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# Damage Prediction Of Concrete Undergoing Alkali-Silica Reactions Using Few-Shot Learning

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A nondestructive damage prediction technique for concrete structures undergoing alkali-silica reactions (ASR) is presented. Currently, damage evaluation methods for concrete structures often rely on supervised learning techniques, which require an observed, or measured, assessment of the damage. However, in practice, measurements of damage or damage indicators during routine inspections are typically not sufficient to support supervised learning. Therefore, a few-shot learning approach is proposed to predict ASR damage in concrete with minimal expansion measurements that may be taken during routine inspections. Using meta-learning, a machine learning algorithm can "learn to learn", allowing the model to make accurate predictions with only a few training points. Given a set of similar data sets or tasks, the model uses meta-learning techniques to determine initial parameters. Well-learned initial parameters are close to some local optimum for every task in our set of data sets. Therefore, the network's loss can be minimized with just a few gradient steps. This allows the model to make accurate predictions for few-shot learning. For concrete structures undergoing ASR, features of ultrasonic waves have been shown to be indicative of damage. Coda waves, or multiply scattered ultrasonic waves, have been found to be sensitive to small changes in complex materials such as concrete. The velocity variation of coda waves, for example, has been shown to be highly correlated with the expansion of concrete, with a relationship following an exponential trend. Thus, in this paper, an exponential model is formed between the concrete expansion and the velocity expansion of coda waves in the concrete. The initial values of the model parameters are determined using meta-learning. After meta-training on similar curves, the model was optimized so that the parameters are updated using the loss evaluated on test tasks, which the model has not seen previously. During meta-optimization, the gradient is computed with the meta-learned initial parameters, but the loss is computed using the test task specific parameters. This allows the initial parameters learned using meta-learning to be optimized for every task in our set of similar tasks. After meta-learning, the model is trained and tested with a limited number of velocity variation and expansion measurements collected from a concrete structure to predict concrete expansion using velocity variation of coda waves. The proposed method has been validated using experimental studies. The experiment was conducted using two control specimens, which did not contain any reactive aggregates and four reactive specimens. Ultrasonic signals were collected using piezoelectric sensors, and the expansion of each specimen was measured about every three weeks. The results show that the model was able to accurately predict the expansion of the concrete structure undergoing ASR with only ten training samples evenly spaced out throughout the experiment period. In addition, the results show that the model can be generalized across all six concrete specimens with a mean absolute percentage error of less than 10%.