Using AI to Manage Uncertain Requirement for Complex Systems: from Textual Requirements to Simulable models.

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1 Introduction

The development of complex products is characterized by multiple combinations of interconnected processes with dynamic interactions between disciplines or domains. These couplings present major challenges when it comes to integrating eco-design approaches into systems engineering (Göknur Sirin and Yubo Wanget al.). This paper addresses the automatic management of uncertain requirements in complex systems via MBSE (Alaa Abdalazeim et al. and Roberto Monaco et al.). In this paper, we first focus on how to make the validation of these requirements more flexible and modular. Then, before automatically generating these requirements, it is necessary to determine whether it is possible to integrate uncertainties to create a simulation model with a level of confidence or tolerance (Walker and A. waz et al.). Finally, is it possible to automatically isolate and capture requirements and uncertainty information based on the type of requirements (simple, contradictory, interdependent, random, deterministic, chaotic, etc.) using AI? The main objective of this work is to explore innovative strategies to improve the eco-design loop of uncertain complex products by using a more efficient process focused on automation, MBSE approach and AI to automatically capture and classify uncertain requirements (Anupam Bhardwaj et al.).

2 Methods

In this work, we propose innovative concept including a textual requirement management capture using AI. The concept starts with the collection of needs and requirements in textual form.

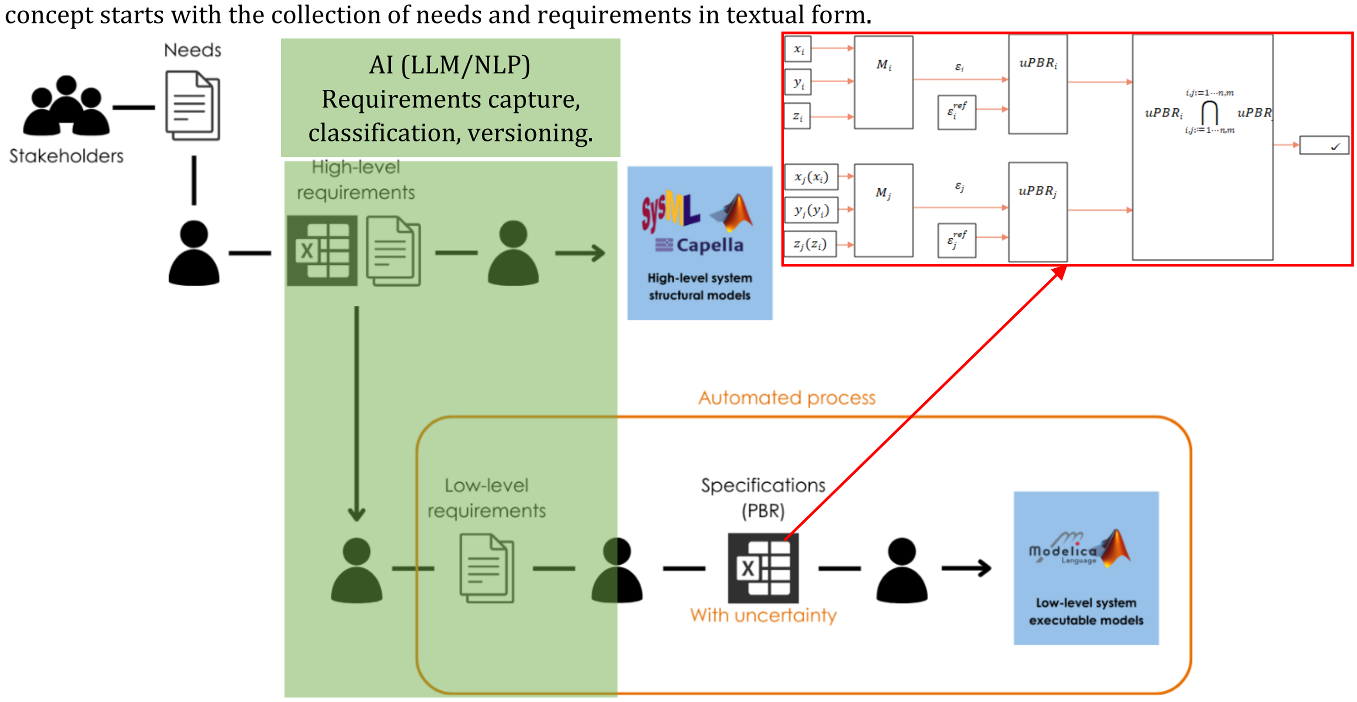

Figure 1: Uncertain Requirement Management Using AI in MBSE Approach (Input: textual requirement, Outplut: simulable Model Including Uncertain Variable Calculations/Modulations)

Based on these information, reformatization step is proposed to put them into a template that is easier for AI to handle. And the last step is to train and use AI prompts to retrieve/classify the information, and this output information will serve as inputs for the PBR modelling.

3 Results

In this we present the results and the behaviour of the uncertain requirement variables at the end of the concept.

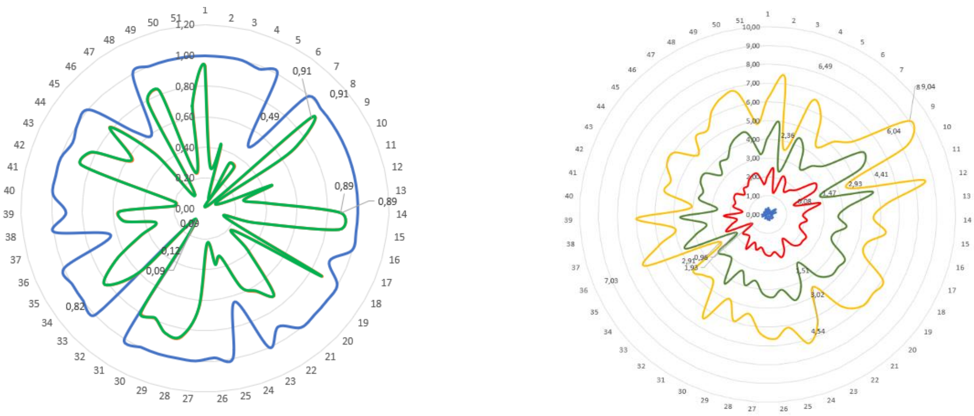

Figure 2: Kolmogorov-based uncertainty results, chaotic behaviour (left) and Bayesian Inference Results, deterministic behaviour(right)

4 Discussion

In this paper, we have presented a comprehensive framework for automating the management of uncertain requirements in complex systems. By leveraging AI-driven models and MBSE approaches, the integration of eco-design principles into systems engineering has been made more efficient and flexible. Our results demonstrate that the proposed methodology significantly enhances the capability to handle dynamic, uncertain, and interdependent variables within simulation environments, offering greater adaptability for evolving engineering challenges. While our approach shows promising results, further refinement is required to fully capture the complexity of real-world applications, particularly in highly chaotic systems. Future work should focus on expanding the AI models to incorporate a broader range of uncertainty types, and on improving the interoperability of MBSE toolchains across diverse industries. Additionally, there is a need for more empirical validation through case studies to assess the practical implementation of this framework in real-world scenarios.

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