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Considering spatial dependence in areal interpolation method based on eigenvector spatial filtering

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Spatial data are often aggregated into spatial units. Because there exist many types of spatial units such as census units and grids, the difference in the spatial units among the spatial data often complicates the analyses. Transferring spatial data from one zonal system to another is useful for solving this problem. This process is called areal interpolation (e.g., Sadahiro 1999). We assume that areal interpolation is the conversion of spatial data from source units into target units.

Spatial dependence is a general property of spatial data, and it implies that data at nearby locations are similar whereas those separated widely are less similar. Thus, for accurate areal interpolation, it is quite natural to consider spatial dependence. However, there are no significant studies that have considered spatial dependence with respect to areal interpolation, except for Kyriakidis (2007), Gotway and Young (2007), and Mugglin et al. (1999). In addition, from the viewpoint of practical use, the methods proposed by these researchers are inferior to the conventional methods mentioned above. First, they are complex and difficult to implement. Second, their computational burden is large.

In this study, we propose a new areal interpolation method that is an extension of the regression-based method suggested by Flowerdew and Green (1992) in order to consider spatial dependence. A distinct advantage of our method is that it can be implemented by using ordinary least squares (OLS), which is most frequently used as a parameter estimation technique for the regression model, and can be easily handled with light computational burden. However, it is well known that OLS by itself is not suitable when the residuals of the regression model are spatially dependent. Therefore, we employ the eigenvector spatial filtering technique (Tiefelsdorf and Griffith, 2007). More precisely, we incorporate the technique into the areal interpolation method by adding the eigenvector of the geographic connectivity matrix as an explanatory variable to the basic model of regression-based areal interpolation. Because the constructed model itself is essentially identical to the traditional linear regression model, no specific procedures are required to obtain OLS estimators. Thus, as compared to other areal interpolation methods that consider spatial dependence, the proposed method has the advantages that it can be easily implemented and is computationally efficient.

Finally, in order to examine the effectiveness of the proposed model, we apply it to the aging ratio data of 2007 North Kanto area, Japan. In this study, the conventional regression-based method and the proposed method are compared, where the former does not consider spatial dependence but the latter does. The methods are applied to the areal interpolation of the aging ratio whose source units are the municipalities in 2007, and the target units are the municipalities in 1995. The predictive error of the proposed method is 7.63 percentage points less than those of the regression-based method in terms of the average differential between the observed and predicted values. This indicates that it is important to consider spatial dependence in areal interpolation.

Keywords: areal interpolation, spatial dependence, eigenvector spatial filtering