Improve CNN-based Crack Segmentation Using Weighting Strategies

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Convolutional Neural Network (CNN) – based crack segmentation has outperformed traditional approaches thanks to its capability to automatically extract crack features from images. Although these advanced techniques show promising achievements in crack segmentation, imbalanced crack datasets diminish the model performance because the number of background pixels (easy samples) dominates the number of crack ones (hard samples), posing the network to biasedly classify instances to background pixels. Improving loss function by assigning more weight to hard samples is the common method of handling the inevitable issue. However, properly weighting on crack and non-crack pixels refers to one of the most challenging parts of designing loss functions for the CNN networks. This study incorporates distance transform maps as adaptive loss weighting strategies to place more penalties on false predictions. These distance map-based weighting methods are implemented on Binary Cross Entropy loss (BCE) and Jaccard loss (IoU loss). U-net architecture is chosen as the baseline model to perform crack segmentation on three imbalanced benchmark datasets including Concrete Crack Conglomerate Dataset, Bridge Crack Library, and Labelled Cracks in the Wild (LCW) Dataset. The experimental results revealed that distance map-based weighting methods boost the performance of BCE loss compared to other weighting strategies like Inverse Frequency Weighting (IFW), Inverse Median Frequency Weighting (IMFW), and Focal Weighting (FW). For Jaccard loss, weighting false positive and false negative predictions slightly improve the imbalanced crack segmentation.