Fourier Transform in Identification of Damage Area in Earthquake

Big earthquake is one of the most serious natural disasters in the world. In the devastating Wenchuan earthquake measuring 8.0 Ms last year, China suffered a large amount of fatalities and high economic loss. Since the accurate prediction of the earthquake is difficult, finding an effective approach to identify earthquake induced damage areas is sufficiently significant to provide valuable information during emergency response and recovery assessment procedures. Fourier transform can perform as a promising way in such applications because of its advantages in image processing.

In image processing, the Fast Fourier Transform (FFT) decomposes an image into its sine and cosine components. The output image after the transformation represents the image in the frequency domain in which each point represents a particular frequency contained in the spatial domain image (Fig.1). Applying filters to images in frequency domain is computationally faster than in the spatial domain, for FFT turns the complicated convolution operations into simple multiplication. An Inverse FFT (IFFT) can be applied to the edited Fourier image to get the result of the convolution in spatial domain.

$$F(u, v) = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} [f(x, y)e^{-j2\pi ux/M}e^{-j2\pi vy/N}]$$ (1)

M and N are the numbers of pixels horizontally and vertically respectively. And u, v is the spatial frequency variables. Both the pre- and post-image of the area are transformed and their Fourier images are edited by filtering and some other functions in frequency domain. So the noise has been reduced and specific features like straight highways have been identified. IFFT calculated the new data to represent the edited spatial images. IFFT equation is

$$f(x, y) = \frac{1}{N_1N_2} \sum_{u=0}^{M-1} \sum_{v=0}^{N-1} [F(u, v)e^{j2\pi ux/M}e^{j2\pi vy/N}]$$ (2)

By subtracting the inverse Fourier transformed post- and pre-earthquake images, we get the difference picture resulting from the earthquake. In this way, combining with some other technology in geography and civil engineering like level slicing, FFT acts as a fast and reliable tool in the identification of the earthquake damage area.