Unsupervised Deep Learning based crack detection for stamped metal products

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Crack detection plays an important role in the industrial inspection of stamped metal products. Supervised learning methods are widely used in the quality assessment process. However, they require a large number of labeled data which are difficult to obtain in a well-tuned production line. Unsupervised learning shows an outstanding performance in anomaly detection. This study proposes an unsupervised method for crack detection on stamped metal surfaces that can perform classification and segmentation without using crack images during training. A VQ-VAE2-based model is adopted to clearly reconstruct input images and retain crack details. Meanwhile, the latent features in different scales are quantized to be discrete representations using a codebook. Then, an autoregressive model named PixelSNAIL is utilized to learn the distribution of the discrete representations from non-crack samples. The model can assign low probabilities to the discrete features which deviate from the non-crack distribution in the testing stage. These crack candidate features are resampled by the vectors in the codebook which have the highest dissimilarity with them. The edited representations are then fed into the decoder to yield resampled images that have the biggest differences in the crack area from the original reconstructions. Crack patterns are extracted at the pixel level by subtracting resampled images from the reconstructions. Prior knowledge that crack patterns tend to appear darker is leveraged to enhance the crack features. A robust classification criterion is introduced based on the probability given by the autoregressive model. Extensive experiments are carried out with images captured from stamped metal panels. Models are evaluated with the testing dataset containing 180 normal images and 180 crack images. Firstly, the reconstruction performance of our VQ-VAE2-based model is compared with other two state-of-art reconstruction models VAE and VQ-VAE1. Secondly, the results of crack detection including both segmentation and classification compared with two advanced unsupervised anomaly detection methods f-AnoGAN and VQ-VAE1-based. Thirdly, the ablation study is conducted to prove the effectiveness of the criterion. The results indicate that the proposed technique shows robust performance and high accuracy as well.