Improving Industrial Quality Control with Computer Vision

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Context and Overview

- Valeo, a leading global automotive supplier, aims to enhance industrial performance through advanced production systems

- Use computer vision (CV) models to automatically sort parts rejected by Automated Optical Inspection (AOI) machines

Problem Definition

- **Classification**: The model needs to identify images as either belonging to the good class or one of the defect classes. (6 classes in training set)

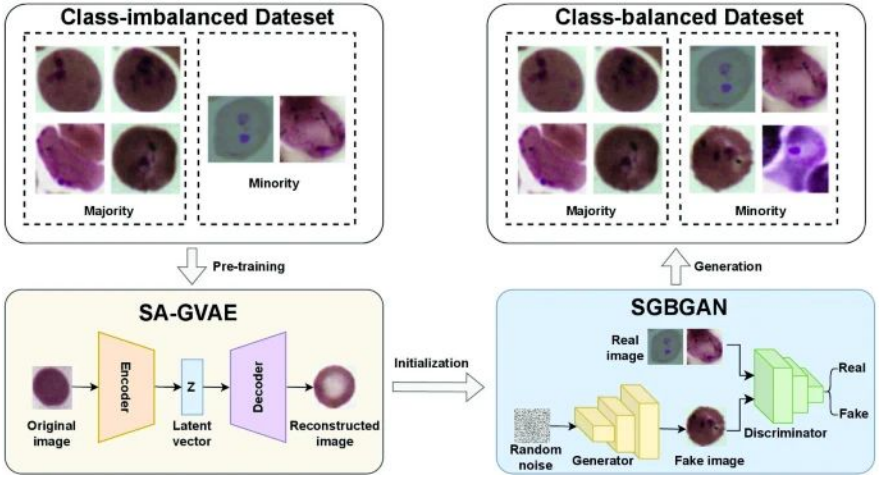
- **Anomaly Detection**: The model must also detect images that do not belong to any of the predefined classes, which could indicate defects that were not part of the training dataset.

- **Specific Evaluation Metric** that severely penalize parts detected as good when they are actually defective, and then the failure to detect a drift

General Observations

- Class imbalance : not all classes are equally represented
  - Generate samples to augment the minority class by using GANs ..

☹ Poor data quality of synthetic data, mode collapse,



General Observations

- Class imbalance : not all classes are equally represented
  - Use a cost sensitive loss by introducing weights

Better represents what the real data distribution (defects are rare)

$$L(\theta) = -\sum_{j=0}^{1} w_j \sum_{y_i=j} f(P(y_i|x_i,\theta))$$

where w_j is the weight for class j, y_i is the true label for the i-th sample, x_i is the feature vector for the i-th sample, and $f(P(y_i|x_i,\theta))$ is a function of the predicted probability for the true class y_i.

In scikit-learn, the weights w_j are calculated as follows:

$$w_j = \frac{N}{C \cdot |y_i = j|_{i=1\ldots N}}$$

where N is the total number of samples, C is the number of classes and $|y_i = j|_{i=1\ldots N}$ is the number of samples belonging to class j.

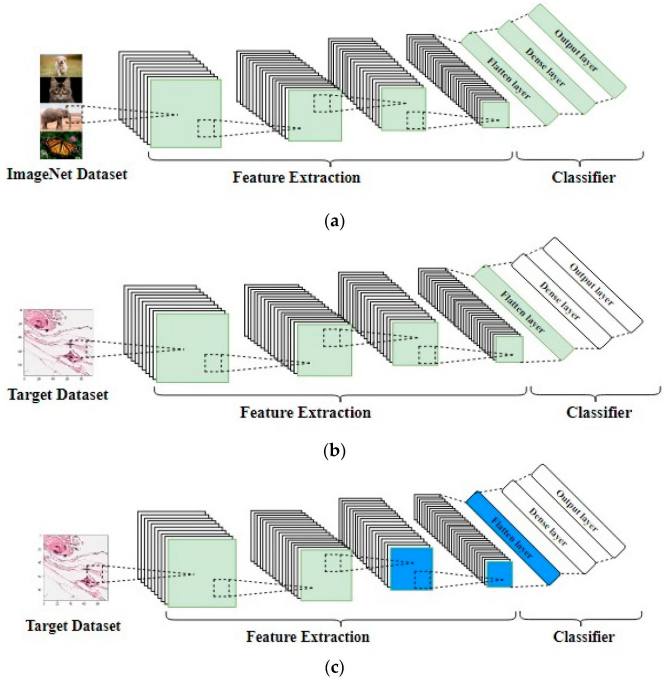
General Observations

- Choice of model for Image based tasks (CNNs and ViTs)

  Capture well features compared to manual features extractors (SIFT)

- Transfer Learning given small training set by using pretrained models and **their learned features** for our task through fine tuning

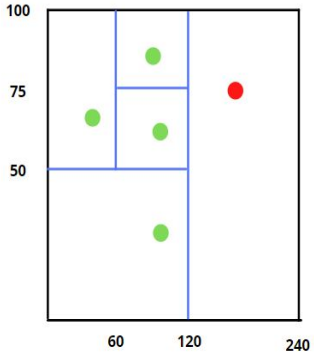


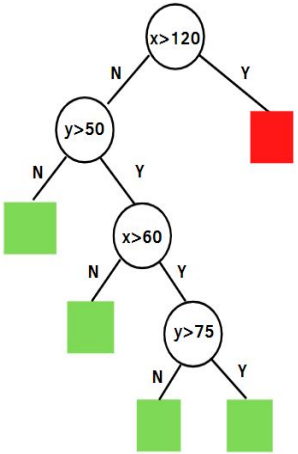
General Observations

- Unseen class, use Isolation Forest

Suited for tabular anomaly detection but images are of high dimensional

- Use a simple **threshold-based** rule on the output probabilities of the model





Data Augmentation

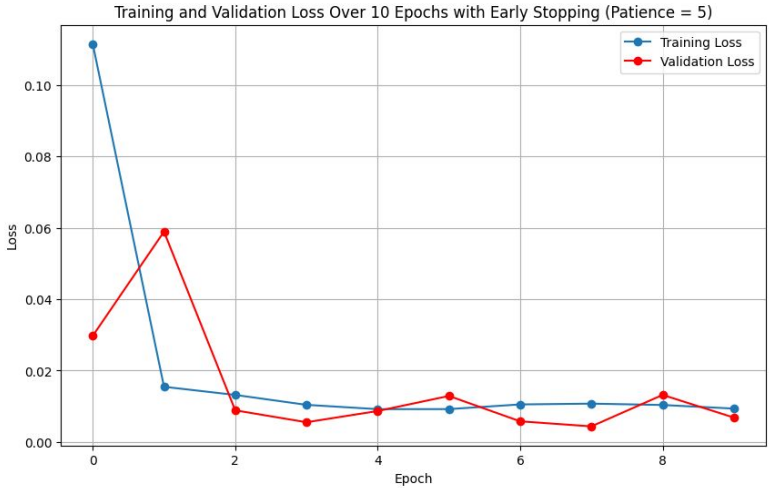
- **Goal**: Improve generalization & prevent overfitting.
- **Preprocessing**: Resized all images to 256×256 pixels.
- Applied Transformations:
  - ✅ **Random Horizontal Flip** (50% probability).
  - ✅ **Random Rotation** (±15°) – handles angular variations.
  - ✅ **Random Affine Transformations** – slight translations to simulate distortions.
  - ✅ **Color Jittering** – modifies brightness, contrast, saturation, and hue for robustness.

Model Architecture

- Pretrained model: **ResNet-18**
  - Replaced final fully connected layer to match dataset classes.
  - Fine-tuned only the last residual block (layer4) & classification head; rest frozen.
- Optimization & Regularization:
  - Optimizer: Adam (learning rate = **0.001**).
  - Weight Decay: **1×10−4** to prevent overfitting.
  - Loss Function: **Weighted cross-entropy** to handle class imbalance.
- Training Setup:
  - Epochs: **10** (Early stopping after **5** epochs if no validation loss improvement).
  - Metrics Tracked: Training/validation loss, validation accuracy.
  - Model Selection: Best model saved based on lowest validation loss.

Results

- Validation accuracy of **98%**
- **Thresholding rule** on output probabilities
- Ranked **3th** on the academic leaderboard



Rang	Date	Participant(s)	Score public
1	14 mars 2025 20:47	lucas-versini & Gabou	0,9941
2	13 mars 2025 23:57	shiwenli	0,9889
3	**4 mars 2025 06:57**	**midsougou**	**0,9827**
4	12 mars 2025 15:51	MikeHutten & TheoNiemann	0,9818
5	25 février 2025 12:30	NicolasThiou & yacdad	0,9815
6	**-**	**benchmark**	**0,9659**
7	16 mars 2025 22:19	evan964	0,9415
8	17 mars 2025 23:13	EliotMorard	0,9320

Conclusion

- Pleased with my first ever challenge participation
- Could improve performances by trying modeling by hands some parts of the models or other architectures

Link Github :
https://github.com/midsougou/Improving-Industrial-Quality-Control