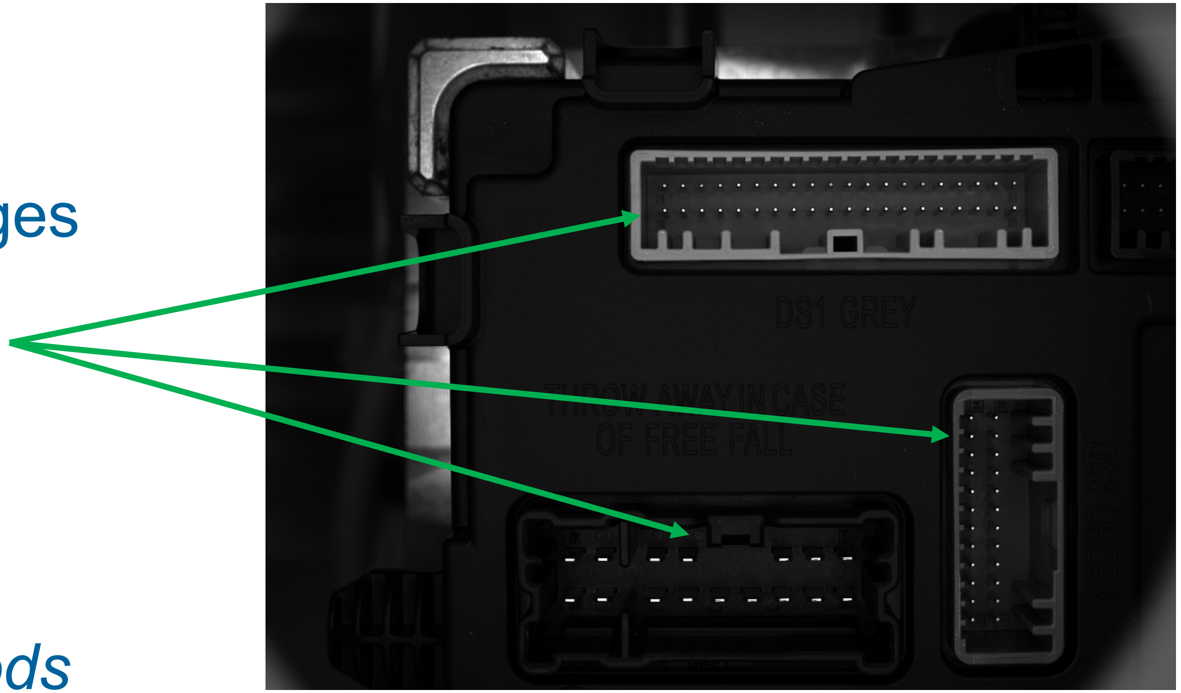


- *Task made for unsupervised methods only*

Inspection classes of AutoVI and the extensions

Pin_PCB

- «Detecting of the missing or damages pin»
- « Multiple regions of interest»
- *Task made for unsupervised methods only*



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AutoVI, support for research applications and transfer for industry

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> Benefits of AI approaches for anomaly detection :

- detect a large diversity of defect types (aspects and logicals)
- locate defects at any position on the part
- work with a very low defect occurrence rate
- detect both known and unknown defects (novelty detection)
- be setup and transposed with minimal human supervision
- have a direct application in an inspection cell
- locate the defect

AutoVI, support for research applications and transfer for industry

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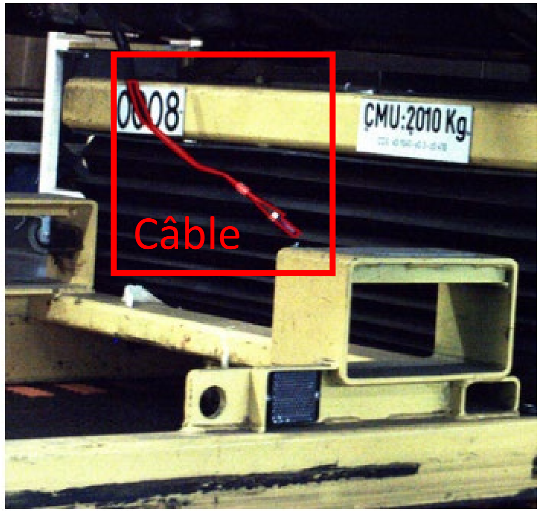
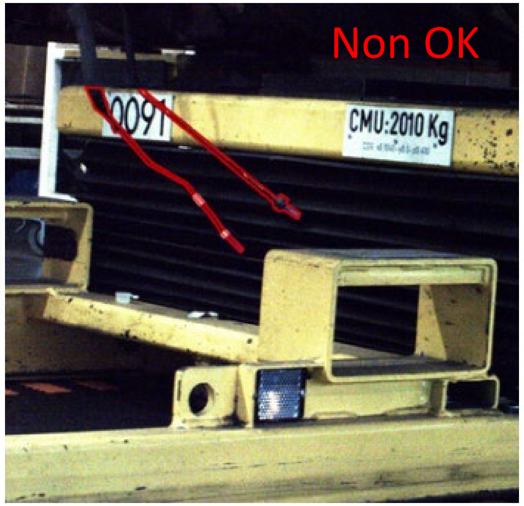
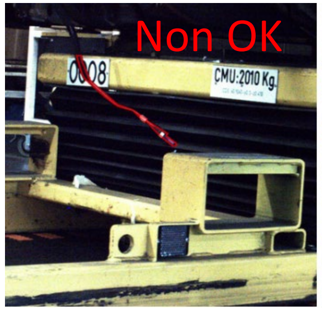
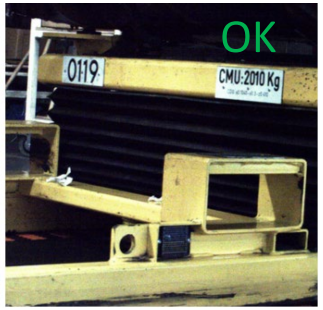
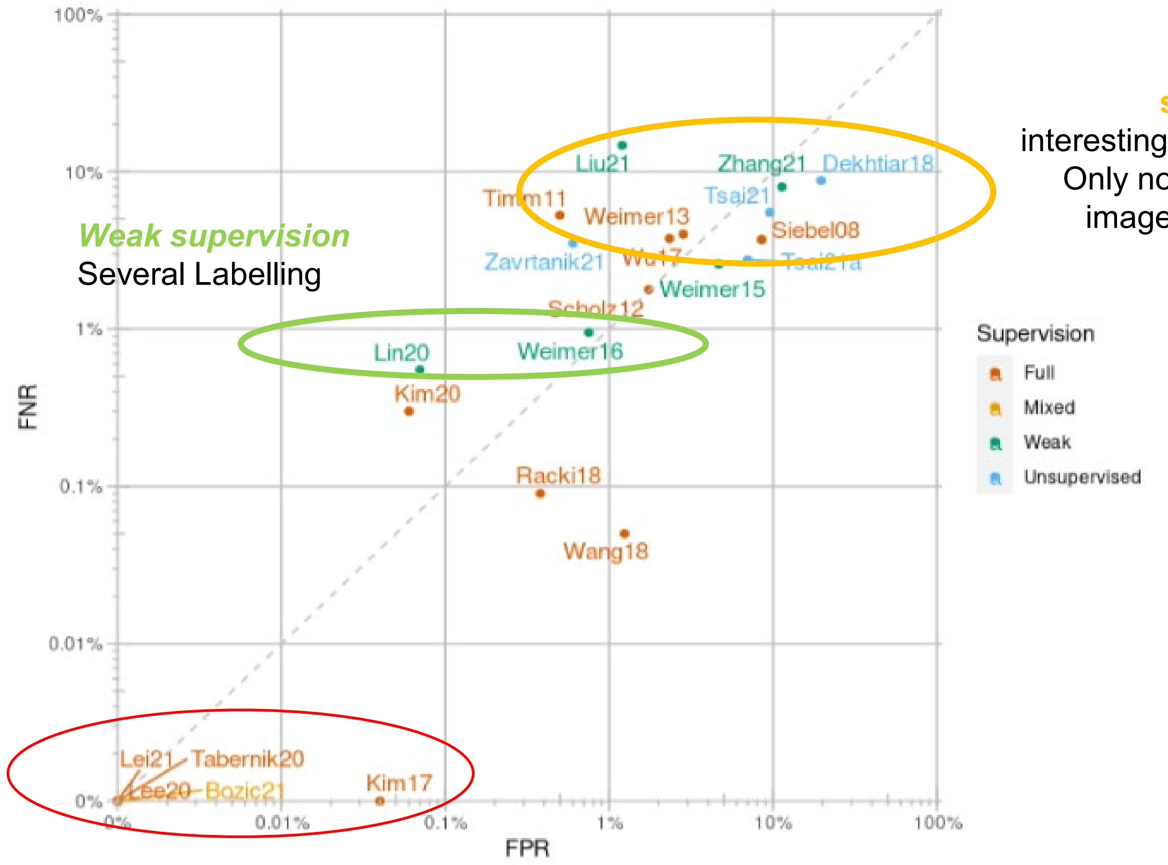
> "AI-based methods can fulfil the requirements".

	Supervised	Mixed supervised	Unsupervised
outputs :			 

AutoVI, support for research applications and transfer for industry

> AI, supervised, semi-supervised and weakly supervised methods

Mixed - supervised
interesting performances
Only non-defective
images labeling



Supervised
Best performances
Image Labeling &
segmentation

Deep Learning methods evaluation on the DAGM public Dataset (internal experiments made by UTC)

AutoVI, support for research applications and transfer for industry

> Evaluation metrics

- **ROC curve**: Balance between *True Positive Rate* (TPR) and *False Positive Rate* (FPR) depending on threshold values (Positive = Defect)
- **AUROC** (Area Under ROC curve): Global performance metric

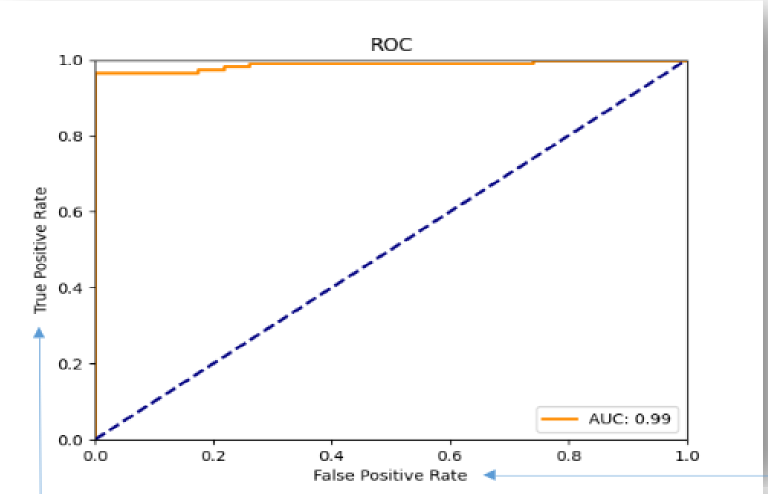
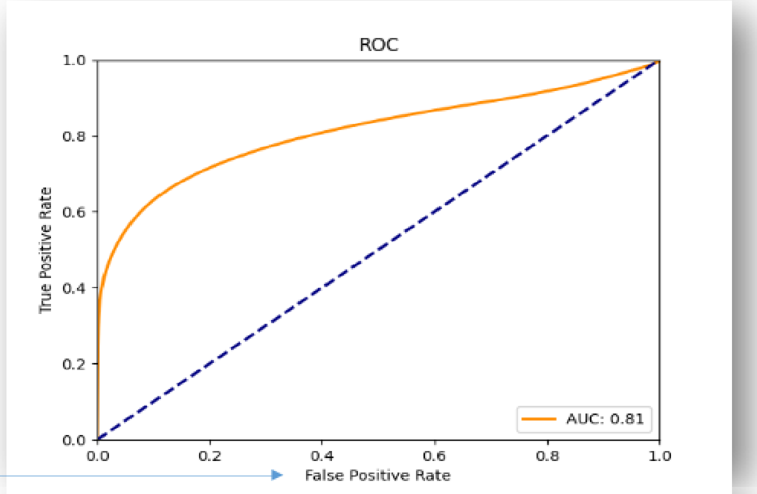


Image ROC



Pixels ROC

		Ground Truth	
		Positive	Negative
Prediction	Positive	True Positives	False Positive
	Negative	False Negative	True Negative

AutoVI, support for research applications and transfer for industry

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> Semi-supervised methods on AutoVI

Classification results measured by AUROCs (in %). The AUROCs shown here are calculated as the means and standard deviations of the AUROCs observed in the eight experiments. Best results are outlined in **bold**. Best results differ from the others according to the Welch's *t*-test at the 5% significance level. If several good results are not significantly different, they are all considered to be the best. The mean AUROCs from the MVTec AD, MVTec LOCO and VisA datasets are reproduced from Table 2.

	CFlow	DRAEM	DSR	Eff.AD	PaDiM	Patchcore
Wiring	46.1±8.6	71.8±2.3	75.9±2.4	**79.7±0.8**	**79.2±1.3**	77.2±0.3
Clip	49.3±12.7	**76.6±3.6**	**81.1±6.8**	**76.8±1.2**	62.6±2.0	73.3±0.9
Staple	51.2±6.7	74.2±12.1	**96.2±3.1**	84.3±1.5	54.6±3.0	92.3±0.6
T. screw	48.7±14.1	63.9±11.8	70.2±10.2	62.4±2.7	49.4±2.7	**89.3±0.7**
Pipes	64.2±19.7	89.2±5.5	56.9±8.6	91.2±1.2	98.9±0.6	**99.8±0.0**
U. screw	48.8±13.0	96.0±2.8	**97.9±2.2**	91.0±0.2	82.6±1.7	**98.9±0.1**
Mean	51.4±5.9	78.6±10.8	79.7±14.3	80.9±9.8	71.2±17.3	**88.4±10.1**
MVTec AD	98.2	98.0	98.2	99.1	97.9	99.0
MVTec LOCO	–	73.6	82.6	90.7	–	80.3
VisA	91.5	–	–	98.1	–	–

AutoVI, support for research applications and transfer for industry

➢ Transfer to industry

Suggested usage of the reviewed algorithms based on the results of our benchmark study.

	CFlow	DRAEM	DSR	Eff.AD	PaDiM	Patchcore
High variability			✓			✓
Small defects		✓		✓	✓	✓
Complex scenes			✓	✓		✓
Struct. defects	✓	✓	✓	✓	✓	✓
Logical defects				✓		

AutoVI, support for applied research and transfer to industry

- Good performance of AutoVI methods, but room for improvement remains
- Authentic conditions reduce the gap between "research" and "application"
- Adjusting current methods will help achieve robust and fast transpositions

	CFlow	DRAEM	DSR	Eff.AD	PaDiM	Patchcore
Wiring	46.0	67.3	74.7	72.7	**78.9**	76.9
Clip	49.0	74.0	74.9	**77.6**	62.6	73.2
Staple	50.1	70.0	**94.7**	75.7	54.4	92.2
T. screw	49.8	62.9	70.3	48.8	49.4	**89.2**
Pipes	63.6	88.7	55.2	81.2	98.9	**99.8**
U. screw	49.6	96.3	97.5	90.9	82.0	**98.9**
Mean	51.6	76.5	77.9	74.5	71.0	**88.4**

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How to contribute to AutoVI?

> Contact us => alexandre.durupt@utc.fr

> We lead :

- Preliminary image analysis using results from current method studies
- Publication in AutoVI
- Ongoing and comprehensive studies on AutoVI classes

Moving Forward Together*

*Progressons Ensemble

AutoVI, this project was funded by Renault Group and the National Research Agency (project TEMIS ANR-20-CE10-0004)

AutoVI is supported by the GIS (Groupement d'Intérêt Scientifique), S.mart brings together an open academic community to drive the scientific, technological, and societal transformation towards a sustainable Industry of the Future.

Société des Ingénieurs de l'Automobile
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MOVING FORWARD TOGETHER*

**PROGRESSONS ENSEMBLE*

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