Ph.D. in Information Technology
Thesis Defense

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Emilia Lenzi – XXXVII Cycle

Urban Analysis Frameworks: From Data Modeling to Sequential Group Recommendations

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Abstract:

This interdisciplinary doctoral thesis investigates the convergence between Computer Science and Architecture, fields that often appear to have diverging foundations. Computer science is basically formal, quantitative, and data-driven, whereas architecture and urban planning are rooted in contextual specificity, human-centered design, and complex stakeholder interactions. Based on this observation, the thesis addresses a core research question: Where and how could Computer Science and Architecture converge to advance the design and management of urban systems?
To answer this, the thesis introduces INTERPRET: an INtegrated and adapTive framEwoRk to support Policy-makers in the urban EnvironmenT.
The framework combines Human-Centered Conceptual Design (HCCD), spatial clustering methods (SiMBA: Systematic clustering-based Methodology to support Built environment Analysis), Geographic Information Systems-based diagnostic tools (GIS Tools), and a novel recommendation framework (ADAPT: fAirness and Diversity for sequentiAl group recommendaTions) designed for fairness and diversity in group decisions.
HCCD is introduced as a novel method to structure the dialogue between domain experts and computer scientists, enabling the co-design of data models that reflect real-world constraints and objectives. It lays the foundations for transparency and interpretability in subsequent data-driven analyses, and constitutes a significant methodological innovation in interdisciplinary design processes.
SiMBA is employed as a clustering strategy to identify emergent patterns and typologies across complex urban data. Clustering is particularly suited for exploratory urban analysis, as it enables the detection of meaningful structures in heterogeneous, noisy, and spatially distributed datasets. Rather than prescribing predefined categories, clustering allows urban planners and stakeholders to recognize urban-areas typologies in a bottom-up way, thus supporting scenario definition, comparative analysis, and context-sensitive design.

The GIS plugins Cluster Analysis (CA and City Transport Analyzer (CTA) integrate spatial clustering and transportation diagnostics directly into the Quantum-Geographic Information Systems (Q-GIS) platform. These tools enable planners and decision-makers to perform advanced spatial analyses without requiring programming knowledge, facilitating usability and dissemination.
Finally, ADAPT is a group recommendation framework that models sequential decision-making among diverse stakeholders. The choice of a recommendation-based approach stems from the increasing need to assist group decisions in urban planning processes, where multiple actors must negotiate conflicting priorities. In this context, Fairness and Diversity are critical not only to ensure social acceptance and equity, but also to avoid systemic bias and improve long-term satisfaction with the implemented policies. ADAPT formalizes these concerns and embeds them in its optimization logic.
Each module is grounded in real-world case studies - including Milan and Rio de Janeiro - and evaluated across computational performance and practical applicability. Notably, the thesis demonstrates that urban case studies do not merely benefit from data-driven methods; they also pose novel, non-trivial challenges that stimulate advancements in computer science. Among the challenges addressed in this work are: the absence of ground truth in urban diagnostics, the scarcity of labeled data and small datasets typical of real-world urban planning contexts, and the need to model fairness and diversity in sequential group recommendations. These aspects are systematically tackled through the methodological innovations introduced in HCCD, the validation-by-interpretability approach in GIS diagnostics, and the fairness-aware logic embedded in ADAPT.
The findings suggest that urban system analysis can greatly benefit from the reciprocal exchange between the formalization strengths of computer science and the contextual richness of architecture. This work provides both a practical toolset and a conceptual roadmap for future research at this disciplinary intersection.

PhD Committee

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