Analyzing the Experimental Fluid Dynamics Data with Hilbert and Wavelet Transforms

J. J. Miau¹

Abstract: This paper conducts a review on the experimental works which have been made by the present author with the graduate students in the past ten years to study the unsteady, three-dimensional characteristics of vortex shedding. In viewing that our interest was mainly on the instantaneous characteristics of vortex shedding, the time-series data obtained were treated as a non-stationary process, and analyzed with the Wavelet and Hilbert transformations. First, it is shown that both methods are capable of providing the instantaneous vortex shedding frequency satisfactorily; on the other hand, pronounced fluctuations were noticed in the results reduced by Hilbert transformation, which were attributed to the intrinsic character of this method. Second, it is noted that the vortex shedding signals measured always contain low-frequency modulations, in addition to the fluctuations due to the vortex shedding frequency component. Therefore, in applying Hilbert transformation to the raw signal, an Empirical Mode Decomposition procedure was required beforehand, in order to decompose the signal into a set of mono-components, each of which was free of the dc value. Third, several cases using the Wavelet and Hilbert Transformations for data analysis are presented, in which indicate that the instantaneous vortex shedding frequency is varying with time, in response to the unsteady, three-dimensional characteristics of vortex shedding. Moreover, it can be shown that the low-frequency modulations mentioned actually are associated with variations of the three-dimensional patterns of shedding vortices.

In summary, this series of research efforts reveal the advantage of using the nonstationary data analysis techniques over the conventional time-averaging techniques by that the individual events of interest could be identified with ease and their instantaneous flow behaviors could be explored in a quantitative manner.

¹ Department of Aeronautics and Astronautics National Cheng Kung University Tainan, Taiwan 70101 *jjmiau@mail.ncku.edu.tw*