IBIS : An Interactive Virtual Assistant for System Engineers

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Application Domain: Concurrent Engineering and User-Centered Design

Technical Theme : Advances of AI in combination with immersive technology

One of the key challenges in adopting VR/AR in a Model Based System Engineering approach in industry is how to intuitively exploit system engineering knowledge expressed through descriptive models by different stakeholders. This paper presents a virtual assistant named IBIS in assisting system engineers to perform such activities over SysML models and data in multimodal manner through speech in a VR environment or through text in a chatbot. Development of an underlying system engineering ontology, SysML and VR scene construction, model transformation, training a domain specific language model and query techniques are presented along with its implementation. Results of two different case studies are briefly discussed followed by lessons learnt, challenges and possible avenues of future work.

I. Introduction

A major challenge in concurrent system engineering where the usage of modeling is widely prevalent is that the knowledge is often buried in complex and highly domain specific models. Such models even when built and linked based on a rigorous MBSE approach are difficult to exploit, query and reason particularly for non-domain experts in a VR/AR context which necessitates an intuitive solution where the user can interact through natural language. In other words, we need a virtual engineering assistant/bot which can understand user's questions, retrieve relevant information and perform simple tasks which will be particularly useful in concurrent engineering tasks such as in virtual model inspection, training, mission review/analysis etc .

In this context, we have undertaken an internal research project to develop such a virtual system engineering assistant called 'Intent Based Interactive System engineering assistant', or shortly IBIS [1], with specific focus on system engineering activities. A brief overview of our virtual assistant can be seen in figure 1 where a user interacts through natural language in an immersive VR setting over an underlying system model represented in SysML and associated data stored in a knowledge graph.
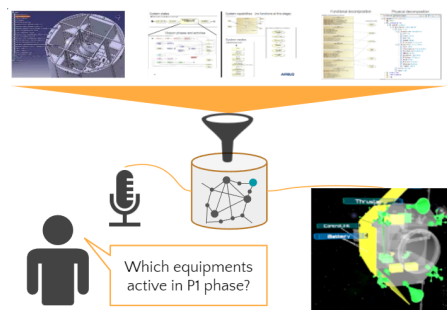

Fig. 1 Virtual Assistant Overview

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II. IBIS Virtual Assistant

In IBIS, we broadly addresses the following questions, how to formalize system engineering knowledge usually expressed as interconnected and hierarchical models, particularly descriptive models such as SysML models, via ontologies and model transformations, and how to exploit such knowledge intuitively through the development of a virtual assistant based on Natural Language Understanding (NLP) and knowledge graph query techniques in the VR context. The toolchain is based on the RASA framework for NLP, Cameo for SysML, UNITY for VR, Protégé/Blazegraph for ontologies and knowledge graphs with continuous integration and deployment being managed with Jenkins, Node-Red in the inhouse cloud [1].

One of the applications of the IBIS assistant to a satellite VR case study is shown in figure 2. Queries are first converted to text through a custom speech-to-text language model and the results would be highlighted or displayed. A short video on this example will be shown during the presentation. In another case study on an aircraft system, the user might pose questions over a chat and the results will be complemented with relevant diagrams such as tree, matrix, graph etc as shown in figure 3.
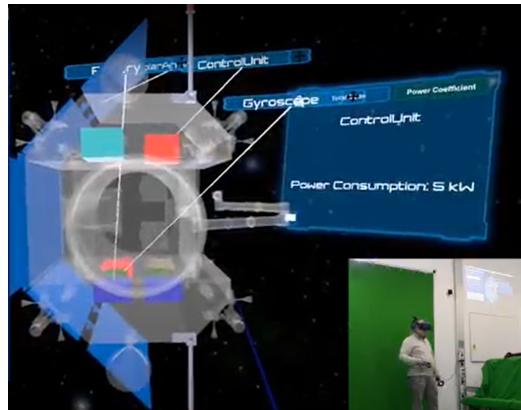

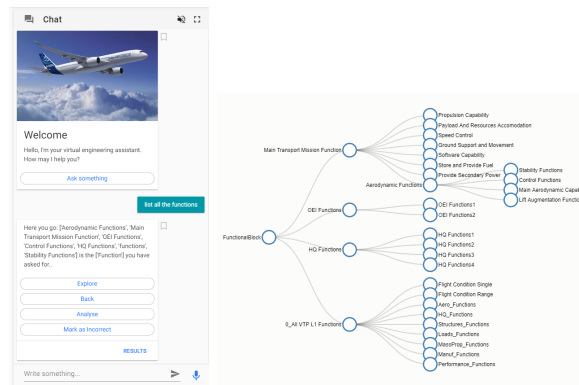**Fig 2. VR Interaction - Satellite case study**

Fig 3. Text Interaction - Aircraft case study

III. Conclusion & Outlook

A key avenue for future work would be improving the existing ontology, pipelines and better integration with model authoring tools and VR environments. Other possible avenues of future extensions include additional capabilities to perform post query tasks such as simulation/trade studies, geometry manipulation in VR etc. Early involvement of end users in training data enumeration, better dialogue designs, and continuous learning may help improve some of the current pitfalls in adopting such assistants in everyday system engineering activities.

References

[1] Ponnusamy, et al, *IBIS : An Interactive Virtual Assistant for System Engineers,* AIAA SCITECH 2023 Forum USA, DOI: 10.2514/6.2023-1960