A growing model for the lodgings and services network in a destination

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Introduction

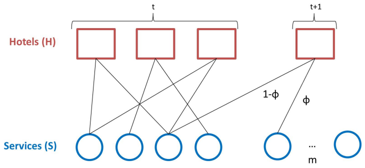
- Tourism is a complex system and susceptible to be analyzed using complex network methodology.
- Previous contributions of complex network methodology in tourism research:
  - Limited in size ($N < 10^2$)
  - Analysis of topological characteristics, communities detection, knowledge diffusion, movement patterns in destination...
- Our **objective** is to build a growing network to represent the development of a tourist destination. It is based on:
  - Evolving bipartite network models [Ramasco et al., *Phys. Rev. E* , 70, 03610666, 2004; Zhang et al., *Phys. A*, 392, pp. 6100–6106, 2013]
  - Studies on within destination movements of tourists [Lew and McKercher, *Ann. Tourism Res.*, 33, pp. 403–423, 2006; McKercher and Lau, *Tourism Geograph.*, 10, pp. 355–374, 2008]

The model. Assumptions

- Assume two categories of nodes, lodgings (H) and services (S).
- A link between a lodging $i \in H$ and service $j \in S$ appears if a representative tourist of lodging i visits service j during his/her staying in the destination.
- Assume that links are unweighted, undirected and permanent.
- Assume that every lodging includes exactly c links to services ($c \geq 1$).

The model. Growing rules

- At any time $t > t_0$, one new lodging and m new services are created in the destination.
- A representative tourist of a new hotel visit c services:
  - $\phi \in [0, 1]$ of them at random.
  - $1 - \phi$ by linear preferential attachment according to service's degree $s_j(t)$.



Representation of the growing rule of the supply network of a tourist destination

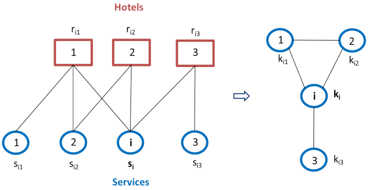
- After some calculations, the evolution of s_j can be described by

$$\frac{\partial s_j}{\partial t} = \frac{(1-\phi) m s_j + c\phi}{mt},$$

- Assuming t sufficiently large, we have

$$p(s) \simeq m(c\phi)^{\frac{1}{1-\phi}} \left(c\phi + m(1-\phi)s\right)^{-\frac{1}{1-\phi}-1}.$$

The model. Degree of the one-mode projection



One-mode projection of the bipartite lodgings-services network

- Notation:
  - $s_j \equiv$ Degree of service j.
  - $k_j \equiv$ Degree of service j in the one-mode projection.
- Then, the relation between k_j and s_j can be approximated by:

$$k_j = (c-1)s_j, \forall j \in S.$$

- So, after some calculations,

$$p(k) \simeq m(c(c-1)\phi)^{\frac{1}{1-\phi}} (c(c-1)\phi + m(1-\phi)k)^{-\frac{1}{1-\phi}-1}.$$

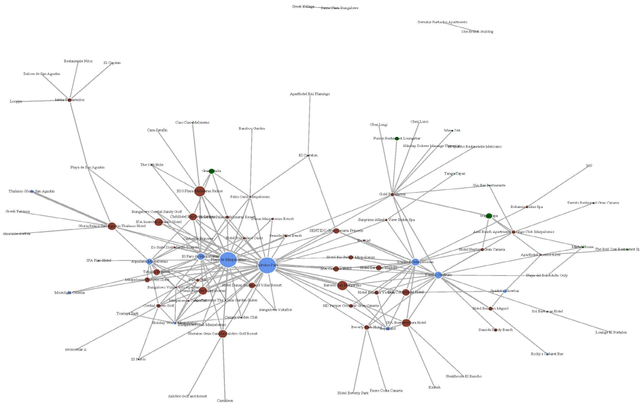
Study site and data

The data are extracted from the tourist activity developed in the southern area of the island of Gran Canaria, Spain, from 2005 to 2016.

Tourist area of Maspalomas (Gran Canaria)

The data was collected from the user opinions published in the web-site trypadvisor.com. It includes some relevant biases:

- Lodgings and services are limited to those published in the web-site.
- The sample is also limited to those registered users.



Representation of the lodging-services network. Lodgings are colored in brown, services in blue and green. The link lodging-service indicates that at least 15 opinions of the service was made by tourists hosted in the lodging. Node's degree is represented by the ball size. Edges' thickness illustrate the number of opinions.

Table 1. Basic statistics. $H \equiv$ Logings; $S \equiv$ Services; $L \equiv$ Links; $< c > \equiv$ Mean degree of lodgings; $< s > \equiv$ Mean degree of services; $\rho \equiv$ Density.

H	S	L	$< c >$	$< s >$	ρ
182	1,496	13,359	73.4	8.9	$9.5\ 10^{-3}$

Simulations and comparison with real data

Lodgings degree distribution in the empirical sample of Maspalomas (Gran Canaria). The lodging's degree in the model is $c = 73$.

Simulations and comparison with real data

Comparison among the cumulative degree distribution of services (s) for the empirical sample of recommendations in Maspalomas (red points), the theoretical predictions (dashed lines), the simulations of the model for a time horizon $T = 5000$ (blue circles) and for a time horizon $T = 180$ (green circles). Every graph assumes a specific value of the percentage of services chosen at random. The other parameters are determined according to the real data.

Simulations and comparison with real data

Comparison among the cumulative degree distribution of services in the one-mode projection (k) for the empirical sample of recommendations in Maspalomas (red points), the simulations of the model (blue circles) and the theoretical predictions (dashed lines).

Extensions

- We include the distance factor in the decision to enjoy a service.
- We assume that the social distance to consume a service is determined by the intermediate attractions and lodgings.
- So, a representative tourist of a new lodging i visit a specific service j with probability $\Pi_{i \to j} \sim s_j d_{ij}^{-\alpha}$, where $\alpha > 0$ and d_{ij} is the length of a geodesic path form i to j.

Left: Representation of the lodging-services network in Maspalomas, Spain. ; Right: Comparison among the cumulative degree distribution of services (s) for the empirical sample and the simulations of the evolutionary network model.

Conclusions

- We have built an evolving bipartite network model that represents the supply network formed by the tourist's visits to services.
- The model fits well real data in the long term for a specific combination of the random and preferential attachment rules.
- Limitations:
  - Micro-motives of the tourist behavior need to be more deeply founded.
  - Rewiring of old links is not allowed in the model.
  - New links to old hotel are not allowed either.
  - Removal of lodging/services due to aging or closure is not included.
- Extensions:
  - Overcome previous limitations.
  - New comparisons with data from larger destinations in terms of visitors, lodgings and services.

Thank you for your feedback!