QMR: Modeling quality mobility routes under uncertainty

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Presentation

The research presented is located within a collaborative project between Complutense University and a wider project, the government project from the Comunidad de Madrid '**Madrid on foot, secure way to school**' which favors independent movement of children to school, and make them safe by incorporating the perception of children and parents in urban mobility.

- **Objetives**

  To present a mathematical model to calculate quality mobility routes (QMR) around a point of interest. In particular to model and solve some of the problems present in '**Madrid on foot, secure way to school**' project, and develop a comprehensive mobility map. With this aim, the paper is focused on the construction of optimal routes on foot and using different means of transport, by making a study of the paths either on foot, by car or by public transport.

Framework

The model used is the well known programming linear model based on asigning costs d_{ij} to each arc (i,j) of the graph which model the map around the school. These costs measure the risk of each street (arc) on the map.

$$\min \quad d = \sum_{i=1}^{n}\sum_{j=1}^{n} d_{ij} x_{ij}$$

$$\text{subject to:} \ (1) \sum_{k=2}^{n} x_{1k} = 1$$

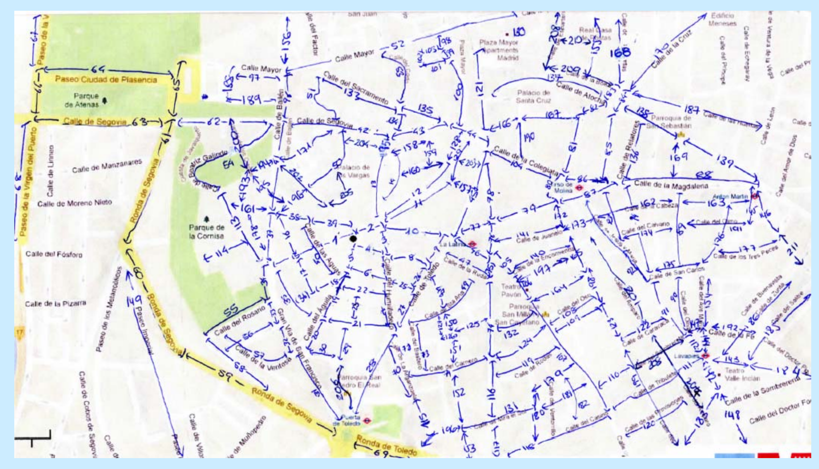
$$(2) \sum_{K=1}^{n-1} x_{kn} = 1$$

$$(3) \sum_{j=1}^{n} x_{ij} = \sum_{K=1}^{n} x_{ki} \ , \ \forall i \in \{2, \dots, n-1\}$$

$$\text{where} \quad x_{ij} = \begin{cases} 1, & \text{if } (i,j) \text{ is chosen} \\ 0, & \text{otherwise} \end{cases}$$

Research methodology used

Data collection took place in the school 'Nuestra Señora de la Paloma' in Madrid. We conducted a survey to parents and students in the 5th and 6th grade (81 subjects in total), which were given a map of the environment of the school and asked to assign by color a safety value to each street they known, being green allocation safer blue security assignment intermediate, and red the least secure.



Different mathematical techniques are used:

- **Cohesive and Hierarchical Implicative Classification (CHIC)** and **barycentric coordinates** to obtain a safety rating for each street. This analysis allows for association rules in a data set and individuals across variables set trends property set using a non-linear measure of inferential. Statistic is not symmetric using the idea of involvement of Boolean algebra and artificial intelligence. It seeks to identify facts and rules that are interrelated and form progressive security structures.
- These ratings are used to work on a Shortest Path Problem using **Dijkstra's algorithm**, providing the mobility maps.

Results

1. Global Analysis, Cohesive and Hierarchical Implicative Classification

The implicative graph (Fig. 1) represents the relationship of involvement with some streets and others a confidence level of 99% (red), 95% (blue), 90% (green) and 85% (gray).

Hierarchical tree shows significant relationships at different levels such implications red marking on the streets (or sets of streets) related. We obtain 58 relations between nodes, and the only significant study.

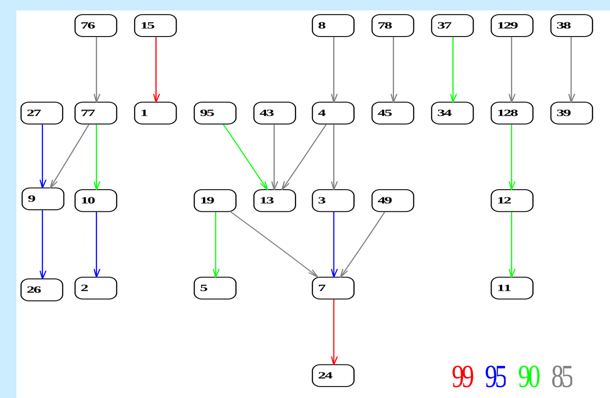


Fig.1: Implicative Graph

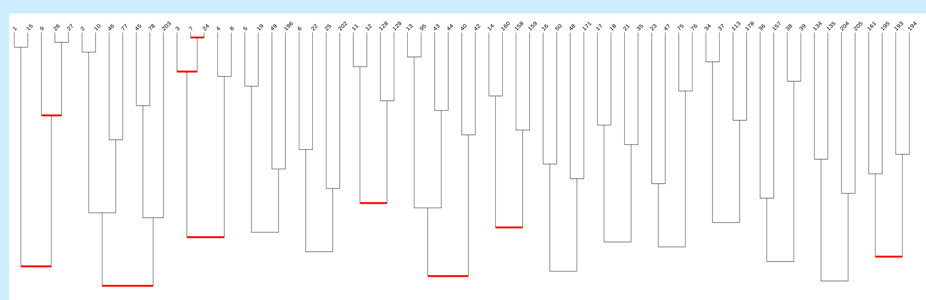


Fig. 2: Similarities tree

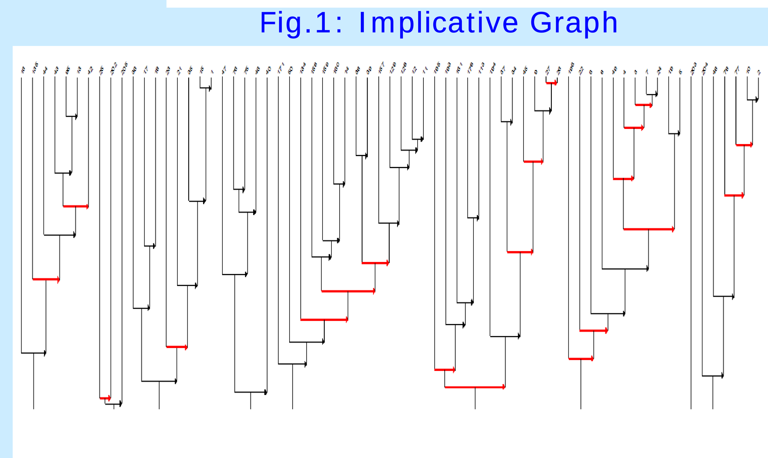
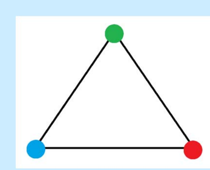


Fig. 3: Cohesitive tree

This graph (Fig. 2) provides 52 relations between streets, of which we will study the significant similarity greater than or equal to 0.5. Thus only study three relationships, corresponding to 1.8 and 17 levels **of similarity tree**. Security zones depending on the housing of the respondents, or areas which generally are considered safer than those near a supermarket, etc. Variable (parents, students in the fifth, or sixth graders) is the largest contributor to each relationship obtained streets, which allows conclusions of the different perception of safety on streets and zones according to a group of individuals or another.

2. Tetrahedron Method



Final weight is obtained
-To solve the Problem: ignores the unanswered
-Solution: add a point to have all the data: tetrahedron
1- The relationship between the Cartesian coordinates and barycentric tetrahedron
2- To obtain the projected point.
3- Distance to each vertex of the triangle
4- Extending the interval [0,1]

$$p_j = \frac{(1/d_j)}{(1/d_V + 1/d_A + 1/d_R)} \quad \forall j = V, A, R$$

$$n_F = 0 \cdot p_R + 0.5 \cdot p_A + 1 \cdot p_V$$

3. Algorithms: Dijkstra and Kruskal

Dijkstra for calculating minimun paths,
Kruskal for showing the areas of influence.

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STEP 1: INICIALIZATION
    U(1)=0, U(J)=D(1,J) PARA J=2...N
    P={1} ; T = V-{1}
    P(J)=1 FOR J=1,…N
STEP 2:
    OWNED SEARCH K T SUCH THAT U(K)=MIN(U(J))
    DO P=P+K ;  T = T-K
STEP 3:
    TEMPORARY LABEL REVIEW.
    FOR ALL J IN T, CALCULATE U (J) = MIN (U (J), U (K) +
D (K, J)).
     IF REACHED AT LEAST U (K) + D (K, J) THEN P (J) = K.
    GO TO STEP 2
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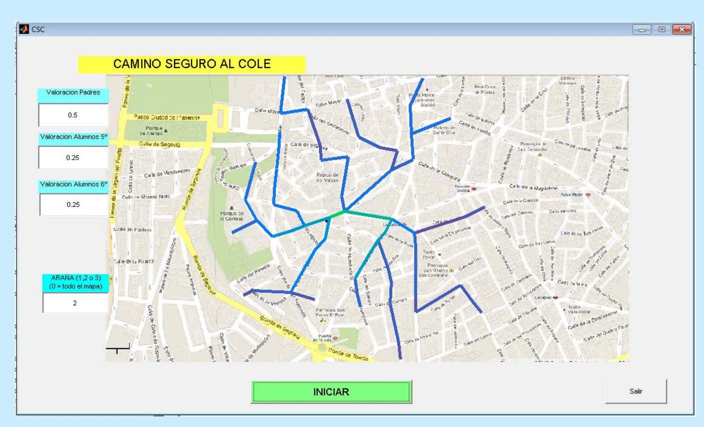
4. Result model: Interactive Programme

Developed in MatLab and ready to be used by the CaminoSeguro app for Android also develped by our reseach group as part of the final project.



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