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Research Article

Complexities in Assessing Structural Health of Civil Infrastructures

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The complexity in the health assessment of civil infrastructures, as it evolves over a long period of time, is briefly discussed. A simple problem can become very complex based on the current needs, sophistication required, and the technological advancements. To meet the current needs of locating defect spots and their severity accurately and efficiently, infrastructures are represented by finite elements. To increase the implementation potential, the stiffness parameters of all the elements are identified and tracked using only few noise-contaminated dynamic responses measured at small part of the infrastructure. To extract the required information, Kalman filter concept is integrated with other numerical schemes. An unscented Kalman filter (UKF) concept is developed for highly nonlinear dynamic systems. It is denoted as 3D UKF-UI-WGI. The basic UKF concept is improved in several ways. Instead of using one long duration time-history in one global iteration, very short duration time-histories and multiple global iterations with weight factors are used to locate the defect spot more accurately and efficiently. The capabilities of the procedure are demonstrated with the help of two informative examples. The proposed procedure is much superior to the extended Kalman filter-based procedures developed by the team earlier.

1. Introduction

The complexity concept is very difficult to define for engineering applications. Considering practical necessity, the users often initially attempt to solve a problem using common sense. However, the solution strategy evolves over a very long period of time. It is not uncommon to find that the initial solution strategy was developed without using any mathematics-based concept. The same basic concept is being developed at present using the current state-of-the-art advanced mathematical concepts embedded in highly powerful computational frame work. To assess health of an earthen utensil, our forefather tapped it and listened to the sound it produced. The world communities at present are trying to assess the health of civil infrastructures to help maintain our way of life. Some of these infrastructures were designed a long time ago and their design life may have expired. They need to be replaced; however, we do not have resources to replace them. Their design lives need to be extended. One attractive economical approach has attracted the attention of the profession is to inspect them as comprehensively as possible to identify the location, type, and severity of defects if any and then repair them in the most cost effective way to bring them back to the original state when initially designed.

Because of its relevance and importance, the structural health assessment (SHA) of civil infrastructures has attracted multidisciplinary research interest from all over the world. The basic health assessment problem of earthen utensils has now extended to infrastructures. As the health assessment concept started maturing over thousands of years, the users are now demanding different types of capabilities. Essentially, a simple concept has become very complex to satisfy the current needs. Similar challenges are faced by physicians to assess human health. They now have access to numerous equipment and test protocols with various degrees of sophistication. They need to use them very judiciously using information on cost and benefit.