POPULAR SCIENTIFIC ABSTRACT

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Random Decrement Based Vibration Analysis of Nonlinear Systems

When analyzing the vibration of a structure like an aircraft or a suspension bridge, one purpose could be to estimate the frequencies of vibration. In order to compute such an estimate, the structure must be described mathematically in the form of a mathematical model. It is common for vibrating structures to be described mathematically by its modal parameters. The modal parameters describe the natural frequencies of vibration, how fast vibrations die out, and the vibration patterns of the structure. A vibrating structure can be classified as being linear or nonlinear, where a linear structure is characterized by its modal parameters being independent of how much the structure vibrates. For instance, this means the natural frequencies of a linear structure are the same, no matter if the amplitude of vibration is small or large. A nonlinear structure on the other hand can exhibit complicated vibration behavior. Additionally, the modal parameters alone cannot fully describe the dynamics of a nonlinear system. By far, most vibration analyses that takes place are based on an assumption of the structure being linear. This assumption enables the application of many mathematical tools designed for this type of analysis, known as modal analysis. When dealing with a fundamental assumption of linearity, it should always be investigated if the structure being analyzed is indeed behaving linearly. A consequence of not investigating the assumption of linearity is the lack of confirmation that the mathematical model chosen was the correct one. This means it is not known if the modal analysis of an aircraft or a suspension bridge will yield a full dynamic description, which is usually the aim of modal analysis. One branch of modal analysis that deals with random vibrations measured on a structure where the input forces are unknown, is termed operational modal analysis. While it is common practice in experimental modal analysis to investigate the assumption of linearity, it is not the case in operational modal analysis. The aim of this PhD project is to make operational modal analysis more robust such that it can be applied on nonlinear systems. To achieve this, the application of the random decrement technique on several experimental and computer simulated test cases is investigated. The random decrement technique has been applied to analyze nonlinear systems before, however new procedures and further insight have been obtained through the research presented in this PhD project. A novel analysis procedure for investigating the assumption of linearity is developed. The outcome of this analysis procedure is a characterization of the nonlinear behavior of a structure and can be used to classify a structure as being either linear or nonlinear. The random decrement technique is also used to obtain modal parameters of nonlinear system by applying it at specific vibration amplitudes. In this way a set of vibration amplitudes are associated with a set of modal parameters which yields a more complete description of the structure than a standard modal analysis would provide.