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EVIDENCE-BASED RESILIENCE ENGINEERING OF DYNAMIC SPACE SYSTEMS

Abstract

This paper will present a method for the design of complex space systems under severe uncertainty when the characteristics of the subsystems are time-varying. The approach proposed in this paper represents a complex space system as a network of interconnected nodes, each of which is characterised by one or more quantities of interest. The quantities of interest of each subsystem are dependent on a number of decision and uncertain variables that are strictly related only to that subsystem. A set of scalar quantities, called coupling functions, exchange information between pairs of subsystems. Each pairing function is dependent on a set of coupling uncertain parameters.

The uncertainty associated to all uncertain variables is modelled using Dempster-Shafer theory of evidence. Thus the network is called Evidence Network Model (ENM). This work in particular will consider the case in which the quantity of interest of each subsystem has a state that depends on the uncertainty and can change with time. In this way we can simulate continuous transitions between fully functioning and degraded states and the effect of disruptions and shocks that can perturbed the system. One of the quantities of interest is the mass of the subsystem that we will use as generic performance indicator of the overall system. Hence, the value of the ENM is the sum of the individual masses of each subsystem. The problem is, therefore, to minimise the system mass under uncertainty while all the other quantities of interest are concurrently optimised. Following the method proposed in [1] and further developed in [2,3,4,5] we will show how to efficiently compute the value of the ENM and to optimise the design so that the solution is robust and resilient to disruptions. In doing so we will introduce elements of graph theory to analyse the dynamics of the network and assess the dependency of each node on the design and uncertain parameters of other nodes. The approach will be applied to the case of the design of a small satellite in Low-Earth Orbit.

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