NATIONAL GEOSPATIAL-INTELLIGENCE AGENCY
20.1 Small Business Innovation Research (SBIR)
Proposal Submission Instructions

GENERAL INFORMATION

The National Geospatial-Intelligence Agency has a responsibility to provide the products and services that decision makers, warfighters, and first responders need, when they need it most. As a member of the Intelligence Community and the Department of Defense, NGA supports a unique mission set. We are committed to acquiring, developing and maintaining the proper technology, people and processes that will enable overall mission success.

Geospatial intelligence, or GEOINT, is the exploitation and analysis of imagery and geospatial information to describe, assess and visually depict physical features and geographically referenced activities on the Earth. GEOINT consists of imagery, imagery intelligence and geospatial information.

With our unique mission set, NGA pursues research that will help guarantee the information edge over potential adversaries. Information on NGA's SBIR Program can be found on the NGA SBIR website at: https://www.nga.mil/Partners/ResearchandGrants/SmallBusinessInnovationResearch/Pages/default.aspx. Additional information pertaining to the National Geospatial-Intelligence Agency's mission can be obtained by viewing the website at http://www.nga.mil/.

Inquiries of a general nature or questions concerning the administration of the SBIR Program should be addressed to:

National Geospatial-Intelligence Agency
Attn: SBIR Program Manager, RA, MS: S75-RA
7500 GEOINT Dr., Springfield, VA 22150-7500
Email: SBIR@nga.mil

For technical questions and communications with Topic Authors, see DoD Instructions, Section. 4.15. For general inquiries or problems with electronic submission, contact DoD SBIR Help Desk at dodsbirsupport@reisystems.com or 1-703-214-1333 between 9:00 am and 5:00 pm ET.

PHASE I PROPOSAL INFORMATION

Follow the instructions in the DoD SBIR Program BAA for program requirements and proposal submission instructions at https://sbir.defensebusiness.org/.

NGA has developed topics to which small businesses may respond to in this fiscal year 2020 SBIR Phase I iteration. These topics are described on the following pages. **The maximum amount of SBIR funding for a Phase I award is $100,000, and the maximum period of performance for a Phase I award is nine months.** While NGA participates in the majority of SBIR program options, NGA does not participate in the either the Commercialization Readiness Program (CRP), Discretionary Technical Assistance (DTA or in future BAAs TABA (Technical and Business Assistance)) or Phase II Enhancement programs.

The entire SBIR proposal submission (consisting of a Proposal Cover Sheet, the Technical Volume, Cost Volume, and Company Commercialization Report) must be submitted electronically through the DoD

SBIR/STTR Proposal Submission system located at https://www.dodsbirsttr.mil/submissions/for it to be evaluated.
The Proposal Technical Volume (Volume 2) must be no more than 20 pages in length. The Cover Sheet (Volume 1) and Cost Volume (Volume 3) do not count against the 20-page Proposal Technical Volume page limit. Any Technical Volume that exceeds the page will not be considered for review. The proposal must not contain any type smaller than 10-point font size (except as legend on reduced drawings, but not tables). The vendor may submit supporting documents (Volume 5) but that material WILL NOT be reviewed by the evaluation team as part of the proposal evaluation. Fraud, Waste and Abuse Training (Volume 6) will be addressed at time of contract award.

Selection of Phase I proposals will be in accordance with the evaluation procedures and criteria discussed in this BAA (refer to Section 6.0 of the BAA).

The NGA SBIR Program reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality in the judgment of the technical evaluation team will be funded. The offeror must be responsive to the topic requirements, as solicited.

An **unsuccessful offeror has 3 days after notification that its proposal was not selected to submit a written request for a debriefing to the Contracting Officer (CO).** Those offerors who get their written request in within the allotted timeframe above will be provided a debriefing.

Federally Funded Research and Development Contractors (FFRDC) and other government contractors, whom have signed Non-Disclosures Agreements, may be used in the evaluation of your proposal.
NGA typically provides a firm fixed price level of effort contract for Phase I awards. The type of contract is at the discretion of the Contracting Officer.

Phase I contracts will include a requirement to produce one-page monthly status reports and a more detailed interim report not later than 7½ months after award. These reports shall include the following sections:

- A summary of the results of the Phase I research to date
- A summary of the Phase I tasks not yet completed, with an estimated completion date for each task
- A statement of potential applications and benefits of the research.

The interim report (draft final report) shall be prepared single spaced in 12 pitch Times New Roman font, with at least a one-inch margin on top, bottom, and sides, on 8½" by 11" paper. The pages shall be numbered.

PHASE II GUIDELINES

Phase II is the demonstration of the technology found feasible in Phase I. All NGA SBIR Phase I awardees from this BAA will be allowed to submit a Phase II proposal for evaluation and possible selection. To minimize the gap between the Phase I and Phase II, it is suggested that the vendor submit their proposal during month 7 of the Phase I award.

The NGA SBIR Program is committed to minimizing the funding gap between Phase I and Phase II activities. Phase I awardees may submit a Phase II proposal without invitation; However, it is strongly encouraged that an UNCLASSIFIED Phase II proposal not be submitted until sufficient Phase I progress can be evaluated and assessed based on results of the Phase I proof-of-concept/feasibility study Work Plan. Therefore, it is highly recommended to submit your UNCLASSIFIED proposal 60 days prior to the end date of their Phase I contract in order to be considered for funding. All NGA SBIR Phase II proposals will receive timely.

Small businesses submitting a Phase II Proposal must use the DoD SBIR electronic proposal submission system (https://www.dodsbirsttr.mil/submissions/). This site contains step-by-step instructions for the preparation and submission of the Proposal Cover Sheets, the Company Commercialization Report, the Cost Volume, and how to upload the Technical Volume. For general inquiries or problems with proposal electronic submission, contact the DoD SBIR/STTR Help Desk at (1-703-214-1333) or Help Desk email at dodsbirsupport@reisystems.com (9:00 am to 5:00 pm ET).

NGA SBIR Phase II Proposals have three UNCLASSIFIED Volumes: Proposal Cover Sheets, Technical Volume, and Cost Volume. The Technical Volume has a 40-page limit including: table of contents, pages intentionally left blank, references, letters of support, appendices, technical portions of subcontract documents (e.g., statements of work and resumes) and any attachments. Do not include blank pages, duplicate the electronically generated Cover Sheets or put information normally associated with the Technical Volume in other sections of the proposal as these will count toward the 40-page limit.

Technical Volumes that exceed the 40-page limit will be reviewed only to the last word on the 40th page. Information beyond the 40th page will not be reviewed or considered in evaluating the offeror's proposal. To the extent that mandatory technical content is not contained in the first 40 pages of the proposal, the evaluator may deem the proposal as non-responsive and score it accordingly.

The NGA SBIR Program will evaluate and select Phase II proposals using the evaluation criteria in Section 8.0 of the DoD SBIR Program BAA. Due to limited funding, the NGA SBIR Program reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

NGA typically provides a firm fixed price contract as a Phase II award. The type of contract is at the discretion of the Contracting Officer.

Phase II proposals shall be limited to $1,000,000 over a two-year period with a Period of Performance not exceeding 24 months. A work breakdown structure that shows the number of hours and labor category broken out by task and subtask, as well as the start and end dates for each task and subtask, shall be included.

Phase II contracts shall include a requirement to produce one-page monthly status and financial reports, an interim report not later than 11 months after contract award, a prototype demonstration not later than 23 months after contract award and a final report not later than 24 months after contract award. These reports shall include the following sections:

- A summary of the results of the Phase II research to date
- A summary of the Phase II tasks not yet completed with an estimate of the completion date for each task
- A statement of potential applications and benefits of the research.

The interim and final report shall be prepared single spaced in 12 pitch Times New Roman font, with at least a one-inch margin on top, bottom, and sides, on 8½" by 11" paper. The pages shall be numbered.

USE OF FOREIGN NATIONALS

See the “Foreign Nationals” section of the DoD program announcement for the definition of a Foreign National (also known as Foreign Persons).

Due to the nature of our business, the use of foreign nationals on a NGA contract is PROHIBITTED. ALL offerors proposing to use foreign nationals on the effort will be ineligible for award. This includes the use at universities or any other subcontractor.

DISCLOSURE OF INFORMATION

(a) The Contractor shall not release to anyone outside the Contractor's organization any unclassified information, regardless of medium (e.g., film, tape, document), pertaining to any part of this contract or any program related to this contract, unless—

(1) The Contracting Officer has given prior written approval; or
(2) The information is otherwise in the public domain before the date of release; or
(3) **The information results from or arise during the performance of a project that has been scoped and negotiated by the contracting activity with the contractor and research performer and determined in writing by the Contracting Officer to be fundamental research*** in accordance with National Security Decision Directive 189, National Policy on the Transfer of Scientific, Technical and Engineering Information. In effect on the date of contract award, and the USD (AT&L) memoranda on Fundamental Research, dated May 24, 2010, and on Contracted Fundamental Research, dated June 26, 2008 (available at DFARS PGI 204.4).

(b) Requests for approval under paragraph (a)(1) shall identify the specific information to be released, the medium to be used, and the purpose for the release. The Contractor shall submit its request to the Contracting Officer at least 10 business days before the proposed date for release.

***Note: This has to be negotiated prior to award of the contract. A request for determination after award will not be entertained and will result in the clause being pushed down to all subcontracts. Non-performance could result in cancelation of contract.**

5X52.227-9000 UNAUTHORIZED USE OF NGA NAME, SEAL AND INITIALS

(a) As provided in 10 U.S.C. Section 425, no person may, except with the written permission of the Director, National Geospatial-Intelligence Agency, knowingly use the words “National Geospatial-Intelligence Agency”, National Imagery and Mapping Agency” or “Defense Mapping Agency”, the initials “NGA”, “NIMA” or “DMA”, the seal of the National Geospatial-Intelligence Agency, National Imagery and Mapping Agency or the Defense Mapping Agency, or any colorable imitation of such words, initials, or seal in connection with any merchandise, retail product, impersonation, solicitation, or commercial activity in a manner reasonably calculated to convey the impression that such is approved, endorsed, or authorized by the Director, NGA.

(b) Whenever it appears to the U.S. Attorney General that any person is engaged or about to engage in an act or practice which constitutes or will constitute conduct prohibited by paragraph (a), the Attorney General may initiate a civil proceeding in a district court of the United States to enjoin such act or practice. Such court shall proceed as soon as practicable to hearing and determination of such action and may, at any time before such final determination, enter such restraining orders or prohibition, or take such other action as is warranted, to prevent injury to the United States, or to any person or class of persons whose protection the action is brought.

5X252.204-7000-90 PUBLIC RELEASE OF INFORMATION

Information pertaining to this contract shall not be released to the public except as authorized by the Contracting Officer in accordance with DFARS 252.204-7000, Disclosure of Information. Requests for approval to release information pertaining to this contract shall be submitted to the Contracting Officer by means of NGA Form 5230-1, National Geospatial-Intelligence Agency Request for Clearance for Public Release.

NGA SBIR 20.1 Topic Index

NGA SBIR 20.1 Topic Descriptions

NGA201-001 TITLE: Synthetic Data for Computer Vision in Remote Sensing

TECHNOLOGY AREA(S): Information Systems

RESEARCH & TECHNOLOGY AREA(S):

ADVANCED CAPABILITIES:

ACQUISITION & SUSTAINMENT AOR:

OBJECTIVE: Develop novel techniques to identify and locate uncommon targets in overhead and aerial imagery, specifically by leveraging synthetic data to augment data classes for which minimal labeled data samples exist. Initial focus will on synthetic aperture radar (SAR) and panchromatic electro-optical (EO) imagery, with a subsequent extension to multi-spectral imagery (MSI).

DESCRIPTION: The National Geospatial Intelligence Agency (NGA) produces timely, accurate and actionable geospatial intelligence (GEOINT) to support U.S. national security. To continue to quickly and efficiently exploit the growing volume of imagery data and complexity of monitored objects, NGA must continue to improve its automated and semi-automated methods. Recent advances in computer vision will enable intelligence analysts to identify rare objects within large data volumes by leveraging AI tools. However, these approaches are data driven – presenting a challenge when few measured training samples exist. One approach to this problem is leveraging synthetic data for the sensor modality of interest (e.g. Xpatch, DIRSIG, Blender, IRMA).

However, when using synthetic data to train a network, one must address the tendency of the network to learn distinct synthetic features vs. the unique phenomenology representative of an object of interest. Architectures which seek to generate realistic data, as well as classification networks which are robust to the synthetic-measured gap are of interest.

PHASE I: Design and demonstrate methods that utilize synthetic SAR or EO data to augment a single few-shot class using government furnished SAR or EO image chips. Phase I will deliver a proof of concept algorithm suite, all data collected or curated, and thorough documentation of conducted experiments and results in a final report, with the goal of bolstering a strong Phase II proposal.

PHASE II: Develop enhancements to address identified deficiencies from Phase I. Extend Phase I capabilities by increasing the scale of the synthetic augmentation to include multiple few shot targets. This phase will also extend classification to include detection of objects of interest within a larger scene. Deliver updates to the proof of concept algorithm suite and technical reports. Phase II will result in a prototype end-to-end implementation of the Phase I few-shot detection system extended to process EO, SAR, and MSI imagery and a comprehensive final report.

PHASE III DUAL USE APPLICATIONS: Deep Learning, specifically Generative Adversarial Networks (GANs), have recently allowed the quick generation of convincing synthetic images and the refinement of simulated images to appear photorealistic. Applying these generative techniques to train computer vision classification and detection models in data-starved scenarios would have wide-spread applications across the government and commercial sectors.

REFERENCES:
1. Howe J; Pula K, and Reite A. "Conditional Generative Adversarial Networks for Data Augmentation and Adaptation in Remotely Sensed Imagery" arXiv:1908.13809

2. Andersh et al. “Xpatch 4: the next generation in high frequency electromagnetic modeling and simulation software", IEEE 2000 International Radar Conference.

3. Brown, S., Goodenough, A., “DIRSIG 5: core design and implementation”, SPIE 2012

4. Hess, R., 2010. “Blender Foundations: The Essential Guide to Learning Blender 2.6”, Focal Press.

5. Savage, J. et al, “Irma 5.2 multi-sensor signature prediction model”, SPIE 2008

6. Christopher Bowles et al, “GAN Augmentation: Augmenting Training Data using Generative Adversarial Networks”, arXiv preprint arXive:1810.1086

7. Kar, A. et al, “Meta-Sim: Learning to Generate Synthetic Datasets”, arXiv:1904:11621

8. Lau, F., ScarGAN: “Chained Generative Adversarial Networks to Simulate Pathological Tissue on Cardiovascular MR Scans”, arXiv:1808.04500

9. Lewis, B. et al, “A SAR dataset for ATR Development: the Synthetic and Measured Paired Labeled Experiment (SAMPLE)”, SPIE 2019

KEYWORDS: Computer Vision, Synthetic Data, Generative Adversarial Networks, Machine Learning, Deep Learning, Few Shot Learning, Image Processing

NGA201-002 TITLE: Hierarchical Computer Vision in Remote Sensing

TECHNOLOGY AREA(S): Information Systems

RESEARCH & TECHNOLOGY AREA(S):

ADVANCED CAPABILITIES:

ACQUISITION & SUSTAINMENT AOR:

OBJECTIVE: Develop novel techniques that incorporate class ontologies into automated detection and classification algorithms. Initial focus will be on panchromatic electro-optical (EO) imagery with a subsequent extension to multi-spectral imagery (MSI) and/or synthetic aperture radar (SAR) imagery.

DESCRIPTION: The National Geospatial Intelligence Agency (NGA) produces timely, accurate and actionable geospatial intelligence (GEOINT) to support U.S. national security. Intelligence analysts are central to the success of the NGA. Recent advances in computer vision will enable intelligence analysts to identify rare objects within large data volumes by leveraging AI tools. Of specific interest to this solicitation are techniques to exploit target hierarchies to help characterize objects which have few labeled data samples. These approaches will leverage both functional based hierarchy and data clustering approaches to provide support for rare object identification.

Most classification and detection work has focused on a flat class structure despite known correlations amongst the classes, i.e. an object which is labelled a “truck” can also be labelled a “vehicle”. The NGA is seeking the development of innovative techniques that will not only detect objects for a given class but provide a class hierarchy and naturally produce a general class label when insufficient training samples exist to support more specific class labels. The government has established a hierarchical detection dataset, xView, to support this research; but other datasets containing well-defined hierarchical structures such as ImageNet may also be used.

PHASE I: Design and demonstrate methods that incorporate class hierarchies into object detection and classification, providing multiple labels per class at inference time using panchromatic EO remote sensing imagery with consideration for an extension to MSI and SAR imagery. Phase I will deliver a proof of concept algorithm suite, all data collected or curated, and thorough documentation of conducted experiments and results in a final report, with the goal of bolstering a strong Phase II proposal.

PHASE II: Extend Phase I capabilities by increasing the breadth and depth of hierarchies, incorporating unlabeled data with semi-supervised techniques, and automatically learning hierarchical structures from visual correlations in unlabeled data. Develop enhancements to address identified risks and deficiencies from Phase I. Deliver updates to the proof of concept algorithm suite and technical reports. Phase II will result in a prototype end-to-end implementation of the Phase I hierarchical detection and classification systems extended to process MSI and/or SAR imagery and a comprehensive final report.

PHASE III DUAL USE APPLICATIONS: Computer vision technology incorporating hierarchical structure in learning and inference would be widely applicable across the government and commercial sectors. Military applications include national security, targeting, and intelligence. Commercially, such technology would apply to online retail, social networking, and photo software: any domain requiring computer vision with a hierarchical ontology

REFERENCES:
1. Lam, Darius, et al. "xView: Objects in context in overhead imagery." arXiv preprint arXiv:1802.07856 (2018).

2. Sergievskiy, Nikolay, and Alexander Ponamarev. "Reduced focal loss: 1st place solution to xview object detection in satellite imagery." arXiv preprint arXiv:1903.01347 (2019).

3. Silla, Carlos N., and Alex A. Freitas. "A survey of hierarchical classification across different application domains." Data Mining and Knowledge Discovery 22.1-2 (2011): 31-72.

4. Redmon, Joseph, and Ali Farhadi. "Yolov3: An incremental improvement." arXiv preprint arXiv:1804.02767 (2018).

5. Kuznetsova, Alina, et al. "The open images dataset v4: Unified image classification, object detection, and visual relationship detection at scale." arXiv preprint arXiv:1811.00982 (2018).

6. Reite, Aaron, et al. “Unsupervised Feature Learning in Remote Sensing.” arXiv preprint arXiv:1908.02877 (2019).

KEYWORDS: Computer Vision, Machine Learning, Deep Learning, Image Processing

NGA201-003 TITLE: Semi-supervised Detection in Remote Sensing

TECHNOLOGY AREA(S): Information Systems

RESEARCH & TECHNOLOGY AREA(S):

ADVANCED CAPABILITIES:

ACQUISITION & SUSTAINMENT AOR:

OBJECTIVE: Develop novel techniques to identify and locate uncommon targets in overhead and aerial imagery, specifically by leveraging unsupervised or semi-supervised machine learning. Initial focus will be on panchromatic electro-optical (EO) imagery with a subsequent extension to multi-spectral imagery (MSI) and/or synthetic aperture radar (SAR) imagery.

DESCRIPTION: The National Geospatial Intelligence Agency (NGA) produces timely, accurate and actionable geospatial intelligence (GEOINT) to support U.S. national security. To continue to quickly and efficiently exploit the growing volume of imagery data and complexity of monitored objects, NGA must continue to improve its automated and semi-automated methods.

Recent advances in deep learning have dramatically improved the state-of-the-art for techniques such as object detection and semantic segmentation, including scenarios where little data is available for training (i.e., few/low-shot learning). NGA seeks innovative approaches that leverage a relatively small amount of target and task specific labeled data in combination with unlabeled data to support object detection and semantic segmentation. These approaches should provide a capability to quickly identify new target subclasses and classes with little to no labels. The government has established a detection dataset, xView, to support this research.

PHASE I: Design and demonstrate methods that leverage unlabeled data in combination with small volumes of labeled data to advance the state-of-the-art detection performance in panchromatic EO with special consideration for few-shot classes. Phase I will deliver a proof of concept algorithm suite, all data collected or curated, and thorough documentation of conducted experiments and results in a final report, with the goal of bolstering a strong Phase II proposal.

PHASE II: Extend Phase I capabilities by increasing the scale of the unlabeled dataset, sub-category discovery, and hierarchical classification. Develop enhancements to address identified risks and deficiencies from Phase I. Deliver updates to the proof of concept algorithm suite and technical reports. Phase II will result in a prototype end-to-end implementation of the Phase I few-shot detection system extended to process MSI and/or SAR imagery and a comprehensive final report.

PHASE III DUAL USE APPLICATIONS: Technology enabling the automated search for uncommon objects in overhead imagery would be widely applicable across the government and commercial sectors. Military applications include national security, targeting, and intelligence. Commercially, such technology would apply to urban planning, geology, agriculture, economics, and search and rescue; and all other domains that benefit from identifying objects in overhead imagery.

REFERENCES:
1. Lam, Darius, et al. "xView: Objects in context in overhead imagery." arXiv preprint arXiv:1802.07856 (2018).

2. Sergievskiy, Nikolay, and Alexander Ponamarev. "Reduced focal loss: 1st place solution to xview object detection in satellite imagery." arXiv preprint arXiv:1903.01347 (2019).

3. Xie, Qizhe, et al. "Unsupervised data augmentation." arXiv preprint arXiv:1904.12848 (2019).

4. Wu, Zhirong, et al. "Unsupervised feature learning via non-parametric instance discrimination." Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition. 2018.

5. Reite, Aaron, et al. "Unsupervised Feature Learning in Remote Sensing." arXiv preprint arXiv:1908.02877 (2019).

KEYWORDS: Computer Vision, Machine Learning, Deep Learning, Detection, Segmentation, Few Shot Learning, Unsupervised Learning, Semi-supervised Learning, Image Processing

NGA201-004 TITLE: Improved analysis of overhead imagery using low-shot learning with spatio-temporal constraints

TECHNOLOGY AREA(S): Information Systems, Sensors

RESEARCH & TECHNOLOGY AREA(S):

ADVANCED CAPABILITIES:

ACQUISITION & SUSTAINMENT AOR:

OBJECTIVE: Develop techniques to improve the detection, classification, and/or identification of objects in overhead imagery, as well as the characterization of any changes over time (including but not limited to appearance, orientation, and movement). Design a system that allows an image analyst to apply these techniques to multi-source sensor data to improve analysis products and/or accelerate current workflows.

DESCRIPTION: The National Geospatial-Intelligence Agency (NGA) and other Department of Defense (DoD) partners use geospatial intelligence (GEOINT) derived from still and full-motion overhead imagery to support U.S. national security. Imagery captured from satellite and airborne platforms and associated metadata can vary significantly in quality and frequency of collection. As a result, GEOINT analysis is a challenging task that typically involves analysis of multiple, independent data sources and correlation/fusion of results.

This topic seeks to explore innovative techniques for improving GEOINT analysis by explicitly leveraging spatio-temporal context. One of the most fundamental tasks in computer vision is to detect objects in an image, and several techniques have been described in the academic literature for training models with only few training samples [Ref 1-2]. However, these were developed for generic use cases (e.g., common household objects, commercial applications) but GEOINT data has some unique characteristics that can be exploited. In particular, GEOINT has both a spatial and a temporal component that provides additional context that can both inform and constrain the analysis problem. To use a concrete example, consider the task of object detection in a sequence of images with varying quality: if objects are identified with high confidence in a high-quality image, then this information could be used to bias (i.e., relax or constrain) the analysis of images taken over the same location with different resolutions, collection geometries, scale, illumination, seasonal variations, and sensor modality. Object identity/disambiguation across multiple images should be addressed with meaningful confidence estimates.

The proposed approach should have a mathematical basis and/or intuitive underpinning and be computationally tractable on modern hardware (i.e., CPU / GPU). The proposer should provide software and a detailed technical report.

PHASE I: Design a proof-of-concept system to incorporate spatio-temporal context into the GEOINT analysis process. Offerors should clearly detail anticipated challenges associated with collection from different times, geometries, and platforms and how to address those challenges with processing and/or mitigation strategies, together with methods to provide uncertainty estimates for the automated analysis to be produced. The technical approach should be described in the report and be accompanied with a demonstration and/or experimental results on sample data.

PHASE II: Implement Phase I capabilities in software and apply to operational imagery. Design and develop a user interface and/or integrate with existing tools to expose algorithm functionality to imagery analysts. Deliverables include a final report and software.

PHASE III DUAL USE APPLICATIONS: Phase III would extend Phase II capabilities to other sensors or modalities, e.g., infrared (IR) or synthetic aperture (SAR). The technology can also be applied to commercial motion imagery systems to improve the quality and information content of video products. The system has military and Intelligence Community application for still and motion imagery content exploitation.

REFERENCES:
1. L. Fei-Fei, R. Fergus and P. Perona. “One-Shot learning of object categories.” IEEE Transactions on Pattern Analysis and Machine Intelligence, 28(4), 594 - 611, 2006.

2. W. Wang, et al. “A Survey of Zero-Shot Learning: Settings, Methods, and Applications.” ACM Transactions on Intelligent Systems and Technology, 10(2), article 13, 2019.

KEYWORDS: GEOINT, machine learning, neural networks, low-shot learning, artificial intelligence, spatio-temporal data, imagery, uncertainty estimation

NGA201-005 TITLE: Learning traffic camera locations using vehicle re-identification

TECHNOLOGY AREA(S): Information Systems

RESEARCH & TECHNOLOGY AREA(S):

ADVANCED CAPABILITIES:

ACQUISITION & SUSTAINMENT AOR:

OBJECTIVE: Learn the relationship between traffic cameras in order to infer geographical locations and orientations of an ensemble of traffic cameras.

DESCRIPTION: As cities continue to urbanize, surveillance cameras are increasingly used for the purpose of traffic monitoring and surveillance in intelligent transportation systems worldwide. As imagery and video technology has become more sophisticated and affordable, the quantity of these cameras have increased as well as the resolution and temporal frequency of collection, often approaching high-resolution video quality. This trend will only increase with the adoption of 5G technology, causing traffic camera imagery to become ever richer and more prevalent.

The precise location and orientation of a traffic camera are frequently not included in its imagery, often due to limited access. Thus, given feeds from an ensemble of traffic cameras from a region of interest (such as a neighborhood, city, or even broader parts of a country), the geographic relations between cameras are unknown. This makes the task of tracking or geo-locating a target or object of interest that may appear in camera imagery unfeasible.

However, there is information in the image content that can be leveraged to establish relations between cameras. Object detection (to include vehicle detection) is a well-studied computer vision problem. In particular, there have been advances deep learning research toward the problem of vehicle re-identification [1] across multiple cameras with different angles, illuminations, and resolutions.
The goal of this problem is to use computer vision techniques, including but not limited to vehicle re-identification, to model statistical correlations or similarities between pairs of cameras that correspond to geographical proximity. Given an ensemble of related traffic camera imagery, construct a proximal network among the cameras [2]. The induced network should approximate the physical road network thus providing estimates to camera location and

orientation.

PHASE I: Develop algorithms and demonstrate ability to perform multi-camera vehicle re-identification. Identify the statistical techniques used to correlate pairs of cameras based on computer vision capabilities developed.

PHASE II: Construct a working prototype that builds a network representing camera proximities using the technologies and tools identified in Phase I at scale. Demonstrate that this induced network provides geographical information by incorporating open source information such as physical road networks. Quantify estimates of geographic resolution and uncertainty.

PHASE III DUAL USE APPLICATIONS: Military Applications: Automated surveillance, Technical Intelligence, Photogrammetry, vehicle tracking and route prediction
Commercial Applications: Photogrammetry, Surveillance

REFERENCES:
1. Liu, Xinchen, et al. "Large-scale vehicle re-identification in urban surveillance videos." 2016 IEEE International Conference on Multimedia and Expo (ICME). IEEE, 2016.

2. Atanasov, Nikolay, et al. "Joint estimation and localization in sensor networks." 53rd IEEE Conference on Decision and Control. IEEE, 2014.

KEYWORDS: computer vision, deep learning, photogrammetry, pattern recognition

NGA201-006 TITLE: Automating tilt and roll in ground-based photos and video frames

TECHNOLOGY AREA(S): Information Systems

RESEARCH & TECHNOLOGY AREA(S):

ADVANCED CAPABILITIES:

ACQUISITION & SUSTAINMENT AOR:

OBJECTIVE: Fully automate the processes to recover camera orientation parameters in ground-based photos and video frames.

DESCRIPTION: NGA would like to better understand the earth using ground-based cameras and videos systems that are used at or close to the earth's surface. Analysts today use manual methods to recover orientation parameters by rotating them to adjust for roll displacement. Adjusting for pitch is also a manual process where analysts estimate the true horizon and add an upper and lower bound. We are looking to fully automate these techniques through advanced computer vision techniques. Due to the increasing resolution of consumer-grade cameras and video systems, it is now becoming possible to extract relevant image data from ground level photos and videos with high accuracy from a wide variety of sources. There have been several papers on this subject that describes research in these areas. This topic desires a fully automated batch processing module for use by government and commercial applications. The fully automated system will accept images in which a horizon has been labeled by computer vision techniques. The module will automatically estimate pitch and roll. Subsequently upper and lower error bounds for the horizon will be automatically estimated. By doing this it is possible to determine the pitch and roll of the camera to the ground-based photo or video frame without any examination of metadata. Offerors might want to suggest other ideas like a fully automated three point camera model solution established through using vanishing lines. This could help us automate other modules that we are currently looking at in our processing chain. Proposed evaluation criteria, and methods to obtain ground-truth imagery sets for both development and testing, should be specified in the proposal.

PHASE I: Identify potential solutions for estimating pitch and roll in ground based images when given an image and a previously extracted horizon line using advanced computer vision techniques. No metadata will be included in the image, but some government supplied testing data is available. The ground-based photos and video frames will need to have a pitch upper and lower bound identified and labeled. Design an approach to automate camera orientation parameters, with proof of concept demonstrations.

PHASE II: Obtain, develop, integrate, demonstrate and evaluate a prototype that incorporates real-world ground-based photos and video frames. Test and develop algorithmic methods to fully automate the extraction of camera orientation parameters while rigorously tracking error. Generate and/or collect a wide body of data for training and testing, and develop performance figures under varying operating conditions and varying sensor types, taking into account possible confounding factors.

PHASE III DUAL USE APPLICATIONS: Integrate a fully tested module as described above. Developers might consider licensing of software, but might also consider providing services against large databases of imagery supplied by commercial companies.

REFERENCES:

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