The MBSE Futurist's Dilemma: Diffusing systems engineering practices in an AI dominated era

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Abstract. It is well recognized that Systems Engineering is a transdisciplinary and integrative approach to enable the successful realization, use, and retirement of engineered systems. The importance of using systems principles and concepts, and scientific, technological, and management methods is core to systems engineering. Modern systems are subjected to an enhancing footprint of intelligence in product functionality and inter-connectivity. AI and other advanced technologies are increasingly popular among scientists and engineers to inculcate differentiating intelligence in modern systems. These systems are envisioned to emulate and simulate beyond human intelligence to achieve their goals and perform better than their "traditional" predecessors. They function in a completely different manner than their predecessors, and demand different approaches during its life cycle. In the current context of open communications, applications availability and big data, excessive emphasis on technology aspects and fading SE approaches would not be the answer support the design and management of complex intelligent systems. The answer has to come by achieving the following objectives: (a) Self-awareness, (b) Self-control, (c) Self-improvement through learning and (d) Machine-to-Machine & Machine-to-Environment Connectivity. An emerging view is that some of the prevailing SE approaches and tools don't accommodate system design life cycle that address such objectives that are necessary in the modelling of an intelligent system. The panel is designed to gather the industry and academia experts to share their research and knowledge where SE methodologies can be improved to meet the current era needs of AI and advanced technologies, with focus on (1) MBSE for AI applications (2) Potential SysML extensions for intelligent systems (3) Systems Engineering approaches for Intelligent system Applications (4) Lessons learned from implementing MBSE in AI applications

Biography

Ramakrishnan Raman (Honeywell)
Dr. Ramakrishnan Raman received B.Tech and MS degrees from IIT Madras, and PhD from IIIT-Bangalore. He is a certified Six Sigma Black Belt and is INCOSE certified Expert Systems Engineering Professional - ESEP. He has extensive systems and software engineering experience in domains of Building/ Industrial Automation, and Aerospace. He has been the Lead Systems Engineer and Architect for the design of many complex systems globally over the years. He is currently Principal Systems Engineer at Honeywell Technology Solutions, Bangalore. He has to his credit publications in refereed international conferences & journals, pertaining to complex systems architecture design, Artificial Intelligence – Machine Learning.

Position Paper

Modern systems are subjected to an enhancing footprint of intelligence in product functionality and inter-connectivity. AI and other advanced technologies are increasingly popular among scientists and engineers to inculcate differentiating intelligence in modern systems. These systems are envisioned to emulate and simulate beyond human intelligence to achieve their goals and perform better than their "traditional" predecessors. They function in a completely different manner than their predecessors, and demand different approaches during its life cycle. In the current context of open communications, applications availability and big data, excessive emphasis on technology aspects and fading SE approaches would be detrimental towards robust design and management of complex intelligent systems. The need for increasing self-awareness, self-control and self-evolution requires enhancements in conventional systems approaches. An emerging view is that some of the prevailing SE approaches and tools don't accommodate system design life cycle that address such objectives that are necessary in the modelling of an intelligent system. Balancing the impulse for inculcating advanced intelligence against the imperative in ensuring robust intelligent systems with well understood behaviors and unintended consequences is required.

Stephen Piggott (Canadian Space Agency)
Stephen Piggott graduated from the University of Toronto with a BASc and later earned an MASc at UofT's Institute

for Aerospace Studies in aerospace control systems. In his 30+ years in the aerospace industry he has worked in controls, simulation and structures before becoming a Systems Engineer and the joining the Canadian Space Agency almost 20 years ago. Since then he has worked on programs at various stages of the life cycle including delivering parts of the Mobile Servicing System to the International Space Station, supporting its operational phase, preliminary design of Canada's contribution to the James Webb Space Telescope, and most recently as SE lead on Canadarm3 for the Lunar Gateway.

Mr. Piggott has been involved in a number of SE's subdomains but has taken a particular interest in MBSE and SysML including authoring a paper for INCOSE Symposium 2008. He has been leading and mentoring CSA and industry to encourage adoption of SysML and digital requirements management, which is bearing fruit as the Gateway partnership moves increasingly to integrate MBSE into its work practices. Canadarm3 is intended to work in a highly automated fashion which is pushing Mr. Piggott to learn more about AI

Position Paper

Human spaceflight is an enterprise fraught with considerable risk for the crew, which needs to be controlled through rigorous system design, safety analysis and verification to control all foreseeable hazards. The insertion of a self-learning system would create significant uncertainties that may not be acceptable without constraints, on top of which, the opportunities to train such a system are many orders of magnitude smaller than in the domains such as face recognition which have been successful. Consequently, the use of the type of AI discussed in many contexts is questionable in the space domain. However, there are several useful forms of AI, some of which are more predictable. For instance, knowledge bases and structured decision trees are more amenable to analysis. In addition, there are potentially many problems that can be solved by an AI and where the results can always be verified for safety, for example, robot path planning problems and optimal scheduling problems.

In any case, MBSE can be used to construct models of any use of AI and make the process of development more predictable, consistent and reliable. Requirements can define the scope. Models can respond to the requirements with design concepts. Models can define the programming or training process. Models can describe how the results need to be verified. If the problem domain can be reasonably described mathematically, which is the case for significant areas of spaceflight engineering, these models can be automated and the design varied to find successful and optimal solutions. Even if it isn't, the well-known benefits of MBSE for structuring and communicating the approach and solution will help the AI development to a successful conclusion. SysML, since it is in widespread use and sanctioned by INCOSE, is suggested as a way to describe the requirements, design and verification for a problem in which AI may be the best solution.

Vincent Arnould (Hensoldt)

Vincent Arnould is a System Architect in the Defense domain currently working for HENSOLDT. He has been graduated in 2000 from the French Engineering School Centrale Marseille where he studied Mechanic and Acoustic. He has first worked as Software Developer at THALES, in the Paris area, in the field of Modeling and Simulation for SE, where he achieved several publications on Model Driven Engineering and participate in the definition of SysML at the OMG. After that, he has joined Naval Group in Toulon, where he has spent 15 years, dealing first with Combat Management Systems (CMS) as Software Architect, and as Industrial Bid Manager, then for the whole Combat System as System Engineering Manager and Combat System Architect, deploying industrially the MBSE approach, as for example on the GOWIND frigates. In 2018, he published two articles at the IEEE/INCOSE SoSE conference. The last two years he was part of the LEIDOS Team as Senior Architect on the Battle Management, Command, Control, Communication and Intelligence (BM3CI) Systems-of-Systems engineering, at the NATO Communication and Information Agency (NCIA) in The Hague, Netherlands.

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I will try to bring an analysis on the positioning of MBSE in regards of AI.

The MBSE approach should not be seen as a hindrance or an incompatible approach in regard of the advent of AI. On the contrary. Both disciplines are maturating and will emphasize each other in the future.

First both MBSE and AI help to cope and deal with complexity. But their mutual integration will also be a source of huge opportunities, from both perspectives:

• MBSE can help the design of intelligent systems by formalizing the necessary split between the humans and the AI: what does the humans and what does the AI. A necessary work to understand how to capture the AI components into the architecture is still to be conducted.

• In the other way around, the AI is also able to help the design of system through integration of AI inside the MBSE tooling, for example enabling the automated exploration of the design space and optimum solution finding. Some existing tools already exists in this field, and many others should come in the future.

Juan Navas (Thales Group)

Juan Navas is a Systems Architect with +10 years' experience on performing and implementing Systems Engineering practices. He has evolved on several industrial domains, developing complex modern systems. He has worked on the design and the procurement of instrumentation & control systems and simulation systems for petrochemical plants, nuclear fuel cycle plants and nuclear power plants.

He has also lead projects to improve software and systems engineering performance following Model-Based Systems Engineering approaches.

He currently leads the team at Thales Corporate Engineering that accompanies managers and architects implement MBSE approaches on operational projects, helping them define their engineering schemes, objectives, and guidelines.

He holds a PhD on Computer Science, a MSc on control and computer science, and Electronics and Electrical Engineering Degrees.

Position Paper

In 5 years, the number of devices that can be connected to a network will be multiplied by four. More devices means more data being collected and being exploited. Data is and will be everywhere, which will lead to an exponential number of connections, and hence an exponential number of opportunities to arrange them on innovative ways and to provide new services.

The orchestration of such devices to build up solutions that satisfy the expectations of our customers becomes a key expected competency of systems providers. Model-based Architecture Design, a subset of Model-Based Systems Engineering (MBSE), is what defines connections between building blocks, coordinating them so as to reach a common and shared purpose, which is the reason to exist of the system they make part of. MBSE has proven its effectiveness on designing, developing, integrating and validating complex systems. MBSE improves communication between technical and non-technical stakeholders, leads to securing the design and check its consistency, and enables the automatic production of engineering deliverables, to name a few its benefits. More and more of the components that will integrate our systems tomorrow will have some kind of intelligence, ranging from reactiveness to self-awareness capabilities. In such a context, how MBSE and in particular Model-Based Architecture practices shall evolve to cope with these needs? One first illustration is the need to identify where the self-awareness, self-control and self-improvement capabilities shall be implemented. Here, a set of ordered and consistent practices enabling the characterization of the operational context and the elicitation of needs at the system-level, lead to the characterization of the required AI-related capabilities required from the components of the architecture.

Hany Fawzy (Canadian Space Agency)

Hany Fawzy graduated from Electronics and Telecommunication Department, Faculty of Engineering, Cairo University in 1985. Following that, he continued his postgraduate studies in Computer Engineering and Computer Science in Egypt and France, where he obtained his Ph.D. degree from University of Nancy 1 (Lorraine University) in Artificial Intelligence in 1992. Following that, Dr. Fawzy continued his research in the domain of AI application in different fields such as telecommunications and health systems. Dr. Fawzy joined the industry in 1998, and worked for multiple companies such as Motorola and Harris in the fields of Systems Engineering and Project Management. In 2005, Dr. Fawzy joined the Canadian Department of Defense as a Systems Engineer and participated in managing the System of Systems engineering cycle of the intelligent Land Command Support System. In 2011, Dr. Fawzy joined the Canadian Space Agency (CSA) as a Senior Systems Engineer, he worked as Lead Systems Engineer for RadarSat Constellation Mission Ground Segment. Currently he's a member of CSA Lunar Gateway Program Systems Engineering Team. In his function, he supports the different Artificial Intelligence activities within the gateway program as well other CSA AI scientific and industrial initiatives.

Position Paper

The world are on the footsteps of a time where the advances of technology supported by AI will force all stakeholders to re-examine their traditional methods for designing and engineering of all future intelligent and autonomous systems. During the panel, I will outline my thoughts and effort on going by me and my organization to provide with answers to the questions raised.

Intelligent and autonomous systems would have the advantages of being self-awareness, self-control, self-improvement through learning and are self-sufficient. The current MBSE or system engineering methodologies and architecture approaches doesn't yet respond to those new features and how to address them in any modeling language. There are multiple challenges to System Engineering for such Intelligent and AI based systems such as Lack of human role to review and responsibility as well as public trust and users acceptance. Also, learning would require huge and continuous data and self improvement might require continuous source of huge amount of data, meta data and retraining needs of the release application in case of ML and deep learning applications.

A new concept of self-awareness and situation awareness now appear, how we would handle the modeling such a concept. How we can manage the bias for deciding and make decisions. Add to all the previous, how the testing and validations requirements will be met in stochastic model. At the moment we will not address the ccyber security aspects as we are not able to determine the increase threat surface of AI based system. In fact, coming to areas like aerospace industry, there are a lot of challenges would appear for certification where the bias need to be needed and trace for audit is required. AI and autonomous systems lifecycle management, what will be the future Engineering lifecycle and planning to migrate from and for traditional systems to intelligent and autonomous ones.