Under the social microscope: characterizing human mobility

What… and Why

Analysis of (big) mobility data has revealed distinctive statistical patterns, that can be used for:

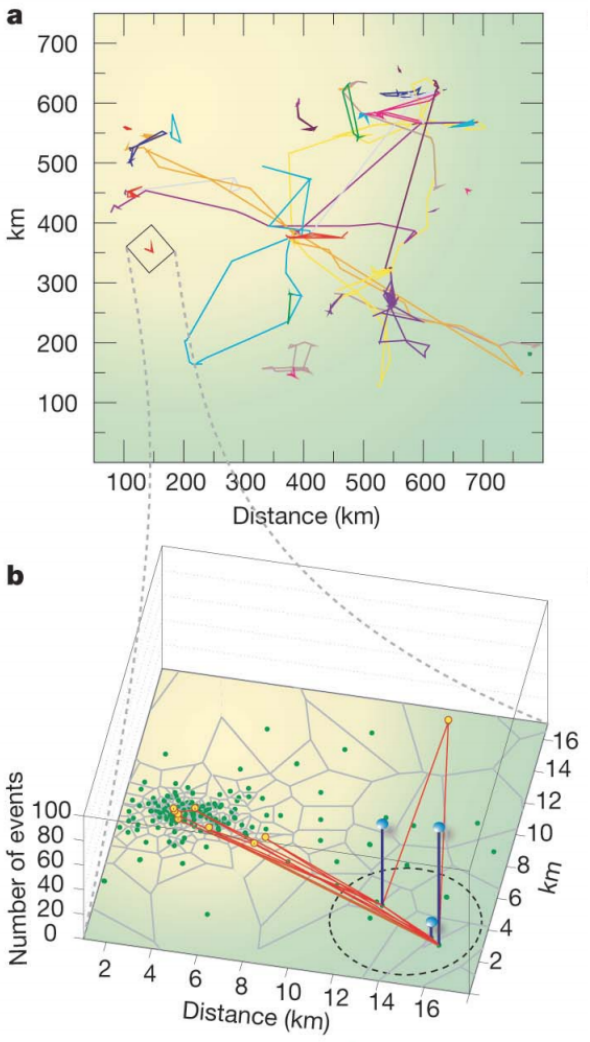
- **validating** mathematical models and simulation algorithms
- **training** AI models for predictive tasks (monitoring of well-being, health, location prediction, etc.)

Human Mobility Measures

From movements data we can compute several measures that can be used to characterize the individual and collective mobility:

- Individual measures: features related to the mobility patterns of a single individual
- Collective measures: mobility patterns of an entire population of individuals

Jump length (or traveling distance)



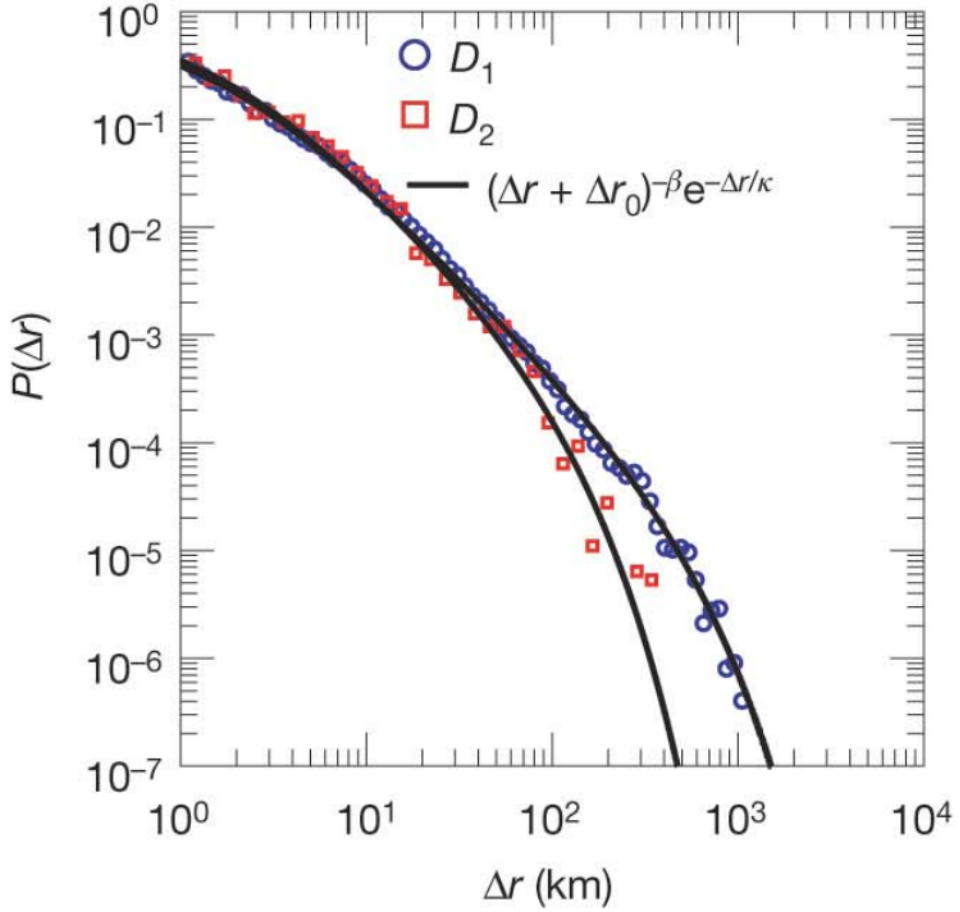
The distance between two consecutive locations visited by an individual

For GPS data, we need to detect locations

Understanding individual human mobility patterns (Gonzalez et al., Nature, 2008).

Jump length (or traveling distance)

Gonzalez et al., Understanding individual human mobility patterns, Nature, 2008.



D1: 100,000 for 6 months
D2: 200, 1 week, every 2h

$$\beta = 1.75 \pm 0.15$$

$$\Delta r_0 = 1.5km$$

$$\kappa = 400km$$

$$P(\Delta r) = (\Delta r + \Delta r_0)^{-\beta} \exp(-\Delta r/\kappa)$$

Radius of gyration

The characteristic distance traveled by an individual

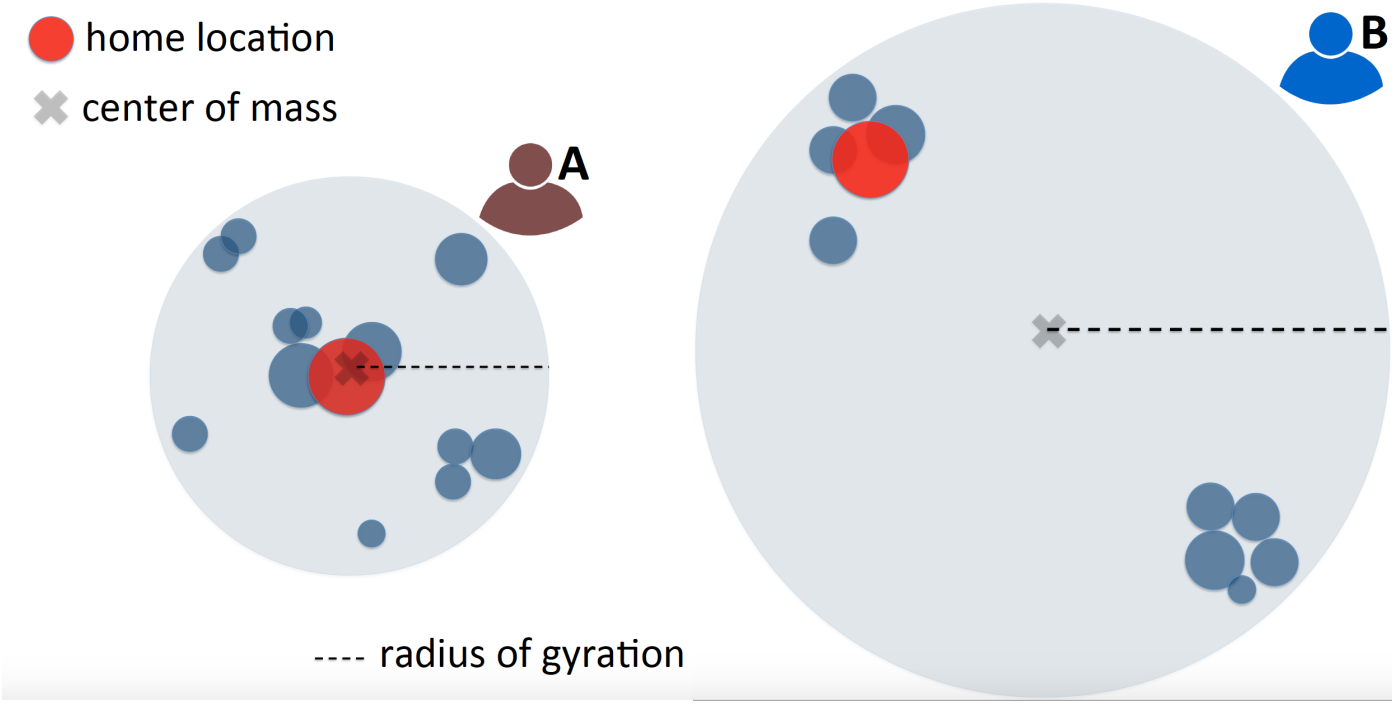
For GPS data, we need to detect locations

$$r_g = \sqrt{\frac{1}{N}\sum_{i=1}^{N} w_i (r_i - r_{cm})^2}$$

$$r_{cm} = \frac{1}{N}\sum_{i=1}^{n} w_i r_i \qquad N = \sum_{i=1}^{n} w_i$$

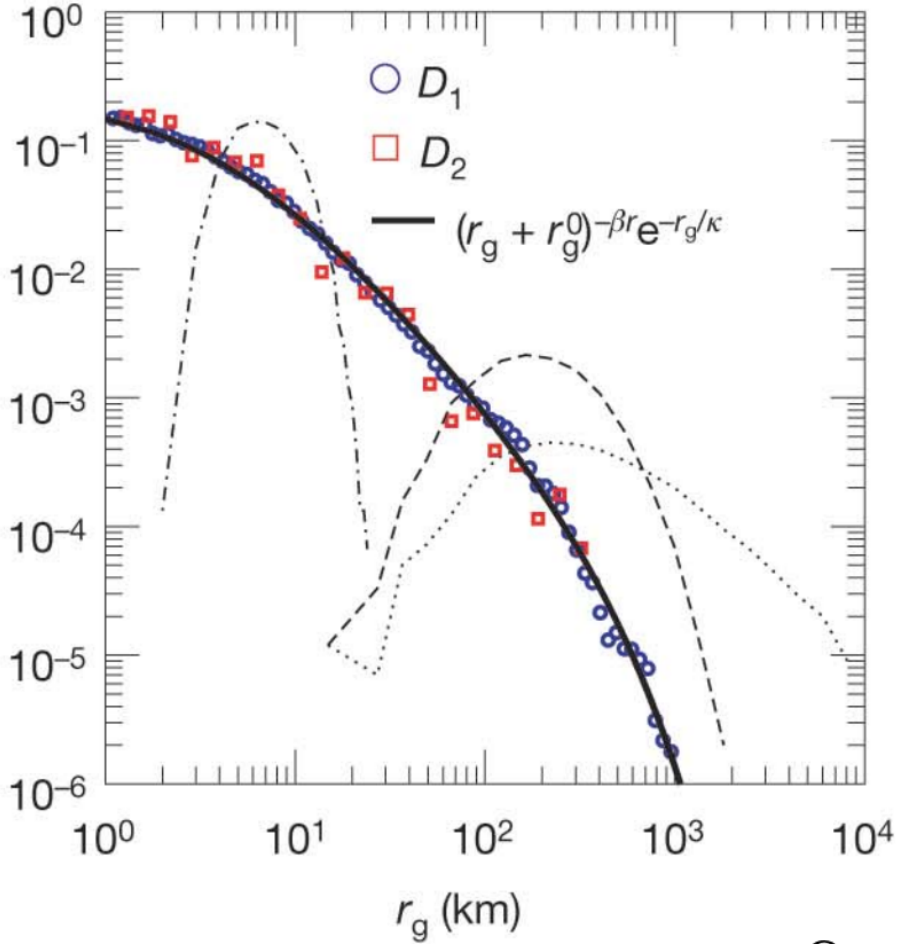
Radius of gyration

The characteristic distance traveled by an individual



Radius of gyration

Gonzalez et al., Understanding individual human mobility patterns, Nature, 2008.



$$r_g^0 = 5.8km$$

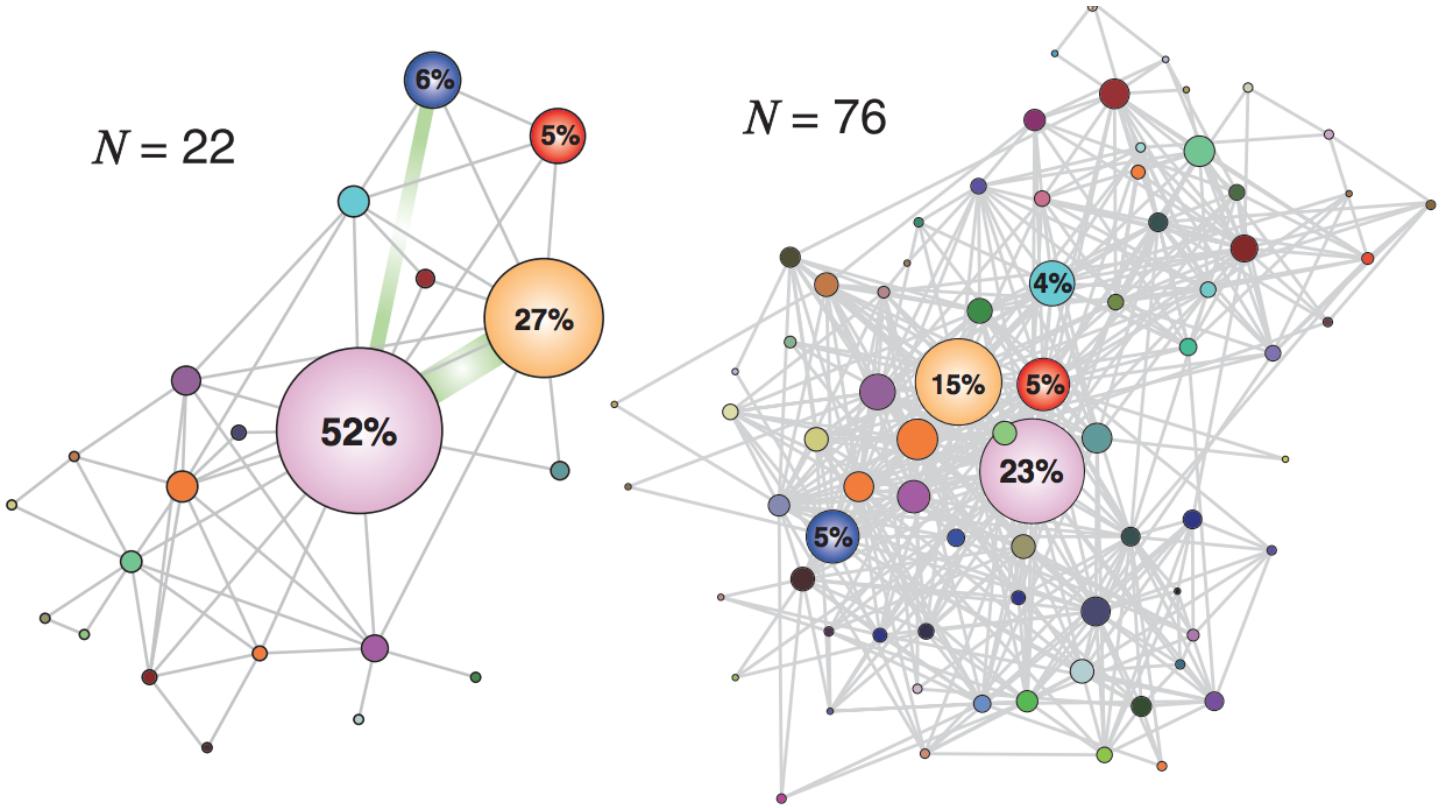
$$\beta_r = 1.65 \pm 0.15$$

$$\kappa = 350km$$

$$P(r_g) = (r_g + r_g^0)^{-\beta_r} \exp(-r_g/\kappa)$$

Individual Mobility Networks (Motifs)

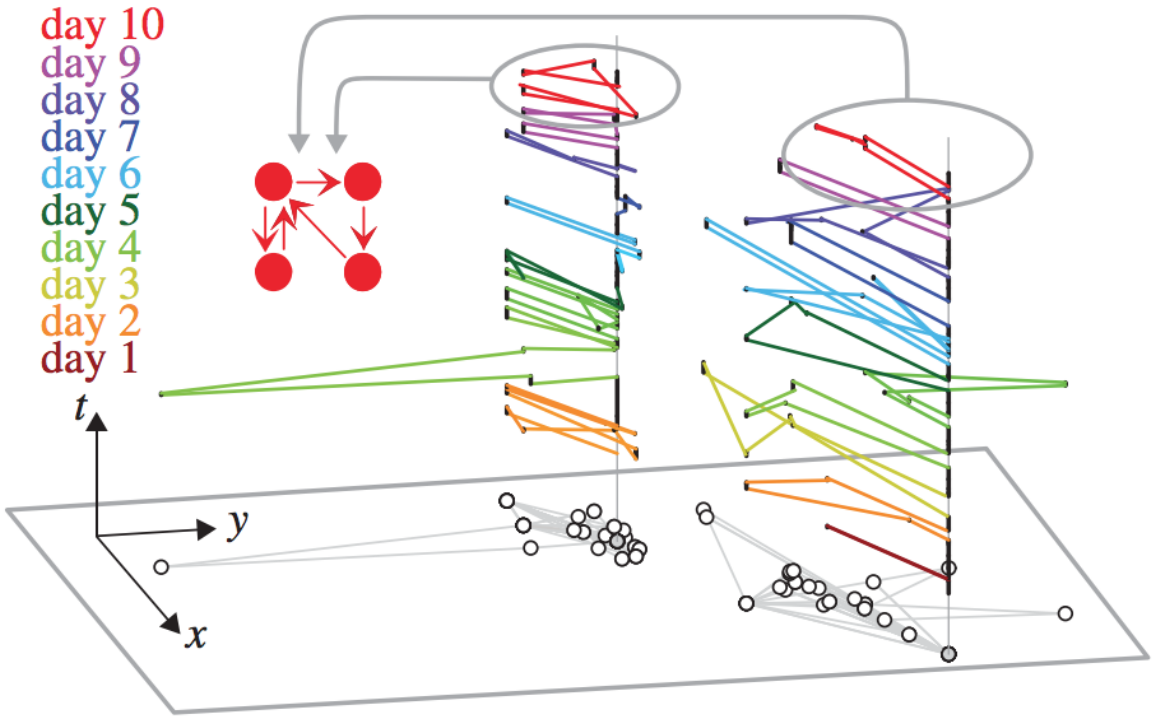
IMN: a network describing the typical movements of an individual



Song et al., Limits of predictability in human mobility, Science, 2010.

Individual Mobility Networks (Motifs)

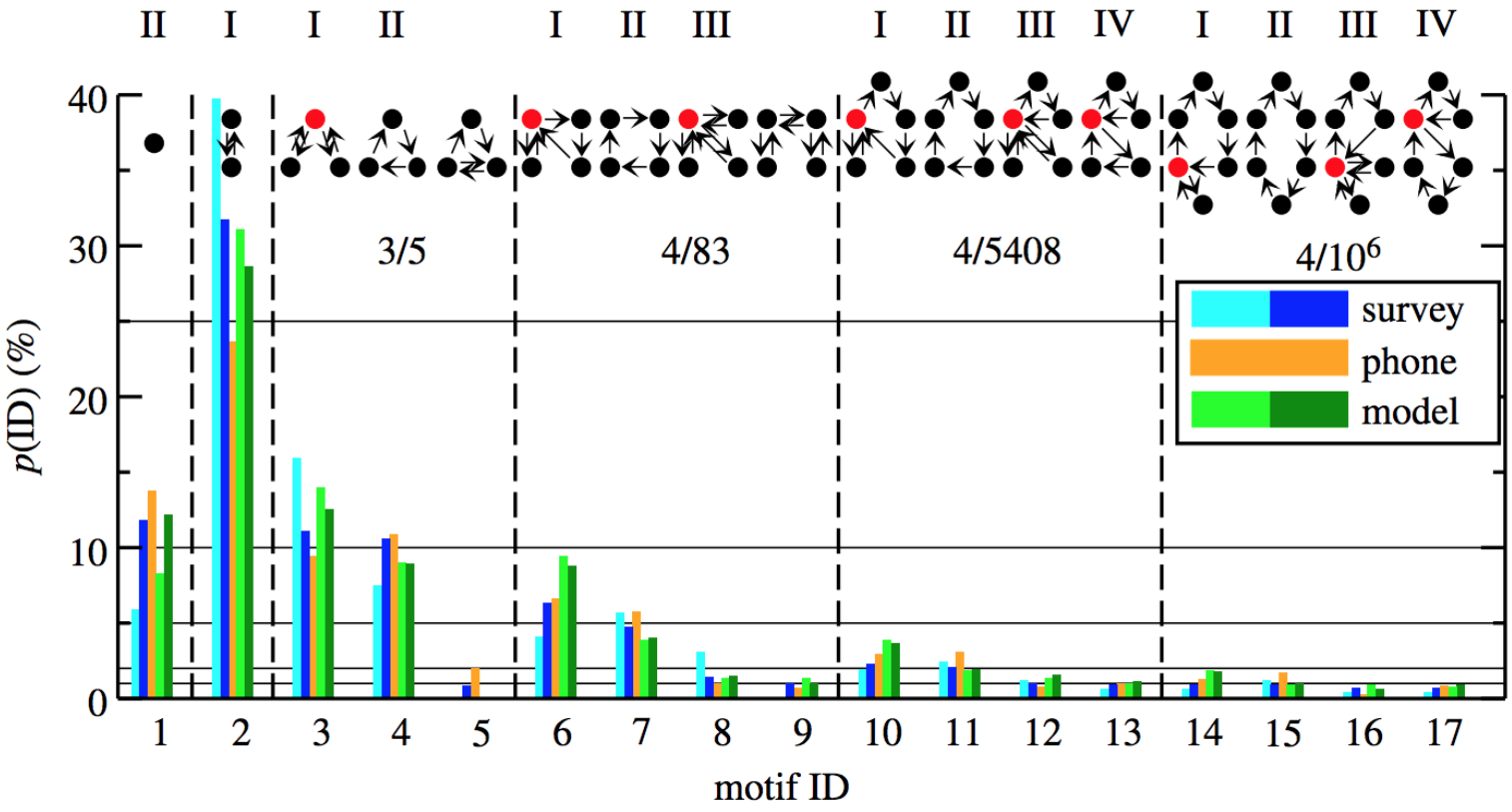
Daily Motif: a frequent network describing the daily movements of an individual



Schneider et al., Unravelling individual daily mobility motifs, Journal of the Royal Society Interface, 2013.

Individual Mobility Networks (Motifs)

17 daily motifs have been found in different mobility data sources



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OD matrix

origin \ destination	a	b	c	d	e	f
a	-	3	27	2	1	0
b	1	-	4	0	0	5
c	8	3	-	1	13	6
d	2	1	5	-	0	2
e	11	0	6	5	-	1
f	0	3	2	2	0	-

(self-loops are usually not considered)

total out-flow from i

$$\sum_j T_{ij} = O_i$$

total in-flow to j

$$\sum_i T_{ij} = D_j$$

total flow

$$\sum_{ij} T_{ij} = N$$

Human Mobility and Machine Learning

Human mobility patterns, both at individual and collective level, can be used for several **predictive and analysis tasks**:

Human Behaviour Prediction

- Car Crash Prediction
- Influenza like-symptoms prediction
  Are you getting sick? Predicting influenza-like symptoms by using human mobility behaviors (Barlacchi et al.)

Human Mobility for Social Good

- Predicting socio-economics behaviours from mobility data
  Predicting poverty and wealth from mobile phone metadata (Blumenstock J. et al.)