Mitigating climate and health impact of small-scale kiln industry using multi-spectral classifier and deep learning

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Problem Statement

Small scale industries, particularly bull-trench brick kilns, are one of the major causes of air pollution in South Asia [1].

Satellite image courtesy Digital Globe

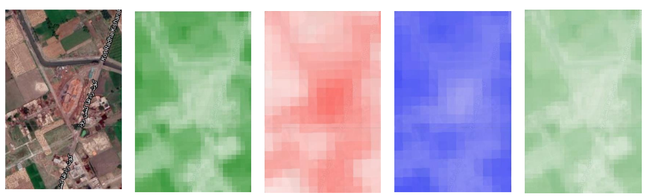
Objectives

- Fine-grained localization of brick kilns
- Detection of illegal kiln activity during SMOG period

Datasets

Satellite	Spatial Resolution	Revisit time
Sentinel-2	10, 20, 60 meters	5 days
Landsat-8	30 meters	16 days
Sentinel-5P TROPOMI	5.5 x 3.5 km^2	< 1 day
MAXAR Technologies	30 centimetres	> 1 year

Multispectral Indices – kiln surroundings

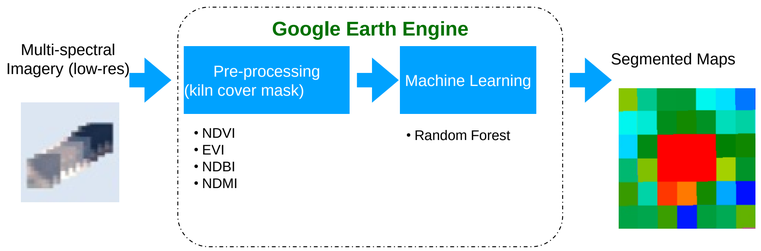


Satellite image EVI NDBI NDMI NDVI

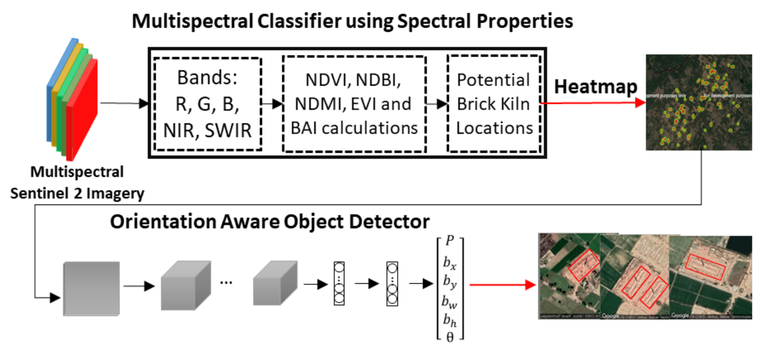
Satellite image NDVI

Kiln Localization

Coarse-grained kiln localization



Fine-grained kiln localization



Quantitative Evaluation

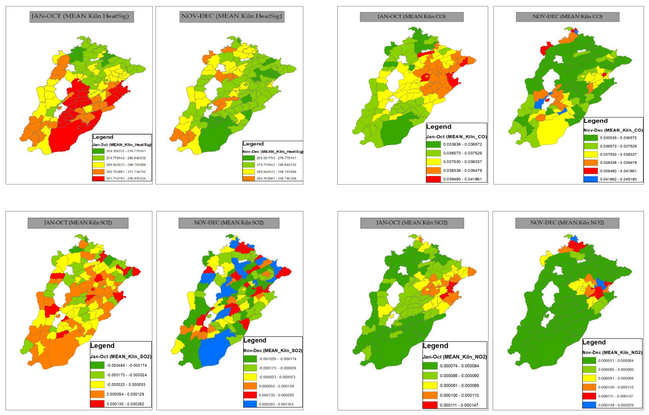
Testing Datasets	Network Architecture	F1 score	Inference Time (seconds)
Pakistan (Kasur)	i. Multispectral Approach	0.12	**3**
	ii. Two-stage Faster R-CNN	0.79	195.5
	iii. Two-stage SSD	0.75	179.5
	iv. Kiln-Net	**1**	162.5
	v. Proposed	**0.97**	**7.04**
India (New Delhi)	i. Multispectral Approach	0.14	**4**
	ii. Two-stage Faster R-CNN	0.95	276.1
	iii. Two-stage SSD	0.97	255.3
	iv. Kiln-Net	**1**	232.8
	v. Proposed	**0.99**	**8.16**
Afghanistan (Deh Sabz)	i. Multispectral Approach	0.29	**8**
	ii. Two-stage Faster R-CNN	**0.88**	553.2
	iii. Two-stage SSD	0.82	416.4
	iv. Kiln-Net	0.72	279.6
	v. Proposed	**0.83**	**23.1**

Top-2 ranking methods are in bold and, in particular, red (1st) and violet (2nd).

Qualitative Evaluation

Kiln-Net [2] vs Proposed in India (row 1) and Pakistan (row 2)

Heat Signatures and Gaseous Emissions



Mean values of heat signature, CO, SO2 and NO2 in Punjab Pakistan

References

[1] Seay, Brannon, Anna Adetona, Natasha Sadoff, Marcus C. Sarofim, and Michael Kolian. "Impact of South Asian brick kiln emission mitigation strategies on select pollutants and near-term Arctic temperature responses." *Environmental research communications 3, no. 6 (2021): 061004*.

[2] Usman Nazir, Usman Khalid Mian, Muhammad Usman Sohail, Murtaza Taj, and Momin Uppal. "**Kiln-Net**: A gated neural network for detection of brick kilns in South Asia." *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* 13 (2020): 3251-3262.

[3] Usman Nazir, Muhammad Awais Ather, and Murtaza Taj. "Detection of Illegal Kiln Activity During SMOG Period." *International Conference on Robotics and Automation in Industry* (2023).