PS-11: AI/ML Based Spectral-Spatial Anomaly Detection in Hyperspectral and Thermal (IR) Remote Sensing Datasets

PS Description:

Anomaly detection in **hyperspectral** and **thermal remote sensing** datasets is a critical task in remote sensing applications such as environmental monitoring, mining, precision agriculture, and disaster management. These datasets offer rich spectral and/or thermal information, allowing the identification of materials, objects, or behaviours that deviate from the norm.

Hyperspectral data cubes contain images in hundreds of contiguous spectral bands, where each pixel has a spectral signature, making it possible to distinguish materials. Deep learning based spectral-spatial anomaly detection results (suppressing natural anomalies) would eventually enhance the data interpretability and material identification.

Similarly, slight temperature changes due to human activities such as industrial operations, fire incidents, machine operations etc. in thermal datasets could be detected using deep learning based thermal anomaly detection and subsequent material identification referencing material thermal emissivity.

Objectives:

1) Manmade anomaly detection using satellite hyperspectral images (400-2500 nm) through deep learning and Generative AI.
2) Characterization of materials in detected anomalies (pixels) through spectral data analytics.
3) Thermal anomalies detection associated with human activities using deep learning techniques.
4) Characterization and identification of thermal anomalies using thermal emissivity of various materials.
5) Multimodal sensor data fusion (thermal and Hyperspectral) to augment anomaly detection.

Stages, Datasets, Desired Outputs & Rules:

S No	Stage	Time-line	Datasets	Desired Outputs	Accuracy Assessment Rules
1.	I (03 months in total)	T0+45 days	**Training Datasets** **Hyperspectral** https://zephyrhours.github.io/sources.html https://paperswithcode.com/datasets?mod=hyperspectral-images&page=1 https://www.scidb.cn/en/detail?dataSetId=5badf8a68a70450c9fe60b0accb6db27 https://ieee-dataport.org/documents/hyperspectral-anomaly-detection-data https://github.com/NomanShahRaza/hyperspectral_anomaly_datasets https://github.com/lzw-lzw/Hyperspectral-anomaly-detection-methods/tree/master/DATASET https://data.niaid.nih.gov/resources?id=zenodo_13370799 **Training Datasets** **Thermal** https://ieee-dataport.org/documents/mirsat-ql https://ieee-dataport.org/documents/fa	Start-Ups should be able to train their deep learning model(s) for anomaly detection using these open source hyperspectral and thermal datasets. They are free to supplement it with other datasets. Natural anomalies for both datasets should be supressed. Proposed model should be able to capture anomalies in 30 Km x 30 Km or larger hyperspectral images with spatial resolution ranging from 5 to 30 m. Thermal-IR anomaly detection model should be able to work in video as well as satellite images. It should not be constrained by spatial resolution of datasets. The participants can focus on assessment of their trained models based on parameters given in subsequent column.	Combination of statistical measures and visual evaluation. F1 score, ROC-AUC, PR- AUC and comparing the algorithm's anomaly detection results with the ground truth map by experts.

S No	Stage	Time -line	Datasets	Desired Outputs	Accuracy Assessment Rules
			r-ir-images-semantic-segmentation https://ieee-dataport.org/documents/flame2-dt https://ieee-dataport.org/open-access/flame-2-fire-detection-and-modeling-aerial-multi-spectral-image-00dataset https://ieee-dataport.org/open-access/flame-3-radiometric-thermal-uav-imagery-wildfire-management https://ieee-dataport.org/open-access/tight-masks-kaist-thermal-pedestrian-images		
2.		T45+ 45 days	**Mock Datasets** **Hyperspectral** After initial 45 days, 01 selected PRISMA / EnMAP hyperspectral image would be provided for testing the efficiency of proposed anomaly detection deep learning model. **Thermal** After initial 45 days, 01 selected Landsat-8/9 thermal / SWIR image would be provided for testing the efficiency of proposed thermal	Proposed model(s) should be able to handle and undertake necessary pre-processing steps in real satellite hyperspectral and thermal images & videos. Non-natural spectral and thermal anomalies should be detected from these datasets.	F1 score, ROC-AUC, PR- AUC and comparing the algorithm's anomaly detection results with the ground truth map by experts. Speed of anomaly detection and computational hardware requirements would be factorized. **Ground truth datasets for given each PRISMA / EnMAP & Landsat-8/9 images would be provided on 15 Oct 2025, so that Start-Ups can judge their performance.**

S No	Stage	Time-line	Datasets	Desired Outputs	Accuracy Assessment Rules
			anomaly detection deep learning model.		**Everything done till here is for self-assessment and would not be used for shortlisting.**
3.	Shortlisting of top 15-20 participants at the end of Stage-1		**<u>Shortlisting Datasets (shortlisting of top 15-20 participants)</u>** **<u>Hyperspectral datasets</u>** On 30 Oct 2025 at 1100h , 01 selected PRISMA / EnMAP hyperspectral image would be provided. **<u>Thermal datasets</u>** On 30 Oct 2025 at 1100h, 01 selected Landsat-8/9 thermal / SWIR image would be provided.	Proposed model(s) should be able to handle and undertake necessary pre-processing steps in satellite hyperspectral and thermal images & videos. Non-natural spectral and thermal anomalies should be detected from these datasets.	Start-Ups need to submit the Hash Value of the final model in a text file along with the anomaly detection results on shortlisting datasets. The Hash value of the model will be verified during the offline evaluation of the selected participants. **Report format to be submitted by Start-Ups for evaluation (PRISMA & Landsat shortlisting datasets).** 1) Hash Values of the final model in a text file. 2) Anomaly detection results in geotiff and .png formats. 3) Accuracy report in excel format with data name (Prisma/EnMAP and Landsat-), overall accuracy, F1 score, ROC-AUC, PR- AUC values and hardware used.

S No	Stage	Time -line	Datasets	Desired Outputs	Accuracy Assessment Rules
					4) Naming of all files should include Start-Up name. **<u>Deadlines for reports submission:</u>** **By 2359h on 31 Oct 2025 (Shortlisting Datasets.)**
4.	Offline Evaluation of the 15-20 Shortlisted participants at the end of Stage-1		**<u>Holdout ground truth datasets:</u>** **01 set each ground truth maps for PRISMA/ EnMAP & Landsat-8/9 datasets published on 30 Oct 2025 wouldn't be provided to start-ups. These two would be utilized for evaluation & shortlisting of 15-20 top participants, at the end of Stage-1.** **<u>Holdout Dataset (for offline/ on prem evaluation of shortlisted participants)</u>** **01 set each of PRISMA/EnMAP & Landsat-8/9 datasets to evaluate 15-20 shortlisted start-ups will be provided at IITD premises on the day of offline evaluation.** **<u>Holdout ground truth datasets:</u>** **01 set corresponding ground truth maps for PRISMA/EnMAP & Landsat-8/9 (on prem evaluation datasets)**	Proposed model(s) should be able to handle and undertake necessary pre-processing steps in satellite hyperspectral and thermal images & videos. Non-natural spectral and thermal anomalies should be detected from these datasets.	**15-20 Shortlisted start-ups would be provided with A100 80 GB (with 2 hrs time limit**) to run their respective models at IITD premises. The number may vary based on the overall performance at the discretion of the Jury for this Problem Statement. he shortlisted participants will be published alongwith the cutoff score as per the evaluation criteria. Participants individual scores will be shared over the email. A maximum of 6 participants would be shortlisted for Stage-2 **<u>Marking criteria</u>:** **Detailed report submitted by Start-Ups: 30% (Team composition 6%, understanding of the PS 12% and approach adopted for the solution proposed 12%)**

S No	Stage	Time -line	Datasets	Desired Outputs	Accuracy Assessment Rules
			wouldn't be provided to start-ups. These two would be utilized for final offline evaluation. Once the evaluation by experts is undertaken corresponding ground truth images would be published along with selected Start-Ups performance reports and cut off. The performance reports of other startups would be sent to them online.		**Hyperspectral anomaly findings and relevance: 40% (accuracy 15%, model complexity 10 % and hardware requirements 15%)** **Thermal anomaly findings and relevance: 30% (accuracy 10%, model complexity 10% and hardware requirements 10%)**
5.	II	04 Months	PRISMA / EnMAP hyperspectral images SWIR & Thermal bands of Landsat-8/9 satellites SatVU thermal datasets	Matching of spectral anomalies with signature libraries. Monitoring industrial activities, forest fire etc. Material matching using reference thermal emissivity. Interface development for anomaly hyperspectral and thermal detection. Further information, if any, will be released to Stage-2 participants before the beginning of Stage-2.	F1 score, ROC-AUC, PR- AUC and comparing the algorithm's anomaly detection results with the ground truth map by experts. Speed of anomaly detection and computational hardware requirements would be factorized.
6.	III	05 months	Start-Ups working within premises Own hyperspectral & thermal datasets	Monitoring activities of interest using hyperspectral and thermal datasets. Spectral and thermal signature matching and classification	F1 score, ROC-AUC, PR- AUC and comparing the algorithm's anomaly detection results with the ground truth map by experts. Speed of anomaly detection and computational hardware

S No	Stage	Time -line	Datasets	Desired Outputs	Accuracy Assessment Rules
				Interface development for anomaly detection and signature matching in hyperspectral & thermal datasets Further information, if any, will be released to Stage-3 participants before the beginning of Stage-3.	requirements would be factorized.

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.