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Applying face recognition algorithms for tsunami inundation forecasts

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We developed a method to rapidly transform a real-time low-resolution tsunami simulation result into a high-resolution inundation model. The method precomputed a pair of database composed of low- and high resolution maximum tsunami heights and flow depths at specified areas originating from various earthquake scenarios. Furthermore, the method utilizes a principal component analysis (PCA) and a linear discriminant analysis (LDA) commonly used in computer vision fields, particularly for the purpose of a face recognition. The PCA aims to extract the main feature of the database, while the LDA improves the data separability for accurate classifications. After the projection to the PCA and LDA subspaces, the new input of a low-resolution linear tsunami model can be used to generate a high-resolution nonlinear tsunami inundation map within seconds. This is a significant improvement to the conventional approach using a direct forward model to simulate the tsunami inundation, which is typically very time consuming, and thus insufficient for a real-time application.

Our proposed method was applied to the 2011 Tohoku tsunami, with the study site around the Rikunzen-takata bay. A total of 56 point sources were distributed along the subduction zone of the Japan Trench, and the maximum tsunami heights and flow depths around the study site were simulated and stored. Similar to the direct forward modeling method, the algorithm can be executed when the source estimate is available, typically 10 to 30 min after the earthquake. The estimated flow depths by the direct forward method, which requires approximately 40 min computing time, are quite accurate when compared with the 2011 observations. In contrast, our method can achieve a comparable accuracy with a significantly less computing time, i.e. $\sim$5 min computation of the linear propagation model plus a few seconds transformation from the low- to high resolution map using the PCA-LDA approach. This indicates that our method is capable of producing rapid tsunami inundation forecasts compared to the conventional approach, thus it is more suitable for a real-time application.