Multi-modal route enjoyment prediction

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Keywords: Wayfinding; Volunteered Geographic Information; Crowdsourcing; Recreation; Digital Communities; Geographic Information Systems.

1. Motivation and significance of the topic

Online route planners have become part of our daily lives. More and more people use online route planners for different **outdoor activities**, such as recreational traveling, sightseeing, hiking, or cycling [1,2]. Coinciding, in the last decade **recreational wayfinding** – point to point wayfinding tailored to the needs of different outdoor activity modes such as the ones listed above – and **tracking functionalities** have been receiving a burgeoning interest in popular web applications and location-based services within the transportation community which compute the optimized routes for tourists and sportsmen. Both trends are driven by **location-aware platforms** that are becoming more accessible and affordable. Corresponding with the growing interest in these applications, is the steadily growing vast set of **community generated detailed records of object locations and movements**. Non-professional end-users produce new geodata about their movements, originating from web 2.0 tools and mobile devices. These records often describe the same geographic features in different forms and vary in quantity, quality and accuracy [3, 4].

Furthermore, the **criteria and trade-offs** which are important to the end-users of route planners are different for different users. A shortest, and in general single criterion optimal path is not what travellers or sportsmen nowadays typically need when planning a trip or route. Instead, the adequacy of route choice decisions for these particular activity modes lies primarily on the

subjective preference of the user; thus, the wayfinding is not only pre-conditioned by time and distance, but also by personal interests, experiences, and feelings. While a recreational hiking enthusiast may seek for the shortest path with as less height differences as possible but with an attractive scenic view, a mountain biker might prefer unpaved and hilly single trails for freeriding.

It has been shown [5] that such intrinsic **route characteristics** (e.g., the road or terrain type of routes for cycling, scenic views, saftey) have a significant influence on route ranking. In seconds a cyclist, for example, will semantically categorize a busy single carriageway in a city center without a cycle lane as an unsafe and "ugly" environment to cycle. On the contrary, cycling along a long and winding road through picturesque landscapes will be pigeonholed as a scenic and unforgettable experience. Notwithstanding the intricate and detailed nature of contemporary commercial and community-driven **digital road networks**, these networks often lack these specific attribution of intrinsic route characteristics to facilitate the **computation of optimized routes** for the mentioned groups of interest.

It is obvious that manual annotation of digital road networks in terms of attractiveness and suitability for these groups is a laborious process which requires active user involvement. Distributing the task over a large crowdsourcing community facilitates annotation efforts significantly. However, due to the vast volume of accessible digital road networks, **(semi-) automating the route annotation process** would prove more advantageous to manual annotation.

Figure 1 - Example of user-generated content on RouteYou.com

The problem above can be answered by using the mentioned gamut of **volunteered geographic information (VGI)** to underpin this annotation process. In furtherance to solving the problem, non-professional end-users are willing to share **revealed or stated preferences** about their recreational trips through streams of georeferenced user-generated content on the web. Geotagged *scenic* imagery along a recreational trip, or meticulously created movement diaries, for example, are easily shared through web 2.0 environments. Figure 1 shows an example of user-generated content within the community website RouteYou.com. Several examples in literature [6, 7, 8], and use cases in community labs, such as RouteYou, have shown the applicability and validity of this approach. In the next section, we will go more in detail on the route enjoyment prediction, i.e., the key component of the proposed (semi-)automatic route annotation process.

2. Multi-modal route enjoyment prediction

Three different route enjoyment prediction mechanism are currently being developed at each of the research institutes that are involved in this position paper. The goal is to **combine these approaches** into a multi-modal prediction, using the revealed and stated preference methodologies proposed in the current work. Following section will give a brief overview of the current activities and research status.

As previously mentioned the human brain excels in perceiving and semantically categorizing a visual scene. However, a lot of this information still resides with the followed subject or producer of user-generated content on the web. As a first example of a research track in this domain, RouteYou aimed at eliciting this unique information from digital community members through **location-based questionnaires using Google Street View images**. A web-application featured a recurring **forced choice task** annotating Street View images with **personal experiences and feelings**, based on **previously shared activities** of the surveyed user. A use case within this recreational community website proved this a novel way of **querying the cognitive map** of the end-user, extracting unique information about the road infrastructure or the surroundings.

As a second research track, Alivand and Hochmair [8] used **regression analysis** on traveller's reported scenic trips - for example on panoramio or RouteYou - to extract **scenic attributes**. Using **mapped data** and **geographic information systems** (GIS), they were able to extract 11 scenic attributes, along with widely used route characteristics (such as travel time, length, road type) and their trade-off in route selection process. For example, during a scenic trip a user will prefer mountains, water bodies and forest along his way compare to the other attributes. It also showed that travel time, shape and length play an important role in choosing a scenic route. In order to quantify the scenic beauty of the street networks, they used viewshed analysis as the most reliable visibility analysis and an approximate digital surface model (DSM). Although, this approach probably gives the reliable results due to use of exact maps data and geographic information, it needs lots of time consuming computations like viewshed which for a big area such as a country it needs lots of time to compute scenic values of all the network links.

In the last research track, **content-based classification methods** where proposed as a way of gathering types of roads or terrain. Verstockt *et al.* [7] proved that **visual features**, based on color, texture, and edge orientation, extracted from images of online geographic services (OpenStreetMap, Google Street View) achieve **high road type discrimination accuracy** when used in classification tasks.

We aim at combining these three research tracks forming **a human-computer interaction**, using **state-of-the-art machine learning techniques** and **geographical analysis** in combination with a **training process based on community input**. One direction for future work is revealing the scenic attributes from a dataset of routes annotated by crowdsourcing effort, and using such attributes to predict the adequacy or attractiveness of novel routes. Another direction is to try to couple the user provided assessments for a short segment of a route to the content-based data available for that segment (Flickr or Panoramio images, Google Street View images, OpenStreetMap data), and statistical information such as the road type on the segment, total route length, vicinity to historical and cultural landmarks. This can than be used to train a scenic route prediction model correlated to the general user assessment criteria.

3. Conclusions and future work

In summary, On W3C LGD14 we plan to open a discussion on some insights and best practices using and integrating user-generated content for **multi-modal route enjoyment prediction**. We will underpin this discussion with evidence-based research and hands-on experience in aggregating and combining a wide spectrum of geographical information and applications in revealed and stated preference methodologies within specific scientific and commerical use cases. We will give an outlook on ongoing and future work linking models trained on content-based features of a route and user-specific assessments of the adequacy of the route, thus enabling automatic higher level semantic annotation of digital road networks.

Acknowledgements

The research activities as described in this paper were funded by Ghent University, iMinds, University of Florida, RouteYou nv, the Institute for the Promotion of Innovation by Science and Technology in Flanders (IWT), the Fund for Scientific Research-Flanders (FWO-Flanders), the Belgian Federal Science Policy Office, and the EU.

References

[1] K. Pippig, D. Burghardt, N. Prechtel 2013 “Semantic similarity analysis of user-generated content for theme-based route planning” In Journal of Location Based Services, 7(4), 223 - 254

[2] W. Souffriau, P. Vansteenwegen 2010 “Tourist Trip Planning Functionalities: State-Of-The-Art and Future” In Current trends in Web Engineering, Lecture Notes in Computer Science, 6385, 474 - 483

[3] A. Beller, Y. Doytsher, E. Shimbersky 1997 “Practical Linear Conflation in an innovative software environment” In Proceedings of 1997 ACSM/ASPRS, 7-10 april 1997. USA: Washington, Seatle.

[4] A. Flanagin, M. Metzer 2008 “ The credibility of volunteered geographic information” In GeoJournal, 72(3), 137 - 148

[5] S. Reddy, K. Shilton, G. Denisov, C. Cenizal, D. Estrin, and M. Srivastava 2010 “Biketastic: sensing and mapping for better biking,” in Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, ser. CHI ’10. New York, NY, USA: ACM, 2010, pp. 1817–1820.

[6] S. Verstockt, V. Slavkovikj, P. De Potter, J. Slowack, and R. Van de Walle 2013 “Multi-modal bike sensing for automatic geo-annotation: geo-annotation of road/terrain type by participatory bike-sensing,” in 10th International Conference on Signal Processing and Multimedia Applications, Proceedings, 2013, pp. 39–49.

[7] S. Verstockt, V. Slavkovikj, O. Janssens, P. De Potter, J. Slowack, and R. Van de Walle 2013 “Web-based Enrichment of Bike Sensor Data for Automatic Geo-annotation,” in Proceedings of the Second ACM SIGSPATIAL International Workshop on Crowdsourced and Volunteered Geographic Information, ser. GEOCROWD ’13. New York, NY, USA: ACM, 2013, p. 6370.

[8] M. Alivand, H. Hochmair 2013 “Extracting Scenic Routes from VGI Data Sources” in Proceedings of the Second ACM SIGSPATIAL International Workshop on Crowdsourced and Volunteered Geographic Information, ser. GEOCROWD ’13. New York, NY, USA: ACM, 2013