USING EXPECTED DISTANCES ALONG THE NETWORK FOR DESIGNING IRRIGATION NETWORKS BY USING A P-MEDIAN MODEL

REsearch GROup on LOCation

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ABSTRACT

The increasing need to rationalize water resources in the agricultural sector has forced the introduction of new water distribution systems. The design and dimensioning of the network of pressurized water for irrigation has the following phases: Location of hydrants, Network Designing, Determination of circulating flows for each of the lines and Determination of pipe diameters.
Clearly the cost of pipes and hydrants between parcels depend on the location of fire hydrants and which parcels are assigned.
The location - allocation approaches can help to find solutions that minimize this cost.

The p-Median Problem (Hakimi, 1964) is a common location-allocation model for finding p facility locations among a set of candidates so that the total access distance, required to serve a fixed demand, is minimized.
The p-median model aims at determining the location of a number of service centers (hydrants) and to assign each demand item (parcel) to a center such that total travel cost is minimized. In this case, the travel cost is related to the total length of pipelines in the network required for linking hydrants to parcels.

$$z \equiv \text{Min} \sum_{i \in I} \sum_{j \in J} a_j \, d_{ij} \, x_{ij}$$

Since the surface of parcels is directly related to the water need, the section size of pipeline will be bigger when the parcel has a greater surface.

$$\sum_{i \in I} x_{ij} = 1; \quad j \in J$$

A parcel can never be served by more than one hydrant.

$$\sum_{i \in I} h_i = p;$$

The total number of hydrants that will serve to parcels should be a fixed number *p*, which is known a priori.

$$x_{ij} \le h_i \,;\; i \in I, \; j \in J$$

Parcel can be served by an hydrant only if the service is already located there

The total number of parcels is n (|I|, indexed by i), and the total number of candidate points where hydrants can be located is m (|J|, indexed by j).

a_j is the area of parcel A_j (m^2);

d_{ij} is the distance from candidate point *i* to parcel *j* (m);

x_{ij} is a binary variable which takes value 1 when parcel j is served by a hydrant located at candidate point i, and 0 otherwise.

$y_i=(y_{i1},y_{i2})$ are planar coordinates associated to candidate point *i*.

h_i is a binary variable which takes value 1 when point *i* is provided with a hydrant, and 0 otherwise.

$$L \cdot h_i \le \sum_{j \in J} x_{ij} ; i \in I$$

$$\sum_{j \in J} x_{ij} \le U \cdot h_i \,; \quad i \in I$$

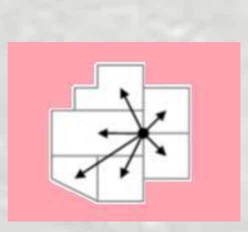
To prevent that some hydrants are allocated to an excessively large number of parcels or reversely, two limits (inferior L and superior U) are established.

$$h_i \in \{0,1\}; i \in I \quad x_{ij} \in \{0,1\}; \quad i \in I, \; j \in J$$

Binary decision variables

How the definition of distance should be interpreted?

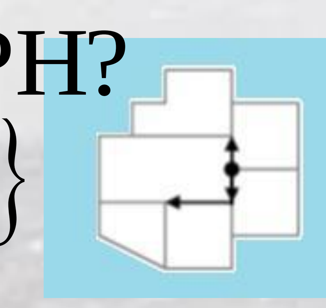
EUCLIDEAN?



$$d_{ij} \equiv d_2(y_i, \text{center}(A_j))$$

ALONG THE GRAPH?

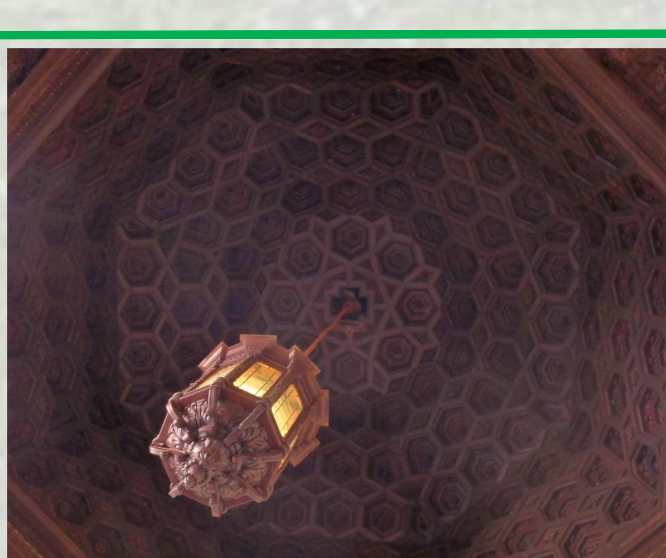
$$d_{ij} \equiv \min\{d_G(y_i, v_{jk}) : v_{jk} \text{ is a vertex of parcel } A_j\}$$



PROPOSAL: USING EXPECTED DISTANCES ALONG THE NETWORK

$$\partial A_j \equiv \bigcup_k l_k(A_j) \Rightarrow \text{length}(\partial A_j) = \sum_k \text{length}(l_k(\partial A_j))$$

$$d_{ij} \equiv d_E(y_i, \partial A_j) = \frac{1}{\sum_k \text{length}(\partial A_j)} \left(\sum_k \int_{u \in l_k(A_j)} d_G(y_i, u)\, du \right)$$



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