# A wavelet-based parametric characterization of temporal features of earthquake accelerograms

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## ABSTRACT

Simulation of aftershock accelerograms is crucial to ascertaining structural safety against the additional cumulative damage during the aftershocks that would follow an anticipated main shock. Besides being consistent with a specified response spectrum, such an accelerogram should incorporate realistic temporal features. This paper considers a wavelet-based description of the time–frequency characteristics of a class of earthquake accelerograms and proposes three-parameter models for the modulation of wavelet coefficient envelopes of different frequency bands. Estimation of the modulation parameters is attempted through simple scaling models using easily available seismological and site parameters and with the help of the data of 1999 Chi-Chi earthquake and its aftershocks. Sensitivity of the simulated motions to the uncertainty in the estimation of modulation parameters is also studied. Further, it is shown that the simulated ground motions show expected variations in their temporal characteristics with regard to variations in the governing seismological and site parameters.

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## 1. Introduction

Recent examples of structural collapse caused during aftershocks, e.g., that of Basilica of St. Francis in Assisi during the 1997 Umbria-Marche earthquake [1], have emphasized the need to account for additional damage during aftershocks in the earthquake-resistant design process. Ability of the aftershocks to cause collapse of a partially damaged structure has also been highlighted in the analytical studies by Mahin [2] and Gupta et al. [3]. It is therefore desirable that structures designed by the existing design philosophy are checked for the additional cumulative damage due to aftershocks, and additional safety margins are provided if that damage is found to be significant with respect to the main shock damage. This requires simulation of accelerograms for the anticipated aftershock motions, at least in the case of first one or two aftershocks, besides the accelerogram for the main shock motion.

While the simulation of earthquake accelerograms based on seismological models (e.g., see [4]) always remains a possibility, it is desirable for engineering applications that the generated accelerogram is compatible with a specified response spectrum [5]. To this end, it is convenient to use wavelet-based simulation (e.g., [6]), provided temporal features of the accelerogram to be generated are specified a priori, possibly via a recorded

seed accelerogram. In this regard, it is important that seed accelerograms recorded at the same station during a main shock–aftershock sequence are used to simulate accelerograms for the motions during an anticipated main shock–aftershock sequence. Recently, Das and Gupta [7] have used this methodology to simulate accelerograms consistent with seismic hazard specified via response spectrum of the anticipated main shock motion. Due to the availability of a large database of recorded motions, it is sometimes possible to select records that can represent, after suitable scaling, the hazard of a scenario earthquake [8]. However, it is not always possible to find a suitable recorded motion, particularly for prescribing the temporal features of an aftershock motion, together with the corresponding main shock motion (at the same site). It will therefore be useful to develop models for characterizing the temporal features of the anticipated main shock and aftershock motions at the given site. Such models should realistically simulate the continuous evolution of the frequency composition of a ground motion due to the arrival and dispersion of different types of seismic waves.

There have been attempts on the simulation of synthetic accelerograms with or without explicitly accounting for the arrival and dispersion of various seismic waves, e.g., [9,10]. However, a little has been done on the direct characterization of temporal features of accelerograms in terms of known seismological and site parameters. Such a characterization may be particularly useful when little is known about the soil profile at the site of interest. Iyama and Kuwamura [11] attempted a direct characterization of temporal features of accelerograms via different 'S'-shaped energy arrival curves for component time-histories corresponding

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