Opportunity Title: Multi-valued Logic for Neuromorphic Computing: from Machine Learning to Machine Understanding
Opportunity Reference Code: IC-16-17

Organization	Office of the Director of National Intelligence (ODNI)
Reference Code	IC-16-17
How to Apply	**Create and release your Profile on Zintellect** – Postdoctoral applicants must create an account and complete a profile in the on-line application system. **Please note: your resume/CV may not exceed 2 pages.** **Complete your application** – Enter the rest of the information required for the IC Postdoc Program Research Opportunity. The application itself contains detailed instructions for each one of these components: availability, citizenship, transcripts, dissertation abstract, publication and presentation plan, and information about your Research Advisor co-applicant.
Application Deadline	4/15/2016 6:00:00 PM Eastern Time Zone
Description	Neuromorphic computing is one of the strongest candidate to address the physical limitations in computational power known as Moore's Law. Neuromorphic computing is not an alternative to classical computing; it is rather the computational paradigm that replicates the human brain thinking in patterns. Intelligent techniques in machine learning/deep learning and neuromorphic computing have attractive properties – such as the ability to learn, or to make explanatory decisions – this makes them suited for broad classes of problems; however there is not one technique suited to solve every problem we encounter today in sophisticated pattern recognition tasks. Two prominent techniques aim to reconcile key challenges in pattern recognition, change detection, and more specific applications such as automated target recognition and malware detection. First, neural networks are very good at pattern recognition, yet they do not provide explanations on how they render a certain outcome. Second, fuzzy logic systems can reason with imprecise information, and explain their decisions, yet they cannot automatically obtain or compose the rules used to make decisions. This topic concerns the possible development of hybrid systems that combine the power of complementary techniques, and advance machine learning towards machine understanding, using memristor arrays - the building blocks of neuromorphic computing -- as foundational theoretical and implementation environments for this technological advancement. Fuzzy logic yields inference mechanisms under cognitive uncertainty, whereas computational neural systems provide learning, adaptation, fault-tolerance, and generalization and parallelization. Fuzzy neural networks with threshold gates are such examples of potentially powerful hybrid systems. There

are claims that the synergy between multivalued/fuzzy logic and threshold gate networks can have a 100% reliability in specific pattern recognition tasks. This research aims to investigate classes of pattern recognition problems for which this assertion is true.

Example Approaches

Research in this area could consider some of the following areas:

- Asses the suitability of fuzzy logic into threshold gate networks. This research addresses the quality of fuzzy computations performed inside a neuron, which will be on or off, yet subjected to a thresholding calculus that accounts for the intensity and distance of other neurons in the net.
- Analyze how well threshold gates simulate fuzzy reasoning. An algorithm could be written, for example, that would mirror controlling the error through back-propagation techniques in deep learning; The results could reassure us that tasks such as malware identification could be performed with 100% reliability. An algorithm could be implemented with threshold gate neural networks and could be compared with other existing algorithms that display high fidelity.
- Fuzzy logic may be either a natural or forced fit in hierarchical neural networks, possibly to achieve machine understanding. This research direction could assess the suitability of fuzzy logic as a candidate to describe the behavior of a memristor.

Some example approaches could be:

- Initial survey of the state-of-the-art in fuzzy neural networks,
- Devise or assess a fuzzy logic-based algorithm for training and pattern recognition.
- Identify weaknesses that challenge the fuzzy logic approach to threshold logic networks.
- Assess the balance between speed and accuracy.

Eligibility Requirements

- **Citizenship:** U.S. Citizen Only
- **Degree:** Doctoral Degree.
- **Discipline(s):**
  - **Business** (11 👁)
  - **Chemistry and Materials Sciences** (12 👁)
  - **Communications and Graphics Design** (6 👁)
  - **Computer, Information, and Data Sciences** (16 👁)
  - **Earth and Geosciences** (21 👁)
  - **Engineering** (27 👁)
  - **Environmental and Marine Sciences** (14 👁)
  - **Life Health and Medical Sciences** (45 👁)
  - **Mathematics and Statistics** (10 👁)

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- **Other Non-Science & Engineering** (13 👁)
- **Physics** (16 👁)
- **Science & Engineering-related** (1 👁)
- **Social and Behavioral Sciences** (28 👁)