

Mapping Land Naturalness from Sentinel-2 using Deep Contextual and Geographical Priors

Burak Ekim, Michael Schmitt

University of the Bundeswehr Munich, Germany

Motivation

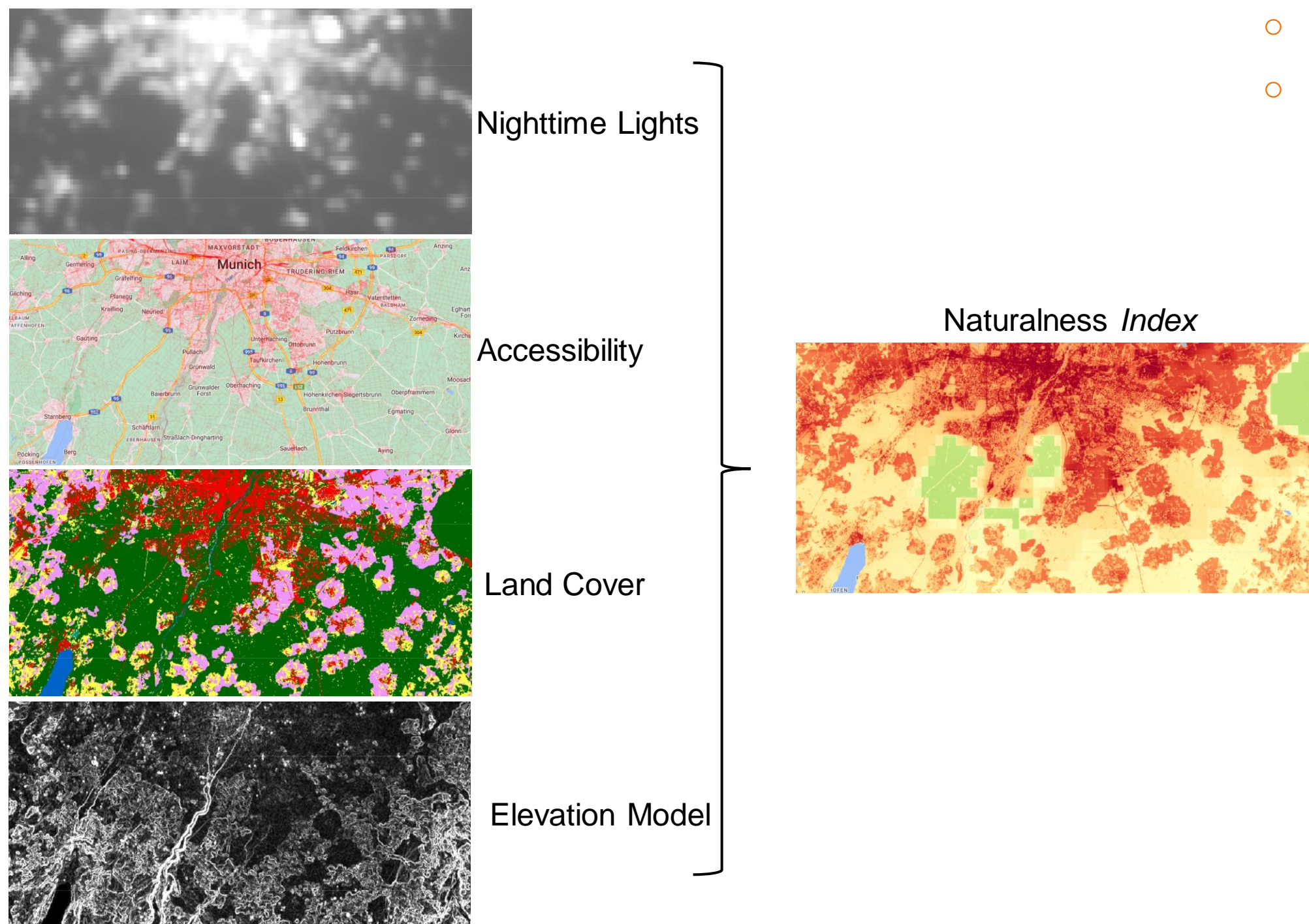
- Human beings have always changed the land to suit their needs. Unfortunately, the cumulative effect of these activities and changes has had serious effects on the planet that we all live in. Earth Observation offer valuable tools for monitoring natural environments and assessing the impacts of modern human activities and climate change.
- In this study, we propose the task of quantifying land naturalness using Sentinel-2 imagery. The model outputs a land naturalness map, indicating the extent of modern human influence or absence thereof.

Motivated by the influence of a land's location and immediate surroundings on its naturalness level, we propose a multi-modal architecture that incorporates geo-coordinates and embedded contextual information to capture nuanced spatial and geographical relationships effectively.

Naturalness Index

- The Naturalness Index is a composite geo-index used to quantify the natural state of the Earth's surface through geo-indicators. Higher NI scores indicate a more natural state, while lower scores indicate higher levels of modern human modification.

Geo-indicators



Dataset

- We use the MapInWild dataset, a multimodal dataset for mapping wilderness areas. For our study, we use only Sentinel-2 imagery. The dataset comprises over 1000 regions, each in the shape of 1920x1920 pixels and sampled from the WDPA. We expand the dataset by introducing naturalness maps derived from the Naturalness Index.

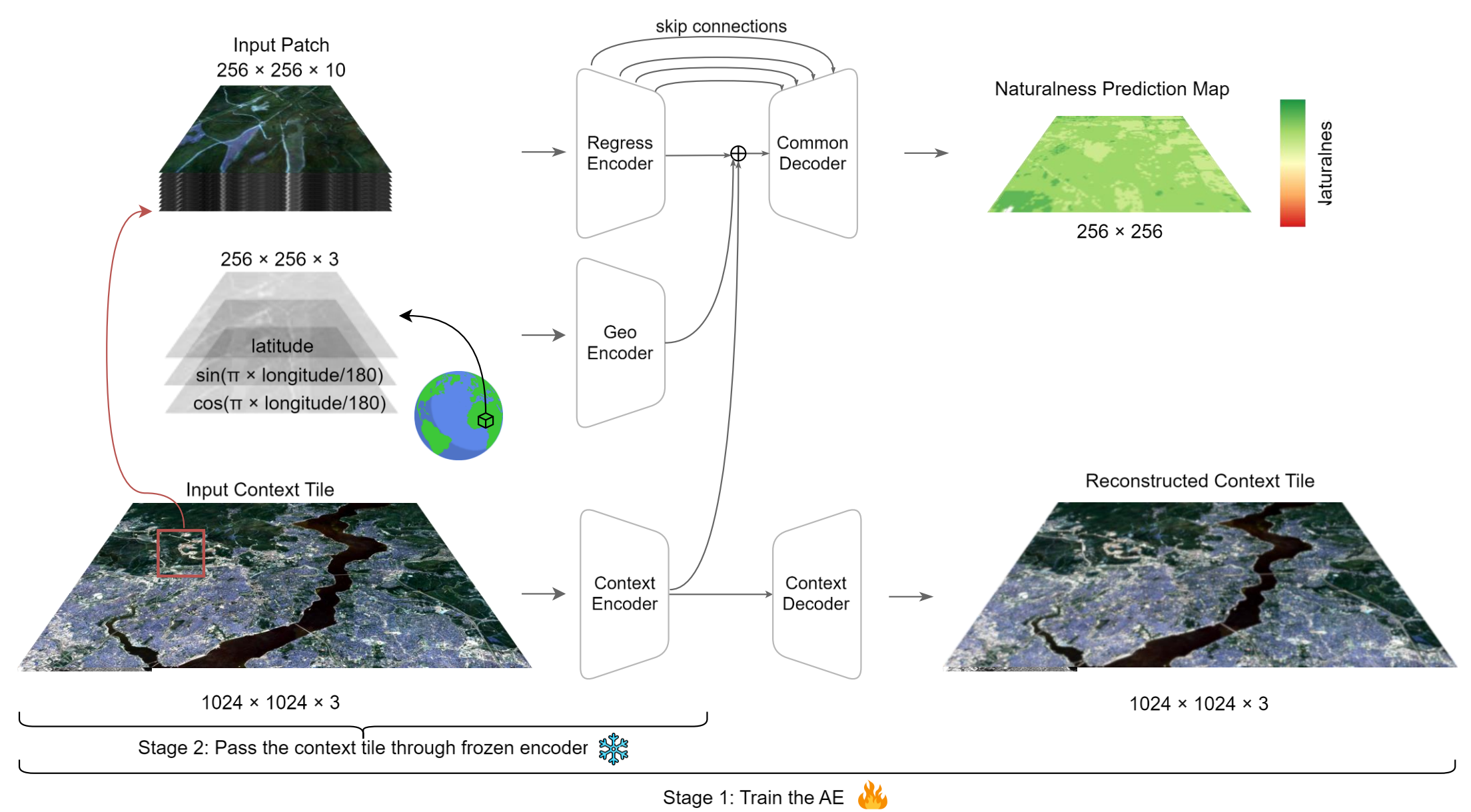
Conclusion

- Our study introduces a novel approach incorporating cyclically encoded geo-coordinates and embedded contextual information for quantifying land naturalness using Sentinel-2 imagery, providing valuable insights into the extent of modern human influence on the environment.
- Integration of contextual and geographical priors enhances the model's ability to quantify land naturalness accurately, essential for preserving biodiversity, promoting ecosystem integrity, and guiding conservation effort.

References

- Ekim B, Dong Z, Rashkovetsky D, Schmitt M (2021) The Naturalness Index for the Identification of Natural Areas on Regional Scale. International Journal of Applied Earth Observation and Geoinformation, 105: 102622
- Ekim B, Stomberg TT, Roscher R, Schmitt M (2023) MapInWild: A Remote Sensing Dataset to Address the Question of What Makes Nature Wild. IEEE Geoscience and Remote Sensing Magazine 11 (1): 103-114

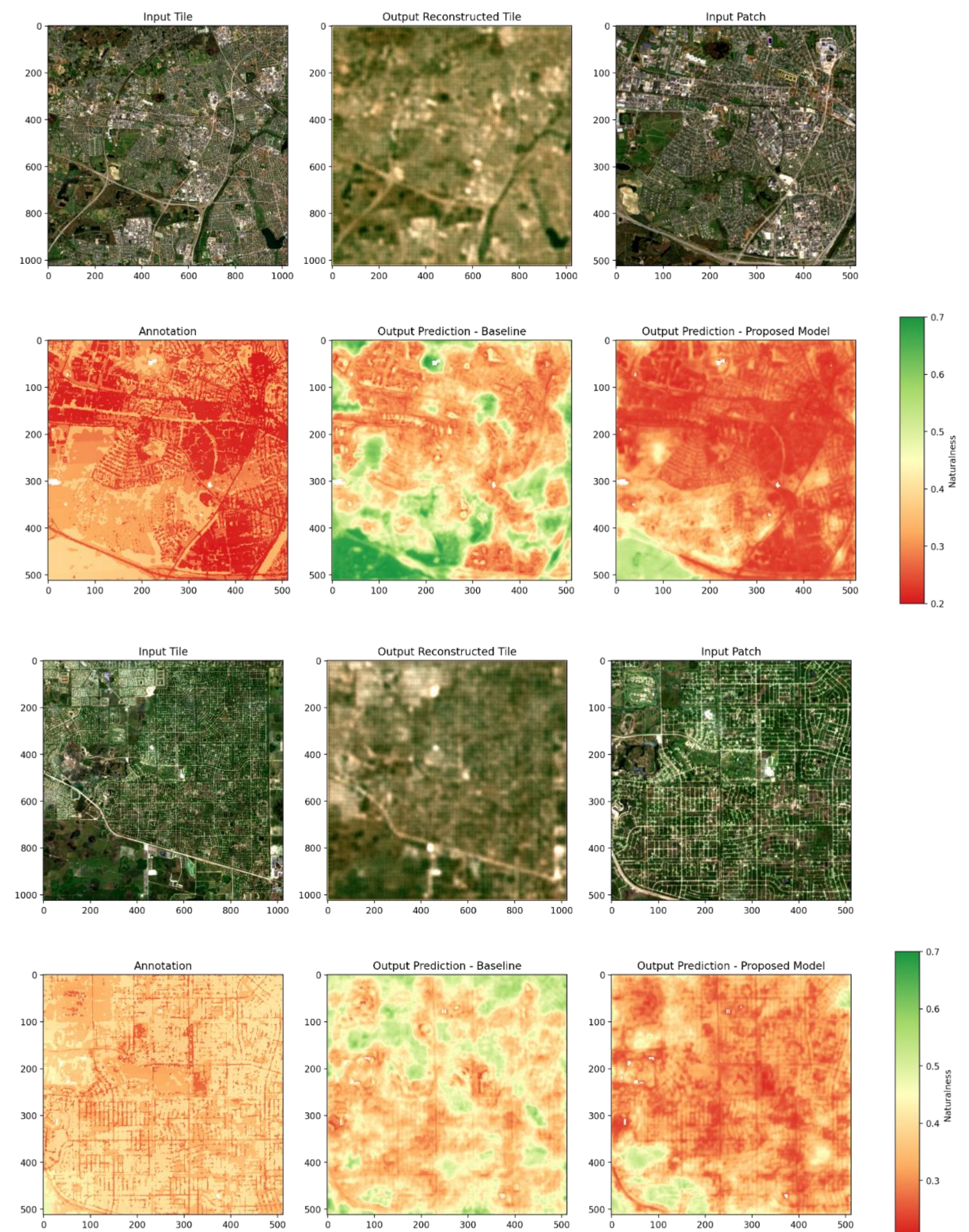
Methodology



- An autoencoder is employed initially to reconstruct input context tiles, thereby encoding contextual information into a compact latent representation.
- The broader context tiles are processed through a pre-trained and frozen *Context Encoder*.
- Simultaneously, smaller patches cropped from these tiles are fed into the *Regress Encoder*.
- Geographic coordinates are encoded separately using the *Geo Encoder* module.
- The high-dimensional latent vectors obtained from each encoder are concatenated.
- Finally, the concatenated latent vectors are fed into the *Common Decoder*, to generate the naturalness prediction map.

Results

- The proposed model exhibits enhanced predictive performance in comparison to the baseline model. This suggests that the incorporation of geographical and contextual priors positively influences the accuracy of predictions regarding modern human influence.



Acknowledgement

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