Object detection of ground penetrating radar images using deep convolutional neural network and autoencoder

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Ground penetrating radar (GPR) has recently acquired huge amounts of images for infrastructure monitoring and geological purposes. Therefore, automatic recognition of targets in GPR images is an emerging technique. In this study, we developed a deep learning algorithm to detect embedded target signatures especially originated from pipes, steel reinforced bars and internal voids. These targets appear as characteristic hyperbolic pattern in GPR images. The proposed method automatically classifies targets in the following steps: (1) Creation of labeled images, (2) Learning deep convolutional neural network with the labeled images, (3) Application of the optimized network to the validation images, and (4) The detection of objects with lower relative permittivity using autoencoder.

As a result of the application, the deep convolutional neural network showed the accuracy of 99.7-99.9 % in teaching data, while the accuracy was 93.9-99.7 % in validation data. On the other hand, the application of conventional neural networks with three layers showed the accuracy of 97.7-99.3 % in teaching data and 41.9-57.9 % in validation data, indicating significantly higher accuracy of the deep-convolutional neural network for validation data. The autoencoder optimized with typical patterns of objects with reverse polarity (higher relative permittivity) detected different image patterns that correspond to objects with lower relative permittivity. These results suggest the effectiveness of the deep learning algorithm to detect characteristic pattern in GPR images.

Keywords: Ground penetrating radar, Deep convolutional neural networks, Target detection