

Habits in behaviours: the human beauty and vulnerability

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*Several **inspiring**
collaborators
and **talented**
students*

What make us **human**?

We think



“Humans have a unique ability to understand the beliefs of another person”
(Credit: Thinkstock)



We feel

“Our open-ended ability to imagine and reflect on different situations, and our deep-seated drive to link our scenario-building minds together.”
(Credit: Suddendorf)

We behave



Habits, culture, emotions, storytellers, ability to **control and alter our environment...**
“We take advantage of others' experiences, reflections and imaginings to prudently guide our own behaviour”.
(Credit: Suddendorf)

Habits: Routine of behaviors

Don't go away

Unless we form new habits and
make them strong enough **to override the previous**
habit patterns



Daily circadian rhythm

Humans are **complex** creatures to study

Technology made it simpler, faster, or scalable



Geographical
barriers dissipation



Higher (true and fake)
information **accessibility**



Networking
pervasiveness



“The new petrol”

Digital Evolution

Humans are complex creatures to study

Technology



"The new petrol"

5.7 billion mobile subscribers,
about 71% of humans on Earth

Geographical
barriers dissipation

Networking
pervasiveness

Inria
inventors for the digital world

Digital Evolution

Concert 90s



Digital Evolution

Concert 2017

Concert 90s



Pervasive connectivity
makes our **real** life and **virtual** activities
seamlessly merged together



Fortunately, **not all events**
are seen through the eyes
of a smartphone

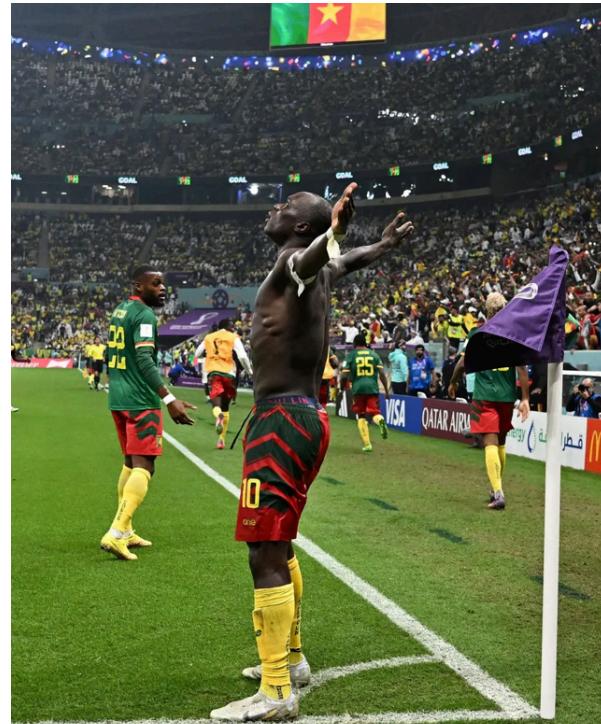
World Football Cup
2022!!!



World Football Cup 2022!!!

Cameroon 1 x 0 Brazil

BRAVO!!!



New opportunities

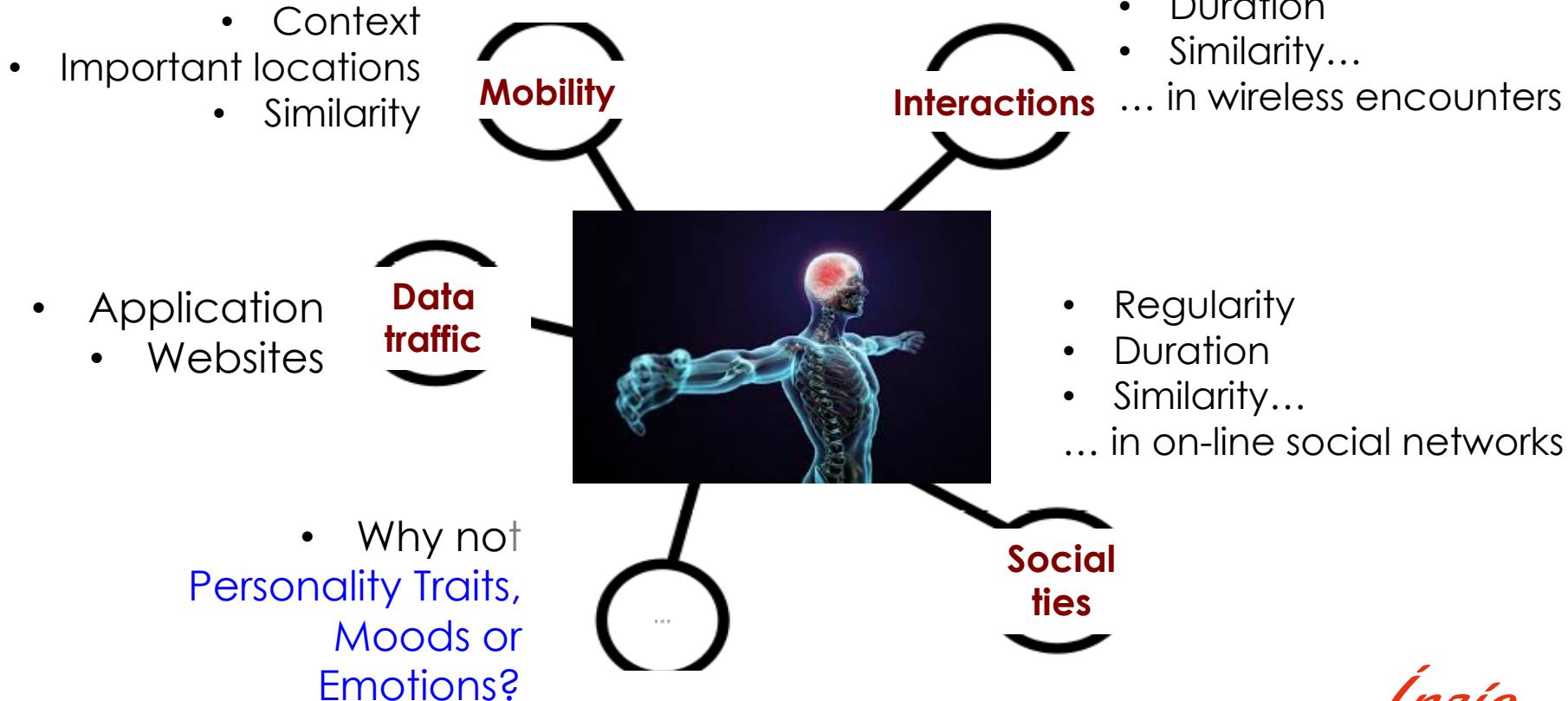


Digital datasets **mirror** human **behaviors**

- dynamics, interests, needs, etc

Enforcing the understanding of **where, for what, and when**
network usability happens

Here, human behavior translates in



>20 articles → <http://pages.saclay.inria.fr/aline.viana/>

Human



The **most studied** behavior in literature

Intrinsic of human beings and **less impacted** by of
technology advances

The human mobility beauty

How we move?



Limits of Predictability in Human Mobility



Chaoming Song,^{1,2} Zehui Qu,^{1,2,3} Nicholas Blumm,^{1,2} Albert-László Barabási^{1,2*}

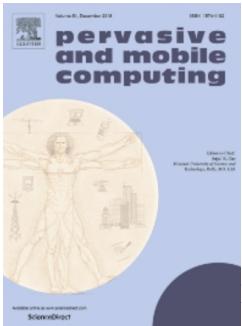
Understanding individual human mobility patterns

Marta C. González¹, César A. Hidalgo^{1,2} & Albert-László Barabási^{1,2,3}

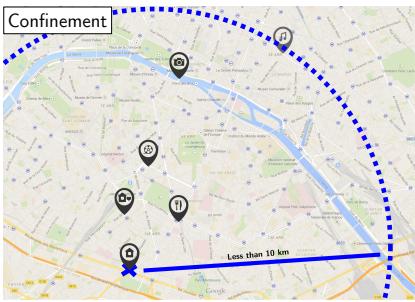
On the Regularity of Human Mobility

[EPJ DataScience11, ACM TSAS21] [ACM SigSpatial19, EPJ DScience21, ACM TSAS21]

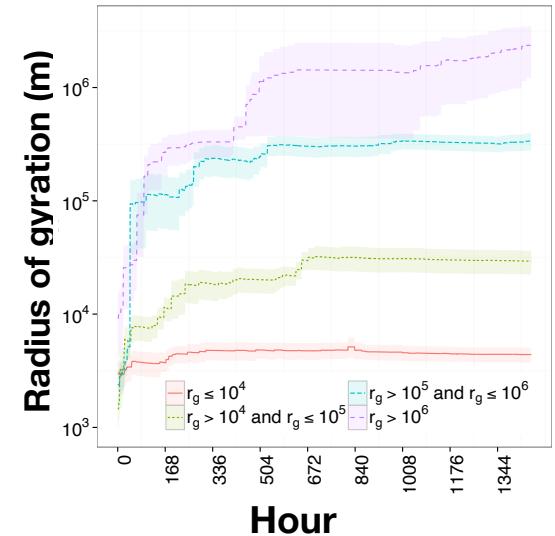
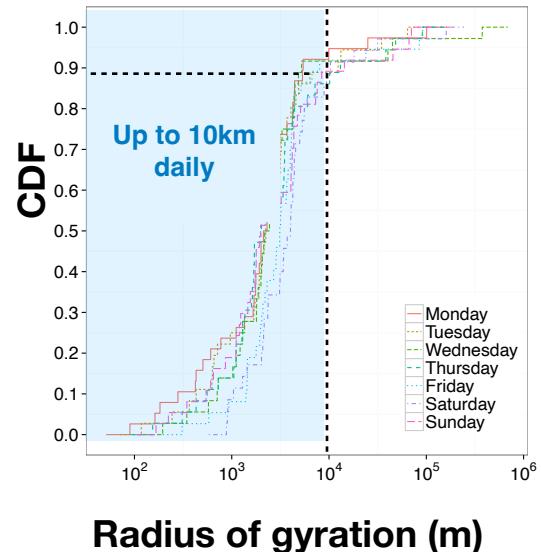
Eduardo Mucelli Rezende Oliveira^{a,b,*}, Aline Carneiro Viana^b, Carlos Sarraute^c, Jorge Brea^c, Ignacio Alvarez-Hamelin^d



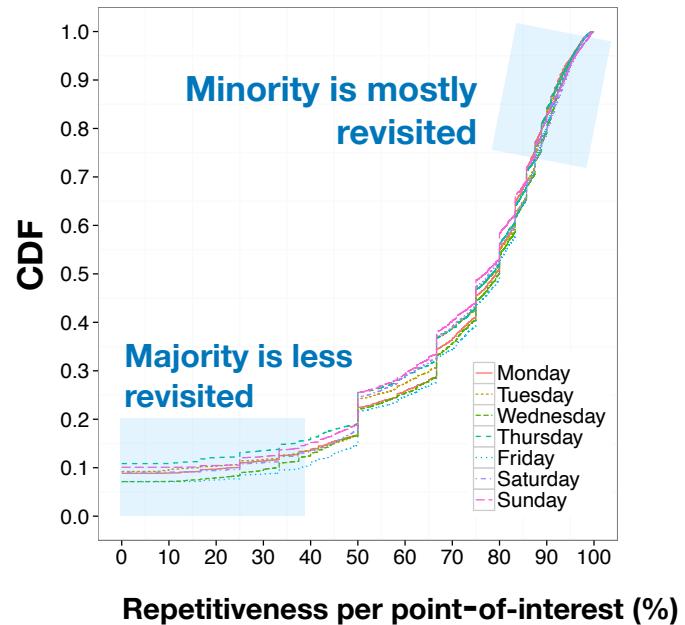
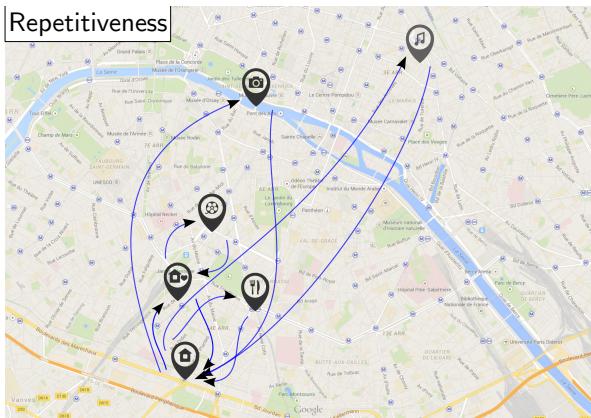
- Population trip distance distribution follows a truncated power law
- Confined mobility



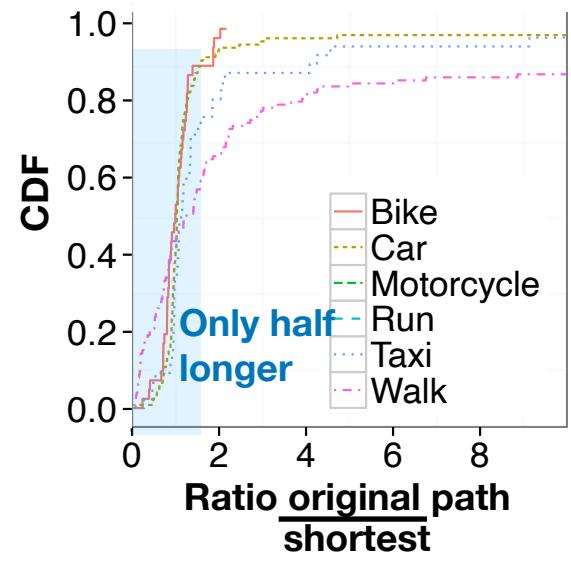
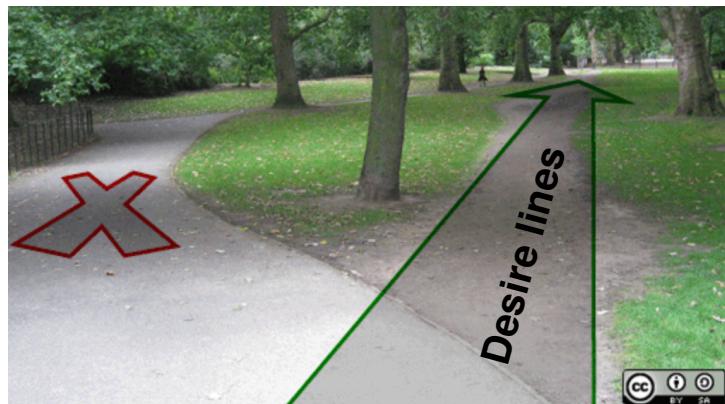
$$r_g^u(t) = \sqrt{\frac{1}{n} \sum_{p=1}^n (\vec{r}_p^u - \vec{r}_{cm}^u)^2} \quad \vec{r}_{cm}^u = \frac{1}{n} \sum_{p=1}^n \vec{r}_p^u$$



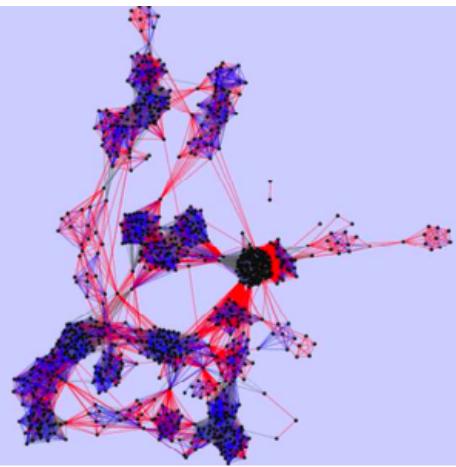
- Population trip distance distribution follows a truncated power law
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- Frequent travels to a limited number of *preferable* places



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- Shortest path preference - *principle of the least effort*



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High predictability of human mobility (upper bound: 93%)

Thanks to *frequent travels to a limited number* of places

In mobility: Moments of...



ROUTINE

Habits!

ROUTINE



In mobility: Moments of...



ROUTINE

EXPLORATION

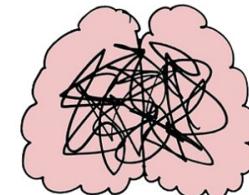
Habits!

ROUTINE



Novelty!

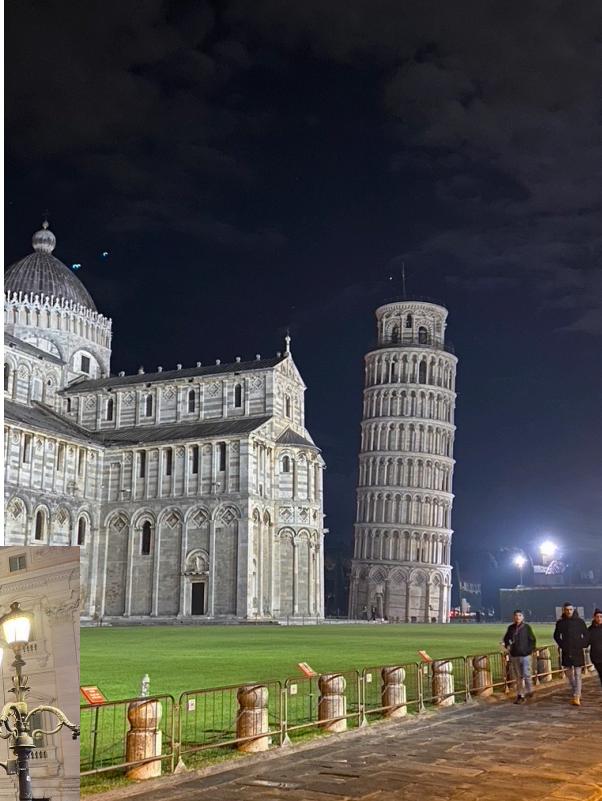
NO ROUTINE



[EPJ DataScience11, ACM TSAS21]
[ACM SigSpatial19, EPJ DScience21,
ACM TSAS22]

[ACM SigSpatial20, ACM SigSpatial21,
ACM TETC22]

Moments of EXPLORATION



Moments of EXPLORATION



Where is our
location of
interest?

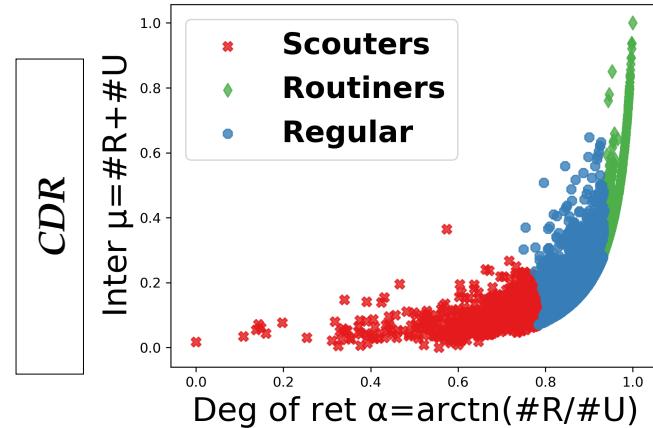
Moments of EXPLORATION



Moments of EXPLORATION

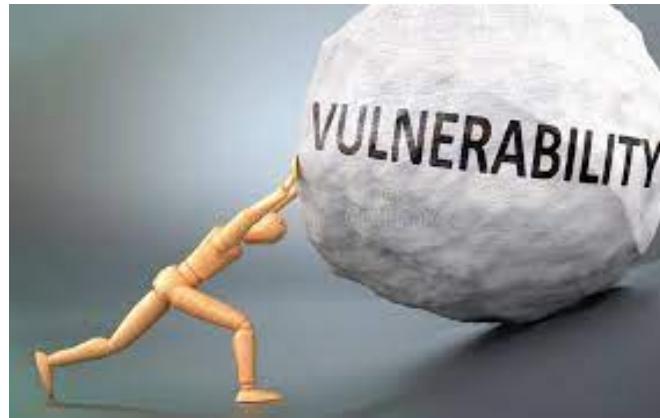
How often does an individual explore?

How many new places does she visit consecutively?



	<i>Scouters</i>	<i>Routiners</i>
<i>Relocation Activities</i>	<ul style="list-style-type: none">- Discover many places- Break routines- Large sets of known places	<ul style="list-style-type: none">- Few discoveries- Rarely interrupt routines- Small sets of known places
<i>Temporal Activities</i>	<ul style="list-style-type: none">- Explore for large amounts of time	<ul style="list-style-type: none">- Spend shorter amount of time exploring
<i>Spatial Activities</i>	<ul style="list-style-type: none">- Walk long distances in general	<ul style="list-style-type: none">- Have a confined mobility

The human mobility vulnerability



Habits!

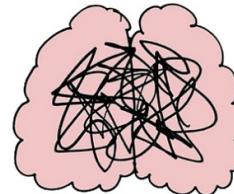
ROUTINE



Helps mobility prediction

Novelty!

NO ROUTINE



Impacts mobility prediction but still....

Daily **circadian** rhythm

And **contextual** influence

We know how to deal with

(1) **uncertainties** and (2)
heterogeneous novelty-seeking
behaviors

Per individual Spatiotemporal *mobility*
perceptive anticipation

Habits!

ROUTINE



Helps mobility prediction

Novelty!

NO ROUTINE



Impact mobility prediction
but still....

Daily circadian rhythm

And contextual influence

They know where you are going
the most part of the time!!

Context-enhanced Trajectory Reconstruction

Mitigating sparsity and irregularities

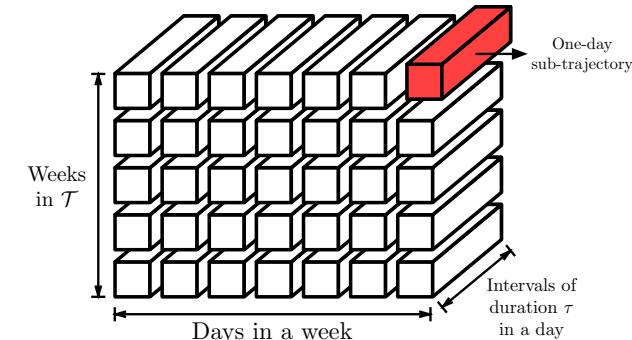
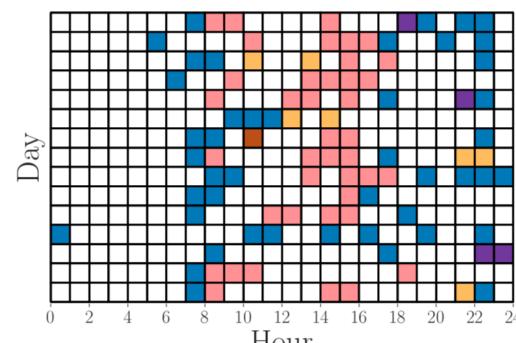
Daily periodicities stronger than weekly ones - **repetitive patterns**

Consecutive time slots show **similarities** in locations of the user

Pattern of **long static** phases with **fast** movements in between

Overnight **invariance**

[IEEE Globecom17,
COMNET18, EPJ Data
Science19]



Context-enhanced Trajectory Reconstruction

Mitigating sparsity and irregularities

Customized Tensor Factorization

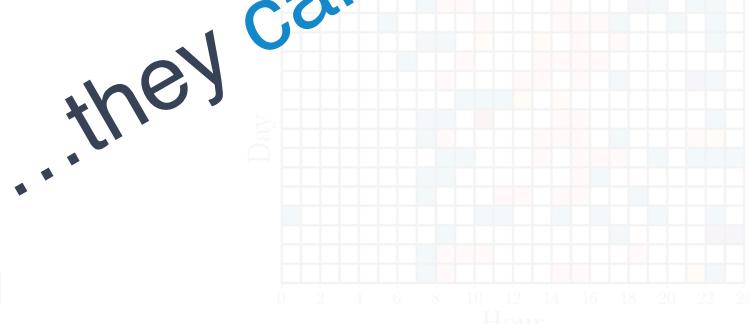
Daily periodicities stronger than weekly ones - repetitive patterns

Consecutive time slots show similarities in locations of the user

Pattern of long stay phases with fast movements in between

Overnight it's silence

Even if short segments revealed...



...they can still track you!!



Unique in the Crowd: The privacy bounds of human mobility



Yves-Alexandre de Montjoye^{1,2}, César A. Hidalgo^{1,3,4}, Michel Verleysen² & Vincent D. Blondel^{2,5}

Uniqueness: 4 random time-ordered locations identify 1 user
among 1.5 million, 95% of time

Revisiting “Unique in the Crowd” results: after
context-enhanced trajectory reconstruction

Instead, **62 random locations**, 85% of time

Sparsity brings fake uniqueness and hides diverse patterns of mobility

Completeness brings many similar users trajectories, what limit uniqueness

Unique in the Crowd

Revised once trajectories are reconstructed

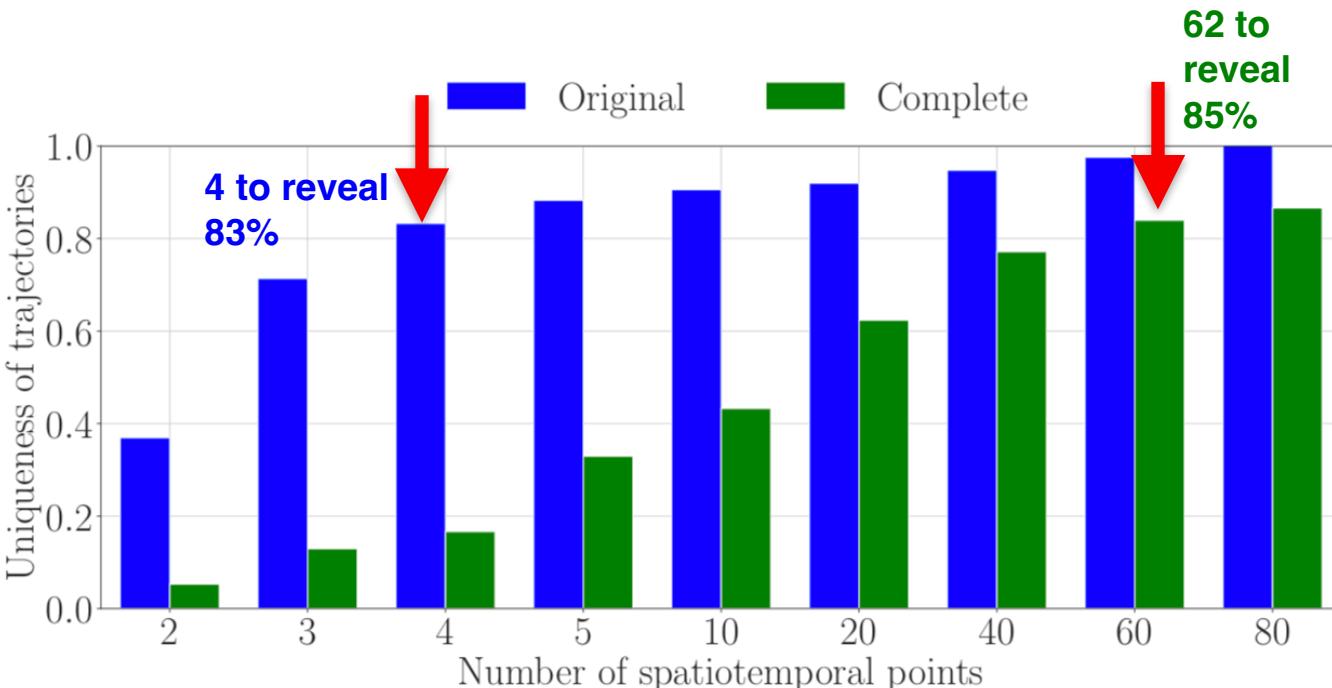


Figure 10 Revisited results from [5]. Ratio of trajectories with uniqueness $|U| = 1$ for a number of spatiotemporal points in the abscissa, for original (left) and complete (right) trajectories.

Unique in the Crowd: The privacy bounds of human mobility

Yves-Alexandre de Montjoye^{1,2}, César A. Hidalgo^{1,3,4}, Michel Verleysen² & Vincent D. Blondel¹

SCIENTIFIC
REPORTS

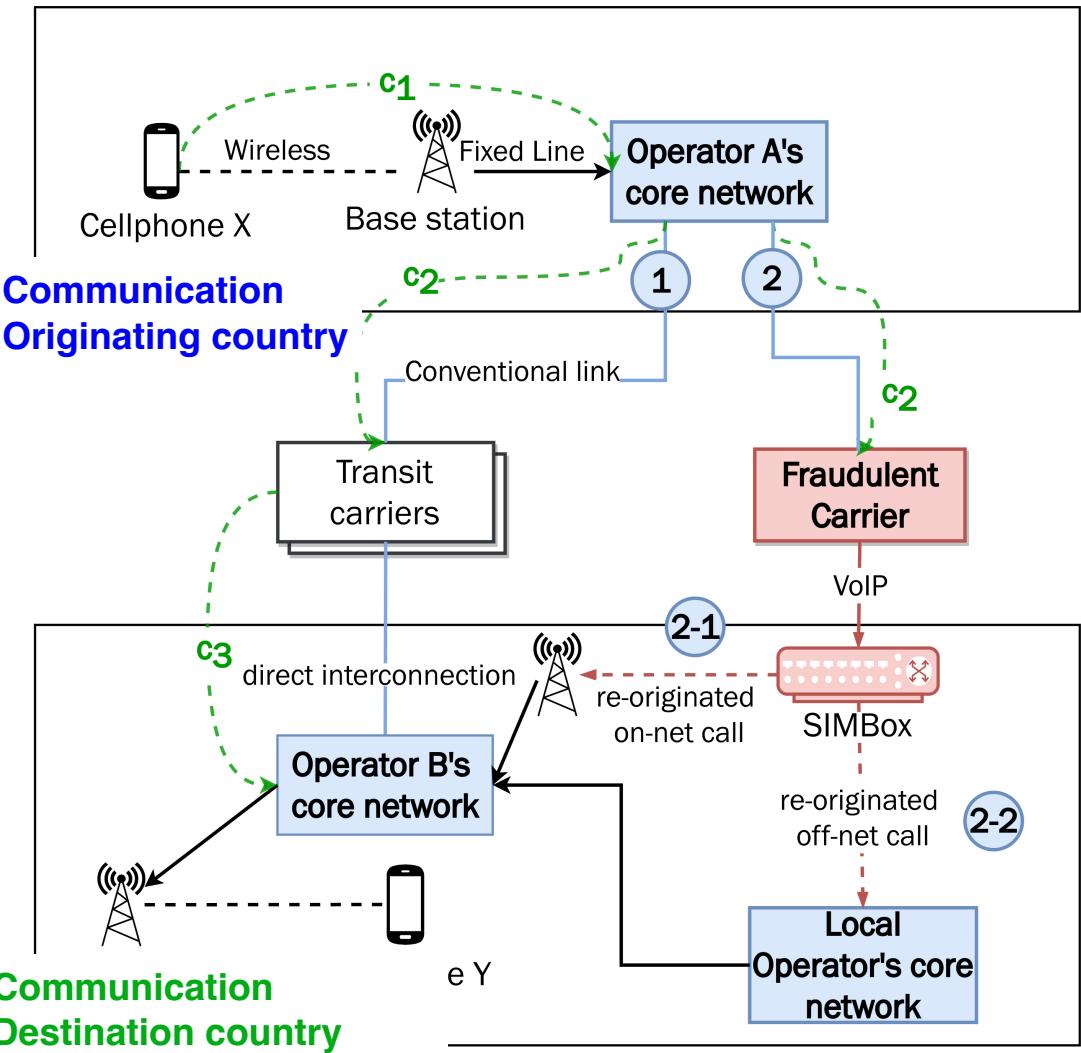
Uniqueness: 4 random locations identify 1 user among 1.5 million, 95% of time

They still know it is you!!

Revisiting “Unique in the Crowd” results: after context-enhanced trajectory reconstruction

Instead, 62 random locations, 85% of time

Frauds in cellular network: The SIMBox type



[IEEE Comm. Tutorial Survey21]

[ACM CoNEXT Student Workshop23]

Frauds in cellular network: The SIMBox type

They are imitating your behaviors!!!
Mobility, traffic generation, social contacts



Do not panic: There is still hope

Federated learning but **capable of**
Perceiving vulnerabilities in individual behaviors
Dependent on users' privacy **choices**
Adapted to moments of heterogeneity (in mobility, in interest, etc),
uncertainties, contextual conditions
Being **simple**, do not add more complexity than *being human* already do

Merci beaucoup!

You are Human Beings!

So think as one when designing solutions
for human users!

Students A. J. Kouam, L. Amichi, D. Do Couto, G. Chen, E. Mucceli, A. Di Luzzio, D. Madariaga, J. Esper, P. Katsikouli

Collaborators A. Tchana (INP), J. Almeida and A. Loureiro (UFMG), N. Achir (Inria/TRiBE), M. Fiore (IMDEA), M. Crovella (Boston Univ.), J. Stefa, A. Mei (Sapienza Univ. of Rome), K. Jaffres-Runser (Univ. of Toulouse), L. Santos, R. Stanica (Inria), C. Sarraute (GranData)

Period Since 2014