Joseph Picchi (UID: 605-124-511)

Professor Eggert, TA: Joe Halabi

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Using Digital Twins to Design More Sustainable Cities

The City of Los Angeles is plagued by relics of poor city planning: unreliable public transportation, view-blocking smog clouds, and infamous volumes of traffic. Dr. Fabian Dembski and his colleagues developed a model to address such issues in small and medium sized cities as they continue to grow into large urban centers. In collaboration with the University of Stuttgart and the High-Performance Computer Center Stuttgart (HLRS), Demski's team created a digital twin of the city of Herrenberg, Germany (Gedenk 2020). Digital twins are virtual representations of material systems, which are commonly used by engineers to model and simulate dynamic processes in structures like engines and utility networks (Saddik 2018). By extending this model to the scale of an entire city, the researchers unified myriad economic, topological, environmental, and demographic factors into a visualizable 3D model that enables multidimensional analysis of urban developments and democratization of the urban planning process.

The Herrenberg digital twin model uses open-source software and high-performance computing to integrate and run simulations on large datasets describing urban phenomena. The model consists of 5 components. The first is a 3D model of the city itself, which was constructed using geographical data, building information models, and laser scans of public environments (Dembski 2020). The second is a street network model that uses space syntax to implement the

2D layout of the city grids, traffic census data to model realistic use of the street network, normal angular choice (NACH) to measure the centrality of road segments and threshold potentials for traffic, and a sensor network distributed throughout the city to record real-time measurements of particulate matter, temperature, and humidity (Batty 2004). The third component used open-source simulation of urban mobility (SUMO) software to model realistic traffic patterns, simulate traffic and exhaust control mechanisms, and display simulation results in 3D. The fourth component was an airflow simulation that coupled OpenFOAM fluid dynamics software with historical weather and climate data to replicate the interactions between local weather phenomena and urban pollution (namely emissions distributions). The fifth and final component was volunteered geographic information from Herrenberg residents who tracked their transportation mediums, rated the quality of public spaces, and collected sound and image samples using a smartphone app. These 5 components were unified into a single model that could be visualized in virtual reality using collaborative visualization and simulation software (COVISE), thus offering a powerful predictive tool for the consideration of proposed urban developments (Dembski 2020).

The digital twin model is an important step in the democratization of city planning and the multidimensional analysis of urban developments. For one, it enables citizens who lack technical or political backgrounds to easily visualize proposed changes in their city of residence, thereby encouraging feedback from many different entities with varied personal interests. Furthermore, the digital twin can simulate processes with multifaceted effects, raising attention to economic, demographic, and environmental impacts that are oftentimes forgotten or neglected in the decision-making process. Given these benefits, there is still room for improvement in the model, especially in its scalability to large-sized cities like Los Angeles. Larger datasets and more complex urban dynamics place a computational strain on the model, necessitating its augmentation with artificial intelligence and more efficient data processing algorithms (Gedenk 2020). However, by incorporating these improvements, digital twin cities could represent an important tool for the implementation of more efficient, equitable, and sustainable urban planning practices in cities around the world.

Works Cited

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