Special Notice 11-SN-0012

Special Program Announcement for 2011 Office of Naval Research

"Computational Methods for Decision Making – Resource Optimization, Image Understanding, Information Integration, and Cyber Security"

I. INTRODUCTION:

This announcement describes an applied research program, entitled Computational Methods for Decision Making to be launched under the ONRBAA11-001, Long Range Broad Agency Announcement for Navy and Marine Corps Science and Technology 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; Mathematics, Computers and Information Research (Code 31) sub-section. The submission of proposals, their evaluation and the placement of applied research contracts and 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:

The proposed topic will lead to: 1) Identification and understanding of key issues; 2) Development and maturation of algorithms and methods; 3) Determination and demonstration of performance of algorithms, methods, techniques, and strategies for automated computational methods and information systems that support decision making. The algorithms, methods, techniques, and strategies must support autonomous information processing systems that can successfully and securely execute a variety of missions in complex environments while exploiting multiple sources of sensor and open domain data. The program will pursue a wide variety of approaches that enable automated systems to, within the context of a mission, automatically analyze multiple sources of data supporting interpretation of the data; combine data and interpretations from multiple data sources to provide understanding of the battle space; provide management of sensor and other resources to maintain and improve the battle space picture; and enable and build high performance software systems that are defect free and trustworthy to implement these algorithms, methods, techniques, and strategies.

Background:

The development of automated decision systems provides 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. Additional challenges occur when we consider that the computing hardware and software environment must protect the data and function

correctly, while simultaneously providing security and trustworthiness. These issues will likely be exacerbated in practical implementations that are distributed and employ networks. The quality of the decisions developed by the system is dependent upon the quality of the underlying data and its relation to the mission. The quality of the decisions is also impacted by the security of both the data and the computing hardware.

The processing and interpretation of data requires understanding of the context of the mission. The context of a mission enables a set of hypotheses, expressed as models, to provide a viewpoint that enables a system to determine data relevant and important to producing a picture of the battle space (situational awareness). 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 the effects arising from incompleteness, imprecision, and contradiction in the data upon inferences and decisions.

A key issue for Naval Forces in developing situational awareness is to understand what is known, how well it is known, and what is unknown, and to provide strategies to determine new data that should be collected to maintain or improve situational awareness. In turn, this requires capabilities to perform optimization of scarce resources in order to support a mission. If the process is to be automated and timely relative to a mission, then algorithms must be implemented that can sense, interpret, reason and successfully act in an open world with uncertain, incomplete, imprecise, and contradictory data. These information processing systems should also be capable of autonomously validating their hypotheses and derived models, as well as autonomously developing new hypotheses and models as warranted. Achieving operational capabilities such as Persistent Pervasive Tactical Surveillance could be straightforward if information processing systems were capable of understanding the information and quality of information that they need to produce and maintain a model of the world, given its hypotheses and mission goals.

This applied research topic aims to develop knowledge and understanding of key technologies that will enable rapid, accurate decision making by autonomous processes in complex, time varying adaptive environments that are probed with heterogeneous sensors and supported by open source data. The applied research results should lead to understanding, computational theory, algorithms, techniques, strategies, and practical implementations providing security and trustworthiness that enable information processing systems and decision aids to adapt in an open, complex, and uncertain environment over an arbitrary set of missions.

Objectives:

The Office of Naval Research Computational Methods for Decision Making Applied Research Program is partitioned into four thrusts: Resource Optimization, Automated Image Understanding, Information Integration, and Cyber Security thrusts. Together these thrusts seek to develop new technological capabilities that support Naval Operations across a wide variety of missions. Each of these thrust areas is described below.

The objectives of the Resource Optimization thrust are the development and application of mathematically rigorous techniques (e.g., mathematical optimization) that provide optimal or provably near-optimal solutions to resource-allocation problems. These techniques will serve as the basis of automated decision aids in support of naval planning and execution. Within the Resource Optimization thrust are currently two themes: Maritime Mission Planning; and Sensor Management and Allocation. Maritime Mission Planning seeks capabilities that improve power projection and achieve far better utilization of expensive Navy maritime assets. Sensor Management and Allocation seeks to achieve an ability to optimally task and re-task large sensors networks based on current picture and sensor availability to understand the battle space and maintain dynamic persistent surveillance. For each theme, the goals are mathematical-optimization model and algorithm development that serve as the basis for decision aids.

The objective of the Automated Image Understanding thrust is to develop efficient computational methods based on principled approaches that advance the understanding of issues governing performance that are needed to support system engineering. Image understanding is a broad field that requires advances along many directions. Under this thrust, we plan to address the following issues: (a) developing principled methods for fusion of multiple imaging modalities based on the physics of image formation, leading to image enhancement and improved recognition capabilities; (b) methods for integrating images from multiple platforms for improved object recognition, scene modeling, and meaningful change detection; (c) developing methods for indexing images based on semantic content for storage and retrieval; (d) detection and tracking of objects on water or in urban areas and inferring the threat level they may pose (including real-time detection of partially occluded objects in urban clutter); and (e) developing robust recognition methods that integrate low-level image processing with high-level knowledge. This effort will also require investigating best representations, or hybrids of representations, for description and recognition of objects and activities. Furthermore, we want to extend recent advances in reasoning with image/video that make recognition of objects and activities more robust. Domain knowledge plays a critically important role in reasoning; hence an additional area of applied research would be methods for building visual knowledge bases, and generative and/or discriminative models. This also involves investigation of suitable representations for high-level semantic knowledge, which may come in various forms including contextual information, background models, shape and appearance and behavior information, relationship to other objects and other forms.

The objective of the Information Integration thrust is to develop efficient, theoretically sound, and consistent algorithms for organization and fusion of high-dimensional data sources and investigate their application and potential to naval applications. The Information Integration thrust is developing, maturing and assessing algorithms that organize high-dimensional datasets of interest to Naval Operations. Of particular interest are image, video, structured database, social or complex networks, hyper-spectral, multispectral, acoustic, sensor array, text, and other structured and unstructured datasets. Methods that lead to structuring datasets in an organized and meaningful way should facilitate more efficient and accurate processing tasks including data matching or alignment, data merging, data search, outlier detection, learning and classification, query response, reasoning and decision making. A further objective of the Information Integration thrust is interest in automated algorithms that fuse high-dimensional datasets that are comprised of uncertain,

incomplete, imprecise, and contradictory data for the purpose of recognizing and classifying features, objects, entities, activities, patterns of interest, and relationships. A further objective of the Information Integration thrust is to assess and understand the quality of the resulting fused battle space picture and its impact on decision making.

The objective of the Cyber Security thrust is to develop a software development environment that enhances the robustness and security properties of the resulting codes, while minimizing penalties to code performance and overhead. Currently flaws in software are a major contributor to the vulnerability of cyber systems. Most if not all of these vulnerabilities originate from improper software implementations. Identified flaws that lead to improper implementations include, but are not limited to, buffer overflow, stack and heap overflow, dangling pointers, input data format violation, and race conditions. Methods for software implementation still lead to these deficiencies. Significant investment has been made to address this issue through techniques that seek to provide formal or other forms of software verification. However, complementary efforts to verification, which lead to understanding of techniques that enhance the development and generation of robust secure code, are under-explored. Alternatively, automated methods that capture and utilize work flow, thought/design-decision, and documentation during software coding that also are aware of software implementation issues could address this need. Only rarely are all of the details for the implementation of software specified in advance. Currently programmers make instantaneous detailed design decisions during software coding. These instantaneous decisions (and assumptions) have far reaching effects, and they are often forgotten and lost. A tool that captures and documents these design decisions (and hence assumptions) automatically as coding is in progress can significantly enhance maintainability, robustness, and security of codes. The availability these tools also provides an opportunity to provide feedback to programmers to improve the correctness of their product and enhance productivity and efficiency.

Research Areas:

ONR is interested in receiving responses that address specific interests in each theme. These interests are described below.

1) Resource Optimization:

To a large extent, current mathematical-optimization techniques used for Navy planning-and-execution problems operate in a centralized manner, meaning that the necessary information is imported to a centralized computing node at which a solution (or a sequence of solutions, in a dynamic environment) is determined. This approach is appropriate in many scenarios, and it has the advantage of producing high-quality solutions. In others scenarios, however, a de-centralized approach may be more appropriate. Consider, for example, the task of mission planning and execution for UAVs or UUVs, where communication bandwidth may be severely constrained and communication latencies may be detrimental. In such a case, it may be desirable to have a decision aide that is capable operating in a distributed or de-centralized manner. Specific research areas of interest include:

a) Model and algorithmic development for de-centralized optimization for Navy planning and execution problems;
b) Hybrid techniques – methods that can operate either in centralized or de-centralized mode depending on the available communications connectivity and mission requirements;
c) Rigorous empirical and/or theoretical analysis of the "price of anarchy"; that is, a measure of how solution quality degrades in a de-centralized system versus a centralized system.

2) Automated Image Understanding

The development of principled methods and algorithms as well as understanding their performance limits are the focus of this thrust. These algorithms and methods should function in complex scenes with a variety of objects, activities, and events. Examples of environments that exhibit appropriate scene complexity are urban, port/harbor, and riverine areas. Technical approaches should be general in nature, robust with respect to appearance variations, and computationally efficient. Specific areas of interest to ONR are:

a) Investigation and development of representations for objects and actions that are optimized for recognition, inference, and scene understanding. These representations must be insensitive to scale, pose, and appearance, and in the case of actions, insensitive to durations. Features and attributes that comprise these representations should be readily detectable, persistent, and efficient, and should support techniques for fast matching.
b) Integration of low-level processing and high-level knowledge for simultaneous segmentation, grouping, and recognition. This includes recognition of specific objects and object categories, and recognition of human and vehicle movements and actions. This theme focuses on efficient techniques for building visual knowledge bases that are portable and extensible, identification of object attributes and activities that should be included in knowledge bases, representations of high level knowledge, understanding stages in which low-level and high-level information algorithms interact, methods for visual reasoning with images using contextual information and developing background models.
c) Methods for adaptive and collaborative tracking and recognition of object and activities using a network of imaging sensors (including EO/IR video and other modalities). The network will include sensors that are stationary and mobile. We are seeking methods and techniques where the network can autonomously determine if additional information is needed for accurate recognition. In conjunction with the Resource Optimization thrust the network should also determine strategies for acquiring the needed information. In cases where multiple objects of interest are present in the scene, the network should optimally allocate the imaging assets to track and recognize the most interesting objects/activities.
d) Development of interactive surveillance methods by networks of imaging sensors, with potentially non-overlapping coverage, that can track and recognize objects; reason about and resolve ambiguities due to occlusions, loss of tracks, and gaps in the visual information; and be queried easily by the user.
e) Investigation of Compressive Sensing (CS) approach in image understanding. In particular (1) investigate and further develop approaches to recognition inspired by the CS approach, and

(2) investigate the degradation in recognition performance and false alarm rates associated with images acquired by CS cameras.

3) Information Integration:

The information integration effort is focused upon the development, maturation, evaluation, and understanding of algorithms that address the value of missing and conflicting information with respect to informing models of the world that support decision making in autonomous, manned, and hybrid decision making processes. For the purposes of this Special Notice, proposers may assume that all data sources have been aligned; however, methods that can relax the assumption of aligned data or automatically align data sets are preferred. Of particular interest to ONR are methods that enable the use of unstructured data in conjunction with sensor data. Specifically ONR seeks to improve the automated performance of systems that

a) Develop, assess, and understand algorithms that enable an automated system to infer the values of missing data. ONR is interested in automated methods that for a single modality, or multiple modalities, enable missing data to be inferred.

b) Develop, assess, and understand algorithms and methods that define the value of acquiring new data. These methods should also determine appropriate data that should be collected to support the formation of an operational battle space picture that can be used to support decision-making or mission focused autonomy. In creating a strategy for data collection, it is desirable that the algorithms and methods provide implementable strategies that can resolve contradiction arising from integrating information derived from uncertain, incomplete, and imprecise data.

c) Similar to b) above, ONR is interested in sensor systems in which the use of an outer metric associated with a system function (e.g., detection, tracking, object recognition) is used to adapt the parameters of the data processing and information integration algorithms. This capability will require the system to adapt itself based upon an estimate of the achievable performance of the system. In turn, this will require additional capabilities that determine when the underlying data support the existing model or when the underlying data is incompatible with the model and a new model is hypothesized, instantiated, validated, and verified.

4) Cyber Security

Develop and demonstrate tools and an environment that lead to the generation of robust and secure codes. The development environment and tools should support codes at both the system (or operating system) level, as well as at the software application level.

a) Security- and vulnerability-aware compilers with automatic insertion of constructs that guarantee robustness and security of codes written in unsecured languages.

b) Automated generation of secure and robust codes from high-level description (design-entry) of function that leads to software that is both readable and efficient.

c) Methods that automatically capture and utilize work flow, thought/design-decision, and documentation during software coding that lead to functioning code that meets performance and security requirements.

III. WHITE PAPER SUBMISSION

White papers should not exceed 4 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 inch. The cover page should be labeled "White Paper for 2011 Computational Methods for Decision Making" and include the following information: title of the proposed effort, technical point of contact, telephone number, fax numbers, and e-mail address. The 4-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; (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. A resume of the principal investigator, not to exceed 1 page, should also be included after the 4-page body of the white paper.

White papers are required for 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. Only the authors of white papers that appear to be of particular value to the Department of the Navy will be invited to submit full proposals. Initial Government evaluations and feedback will be issued via e-mail notification from the Technical Point of Contact.

Detailed Full Proposal (Technical and Cost volumes) 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 not be submitted by any offeror whose white paper was not identified as being of particular value to the Navy or any offeror who did not submit a timely white paper.

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 should be submitted electronically to the program technical points of contact, Dr. Behzad Kamgar-Parsi. His e-mail address appears at the end of this Special Notice. These 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 2:00pm EDT, 28 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 27 May 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 4:00 PM (Daylight Standard Time) on 28 June 2011. Full Proposals received after that date will be considered as time and availability of funding permit.

ONR anticipates that both grants and contracts will be issued for this effort. Proposals for contracts should be submitted in accordance with the instructions at Section IV, application and Submission Information, item 2.b., Full Proposals. Full proposals for grants should be submitted in accordance with the instructions at Section IV., Application and Submission Information, item 5., Submission of Grant Proposals thorough Grants.gov. All full proposals for grants must be submitted through http://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 (311) and the Program Officer's name, last name first, in brackets ([Kamgar-Parsi, Behzad]). All full proposals for grants must be submitted through www.grants.gov. All attachments to the application should also include this information to ensure the proposal and its attachments are received by the appropriate Program Office.

ONR plans to fund five (5) to ten (10) individual awards with a value of $250K per year. However, lower and higher cost proposals will be considered.

The Research and Development (R&D) efforts to be funded consist of Applied Research. The funds available to support awards are budget Activity 2. 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 **01 August 2011**. Projects will have an estimated contract or grant award date of **31 October 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, ONR BD 311, E-mail Address: behzad.kamgarparsi@navy.mil

Business Point of Contact:

Mr. Casey W. Ross, Contract Specialist, ONR BD 0251, E-mail Address: casey.w.ross@navy.mil