# 2004 National Geospatial-Intelligence Agency

# Sensors and Image Science Broad Agency Announcement

# HM1582-04-0004

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## 1. INTRODUCTION

This Broad Agency Announcement (BAA) by the National Geospatial-Intelligence Agency (NGA) announces a fiscal year 2004 competition for research in Automated Data Extraction (ADE). It consists of three parts, a Radar ADE Initiative, the Neuroscience Enabled Geospatial Intelligence Initiative (NEGI), and Non-literal Spectral Processing, Exploitation, and Analysis (PEA). The Basic and Applied Research Office of the NGA InnoVision Directorate has a continued need for new approaches to the ADE Problem.

## 2. GENERAL INFORMATION

Through this competition, NGA expects to make awards in several specific research topics. These awards are subject to the availability of funds. All awards will be based on merit competition. Depending on the quantity and quality of proposals received, NGA may elect not make any award(s) under individual research topics. The total initial amount of available funding for FY04 is about $2,570,000. Additional funding may become available at the end of the fiscal year.

Awards are for a basic period of either one or two year base (funded incrementally), with either three or four one-year options with the total period of performance not to exceed five years.

## 3. AREAS OF INTEREST

In paragraph 8, this BAA describes three research topic areas, comprising NGA's most important enabling technologies. These descriptions provide offerors with a frame of reference for NGA research interests. NGA encourages innovative ideas that address these interests. Offerors are urged to consider the research issues carefully.

## 4. CONDITIONS

This competition is specifically for the research topics described in paragraph 8. . It explains NGA's research needs upon which the topics are based and the terms and conditions of this competition.

NGA encourages and accepts proposals from a colloboration of universities and industry, because research in multidisciplinary topics may require forming teams with strengths in multiple science and engineering fields. Offerors who propose a teaming arrangement must name one Principal Investigator as the responsible technical point-of-contact. If two or more institutions collaborate on a proposal, award will be made to a prime contractor for the purposes of contract administration. The proposal must describe the relationship among the institutions and their respective roles.

Any contract issued under the authority of the BAA will include DFARS clause 252.227-7013 entitled Rights in technical data-Noncommercial items and Clause 252.227-7014 Rights in noncommercial computer software and noncommercial computer software documentation. The Government expects rights to technical data, to include software and software documentation, in accordance with the terms and conditions of 252.227-7013 and 252.227-7014.

# 5. REQUIREMENTS FOR PROPOSALS

## 5.1. General

NGA intends to award all available FY04 funds. To be considered and evaluated, the full proposal must be received by the Government by the time and date as identified in paragraph 9.

The Government will evaluate all proposals submitted under the terms and conditions of this BAA. Proposals will be evaluated against criteria in paragraph 6. The estimated contract start date identified in paragraph 9 should be used for budget and proposal purposes. You may, however, request a later start date and could therefore develop your budget in accordance with your proposed start date.

Registration in the DoD's Central Contractor Registry (CCR) database is a prerequisite for receiving an award resulting from this BAA. Proposals shall reflect compliance or initiation of compliance with this regulation. Call (888) 227-2423 or access via Internet at http://ccr2000.com/ for more information. Offeror's DUNS number (and CAGE code if one has been assigned) must accompany proposal in order to verify CCR registration. Proposals shall identify the Offeror's taxpayer identification number.

Representations and certifications are not required for inclusion in the proposal but will be provided for completion upon determination that an offerors proposal has been selected for award. All applicable certifications and representations shall be compliant and signed by an individual with the authority to bind the offering entity prior to award.

Requests for hard copies of the announcement will not be honored. Interested parties may stay apprised of this solicitation including revision information and answers to submitted questions by checking the web-site at nga.gov .

## 5.2. Submission

Proposals shall be formatted ONLY as .pdf files and must be less than 2MB in file size. The proposal shall reference BAA Number **HM1582-04-0004**. Proposals shall be submitted by E-Mail to sia04@westfields.net.

NGA will send an acknowledgment of receipt of the proposal to the originator of the e-mail that forwarded the proposal. Acknowledgment and notification will be sent via e-mail according to the schedule in paragraph 9, with a copy to the appropriate proposing office.

## 5.3. Content

Proposals must be complete and self-contained to qualify for review. Proposals shall be prepared single-spaced in 12 point Times New Roman font, with at least one inch margins on top, bottom and sides, for printing on 8½" by 11" paper.

Separate attachments, such as institutional brochures or reprints that are not germane to the proposal, are not allowed, and will not be reviewed.

### *5.3.1. Cover Page*

The cover page shall include the BAA number, proposal title, NGA topic or research area of interest and relevant section in paragraph 8. A single proposal may span several topic areas; please ensure the topics are clearly identified. The cover page must also indicate the name, phone number, fax number, postal address, and e-mail address of both the Principal Investigator AND an appropriate contract administrator.

### *5.3.2. Executive Summary*

Provide a proposal summary no longer than one page. This shall summarize the significant and important characteristics, approaches and proposed research to further the objectives in the relevant area of paragraph 8.

### *5.3.3. Project Description*

The project description portion of the proposal shall be limited to ten (10) pages and should:

A. Describe in detail the research to be undertaken. State the objectives and approach and the relationship to state-of-knowledge in the field and to similar work in progress. Include appropriate literature citations and prior work. Discuss the nature of expected results.

B. Describe the facilities available for accomplishing the research objectives. Describe any equipment proposed for acquisition under this program and its application to the research objectives.

C. Identify other parties to whom the proposal has been/will be sent.

D. Describe deliverables including monthly reports, final report, and proposed demonstrations. Offerors may propose additional deliverables.

#### *5.3.4. Personnel*

Describe the qualifications of the Principal Investigator and the qualifications of other key researchers involved in the project. Include curriculum vitae. For teaming or collaborations, one individual must be the designated Principal Investigator for purposes of technical responsibility and contact. The page limit shall be two (2) pages per person.

### 5.4. Cost

The financial portion of the proposal shall contain cost estimates in sufficient detail for meaningful evaluation. Include name, address and telephone number of the offeror's cognizant Defense Contract Audit Agency audit office. Not withstanding the overall size requirement of 2 MB limitation, there is no page limitation on the cost proposal. Cost elements shall include, but are not limited to:

A. Estimated number of hours by labor category and the unburdened hourly rate.

B. Travel costs and time, and the relevance to stated objectives. This shall include a breakdown of the number of travelers, location, and duration; and estimated costs for transportation, rental car and per-diem. Travel shall be accomplished in accordance with the Joint Travel Regulations. No fee will be allocated to travel costs and the G&A associated with travel.

C. Other direct costs: Includes: materials, supplies, publication, documentation and dissemination, consultant services, computer services, communication costs not included in overhead.

D. Indirect costs.

E. Profit/fee.

## 6. EVALUATION CRITERIA AND SELECTION PROCESS

### 6.1. Evaluation Criteria

The primary evaluation criteria, of most important weight and equal to each other, are:

A. Scientific and technical merits of the proposed research; and

B. Relevance and potential contributions of the research to the section 8 objectives.

Other evaluation criteria, of lesser importance than A and B but equal to each other, are:

C. The qualifications of the principal investigator and other key research personnel; and

D. The adequacy of current or planned facilities and equipment to accomplish the research objectives.

Evaluation criteria, of lesser importance than C or D is:

E. The realism and reasonableness of cost, including proposed cost sharing.

Past performance of offerors will also be evaluated using cited references and other data available to determine an overall degree of performance risk for the proposal.

### 6.2. Selection Process

Proposals will be grouped together by specific research topic area. An expert technical team evaluates all proposals in the same group. The evaluation process consists of the following steps:

A. Proposals will be evaluated and scored against the criteria above and ranked in terms of preference for contract award by a government evaluation team. Proposals not selected for award will be noted as Non-Selectable.

B. The Evaluation Team will consider the overall contribution of each proposal as reflected by the evaluation scores, the potential contribution to the advancement of the targeted technical topic(s), the amount of similar or related research currently underway on a given topic, and the amount of available funding. This step reconciles recommendations about proposals spanning more than one technical area, and allows for strategic consideration of the diversity of proposals across the topic areas. It is NGA's intent to distribute awards across the three topic areas if enough proposals are found selectable. Scores will not be matched across topic areas but only within them for selection purposes. Scores are an important factor, but not the sole factor for an award determination. The Government may make an award to a lower scored offeror if that particular research offered covers a topic area not already addressed.

C. The Evaluation Team will forward a list of proposals recommended for award ranked in order of preference, along with a description and results of the evaluation process, to the Director of Basic and Applied Research Office (IB) for research topic areas 1 and 2 and to Director of Full Spectrum Office (IJ) for research topic area 3 for approval.

D. Once approved, this final selection list will be forwarded to the Contracting Officer for negotiation and award.

In summary, the Evaluation Team will recommend the proposals that most effectively advance the objectives of paragraph 8. The number of awards made is dependent upon the amount of available funding. If additional funding becomes available by December 31, 2004 from within NGA, or from other U.S. Government agencies, NGA may choose to make additional awards under the terms of this BAA from the remaining selectable proposals. The sponsoring organization will be free to support any 'selectable' proposal(s) that addresses the research interests of that organization.

Employees of MITRE Corporation, a Federally Funded Research and Development Center (FFRDC) will be serving as expert advisors on proposals.

# 7. AWARDS

Awards will be made at funding levels commensurate with the research and in response to Agency missions. NGA reserves the right to select only a portion of the proposal for award. If research shows potential, there is potential for expanded research. Further, awards will generally be made for one to two base year(s) at NGA's discretion with options for three or four additional years (1 year per each option period). Total period of performance will not exceed five years for any contract award. Negotiations may result in funding levels or periods of performance more or less than originally proposed. Awards are expected to be in place by August 30, 2004 or the start date identified in the proposal. The Government anticipates use of cost reimbursement contracts for award under this BAA.

# 8. SPECIFIC RESEARCH TOPICS FOR FY04

The following topics represent NGA research interests. An award in any topical area will be made only if a sufficiently meritorious proposal is received. NGA reserves the right to allocate available funds among topics based on the quality of the responses and NGA priorities. An individual topic area may have no awards, a single award or multiple awards.

## 8.1. Area 1: Radar Based Automated Data Extraction (ADE)

POC: Dr. Paul Salamonowicz, (703) 735-3065, SalamonP@nga.mil

The research area known as Automated Data Extraction (ADE) encompasses the mathematics, related algorithms and tools designed to extract useable information from imagery, hardcopy maps, and text data for the development of geospatial intelligence. ADE is construed to include both fully automatic tools and those designed to assist a human operator, although wherever possible, the implementation of fully automated, upstream ADE requiring little downstream intervention by human analysts is the goal. ADE as addressed here includes the following types of algorithms: automated registration (AR), change detection (CD), automated feature extraction (AFE) and automated target recognition (ATR). These are loosely defined as follows:

AR is the means of bringing two or more images into congruence so that pixels of one image can be matched to corresponding pixels in other images. AR generally requires knowledge of the sensor geometry models as well as the physics of the imaging systems.

CD is the automated detection of both feature and broad area changes between two or more images that are in some way significant. Changes may be major or minor in extent, such as the presence of a vehicle in one image and its being missing in another. Major changes that are "normal", such as effects due to temporal changes (lighting conditions, moisture changes, other seasonal variations) must recognized and accounted for so as to minimize false positives.

AFE is the means of identifying, delineating, and attributing or categorizing predefined geospatial "features" in the image. These features include natural land cover, topography, and cultural. Examples include but are not limited to roads, buildings, vegetation, bodies of water and lines of communications. In some instances, it is of interest to attribute the characteristics of the features; e.g., road materials such as asphalt vs. concrete and types of trees such as deciduous, conifer or mixed.

ATR is the detection, categorization and identification of targets of interest, typically of intelligence value. These include traditional military targets such as ships, tanks and aircraft. However, non-traditional targets are becoming increasingly important. ATR also includes the detection and potential identification of hidden objects such as a facility or vehicle camouflaged or concealed in woods, tunnels and by other means.

This topic seeks to advance the state of the art in ADE for radar imagery or radar in conjunction with other image types. Emphasis can be on (1) extending or modifying existing algorithms that results in significantly improved speed and reliability of the algorithm or (2) on novel approaches. While any radar based technique that can eventually be implemented will be considered, there is particular interest in (1) AR techniques for radar-to-radar registration or radar-to-non-radar image registration and (2) fundamental AFE and CD applications using polarimetric SAR, in particular C- and L-band. Much work has been done in the AR, AFE and CD topics. The goal of this research is to extend beyond these capabilities. In order to achieve this goal, successful proposals must demonstrate not only a solid research plan but also that the current state of the art is well understood.

Approximately $600,000 of the available funds will be allocated to this topic area.

### 8.2. Area 2: Neuroscience Enabled Geospatial-Intelligence Initiative

POC: Dr. Jeffrey L. Kretsch, (703) 735-3159, KretschJ@nga.mil

The National Geospatial-Intelligence Agency (NGA) has long-term needs in the areas of automated vision systems and systems to assist human geospatial analysts. In order to provide new engineering approaches, basic research into the nature of vision as an information processing task remains a critical need. For over 30 years, traditional approaches to computer vision have failed to grasp the basic nature of the vision problem. As a result, many of the available techniques in computer vision are brittle, and perform poorly at recognition tasks that are simple even for children or animals. The brain of an experienced geospatial image analyst serves as an existence proof that the information-processing problems of expert vision are tractable using design principles embodied in biological systems. Publicly funded research over the last 15 years has produced an unprecedented volume of useful information about how the brain works, and in particular a physical understanding of how visual signals are processed, interpreted, and exploited by human and animal brains. Neuroscience is thus poised to serve as a potent enabling technology for the computer vision problems facing the NGA and the Intelligence Community as a whole.

The priority of this research is to provide a basic visual science foundation for future engineering. There are three medium-term application areas that may benefit from ongoing research. These are *image triage*, or the automated scoring, labeling, and prioritization of images based on their content to make human analyst labor more effective and efficient; *process automation*, beginning with simpler, more tractable, and repetitive visual analysis tasks, but ultimately including all analyst functions; and *multi-source inference*, or fusion and cross-referencing of a variety of intelligence sources (e.g., image, signal, and human sources). Within each of these areas, there is a need to understand the phenomenological strengths and weaknesses of human visual perception, for the design of intuitive software interfaces that are able to present the geospatial analyst with dense access to needed information with low cognitive load.

Funded research techniques may include human psychophysics, noninvasive brain imaging, neuromimetic machine vision methods that serve as predictive and/or explanatory models of the functional architecture of visual cortex, and analysis of the statistical structure of natural visual scenes. No funding is available for invasive research involving animal subjects.

**A general framework for approaching problems in human vision**

The processing of visual information by the human visual system is carried out by the joint action of a host of distinct processing components. These subsystems can initially be thought of as "black boxes" corresponding to anatomical subsets of the visual system that receive input and transform it in some way to produce an output, which is used in turn as input by other subsystems. A recent systems model for human vision is summarized in Figure 1 (adapted from Kosslyn, 1994). This diagram is provided here as a modifiable conceptual framework with which to map out the various sub-problems of vision that research funded under the program may wish to address. Funded research may address any salient aspects of visual processing, but the group of funded research projects should be able to be related to each other through a common framework, the granularity of which has been deliberately kept low for simplicity and generality. Although the systems diagram appears to imply sequential processing, one must assume that all processes are running at the same time on continuously updated sensory input. The process of identifying objects within images, as an example, can be thought of as the search for a satisfactory match between the input image and stored visual memories, representations, or criteria. This search can be broken down into a sequence of operations within the subsystems of the model.

The *visual buffer* in this conceptualization corresponds to a collection of areas of the cerebral cortex that have a retinotopic organization. The visual buffer is more than a temporary store (as the name would otherwise seem to imply), as considerable processing of visual information takes place within it; for example, figure-ground segregation and segmentation rely in part on local interactions within the visual buffer. There is more information in this buffer than can be fully processed by the brain, a fact that necessitates an *attentional window* for in-depth processing of a subset of interest. The "gating" operation performed by the attention window can be conceived in terms of lowering thresholds of response to attended regions of the visual image. This gating allows areas of an image where an object may be present, for example, to be focused upon and analyzed in detail.

# System Model of the Human Visual System (Kosslyn, 1994)

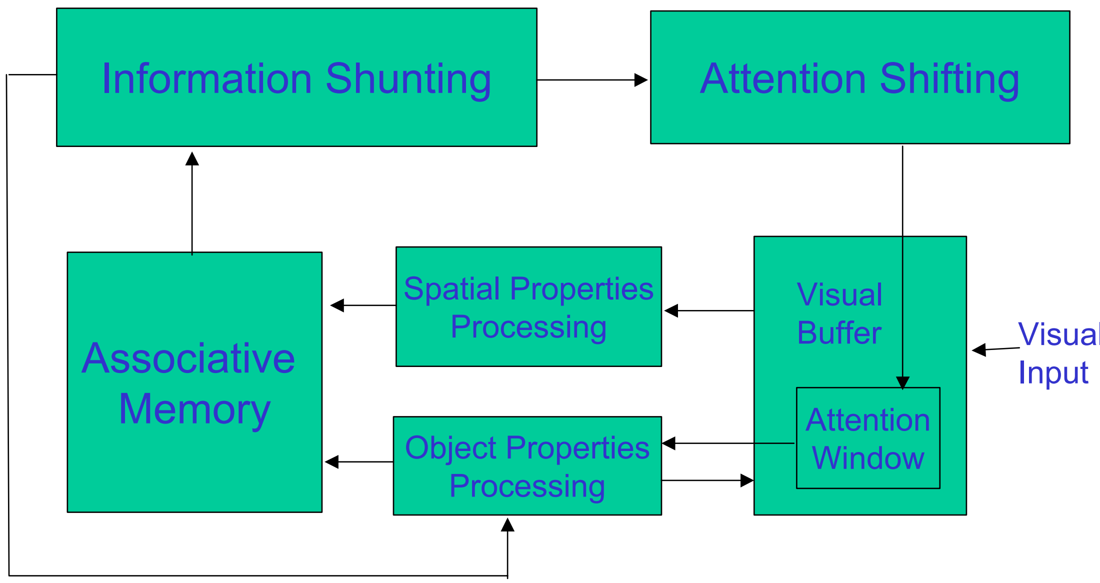


Figure 1

Much of the visual brain is divided into two major processing streams, the *ventral stream* or "form processing pathway", and the *dorsal stream* or "space/motion processing pathway". In the diagram in Figure 1, these correspond to the *object properties processing* subsystem and the *spatial properties processing* subsystem, respectively. These two analysis modules extract separate kinds of information, one about the identity of an object and the other about spatial information, such as how the object is situated in space, rotated, in what direction it is moving, etc. These preprocessed representations of a scene are then used to access the *associative memory* subsystem, which binds together a range of attributes and scene properties to form representations of events, environments, objects, and relationships.

The remaining subsystems are used to assess what conclusions might be drawn at any point during the analysis of a scene, and what part of a scene to focus on next using *top-down processing* in order to attempt to answer questions of interest or to exhaust the information content of a scene. The *information shunting* subsystem is used, for example, to take the results of analysis and use them to alter the way in which new information is interpreted. Some of the major ways that this occurs, summarized in the *attention shifting* subsystem, are in anticipatory priming (in which the threshold for detecting certain kinds of stimuli, like the color red, is lowered), covert attention (in which an internal, circuit-level version of changing eye position is used to focus on one part of the visual field at the expense of others), and overt attention or active perception (in which the eyes, head, and body are moved to get new visual input).

The result of all of these processes acting together is a robust general purpose system that can respond to novel stimuli, relate them to past experience, generate queries, and use those to seek new information.

**Proposed research**

The long-term priority of the research is to develop a well-grounded basis for understanding the problems of vision and the ways in which natural nervous systems have solved them. The ultimate benefit of this knowledge will be the ability to construct automated vision systems that meet or exceed the performance of expert humans.

The results of on going research on the functional anatomy of the visual system will provide the basis for numerical simulations of neural systems. These working software simulations may form the basis for prototype applications deliverable to the NGA as side benefits along the course of the research program. Research may be performed at any point along this visual chain. In order to fulfill these aims, we propose a research program divided into three major overlapping program areas, discussed below. Because of the breadth of these areas, funded research is likely to fit into one or more of these, although research questions not listed here are welcome and encouraged.

**Neuroscience-Enabled Geospatial Intelligence (NEGI) Foundations:** The Foundations program area will support basic research in theoretical and experimental neuroscience that bears directly on the problem of enabling computer vision systems to perceive structure and meaning in images in a way that approximates human perception. Major questions of interest include:

- **How has evolution exploited the statistical structure of natural sensory environments to decompose scenes into attributes or features that are most useful for informing behavioral decisions?** Specifically, how can stereotypy in large data sets be used by neural mechanisms to learn criteria for invariant object recognition, image segmentation, contour completion, or other analysis, in the presence of occlusion, distortion, transparency, and noise? Research areas of interest include the columnar circuit architecture of neocortex, the adaptive transfer function properties of neurons, the learning properties of synapses, and feedback loops between the cortex, thalamus and midbrain.

- **How do nervous systems exploit the temporal structure of movies or other image sequences to learn criteria for view-invariant object recognition?** The encoding of object identity by neurons in the ventral stream of visual cortex has both view-dependent and view-independent properties. There is evidence that neurons learn associations between views of the same object. Other approaches suggested by neuroscience are the learning of "generator functions" for geometric transformations (rotation, translation, scaling, distortion) related to space-time receptive fields, and the learning of degree-of-freedom manifold models of both animate and inanimate objects.

- **How does the brain model part-to-whole relationships in visual scenes (e.g., visual edge, surface, wing, airplane, airport, city, etc.)?** Effective parts-based structural models are especially well-suited to deal with occlusion, the recognition of familiar objects under new viewing conditions, and the use of structural analogy to handle novel situations (e.g., noting the appearance of a novel type of vehicle). Work in this area should focus on cortical interarea relationships in dorsal and ventral stream hierarchies, in which local features are progressively assembled into more holistic representations of objects and scenes.

- **In what ways does high-level perception depend on foveated vision and active perception?** Retinotopic areas of visual cortex are organized into information iso-dense mappings, with the majority of neurons devoted to processing visual input near the center of the visual field. We are interested in the informational, architectural, and behavioral constraints that come to bear on foveated systems as opposed to uniform-density visual systems.

- **How can multiple different sensory or data modalities be brought together and analyzed for joint structure?** The more that is learned about primary and early monosensory areas, the greater of a foundation we have for interpreting multisensory association areas, because we know what kinds of inputs are sent to them for combined analysis. Short-term multisensory binding appears to take place in hippocampus, entorhinal cortex, and prefrontal cortex. There is evidence for longer-term binding in hippocampus, entorhinal cortex, angular gyrus, and Area 19. This inquiry should also focus on the stereotypical aspects of circuit architecture and encoding properties across the entire cortex, which make it possible to make direct comparisons between different sensory modalities.

Together with the Knowledge Representation and High-Level Inference program areas below, this basic research will clarify the algorithmic requirements of the visual tasks performed by image analysts.

**NEGI Knowledge Representation:** The Knowledge Representation program area supports research that addresses the processing steps that transform sensory data into adaptive feature or attribute descriptions, and ultimately into conceptual expressions. The appropriate representation of attributes and concepts at the software or hardware level is crucial to the success of any method that attempts to model human cognitive capabilities (for example, computer vision). Recent neuroscience research has overturned a number of previously dominant theories of concept representation in the brain, and has suggested new approaches that may substantially clarify and simplify the processing required for computer vision tasks. These new approaches include modality-specific representations, environment- and context-specific representations, dynamic modifications to existing categories and concepts, consolidation, and simulation-based inference (or imagination). Questions of interest include:

- **Based on the statistical structure of sensory data, and the goals of sensory analysis, how should the labor of representing structure be divided among representational resources (neurons, basis functions, filters, etc.)?** Motivated by the interaction between neuroscience and machine learning, recent developments in generative probabilistic modeling of sensory data, and independent components analysis for blind source separation and deconvolution, have laid a foundation for research into the relationships between structural analysis of stereotypy in sensory data, the response properties of neurons in the brain, and measures of efficient encodings of information. Several of these methods have offered utility-based explanations for the receptive fields of neurons in sensory cortex, and are poised to suggest novel directions for automated sensory data analysis. There is special interest in the commonalities and differences between encodings of a variety of sensory modalities, and the capability of the cerebral cortex to make adaptive feature maps.

- **What resource-to-performance tradeoffs are exploited by the use of parts-based versus consolidated representations of familiar objects?** Faces appear to be processed in the human and nonhuman primate brain using relatively consolidated representations that depend on a very high level of expertise, derived from frequent exposure to exemplar data. Less familiar types of objects tend to recruit feature-based or parts-based compositional representations, in which each feature is common enough to warrant an individuated representation. One question of interest is whether learning tracks along a continuum between parts-based and consolidated representations with increasing exposure to exemplars.

- **How are conceptual categories represented in the human brain?** Debates in the cognitive science community about the inferential vs. informational content of concepts, how they are acquired, how they are compared, and how they are used to plan and execute behaviors are ongoing. Whether concepts are atomic or composed, and the role that symbolic language may play in the binding of conceptual classes, bear on the problem of how a software system might best acquire and use concepts in the analysis of image and multisensory data.

- **What role do multisensory representations in association cortex and hippocampus play in cognition?** The hippocampus and entorhinal cortex, in particular, are involved in the assembly of high-level information from a variety of different sensory modalities into a seamless and context-sensitive holistic view of a sensory scene. Hippocampal representations appear to rapidly bind and store information about new environments, or about events in time, transferring the content of these memories to the rest of the cortex during sleep.

- **How does the brain use offline, imaginative simulations of the sensory world to make inferences?** Specifically, how are the prefrontal cortex and other cortical areas involved in "top-down" executive control of perceptual representations? How are queries generated inside the brain, and what are the dynamics of different cortical areas during what we regard as the thought process?

- **How are resources conserved in the brain?** Several principles, such as energy-efficient encoding of sensory events in the cortex, minimization of wiring length in the brain, sparse or low-entropy codes, and foveated vision with active perception, all appear to have optimized the efficient use of resources in the brain. Similar computational limitations are faced by artificial systems, and important lessons can be learned from natural nervous systems in this regard.

**NEGI High-Level Inference:** The High-Level Inference program area seeks to address issues of how nervous systems make inferences (judgments, predictions, assessments, etc.) from sensory data. The rapidly maturing field of Bayesian causal inference is likely to be combined with new work being done in cognitive and behavioral neuroscience to identify those engineering principles that are central to inference and prediction. These fields have begun to converge with game theory and risk analysis in the emerging field of "neuroeconomics", and are expected to have a potent enabling effect on the automated analysis of sensory imagery in a security context. Questions of interest include:

- **How well can the architecture and dynamics of neural systems by explained in light of Bayesian models of conditional probability?** Expectation maximization, information maximization, generative probabilistic modeling, and several otherrelated theoretical frameworks have given theoretical neuroscience a powerful mathematical language in which to predict and explain the behavior of natural nervous systems. This body of theory also sets theoretical upper bounds on the performance of learning systems given a set of training data, whether they are natural or artificial.

- **How do constraints on representation interact with constraints on inference?**

Representations are used to perform inferences, but the format in which information or knowledge is encoded makes certain inferential operations more or less difficult.

- **What kinds of objectives appear to be active in human perception and inference?** Human observers sometimes sacrifice performance on a given task in order to acquire more information about the task from failures as an efficient sampling strategy. What other objectives affect human learning, and can artificial systems benefit from versions of these parallel objectives?

- **How is value represented in the brain, and how can artificial neural systems best process measures of value?** Studies of the substantia nigra pars compacta and ventral tegmental area, and the mesocortical dopamine projection into nucleus accumbens and frontal cortex, appear to be the physical system underlying reward-based operant conditioning of behavior in mammals. Estimates of value, or the more subjective measure of utility, appear to be processed in this system and are considered necessary as a basis for survival-oriented decision-making in undersampled or nonstationary environments.

Additional questions in the High-Level Inference program area are expected to emerge as information is gained from the prior two research programs, in particular the closely related Knowledge Representation area.

Approximately $1,470,000 of the available funds will be allocated to this topic area.

**References**

Kosslyn SM (1994) *Image and Brain.* Cambridge, MA: MIT Press.

## 8.3. Area 3: Non-literal Spectral Processing, Exploitation, and Analysis (PEA)

P.O.C. Ernest P. Reith, (703) 735-3222, ReithE@nga.mil

NGA continues to explore and expand their understanding of non-literal spectral processing, exploitation, and analysis (PEA) capabilities to solve enduring and emerging problems. These non-literal PEA capabilities and sources need to address multiple applications of NGA interest and be robust, user friendly, highly automated, and reliable. PEA capabilities of interest would include, but not be limited to, non-linear sub-pixel and mixed pixel detection and identification, modeling spectral/signature variability, and background-foreground separation of solids, liquids, and gases. NGA is requesting research in new methods and techniques to derive geospatial intelligence and develop advanced PEA tools from unique spectral sources. Consideration will be placed on offerers exhibiting unique synergistic PEA methods and techniques utilizing complementary sources (SAR, LIDAR, etc.) yielding high value geospatial intelligence.

Exemplar research projects are automated land surface, environmental, and mineral mapping applications via dynamic spectral library matching of hyperspectral and SAR data.

The amount to be allocated to this topic is $500,000.

# 9. SIGNIFICANT DATES

The following table provides the significant dates referred to in the body of this announcement. (Match these dates to Acq Plan and Eval Plan)

| **Action** | **Responsibility** | **Due Date** |
|---|---|---|
| Issue announcement in Fed Biz Opts | Government | 12 Apr 04 |
| Proposal due | Principal Investigator | 27 May 04 |
| Acknowledge receipt of proposals | Government | 28 May 04 |
| Contract Award | Government | 30 August 04 |
| Estimated Start date | Principal Investigator | 30August 04 |

## 9.1. Late Submissions

Proposals will be considered for award if submitted in a timely manner. If a proposal is submitted in an untimely manner, after 3:00 P.M. (Eastern Daylight Savings Time) on May 27, 2004. The criteria in Federal Acquisition Regulation part 15.208 will apply.

# 10. POINTS of CONTACT

## 10.1. Contracting

Mr. Eric Rauch at 703-735-3920 or rauche@nga.mil.

## 10.2. Technical Issues

Dr. Paul Salamonowicz at 703 735-3065, Section 8.1

Dr. Jeffrey L. Kretsch at 703-735-3159, Section 8.2

Mr. Ernest Reith at (703) 735-3222, Section 8.3