

## Multi-criteria and routing algorithms blending to support complex decision tasks in WebGIS applications

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**Abstract.** The diffusion of location-based services and web mapping applications has boosted the role of non-specialized users as geospatial data and processing consumers. Typical users operations include web maps visualization, sports activities tracking, geospatial layers querying, etc. However, the increasing computational capabilities of both mobile and desktop devices, as well as cloud-based services, has enabled non-specialized users for more complex tasks. These include location-based gaming, routing, and multi-criteria spatial decision making, among others [1].

Focusing on multi-criteria spatial decision making, many approaches that integrate Multi-Criteria Decision Making (MCDM) methods to Geographic Information Systems (GIS) have been developed over the last two decades. MCDM is used to facilitate the concurrent comparisons of multiple criteria to evaluate possible alternatives and select the best one according to the decision maker's priorities, which are converted into weights for the criteria. In the context of GIS, alternatives usually consist of a set of spatial entities (such as point locations, areas or routes). Traditional GIS-based MCDM applications include infrastructures site selection, natural hazard management, and real estate, for example. Most GIS-based MCDM tools are currently designed for GIS professionals only [2]. However, the possibility of delivering online interactive maps to support complex spatial decision making - enabled by modern GIS technologies - is critical to support non-specialized users in their daily-life decisions involving geospatial data.

To that end, this work presents the development of an MCDM procedure conceived for WebGIS applications to support non-specialized users in performing complex spatial decision tasks. The procedure is applied in the context of green tourism promotion and, specifically, to the selection of the best path to walk within a natural park [3]. A prototype WebGIS application - implementing the proposed MCDM procedure - was developed within the INSUBRI.PARKS project [4], an Interreg funded project dedicated to the design of a unified territorial marketing strategy for the natural parks of the Insubria region (ranging between Northern Italy and Southern Switzerland).

The application exploits points of interest and the path network of the Spina Verde Park (Lombardy region - Northern Italy) which is used as a test site. Points of interest are classified into six categories according to the INSUBRI.PARKS focus themes,

namely: history, nature, military archaeology, anthropic activity, sport, and religion building heritage. Each edge of the path network is enriched with the counts by theme of points of interest that are located in its proximity (100m). The themes are used as criteria for the MCDM while counts are used as starting criterion scores for each edge which correspond to a decision alternative. Through the application interface, users are requested to assign weights to the criteria according to their preferences (see Fig. 1).

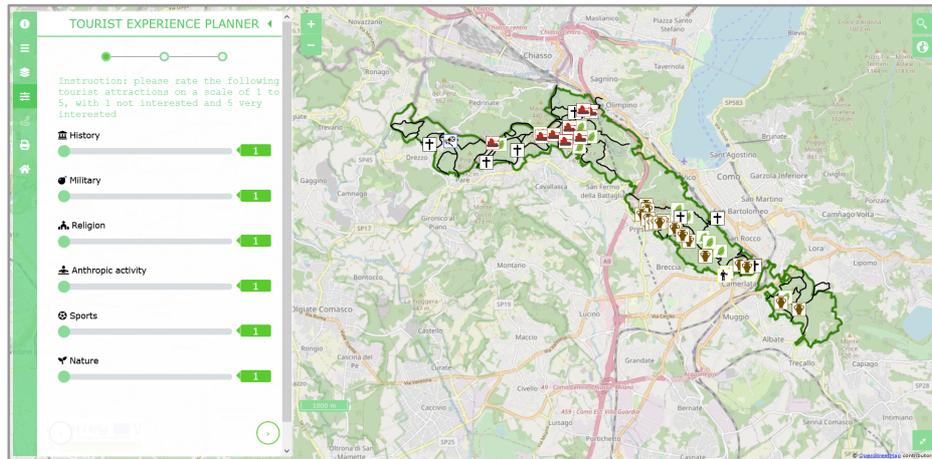


Fig. 1. Web interface of the prototype WebGIS application.

These weights are used to perform the multi-criteria analysis, which is based on the Analytic Hierarchy Process (AHP) method [5] and provides a weighted score to each alternative (i.e. edge of the path network). The scored path network is finally used to run the Yen's K-shortest paths algorithm [6] thus obtaining a ranked list of paths, built as combinations of contiguous edges, that best fit the users expressed preferences [3]. The application is fully based on free and open source software such as Python Pandas, GeoServer, OpenLayers and pgRouting, wrapped into a Django Python web framework. The application runs the full procedure on-the-fly and is available at <http://insubriparks.com.polimi.it:8000/webgisMCDM>, whereas the raw source code is published on GitLab ([https://gitlab.com/geolab.como/insubri\\_parks\\_itinfrastructure/-/tree/master/webgis](https://gitlab.com/geolab.como/insubri_parks_itinfrastructure/-/tree/master/webgis)).

The proposed GIS-based MCDM procedure was here applied to the selection of the best path to walk within a natural park. However, the procedure may be adapted to other decision tasks involving multiple spatially contextualized criteria such as planning public events or selecting the best neighborhood to live in a city, and many others.

The ultimate goal of the proposed procedure and prototype application is to demonstrate the feasibility of making available complex spatial analysis workflows, through innovative WebGIS services, also to not-specialized users. This task is pivotal to raise awareness on the capabilities of modern GIS and geospatial data to the largest public and - in turn - to promote novel uses of the available geospatial information also outside the professional and academic fields. Future work is expected to focus on the

procedure revision and empowerment with additional tests on the best software architecture to deploy the service to other case studies.

### **Riferimenti bibliografici**

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