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INVESTIGATION OF ISOTROPY OF INTRA-EVENT RESIDUALS OF PGV AND PGD USING DIRECTIONAL SEMIVARIOGRAM

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It is vital to consider spatial correlation of intensity measures in seismic assessment of spatially distributed lifeline systems. In recent years, various researches has been conducted to consider spatial correlation of intensity measures. Previous studies using different intensity mesures proposed various models of spatial correlations. All these models are proposed under assumption of isotropy of intraevent residulas of intensity measures while Garakaninezhad and Bastami (2017) showed that this assumption is not acceptable for peak ground acceleration (PGA) and spectral accelerations in different periods (Sa). Current study, investigates the assumption of isotropy of intraevent residuals of peak ground velocity (PGV) and peak ground displacement (PGD) using directional variogram method.

Residual of an intesity measure at site *i* in earthquake *j* is defined as:

$$\delta_{ij} = \ln(Y_{ij}) - \ln(\overline{Y_{ij}}) \tag{1}$$

where Y_{ij} is the recorded value of intensity measure and $\overline{Y_{ij}}$ is predicted value of intensity measure using ground motion prediction equation at site *i*. The residual value is composed of two values of intra event residual (ε_{ij}) and inter-event residual (η_j). The intra-event residual depends on the event (earthquake *j*) and location (site *i*) while inter-event residual depends on only the event. Consequently, normalized intra event residual of intensity measure can be calculated as:

$$\varepsilon'_{ij} = \frac{\varepsilon_{ij}}{\sigma} = \frac{\ln(Y_{ij}) - \ln(\overline{Y_{ij}})}{\sigma} \tag{2}$$

where σ is standard deviation of vectors of intra-event residula at different sites. Jayaram & Baker (2008) showed that the vector of intra event residuals of intesity measures follows a multivariate normal distribution with zero mean and standard deviation of σ. Semivariogram is known as an statistical tool to represent the spatioal correlations and is defined as:

$$\hat{\gamma}(\mathbf{h}) = \frac{1}{2N_{\mathbf{h}}} \sum_{\mathbf{s}_\beta - \mathbf{s}_\alpha \in \mathbf{h}} [\varepsilon'(\mathbf{s}_\beta) - \varepsilon'(\mathbf{s}_\alpha)]^2, \tag{3}$$

where $\mathbf{s}$ represents the loction of intrested point, $N_{\mathbf{h}}$ represents the number of pair points which has the distance vector of $\mathbf{h}$. The value of semivariogram is generally depends on distance lag ($||\mathbf{h}||$) and direction of vector $\mathbf{h}$. In the case which the value of semivarigram is depends only $||\mathbf{h}||$ the random field is known as isotropic and semivariogrm can be calculated as:

$$\hat{\gamma}(h) = \frac{1}{2N_h} \sum_{s_\beta - s_\alpha \in h} [\varepsilon'(s_\beta) - \varepsilon'(s_\alpha)]^2, \quad (4)$$

An accepted method to test the assumption of isotropy of a random field is known as directional semivariogram (Goovaerts, 1997). In this method, the semvarigram is obtained for different directions considering all paire points included in specific direction (see Figure 1).

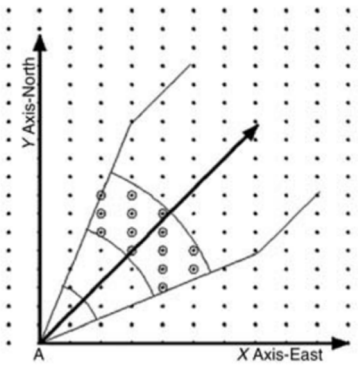

Figure 1. Pair points considered in directional semivariogram (Garakaninezhad and Bastami, 2017).

Differences in parameters of directional semivariogram rejects the assumption of isotropy for a random field. In this study, the assumption of isotropy of intra event residuals of PGV and PGD is investigated using the method of directional semivariogram, and it is shown that the assumption of isotropy is not acceptable for PGV and PGD in contrast with previous studies. Figure 2 shows instances of the directional semivariogram of PGV of Iwate 2008 earthquake in different directions with different ranges.

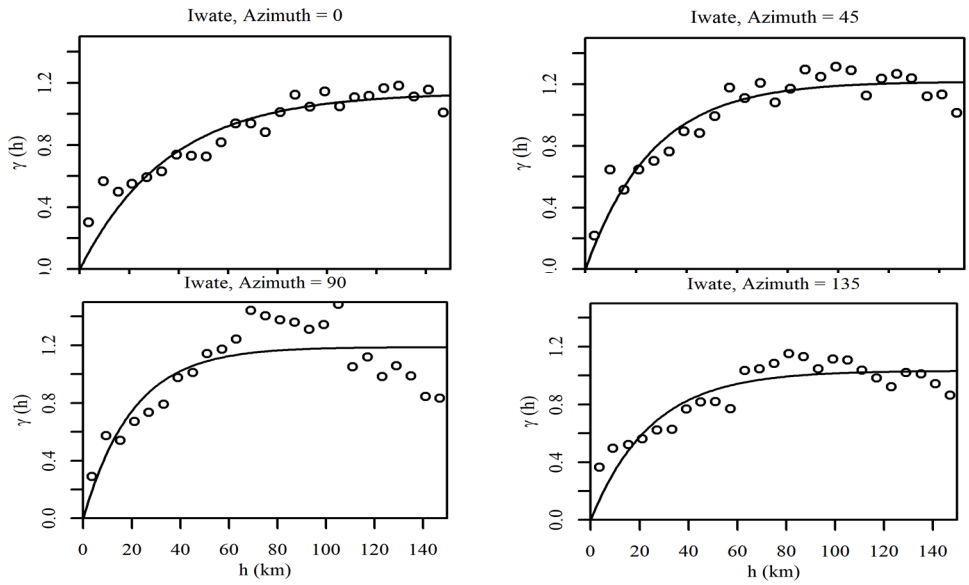

Figure 2. Directional semivariogram of Iwate 2008 earthquake with different range.

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