Prediction of hourly PM$_{2.5}$ using a space-time support vector regression model

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Abstract: Real-time air quality prediction has been an active field of research in atmospheric environmental science. The existing methods of machine learning are widely used to predict pollutant concentrations because of their enhanced ability to handle complex non-linear relationships. However, because pollutant concentration data, as typical geospatial data, also exhibit spatial heterogeneity and spatial dependence, they may violate the assumptions of independent and identically distributed random variables in most of the machine learning methods. As a result, a space-time support vector regression model is proposed to predict hourly PM$_{2.5}$ concentrations. First, to address spatial heterogeneity, spatial clustering is executed to divide the study area into several homogeneous or quasi-homogeneous subareas. To handle spatial dependence, a Gauss vector weight function is then developed to determine spatial autocorrelation variables as part of the input features. Finally, a local support vector regression model with spatial autocorrelation variables is established for each subarea. Experimental data on PM$_{2.5}$ concentrations in Beijing are used to verify whether the results of the proposed model are superior to those of other methods.

Keywords: Real-time air quality prediction; spatial heterogeneity; spatial dependence; support vector regression; spatial clustering; Gauss vector weight function

1. Introduction

Epidemiologic studies have demonstrated that short-term (acute) exposure to air pollution can damage human health; of specific concern is particulate matter, which includes fine particulate matter (PM$_{2.5}$), that can accumulate in the respiratory system and directly increase the risk of death caused by lung cancer, cardiovascular disease, and pulmonary illness (Dominici et al., 2006; Diaz-Robles et al., 2015; Kloog et al., 2014; Di et al., 2017). Therefore, to protect the public from particulate matter or air pollution, real-time air quality prediction has been an active field of research in atmospheric environmental science.

Existing methods for real-time air quality prediction can be roughly classified into two
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