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Integrated framework of fault and anomaly detect ion for underground transmission-lines through multiscale mask DCNN

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Accurate anomaly and fault detection of underground transmission lines (UTLs) are important and indispensable for effective operation and maintenance because UTLs are constructed in a cramped environment and faults of UTLs would result in significant economic loss and human casualties. To detect anomalies and faults of UTLs in autonomous manner, this study proposes an integrated framework of non-destructive anomaly detection through effective statistical image strengthening and multiscale mask deep convolutional neural network (MS Mask DCNN) [1]. Thermal images measured from an infrared camera during patrol inspection are used for the proposed framework. The integrated framework of fault and anomaly detection features four characteristics. First, measured thermal images are preprocessed through z-score normalization and image strengthening with bi-histogram equalization with a plateau limit (BHEPL) [2]. The manipulated images are effective for training a neural network to detect UTLs. Second, the manipulated thermal images are fed into MS Mask DCNN, which only detects UTLs by eliminating pixels related to environments. Third segmented UTLs are refined through a contour method to increase the accuracy of detection for UTLs. This phase compensates limits of MS Mask DCNN for real-world applications because neural networks cannot ensure perfect accuracy of 100 %. The fourth phase detects anomaly or faults and their location, then an alarm is triggered by analyzing temperature of segmented UTLs for not only a single phase but also multi-phases of UTLs with an unsupervised clustering method. Field experiments for ultrahigh-voltage UTLs under normal and abnormal conditions demonstrate that the proposed method is effective for anomaly detection in real-world applications. Specifically, the proposed statistical image strengthening method provides strengthened thermal images for easy extraction of UTLs through MS Mask DCNN and the suggested MS Mask DCNN outperforms other mask-based CNNs. The contour and unsupervised clustering methods help to enhance the classification capabilities of the MS Mask DCNN and the accuracy of anomaly detection by eliminating a thermal reflection caused by low emissivity objects within a thermal image. These results confirm that the proposed framework would be effective for actual field applications with a novel patrol inspection system deployed on a mobile robot in that this method would decrease risk on human casualties during periodic operation and maintenance of UTLs which are the most critical concerns nowadays.

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