Gaia-Xcelerate SUMMIT 2023

Alicante, Spain

9 & 10 November

In partnership with gaia-x

Hub Spain

OUR PARTNERS

DAWEX aruba.it CASAMEDITERRANEO

UNDER AUSPICES OF

EU23 SPANISH PRESIDENCY COUNCIL OF THE EUROPEAN UNION

#GaiaXSummit23

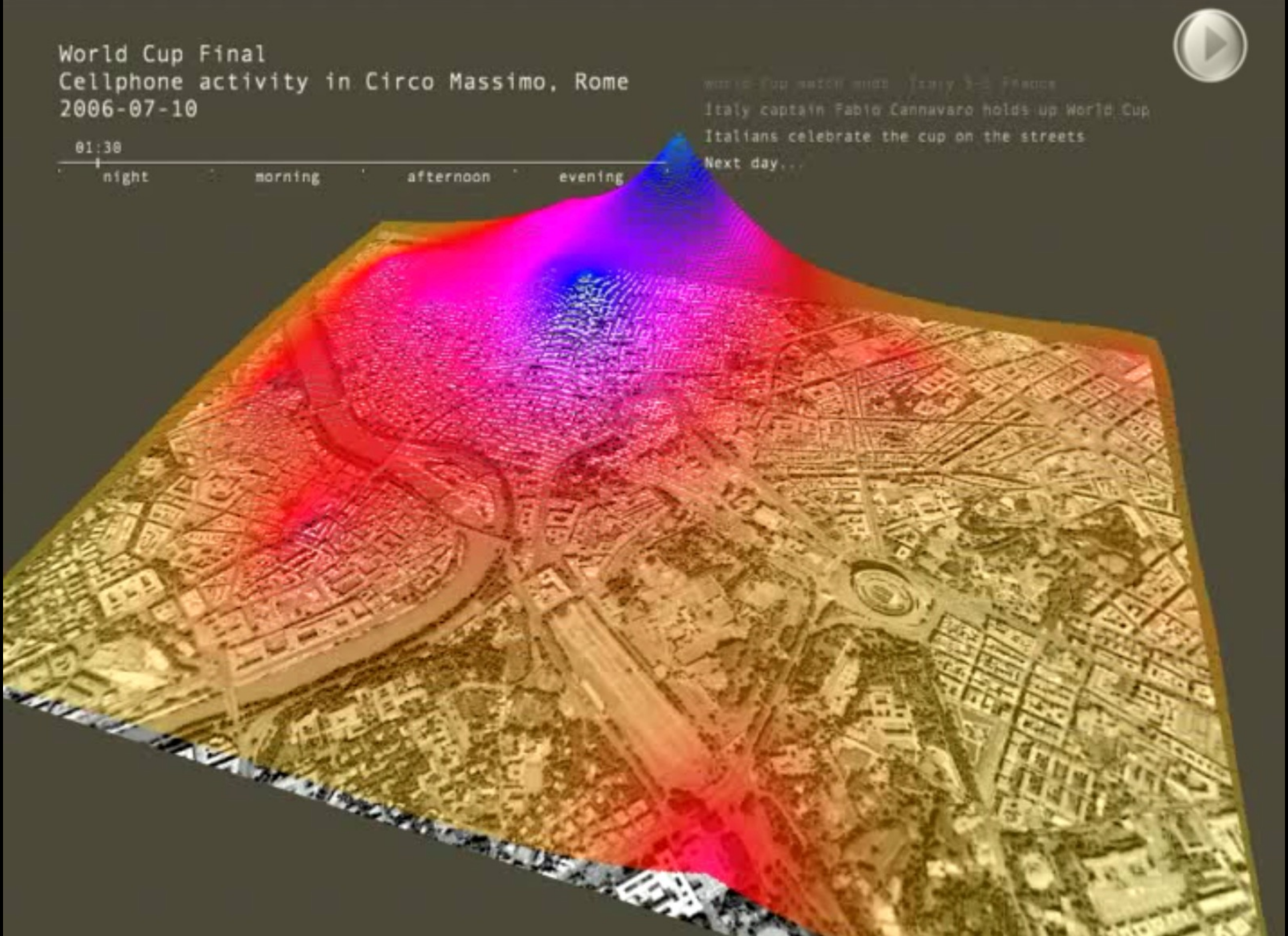
Senseable Cities
The Impact of Data at the Urban Scale

Carlo Ratti

Director

Senseable City Lab & Carlo Ratti Associati

#GaiaXSummit23


World Cup Final
Cellphone activity in Circo Massimo, Rome
2006-07-10
01:30
night
morning
afternoon
evening
Italy captain Fabio Cannavaro holds up World Cup
Italians celebrate the cup on the streets
Next day...

Environment and Planning B: Planning and Design 2006, volume 33, pages 727 – 748

DOI:10.1068/b32047

Mobile Landscapes: using location data from cell phones for urban analysis

Carlo Ratti, Dennis Frenchman
SENSEable City Laboratory, Massachusetts Institute of Technology, room 10-485,
77 Massachusetts Avenue, Cambridge, MA 02139, USA; e-mail: ratti@media.mit.edu
Riccardo Maria Pulselli
Department of Chemical and Biosystem Sciences, University of Siena, Italy;
e-mail: pulselli@unisi.it
Sarah Williams
Spatial Information Design Laboratory, 1172 Amsterdam Avenue, 400 Avery Hall, Columbia University, New York, NY 10027, USA
Received 18 February 2005; in revised form 20 September 2005

Abstract. The technology for determining the geographic location of cell phones and other handheld devices is becoming increasingly available. It is opening the way to a wide range of applications, collectively referred to as location-based services (LBS), that are primarily aimed at individual users. However, if deployed to retrieve aggregated data in cities, LBS could become a powerful tool for urban analysis. In this paper we aim to review and introduce the potential of this technology to the urban planning community. In addition, we present the 'Mobile Landscapes' project: an application in the metropolitan area of Milan, Italy, based on the geographical mapping of cell phone usage at different times of the day. The results enable a graphic representation of the intensity of urban activities and their evolution through space and time. Finally, a number of future applications are discussed and their potential for urban studies and planning is assessed.

Spatial Resolution ~500 m
Temporal Resolution ~100 min

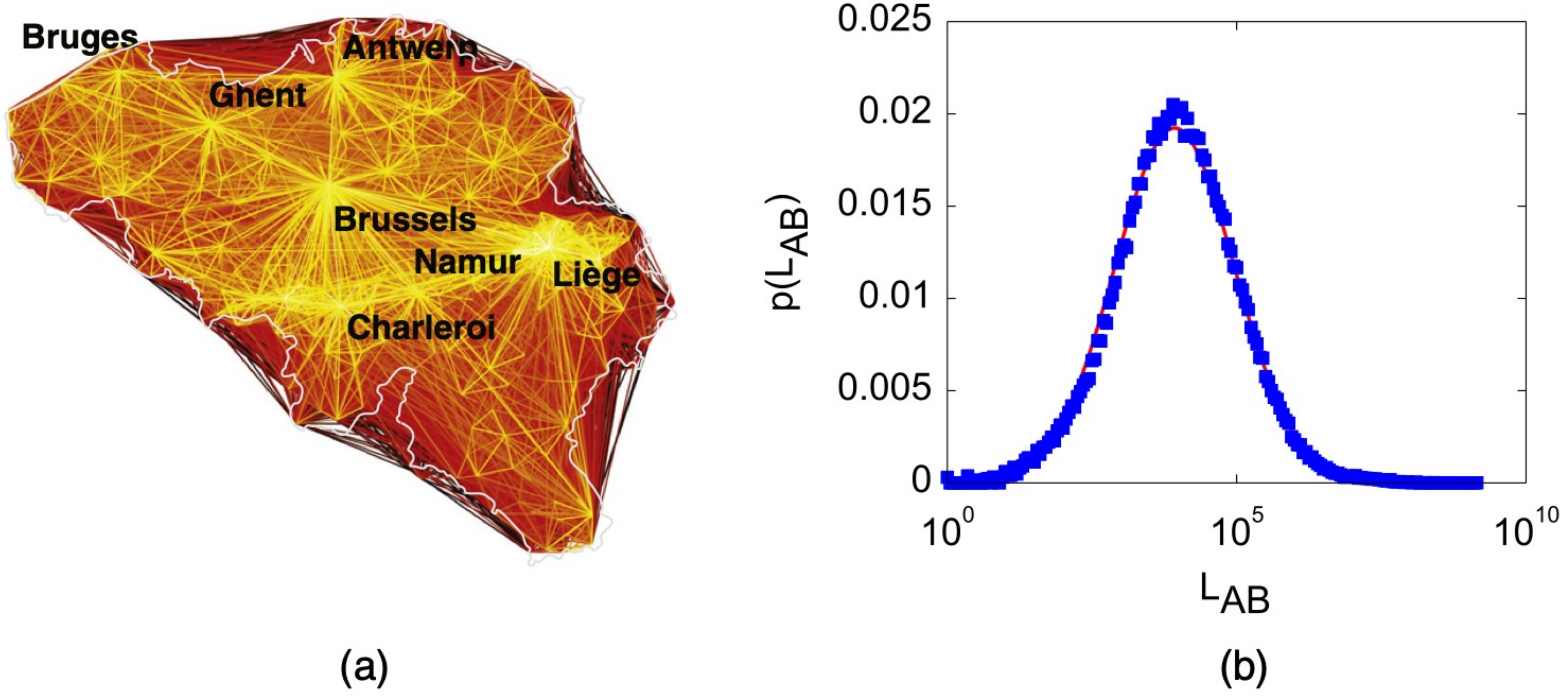


Figure 2. (a) Illustration of the macroscopic communication network [only the top 30% of the links (those having the strongest intensity) are represented]. Colors indicate the intensity of communication between the cities: bright colors indicate a strong intensity. (b) Intensity distribution of the macroscopic network, self-edges are not considered. The red curve shows the lognormal best fit, with parameters $\mu = 3.93$ and $\sigma = 1.03$.

This result suggests that the communication between cities is ruled by the following gravity model, which is symmetric, scales linearly with the population sizes and decreases with d^2:

$$L_{\mathrm{AB}} = K \frac{P_{\mathrm{A}} P_{\mathrm{B}}}{d_{\mathrm{AB}}^2},$$

there, the scaling constant K is the gravity constant for a timespan of 6 months of calling activity.

Journal of Statistical Mechanics: Theory and Experiment
An IOP and SISSA journal

LETTER

Urban gravity: a model for inter-city telecommunication flows

Gautier Krings[1,2], **Francesco Calabrese**[2], **Carlo Ratti**[2] **and Vincent D Blondel**[1]

[1] Department of Applied Mathematics, Université catholique de Louvain (UCL), 4 Avenue Georges Lemaitre, B-1348 Louvain-la-Neuve, Belgium
[2] SENSEable City Laboratory, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA 02139, USA
E-mail: gautier.krings@uclouvain.be, fcalabre@mit.edu, ratti@mit.edu and vincent.blondel@uclouvain.be

Received 8 May 2009
Accepted 15 June 2009
Published 14 July 2009

Online at stacks.iop.org/JSTAT/2009/L07003
doi:10.1088/1742-5468/2009/07/L07003

Spatial Resolution ~50 m
Temporal Resolution ~10 min

nature

Article

The universal visitation law of human mobility

https://doi.org/10.1038/s41586-021-03480-9

Received: 30 May 2017

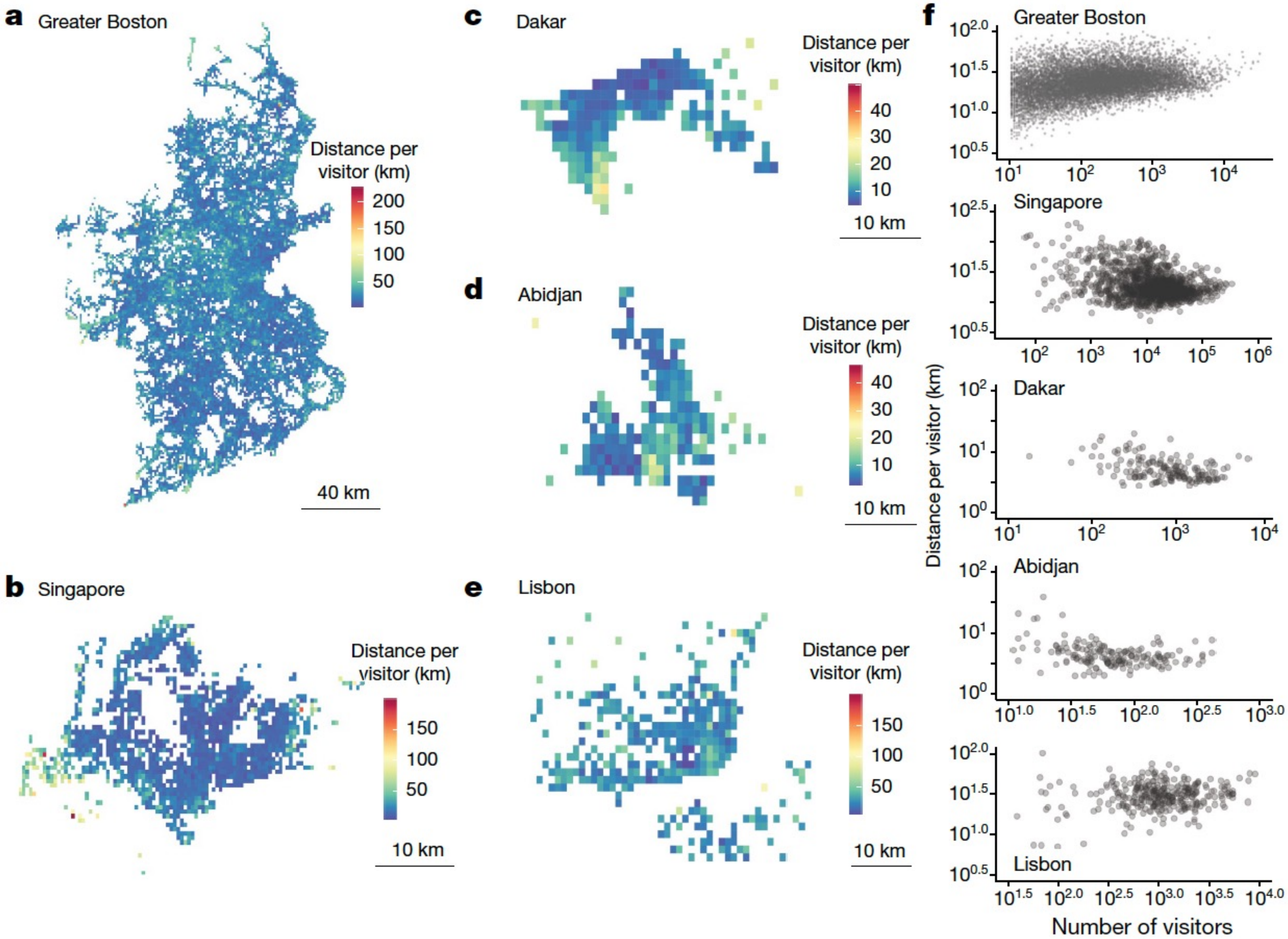
Accepted: 22 March 2021

Published online: 26 May 2021

Check for updates

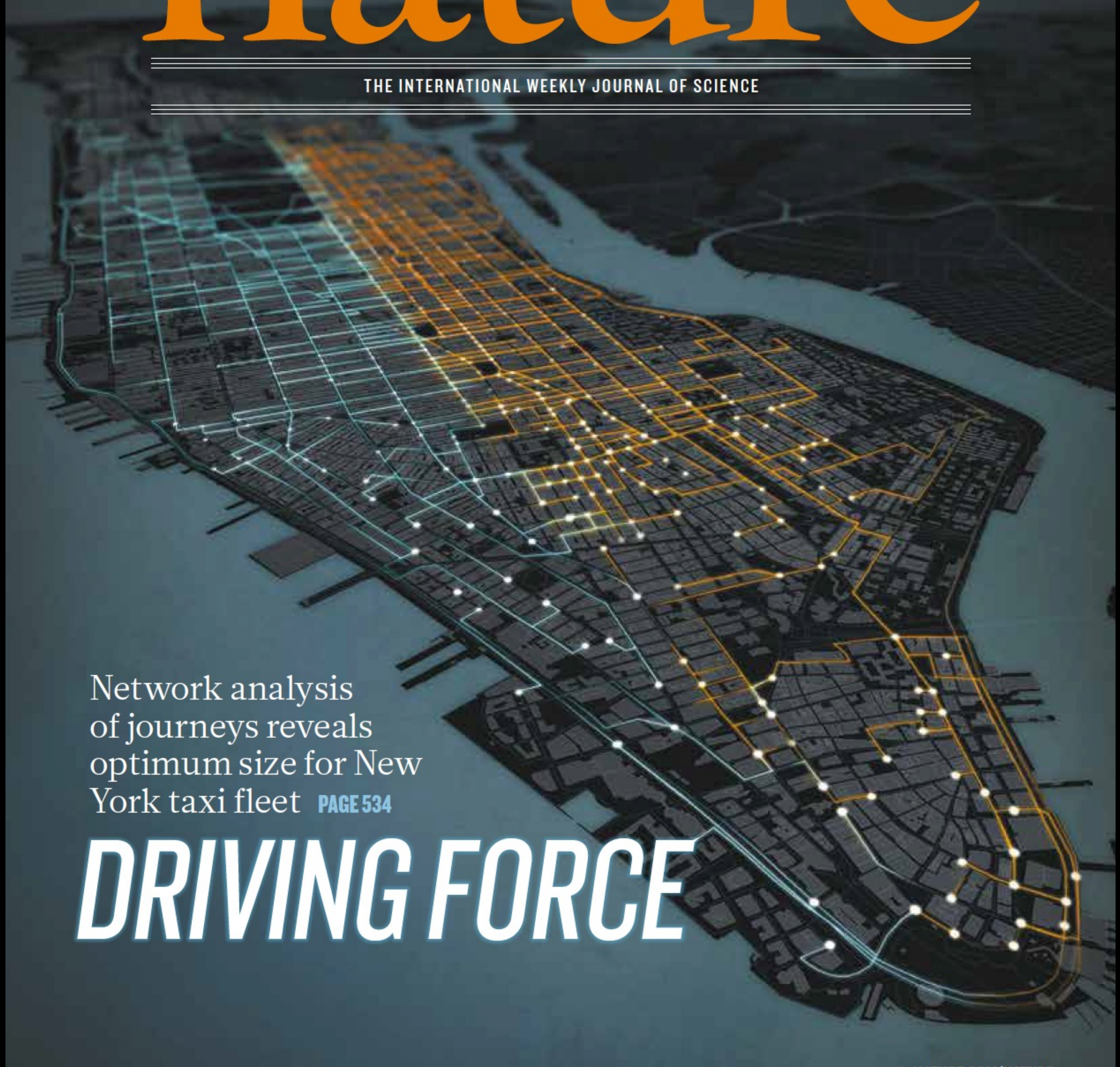
Markus Schläpfer[1,2,3,9], Lei Dong[1,4,9] ✉, Kevin O'Keeffe[1,9], Paolo Santi[1,5], Michael Szell[1,6,7], Hadrien Salat[3,8], Samuel Anklesaria[1], Mohammad Vazifeh[1], Carlo Ratti[1,10] & Geoffrey B. West[2,10]

Human mobility impacts many aspects of a city, from its spatial structure[1–3] to its response to an epidemic[4–7]. It is also ultimately key to social interactions[8], innovation[9,10] and productivity[11]. However, our quantitative understanding of the aggregate movements of individuals remains incomplete. Existing models—such as the gravity law[12,13] or the radiation model[14]—concentrate on the purely spatial dependence of mobility flows and do not capture the varying frequencies of recurrent visits to the same locations. Here we reveal a simple and robust scaling law that captures the temporal and spatial spectrum of population movement on the basis of large-scale mobility data from diverse cities around the globe. According to this law, the number of visitors to any location decreases as the inverse square of the product of their visiting frequency and travel distance. We further show that the spatio-temporal flows to different locations give rise to prominent spatial clusters with an area distribution that follows Zipf's law[15]. Finally, we build an individual mobility model based on exploration and preferential return to provide a mechanistic explanation for the discovered scaling law and the emerging spatial structure. Our findings corroborate long-standing conjectures in human geography (such as central place theory[16] and Weber's theory of emergent optimality[10]) and allow for predictions of recurrent flows, providing a basis for applications in urban planning, traffic engineering and the mitigation of epidemic diseases.


a Greater Boston
Distance per visitor (km)
200
150
100
50
40 km
b Singapore
Distance per visitor (km)
150
100
50
10 km
c Dakar
Distance per visitor (km)
40
30
20
10
10 km
d Abidjan
Distance per visitor (km)
40
30
20
10
10 km
e Lisbon
Distance per visitor (km)
150
100
50
10 km
f Greater Boston
Singapore
Dakar
Abidjan
Lisbon
Distance per visitor (km)
Number of visitors

nature

THE INTERNATIONAL WEEKLY JOURNAL OF SCIENCE



Network analysis of journeys reveals optimum size for New York taxi fleet PAGE 534

DRIVING FORCE

NATURE.COM/NATURE
24 May 2018 £10
Vol. 557, No. 7706

Spatial Resolution ~5 m
Temporal Resolution ~1 min

Article | Published: 18 October 2021

Vector-based pedestrian navigation in cities

Christian Bongiorno, Yulun Zhou, Marta Kryven, David Theurel, Alessandro Rizzo, Paolo Santi, Joshua Tenenbaum & Carlo Ratti

Nature Computational Science **1**, 678–685 (2021) | Cite this article

Abstract

How do pedestrians choose their paths within city street networks? Researchers have tried to shed light on this matter through strictly controlled experiments, but an ultimate answer based on real-world mobility data is still lacking. Here, we analyze salient features of human path planning through a statistical analysis of a massive dataset of GPS traces, which reveals that (1) people increasingly deviate from the shortest path when the distance between origin and destination increases and (2) chosen paths are statistically different when origin and destination are swapped. We posit that direction to goal is a main driver of path planning and develop a vector-based navigation model; the resulting trajectories, which we have termed pointiest paths, are a statistically better predictor of human paths than a model based on minimizing distance with stochastic effects. Our findings generalize across two major US cities with different street networks, hinting to the fact that vector-based navigation might be a universal property of human path planning.

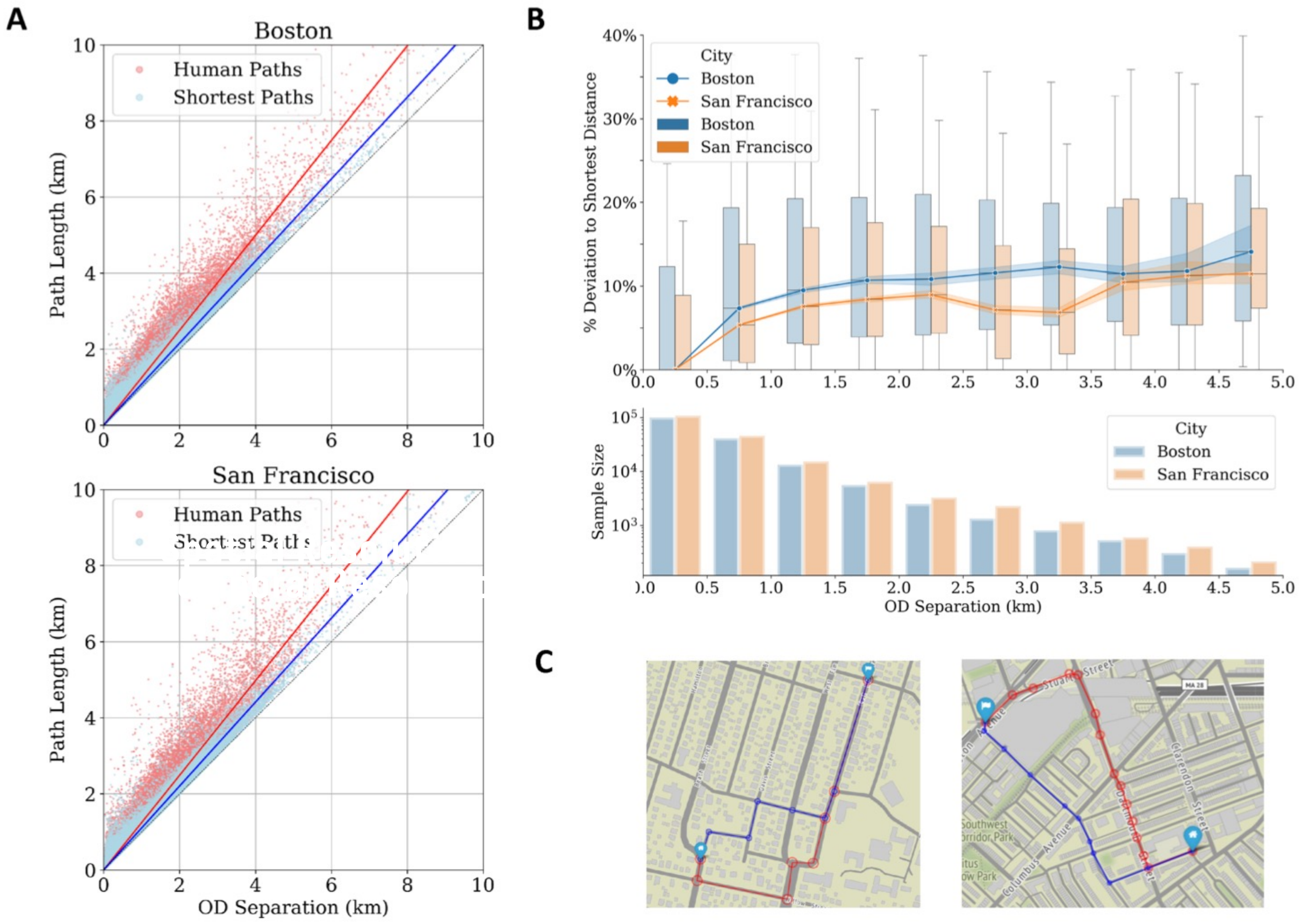


Figure 1: **Differences between human paths and shortest paths.** A. Aggregated comparisons between the path lengths of human and shortest paths in Boston and San Francisco, as a function of the Euclidean distance between origin and destination (x-axis); B. Relative differences in path length are larger in longer paths; C. Examples of human paths (red) and their corresponding shortest paths (blue).

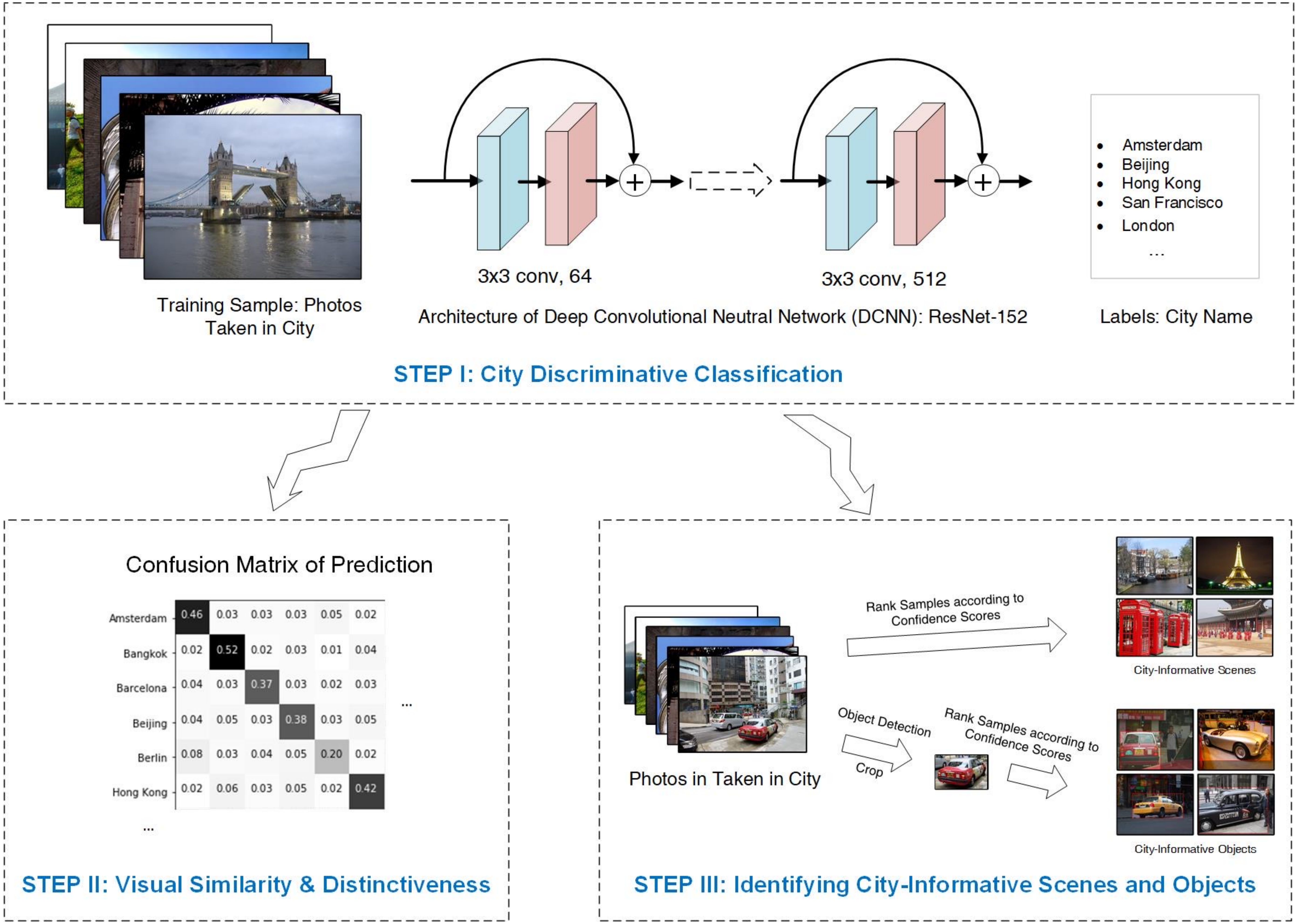
Big Data…
… from CITY-SCALE…
… to BUILDING-SCALE…
… to INDIVIDUAL-SCALE…

Urban Visual Intelligence


Google maps
Street View
google.com/streetview


Antigua Estación de Benalúa P
Pl. de l'Arquitecto Miguel López
Alicante, Valencian Community
Google Street View
Nov 2008
Miguel López
AC Hotel by Marriott Alicante
Plaza Migue
el Restaurante
Alicante
Google


Car 0.971
Car 0.996
Walk 0.986
Car 0.999
Stand 1.000
Walk 0.998
Bus 0.987
Van 0.949
Car 0.998
Car 0.998
Walk 1.000
Walk 0.999
PHARMACIE LAFAYETTE
PORTE DE MONTREUIL


3x3 conv, 64
3x3 conv, 512
Amsterdam
Beijing
Hong Kong
San Francisco
London
...
Training Sample: Photos Taken in City
Architecture of Deep Convolutional Neutral Network (DCNN): ResNet-152
Labels: City Name
STEP I: City Discriminative Classification
Confusion Matrix of Prediction
Amsterdam 0.46 0.03 0.03 0.03 0.05 0.02
Bangkok 0.02 0.52 0.02 0.03 0.01 0.04
Barcelona 0.04 0.03 0.37 0.03 0.02 0.03
Beijing 0.04 0.05 0.03 0.38 0.03 0.05
Berlin 0.08 0.03 0.04 0.05 0.20 0.02
Hong Kong 0.02 0.06 0.03 0.05 0.02 0.42
...
STEP II: Visual Similarity & Distinctiveness
Rank Samples according to Confidence Scores
City-Informative Scenes
Object Detection
Crop
Rank Samples according to Confidence Scores
Photos in Taken in City
City-Informative Objects
STEP III: Identifying City-Informative Scenes and Objects

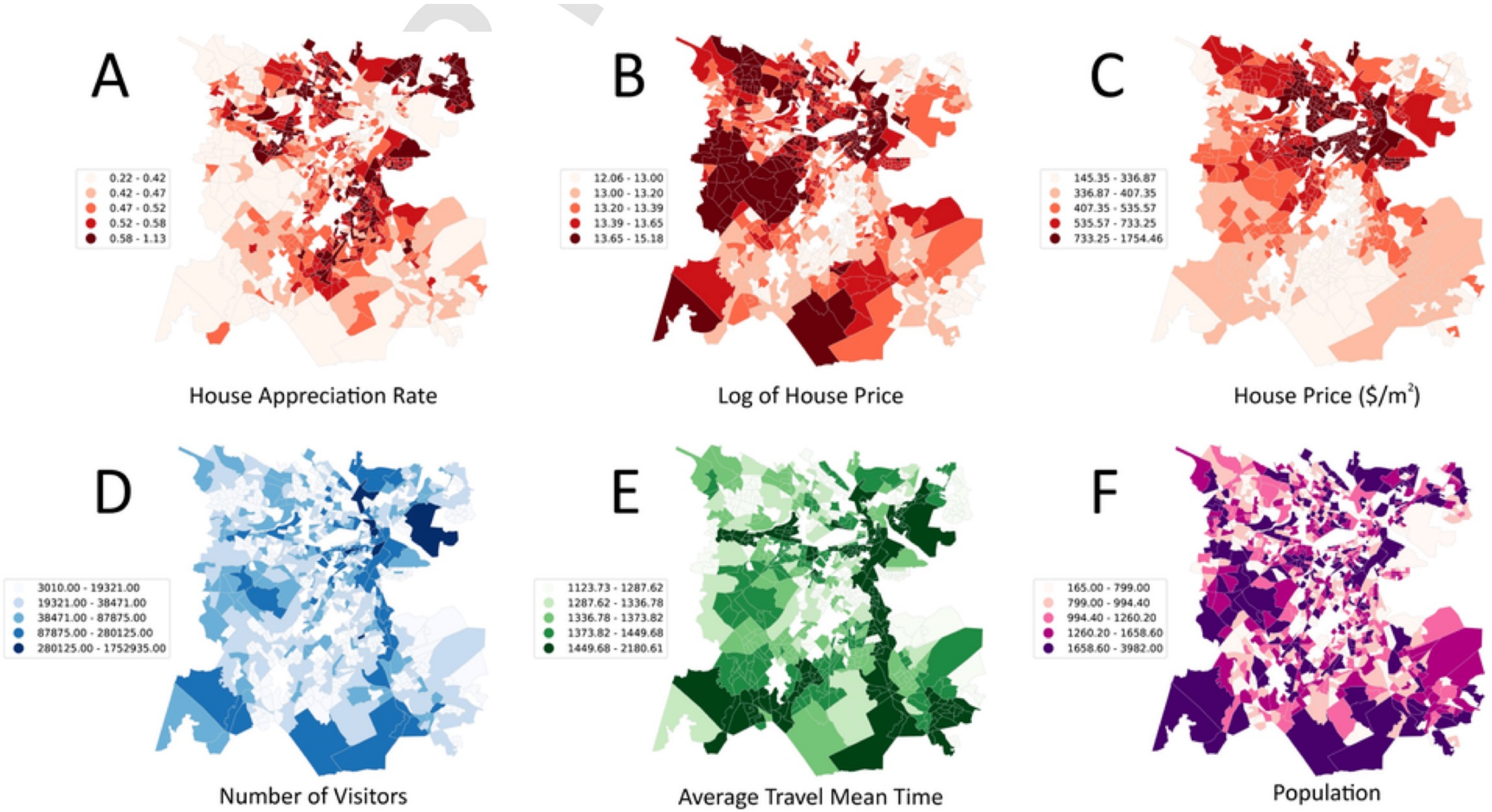


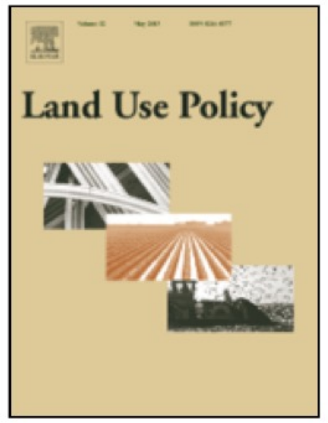
Fig. 3. Data distributions at census block group (CBG) level: (A) average house appreciation rates. (B) The natural logarithm of house prices. (C) Average house price per square meter. (D) Number of visitors to each CBG. _ Averaged travel mean time to other CBGs. (F) Population.

ELSEVIER

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com



Understanding house price appreciation using multi-source big geo-data and machine learning

Yuhao Kang [a, b], Fan Zhang [a, *], Wenzhe Peng [c], Song Gao [b], Jinmeng Rao [b], Fabio Duarte [a, d], Carlo Ratti [a]

[a] Senseable City Lab, Department of Urban Studies and Planning, Massachusetts Institute of Technology, Cambridge, MA 02139, United States
[b] Geospatial Data Science Lab, Department of Geography, University of Wisconsin, Madison, WI 53703, United States
[c] Department of Architecture, Massachusetts Institute of Technology, Cambridge, MA 02139, United States
[d] Urban Management Program, PUCPR, Curitiba 80215-910, Brazil

ARTICLE INFO

Keywords:
House price appreciation rate
Street view images
House photos
Human mobility patterns
Geographically weighted regression

ABSTRACT

Understanding house price appreciation benefits place-based decision makings and real estate market analyses. Although large amounts of interests have been paid in the house price modeling, limited work has focused on evaluating the price appreciation rate. In this study, we propose a data-fusion framework to examine how well house price appreciation potentials can be predicted by combining multiple data sources. We used data sets including house structural attributes, house photos, locational amenities, street view images, transportation accessibility, visitor patterns, and socioeconomic attributes of neighborhoods to enrich our understanding of the real estate appreciation and its predictive modeling. As a case study, we investigate more than 20,000 houses in the Greater Boston Area, and discuss the spatial dependency of house price appreciations, influential vari-

PNAS RESEARCH ARTICLE | SOCIAL SCIENCES
SUSTAINABILITY SCIENCE

OPEN ACCESS

Urban visual intelligence: Uncovering hidden city profiles with street view images

Zhuangyuan Fan[a], Fan Zhang[b,1], Becky P. Y. Loo[a,c], and Carlo Ratti[d]

Edited by Richard Shearmur, McGill University, Montreal, Quebec, Canada; received November 30, 2022; accepted May 18, 2023 by Editorial Board Member Susan Hanson

A longstanding line of research in urban studies explores how cities can be understood through their appearance. However, what remains unclear is to what extent urban dwellers' everyday life can be explained by the visual clues of the urban environment. In this paper, we address this question by applying a computer vision model to 27 million street view images across 80 counties in the United States. Then, we use the spatial distribution of notable urban features identified through the street view images, such as street furniture, sidewalks, building façades, and vegetation, to predict the socioeconomic profiles of their immediate neighborhood. Our results show that these urban features alone can account for up to 83% of the variance in people's travel behavior, 62% in poverty status, 64% in crime, and 68% in health behaviors. The results outperform models based on points of interest (POI), population, and other demographic data alone. Moreover, incorporating urban features captured from street view images can improve the explanatory power of these other methods by 5% to 25%. We propose "urban visual intelligence" as a process to uncover hidden city profiles, infer, and synthesize urban information with computer vision and street view images. This study serves as a foundation for future urban research interested in this process and understanding the role of visual aspects of the city.

urban studies | socioeconomic status | built environment | computer vision | sustainable development goals

An in-depth study of the urban environment is vital for knowing cities and the lives within (1–4). The urban environment is a complex system that manifests itself through many measurable patterns, including land use diversity, building density, street network connectivity, presence of greenery, and food and retail business. Leveraging

Significance

We demonstrate that urban features extracted from street view images through a computer vision model can effectively estimate the hidden neighborhood socioeconomic status, such as travel behaviors, poverty status, health outcomes and behaviors, and crime. Specifically, models using street view features alone can estimate up to 83% of the variance in vehicle miles traveled, 64% in violent crime occurrences, and 68% in the population lacking physical activities. These results outperform models using other commonly adopted data such as points of interest, population, and demographics. With the increasing availability of street

Opinion **Artificial intelligence** + Add to myFT

Welcome to a world where AI can value your home

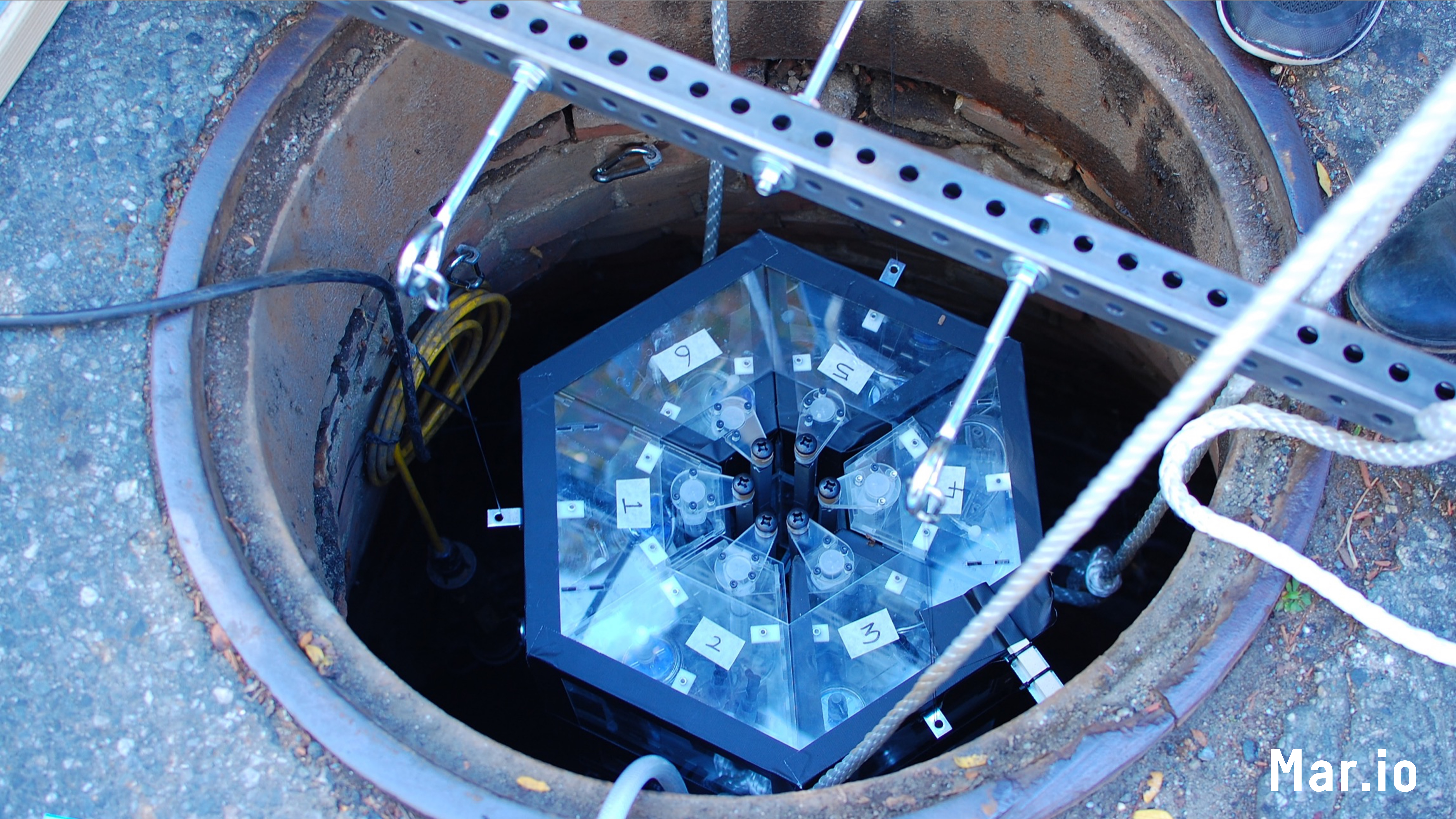
If you thought that your neighbours were judgmental about the state of your front lawn, get ready for the bots

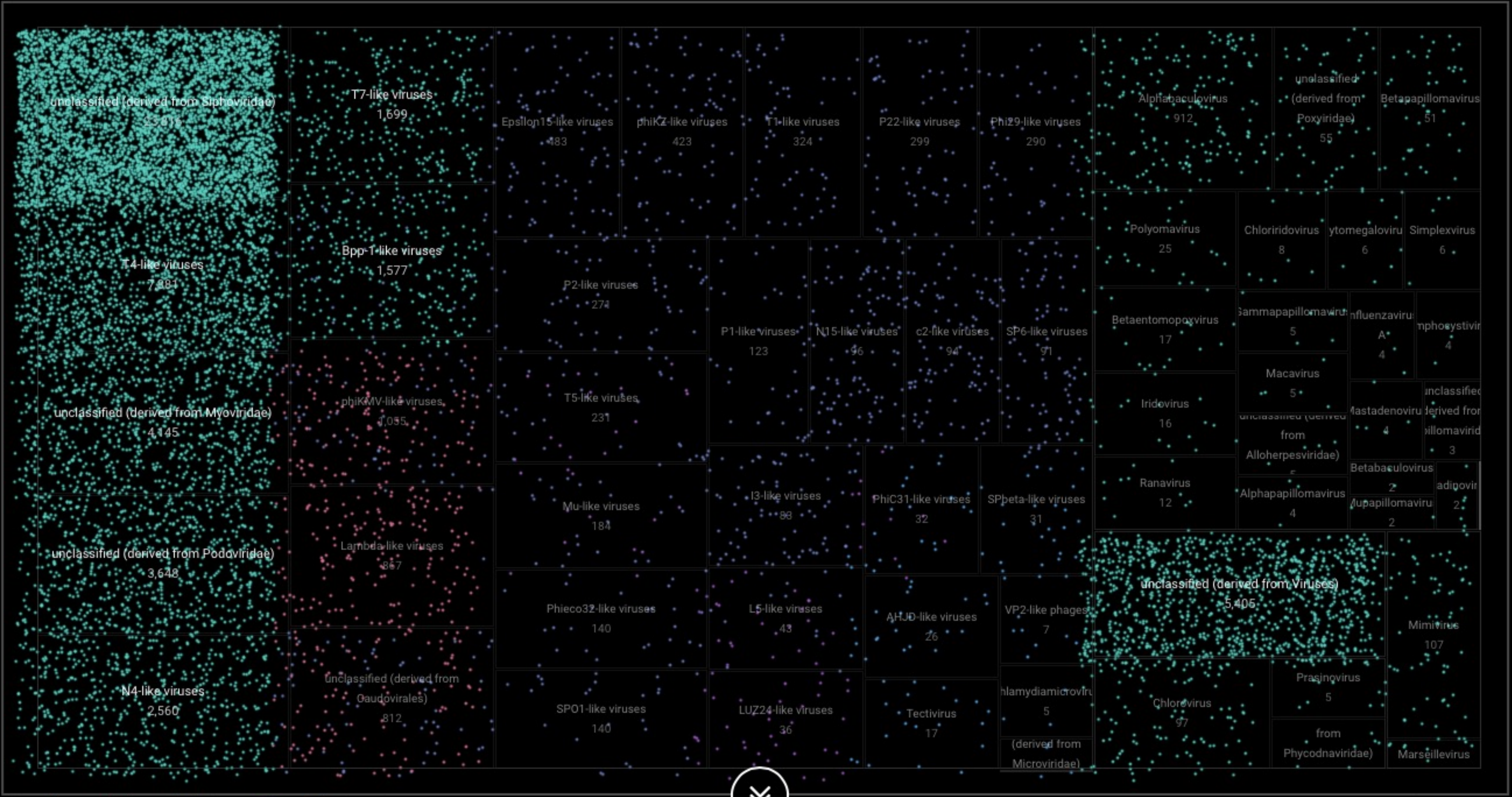
CARLO RATTI + Add to myFT

Imagine a dystopian future where everyone repaints their house a specific colour to game the system and impress the Google

Health & the City


GREAT MARLBOROUGH
ARGYLL PLACE
PUMP
WORK HOUSE
PORTLAND MEWS
BENTINCK STREET
EDWARD STREET
RICHMOND BUILDINGS
RICHMOND MEWS
BREWERY YARD
MARSHALL ST
TYLER COURT
LITTLE MARLBOROUGH ST
TYLER STREET
CARNABY
WEST STREET
MARSHALL STREET
DUFOURS PLACE
BROAD STREET
PUMP
CAMBRIDGE ST
NEW STREET
BREWERY
DUCK LANE
HOPKINS ST
HUSBAND ST
PETER STREET
HEARDS COURT
OLD COM
KING STREET
CROSS STREET
FOUBERTS PL
SOUTH ROW
CROSS ST
SILVER STREET
UP JAMES ST
UP JOHN ST
BRIDLE STREET
GREAT PULTENEY STREET
LITTLE WINDMILL STREET
WILLIAM AND MARY YARD
LITTLE PULTENEY STREET
GREAT CROWN CT
PUMP
UP RUPERT ST
BURLINGTON MEWS
NEW BURLINGTON STREET
REGENT STREET


Mar.io



Host Bacteria Animal Unknown Plant Other Eukaryote

In a sample of sewage water


Underworlds
ABOUT
PROJECTS
PARTNERS
TEAM
BLOG
Pipe Count
-
Area
- m2
Population*
-
Median Age*
-
White -%
Black -%
Asian -%
Other -%
Median Income*
-
Water Travel Time of This Area
0
30min.
60min.
Arlington
Somerville
Cambridge
Boston
Everett
Chelsea
Watertown
Charlestown
Harvard Square
Back Bay
Brighton
Allston

PLOS COMPUTATIONAL BIOLOGY

RESEARCH ARTICLE

Longitudinal wastewater sampling in buildings reveals temporal dynamics of metabolites

Ethan D. Evans[1], **Chengzhen Dai**[1☯], **Siavash Isazadeh**[1☯], **Shinkyu Park**[2], **Carlo Ratti**[2], **Eric J. Alm**[1*]

1 Department of Biological Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts, United States of America, **2** Senseable City Laboratory, Massachusetts Institute of Technology, Cambridge, Massachusetts, United States of America

☯ These authors contributed equally to this work.
* ejalm@mit.edu

OPEN ACCESS

Citation: Evans ED, Dai C, Isazadeh S, Park S, Ratti C, Alm EJ (2020) Longitudinal wastewater

Abstract

Direct sampling of building wastewater has the potential to enable "precision public health" observations and interventions. Temporal sampling offers additional dynamic information that can be used to increase the informational content of individual metabolic "features", but few studies have focused on high-resolution sampling. Here, we sampled three spatially

Biobot Analytics Awarded NIDA Funding for Nationwide Wastewater-Based Monitoring Program for High Risk Substances | READ MORE HERE

Intelligence from Wastewater to Save Lives

We analyze sewage with molecular technologies and AI to provide early warning of population health threats across the globe.

EXPLORE OUR DATA

Display a menu

Thank you!

[name of the presenter] [email]

#GaiaXSummit23