Title: Seismic damage identification of high arch dams based on an unsupervised deep learning approach

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Objectives

Arch dams have been widely constructed around the world due to the advantages of economy, safety and reliability. The strong uncertainty of earthquakes makes it possible for arch dams to be subjected to over-designed earthquakes, which may lead to extremely serious casualties and property losses. In actual concrete arch dam engineering scenarios, the dynamic data obtained by the health monitoring system of an arch dam are incomplete. The data acquired typically depend on the state of the dam structure, that is, whether it is intact or incomplete. Accordingly, the formulation of an accurate, efficient, and intelligent damage warning and identification model for concrete arch dams is necessary to ensure infrastructure safety.

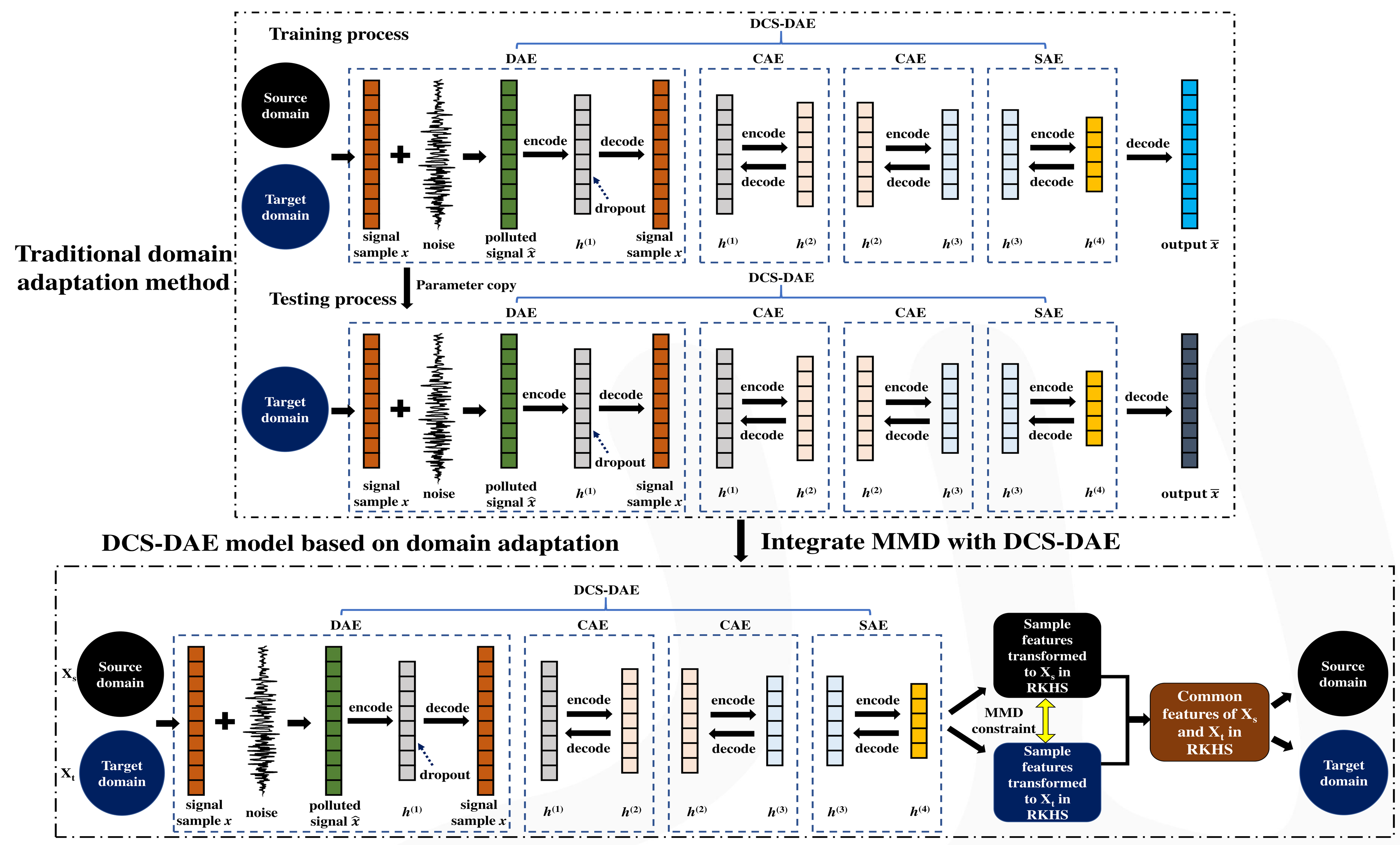

Figure.1 Schematic diagram

Methods

Guided by the direct extraction of damage sensitivity features from the acceleration response signals of the arch dam, A DCS-DAE model based on domain adaptation is proposed considering the anomaly detection requirements of arch dams under different water level conditions in actual engineering scenarios. The core idea of the proposed method is to constrain the data probability distribution of feature spaces in the source and target domains using maximum mean discrepancy. This fusion enables the DCS-DAE model to be capable of feature extraction. Moreover, it resolves the problem in which the objective function cannot be applied to other similar scenarios because of the lack of consistency constraints of feature spaces in the source and target domains.

Results

The impact of environmental loads and modeling errors on the source domain model can be effectively measured by MMD. The performance attenuation of the DCS-DAE model without domain adaptation in each target domain is positively correlated with the MMD value in each target domain; the higher the MMD value, the lower the anomaly detection performance. Moreover, in the training of the DCS-DAE model based on domain adaptation, with a decrease in the MMD value, the performance of anomaly detection gradually improves. Therefore, in practical engineering, the influence of environmental load or model error on structural anomaly detection can be determined according to the MMD value.

Conclusions

Four working conditions are designed to reproduce the uncertainty of structural modeling and the variability of water levels. The conditions are based on the post-seismic water level detection requisites of dams in practical engineering. The results show that the proposed anomaly detection model enhances the generalization performance of the DCS-DAE in terms of feature design. Hence, the constructed model can "infer other things from one fact." The results of this study are meaningful for the real-time cross-domain monitoring of structures under variable load conditions, providing a driving force to apply similar methods to practical arch dam projects.

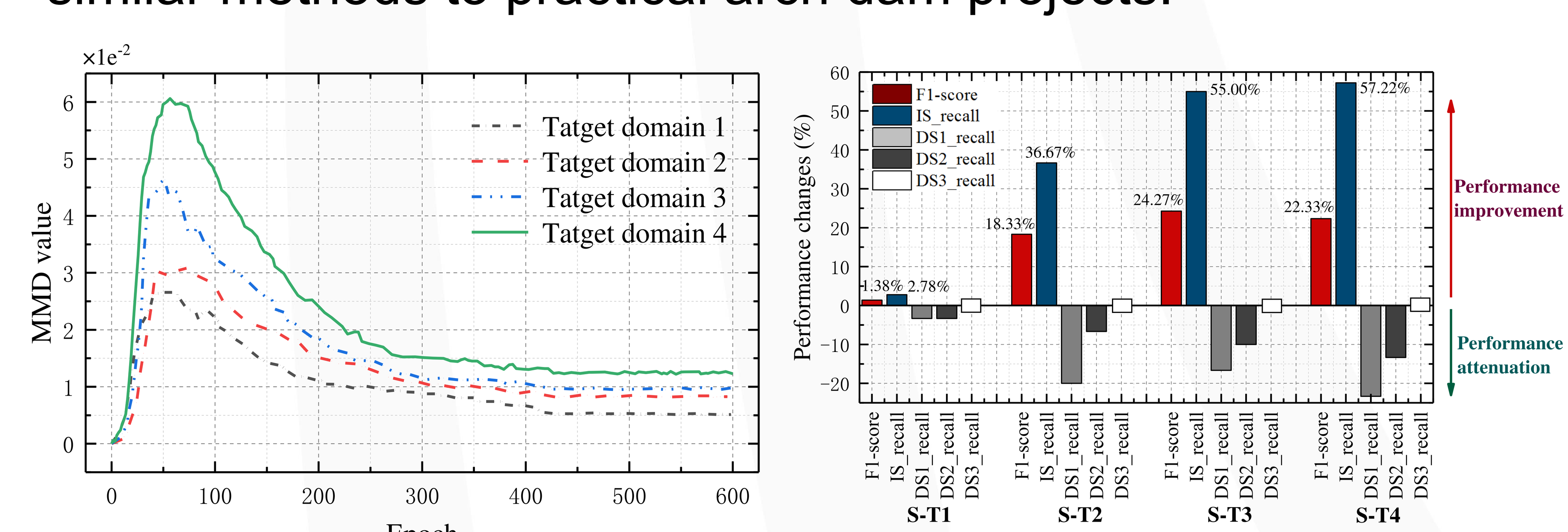

Figure.2 Performance of DCS-DAE model based on domain adaptation

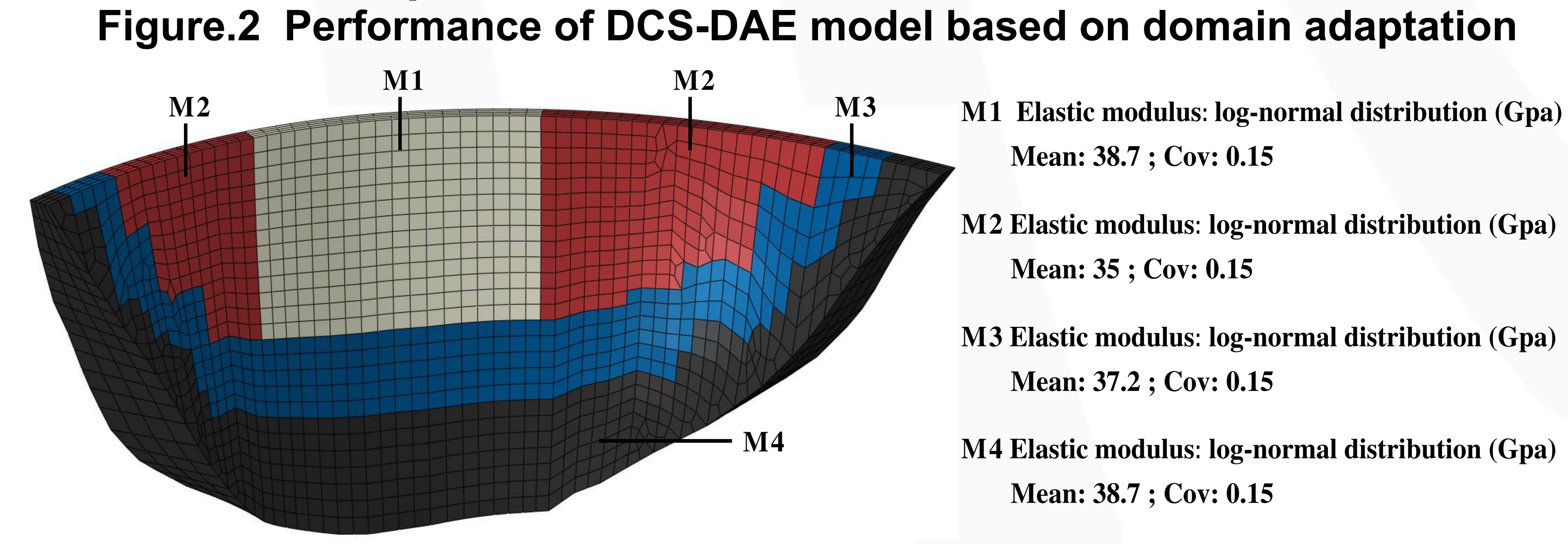

Figure.3 Schematic of arch dam partition and selection of random parameters