Expert Systems for Adaptive Control of Large Space Structures

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It is expected that space systems for the future will evolve to structures of unprecedented size with associated extreme control requirements. The current methods for active control of large space structures suffer from basic limitations: strong dependence upon high fidelity parameter estimates, and the inability to recognize system performance changes.

A method is necessary that is sufficiently general to initiate stable control of a vehicle and subsequently "learn" the true nature of the structure. It is the author's contention that a suitably constructed expert system (ES) would be capable of learning by appending observations to a knowledge base. To verify that an expert system can control a large space structure, numerical simulations of a simple structure subjected to periodic vibrations and the performance of a classical controller have been performed. The expert system was then exercised to show its ability to truthfully mimic nominal control and to demonstrate its superiority to the classical controller, given sensor failures.

An ES-generating software package named TIMM™ (The Intelligent Machine Model) was employed in this study. It uses the pattern matching technique. TIMM does not attempt exact matching of patterns, because this poses too stringent a requirement. Instead it incorporates a model of inexact reasoning, i.e., partial match inferencing.

A simple beam was chosen as a model. A numerical simulator was constructed to show the open loop behavior of the structure, and its behavior when controlled (closed loop). The controller was exercised to show nominal action, plus its behavior when various sensors failed. This data was subsequently used to create the various data bases needed to develop and exercise the generated expert system.

FIGURE 1 illustrates the performance of the ES using both data models as the knowledge base. This case simulates the learning by an adaptive controller from experience by appending the "in-space" truth observations to the "ground-based" truncated knowledge base. As can be seen, the force ranges selected for the truth data with data dropout are virtually identical to the actual truth forces, in spite of the erratic behavior of these force values. This dramatic result appears to show that an expert system can be highly effective at "learning" from experience.

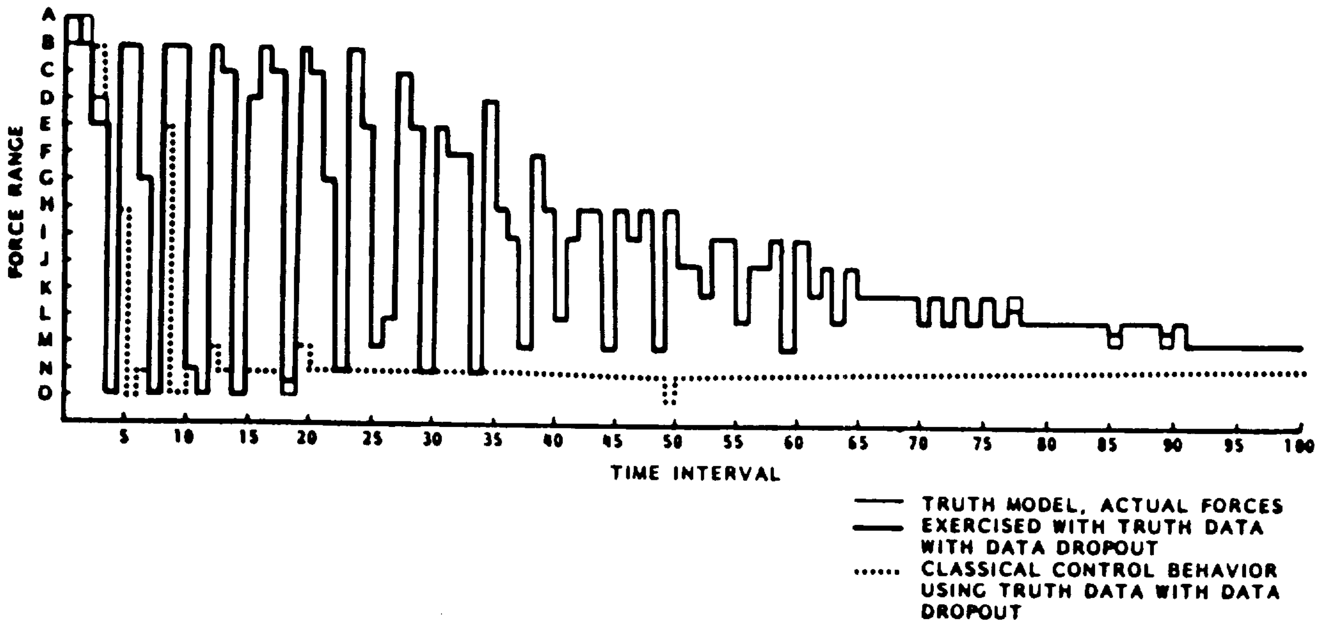

FIGURE 1. Data Loss for Expert System Trained with Truncated and Evaluation Models (Learning)