Processing of ground penetrating radar (GPR) data for underground cavity by Convolution neural network

*Shinichiro Iso[1], Akira Saito[1], Kyosuke Onishi[2], Toshifumi Matsuoka[3], Yukio Tobe[4], Toru Takahashi[3]

1. Graduate School of Creative Science and Engineering Dept. of Resources and Environmental Engineering, 2. Public Works Resarch Institute, 3. Fukada Geological Institute, 4. Geofive Co., Ltd.

Title

Processing of ground penetrating radar (GPR) data for underground cavity by Convolution neural network

Background

For many years, GPR (Ground Penetrating Radar) systems have being used to detect cavities underneath the road surface. A system on a vehicle are available to acquire a large amount of data with multi channels, such as 21 channels, faster than about 40 km/h driving. Amount of the data has become larger and larger. The accumulated surveyed road path is supposed to more than 150, 000 km.

Today, the experts take a long time to inspect visually such massive data to identify cavities. It also takes years to become a skilled expert. These years, besides development of the new machine learning design, the Machine Learning and parallel computation technology, such as Deep Learning and GPU frameworks and computer hardware show drastic improvement.

Deep Learning approach is supposed to work with the acquired data directly and automatically. It means that automation of recognition and classification of the types of reflectors with the acquired data directly. In addition, the learning network can be improved with the accumulated training data less computation effort as a transfer leraning. Such feature will fit the analysis of the GPR data for underground cavity survey.

Iso et. al. presented "Processing of ground penetrating radar (GPR) data for underground cavity survey by deep learning", at the 135th SEGJ Conference in 2016 in Japan. It shows a possibility of the being effective of usage of Deep Learning to distinguish cavities, metal pipes and others for 2D GPR cross-section. However, this previous study, in order to classify the target reflectors, users need to pick the specific reflection anomaly, the top of the shape of hyperbolic curves, manually. The classification result failed in some cases, even though considering amount of training data is limited.

Purpose

The aims of new study are 1) eliminating the manipulation of users to pick the target reflectors and 2) mitigating the errors of cavity classification, with the new Deep Learning network. Besides the limited training data, the problems are supposed to be caused by the limitations of the Learning Network design in the previous study. It uses Deep Neural Network with the hidden three layers as a Deep Learning. This is a simple learning network, and it may not be fit to find out the target objective in the large image region. The new study uses the Convolution Neural Network, CNN, design as a Deep Learning to distinguish and locate cavities and the others. The CNN is one of the feed-forward artificial neural network and widely used for 2D image recognition in the other industries these years. The study bases the real acquired data for training images and evaluate with the other set of real 2D GPR data.

Conclusion / Discussion

The results are compared and discussed with the previous study to the recognition accuracy and efficiency of training effort (CPU time and training images) for initial training and transfer learning.

Keywords: Deep Learning, GPR, Automation, data processing, road inspection, cavity survey