A multi-criteria decision making approach for ranking wheelchair accessible tourism

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Abstract. WeMap, a semantic linked data technology-based solution, helps people with mobility disabilities to plan their travels with a door-to-door concept by pointing out its obstacles. It aims to increase the autonomy and ensure the safe movement by preventing a number of incidents on public roads. However, the suitable approach to determine which city is much more wheelchair friendly than others are still fuzzy. This paper evaluates and ranks the wheelchair accessible tourism by applying a multi-criteria decision making method with the datasets from two Swiss cities.

Keywords: multi-criteria decision making, accessible tourism, ranking travel destinations, wheelchair users

1 Introduction

According to the world health organization in 2015, over one billion people - 15% of the world's population is estimated to live with some form of disability. In order to promote accessible tourism for all, good resources should be available. WeMap mobile application [3] offers a focused user innovation based crowdsourcing accessibility map. It suggests favorable routes through the provided access map. It also allows user to search or review an existing place with a specific address, add a new point of interest (POI) or route situation, and generate route services. However, determining a more wheelchair friendly city is still a challenge. This paper evaluates the collected user-oriented information derived from WeMap and ranks cities according to the level of suitability for people with disabilities by applying multi-criteria decision making method [4].

2 TOPSIS-based approach for mobile crowdsourcing data

In need of strategic vision, the evaluation of the most appropriate alternative by considering a number of selection criteria and their interrelations is complex, as decision-making is more challenging due to the events and factors that influence the whole construction process. In order to guide decision makers to rank a limited number of pre-specified alternatives choices, the Multiple Attribute Decision-Making methods [1] defines a decision matrix that contains: (a) A is the set of alternatives, A $= \{a_1, a_2, \cdots, a_m\}$, (b) C is the set of criteria C $= \{c_1, c_2, \cdots, c_n\}$, (c) w_j is the relative importance (the weight) of each criteria j, within the set of weights W $= \{w_1, w_2, \cdots, w_n\}$ and (d) x_{ij} is the evaluation given to alternative i^{th} with respect to criterion j^{th} where $i = \overline{1, m}$ and $j = \overline{1, n}$.

According to [2], the technique for Order Preference by Similarity to ideal solution is named TOPSIS, which ranks and selects a number of possible alternatives by measuring Euclidean distances to arrive at the positive and the negative ideal solutions. The positive ideal solution maximizes the benefit criteria and minimizes the cost criteria, whereas the negative ideal solution maximizes the cost criteria and minimizes the benefit criteria.

In order to evaluate the feasibility of our approach, we used the datasets which was collected by the project WeMap. To date, there are more than 600 Swiss point of interests (POIs) have been collected, mainly from the cities of Sion and Sierre in Canton of Valais. These POIs were categorized into separate subcategories which include accommodations, restaurants, attractions and leisure (museums, shopping, etc.), points of interest (train station, road, rental car location, etc.) and health care (hospitals, clinics and medical offices) that demonstrates diversity on offer. Our approach establishes a ranking of the defined six accessibility criteria [3] and associated to cost and benefit criteria according to TOPSIS methodology:

1. (c_1) slope of more than 10 degrees of angle,
2. (c_2) the dimension of the level landing should be at least 1.5m x 1.5m to allow wheelchair users to stop and rest without blocking the flow of pedestrians,
3. (c_3) some form of substrate is an obstacle to accessibility (e.g. too soft, gravel, grass),
4. (c_4) accessible and reserved parking for people with disabilities,
5. (c_5) entrances to buildings without steps
6. (c_6) disabled toilets including room size requirements, large space, toilet support.

We divided them to a set of:

1. unfavorable criteria (from c_1 to c_3, named c^-)
2. favorable criteria (from c_4 to c_6, named c^+) .

By following the TOPSIS decision making process steps [2], the rating of the Sion and Sierre alternatives with respect to the criteria are expressed by values of a decision matrix. In terms of the cardinality of each finite place's set and a weight vector W is assigned to the negative and positive criteria, where w_j is the weight for C_j^* ($\sum_{j=1}^{n} w_j = 1$,$j = \overline{1, 6}$). We affect the following weights (0.1 ,0.15, 0.1,0.2,0.3,0.15) for each criteria relative to their importance.

Then, the decision matrix is normalized in order to transform the various attribute dimensions into non-dimensional attributes, which allows comparison across the criteria using the formula (1).

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \tag{1}$$

Thereafter, multiplying each column x_{ij} by w_j, to get v_{ij} the weighted normalized decision matrix so that determine the positive and negative ideal solution respectively that maximizes the benefit criteria and minimizes the cost criteria

$$V^+ = \{Max_{j \in C^+}(v_{ij}), Min_{j \in C^-}(v_{ij}), i = \overline{1,m}\} = \{v_1^+, \cdots, v_n^+\} \tag{2}$$

and maximizes the cost criteria and minimizes the benefit criteria

$$V^- = \{Min_{j \in C^+}(v_{ij}), Max_{j \in C^-}(v_{ij}), i = \overline{1,m}\} = \{v_1^-, \cdots, v_n^-\} \tag{3}$$

Subsequently, we need to calculate the positive and negative ideal separation measures for each alternative $i = \overline{1,m}$ respectively

$$S_i^+ = \sqrt{\sum_{j=1}^{n} (v_j^+ - v_{ij})^2} \quad S_i^- = \sqrt{\sum_{j=1}^{n} (v_j^- - v_{ij})^2} \tag{4}$$

that estimates the relative closeness to the ideal solution using the formula

$$C_i^* = \frac{S_i^-}{S_i^- + S_i^+}, 0 < C_i^* < 1 \, where \, C_i^* = 1 \, iff \, A_i = A_i^+ \, and \, C_i^* = 0 \, iff \, A_i = A_i^- \tag{5}$$

Finally, the set of alternatives can be preference ranked according to the descending order of C_i^* or select the one closest to 1.

Figure 1 illustrates the results with the proposed approaches concerning the most practical places for wheelchair users for two cities. The city of Sion provides reasonable access for attractions, accommodations and health care rather than Sierre. That's because Sion is the capital of the Canton of Valais, there are more attractions places than Sierre. Moreover, the cantonal hospital is located in this city with some medical research laboratories. However, the city of Sierre offers a large wheelchair friendly restaurants regarding to Sion and event better distributions of its points of interest. It's probably because the very famous ski resort Crans-Montana is nearby the city of Sierre. The suitable wheelchair accessibilities have been considered to meet the specific needs of their tourists.

3 Conclusion

In this study, we used the TOPSIS decision making to find the suitable city of wheelchair user by using accessibilities information. We used the datasets which was original collected from WeMap, and compared two Swiss cities: Sion and Sierre for different types of point of interests. As future work, we are going to expand its application in more cities in Switzerland.

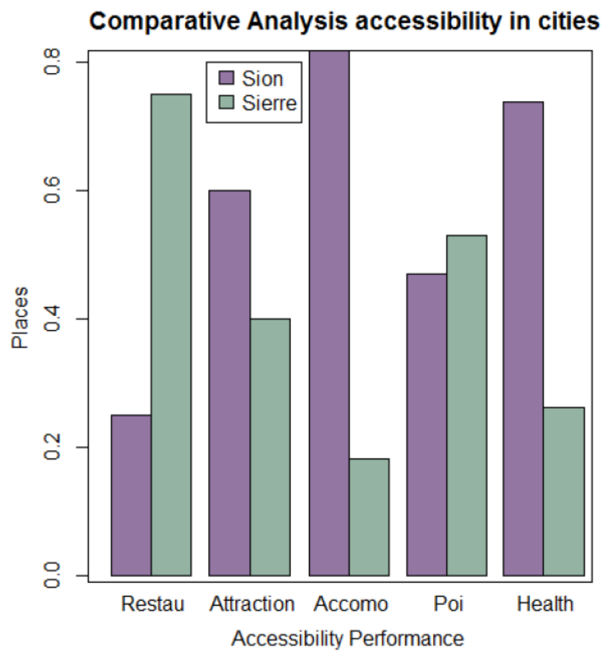

Fig. 1: Comparative analysis accessibility between Sion and Sierre

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