New Results in the Application of Optimal Filtering Techniques to Modelling of Earthquake Data

by

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The main objective of this research program is to apply techniques of optimal estimation and modelling to the characterization of earthquake accelerogram data. Our modelling goal is to account for the non-stationary nature of the data in amplitude as well as frequency.

Furthermore, we wish to account for the measurement noise that will arise from recording devices as well as digitization of continuous records.

Ultimately we wish to relate the significant parameters of our model to physical characteristics of the earthquake source as well as the local ground properties. Hopefully, this would be an aid in micronization studies. The model that we have investigated for a variety of strong motion earthquake records is given by the differential equation

$$\ddot{x}(t) + a\dot{x}(t) + b(t)x(t) = h(t)W(t) \quad . \qquad (1)$$

In this model x represents the strong motion accellerogram, a is the constant damping term, b(t) is a polynomial of prechosen order and h(t) is a time varying amplitude modulation on the input white noise W(t). The parameters to be estimated are the damping a, the coefficients $\{b_i\}$ of the polynomial b(t), and the modulation functions h(t). The function h(t) is obtained initially by a least squares spline fit directly on to the strong motion data. The constants a, $\{b_i\}$ are estimated via a non-linear estimation technique. The quality of the estimated parameters are determined by studying the so-called innovations process as well as the residuals.

Clearly in this model the function h(t) is associated with the earthquake source mechanism and the parameters a, b(t) are associated with local ground properties. This approach has been applied to a number of strong motion records generated from the San Fernando earthquake of 1971. There appears to be interesting consistencies in the estimated parameters, the significance of which is presently under study. In cases where the records are taken from upper stories in buildings a spectral analysis of the residuals yields extremely well defined peaks at the various natural frequencies of the buildings.

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