The Prediction of Disaster Risk Paths Along Railway Lines Based on IECNN Model

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Abstract: Railways play a vital role in modern society, serving as efficient modes of transportation for both goods and people, connecting cities and regions. They contribute to economic development by facilitating trade, supporting logistics, and promoting regional cooperation. Additionally, they offer environmental benefits with lower carbon emissions compared to other modes of transport. In the context of railways, disasters often bring forth significant peril to the environment, economy, and human existence. The intricate intertwining of the railway infrastructure with the multifaceted natural surroundings and the rapid progression of society and economy has led to an escalating focus on disaster risks, particularly when these risks materialize in the form of diverse calamities. Indeed, the realm of disaster risks has expanded into a paramount concern, driven by the intricate interplay between the intricate natural ecosystem and the relentless march of societal and economic advancements. This heightened attention holds special relevance when considering the specific vulnerabilities encountered along the extensive networks of railway lines. Generally, there are many kinds of natural disasters, which include wind disasters, flood waterlogging, hail disasters, as well as geological disasters like earthquakes, collapses, landslides, debris flows. Predicting disaster risk paths along railway lines empowers proactive anticipation of risk propagation, laying the groundwork for curbing or evading their detrimental consequences. This forecasting capability establishes a basis for addressing disaster risks, with the potential to diminish their impact on various dimensions of society and the environment.

In this paper, the embedding layer of Convolution Neural Network (CNN) has been improved and the specific CNN framework is literally referred to as IECNN, which is proposed to predict the disaster risk path along railway lines. Here, we first establish a disaster risk network specific to railway lines, where each node corresponds to two attributes: location and type of disaster. Paths generated through random walks in the disaster risk network provide an effective way to explore the relationship between disaster events and disaster risk factors. In essence, disaster risk paths derive from random walk paths. Then we input the disaster risk paths to the IECNN model to train the neural network. Subsequently, the well-trained model is developed to predict the disaster risk paths along railway lines. In addition, we incorporate Markov chain to calculate the probability of these paths, which can effectively reduce the randomness and confusion of training data. Furthermore, Receiver operating characteristic curve (ROC), area under curve (AUC), accuracy, F1-measure, precision and recall are used to evaluate the prediction model. In order to verify the feasibility and advantages of the proposed model, we employ a dataset encompassing natural disasters occurring along the railway lines in southwest China within the experimental section. Results of the comparative analysis display that the proposed model can not only effectively predict the disaster risk path along the railway lines, but also provide the high performance in terms of every evaluation index. Moreover, some characters of disaster risk path are found and discussed. Resultantly, our results can provide an efficient way to prevent and control risk spread in disaster

events along the railway lines.