Machine Learning Approach for Integration of Multiple Relative Intensity Models

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Among the models submitted to the Collaboratory for the Study of Earthquake Predictability (CSEP) Japan experiment, smoothed relative intensity (SRI) method (Nanjo,2011), provides a high performance, assuming large earthquakes more likely occur in the future at locations with higher seismicity in the past. SRI generates a grid map, each cell of which has the normalized number of earthquakes occurred in a circle centered at the cell during a past training period.

However, SRI would have two potential limitations. Firstly, spatial and temporal parameters, the radius of the circle, and the past training period are fixed over entire regions and manually tuned by users. Secondly, the distribution of earthquakes in the future testing period could differ from the past training period one, since the future testing period is usually much shorter, e.g., 3-month and 1-year in comparison with the past training periods, e.g., 20-year.

To mitigate these limitations, we propose to define the earthquake forecast problem as an image conversion problem where a multi-channel image each of which corresponds to an SRI map with different spatio-temporal parameter in the past, is converted to an SRI map in the future testing period. By training convolutional deep encoder-decoder networks with paired input-output images, multiple SRI forecasts can be combined adaptively so as to minimize the future SRI reconstruction error.

We show the effectiveness of our proposed method through earthquake forecast experiment for the Kanto region in the CSEP Japan, using the data of years from 1923 to 2017, in comparison with SRI methods. In addition, we extend our proposed method with data augmentation transferred from other regions and show its effectiveness.

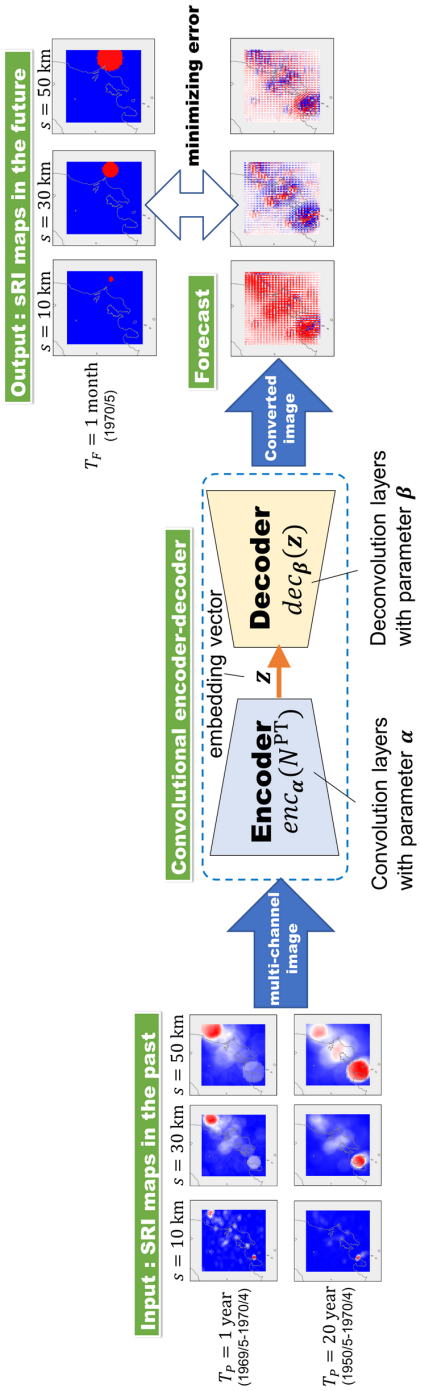

Figure: Proposed framework for converting SRI (smoothed relative intensity) maps in the past to the maps in the future.