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Point and prediction interval estimation of landslide displacement based on a least-squares support vector machine and bootstrapping

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Accurate prediction of landslide displacement is vitally important in landslide early warning systems. However, due to the uncertainty involved in landslide displacement, traditional deterministic (or point) predictions cannot guarantee the reliability of decision making. In this paper, an interval estimation method was developed for the probabilistic prediction of landslide displacement using a least-squares support vector machine (LSSVM) and bootstrapping. This study aimed to construct prediction intervals (PIs) and to perform deterministic prediction. The hybrid method was composed of three steps: First, the LSSVM and bootstrapping were combined to estimate the true regression mean of landslide displacement and the variance with respect to model uncertainty. Second, a new LSSVM was implemented to estimate the noise variance. Finally, the point prediction was derived from the regression mean, and the PI was constructed by combining the true regression mean, the model variance, and the noise variance. The proposed method was applied for the displacement prediction of the Tanjiahe landslide located in the Three Gorges Reservoir Area in China. Simulation and performance comparison showed that the proposed method is a promising technique for providing accurate point prediction and high-quality PIs for landslide displacement.