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Adjustments for baseline shifts in far-fault strong-motion data: An alternative scheme to high-pass filtering

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ABSTRACT

Traditional processing methods of accelerometric strong-motion records rely on band-pass filtering to remove contaminating noise. While filtering of low-frequency noise is often desirable to reduce the distortion of displacement and velocity waveforms, application of crude filtering can lead to the loss of long-period components of earthquake ground motion. This paper focuses on a baseline adjustment algorithm, which reduces noise-induced distortion of ground-motion accelerometric signals, and unlike high-pass filtering, retains potentially useful information at long periods. A brief description of the state of the art techniques in strong-motion data processing is presented, followed by a detailed formulation of the proposed baseline adjustment algorithm and some examples of its applications to recently recorded accelerograms. This method is found effective for high-quality far-fault data where the amplitude of the recorded signal is of structural engineering significance.

1. Introduction

Processing of accelerometric strong-motion records is essential to remove noise contaminating the recorded signal. The effects of noise contamination, albeit of small amplitude and barely distinguished in recorded ground acceleration, is often manifested as clearly visible distortion of derived time series and quantities such as velocity and displacement waveforms as well as long-period response spectrum amplitudes. This reduces the confidence in estimating important ground-motion parameters—such as peak ground velocity (PGV), peak ground displacement (PGD), permanent ground displacement in the near-fault zone, and long-period spectral ordinates—for engineering applications. A large number of strong ground-motion data available in world-wide databases are obtained as digitized records of analog traces, which are more prone to long-period noise contamination than those recorded by modern digital instruments. A comprehensive discussion on the sources and characteristics of noise in digitized analog records is provided by Trifunac et al. [1]. More recently, digital accelerometers being installed in different parts of the world provide high-quality data with broader dynamic range and higher sampling rate. All the same, they are not completely noise free, and the frequency range wherein the characteristics of a ground-motion signal can be considered as usable is limited—often dictated by routine signal processing operations.

Traditional methods in strong-motion data processing have relied on band-pass filtering. While filtering of low-frequency noise is often desirable to reduce the distortion of displacement and velocity waveforms, application of crude filtering can lead to the loss of long-period components of earthquake ground motion. In this paper, we present a baseline adjustment algorithm, which reduces noise-induced distortion of ground-motion signals, and unlike high-pass filtering, retains potentially useful information at long periods. A brief description of techniques in strong-motion data processing is presented, followed by a detailed formulation of the proposed baseline adjustment algorithm and some examples of its application.

1.1. Processing techniques

A standard routine used for processing digital accelerograms involves the following main operations (see for instance [2]):

- Subtraction of the mean of the pre-event portion of the acceleration record to establish zero-baseline (subtraction of the mean of the whole record if the pre-event portion is not available).
- Detrending the recorded acceleration to remove linear trends.
- Low-pass filtering to remove high-frequency noise.
- Zero-padding and high-pass filtering to remove low-frequency (long-period) noise.
- Detrending the integrated velocity trace to remove linear trends.

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