APPLICATIONS OF NEURAL NETWORKS TO THE IDENTIFICATION OF STRUCTURAL SYSTEMS

by

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Abstract

The identification of mathematical models of physical structures on the basis of experimental measurements is a problem that has been receiving increasing attention in the recent past. The main impetus for this phenomenon is the central role that appropriate mathematical models have in active structural control applications. For example, the success of precision active control of large aerospace structures (characterized by many closely spaced natural modes of vibration) is based on the availability of accurate mathematical models of those structures. Since the size, nature, and configuration of these large, flexible structures preclude their system identification on the ground, future space missions have an essential need for efficient on-orbit system identification procedures. Detailed discussions of the many challenging problems encountered in the system identification of structural systems, are available in the proceedings of some recent workshops that were convened to exclusively deal with model determination for large space systems [1].

Similarly, the potential of using active control approaches to reduce the response of large *civil* structures under arbitrary dynamic environments such as earthquakes or wind, has been drawing a considerable amount of interest worldwide. In fact, the National Science Foundation convened in the fall of 1990 the first "U.S. National Workshop on Structural Control Research" [2] to address the research needs of this rapidly emerging field. Among the key research topics that were identified by the attendees as needing much more investigation, is the development of system identification approaches that can cope with the challenging nature of physical structures encountered in the civil engineering field.

A related field in which there is also a rapidly increasing need for accurate mathematical models of large systems is the emerging field of "health monitoring" of structures (civil as well as aerospace types). Techniques are being developed for damage assessment of large structures on the basis of system identification of high-fidelity mathematical models.

Usually, the mass distribution of structural components can be directly measured or accurately estimated. However, the determination of the system structural stiffness forces

and inherent damping characteristics (which constitute the "restoring forces" or internal forces) poses a more challenging problem. Also, structural systems undergoing substantial deformations exhibit nonlinear force-deformation behavior which may be approximated by a linear one using conventional linearization procedures.

With the preceding in mind, the purpose of this study is to explore the possibility of applying neural network techniques to the identification of structural systems. The aplications presented here are:

- Identification of the internal forces in structures, which may exhibit linear or nonlinear force / deflection characteristics.
- Applications of neural networks for the identification of multi degree-of-freedom structures under earthquake excitation, and simulation of the systems' structural response during earthquake events.
- Applications of neural networks to fault diagnosis and fault assessment in civil engineering structures (this is the so called "health monitoring" or "damage detection" problem). Faults and other nonlinear mechanisms may be due to structural damage from earthquakes, aging etc. or to material and construction defects.
- Applications to identification of forces in other mechanical systems, exhibiting nonlinearities such as Coulomb friction and structural hysteresis.
- Applications to modeling of the dynamics of highly nonlinear mechanical systems, such as robotic manipulators.

REFERENCES

[1] "Model Determination for Large Space Systems Workshop," Held at California Institute of Technology, 22-24 March 1988, Jet Propulsion Laboratory Report No. JPL D-5574.

[2] Housner, G.W. and Masri,S.F. (Eds.), "Proceedings of the U.S. National Workshop on Structural Control Research," Held at the University of Southern California, Los Angeles, CA, 25-26 October 1990, USC Publication No. CE-9013.