Peering into the future: How cities grow

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Migration patterns into and out of cities are the result of millions of individual decisions, which in turn are affected by thousands of factors like economics, location, politics, security, aesthetics, sentiments and others. However, it is becoming more and more critical for urban planners to be able to predict the rate of growth of a given city in order to better address future issues that arise from increasing urbanization. Publishing in the *Journal of the Royal Society Interface*, researchers from EPFL have discovered a law that could prove fundamental in forecasting the growth of cities.

Cities are often regarded as living organisms, bustling with life and activity. This metaphorical image has a real basis, as migration in and out of cities is a constant, dynamic force. But as cities boom across the world, it is becoming necessary to determine patterns in urban migration. This would allow the prediction of a city's growth in the future, resulting in better planning for administration, design, logistics, and finance. The problem is that human migration over time and space is motivated by a vast range of individual decisions, giving rise to enormously complex data that are not easy to analyze.

An EPFL research team led by Alberto Hernando has discovered what may be universal laws underlying the seemingly random complexity of city movement. The team analyzed data records from the Spanish National Statistics Institute (INE), covering a period of 111 years (1900 – 2011) and including a total of 45 million people across 8100 municipalities in Spain. The team was able to view population flow in terms of Brownian motion – random movements of particles inside a

medium, like dust floating in air. The exhaustive data available were critical for this innovative approach to work, and they allowed the researchers to uncover laws underlying city growth.

First, the way a city will grow in the future depends heavily on how it grew in the past. Although this seems intuitive, it is not always true since city growth depends on a multitude of factors. By using their model, the team found that it is possible to use past data to predict a city's rate of growth, as long as that city has at least 10,000 inhabitants. They also found that this strong relationship between past and future lasts for approximately 15 years, during which it runs at a constant rate. What this means is that predictions of city growth require at least 15 years' worth of population data for best accuracy.

Second, a city's growth is strongly influenced by how neighboring cities grow. This is especially true when neighboring cities are within 80 Km; as the distance increases, the influence of neighboring cities weakens. This means that predictions of city growth would be challenging for cities like Las Vegas or Perth in Australia, which are large but relatively remote. The relationship between city growth and distance from neighbors means that geography is an important factor when forecasting the future urban sprawl of a particular city.

Following the model's success, Hernando is now interested in extending it to isolate the factors that influence the movement of people. "People move for natural (e.g. disasters, climate change) or non-natural (e.g. volatile economic or social policies, wars) reasons", he says. "Being able to isolate and fit them into a model can help simulate and predict the impact that political or financial decisions can have in a region." In addition, the model can be further applied to forecast the growth of commercial companies by looking at the fluctuations of their value over defined periods of time. "Our long-term goal is to develop a simulation tool including all demographic, social, and economic forces in scene,

where virtual copies of cities grow and develop in hypothetical situations, mimicking the response of their real-world counterparts."

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