Opportunity Title: Weak Supervision in Machine Learning
Opportunity Reference Code: ICPD-2022-20

Organization Office of the Director of National Intelligence (ODNI)

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Application Deadline 2/28/2022 6:00:00 PM Eastern Time Zone

Description **Research Topic Description, including Problem Statement:**

Building systems that can understand visual concepts and describe them coherently in natural language is fundamental to artificial intelligence. Advances in machine learning have had a profound impact on computer vision and natural language processing. In particular, there has been great progress in research on object detection, descriptions of images, and video of ordinary scenes and street views captured by personal cameras. These advances have relied heavily on visual features extracted from systems trained on a large volume of strong labels (boundary boxes drawn around the designated objects). The process for acquiring such data can be expensive and time consuming. An easier and less time-consuming approach to annotating an image or sequence of images is to provide weak labels -- determining what objects, entities and characteristics are present or describing the inferred and perceived activities in natural language. Sometimes these weak labels (image level annotations) can be noisy and may provide only positive labeling. The proposed research could include one or both of the following tasks:

1. Develop a framework to capture weak labels from images and videos.
2. Using weak labels in conjunction with prior contextual knowledge about the scene to advance research in object and activity detection.

Example Approaches:

- In [1], a multiple instance learning-based (MIL) deep learning system is able to capture and localize to cancerous regions within a mega-pixel image. Here, the system is trained on images with weak binary labels determining if the image contains cancerous cells or not. An example approach is to extend this MIL approach to a multi-class problem, where each object type is a class. See also [2] and [3].
- In [4], a robust change captioning was proposed to describe in natural

language the activity occurs between two scenes with possibly different viewpoints, and to localize to regions that explain the inferred activity. Here, the system is trained on pair of images and a caption describing the change. See also [5]. An example approach is to develop a system to correlate visual features within and across scenes with a described activity with the help of additional self-learning tasks to improve feature representations.
- In [6], the authors developed an interactive weak supervision in which a method proposes heuristics and learns from user feedback given on each proposed heuristic.

Relevance to the Intelligence Community:

Using weak labels in object and activity detection would increase Intelligence Community efficiency. "If we were to attempt to manually exploit the commercial satellite imagery we expect to have over the next 20 years, we would need eight million imagery analysts." (Robert Cardillo, NGA Director, GEOINT Symposium 2017)

References:

1. Campanella, et al, “Clinical-grade computational pathology using weakly supervised deep learning on whole slide images”, Nature Medicine, 2019.
2. Ilse, Tomczak, and Welling, “Attention-based deep multiple instance Learning”, International Conference on Machine Learning, 2018.
3. Carion, et al, “End-to-end object detection with transformers”, arXiv:2005.12872, 2020.
4. Park, Darrell, Rohrbach; Proceedings of the IEEE/CVF International Conference on Computer Vision (ICCV), 2019.
5. Gilton, et al, “Detection and description of change in visual stream”, arXiv:2003.12633, 2020.
6. Boecking, et all, “Interactive Weak Supervision: Learning Useful Heuristics for Data Labeling”, arXiv:2012.06046.

Key Words: Image Description, Object Detection, Multiple Instance Learning, Weak Labels, Weak Supervision, Computer Vision, Natural Language Processing

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

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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 👁)