Extracting nudge test parameters from noisy skin mounted accelerometer data

Tina Smith[1], Richard Foster[2] and Michael Baker[2]
[1]Faculty of Education, Health & Wellbeing, University of Wolverhampton, Wolverhampton, UK
[2]Corata Limited, Farnborough, Hampshire, UK
Email: Tina.Smith@wlv.ac.uk

Summary

To correct for soft tissue artefacts in skin mounted accelerometers a transmissibility function can be applied to the data. This function is quantified by analysis of the acceleration-time data from the response to a nudge test; however this data can often be noisy. An application of Fourier analysis can be used to filter the acceleration-time data of the nudge test response. This allows accurate recreation of the signal to determine the required transmissibility function.

Introduction

Data from skin mounted accelerometers are affected by the transmissibility effect of the soft tissue between the accelerometer and the underlying skeleton. To correct for this it is common practice to perform a nudge test and analyse the decaying sinusoidal waveform which is characteristic of the nudge test acceleration response. This enables quantification of the natural frequency (f_n) and damping ratio (ζ) required to define the transmissibility function [1,2].

Analysis of the nudge test data can be compromised due to measurement noise. This study describes an application of the Fourier transform to allow accurate recreation of the signal so the transmissibility function can be determined.

Methods

Participants (n=56) were fitted with an accelerometer (ACL300, Biometrics; 1000 Hz), skin mounted at the 4th lumbar vertebra. While standing the nudge test [1] was performed whereby the skin was displaced downwards then released. Vertical acceleration data was imported into our custom written analysis software (GADget©, v3.4) and inspected for noise. Data for one noisy trial is reported here.

A Fourier transform was applied to the trial to identify the frequency band of the required signal. The data was low pass filtered at the designated cut-off by setting to zero the higher harmonics in the Fourier series and then performing the inverse transform on the result. A decaying sinusoid was fitted to the resulting signal for subsequent estimation of f_n and ζ.

Results and Discussion

Noisy raw vertical acceleration-time data (Figure 1a) indicated a decaying sinusoid response hidden within it. This was at low amplitude and contaminated by significant noise making it difficult to identify the required signal or estimate f_n and ζ.

The Fourier transform revealed a peak at low frequencies (0-20 Hz), followed by a mostly flat spectrum suggesting these higher frequencies were random noise (Figure 1b). Following data filtering (Figure 1c), the required signal was revealed (green line). The blue line is an exponentially decaying sinusoid that corresponds to the identified peaks of the filtered signal. That model signal identifies the parameters needed to define the transmissibility function.

a)
b)
c)

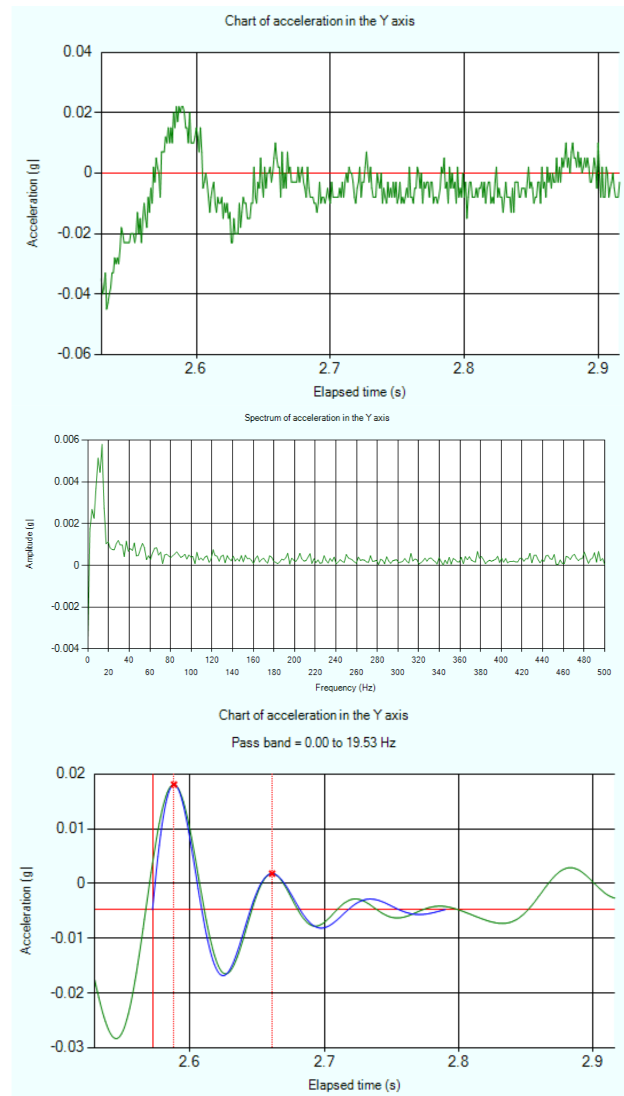

Figure 1: Acceleration-time data before filtering (a), Fourier transform of data (b) and acceleration-time data after filtering (c).

Conclusions

An application of Fourier analysis can enable accurate recreation of noisy nudge test data, to allow analysis of the signal to determine the transmissibility function.

References

[1] Smeathers JE, (1989). *Proceedings of the Institute of Mechanical Engineers*, **203**: 181-186.

[2] Smith T et al. (2017) *Proceedings of ISB XXVI*; Brisbane, Australia.