Opportunity Title: Improving Quantum and Optical Sensors Using Machine Learning Techniques
Opportunity Reference Code: ICPD-2020-01

Organization Office of the Director of National Intelligence (ODNI)

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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.

Additional information about the IC Postdoctoral Research Fellowship Program is available on the program website located at: https://orise.orau.gov/icpostdoc/index.html.

If you have questions, send an email to ICPostdoc@orau.org. Please include the reference code for this opportunity in your email.

Application Deadline 2/28/2020 6:00:00 PM Eastern Time Zone

Description

Research Topic Description, including Problem Statement:

Quantum sensors (e.g. atomic magnetometers, NV centers in diamond, atom interferometers, atomic clocks, Rydberg atom electric field sensors) and novel optical sensors (e.g. optical frequency combs, fiber sensors) can show great sensitivity in the laboratory and in some cases have been demonstrated outside of a laboratory environment. However, barriers to more widespread use include the complexity of operating many of these sensors and the instability of the sensors in a relatively uncontrolled environment. For example, some quantum magnetometers require the ambient magnetic field and any field gradients to be carefully tuned, and some sensors with thermal sensitivities require some feed-forward process to correct for temperature fluctuations. The process of nulling ambient fields or measuring thermal response characteristics can be time-consuming and frustrating, because often the sensor systems have complex and nonlinear behaviors that cannot be modeled well. Fortunately, algorithms used in machine learning are often highly suitable for problems such as these. While machine learning is more typically used to analyze data that has already been acquired, this topic is about using these algorithms to improve the performance of the sensor itself. A working quantum or novel optical sensor should be used to quantitatively improve a sensor when using machine learning algorithms as part of the sensor system, where improvement is along performance parameters such as accuracy, speed, robustness to noise and environmental fluctuations, or along system parameters such as size or complexity.

Example Approaches:

To date only a few published examples of machine learning algorithms applied to quantum systems or traditional sensors exist. Some examples include using artificial neural networks along with co-sensor data to increase the accuracy of the thermal calibration of a sensor, using a sequential Monte Carlo algorithm to optimize the Ramsey pulses driving an NV center in diamond in the presence of environmental noise, using Bayesian optimization to find efficient procedures for generating a Bose-Einstein condensate (BEC), and using a conditional variable auto-encoder to decrease the measurement time of a current map of a quantum dot device. Because this is a relatively new approach to improving sensor performance, this topic is not at all limited to the sensors and algorithms described in this topic or in the literature. However, this topic does not include using machine learning algorithms to process data already acquired by a sensor, or to devise new algorithms without testing them on a real sensor, or modeling sensor performance without demonstrating the algorithms on a real sensor.

Relevance to the Intelligence Community:

The Intelligence Community (IC) is always looking for better techniques to perform technical collection. Small, high-performance sensors would allow operation in previously impossible scenarios and with new functionality. They are also more realistically multiplexed which further increases sensitivity and often adds new capabilities such as directionality. Applying machine learning to these sensors can make them much more accurate and robust, making them even more applicable to IC problems.

Key Words: Machine Learning, Artificial Neural Networks, Atomic Sensor, Quantum Sensor, Optical Sensor, Atomic Magnetometer, Atom Interferometer, Atomic Clock, NV Center, Rydberg Atom, Optical Frequency Comb, Optical Fiber Sensors, Noise Suppression, Sensor Calibration

Qualifications

Postdoc Eligibility

- U.S. citizens only
- Ph.D. in a relevant field must be completed before beginning the appointment and within five years of the application deadline
- Proposal must be associated with an accredited U.S. university, college, or U.S. government laboratory
- Eligible candidates may only receive one award from the IC Postdoctoral Research Fellowship Program

Research Advisor Eligibility

- Must be an employee of an accredited U.S. university, college or U.S. government laboratory
- Are not required to be U.S. citizens

Eligibility Requirements

- **Citizenship:** U.S. Citizen Only
- **Degree:** Doctoral Degree.
- **Discipline(s):**
  - **Chemistry and Materials Sciences** (12)
  - **Communications and Graphics Design** (2)
  - **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)
  - **Other Non-Science & Engineering** (2)
  - **Physics** (16)
  - **Science & Engineering-related** (1)
  - **Social and Behavioral Sciences** (27)