**IRI PANEL-2019**

**ON EXPANDING THE IMPACT OF DATA SCIENCE ON THE THEORY OF INTELLIGENCE AND ITS APPLICATIONS**

**Participants:**

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**ABSTRACT**

The goal for this panel is to propose a schema for the advancement of intelligent systems through the use of symbolic and/or neural AI and data science. Specifically, discussants will explore how conventional numerical analysis and other techniques can leverage symbolic and/or neural AI to yield more capable intelligent systems. This approach could yield significant improvements in such domains as Meteorological and Oceanographic (METOC) signal processing, logistics, scheduling, pattern recognition, optimization, ergonomics, explanation, causal inference and prediction, system diagnostics, education and training, and a plethora of additional applications. Self-reference is inherent to autonomous thought; and, this appears to be indistinguishable from consciousness from a computability perspective. Thus, the question arises, can we program more efficient ways to support the programming (problem-solving) process? The panel will explore these and other advanced topics related to information reuse and integration and of fundamental importance to data science.

**Causal inference and prediction** are of particular interest to the discussants and for all who are working with AI/ML. In fact, LeCun, of deep learning fame, has stated that prediction is the central problem defining all of AI. . Getting this right could have a tremendous impact in a lot of important operational areas:

**Weather**. In weather prediction (METOC), a patented software solution replaced the use of partial differential equations (PDEs) with geographically-dispersed sensor registries for atmospheric modeling. These sensors feed their data to local and centralized computers that learn to predict weather based on mapped previous experiences. AI is needed to map or generalize current data to recorded cases and make viable micro-climatic predictions, which surpass those of PDEs and their associated error marches when solved numerically using triangular elements (Gallerkin methods).

**Radar and Sonar**. Signal processing is used in radar and sonar to actively identify the transmitter or alternatively make a passive identification of friend or foe (IFF). Here, waveforms can be fitted – not by Newton backward/forward differencing and/or Fourier Series, but rather through the synthesis of Type II fuzzy functions – invented by the late Lotfi Zadeh, the father of fuzzy logic and a regular plenary presenter up until the time of his passing. This expands the effectiveness of radar and sonar applications by reducing the number of rules (including mathematical theorems), that would otherwise be needed.

**Logistics**. Most logistic problems require the representation and design of heuristics to solve otherwise intractable problems (e.g., the TSP). The Navy has many such problems involving time-critical shipments to multiple locations in minimal time and at minimal cost.

**Air Operations**. Similarly, aircraft carriers need better algorithms to schedule their takeoff and landing operations in rolling seas, in inclement weather and/or darkness. This includes the design of intelligent autopilots for assistance to complete autonomous operations.

**Intelligence, Surveillance, and Reconnaissance (ISR)**. Naval ISR operations require more advanced pattern-recognition technologies, which can declutter camouflaged images from their backgrounds and track similar targets. Here, symbolic AI needs to be fused with numerical AI (i.e., a bicameral architecture) for maximal success.

**Education, Training, and Retention**. Student education, training, and retention can be integrated with large databases using various forms of AI/ML. In particular, student queries can be mapped to locally appropriate responses. Moreover, student responses can be diagnosed for student-specific remedial education and training. AI will make learning not only possible, but practical and enjoyable like never before. This is of major significance to K-12, university, and military students alike because the educated student will be the effective worker of tomorrow. Witness the dawn of the big electric-blue schoolhouse, which will replace the now obsolete, “little-red schoolhouse”.

**Other Questions and Applications**. The panel needs to explore how to optimize AI/ML in the most-effective way. Optimization implies search; and, search implies heuristics. What applications could benefit from the inclusion of search heuristics (e.g., gradient-descent search in hidden-layer neural networks)? There is also much to explore in the area of intelligent human interfaces. Can AI read brainwaves to help ensure that aircraft behave in accordance with expressed pilot intentions? Can gesture-recognition be expanded into a picture language? Can AI be used to optimize the design of control panels from an ergonomic perspective? Neural networks have been criticized because they do not explain their actions. Can Steve Minton’s explanation-based learning be applied as a subsystem to learn how to explain actions by example – allowing for the use of neural networks (deep learning) in naval applications requiring user trust (e.g., fire-control systems, or the monitoring and control of a nuclear pile aboard a nuclear aircraft carrier or a nuclear submarine)? In the area of causal inference, consider a ship at war, which takes a hit that prevents restarting its engines. Can an AI system reason out what needs to be fixed or replaced based on current performance characteristics of its engines? Maintenance is an on-going major cost for military and civilian applications alike. Can we design acoustic monitors for commercial and military aircraft engines alike, which translate sound waves into reliable engine maintenance guides – thereby mitigating the chance of Type I and Type II errors in engine maintenance schedules to minimize costs? Furthermore, can flight data (e.g., the aircraft was flown through an ash cloud for ten minutes) be integrated in a bicameral architecture to further enhance AI-based diagnostic maintenance? Cost savings of $600 million per year have been estimated to accrue for the Navy alone. Similar AI systems can be designed to shore up the safety of personnel in virtually all occupational specialties. Such designs will benefit from economies of scale (i.e., domain transference). How do you measure the value of a human life? Here is where natural intelligence (NI) exceeds AI. The formal and precise definition of this extension stems from computability theory.

The answers to all of these questions and more serve as the affirmations that set the stage for the development of AI enhancements to contemporary systems, which are becoming increasingly ubiquitous. This panel will explore where we need to apply AI, what type of AI we need to design, and how such AI designs might best be realized. The panelists will kick-off the discussion by presenting a brief introduction on their positions. This will be followed by a period of open discussion between the panelists and audience members.

**On Intelligent Design and Conscious Thought**. A network of parallel intelligent systems would be self-referential (i.e., not unlike the brain). Such systems provide unknown (unknowable, or equivalently, non-recursively enumerable) outputs. Non-recursively enumerable outputs are needed for the solution of solvable problems for which there is no known tractable solution (e.g., a near-optimal solution for a large TSP). Clearly, heuristics and domain-transference are involved. Non-recursively enumerable processes can extract heuristic knowledge from knowledge found in distinct domains by way of randomization. This is important because there is no known (knowable) algorithm for the solution of arbitrary solvable problems of unbounded Kolmogorov complexity. This is certainly a topic open for discussion. How can computability theory lend itself to the definition of consciousness and, in turn, why is consciousness seen as inherent to the solution of novel arbitrarily complex solvable problems, which arise from the definition of networked intelligent domain-specific systems? In keeping with the self-referential equations of Gödel’s Incompleteness Theorem, a theoretical proof cannot be had here – it must be empirical and inherently incomplete, or the Halting Problem or Hilbert’s tenth problem (i.e., a general method for determining whether a given Diophantine equation has a solution in integers does not exist) would be decidable. Networked intelligent systems are empirical and necessarily inherently incomplete. There is, of course, exactly one exception to this stipulation. That exception occurs where the target objective of the system pertains to the Incompleteness Theorem itself.