A Deep Learning Approach for Detecting Built Environment in Transit-Oriented Developments

Recipient/Grant (Contract) Number: University of New Orleans; University of Florida; Florida Atlantic University/69A3552348337

Center Name: Center for Equitable Transit Oriented Communities (CETOC)

Research Priority: Preserving the Environment

Principal Investigator(s):
Xilei Zhao; University of Florida; xilei.zhao@essie.ufl.edu; ORCiD: 0000-0002-7903-4806
John Renne; Florida Atlantic University; jrenne@fau.edu; ORCiD: 0000-0002-1554-7557

Project Partners: None/TBD

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Project Start and End Date: 10/1/2024 – 9/30/2025

Project Description: Transit-Oriented Developments (TODs) are a pivotal strategy for fostering sustainable urban growth amidst escalating urbanization and population spikes. These developments are strategically designed to combat urban sprawl, significantly reduce the reliance on automobiles, cut greenhouse gas emissions, and create more livable, community-focused urban areas, and help address the housing needs. The core philosophy behind TODs lies in integrating residential, business, and leisure spaces with public transportation systems, thereby promoting a lifestyle that prioritizes walking, cycling, and the use of public transit over automobile use. The effectiveness of TODs in achieving these goals hinges on the built environment's configuration, which influences sustainable transportation adoption, boosts economic vitality, ensures accessibility, fosters social equity, and champions environmental stewardship. However, the acceleration of TODs brings forth a pressing challenge: How to accurately and efficiently measure the built environment in TODs across a large geographical region. To tackle this challenge, this project proposes a novel deep learning framework to automate the detection and categorization of essential built environment elements within TODs. By leveraging the well-established 5D framework—density, diversity, design, destination, and distance to transit—this framework seeks to comprehensively identify and map the components that constitute an effective TOD. To accomplish this, the research project will develop a sophisticated deep learning architecture capable of assimilating multi-sourced datasets with various modalities (e.g., imagery, text, tabular, GIS data). These will include high-resolution aerial imagery to capture urban layouts and green spaces; Google Street-View imagery for a pedestrian-level perspective of the urban landscape; parcel and OpenStreetMap data for detailed insights into land use, infrastructure, and building outlines; General Transit Feed Specification (GTFS) data for a comprehensive overview of public transit networks; and Census data to incorporate demographic insights. This wealth of information will be processed using a blend of cutting-edge machine learning techniques, including but not limited to, pretrained Convolutional Neural Networks (CNNs) and attention-based Transformer models for decoding unstructured data (such as images) and Graph Neural Networks (GNNs) for processing structured data analysis (such as GIS and tabular data). The proposed framework aims to create a nuanced and comprehensive understanding of TODs' built environments, facilitating the detection of key features like buildings, pedestrian crossings, transit lanes, green spaces, and more. A database created by the PIs will serve as the primary case studies for this research, providing a diverse range of urban contexts for evaluation and validation of the proposed framework. The project outlines several major tasks: data acquisition, preprocessing, development and validation of the deep learning model, applying the validated model to additional TOD locations, hosting educational workshops, and compiling findings into a final report. The proposed approach will be developed, evaluated, and validated by using randomly selected TOD locations across Florida. This research endeavors to equip urban planners, transit authorities, and policymakers with an advanced tool for automatically identifying critical elements of TODs' built environment, thereby facilitating smarter, more sustainable decision-making nationwide.

USDOT Priorities: *Transformation*, *Climate and Sustainability*, and *Economic Growth*. Using AI to automatically detect the built environment in TODs will transform the research and practice in sustainable transportation planning and technology.

Outputs: 1) Publications & conference contributions 2) Database: An open-source database, including various sources of downloadable data for TOD analyses, to disseminate the research outcomes and encourage future research. This database can be used to generate interactive maps, visualizations of the built environment's impact on equity and accessibility within TODs, & will serve as a resource for urban planners, policymakers, researchers, and the public. 3) Methodologies & Technologies: The project will introduce innovative deep learning architectures that can be directly used to automatically detect and assess the built environment elements within TOD. Code repositories and fine-tuned models' weights will be open sourced to keep transparency and allow for reproducibility for future research. 4) Partnerships: Establish and enhance partnerships with stakeholders from local government, non-profits focused on urban equity and environmental justice, & tech companies specializing in geospatial data and AI.

Outcomes/Impacts: The deployment of a deep learning framework for detailed analysis of TOD built environments enables urban planners and transportation engineers to identify, with high accuracy, the existing gaps and opportunities for enhancement in urban layouts, green spaces, and multimodal transportation facilities. Policymakers may leverage the research findings to support decision-making that promotes the expansion of TODs, incorporates sustainability and equity into transportation funding decisions, and encourages the creation of policies that prioritize the development of pedestrian-friendly, transit-accessible communities to reduce car dependency and increase public transit usage. The deep learning analysis of TODs will help identify inefficiently used spaces or underutilized facilities or infrastructures in and around TODs. Such assessments can serve as evidence for the redistribution of resources towards improvements that yield the highest benefits in terms of accessibility and sustainability. Over time, these resource reallocations can lead to more cost-efficient transportation systems, with savings that can be passed on to residents in the form of lower transportation costs and enhanced services. Automating the analysis process by using deep learning techniques reduces the time and labor traditionally required for urban planning studies, leading to significant cost savings.

Final Research Report: (Link to be provided after project completion).