An Intelligent Tree Planning Approach Using Location-based Social Networks Data

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BNAIC 2020 BENELEARN

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Future Cities Challenge

Introduction

How do we make sure that all citizens in a city can enjoy the necessary amount of green space? We propose a new data-driven criterion taking socio-cultural aspects into account. For this, we create a tree density coefficient, which holds the tree density of venue communities taking the movement of people through the city into account.

1. Location-based social network

We use mobility data of New York City received from the Foursquare mobility technology platform as part of the Future City Challenge in 2019. With this data we construct an LBSN with 15,803 nodes, representing venues, and 248,597 weighted edges, representing movement between venues.

Using the Louvain community detection algorithm we partition the network into different venue communities, where each community holds nodes that are more strongly connected with each other than with nodes outside the network. An example of one community detection run is shown in Figure 1. Due to the stochastic nature of the Louvain detection algorithm, this is repeated many times to gain confidence in the partitions. We use the communities to compute the tree density coefficient.

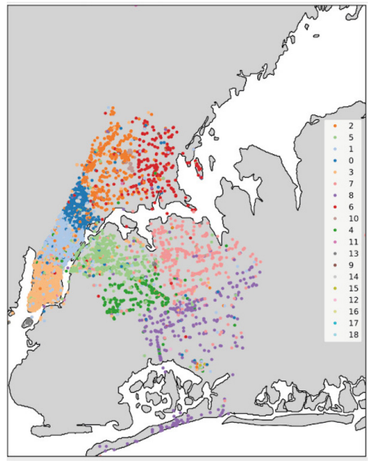

Figure 1: Example of venue communities in New York City.

Figure 2: Tree locations in New York City.

$$\text{Venue tree density of venue } v_i: \quad \mathrm{vtd}_i = 3$$

$$\text{Community tree density of venue } v_i: \quad \mathrm{ctd}_i = \frac{1}{|C_i|} \sum_{v_j \in C_i} \mathrm{vtd}_j, \quad v_i \in C_i$$

$$\text{Tree density coefficient of venue } v_i: \quad \mathrm{tdc}_i = \frac{1}{k} \sum_{t=1}^{k} \mathrm{ctd}_i$$

Figure 3: Tree density equations.

2. Tree density coefficient

To select tree planting locations we compute the tree density coefficient. For this, we combine a tree location data set (Figure 2) of New York with the LBSN. Firstly, for each of the venues the trees in their vicinity are counted. Secondly, for each iteration of the community detection algorithm, we sum the venue tree density of each community to derive the community tree density of the venues. Finally, the tree density coefficient of a venue is the average of all community tree density values of the venue. The equations used to compute the tree densities for venues and communities are shown in Figure 3.

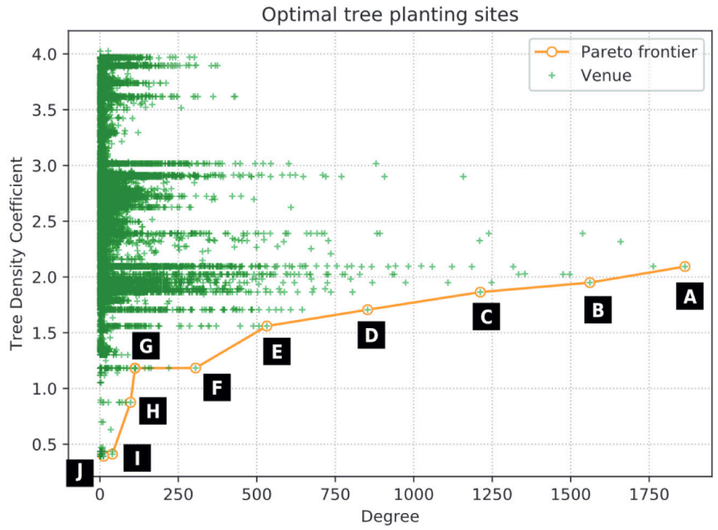

Figure 4: Pareto front maximizing degree while minimizing tree density coefficient.

3. Planting site selection

Applying multi-objective optimization theory, we select tree planting sites by maximizing the degree of venues while minimizing their tree density coefficient. We highlight these venues on the pareto front as shown in Figure 4.

Table 1: Selected tree planting locations based on maximized degree and minimized tree density coefficient

ID	Name	Type	degree	tdc (new)	vtd (previous)
A	MTA Subway - West Farms Square/E Tremont Av (2/5)	Metro Stations	1864	2.0932	2
B	Junction Blvd	Misc. shops	1561	1.9493	0
C	MTA Subway - 179th St (F)	Metro stations	1212	1.8643	0
D	Sammy's Fish Box Restaurant	Seafood Restaurants	853	1.7063	3
E	Rockaway Beach - 116th Street	Beaches	532	1.5598	0
F	Hulu Theater	Music Venues	305	1.1835	0
G	Bean & Bean Organic Coffee	Coffee Shops	112	1.1820	4
H	Peggy Rockefeller Rose Garden	Gardens	98	0.8756	0
I	I-495 / Grand Central Parkway Interchange	Intersections	40	0.4112	0
J	TSA Security Screening	General Travel	12	0.3920	0

Results and conclusion

In Table 1 we show the venues corresponding to the selected locations of Figure 4. An interesting insight is that venue G has four trees in its vicinity, but is still selected as a good planting side, due to its popularity and because the other venues in its community have little to no trees.

We want to note that this work is applicable to similar site selection problems as long as similar data is available. We are currently extending this work to the city of Paris. In future we can see this method being applied to selecting suitable placements for waste bins and similar street furniture.