SIMULATION OF NEAR FAULT GROUND MOTIONS USING NEURO-FUZZY NETWORKS AND WAVELET ANALYSIS

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Keywords: Anfis, Artificial Records, Near-Fault, Pulse-Like, Wavelet Packet Transform

The existence of recorded accelerograms to perform dynamic inelastic time history analysis is of the utmost importance especially in near-fault regions where directivity pulses, known as the most noteworthy characteristics of such ground motions, impose extreme demands on structures and cause widespread damages. But because of the lack of recorded acceleration time histories, it is common to generate proper artificial ground motions. In this study, in order to generate near-fault pulse-like ground motions, first, it is proposed to extract velocity pulses from an ensemble of near-fault pulse-like ground motions using smoothening method presented by Mukhopadhyay and Gupta (2013). The extracted multiple velocity pulse from 1994 Northridge event is shown in Figure 1a. The response spectra of the original pulse-like records are in good agreement with the near-fault prediction model proposed by Rupakhety et al. (2011) where the responses of the residual ground motions after pulse extraction are compatible with the Boore and Atkinson (2008) prediction model, as shown in Figure 1b. Therefore, the non-pulse type record is simulated using Adaptive Neuro-Fuzzy Inference Systems (ANFIS) and wavelet packet transform (WPT) in a way that it is compatible with the Boore and Atkinson (2008) prediction model.

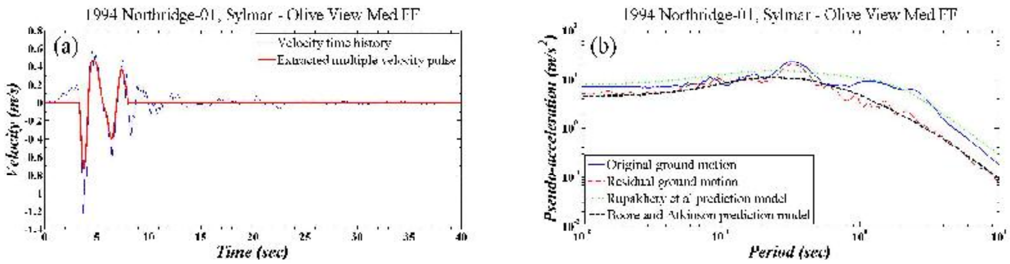

Figure 1. (a) Illustration of extracted velocity pulse, (b) Response spectra

In the next step, the pulse-like ground motion is produced by superimposing directivity pulse models on the previously generated non-pulse type motion. The pulse model based on the Mexican Hat function proposed by Mukhopadhyay and Gupta (2013) is used here:

$$v_{MH}(t) = A\left(1 - \frac{t^2}{\sigma^2}\right)e^{-\frac{t^2}{2\sigma^2}} \quad (1)$$

Where A is amplitude of the function, and σ has a relationship with dominant period of pulse via the following relation:

$$\sigma = 0.2220T_{v,MH} \tag{2}$$

Where $T_{v,MH}$ is dominant period of the pulses. The ultimate goal of this study is to generate near-field spectrum compatible record; therefore, particle swarm optimization (PSO) is applied to optimize the parameters of pulse models. PSO is also used to optimize the cluster radius in subtractive clustering which is used to determine fuzzy if-then rules and membership functions of fuzzy inference system (FIS) and principle component analysis (PCA) is employed to reduce the dimension of ANFIS input vectors. The efficiency of the proposed method is validated using 23 near-fault records to train the neuro-fuzzy networks. The generated pulse-like record for M_w*=7.3, r=6 km,* V_{s30}*=320 m/s* and *fault type=ss*, and associated acceleration and velocity pulses with optimized parameters and its response spectra before and after pulse addition are shown in Figure 2.

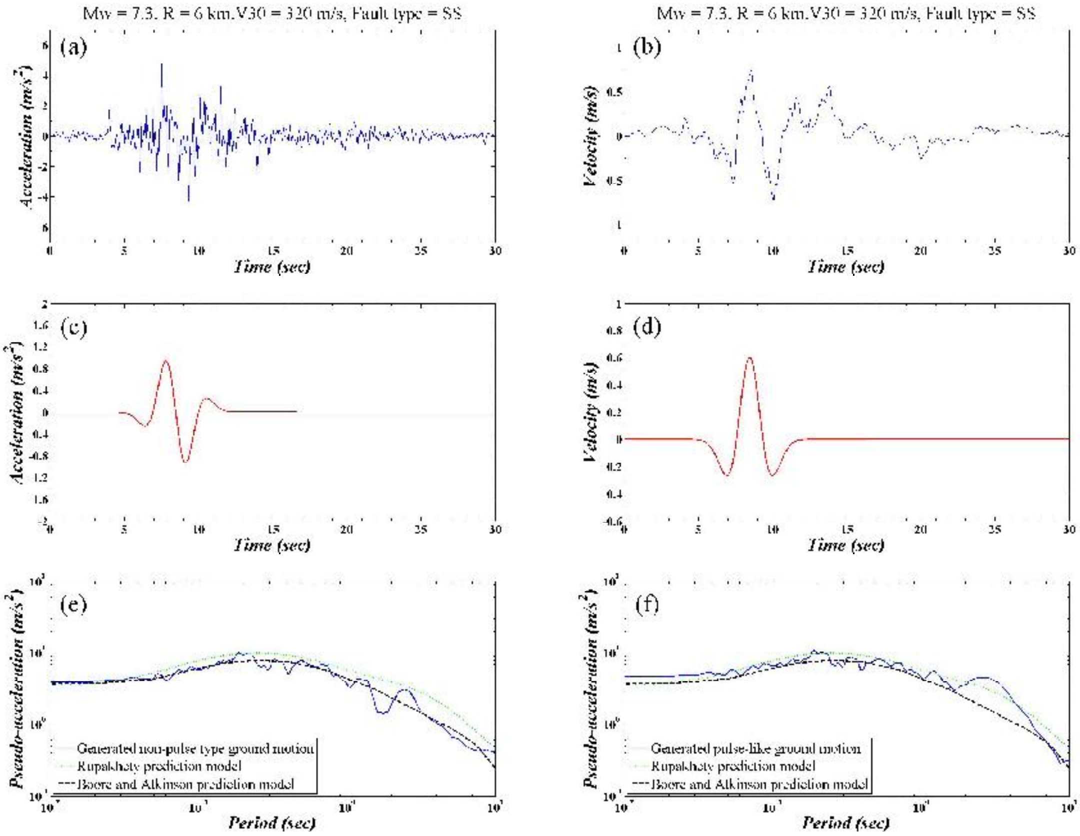

Figure 2. (a) Generated pulse-like acceleration time history, (b) Generated pulse-like velocity time history, (c) Acceleration pulse, (d) Velocity pulse, (e) Response spectra before pulse addition, (f) Response spectra after pulse addition

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