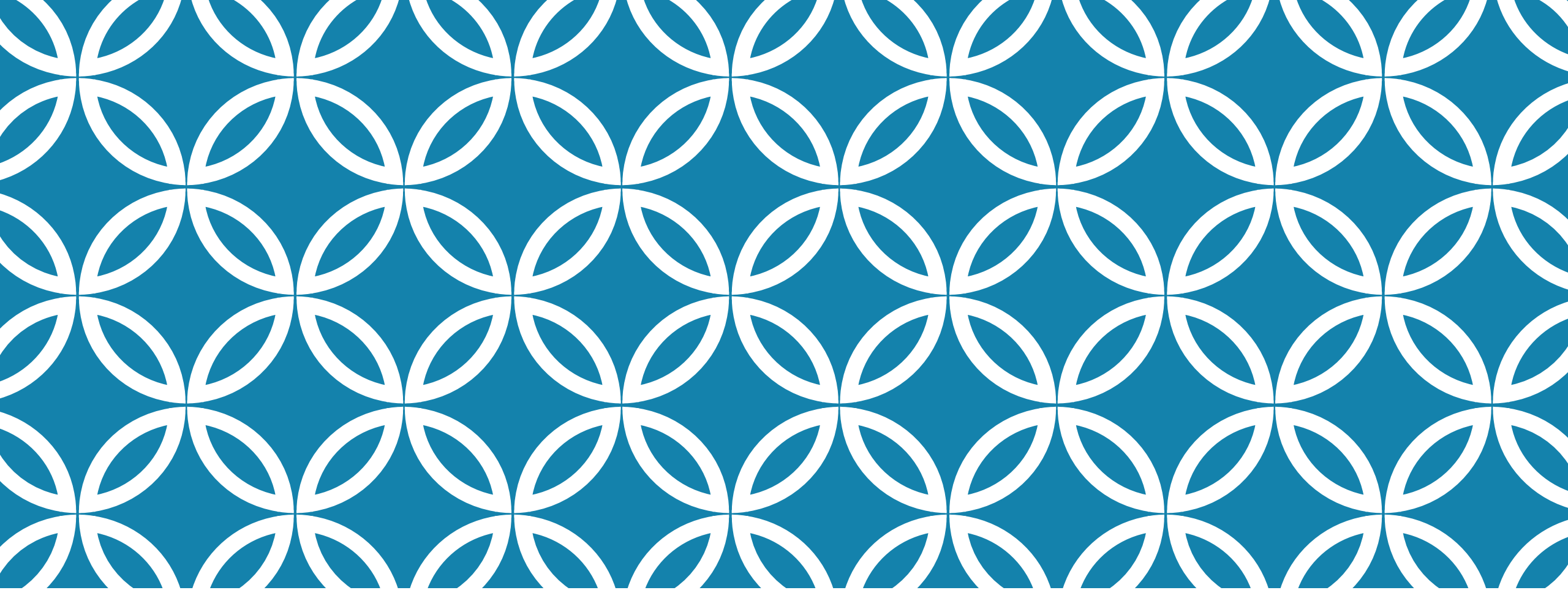

SPECIAL TRACK - AI4SYSSOS CHALLENGES FOR ARTIFICIAL INTELLIGENCE-MACHINE LEARNING IN COMPLEX SYSTEMS AND SYSTEMS OF SYSTEMS

The Sixteenth International Conference on Systems
ICONS 2021
April 18, 2021 to April 22, 2021 - Porto, Portugal

SPECIAL TRACK - AI4SYSSOS CHALLENGES FOR ARTIFICIAL INTELLIGENCE-MACHINE LEARNING IN COMPLEX SYSTEMS AND SYSTEMS OF SYSTEMS

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Education & Certifications

- B.Tech (1995), MS (1997) – IIT Madras
- PhD (2019) – IIIT Bangalore
- Honeywell Six Sigma Plus Black Belt, 2003
- General Management Program - IIM Bangalore, 2005
- INCOSE Certified Systems Engineering Professional (CSEP), 2005-17
- MBA - ICFAI University, 2012
- INCOSE Certified Expert Systems Engineering Professional (ESEP), 2018
- Machine Learning certification courses, including Reinforcement Learning

Areas of Expertise

- Systems Engineering – Complex Systems, System-of-Systems, Model Based Systems Engineering, System Architecture & Design
- Artificial Intelligence – Machine Learning, Reinforcement Learning
- Software Architecture & Design; OOAD (Object-Oriented Analysis & Design) & Design Patterns
- RTCA/DO standards for Avionics Software development, SAE ARP 4754/ 4761
- Redundancy Architectures & Fault Tolerance, Distributed Systems

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- Flight Controls Systems Engineer, Honeywell Aerospace
- Flight Management Systems Engineer, Honeywell Aerospace

CHALLENGES FOR ARTIFICIAL INTELLIGENCE-MACHINE LEARNING IN COMPLEX SYSTEMS AND SOS

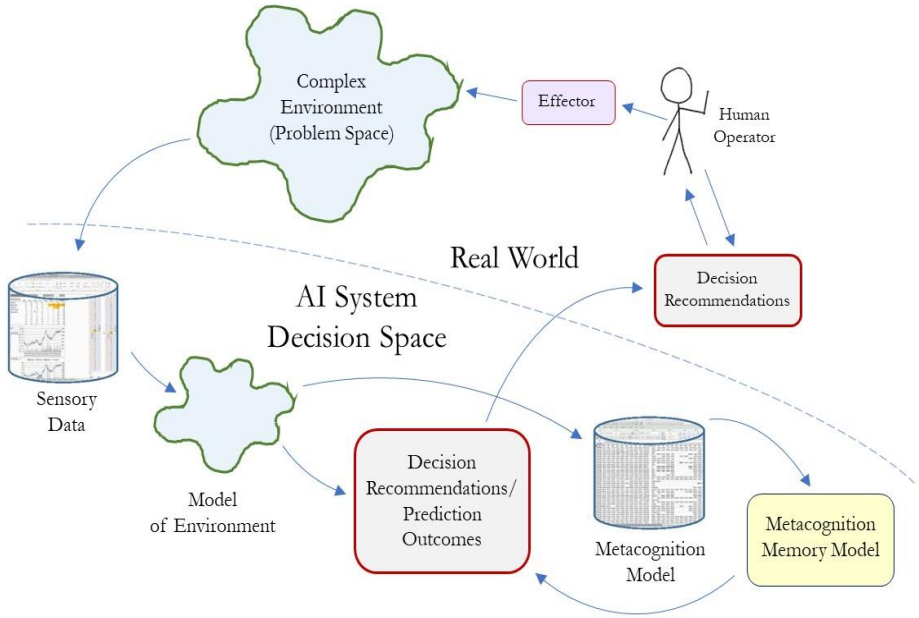
- Complex systems and System-of-Systems (SoS) are now being increasingly inculcated with significant footprint of intelligence in functionality and inter-connectivity.
- Artificial Intelligence-Machine Learning (AIML) and other advanced technologies are being leveraged to inculcate differentiated intelligence in modern systems and system-of-systems.
- These complex systems are envisioned to emulate comparable and beyond human intelligence to achieve the desired goals and perform better than their "traditional" predecessors.
- However, engineering these advanced technologies into complex systems and SoS demand different approaches, and pose different challenges as compared to their predecessors.

TRACK SESSION

#	TITLE	PRESENTER
48001	Metacognition for Artificial Intelligence Systems: An Approach to Safety and Desired Behavior in Complex Systems	Bonnie Johnson bwjohnson@nps.edu
48002	Extending System Engineering Methodology into the era of Artificial Intelligence	Hany Fawzy hany.fawzy@canada.ca
48003	Reinforcement Learning for Emergent Behavior Evolution in Complex System-of-Systems	Anitha Murugesan anitha.murugesan@honeywell.com
48006	Deep Reinforcement Learning for Combat System-of-Systems Architectural Path Selection	Zhemei Fang zmfang2018@hust.edu.cn

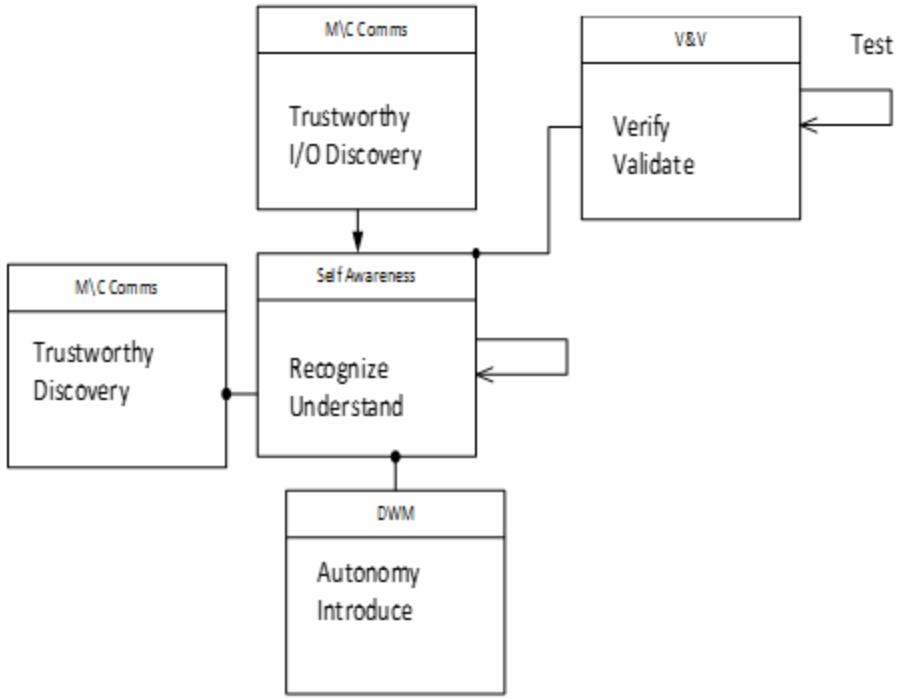
METACOGNITION FOR ARTIFICIAL INTELLIGENCE SYSTEMS: AN APPROACH TO SAFETY AND DESIRED BEHAVIOR IN COMPLEX SYSTEMS [BONNIE JOHNSON]

- Developing AI systems with metacognition is a step towards enabling systems to think, learn, and adapt in real-world environments
- An initial concept for a metacognition capability is proposed as a type of safe fail solution strategy
- The AI system creates and maintains a metacognitive internal model for self-awareness, self-diagnosis, and self-evaluation.
- The mechanism enables the AI system to prevent failure by identifying indicators that a failure might occur and alerting a human operator or shifting itself into a failsafe or manual mode of operation



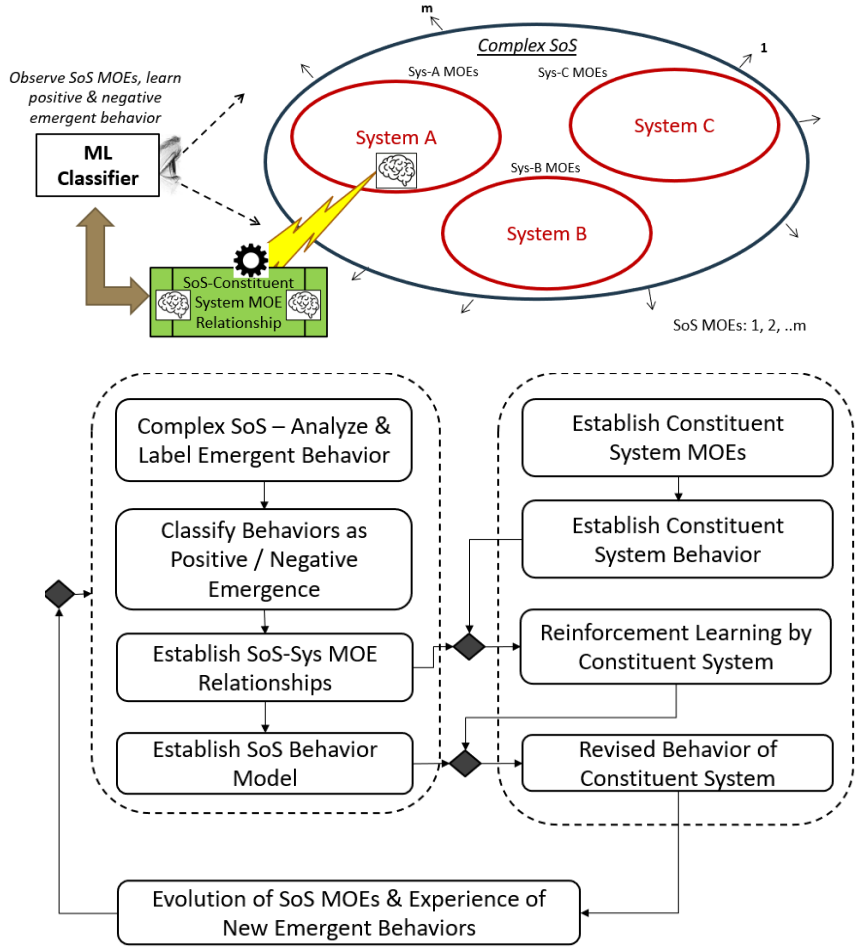
EXTENDING SYSTEM ENGINEERING METHODOLOGY INTO THE ERA OF ARTIFICIAL INTELLIGENCE [DR. HANY FAWZY]

- Artificial Intelligence (AI) will require all stakeholders to re-examine their traditional methods for designing and engineering of all future intelligent and autonomous systems.
- The paper proposes guidelines that are needed to extend system modelling languages to model AI entities
- Following principles are proposed for an extension to SysML:
  - Self awareness; Dynamic world modelling, System of System (SoS) modelling; Trust and data sets; Machin to Machine Communication (interaction); Verification and Validation; Self-Improvement through learning and Autonomy (self control or self sufficient)
  - The profile is organized into two top-level packages: the Ai-Autonomy Library and SysML. The First is a UML Model Library which defines datatypes and reusable concepts, while the other will contain the concepts of AI-autonomy data.



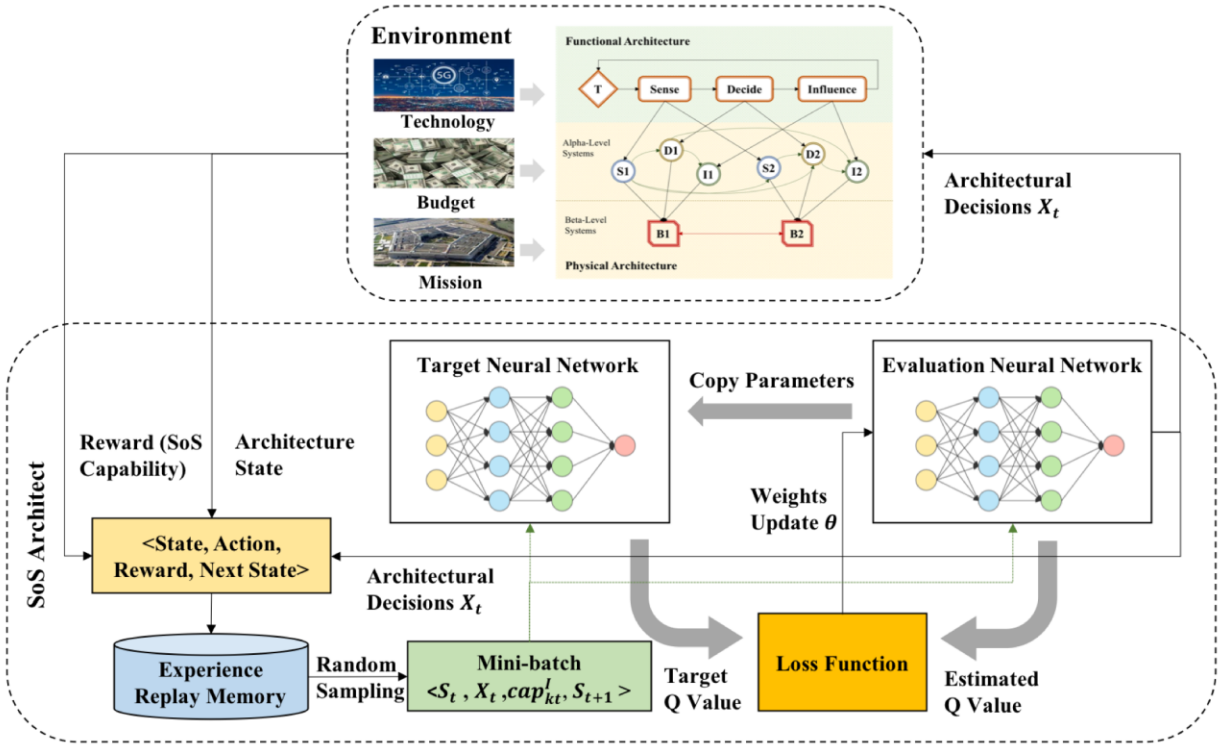
REINFORCEMENT LEARNING FOR EMERGENT BEHAVIOR EVOLUTION IN COMPLEX SYSTEM-OF-SYSTEMS - [ANITHA MURUGESAN]

- In SoS context, the relationships between the Measures of Effectiveness (MOEs) of the constituent systems and SoS is critical to understand emergent behavior evolution
- This work presents an approach towards using reinforcement learning models and techniques for evolving MOEs of the constituent systems and SoS towards addressing emergent behavior
- The approach enables constituent systems to learn and adapt their behaviors in tandem with the evolution of emergent behavior at SoS level.



DEEP REINFORCEMENT LEARNING FOR COMBAT SYSTEM-OF-SYSTEMS ARCHITECTURAL PATH SELECTION - [ZHEMEI FANG]

- Proposes a learning-based framework for managing interdependency-incorporated SoS architecture evolution and path selection
- Case study illustrated of mosaic warfare comprising multi-mission units
- Developed DQN algorithm to support SoS architectural path selection under uncertainty;
- Built a simple parametric model to capture impact of interdependency on SoS capability;
- Applied the method to a synthetic USV-centered naval AMD SoS



SUMMARY OF TRACK

- Significant challenges pertaining to AI-ML in complex systems and system-of-systems
- Cutting edge research on addressing some of the challenges:
  - Augmenting AI system with metacognitive internal model towards addressing Safety for critical systems
  - Extensions to modeling languages for enabling modeling of AI entities
  - Adopting Reinforcement learning to address the evolution in MOEs in complex SoS
  - Using Explainable AI and Model-based System Engineering for vital functions in safety critical systems
  - Adopting Deep Reinforcement Learning for optimal candidate architecture selection