FRONTIER SI

AUSTRALIAN GEOSPATIAL-INTELLIGENCE ORGANISATION (AGO) ANALYTICS LAB PROGRAM

PROPOSAL BRIEFING DOCUMENT

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Objective

The Australian Geospatial-Intelligence Organisation (AGO) Analytics Lab Program (AGO Labs), coordinated through FrontierSI, is investigating a number of ways to better engage and work with industry. Specifically, the AGO is keen to attract a wider pool of companies and technologies to draw on for automated geospatial intelligence. The primary focus of this program is to address AGO capability challenges through a small number of short-term industry projects, with a focus on machine learning and analytics for producing automated imagery analysis, including automated object classification.

Satellite, aerial and drone imagery data that have been collected by AGO can be provided to successful partners if required either via a restricted environment or onsite at AGO depending on agreed contractual arrangements.

What is AGO Labs?

AGO Labs is a way for AGO to rapidly assess new technology capability through a challenge based six-month innovation program. From this process, learnings can be gathered about the barriers and opportunities for AGO to work with an increased breadth of companies. In turn, this could lead to a long-term mechanism for AGO to access, and provide, a pipeline of activities to industry for testing new innovations and thinking in analytics.

One project per Capability Challenge will be funded. The three AGO Capability Challenge Topics are briefly described below. It is recommended that organisations read the full description of each challenge topic to see background, use cases and evaluation criteria, published at https://frontiersi.com.au/opportunities/agolabs/. Further details can also be found in Appendices A, B and C.

Challenge Topic 1: Beautiful Contours

- AGO has to acquire, produce, store and manage global elevation data for delivery to Defence and broader Commonwealth government agencies. To meet even a fraction of those needs, AGO has to engage with vendors to procure diverse geospatial datasets, which includes accurate elevation products at varied scales and points of interest. This strategy supports AGO's mission through current Defence and Intelligence commitments and in turn, satisfies the specific needs of our customers that require greater elevation coverage.
- Over the next several years, AGO will be updating its GEOINT Mission Systems, including the components that store, exploit and manage elevation data. AGO will be using this as an opportunity to explore more advanced ways to meet the elevation data needs of our Defence and Government customers. In outlining this challenge, AGO intends to find innovative concepts, products and processes that will help inform the elevation data systems component of our future upgrade program.
- The capability challenge is split into three categories with various sub-components. There is a 'core' element of the capability challenge, as well as a series of associated 'issues' affecting the broader elevation data life cycle. Whilst it is essential to address the 'core' elements, the remainder are optional.
    - See Appendix A for full details.

Challenge Topic 2: Features Unsupervised

- AGO acquires vast amounts of commercial satellite imagery data over much of the world in order to produce geospatial information and intelligence for its Defence and Government customers. The data collected by AGO are notable for high-resolution, high-revisit rates, and are typically exploited using largely manual/supervised processes in order to create a variety of products.
- In the near future, AGO will significantly increase its access to commercial satellite imagery. To prepare for this change, AGO is seeking new ways to leverage its commercial imagery resources to both expand its GEOINT Mission capacities and enhance the productivity of its staff.
- This Challenge relates to finding new ways to leverage the GEOINT resources available to AGO. The outputs or impacts of these changes may only need to be marginal in order to have significant impact to Mission capacities. In particular, a potential solution is not required to replace an existing conventional spatial data production function to be worthwhile. As a result, this Challenge topic is split into two use-cases. A proposal will not have to address all (or perhaps any, if the idea is sufficiently exciting) of the use-cases in order to be selected.
    - See Appendix B for full details.

Challenge Topic 3: Low-cost object identification models

- AGO wants to explore the use of automated object identification capabilities to complement its existing imagery exploitation processes. The types of objects AGO are tasked to discover and identify from imagery are typically mobile, can be of various sizes (ranging from road vehicles, aircraft, and large ships) and are occasionally fleeting (do not exist for particularly long).

- Conventional Computer Vision and Pattern Recognition (CVPR) Machine Learning model building techniques typically require thousands of example images to train an algorithm, and still more to test and assess it. The development process for existing AGO object-identification ML-based CVPR models using satellite based Earth Observation (EO) images typically features a 5:1 temporal ratio for training-set cultivation to model-development.
- In order to make a meaningful contribution to automated imagery-exploitation processes AGO needs hundreds of effective models, as well as the capacity to build and deploy models to detect new/modified objects quickly. Current AGO model development process creates a significant bottleneck for AGO's capacity to implement automated object identification.
- AGO is looking for innovative ways to reduce the time required to create effective object identification models. The drivers for this change are numerous but are focused on being able to produce more and better models. In that context, it is expected that the potential responses will be reflective of some (but not all) of the various time-drivers for model creation. Whilst respondents do not have to categorise their responses according to these drivers, they will be required to identify where they believe that the greatest time/quality savings are expected to come from. Likewise, a technique or technology would not have to be applicable to all objects in order to be of interest: solutions for specific object-types will be of interest.
    - See Appendix C for further details

The following characteristics currently set the basis for the AGO Labs program:

- Work with new companies.
- Focus on Machine Learning and Analytics.
- Challenge based approach to industry innovation and capability.
- 3 x 6-month project grants.
- Labs program tested in 2019-20 with FrontierSI.

Timeline

Interested parties may submit an AGO Labs project proposal by completing a 2-page summary, using the template downloaded from the AGO Industry page, and emailing to the FrontierSI AGO Labs Project Manager, Chris Morgan, at agolabs@frontiersi.com.au **by 5:00 pm (AEDST), Friday, 6 September 2019**.

Projects will be shortlisted by a panel with representatives from both AGO and FrontierSI. Applicants may be contacted to provided further details on their proposals.

Successful Projects will be notified in September 2019. Projects are expected to start in October 2019 and delivered within a timeframe of 3 to 6 months.

Budget

One project per challenge topic will be funded by AGO Labs, with a budget of up to $100,000. There is no requirement that additional funding will be provided to the project by applicants.

As this activity will help companies pilot technology with AGO for potential future deployment, it is expected that applicants will not operate with full commercial rates, but instead will budget the project at-cost plus 30% overheads.

Intellectual Property

AGO may consider requests to make Background Intellectual Property in the form of data (Background IP) available to the Project, on a case by case basis, pursuant to a non-exclusive, royalty-free, worldwide licence to use the Background IP for the term of the Project and for the limited purposes of carrying out the Project.

Project Intellectual Property (Project IP) in the capability demonstrators produced in the course of the Project will be owned by the participating partners. The Australian Government is granted a perpetual licence to use any Project IP created for Defence Purposes generally (other than Commercialisation) including internal research, development, education and training.

Background IP of participating partners for the capability demonstrators is retained by the participating partners.

Technical and Data Support

Many of the challenge topics may be able to use data sources that the successful project partners already have access to. This is the preferred option for projects. Other open source data sets such as SpaceNet may also provide an option – refer https://spacenetchallenge.github.io/datasets/datasetHomePage.html.

Satellite, aerial and drone imagery data that have been collected by AGO may be provided to successful partners if required.

AGO will, if possible, make technical and operational support resources available to the companies to guide their solution development.

Additional Resources

A webinar will be completed within 1 week of releasing the call for projects. This webinar will include a presentation of the aims of the AGO Labs program, as well as interactive Q&A with AGO and FrontierSI.

Additional questions can be directed to FrontierSI at agolabs@frontiersi.com.au

Evaluation Criteria

Projects that meet the following criteria will be considered, and projects should use the AGO Labs Template found at the AGO Labs website https://frontiersi.com.au/opportunities/agolabs/.

Required

- Project outputs will address the challenge.
- Evaluation of the intended approach.
- Ability of AGO to access and test outputs iteratively during the project.
- Value for money.
- Outcomes that can be operationalised beyond the life of the project.

Constraints and Requirements

- The Australian Government contribution will be limited to $100,000 per project.
- Projects should be completed in a period of approximately a 3 to 6 months.
- A final project report is required at the end of the AGO Labs project.

The final project report should outline key findings and recommendations to FrontierSI and AGO. This report will include lessons learned and suggest options for industry partners to engage and work more effectively with AGO. It will also suggest options for AGO to engage and work more effectively with industry in an AGO Labs style program.

Appendix A – Challenge Topic 1: Beautiful Contours

AGO has to acquire, produce, store and manage global elevation data for delivery to Defence and broader Commonwealth government agencies. To meet even a fraction of those needs, AGO has to engage with vendors to procure diverse geospatial datasets, which includes accurate elevation products at varied scales and points of interest. This strategy supports AGO's mission through current Defence and Intelligence commitments and in turn, satisfies the specific needs of our customers that require greater elevation coverage.

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Elevation Data Challenges

CORE – Integrating variable resolution surfaces and elevation data

Available elevation datasets vary in scale from small (>30m) to large (<1m) regular post-spaced datasets, to irregular high-density point clouds. Integrating these datasets requires managing the various incongruities and artefacts embedded in each dataset. Moreover, addressing errors that may have been generated during capture, post-processing or other ambiguities due to the repetition of objects and terrain, often requires intensive manual analysis to guarantee location accuracy. Limiting elevation errors such as steps, breaks, noise and other artefacts is a key requirement for automated elevation and surface data processing techniques.

CORE – Refining accuracy

Elevation accuracy varies, in both absolute and relative terms, by between source and processing technique. Current means of elevation data integration via different sources are process-intensive and time consuming. Statistical means of reliably resolving 'best fit' elevation accuracy ratings autonomously would limit manual data analysis, improve efficiency in data cataloguing and the utility of diverse datasets.

Stereo-pair discovery

AGO has an expansive library of images over various locations with significant image-recapture. Finding image sources and pairs suitable for stereo-based elevation data extract or elevation data processing can be problematic and time consuming. Pair discovery or nomination services to identify imagery suitable for manual, supervised and unsupervised elevation generation are high highly desirable.

Automated surface-extraction from stereo-pairs

Manually deriving elevation datasets from imagery is a well understood process. AGO are seeking autonomous, reliable and effective methods of deriving first returns, bare earths, and contiguous vertical surfaces (e.g. buildings and man-made structures) from stereo image pairs.

CORE – Building and maintaining surface and bare-earth elevation datasets

A key objective of building a global data-baseline at diverse scales is advancing processing methodology to generate timely elevation products for digital exploitation. Furthermore, creating alternate elevation products from baseline data on a 'as need basis' is an additional consideration. The capability challenge has three elements:

a) How to automate surface and bare-earth dataset creation (or significantly speed up the process)

b) How to autonomously detect surface or elevation dataset change

c) How to automate the update and maintenance of surface and bare-earth datasets

As traditional elevation and surface dataset generation is a process and computationally-intensive process, AGO is searching for a means of mitigating the need for repetitive product re-creation. AGO would instead like to understand the potential for updating only features that require revision and re-processing.

Product Challenges

CORE – Contour Generation

An automatic process for contour line generation, at a global or continental scale, is both procedurally and computationally challenging and time consuming. The effectiveness of contours are driven by their capacity to effectively communicate elevation and terrain features to a reader (a person/not a computer). The precision-requirements of contours are driven by the legibility and communicability of the cartographic product. This introduces a key complexity associated with the need to be internally consistent with complementary vectors that comprise the cartographic dataset (such as spot heights, infrastructure, vegetation and lines of communication features). Particular challenges include:

a) Seamless continuation of contours between adjacent tiles and/or map sheets

b) Smooth (not jagged) contour lines, while maintaining the character and overall impression of the contour lines

c) Irregularities that include contours without connection on either side, contour intersections, contour nodes representing multi-arc-connections and dead-ends

d) Internal consistency with other features, including infrastructure and terrain features

e) Removal of redundant contours and/or noise

f) Automatic cleaning and validation of contour lines

g) Diverse contour datasets at varied spacing to serve multiple product lines

CORE – Generating Elevation Features

AGO is interested in unsupervised generation of traditional and non-traditional elevation features. This may include spot heights, escarpments and cliffs, points of interest, and elevation profiles.

Quality Assurance

Current cartographic-product quality checking and verification methods are manual, labour intensive and time consuming. A more streamlined approach with limited supervision will improve overall productivity.

Drainage enforcement

Drainage basin delineation presents a complex capability challenge due to feature sensitivities associated with elevation uncertainty in such regions. Particular interest relates to the automatic generation of elevation products and associated errors relating to the drainage lines and basins. Reducing manual intervention and improving automatic processing to integrate diverse datasets that output products with sufficient accuracy is essential toward elevation dataset maturity.

Evaluation

In evaluating applications, AGO will be prioritising autonomy and innovation that can influence the lifecycle of elevation dataset interactions. Concepts that seek to explore or employ some level of applied statistical modelling or Artificial Intelligence techniques or technologies will be desirable, but not essential.

Appendix B – Challenge Topic 2: Features Unsupervised

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Use case-1: Intelligent change detection & alerting.

AGO maintains data and mapping products over various Defence sites, including Defence Training Areas and bases. These products fill a range of planning and management functions in Defence, including for the safe storage and use of ordnance. Changes within Training Areas need to be monitored to instigate an update for products, however factors outside Defence lands also have an effect. For example, over time, population growth and urban sprawl brings people closer and closer to previously remote Defence sites. As a precautionary measure, AGO periodically checks for changes in nearby public infrastructure.

With the high revisit rate of commercial imagery, AGO would like to use Computer Vision and Pattern Recognition techniques to detect and classify feature changes. What makes this different from disturbance detection is that AGO is seeking a more intelligent solution to provide an indication of the type of change (for example: addition, subtraction, modification) to features of interest. The types of features of interest include:

a) roads, rail and bridges

b) buildings and building types

c) utilities (power & communications)

d) landcover/vegetation

Ideally, this use case would result in a series of different change-detected features, together with a likelihood estimate of their integrity.

The output likelihood would be used to monitor key features which may differ across each Defence site, such as:

a) Any additions/deletions to overhead power lines near a Training Area used by helicopters would trigger an instant data update for safety purposes

b) Urban encroachment to a Defence site storing explosive ordnance (conventional geo-fencing algorithm) would trigger an advice to base operations

c) A set level of percentage change of road coverage within a Defence site would initiate new products, however percentage change of road coverage outside the site but within the map extent may not.

Use case-2: The features most-likely

Conventional unsupervised feature generation from imagery typically requires that users trade off the volume of false positives (features identified that are not really there) or false negatives (missing features that are there). However, what AGO would like to explore is whether the volume of imagery, and the high revisit rate (multiple collections over the same target, over time) may change that dynamic.

The capability that AGO is seeking to explore is whether the opportunity of multiple source images can be used to reliably improve the automated feature generation process. It is envisaged that this capability would be used to maintain a "most likely" feature dataset, as well as most recent and historical coverages. Features that can be investigated are any non-transient ground feature. Candidates should include a summary of those features they would explore in their study.

Evaluation

In evaluating applications, AGO will be prioritising autonomy and innovation, particularly those using autonomous Computer Vision techniques using Artificial Intelligence/Machine Learning technologies and techniques.

Appendix C – Challenge Topic 3: Low-cost object identification models

AGO wants to explore the use of automated object identification capabilities to complement its existing imagery exploitation processes. The types of objects AGO are tasked to discover and identify from imagery are typically

mobile, can be of various sizes (ranging from road vehicles, aircraft, and large ships) and are occasionally fleeting (do not exist for particularly long).

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Category-1: Minimalist training sets

Techniques and technologies to reduce the number of starting training sets may include such techniques as using synthetic data to complement real data, techniques that require less starting data, or technologies that are able to speed the process of training set-preparation and cultivation.

Category-2: Improved object identification efficacy

These may include general model-development techniques, or specific techniques for particular object types. The latter category may be similar to that described in Aircraft Type Recognition in Remote Sensing Images … by Yuhang Zhang, Hao Sun, Jiawei Zuo, Hongqi Wang, Guangluan Xu and Xian Sun, https://doi.org/10.3390/rs10071123) at an enterprise scale.

Category-3: Model (or algorithm) lifecycle management

This category relates to the management and use of CVPR models over their life cycle. These would include such considerations as model-retraining and model-assurance.

Evaluation

In evaluating applications, AGO will be prioritising the efficacy of the proposed techniques, technologies or processes: both quantitative and qualitative estimates of fielding object identification models. Respondents are not constrained to the categories identified, though an explanation of how a specific technique or technology may offer improved capacity improvement will be required.