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TAKING THE PULSE OF OUR PLANET FROM SPACE

EUMETSAT ECMWF EUSPA

Generative Models for Semantic Information Discovery in EO Images

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24 May 2022

Introduction

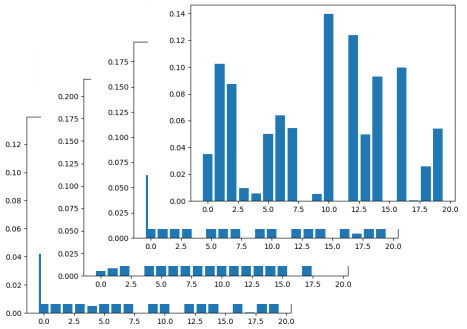
Semantic Data Mining is Earth Observation

Data Mining

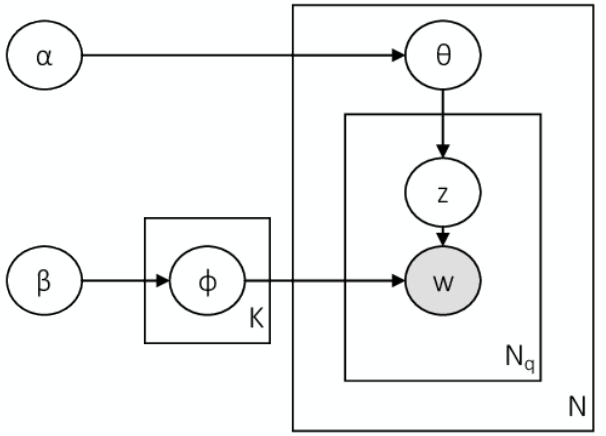
Semantic Data Mining

Data Mining Techniques

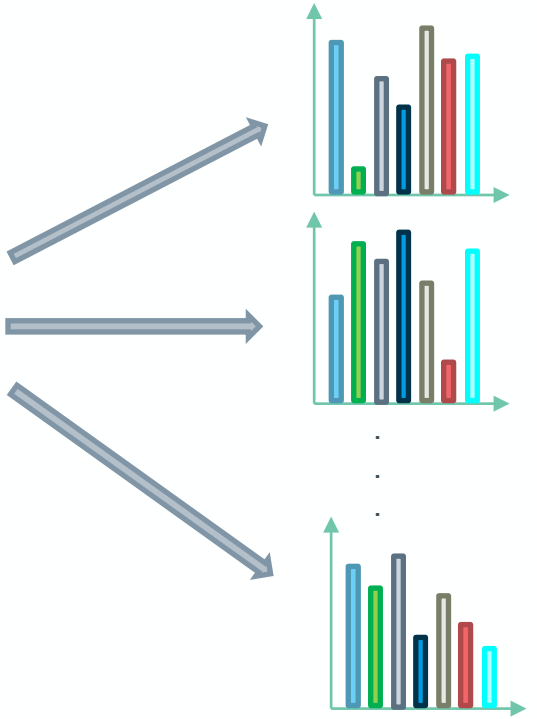
Latent Dirichlet Allocation (LDA)



BOVW Representations



LDA Topic Modeling



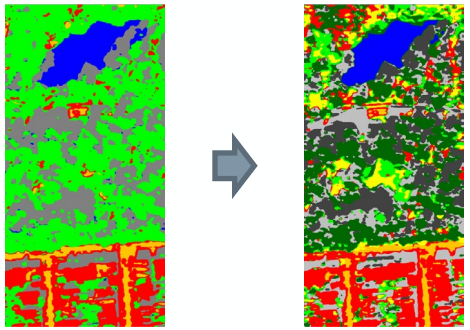
Topics

α, β	Dirichlet Distribution	K	Topics
θ, Φ	Multinomial Distribution	N_q	Documents
Z	Generated Topics	N	Corpus
W	Generated Words		

Experimental Scenarios

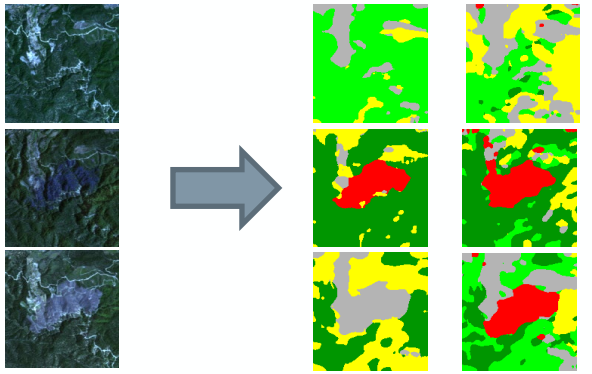
Scenario 1

- Identify neglected semantic classes and correct the GT
- Coincide the semantic perception of machine and human user
- Very high resolution (0.3 m) RGB aerial imagery



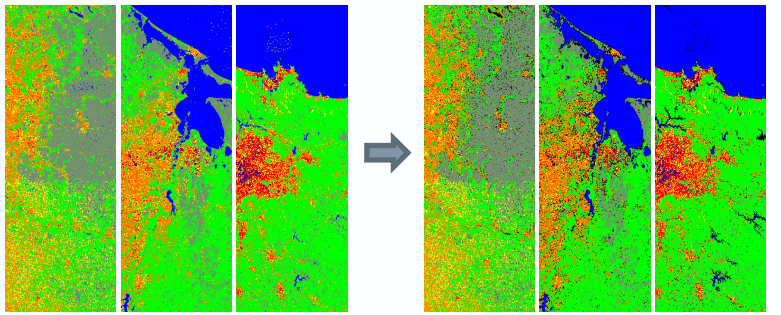
Scenario 2

- Unsupervised wildfire affected area detection
- Detection in a few days and several months after the incident
- Informative spectral bands detection
- Moderate resolution (10 m) multispectral satellite imagery, Sentinel-2



Scenario 3

- Semantic annotation analysis
- Detection of the misclassified or ambiguous patches
- Benchmark dataset annotation enhancement
- StripMap (SM) mode Synthetic Aperture Radar (SAR) satellite imagery, Sentinel-1



- M. Asiyabi, R. and Datcu, M., 2022. Earth Observation Semantic Data Mining: Latent Dirichlet Allocation-Based Approach. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 15, pp.2607-2620.
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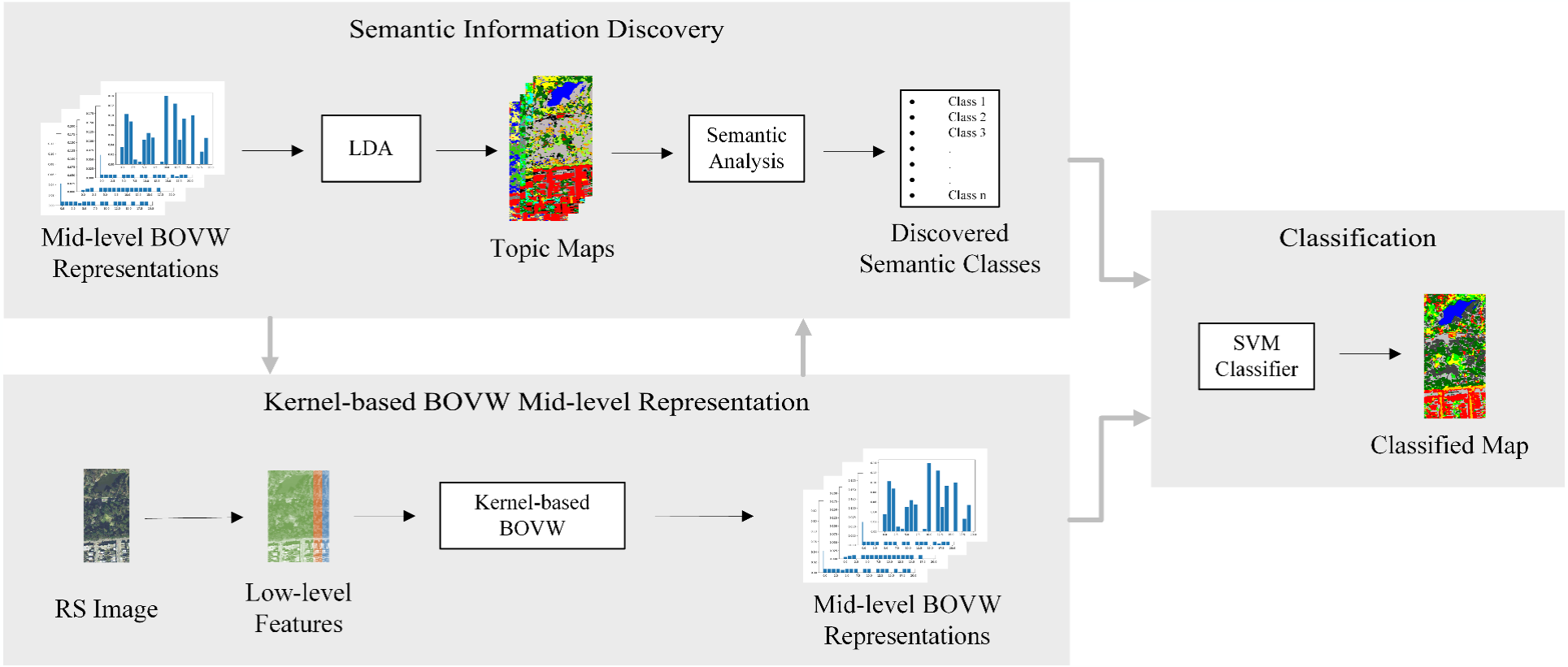
Experimental Scenarios

Scenario 1: Submeter Resolution Land Cover Mapping

Agency:	United States Geological Survey (USGS)
Location:	San Francisco, USA
Acquisition data:	September 2008
Spectral Bands:	3 RGB bands
Spatial Resolution:	0.3 m
Subset Size:	651 × 1323 Pixels

Experimental Scenarios

Scenario 1: Submeter Resolution Land Cover Mapping



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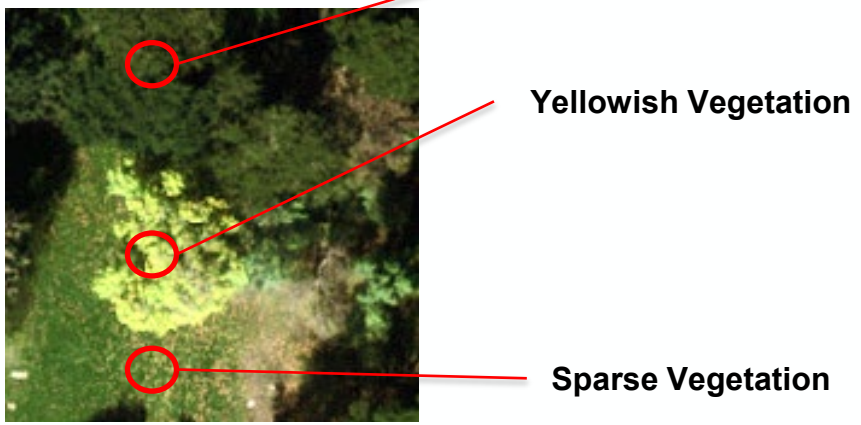

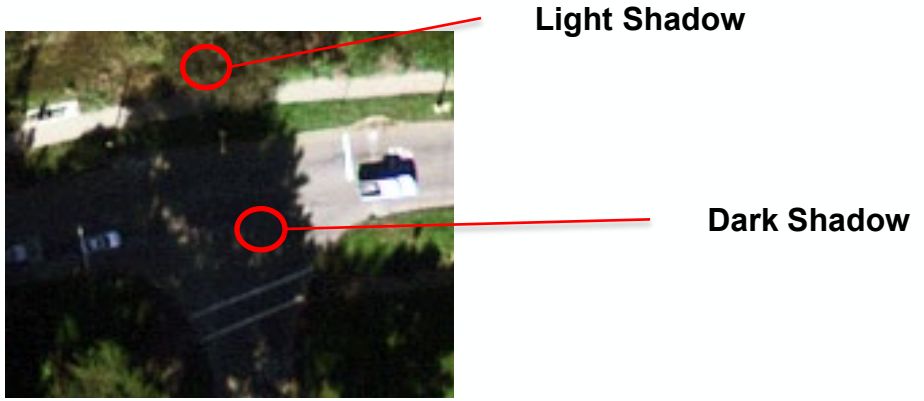

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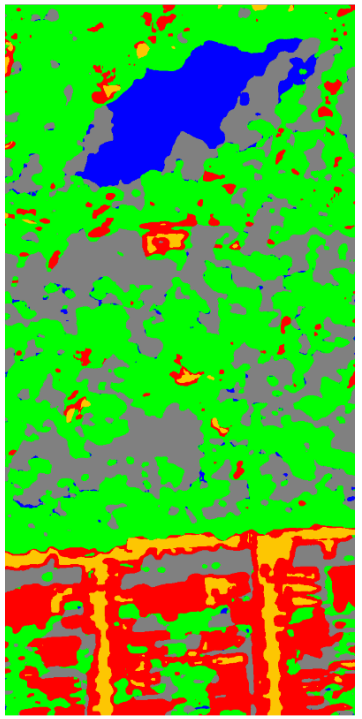
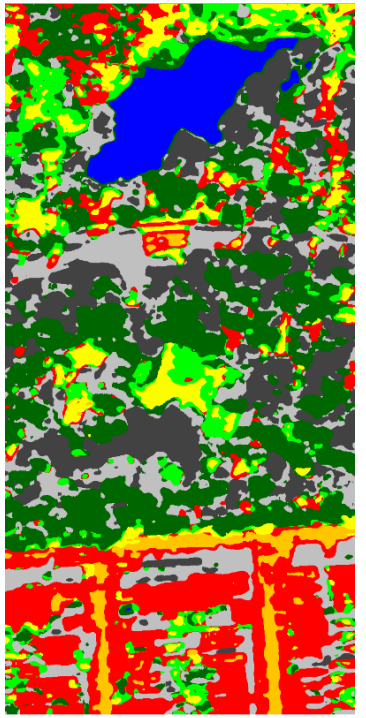
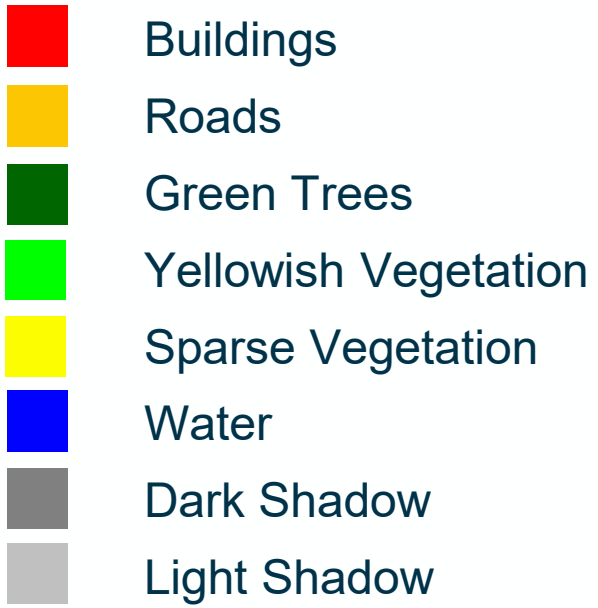


5-Class Classified Map





8-Class Classified Map

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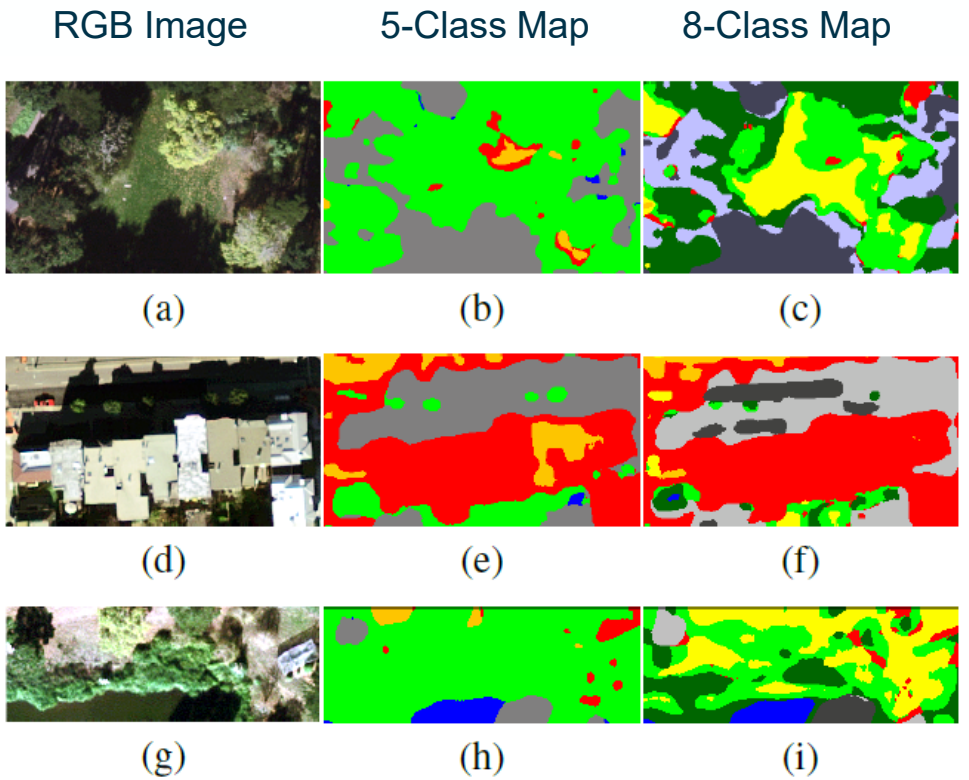

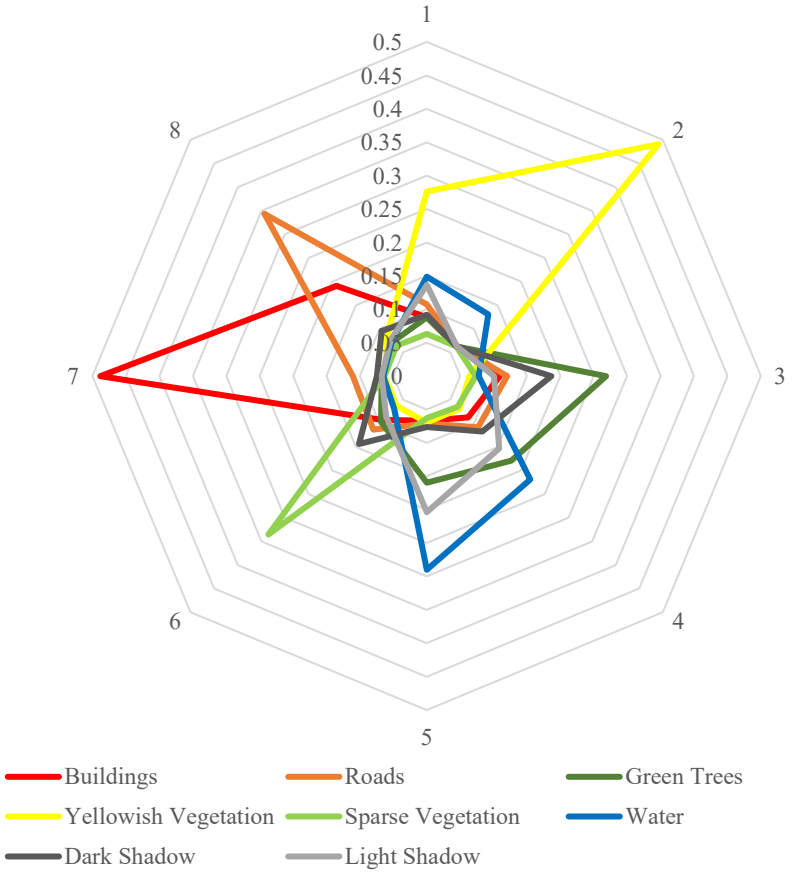

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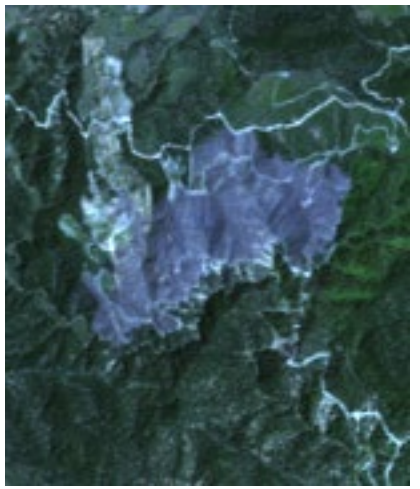
Experimental Scenarios

Scenario 2: Sentinel-2-Based Forest Fire Monitoring

July 2019

October 2019

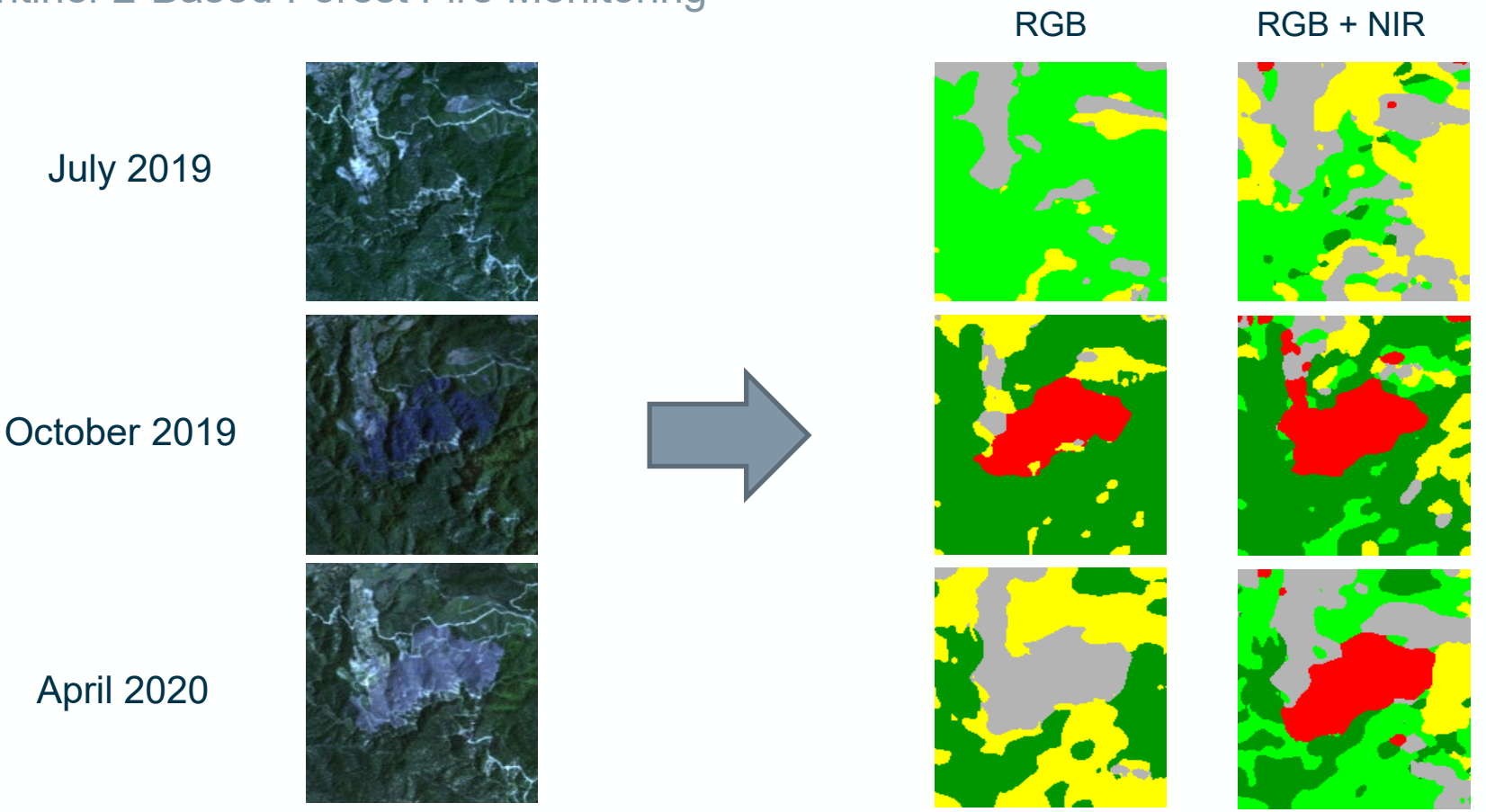


April 2020

Satellite:	Sentinel-2
Location:	Çınarpınar forest unit, Andırın, Kahramanmaras¸ Turkey
Acquisition data:	July 2019 October 2019 April 2020
Spectral Bands:	4 spectral bands (RGB + NIR)
Spatial Resolution:	10 m
Subset Size:	651 × 1323 Pixels

Experimental Scenarios

Scenario 2: Sentinel-2-Based Forest Fire Monitoring



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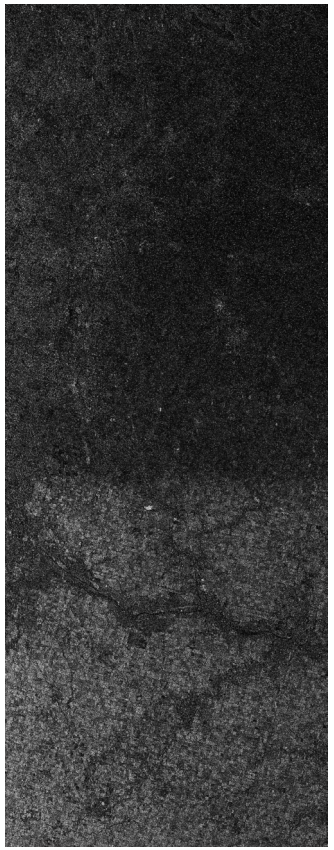
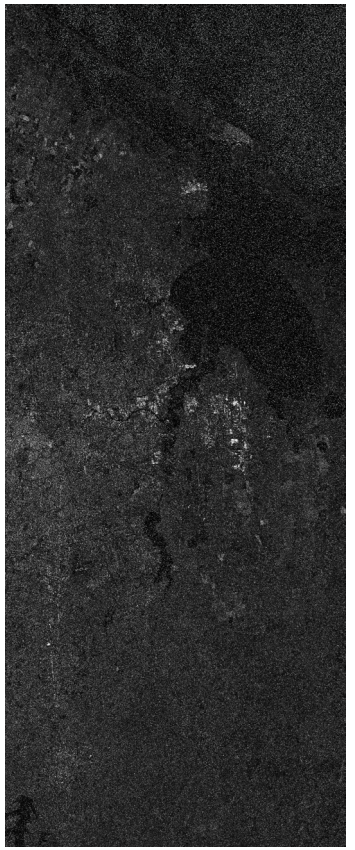
Experimental Scenarios

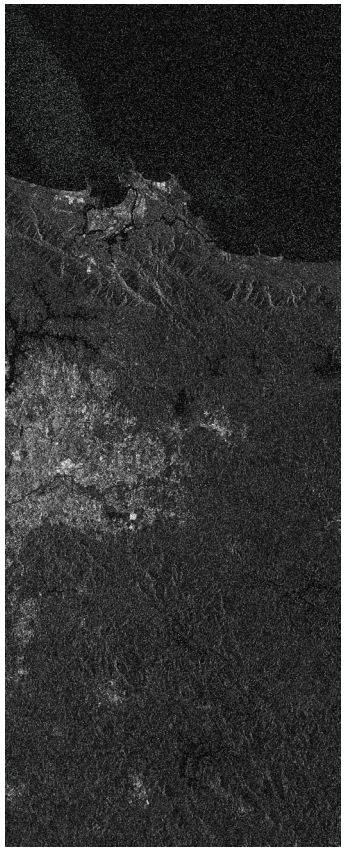
Scenario 3: Sentinel-1 Patch-Based Annotation Analysis



Chicago



Houston

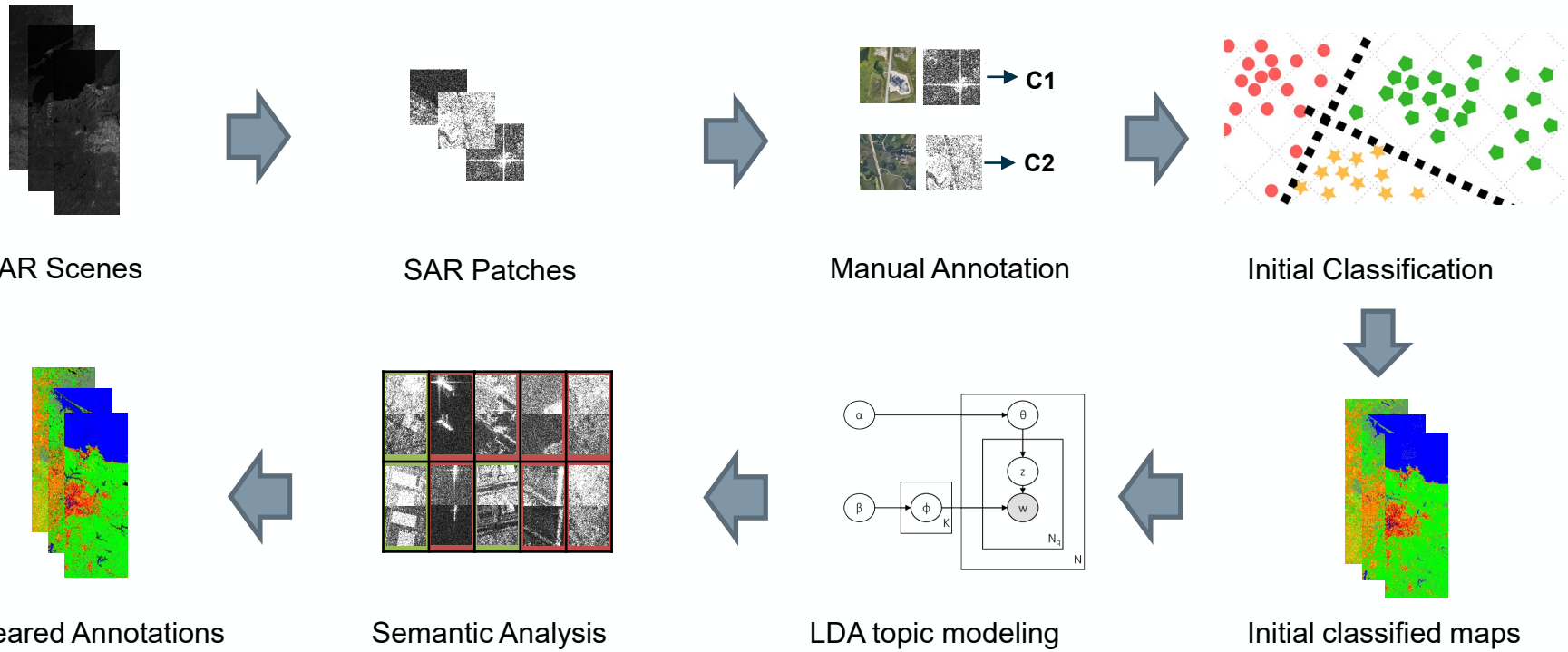


Sao Paulo

Feature	Chicago Scene	Houston Scene	Sao Paulo Scene
Product ID	S1A_S1_SLC__1SDH_20210518T121132_20210518T121201_037942_047A61_DE5A	S1B_S3_SLC__1SDH_20210505T001759_20210505T001823_026762_033263_16AD	S1A_S3_SLC__1SDH_20210516T213551_20210516T213615_037918_0479A0_E1C4
Acquisition Date	2021/05/18	2021/05/05	2021/05/16
Orbit Pass	Descending	Ascending	Ascending
Beam	S1	S3	S3
Mission	Sentinel-1A	Sentinel-1B	Sentinel-1A
Acquisition Mode	SM	SM	SM
Product	Level-1 SLC	Level-1 SLC	Level-1 SLC
Polarization	HH, HV	HH, HV	HH, HV
Subset size (pixels)	54900 ×21000	46600×18800	46700×18600

Experimental Scenarios

Scenario 3: Sentinel-1 Patch-Based Annotation Analysis



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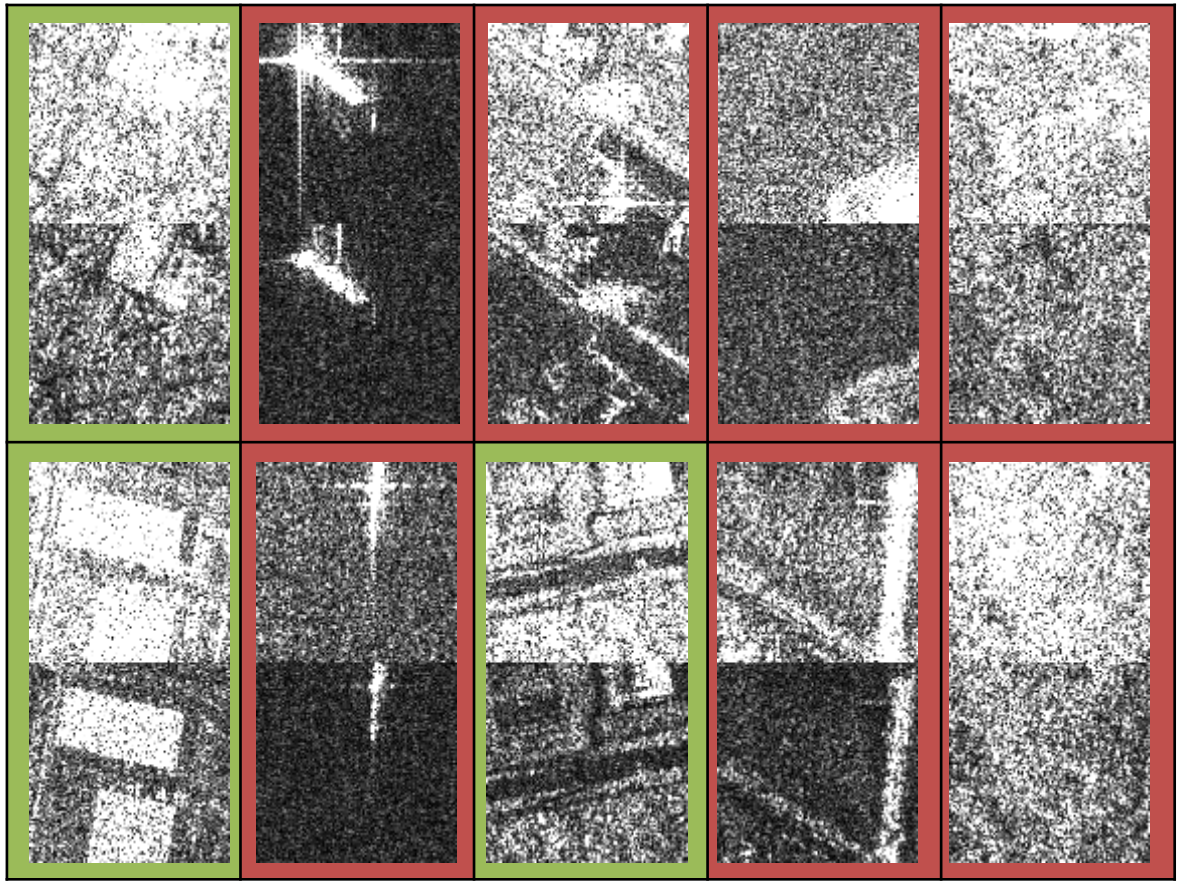
Experimental Scenarios

Scenario 3: Sentinel-1 Patch-Based Annotation Analysis

High Density Urban

Industrial Area



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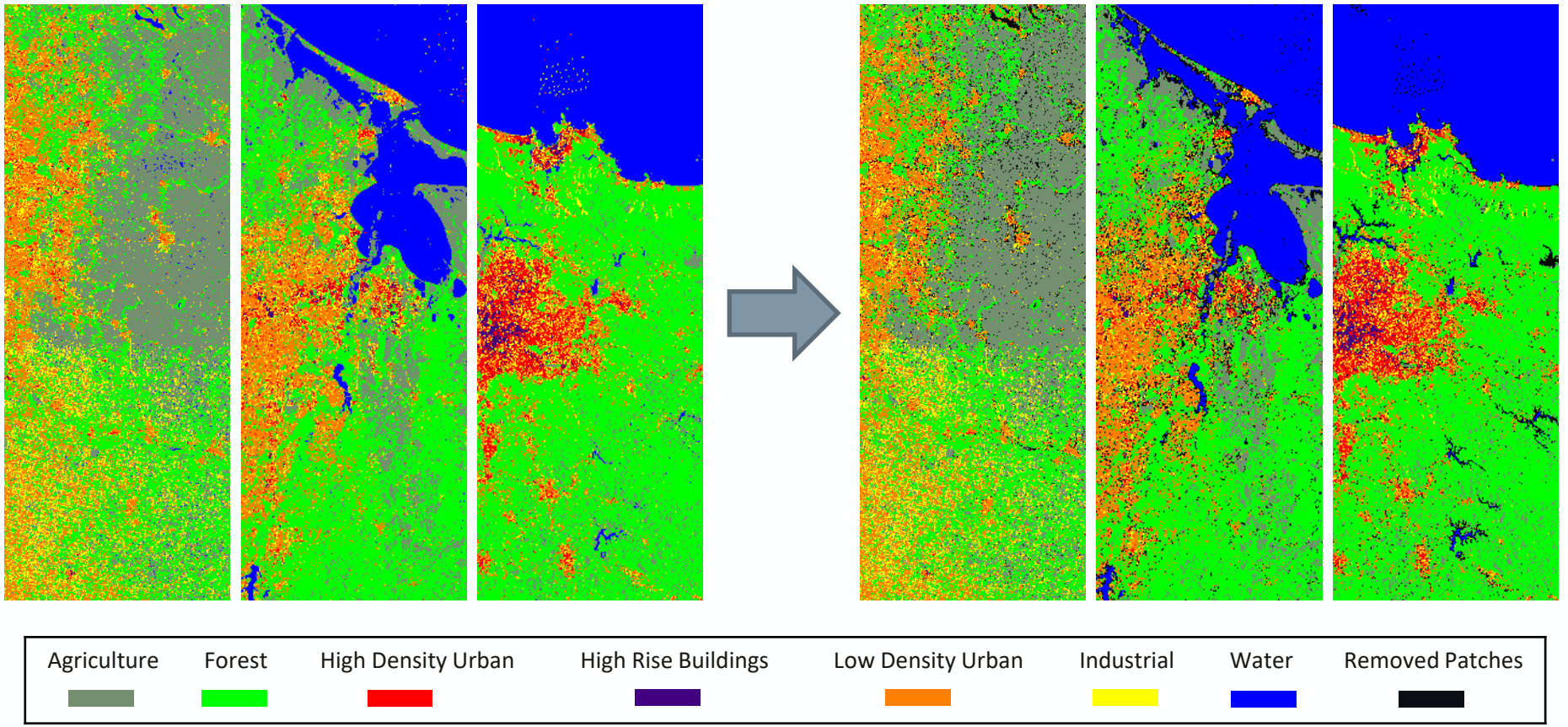

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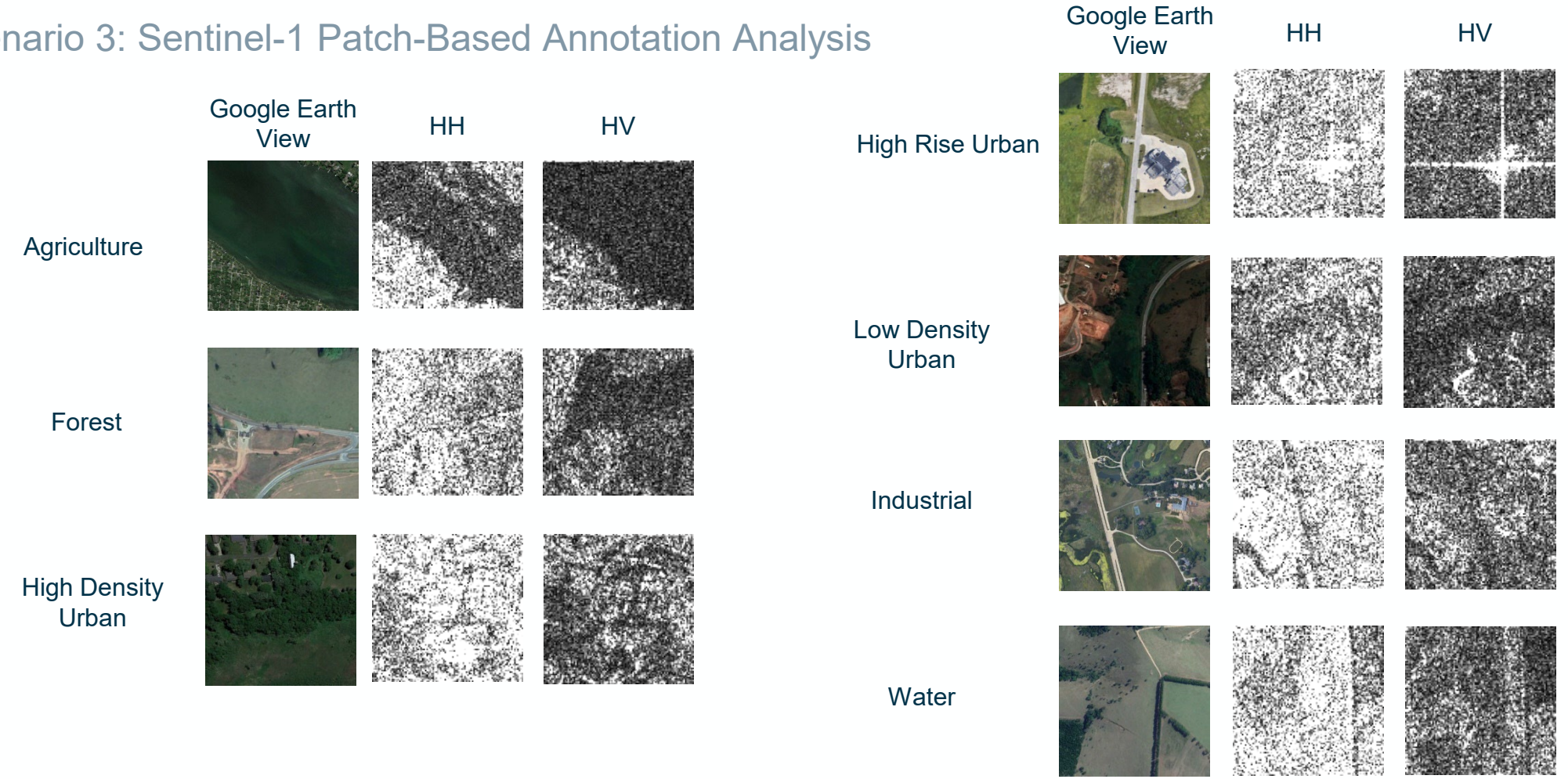

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Conclusion

- Conventional machine learning methods are not capable of extracting the latent semantic information from advanced remote sensing imagery systems with abundant semantic information.
- Well-known data mining techniques are capable of extracting meaningful semantic information from various EO images and enhancing the results of the remote sensing practices in different contexts.
- Land cover classification in very high resolution EO images can be semantically enhanced in terms of a more comprehensive classified map and less classification errors through semantic discovery methods.
- There is a huge difference between the semantic perception of the user and the machine, and data mining semantic analysis can be used to correlate these semantic understandings to enhance the classification results.
- Different natural phenomena, including wildfire affected areas, can be detected accurately and practically in EO images through semantic data mining, even in the situations that are difficult to detect through visual inspection by the user.
- Data mining latent semantic information discovery techniques are capable of enhancing the annotated benchmark datasets by means of detecting the misclassified and ambiguous patches in an annotated dataset.

Future works

- More inspections are necessary with larger-scale datasets to evaluate the competence of the semantic data mining methods for latent information discovery in EO data.
- More automated semantic analysis methods should be developed.
- More reliable quantitative evaluations are necessary.
- Experiments with well-known remote sensing benchmark datasets with high quality annotations and GT maps for evaluating the semantic data mining techniques should be carried out.
- The capability of the other well-known data mining techniques for latent information discovery in EO should be assessed.

Funding

Thank You For Your Attention

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