High Precision Anomaly Detection based on Pre-trained Features Enhanced by Only Large Amount of Normal Samples

Hiroki Kobayashi and Manabu Hashimoto

***Abstract*— As improvement of superior method called PaDiM in anomaly detection, we propose a method based on pre-trained features enhanced by training with consolidating normal samples to its centroid in feature space. PaDiM pre-trains the model with only ImageNet and parameterizes the features of target normal images by normal distribution. However, this method pre-trains the model while ignoring normal images that follow a normal distribution, which leads to performance degradation. In contrast, our method centralizes the features of normal images during pre-training, and as a result, the mean Image/Pixel AUROC of the proposed method was higher than that of PaDiM (94.2/96.2 and 93.6/95.7, respectively) in experiments with the MVTec AD dataset.**

Keywords—Anomaly Detection; Defect Detection; Visual Inspection; Normal Distribution; Pre-train

I. Introduction

In the task of anomaly detection, where images are automatically classified as normal or anomaly, it can be difficult to use anomaly images for training the model because there are so few of them. Therefore, training the model with only normal images has been proposed. Feature extraction-based methods such as PaDiM [1] currently achieve the highest performances among such methods.

First, PaDiM pre-trains the classification model with only ImageNet to obtain a model with generic features. Second, target normal images are input to the feature extraction part of the model. Third, it is assumed that the obtained normal features follow a normal distribution, and they are approximated by normal distribution with parameters. Finally, if the features of an inspection image deviate from this distribution, it is labeled "anomaly", and otherwise "normal".

Since PaDiM pre-trains using only ImageNet, it does not consider whether normal features follow a normal distribution. It is therefore possible that normal features will be distributed multimodally, and the subsequent anomaly detection performance may be low.

In this research, we developed a method that pre-trains the model to consolidate target normal images into the centroid while the model is trained as a classification task with ImageNet. This solves the problem of the multimodal distribution of normal features, and implicitly excludes anomaly features from the range of normal features.

II. Proposed Method

The proposed method pre-trains a model such as WideResNet [2] with a centering constraint of target normal images while the model classifies the class of ImageNet. First, the loss function for classification task $\mathcal{L}_{\text{class}}$ is calculated with the classification network. This gives the model the ability to extract rich features. Second, the loss function for the centering constraint of target normal images is calculated by Eq. (1). This enables target normal images to be consolidated into the centroid, and implicitly excludes anomaly features from the range of normal features.

$$\mathcal{L}_{\text{center}} = ||f(\boldsymbol{x}_{\text{tar}}) - \boldsymbol{\mu}_{f(\boldsymbol{x}_{\text{tar}})}||_2 \quad (1)$$

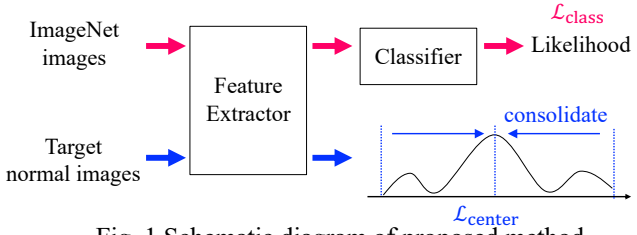


Fig. 1 Schematic diagram of proposed method.

Here, $f(\boldsymbol{x}_{\text{tar}})$ refers to the features of the target normal image, and $\boldsymbol{\mu}_{f(\boldsymbol{x}_{\text{tar}})}$ is the mean of these features in relation to mini-batch samples. Finally, as shown in Fig. 1, the model is pre-trained with a loss function, as

$$\mathcal{L} = \mathcal{L}_{\text{class}} + \lambda \mathcal{L}_{\text{center}}. \quad (2)$$

III. Experimental Results

We conducted experiments using images from the MVTecAD dataset [3] as target normal images for pre-training and approximation by normal distribution. In addition, both normal and anomaly images from MVTecAD were used for evaluating. As shown in Fig. 2, the proposed method had a better performance (AUROC measure) than PaDiM in the wood category of MVTecAD.

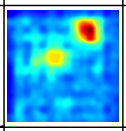
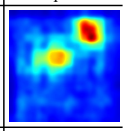
	Input	Ground Truth	PaDiM	Proposed
				
Image-AUROC			99.1	99.6
Pixel-AUROC			89.8	90.8

Fig. 2 Anomaly detection performance.

References

[1] T. Defard et al., "PaDiM: A Patch Distribution Modeling Framework for Anomaly Detection and Localization," ICPR International Workshops and Challenges, 2021.

[2] S. Zagoruyko et al., "Wide Residual Networks," arXiv preprint arXiv:1605.07146, 2016.

[3] P. Bergmann et al., "The MVTec Anomaly Detection Dataset: A Comprehensive Real-World Dataset for Unsupervised Anomaly Detection," IJCV, 2021.

Hiroki Kobayashi is with Chukyo University Graduate School, Nagoya, Japan (email: kobayashi@isl.sist.chukyo-u.ac.jp).

Manabu Hashimoto is with Chukyo University Graduate School, Nagoya, Japan (email: mana@isl.sist.chukyo-u.ac.jp).