PS-03: Visual Search, Retrieval & Detection in Satellite Imageries

1. General Description

The spate of the recent years has witnessed an explosion in satellite imagery that has opened tremendous opportunities for variety of applications like urban planning, environmental monitoring, disaster response etc. Effective use of such data, though, depends extensively on large-scale and accurate annotated datasets, especially for training object detection solutions to automatically detect and localize certain objects like buildings, vehicles etc. Manual annotation of satellite images is a very time-consuming, labour-intensive and expensive task because of the varying resolution of images, the complexity of the scenes and the requirement of expert knowledge to differentiate between visually similar objects. Hence, there is a need to create a scalable, efficient and automatic solution that can do search, retrieve and detect any given object/target features in multispectral satellite imagery datasets. The underlying goal of this problem is to develop a system or framework that accepts one or few image sample/s (not more than 5 image samples/chips) of any object/feature class and can automatically search, identify and detect that object in a wide range of satellite images, producing labeled datasets that can be further used to train and fine-tuned an object detection solutions directly. The solution will allow users to provide input by either uploading an image chip of a feature/object of interest or drawing a box around a feature/object of interest over a selected imagery. Participants are encouraged to view commercially available solution like "The AI Accelerator of RAIC Labs" (https://raiclabs.com/products/ai-accelerator/)," Orcahunter modules of BlackShark.ai (https://blackshark.ai/orcahuntr/)", which can be used as references.

2. Problem Statement

a. Input by uploading sample image chip/s of desired feature/object

<div align="center">OR</div>

Selection of image chip/ feature/object of interest on any satellite imagery by drawing a box using User Interface.

Both modes of input need to be implemented in the solution.

b. Using the uploaded (or selected on image) chip/s, a Visual Search must execute on Multispectral Satellite Imageries provided by Organiser.

3. Expected Outcomes

a. Stage-1

I. Search results to be shown with matching image chips and corresponding satellite imagery.

II. Output file format is explained in the evaluation section under paragraph 9 of the statement.

b. Stage-2: In Stage-2, participants need to develop Visual Search, Retrieval & Detection in Satellite imageries with addition of more number of classes and dataset of 0.5 m spatial resolution. More details will be updated to Stage-1 selected teams/participants.

c. Stage-3: In Stage-3, participants need to develop Visual Search, Retrieval & Detection in Satellite imageries, however, it will be on-premise and on organiser dataset. More details will be updated to Stage-2 selected teams/participants.

4. **Solution Requirement:** The main objective of this problem statement is to develop a solution that accepts one or few image sample/s of any object/feature class and can automatically search, identify and detect that object/feature in a wide range of satellite images, producing labeled datasets which can be further used to train and fine-tune object detection solutions directly. The solution will allow users to provide input by uploading an image chip of a feature/object of interest or drawing a box around a feature/object of interest over a selected imagery. The AI Accelerator of RAIC Labs (https://raiclabs.com/products/ai-accelerator/), Orcahunter modules of BlackShark.ai (https://blackshark.ai/orcahuntr/) can be used as references. Any choices of development, parameters, or working architecture of a solution are up to participants. Any language or framework can be used to develop the solution. **It is to be noted that the solution expected in this Problem Statement is not an object detection solution. So, it should be developed as a generic visual search on the basis of example image chip/s, small example set also shared for reference (Refer Paragraph 7).**

5. **Datasets**

Stage	Type of Dataset	Format	Objects /features to be searched	Remarks
Stage-1	03 meters Multi-spectral Satellite Imagery without georeference	Tiff File (04 bands in Blue, Green, Red and NIR) without georeference	1. Playground 2. Brick Kiln 3. Metro Shed 4. Pond-1 (Dried) 5. Pond-2 (Filled) 6. Sheds 7. Solar Panel 8. STP (Sewerage Treatment Plant)	Mentioned Objects/features are for development reference and generating search results on Mock dataset. **However, Solution should be able to perform any generic feature/object search on the**

				basis of input sample.
Stage-2	0.5 meters multi-spectral Satellite Imagery without georeference	Tiff File (04 bands in Blue, Green, Red and Near-Infra-Red) without georeference	Object/feature classes will be disclosed to Stage-1 selected teams/participants.	Further information will be updated before start of Stage-2.
Stage-3 (In Organiser Premises)	Dataset will be provided by the organiser.	Electro Optical Imagery in Tiff/JP2 file formats *with* georeference	Object/feature classes will be disclosed to Stage-2 selected teams/participants.	Further information will be updated before start of Stage-3.

6. **Dataset arrangement for Stage-1: -**

   a. **Training Dataset:** Folder "training_set.zip" contains images for the solution development. It will be released at T0 i.e. 01st Aug 2025.

   b. **Mock/ Testing Dataset:** Folder "testing_set.zip" contains images which teams/participants should test their solution on, to generate results for specific objects, but will not have access to the corresponding labels during the Challenge. Teams/Participants can submit results of their solution on this set. A leader board will be displayed indicating ranking of their solution based on mAP. The submitted results against Mock Dataset will not be used to evaluate the solution by Organiser. This set will be released on T0 + 45 days i.e. 15th Sep 2025. Solutions can be submitted on every Thursday from week commencing 15th Sep 2025.

   c. **Short_listing/ Pre-Evaluation Dataset:** Folder "short_listing_set.zip" is a pre-evaluation dataset. It will be released on 31st Oct 2025 @ 1200 Hrs for download. Participants have to finally submit the results of their solution on this set for the Stage-1 evaluation till 1600 Hrs of the same day i.e. 31st Oct 2025. Along with the results, the solution and all its associated files need to be zipped and hash value should be generated and submitted by participants on 31st Oct 2025. The Hash value of the solution will be verified during an offline evaluation of the selected participants. They will be shortlisted based on evaluation of their submitted results against this Shortlisting/ Pre-evaluation Dataset only. Hence, it is mandatory for participants to submit their results timely.

   d. **Sample Set:** Folder "sample_set.zip" has example images with corresponding json file having objects/features and extents as mentioned

in Paragraph 5 Table for Stage-1. This set will be released at T0 i.e. 01st Aug 2025.

e. **Holdout Dataset/ Evaluation Dataset:** This set will be made available during offline evaluation after Stage-1 deadline i.e. post 31st Oct 2025. A dataset (hold-out set) will be given to the participants, called for offline evaluation, to run their solution on this dataset. The object classes of this dataset will be different from Mock and Shortlisting Dataset to check the generic nature of the developed visual search solution.

7. **Dataset Guidelines for Stage-1**
As a Visual Search and Detection Challenge, the task is to search and locate bounding boxes around each matching object in input set of satellite imageries. Bounding boxes define the extent of each searched object in respective satellite image. A single image may contain nil, one or more matching objects, or many. As and when available, the dataset will be organised as per the following details: -
   I. **training_set.zip** contains 150 satellite images having four (04) bands of 03-meter resolution in TIFF format without any georeference and labels.
   II. **testing_set.zip** contains 40 satellite images having four (04) bands of 03-meter resolution in TIFF format without any georeference.
   III. **short_listing_set.zip** contains 40 satellite images having four (04) bands of 03-meter resolution in TIFF format without any georeference.
   IV. **sample_set.zip** contains 09 satellite images having four (04) bands of 03-meter resolution and sample json files with objects extents for visual references.
   V. **utilities.zip** has the Jupyter notebook to visualize the sample imagery and corresponding json files.

8. **Sessions with Mentors\Experts**
   a. For Stage-1, the organisers plan to meet participants via online meet or email to resolve their doubts, if any. This provision will be made active from 15th Aug 2025 and details regarding interaction will be shared on this website. Kindly keep viewing this website regularly for updates on this.
   b. There will be sessions with Mentors\Experts in Stage-2 and Stage-3 for the willing selected participants to help them in achieving the best solutions.

9. **Evaluation Methodology for Stage-1**
   a. **Online Solution Evaluation during Stage-1**
      I. General Instructions
         i. Participants can see their ranking against the submitted results generated on **testing_set.zip** which will be hosted

on 15th Sep 2025. Ranking, using a leader-board, will be released by Tuesday of corresponding week commencing 15th Sep 2025.

ii. On 31st Oct 2025, **short_listing_set.zip** dataset will be made available for participants for the duration 1200 Hrs till 1600 Hrs. They need to download, generate results and submit them in given time-window (1200 Hrs – 1600 Hrs).

iii. The final evaluation of the participants will be carried out on the results submitted by them against **short_listing_set.zip** dataset. 15-20 participants will be shortlisted for offline evaluation based on their ranking on **short_listing_set.zip** dataset. The number may vary based on the overall performance at the discretion of the Jury for this Problem Statement. The shortlisted participants will be published along with the cutoff score as per the evaluation criteria. Participants individual scores will be shared over the email.

iv. Scores will be computed based on the evaluation metrics indicated below: -

Category	Criteria	Description
Metric Evaluation	mAP Score (0 – 100%)	Score based on official metric on mock/ testing dataset satellite imagery and features/object class of organizer mentioned in dataset description as mentioned in table of paragraph 5 (Dataset Section).

II. Input

Your solution must take following inputs:

i. Load sample image chip/s or give provision to open tiff imagery for further drawing boxes around desired feature/object to select image chip/s.

ii. Ask the target directory/directories of satellite imagery datasets on which visual search should run.

iii. Ask the location of output directory

III. Output

i. Run your Visual Search Solution on all the satellite imageries in target folder to match the sample chip/s and generate output files.

ii. The output text file is a space-delimited flat text file without headers, as defined below.

iii. The space-delimited fields in the output file are: [x_min, y_min, x_max, y_max, searched_object_name, target_imagery_file_name, similarity_ score]

iv. The coordinate values are the corners of the matching feature bounding box as generated by the solution after visual search and detection; the x-min and y-min values define the top left corner of the bounding box, followed by the x-max and y-max values that define the lower right corner of the bounding box. Similarity or confidence score value is in number if any. In case, there is no similarity score then mention -1 in respective column of output file.

v. Each submission should be named and dated properly such as GC_PS03_[DD-MMM-YYYY]_[Start-up/Group Name without Space].txt.

vi. Output files generated on mock/ testing dataset should be submitted for evaluation.

vii. Results generated on **testing_set.zip** will be evaluated against reference labels of test dataset residing with the organizers. Based on accuracy, the leader-board will be updated to indicate the performance of the solutions.

viii. Results generated on short_listing_set.zip will be evaluated for final selection of top 15-20 participants. Along with results, hash value (using MD5 algorithm) of the solution needs to be submitted by the participant on 31st Oct 2025. The solution and all its associated files need to be zipped and hash value should be generated and submitted. During offline evaluation, the same zip file with the associated solution files should be utilized.

ix. Submissions found incomplete in any manner will not be considered for further processing.

b. **Offline Solution Evaluation after Stage-1 Deadline**

I. Selected participants will be asked to generate the hash value of the solution before any demonstration of the solution. This hash value will be verified with the one submitted by participant on 31st Oct 2025. If any unfair means/practices are found used by participant team, they will be disqualified and organiser can call next participant from the leader board for evaluation.

II. Participant will demonstrate their solution at IIT Delhi on completion of Stage-1 deadline on hold-out dataset.

III. Participants will be allotted slots in which they need to run their solution on reference data provided by the organizers on given resources with following specifications: -

i. OS – Ubuntu 24.04 LTS

ii. CPU – 48+ core

iii. RAM – 256+ GB

iv. GPU - 40 GB

v. Solution Demo Duration: 02 Hours for each selected participant

IV. Based on the results from solution demonstration and presentation, final scores will be computed based on Evaluation Metrics as mentioned below:

Category	Criteria	Description	% Weight
Solution Evaluation And Sample Count	mAP Score	Score based on official metric on hidden hold-out satellite imagery and features/object class of organizer	50
	Number of Sample Image Chips	Minimum number of sample image chips of desired object/feature should be used	
Resource Utilization	Inference Time and Solution Memory Footprint	Solution Execution time on holdout dataset and Memory used by Solution during execution	15
Approach	Methodologies of Solution Development	Start-up need to present Solution development approaches & proposed Architecture	25
Team Capabilities	Technical Capabilities of Start-up Team	Team Composition, Qualifications, Experience and ability to complete the challenge end to end.	10

c. Participants are free to use any language or development framework for the solution.

d. At most top 6 teams will be selected based on final score for Stage-2.

10. Evaluation Criteria for Stage-II is mentioned below:

a. Selected participants will be provided datasets and the object/feature classes as mentioned in Stage-2 under Section 5 - Datasets.

b. Based on the results from solution demonstration and presentation, final scores will be computed based on Evaluation Metrics as mentioned below:

Category	Criteria	Description	% Weight
Solution	mAP Score	Score based on official	50

Evaluation		metric on hidden hold-out satellite imagery and features/object class of organizer	
Resource Utilization	Inference Time and Solution Memory Footprint	Solution Execution time on holdout dataset and Memory used by Solution during execution	30
Sample Count	Number of Sample Image Chips	Minimum number of sample image chips of desired object/feature should be used	10
Approach	Methodologies of Solution Development	Start-up need to present Solution development approaches & proposed Architecture	10

11. Evaluation Criteria for Stage-III would be similar as above.