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A Decision Support System for Improving Pedestrian Accessibility in Neighborhoods

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Abstract

Pedestrian accessibility represents a sustainable method of urban mobility. To improve pedestrian accessibility in neighborhoods, local administrations need to use decision-making tools that perform objective analysis. This paper discusses the case of Romanian cities and offers a theoretical base that would aid the process of decision making. It thus suggests a decision support system (DSS), which is an innovative approach combining two well-known algorithms: the hierarchic-analytic process, used in operations research, and the advanced multi-criteria analysis based on FRISCO formula. The DSS has been made available online, helping public administrations plan chains of interventions without the use of advanced mathematical skills.

Keywords: pedestrian planning; public facilities; urban management; DSS.

1. Introduction

Sustainable urban mobility is a subject of great interest in the European Union, as shown by a number of official documents like the 2007 "Leipzig Charter", the report "Towards a new culture for urban mobility" (European Commission, 2007), and the 2012 "Action Plan for Urban Mobility" (European Commission, 2012). Several key concepts are presented in these documents, namely reducing energy consumption, reducing pollution

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and ensuring transport equity. This paper suggests a possible solution to solve these issues by taking examples from Romanian cities.

With Romania entering the European Union in 2007, it is expected that its urban public administrations follow the guidelines put forth by the European Commission in Brussels. As Europe's economy relies mainly on production and consumption, which takes place in cities, public administrations cannot afford undesirable urban environments.

This argument turns quality of life into a main priority of modern urban management. One of the indicators of quality of life is transportation (Guo & Schneider, 2010). Urban transportation is made up of four modes, namely: personal vehicle transportation, public transportation, and bicycle and pedestrian accessibility. As in the rest of Europe, the rise in private vehicle ownership in Romania has put significant pressure on the built environment. Scientific literature shows that, on average, a pedestrian takes up about $0.8m^2$ while a car takes up about 9.5sqm when parked and 170sqm at a speed of 50km/h (Kwon, Morichi, & Yai, 1998). This argument proves that municipalities face the impossible task of offering parking spaces and road space to an ever-increasing number of private vehicles. Romania's case is particularly striking since private vehicles have doubled since the beginning of the 1990s (Eurostat, 2012b) and the use of public transportation has steadily decreased (Eurostat, 2012a).

Romanian city administrations are currently responding to this situation by improving public transportation, with some important investments being made in cities like Bucharest, Oradea, Timisoara and Arad. Infrastructure for cyclists is also beginning to appear, even if current Romanian legislation is not up to date with modern design principles, since Romanian planning standards have not been updated for more than twenty years. However, the last mode, which is on-foot transport, is the least present in urban management projects, excluding central areas.

Pedestrian-only central areas are already present in many important Romanian cities, like Sibiu, Cluj-Napoca, Brasov and Targu-Jiu, and are currently being implemented in smaller ones like Sebes and Lugoj. But this approach does not solve problems that reside at city level, and pedestrian-only streets are not being incorporated into residential areas where retail is relatively low. As cities are formed out of neighborhoods, a methodology is needed that addresses neighborhood-scale problems.

Using methodologies that address pedestrian accessibility has never been part of Romanian urban planning for several reasons.

The first reason is related to the historical evolution of cities. Maybe the most representative period for pedestrian accessibility is the Middle Ages. In this period we find a self-organization of the built environment that facilitates pedestrian movement by: ensuring a maximal radius of 400m from the central square to the defense walls, creating a hierarchy of streets with selective rules for horseback and carriages, and ensuring small passageways through buildings for shorter pedestrian connections (Morar & Bertolini, 2012). The Industrial Revolution brought factories to cities, which meant a sudden growth of urban population. Although mechanized transportation means were introduced (Costa & Fernandes, 2012), pedestrian access principles were still present. They can be spotted when looking at the limit of residential growth around new railway stations (around 800m), and the 400m average distance between tram stops. The communist era brought a real explosion of urban growth, raising the number of cities in Romania from 152 in 1948 to 260 in 1992. Socialist urban planning was focused on efficiency (Sailer-Fliege, 1999), meaning communal living in apartment buildings and mobility through public transportation. This was beneficial for pedestrian accessibility since residential neighborhoods were dense and generally centered on a civic center, which included daily-life facilities like shops, hairdresser, pharmacy, postal office and so forth. Unfortunately, planning conditions in different cities and various economic conditions in Romania during the 1960s and 1990s did not allow all apartment building neighborhoods to be endowed with public facilities within walking distance.

After the 1990s, investment in residences was carried out by private investors, who did not have the authority to coordinate placement of facilities within reach or ensure quality public transport for new developments. Some of the visible effects of this phenomenon are single-family house neighborhoods where mobility is exclusively dependant on the private vehicle. The same goes for new apartment building neighborhoods that were planned through zonal urban plans (called PUZ in Romanian legislation), which were not based on an up-to-date general master plan (PUG) and were not regulated by any Romanian planning standards regarding pedestrian accessibility.

This is why we wish to aid urban municipalities who wish to follow European guidelines and improve pedestrian accessibility in neighborhoods by suggesting a decision support system based on pedestrian planning principles. Furthermore, urban administrations in Romania often face a lack of funds and a lack of trained personnel (excepting the chief architect, most employees of urban planning departments are not qualified in the field). This makes theoretical and practical support for decision making an important step in aiding the implementation of professional end effective planning practices in Romania.

2. A decision support system (DSS) for improving neighborhood pedestrian accessibility

The key concept behind pedestrian planning is bringing facilities closer to residences, while keeping track of each facility's service area. An example is the work of Morar, Bertolini, and Radoslav (2013), which evaluates access to public spaces in the city of Timisoara using a geographic information system (GIS). In each particular neighborhood, two groups of variables influence general accessibility levels: 'alternatives' (represented by public facilities) and 'decision criteria' (represented by neighborhood characteristics or economic factors).

2.1. Overview of the DSS

The proposed decision support system allows the decision maker to choose the best alternative out of a set of possible interventions, based on a group of custom-defined criteria. Knowing that neighborhood conditions may vary from one case to another, the system can be adapted to any situation.

The system allows the use of an indefinite number of alternatives and criteria. However, in this paper we will present a scenario with five possible decision alternatives: local food shops (A1), green spaces (A2), public spaces (A3), schools (A4) and playgrounds (A5). The selection criteria used are: distance (C1), population type (C2), population density (C3), cost of the intervention (C4) and duration of the intervention (C5).

Underlying the DSS is an innovative approach that combines two well-known algorithms: the hierarchic-analytic process, used mainly in operations management, and the advanced multi-criteria analysis based on the FRISCO formula. A detailed description of this combined algorithm may be found in the work of Grecu and Denes (2012).

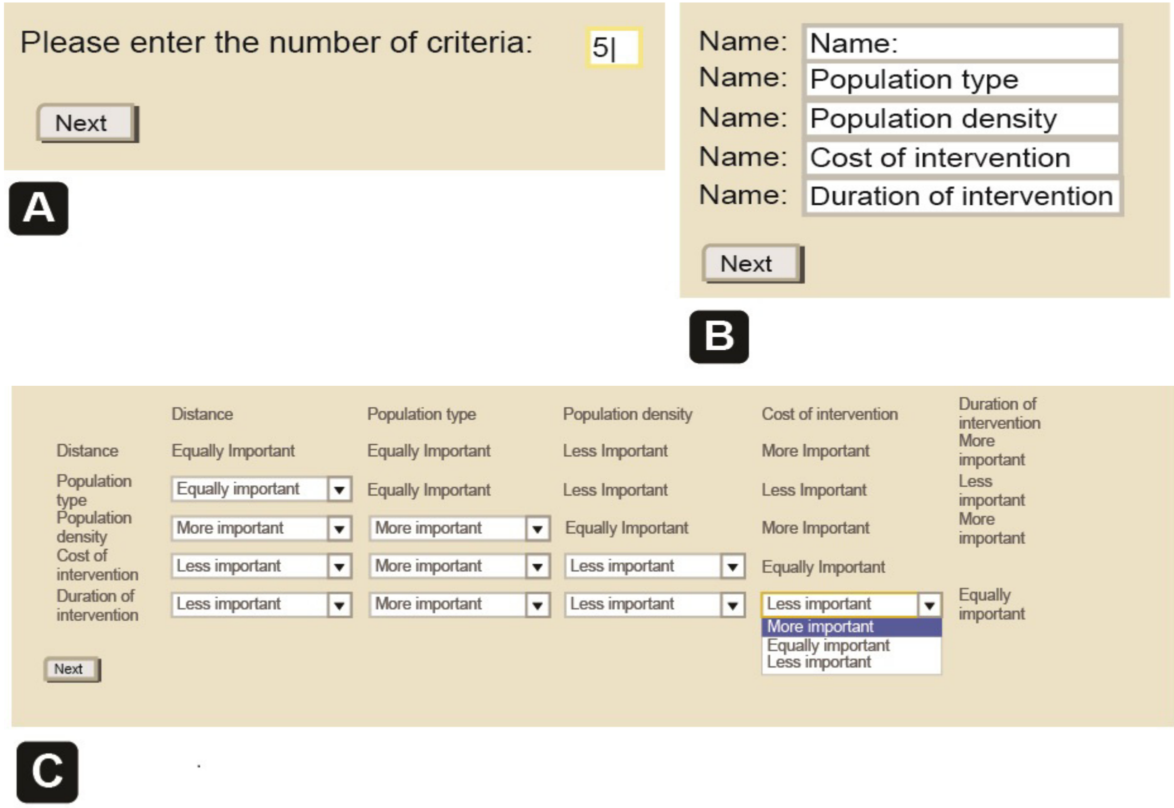
The developed algorithm requires good mathematical abilities from the user, and this can therefore limit the real-life applicability of the proposed decision support system. In order to make it easier to use the DSS and increase the number of potential users, the DSS was implemented online with a user-friendly interface. For this purpose, an extension for the content management system Joomla! 1.5 was developed. It can be easily integrated into any website created with Joomla! 1.5 (Grecu & Rosca, 2011). The purpose of our approach is to offer a finite planning tool to urban decision makers by leaving the computational part to the server. We are thus allowing users to concentrate on planning issues rather than having to understand the formulas that lie behind the algorithm.

2.2. How does the DSS work?

First, the user is requested to enter the number of criteria (fig. 1A) and specify the name of each criterion (fig. 1B, 1–5). Then a quadratic matrix is generated and the user has to compare each criterion against the others. One can choose whether each criterion is more important, equally important or less important than other criteria (fig. 1C).

It is important to remember that the relationships between criteria are the choice of the decision maker. This choice can be based on sociological studies, public surveys, urban planning goals, academic literature reviews or other specific needs.

This step basically establishes a hierarchy of the chosen criteria and each criterion is given a weight.



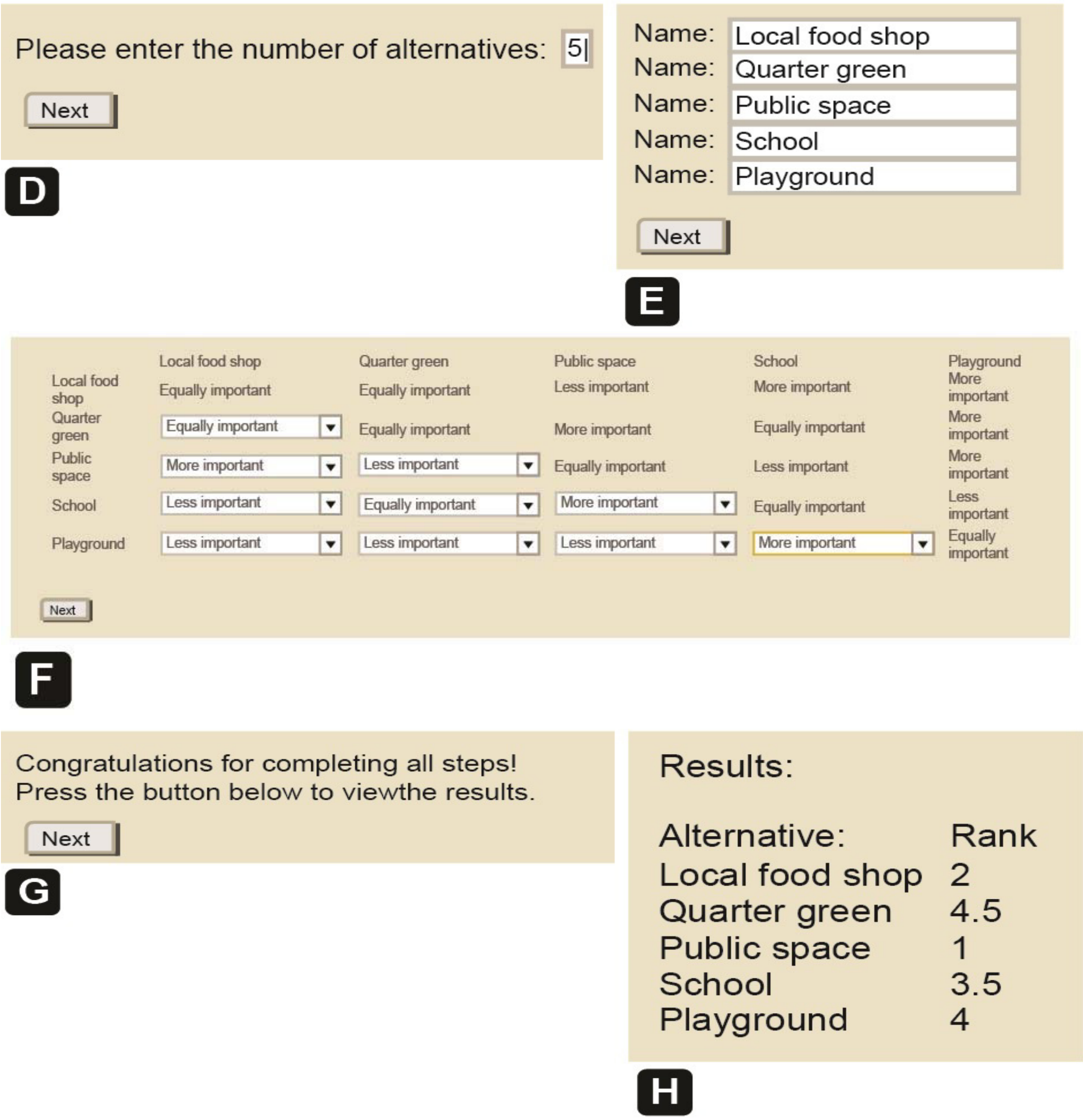


Fig. 1 Functioning of the DSS

Then, the user is asked to enter the number of decision alternatives (fig. 1D), to define/name them (fig. 1E) and then to compare each alternative against the others based on how they satisfy each criterion (fig. 1F). For example, when the alternatives are compared considering the criterion "cost of intervention", the cheaper alternative is considered "more important".

The software then uses the encoded mathematical algorithm and returns the optimal solution, as shown in figure 1H. This allows the urban planner to make an informed decision, based on the specific needs of the community and the particularities of the neighborhood, rather than intuition.

3. Conclusions

The paper has discussed the current challenge faced by Romanian cities, namely handling the ever-increasing number of private vehicles. We have shown that the options for solving this issue are offering more road space, improving public transportation, creating bicycle lanes or improving pedestrian accessibility. Since planning for pedestrians has received less attention than the other alternatives, this paper addresses the issue by presenting the main concepts behind pedestrian accessibility. Discussing access to daily-life public services, while excluding access to jobs, which is subject to more complex combinations of transport modes, we have seen that the average pedestrian accessibility radius is 400–800m. This makes accessibility plans part of neighborhood planning. As Romanian cities vary according to geographical region and historical evolution, so do their neighborhoods. This is why we have developed a flexible decision-making tool, which can be calibrated according to specific needs. We have made this tool available online, thus seeking to help urban administration employees and other researchers in using the complex mathematical algorithms that stand behind it, through an intuitive and user-friendly interface. The computational part is left to be run by the server, while users focus strictly on introducing the criteria and evaluating the final results; this can be considered the main contribution of this research to the field.

The aim of this paper was to address current planning obligations required by European legislation by aiding urban administrations to solve neighborhood-scale problems through an objective approach. Further research may mean creating a series of workshops with Romanian urban planners and administration employees to test the usability of the interface and generate a list of possible improvements.

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