Special Notice 11-SN-0008

Special Program Announcement for 2011 Office of Naval Research

"Machine Reasoning and Intelligence"

I. INTRODUCTION:

This announcement describes a basic research thrust, entitled "Machine Reasoning and Intelligence" to be launched under the Office of Naval Research's (ONR) Long Range Broad Agency Announcement (BAA) for Navy and Marine Corps Science and Technology, ONRBAA11-001 which can be found at http://www.onr.navy.mil/Contracts-Grants/Funding-Opportunities/Broad-Agency-Announcements.aspx. The research opportunity described in this announcement specifically falls under numbered paragraph 1 of the Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (Code 31); Mathematics, Computers and Information Research (Code 311) sub-section. The submission of proposals, their evaluation and the placement of basic research grants will be carried out as described in that Broad Agency Announcement.

The purpose of this announcement is to focus attention of the scientific community on (1) the area to be studied, and (2) the planned timetable for the submission of white papers and proposals.

II. TOPIC DESCRIPTION: Machine Reasoning and Intelligence

The proposed topic will develop fundamental understanding and methods that lead to autonomous systems that can successfully execute a variety of missions in complex environments through machine reasoning while exploiting all sources of sensor and open domain data. The program will pursue a wide variety of approaches that enable automated systems to provide multiple hypotheses that are 1) consistent with a mission; 2) support the use of data that is uncertain, incomplete, imprecise, and contradictory (UIIC); 3) provide a capability to suggest experiments or courses of action that disambiguate between hypotheses; 4) identify data with

appropriate data quality; and 5) represent data that is uncertain, incomplete, imprecise and contradictory, and support computation as well as hypothesis formulation.

Background

Naval forces execute a wide variety of missions and operate in unpredictable environments. In order to reduce risk to human beings while simultaneously making use of limited numbers of highly trained individuals, there is a trend towards increased reliance on autonomous sensors, platforms, and systems. The development of autonomous elements faces a number of significant technical challenges including processing, interpreting and developing decisions using diverse data sources, multiple modalities, unstructured data, and large volumes of data with varying latencies while compressing the time-line for arriving at a decision.

The processing and interpretation of data require understanding of the context of the mission. The context of a mission enables a set of hypotheses, expressed as models, providing a viewpoint that enables a system to determine data that are relevant and important to producing a picture of the battle space. Missions also provide a context in which the inherent uncertainty and imprecision of the data can be identified and understood with respect to subsequent processing steps involving data and inferences over the data. The presence of multiple data sources introduces additional technical issues associated with aligning the data prior to fusion; schemes for fusion; and assessing, understanding, and controlling these effects arising from incompleteness, imprecision, and contradiction in the data upon inferences and decisions.

Autonomous systems, while executing a mission, should also have a capability to adapt to the world as they gain knowledge and experience. This adaption should be flexible and enable a system to fine tune its models if its hypotheses regarding the world are consistent with the data, or to create new hypotheses and instantiate new models that are more consistent with observations. Currently, typical fielded systems are rule-based and operate well in the specific, controlled environment for which they are designed. Examples of this class of automated platforms include embedded controllers such as the cruise control on an automobile. This simple system consists of actuators, sensors, and "computers". When systems of this type encounter variations in the world that fall outside their model of the world, they fail. Systems can be made adaptive through the use of additional sensors and augmentation of the model. Continuing with the automobile cruise-control analogy, the addition of a mm-wave radar enables adaptive cruise control which expands the operational environment of the control system through expansion of the world model and additional information. For most systems the ability to adapt is limited by the model. Again continuing with the analogy, if we require that the automobile be able to execute a parallel parking maneuver, on line real time adaption of the system is not feasible and a new behavioral model that exploits the same physical components must be developed.

The situation for Naval Forces is far more complex than the simple cruise control system analogy. The variety of missions is ever changing and expanding. Naval Forces have significant capabilities that sense the environment and access to vast amounts of unstructured data. Significant investments have been and will continue to be made in "component" technologies such as optimization, signal processing, image processing, knowledge management, cognitive architectures, data fusion, and sensor fusion among others. What are lacking are systems that

can sense, interpret, reason and successfully act in an open world with uncertain, incomplete, imprecise, and contradictory data. These systems should be capable of understanding the information and quality of information that they need to produce and maintain a model of the world given its hypotheses. The systems should be capable of autonomously validating their hypotheses and derived models, as well as autonomously developing new hypotheses and models as warranted.

This research topic aims to develop fundamental knowledge and understanding that enables decision making by autonomous processes in complex, time varying adaptive environments that are probed with heterogeneous sensors and supported by open source data. The research results should lead to computational theory, algorithms, techniques, strategies and practical implementations that enable system adaptation in an open, complex, and uncertain environment over an arbitrary set of missions.

The Machine Reasoning and Intelligence Basic Research Thrust intends to create specific capabilities and develop a fundamental understanding of how to 1) represent data; 2) understand the data in the context of an objective or complete mission; 3) develop a capability to act and react to a dynamically changing picture while making good decisions; and 4) develop systems that include humans in the loop whose performance can be analyzed and understood to provide feedback to the sensors.

Objective

The Office of Naval Research (ONR) is interested in receiving proposals on

a) Developing robust representations of entities, events, actions, soft data (Humint), etc. in an actionable machine form that support analytics, parameter identification, metadata, and metrics. These representations should include a characterization of uncertainty, incompleteness, and imprecision in the data that enables and supports an understanding of these effects on downstream processing or control of these quantities. The representations should also be capable of being instantiated with data from single or multiple sensors as well as unstructured data sources.

b) Developing automated methods for mission relevant identification, discovery, and representation of relationships, intentions, and objectives from raw sensor data, unstructured open source data, or derived quantities such as objects or tracks in a manner that enables computation, inference, and reasoning. These automated methods for a fixed mission should support analysis of existing relationships, intentions, and objectives and synthesis of new relationships, intentions, and objectives in the context of a mission, as well as changes in relationships, intentions, and objectives.

c) Creating efficient computational strategies and techniques that reason about the state of the world and operate on hypotheses, constructs, patterns of activity, etc. in order to achieve mission success. These strategies and techniques should be capable of utilizing existing knowledge to independently form hypotheses regarding the world in the context of a mission. These strategies and techniques must also be capable of

autonomous reasoning that leads to validation of an existing model, adapting an existing model, or synthesizing a new model that is consistent with the data in the context of the mission. These automated reasoning methods should be capable of adapting the underlying models (concept drift) in the presence of new data or generating new hypotheses and models (concept generation) after recognizing that the current underlying model is no longer supported by the available data. For both concept drift and concept generation ONR is interested in metrics and automated reasoning methods that provide a fundamental understanding of when it is appropriate for a system to engage in concept drift and when it is appropriate to engage in concept generation. Further, ONR is interested in understanding strategies, techniques, and algorithms that identify appropriate historical data to support adaptation via concept drift. For concept generation the proposed methods should also be capable of autonomously deducing new hypotheses that describe a collection of entities connected by sets of relationships consistent with incomplete, imprecise, uncertain, and contradictory structured and unstructured data.

d) Development of computational architectures that support the research efforts described above and that are able to identify situations, in the context of any given mission, where the available information is sufficient and of appropriate quality; sufficient but not of appropriate quality; or insufficient to support reasoning with regard to potential targets, uncertainty about objects and activities, behaviors, intent, and consequences of action. These architectures should also be capable of supporting a human in the loop or autonomously reasoning about the data in the context of the mission and developing implementable strategies in order to maintain the quality of the battle space picture.

ONR, for the purposes of this special notice, is not interested in supporting additional research in the development of new sensors, methods for low level processing including those that seek to improve the identification of objects or tracks, automated vision processing, generic optimization methods, linear and non-linear control, or the generation of knowledge bases and ontologies. The focus of this Special Notice is on techniques that will enable an autonomous system to reason about the world and successfully abet the execution of a mission.

III. WHITE PAPER SUBMISSION

White papers should not exceed five (5) single-sided pages, exclusive of cover page and resume of principal investigator, and should be in 12-point Times New Roman font with margins not less than one (1) inch. The cover page should be labeled “White Paper for Machine Reasoning and Intelligence” and include the following information: title of the proposed effort, proposer’s technical point of contact, telephone number, fax numbers, and e-mail address. The five (5) page body of the white paper should include the following information: (1) Principal Investigator; (2) Relevance of the proposed effort to the research areas described in Section II; entitled, “Topic Description: Machine Reasoning and Intelligence” (3) Technical objective of the proposed effort; (4) Technical approach that will be pursued to meet the objective; (5) A summary of recent relevant technical breakthroughs; and (6) A funding plan showing requested funding per fiscal year. The resume of the principal investigator, shall not exceed one (1) page, and shall be included as an addendum to the five (5)-page white paper.

Although not required, white papers are strongly encouraged from all offerors seeking funding. Each white paper will be evaluated by the Government to determine whether the technology advancement proposed appears to be of particular value to the Department of the Navy. Initial Government evaluations and feedback will be issued via e-mail notification from the Technical Point of Contact. The white paper evaluation is intended to give entities a sense of whether their concepts are likely to be funded.

For white papers that propose efforts that are considered of particular value to the Navy but either exceed available budgets or contain certain tasks or applications that are not desired by the Navy, ONR may suggest a full proposal with reduced effort to fit within expected available budgets or an effort that refocuses the tasks or application of the technology to maximize the benefit to the Navy.

White papers shall be submitted electronically to the program technical point of contact, Dr. Behzad Kamgar-Parsi, at Behzad.Kamgarparsi@navy.mil. White papers shall be in Microsoft Word or Adobe PDF format.

To ensure full, timely consideration for funding, white papers should be submitted **no later than 01 April 2011.** White papers received after that date will be considered as time and availability of funding permit.

The planned date for completing the review of white papers is **15 April 2011.**

IV. FULL PROPOSAL SUBMISSION AND AWARD INFORMATION

Full proposals (including one technical volume and one cost volume) should be submitted under ONRBAA11-001 by **15 May 2011**. Full Proposals received after that date will be considered as time and availability of funding permit.

Full Proposals will be subsequently encouraged from those Offerors whose proposed technologies have been identified through the above referenced e-mail as being of "particular value" to the Government. However, any such encouragement does not assure a subsequent award. Full Proposals may also be submitted by any offeror whose white paper was not identified as being of particular value to the Government or any offeror who did not submit a white paper.

ONR anticipates only **grants** will be issued for this effort. All full proposals must be submitted through www.grants.gov. The following information must be completed as follows in the SF 424 to ensure that the application is directed to the correct individual for review: Block 4a, Federal Identifier: enter N00014; Block 4b, Agency Routing Number: Enter the Program Office Code (i.e., 311) and the Program Officer's name, last name first, in brackets (i.e., [Kamgar-Parsi, Behzad]). Applicants who fail to provide a Department code identifier may receive a notice that their proposal will be rejected. All attachments to the application should also include this identifier to ensure the proposal and its attachments are received by the appropriate Program Office.

ONR plans to fund multiple awards with a value of $100,000 to $500,000 per year, using Basic Research funds. However, lower and higher cost proposals will be considered. The period of performance for projects may be from one (1) to three (3) years.

Although ONR expects the above-described program plan to be executed, ONR reserve the right to make changes.

Funding decisions should be made by **15 June 2011**. Projects will have an estimated grant award date of **01 November 2011.**

V. POINTS OF CONTACT

In addition to the points of contact listed in ONRBAA11-001, the specific points of contact for this announcement are listed below:

Technical Points of Contact:
Dr. Behzad Kamgar-Parsi, Program Officer, Behzad.Kamgarparsi@navy.mil

Business Point of Contact:
Lynn Christian, Contract Specialist, Lynn.Christian@navy.mil