Visualizing Integration Uncertainty Enhances User's Choice in Multi-Providers Integrated Maps

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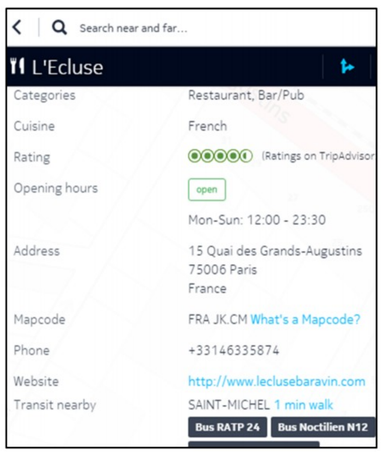
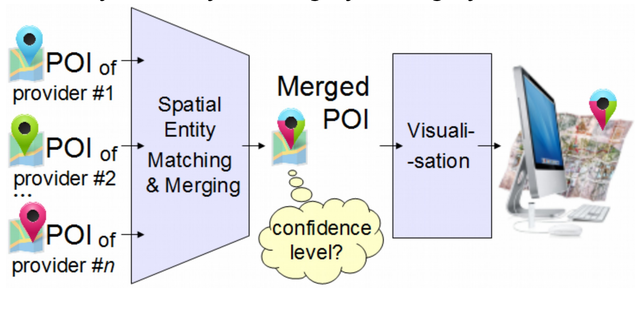
Integration of Multi-Providers' Maps May Be Uncertain

Tourists look for **Points of interest** (POI, e.g., *monuments, museums, restaurants, hotels, etc.*) using **Cartographic Services** (e.g., *Google Maps, Bing, Here, OpenStreetMap, etc.*)



The same POI from several providers may reveal inconsistencies, errors and differences

Current solutions merge POIs from several providers [1, 2, 3, 4] where merging process's output may be *lowly*, *averagely*, or *highly confident*

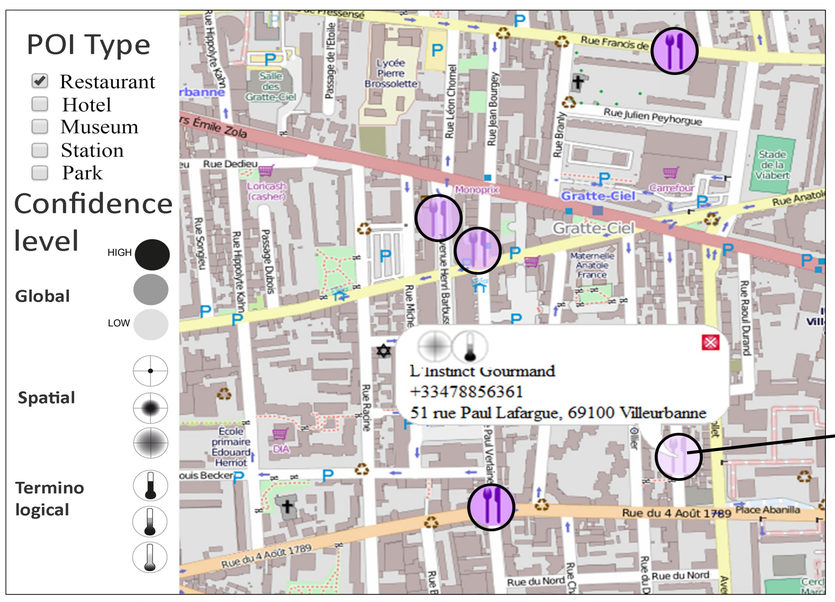


[1] Berjawi, B., Duchateau, F., Favetta, F., Miquel, M., & Laurini, R. 2015. PABench: Designing a Taxonomy and Implementing a Benchmark for Spatial Entity Matching. In the Seventh International Conference on Advanced Geographic Information Systems, Applications, and Services (Lisbon, Portugal, February 22-27, 2015). 7-16.
[2] Olteanu, A. 2007. A Multi-Criteria Fusion Approach for Geographical Data Matching. *International Symposium in Spatial Data Quality*.
[3] Safra, E., Kanza, Y., Sagiv, Y., Beeri, C., and Doytsher, Y. 2010. Location-Based Algorithms for Finding Sets of Corresponding Objects Over Several Geo-Spatial Data Sets. *International Journal of Geographical Information Science*, 24, 1, 69–106.
[4] Sehgal, V., Getoor, L., and Viechnicki; P. 2006. Entity Resolution in Geospatial Data Integration. International Symposium on Geographic Information Systems, 83–90. ACM.

How to Portray Integration Uncertainty? - Previous Experiment

The present study is based on a previous previous experiment [8]

→ Selection of the best icons for *spatial*, *terminological* and *global* (*spatial* and *terminological*) integration uncertainty (based on [5, 6, 7, 8])



→ Primarily visualize **global** integration uncertainty and pop up on demand source information [8]

Clicking on icons switches to the "source" mode

	Provider 1	Provider 2	Provider 3
name	L Instinct Gourmand	L'Instinct Gourmand	L'Instinct Gourmand
type	Restaurant	bar	RESTAURATION
address	51 Rue Paul Lafargue 69100 Villeurbanne France	51 Rue Paul Lafargue, Villeurbanne, France	51 rue Paul Lafargue, 69100 Villeurbanne, France
phone	+33478856361	04 78 85 63 61	04 78 85 63 61
site	undefined	http://www.linstinct-gourmand.fr/	undefined
Distance	10.02 m	33.17 m	142.41 m

[5] MacEachren, A. M. 1992. Visualizing Uncertain Information. In Cartographic Perspectives, 0, 13, 10-19.
[6] MacEachren, A. M., Roth, R. E., O'Brien, J., Li, B., Swingley, D., & Gahegan, M. 2012. Visual Semiotics & Uncertainty Visualization: An Empirical Study. IEEE Transactions on Visualization and Computer Graphics, 18, 12, 2496-2505. DOI= 10.1109/TVCG.2012.279
[7] Thomson, J., Hetzler, E., MacEachren, A., Gahegan, M., & Pavel, M. 2005. A Typology for Visualizing Uncertainty. Conference on Visualization and Data Analysis, IS&T/SPIE Symposium on Electronic Imaging (San Jose, CA, USA , 16-20 January), 146-157.
[8] Berjawi B., Chesneau E., Seccia G., Duchateau F., Favetta F., Cunty C., Miquel M., & Laurini R. 2014. Uncertainty Visualization of Multi-Providers Cartographic Integration. In Journal of Visual Languages and Computing, 25, 6, 995-1002. Elsevier. JVLC.

Is Portraying Uncertainty Useful Information for Tourists? - New Experiment

While looking for POIs through cartographic services, how uncertainty portrayal impacts tourists' behavior?

Preliminary Interviews and Survey

- Preliminary interviews conducted with professionals in the domain of tourism
  - tourist offices of Lyon city
  - Saint-Etienne city
  - Rhône-Alpes Region (France)
- An online survey to identify relevant contexts and scenarios, performed by 394 potential users[1]

Preliminary Outcome

→ Most frequently used cartographic services

1) Google Maps
2) Mappy
3) French ViaMichelin
4) French Géoportail
5) Nokia Here
6) OpenStreetMap
7) Bing Maps
8) Mapquest

→ Most important criteria in differents contexts:

POI Type	Trip Planning	On Site Searching
Accom-modation	price > client feedback (Z-test=5.77 > 1.96)	price > client feedback (Z-test=5.39 > 1.96)
Restaurant	price > client feedback (Z-test=2.03 > 1.96)	price > client feedback (Z-test=2.38 > 1.96)
POI with Tourist Activity	opening hours > price (Z-test=|-2.14| > 1.96)	opening hours > price (Z-test=|-2.02| > 1.96)

[1] https://sites.google.com/site/unimapuvform (in French)

Simulation of a Service in Two Contexts: Planning a Tourist Trip and On Site Looking for POIs

New testers divided into three groups:

- Control group G1 using a cartographic service with no uncertainty information (N=15),
- G2 with POIs having the same uncertainty information for all POIs (N=15),
- G3 with varying levels of uncertainty information (N=15).

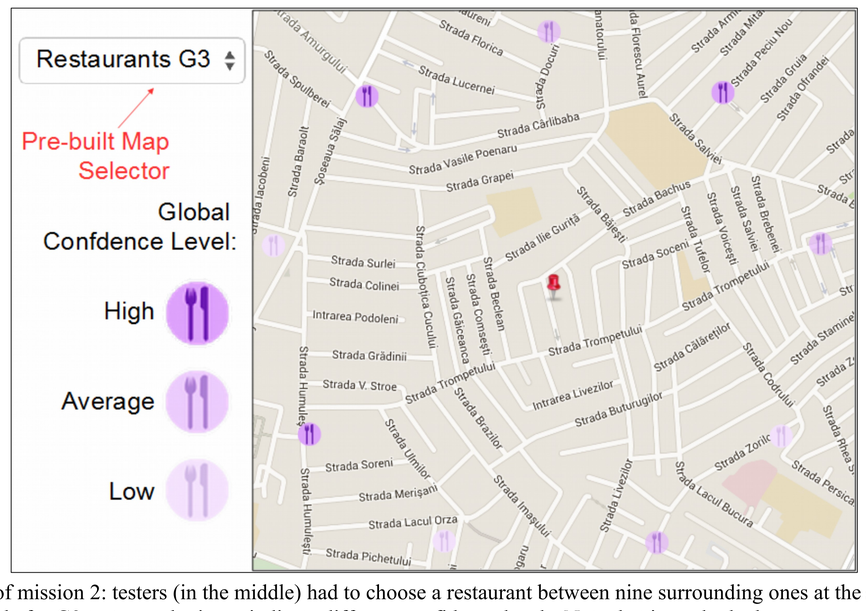
Three simulated missions:

1) testers were asked to imagine they wanted to plan their next holiday trip in Bucharest, and to find an hotel,
2) testers had to find on site a restaurant,
3) testers had to find on site a monument to visit.

Prices and opening hours ranges had three levels:

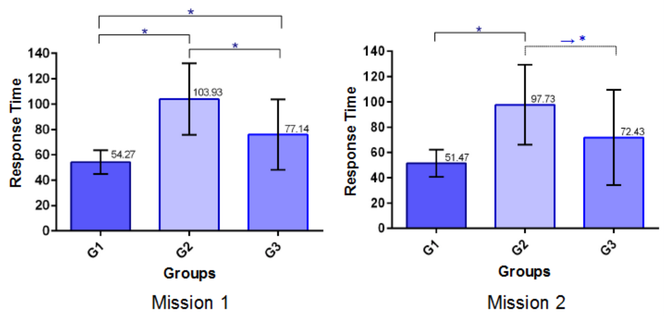
- *high/wide*
- *average*
- *low/narrow*

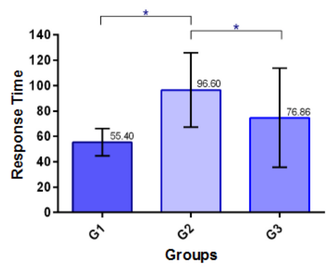
We built maps portraying nine POIs which are the combination of the three levels of prices/opening hours and the three confidence levels. We measured the response times.



Example of mission 2: testers (in the middle) had to choose a restaurant between nine surrounding ones at the same distance
In this example for G3 testers only, icons indicate different confidence levels. Note that icons looked more contrasted on a screen.

Outcome





Mission 3

Adding "source" providers information increases user's cognitive load (G2>G1) but this overload seems to be reduced by visualizing varying confidence levels (G1<G3<G2)

→ Adding varying uncertainty visualization impacts user's choices and time to make them.

Whatever the mission, almost 100% of G3 testers said they used the highest confidence level as the main criterion for their choice.

→ Uncertainty information is taken into account in user's decision.

Conclusion

We conclude that the level of uncertainty has strong impact on tourist's choices of POIs.
Visualizing uncertainty is a useful feature to design cartographic services which integrate POIs from different providers in the context of tourism.

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