Study uses computer vision algorithm to study Google Street View images for signs of urban change

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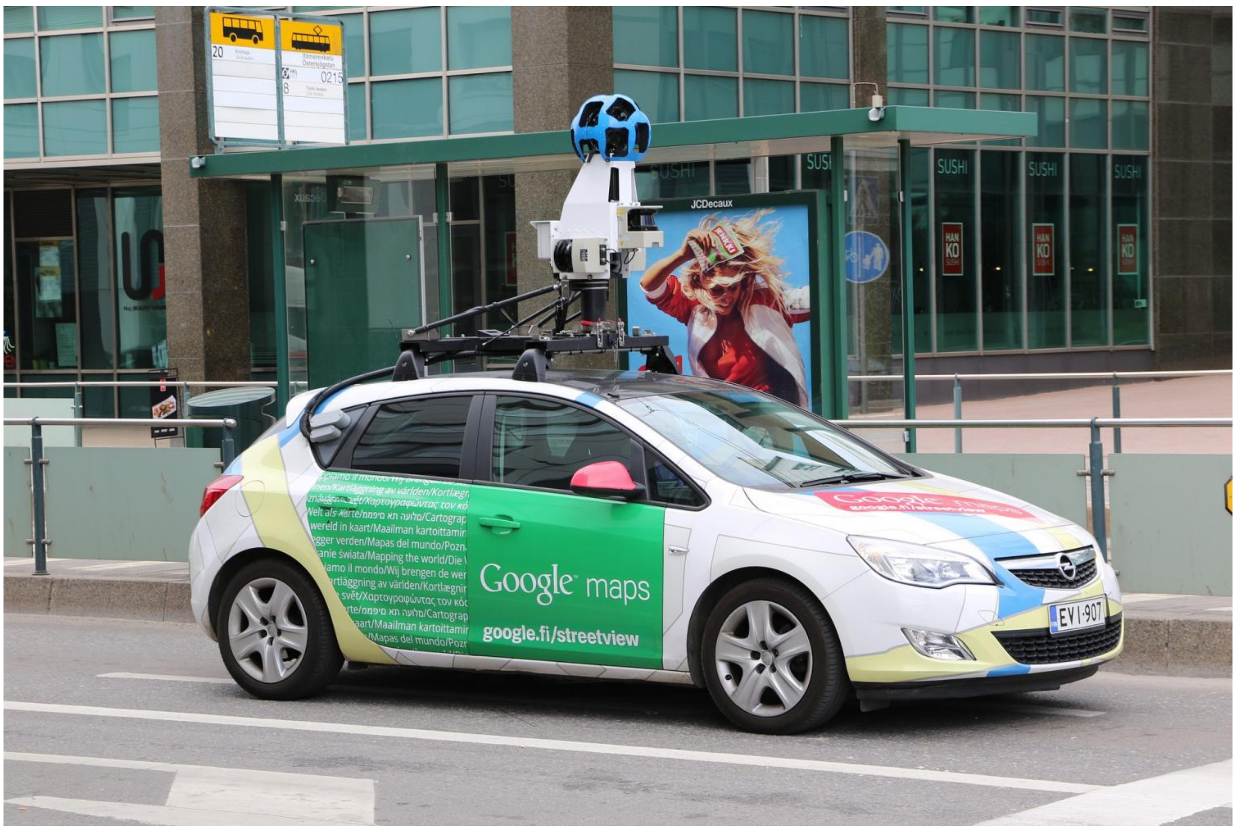

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Harvard scientists are among the co-authors of a new study that uses computer vision algorithms to examine millions of Google Street View images to measure whether and how urban areas are changing. The study both found that two key demographic characteristics - high density and high education - play important roles in urban improvement, and showed support for three classical theories of urban change.

Nikhil Naik, Scott Duke Kominers, and their collaborators are hoping to transform the way scientists study urban environments - with an assist from Google.

In joint work with Edward L. Glaeser, the Fred and Eleanor Glimp Professor of Economics at Harvard and César A. Hidalgo and Ramesh Raskar, associate professors at the MIT Media Lab, Kominers, an Associate Professor in the Entrepreneurial Management Unit at HBS and the Department of Economics and Naik, a Prize Fellow in Economics, History and Politics, authored a study that uses computer vision algorithms to examine millions of Google Street View images in an effort to measure whether and how urban areas are changing.

In addition to demonstrating the effectiveness of the technology, the study both found that two key demographic characteristics - high density and high education - play important roles in urban improvement, and showed support for three classical theories of urban change. The study is described in a July 6 paper in *Proceedings of the National Academy of Sciences*.

"Lots of people, including social scientists and urban planners, are interested in studying why places evolve and how much change happens in different cities," Naik said. "But there is a lack of data on the physical aspects of urban change."

That's where Google Street View imagery comes in.

For the past decade, Naik said, the tech giant has collected millions of

Street View images from across the country as part of its mapping service. What's more, they keep those maps up-to-date by periodically re-photographing the same locations in major cities. Consequently, Street View contains a rich database of urban images that researchers can use to follow cities through time.

Using Street View images to track urban change isn't a new idea, though.

In 2014, then-doctoral student Jackelyn Hwang and Robert Sampson, the Henry Ford II Professor of the Social Sciences, published a pioneering study that employed a team of volunteers to analyze Street View images and locate signs of gentrification across 3,000 city blocks in Chicago.

Naik and co-authors took this idea a step further by using artificial intelligence to automate the process.

"By having a computer do it, we were able to really scale up the analysis, so we examined images of about 1.6 million street blocks from five cities - Boston, New York, Washington, DC, Baltimore and Detroit," Naik said.

At the heart of the system is an artificial intelligence algorithm the collaborators "taught" to view street scenes the same way humans do.

Originally developed in work between Naik, Raskar, and Hidalgo during Naik's graduate studies at the MIT Media Lab, the algorithm computes "Streetscore" - a score for perceived safety of streetscapes, based Street View photos and image preferences collected from thousands of online volunteers.

"We built on this algorithm to calculate Streetchange - the change in Streetscore for pairs of Street View images of the same location captured seven years apart," Naik said. "A positive value of Streetchange is associated with new construction or upgrades, and a negative value is associated with overall decline."

In two validation studies - one using images scored by humans, and another using municipal data from the city of Boston - the authors showed that their algorithm accurately detects whether and how blocks changed between 2007 and 2014.

Armed with Streetchange data generated by the algorithm, Naik et al. then took a "street-level" look at several long-standing theories of urban change from urban economics, planning, and sociology.

"We found a lot of support for what's called the 'human capital agglomeration theory,' which argues that you tend to see urban improvement when you have a significant density of highly educated individuals," Kominers said. "The data suggests that other demographic characteristics - factors like income, housing costs, or ethnic composition - do not seem to matter as much as density and education do."

The study also showed some support for a theory called "tipping," in which neighborhoods that have already developed tend to develop further. The authors also found evidence for the "invasion" theory, which argues that areas around successful neighborhoods - or close to central business districts - tend to see greater improvement over time.

This highlights, Kominers added, that urban inequality is real. "Our findings reinforce the extreme importance of human capital and education at all stages of development," Kominers said. "It matters for people's access to jobs and livelihoods, but it's also important to their abilities to improve their environments. And the patterns of urban change we see help illustrate why urban inequality persists."

Ultimately, Naik said, the study shows that artificial intelligence and geospatial data can be used to measure the built environment and populations and do urban science at unprecedented resolution and scale. "We've focused on urban change here, but there are many possibilities for the future."

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More information: Nikhil Naik et al. Computer vision uncovers predictors of physical urban change, *Proceedings of the National Academy of Sciences* (2017). DOI: 10.1073/pnas.1619003114 , www.pnas.org/content/early/201 … /1619003114.abstract

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