Short-Term Forecasting of the Occurrence Time of Strong Wind Speed during a Typhoon based on LSTM for Sea-Crossing Bridge Operation

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Abstract

Vehicles running on sea-crossing bridges are vulnerable to strong winds with instantaneous speeds of over 20 m/s. Bridge operators should secure the safety of the bridge users by limiting vehicle speeds or restricting the traffic when wind speed measured on the bridges exceeds a certain threshold value. To guarantee the safety of the bridge users during typhoons, an accurate forecasting of the strong winds would be essential. In this study, an Artificial Neural Network (ANN) was considered to model the occurrence characteristics of the strong wind speed at the sea-crossing bridge during typhoons. The Long Short-Term Memory (LSTM), which is generally used in the time-series analysis, was applied. This research utilized 16 years of wind speed data acquired by sensors located on a suspension bridge in South Korea and Best Track data of typhoons from the Regional Specialized Meteorological Center (RSMC) in Tokyo.

Keywords: Strong Winds Prediction, K-means Clustering, Artificial Neural Network, LSTM, Strong winds Warning System.

1 Introduction

Vehicles on bridges adjacent to the coastal area are vulnerable to strong winds with instantaneous speeds of over 20 m/s. Over the years, there have been frequent reports of traffic accidents related to strong winds. In 2012, two successive vehicle overturning accidents occurred on the approaching span of the Gwangan Bridge in South Korea, a sea-crossing double-deck suspension bridge. The recorded maximum instantaneous wind speed at that time was over 20 m/s. In order to guarantee the safety of the bridge users during typhoons, bridge operators should secure the safety of the users by limiting vehicle speeds or restricting the traffic when wind speed measured on the bridge exceeds a certain threshold value, so-called a critical wind speed (1). Therefore, an accurate forecasting of the strong winds would be essential for bridge operator to cooperate with the police department to take a series of safety measures ahead. To address this issue, several conventional methods have been proposed and these can be classified into three categories: (1) Physical-based method, (2) Statistical-based method, (3) Spatial correlation-based method. However, there are fundamental limitations of not being able to accurately handle the numerous factors of strong wind speeds during typhoons. Recently, with the development of the information technology and computer science, there have been studies on predicting future values of a time series for safety operation of civil infrastructures using machine learning. Machine learning, which is a branch of Artificial Intelligence (AI), is a computational technique that can automatically extract the essence characteristics of the datasets, in other words, giving computers the ability to learn without being explicitly programmed. Unlike many previous studies that mainly focused on developing empirical models that are interpretable by humans, machine learning can perform more complex analysis. One of the main advantages of this method is that it

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