



Book of Abstracts

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Prof. Naphtali Rische

Inaugural Outstanding University Professor
Florida International University, USA

Generative AI for Robust Map Generation from Satellite Imagery



Abstract:

Maps comprised of vector tile representations of geographic features play a crucial role in geospatial analysis, navigation, urban planning, smart city development, environmental monitoring, and emergency rescue operations. Conventional map construction relies heavily on supervised machine learning methods, requiring corresponding satellite-map image pairs, an often-unrealistic expectation. Here, we will review advanced generative AI methods for map generation, as well as present deep learning algorithms developed by our team, utilizing our TerraFly Geospatial System and Satellite and Aerial Imagery Repository. One of the methodologies applied focuses on roads as a key element by developing a semantic segmentation model for road extraction from satellite imagery. This method relies on aligned input and output images, which can lead to inaccuracies when ground truth images are misaligned. A novel approach to map construction applies AI, where the model learns how to map underlying objects in satellite imagery through self-supervised techniques and generates accurate maps. In real-world scenarios, this approach may face limitations due to spectral variations in satellite imagery and the adversarial susceptibility of AI models. Our work has addressed these challenges with the goal of practical applicability. We have developed a robust map generation framework encompassing three key components. First, we have designed a novel self-supervised generative adversarial network (GAN) equipped with contrastive learning. This work marks the first application of Kolmogorov-Arnold Network (KAN) layers, replacing standard multi-layer perceptrons (MLPs) in image-to-image generation improving feature expressiveness. Second, we have developed a dual-directional AI method to translate satellite images across spectral bands and generate consistent color-channel imagery, mitigating domain variation issues. Third, we have created a forensic detection framework by integrating a large vision-language model to accurately detect generated map images, ensuring robustness against adversarial misuse. Experiments conducted with a custom dataset from the TerraFly mapping system demonstrate both the quality of generated maps and the effectiveness of forensic detection, paving the way for advanced and trustworthy map generation in real-world applications. The novel algorithms presented here were developed primarily by Arpan Mahara, a Ph.D. candidate under Prof. Rische's mentorship.

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Editor

Professor Nenad Filipović

Technical assistants

Đorđe Ilić

Ognjen Pavić

Lazar Dašić

Proofreaders

Neda Vidanović Miletić

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