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SPACE MISSION DESIGN SUPPORTED BY KNOWLEDGE BASED SYSTEMS: AUTONOMOUS DECISION MAKING IN EARLY DESIGN PHASES

Abstract

Current improvements in machine learning and processors' computational capabilities give to knowledge based systems higher effectiveness within the system design framework. This result is enhanced when knowledge based systems are applied during early design phases, in which the uncertain decision making is an actual critical process. Experience in systems design demonstrates that even though most of the costs are expended in the advanced phases of the life cycle most of them is determined by choices made during the first design phases. Therefore, a poor conceptual study will lead to a worse and expensive system at the end of the design process. These phases can also be considered crucial due to a very poor knowledge about the system, which entails uncertainties on the outcomes related to each taken decisions. To overcome these aspects of early phases, several methods and approaches have been developed, especially when multidisciplinary systems are under development. Examples are given by tradespace exploration and concurrent engineering. In the concurrent engineering approach, the specialists are not permanently and exclusively assigned to design activities, as these are just one of the several tasks they perform in a matrix-organization. This specialist turnover implies that a large amount of knowledge can vary in terms of good design practice and important knowledge from successful past missions. Concerning this flow of knowledge, it is important to avoid any loss of it, which implies the ability of managing and structuring all the knowledge of each expert aiming to a future reuse. Fuzzy case based reasoning offers an effective tool to fulfill those functions within a concurrent design facility. Examples are given by autonomous stakeholder interview with bias avoidance, autonomous tradespace generation and exploration, optimization set-up and real time virtual reality management. The paper analyses applications of fuzzy case based reasoning and proposes a design methodology which considers a merge between knowledge based systems and uncertain reasoning to support and automate concurrent space mission design. Finally, the benefits of this methodology within an academic concurrent design facility are underlined, highlighting the additional challenges born in an academic environment that is possible to overcome, such as short learning curve or intensive team turnover. Thanks to a CubeSat case study, the benefits given by these tools are then globally analyzed and a roadmap for a totally autonomous preliminary design is structured, proving the capabilities and future development of this artificial intelligence tool within aerospace systems design.