Computer model that can replicate the growth of cities has valuable implications for urban planning and sustainability

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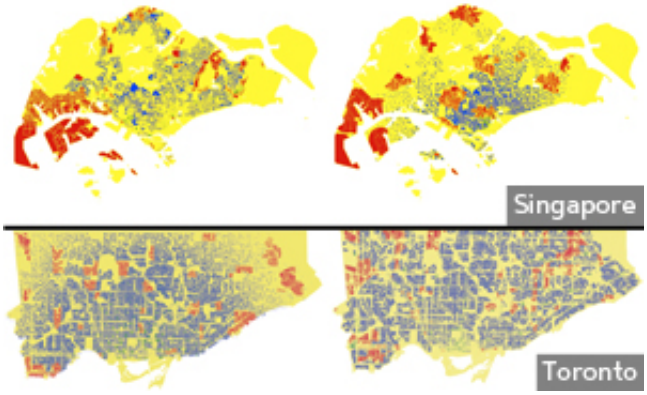

Simulations generated by a model that replicates city growth to determine likely land-use patterns (right) show close alignment between actual land-use maps (left) for two sample cities — Singapore (top) and Toronto (bottom). Credit: J. Decraene et al.

In 2009, the global number of city dwellers surpassed that of rural dwellers. Understanding how cities evolve is vital to a world that will continue to urbanize. Now, researchers at A*STAR have developed a computer model that can reconstruct cities—building them from the 'bottom up'—to investigate the fundamental mechanisms that underpin and govern city growth.

Modeling dynamic urban growth presents many challenges due to the

complexity of city systems and the technical and data requirements of model building. Christopher Monterola and co-workers at the A*STAR Institute of High Performance Computing, together with scientists in the United Kingdom, have built a model based on a so-called cellular automation system, which uses a minimalist approach to simulate city growth and support planning for sustainable cities.

"The overarching vision of our team is to capture the form, structure and dynamics of different cities to better understand, manage, design and evaluate urban systems," explains Monterola. "Essentially, we are trying to generate the recipe for a sustainable, smart city."

The model works by taking a simple set of rules—for example, land value and physical constraints to building such as water bodies and parklands—and defining the probable land use of each cell, or unit of land, according to the information provided by its neighboring cells. The model then takes into account the different land-use sectors—industrial, business and residential—and determines their 'range of influence', to decide how far a certain type of land use will spread within a certain radius. For each simulation, the team set the model center at the original marketplace, or central business district, of a real city, and let the model 'grow' the city from there.

The team validated their results using high-resolution data from various cities, including Singapore, Toronto and Las Vegas. Their model replicated, fairly accurately, the land-use patterns of the actual cities (see image).

"Our results suggest that there are some generic rules that a growing city follows as it evolves," Monterola states. "We found that there was an effective and stable cluster size for business, residential and industrial areas in all the cities studied, and their size ratios are remarkably regular. Hence, sustainability concepts must be somehow anchored on accepting

this innate evolution, and policies need to be planned around such constraints."

The team plans to further develop their urban growth model, for example by investigating the limitations on individual city transport systems and working on ways to make cities run more efficiently and sustainably.

More information: Decraene, J., Monterola, C., Lee, G. K. K., Hung, T. G. G., & Batty, M. "The emergence of urban land use patterns driven by dispersion and aggregation mechanisms." *PLoS ONE* 8, e80309 (2013). dx.doi.org/10.1371/journal.pone.0080309

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