



Representing Uncertainty in Visual Integration

B. Berjawi, E. Chesneau, F. Duchateau, F. Favetta, C. Cunty, M. Miquel, R. Laurini
Laboratoire d'Informatique en Image et Systèmes d'Information
laboratoire Environnement, Ville, Société
bilal.berjawi@liris.cnrs.fr
<http://unimap.liris.cnrs.fr>

Introduction

Point of interest (POI)

geographic object that has a point geometric shape associated with spatial and terminological attributes

Location-Based services (LBS)

provide services and information based on a given address or location. Among LBS, there are navigations, weather, news, **POIs**, etc.

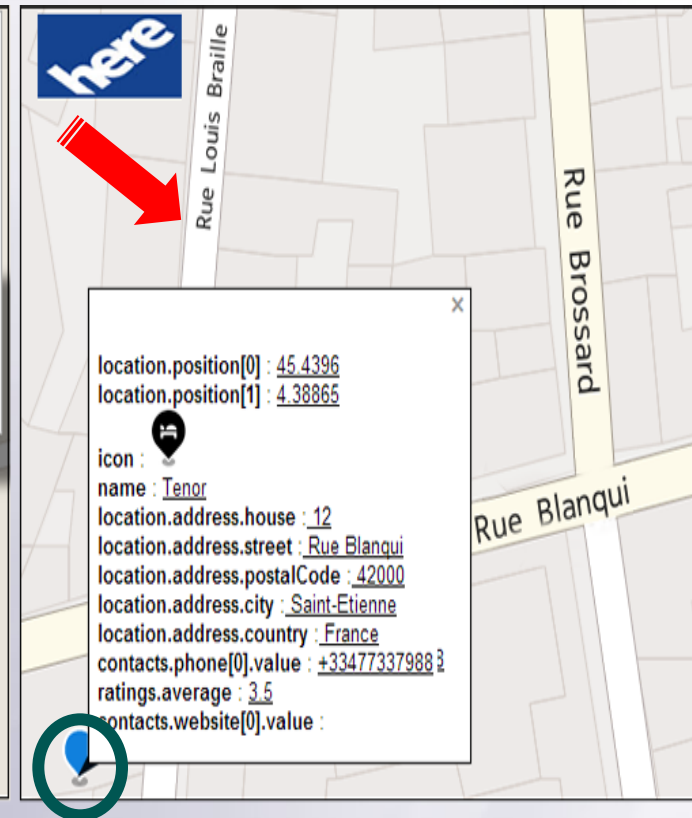
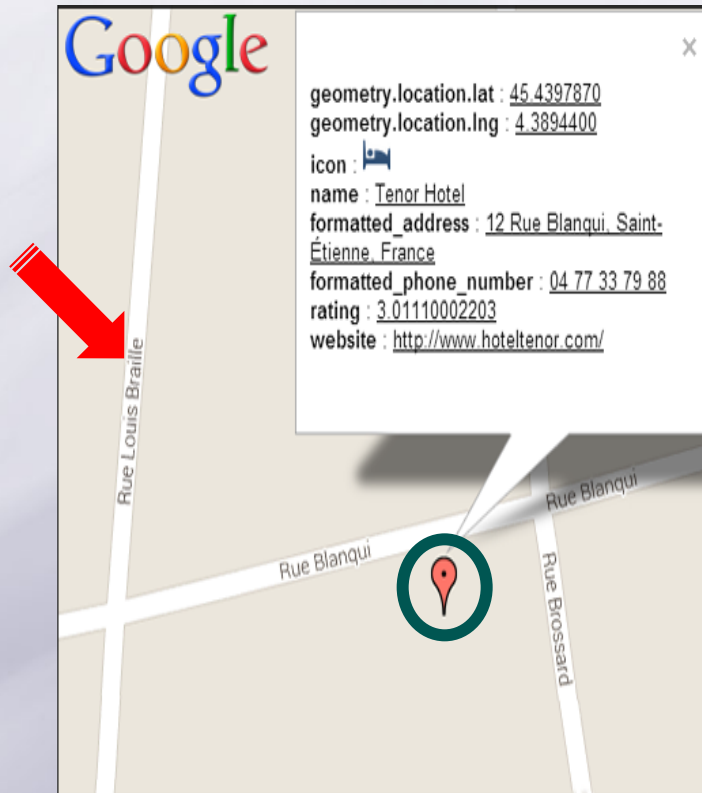
Examples of LBS providers:



Motivation

Differences at :

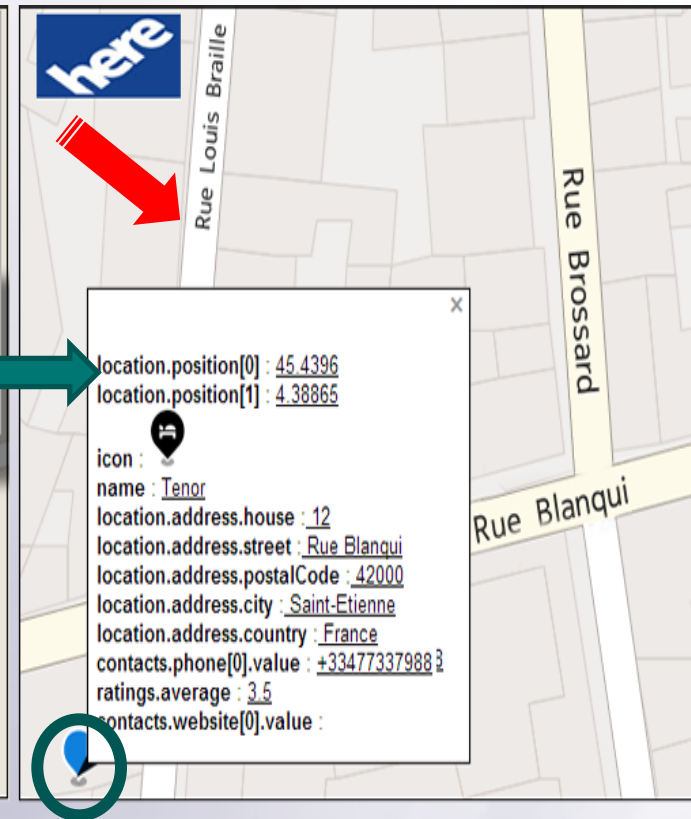
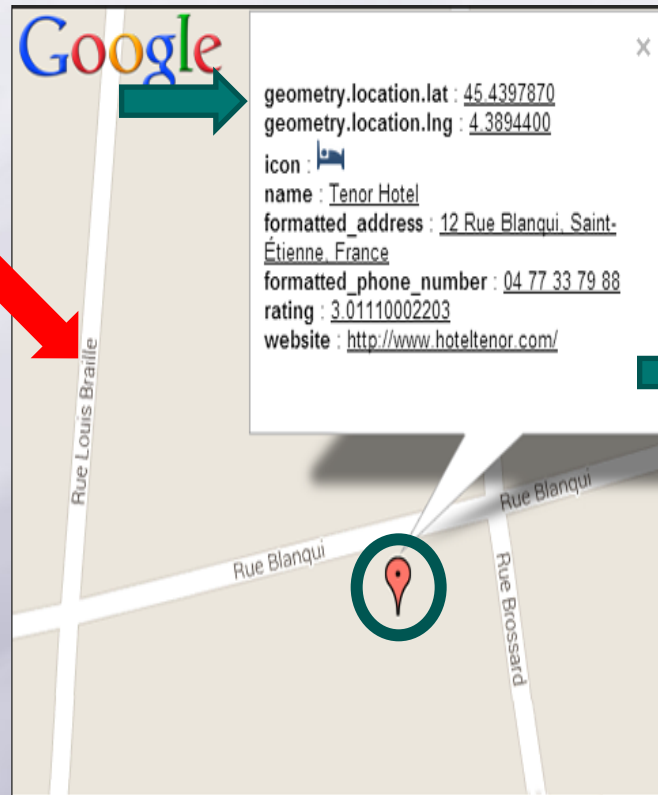
○ Positioning



Motivation

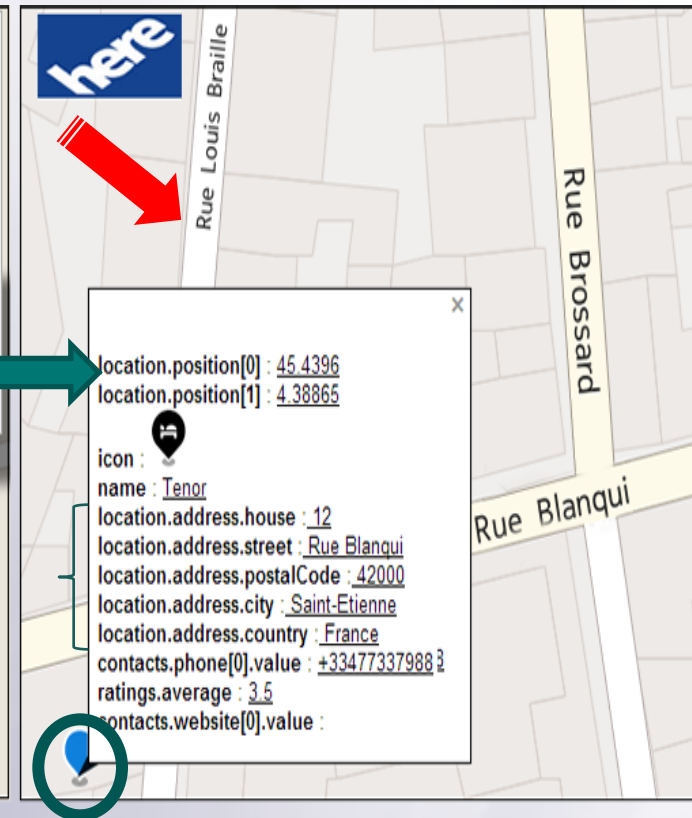
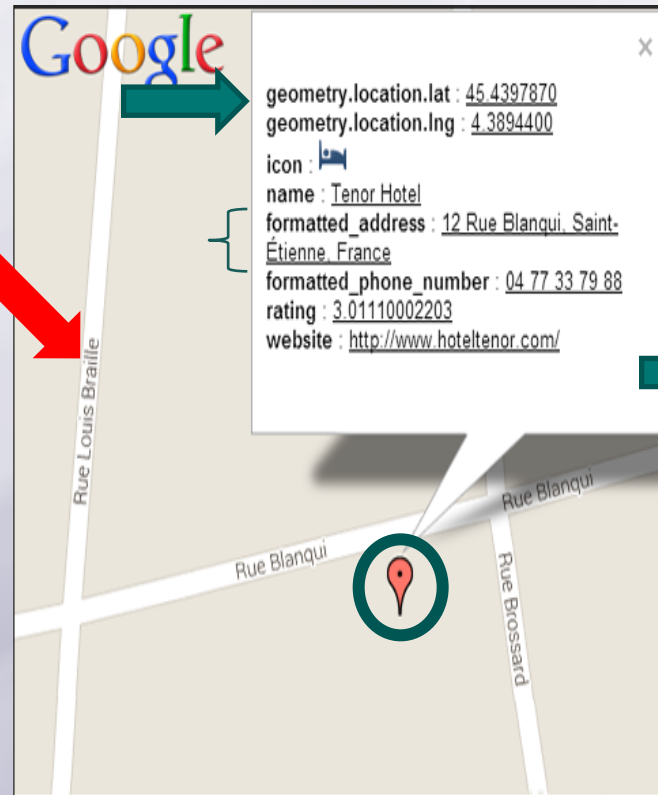
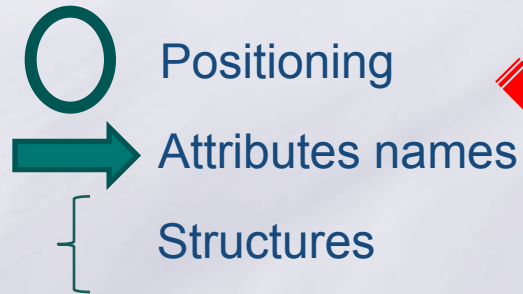
Differences at :

○ Positioning
→ Attributes names







Motivation

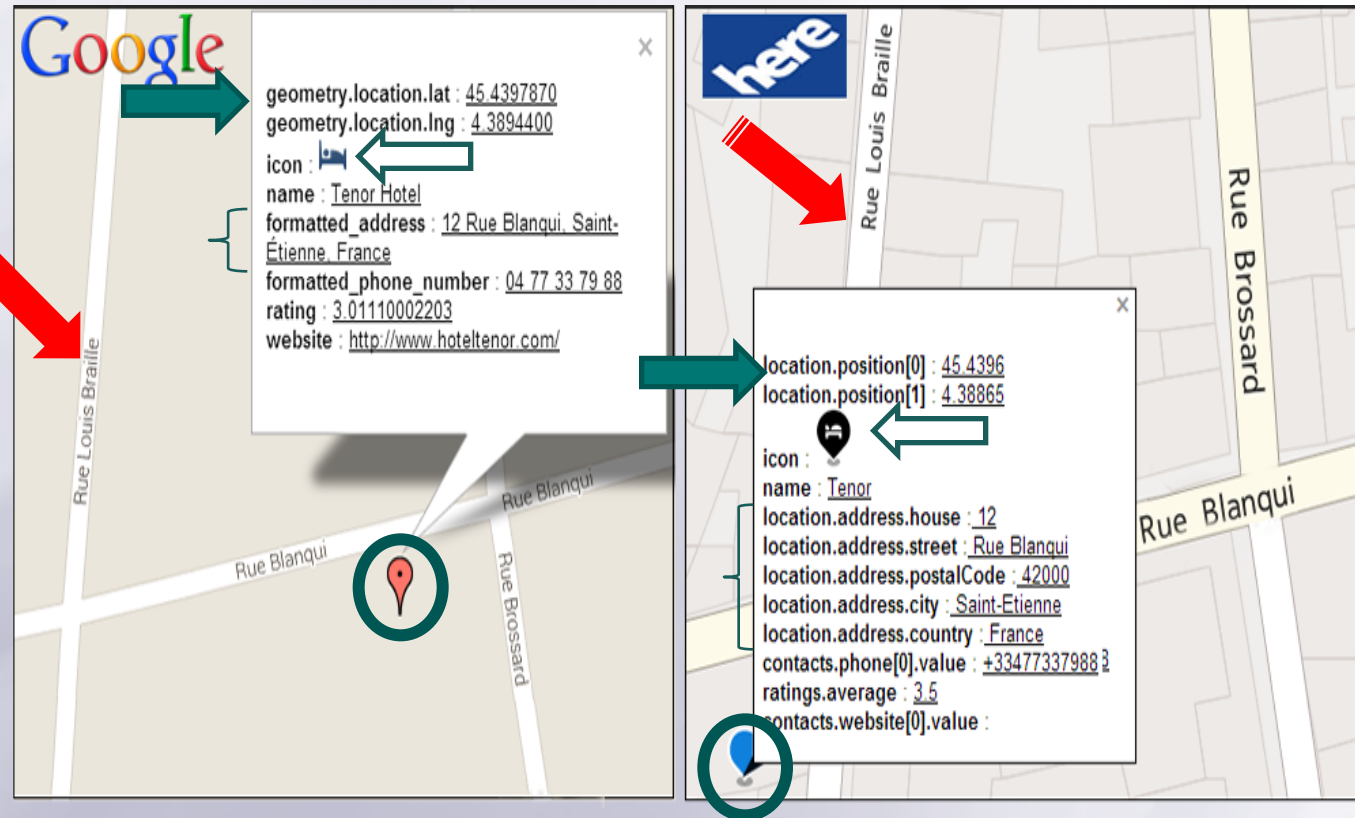
Differences at :



Motivation



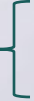

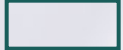
Differences at :

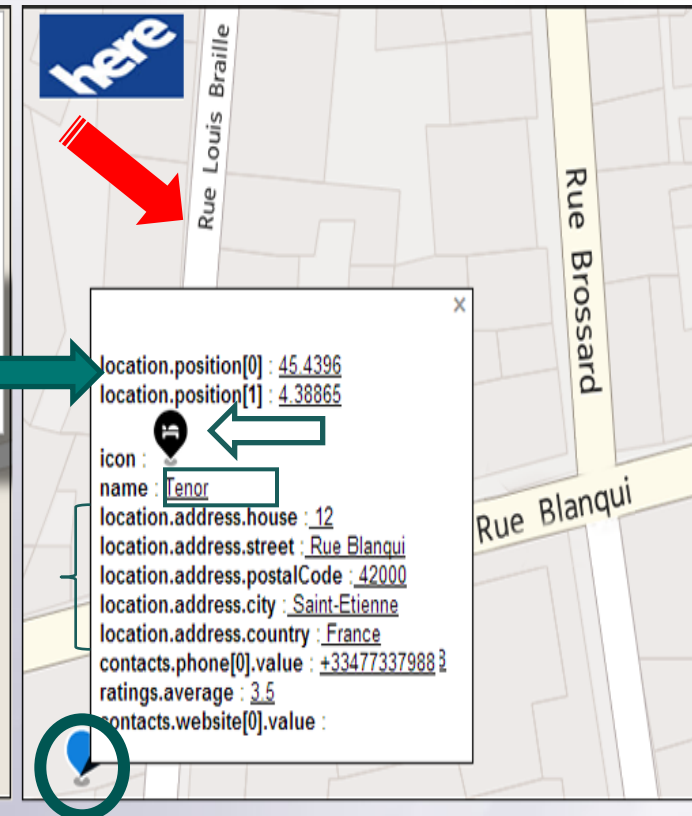
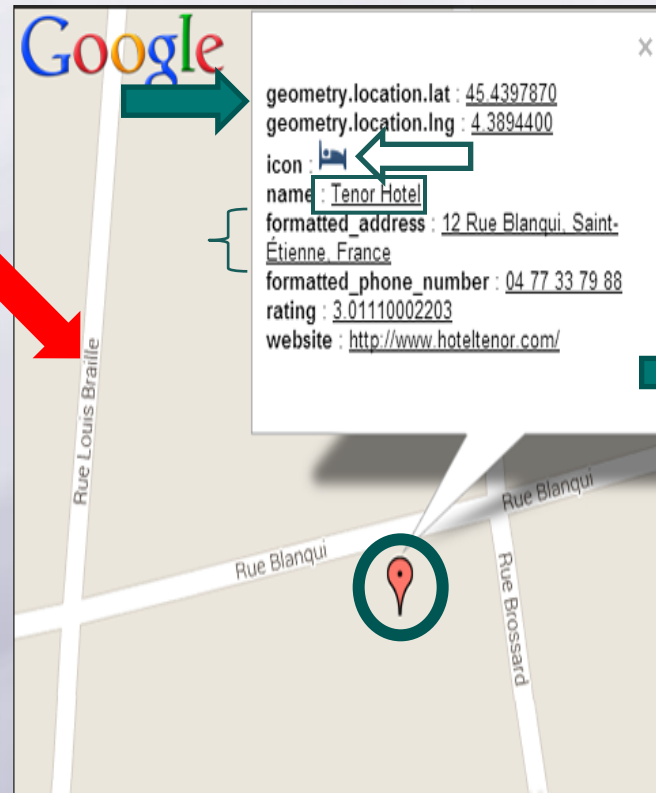
-  Positioning
-  Attributes names
-  Structures
-  Symbols



Motivation


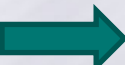
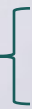

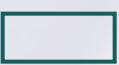

Differences at :

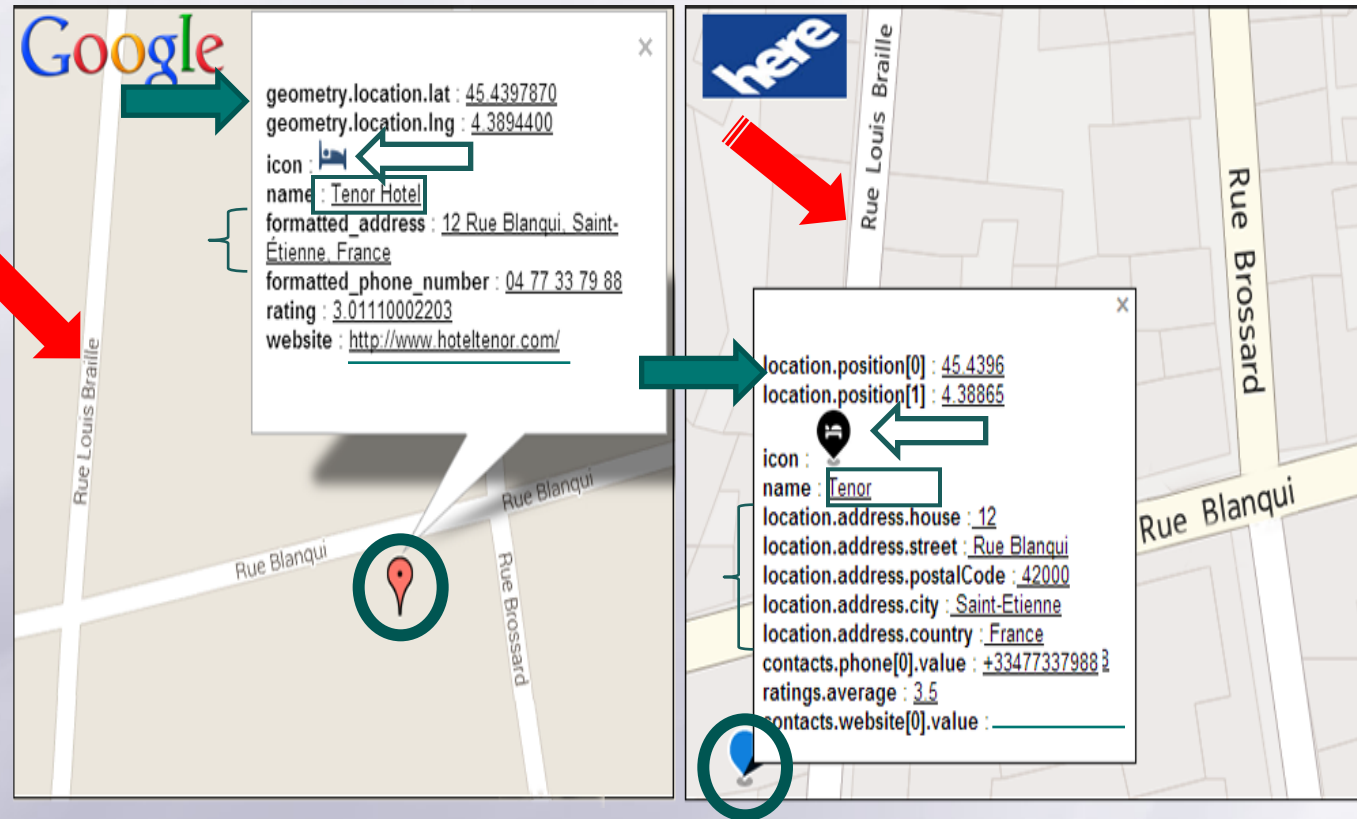
-  Positioning
-  Attributes names
-  Structures
-  Symbols
-  Values



Motivation




Differences at :

-  Positioning
-  Attributes names
-  Structures
-  Symbols
-  Values
-  Incomplete



Specificities & Challenges

Specificities

-  Dynamicity: Providers update their models and data anytime
-  Large scale: LBS providers become more numerous and their data are increasingly voluminous
-  Data quality: Guarantee that the information is integrated as correct as possible and assess its uncertainty

Challenges

-  Detect and integrate corresponding POIs using their terminology and spatial data
-  **Visualize integrated POIs and represent their uncertainty on maps**

Plan

≡ Introduction

≡ Related Work

≡ Representing Uncertainty

≡ Approach Overview

≡ Integration and Uncertainty Computation






≡ Visualization of Uncertainty

≡ Experimental Validation

≡ Conclusion and Future Work

Related Work – Spatial Integration

Spatial entity matching

-  Only spatial information: similarity measures based on probabilistic consideration [1, 2]
-  Spatial & terminological information: combining similarity measures
 -  Theory of Evidence [3, 4]
 -  Learning-based methods [5]
 -  Filtering [6]

[1] C. Beeri, Y. Doytsher, Y. Kanza, E. Safra, and Y. Sagiv, “Finding corresponding objects when integrating several geospatial datasets”. ACM International Workshop on Geographic Information Systems, 2005, pp. 87–96.

[2] E. Safra, Y. Kanza, Y. Sagiv, C. Beeri, and Y. Doytsher, “Location-based algorithms for finding sets of corresponding objects over several geo-spatial data sets,” International Journal of Geographical Information Science, vol. 24, no. 1, pp. 69–106, 2010.

[3] A. Olteanu, “A multi-criteria fusion approach for geographical data matching,” International Symposium in Spatial Data Quality, 2007.

[4] R. Karam, F. Favetta, R. Kilany, and R. Laurini, “Integration of similar location based services proposed by several providers,” In Networked Digital Technologies, 2010, pp. 136–144.

[5] H. Kang, V. Sehgal, and L. Getoor, “Geoddupe: A novel interface for interactive entity resolution in geospatial data,” In International Conference on Information Visualisation, 2007, pp. 489–496.


[6] E. Safra, Y. Kanza, Y. Sagiv, and Y. Doytsher, “Integrating data from maps on the world-wide web,” In Web and Wireless Geographical Information Systems, 2006, pp. 180–191.

Related work – Spatial Integration

Semi-automatic spatial entity matching

-  Detecting the potentially corresponding entities for which a user has to make a final decision [7]

Map conflation

-  Vector objects (punctual, linear and polygonal) and raster images are integrated [8]

[7] H. Kang, V. Sehgal, and L. Getoor, “Geoddupe: A novel interface for interactive entity resolution in geospatial data,” In International Conference on Information Visualisation, 2007, pp. 489–496.

[8] J. J. Ruiz, F. J. Ariza, M. A. Urena, and E. B. Blazquez, “Digital map conflation: a review of the process and a proposal for classification,” International Journal of Geographical Information Science, vol. 25, no. 9, pp.1439–1466, 2011.




Related work – Spatial Uncertainty Visualization

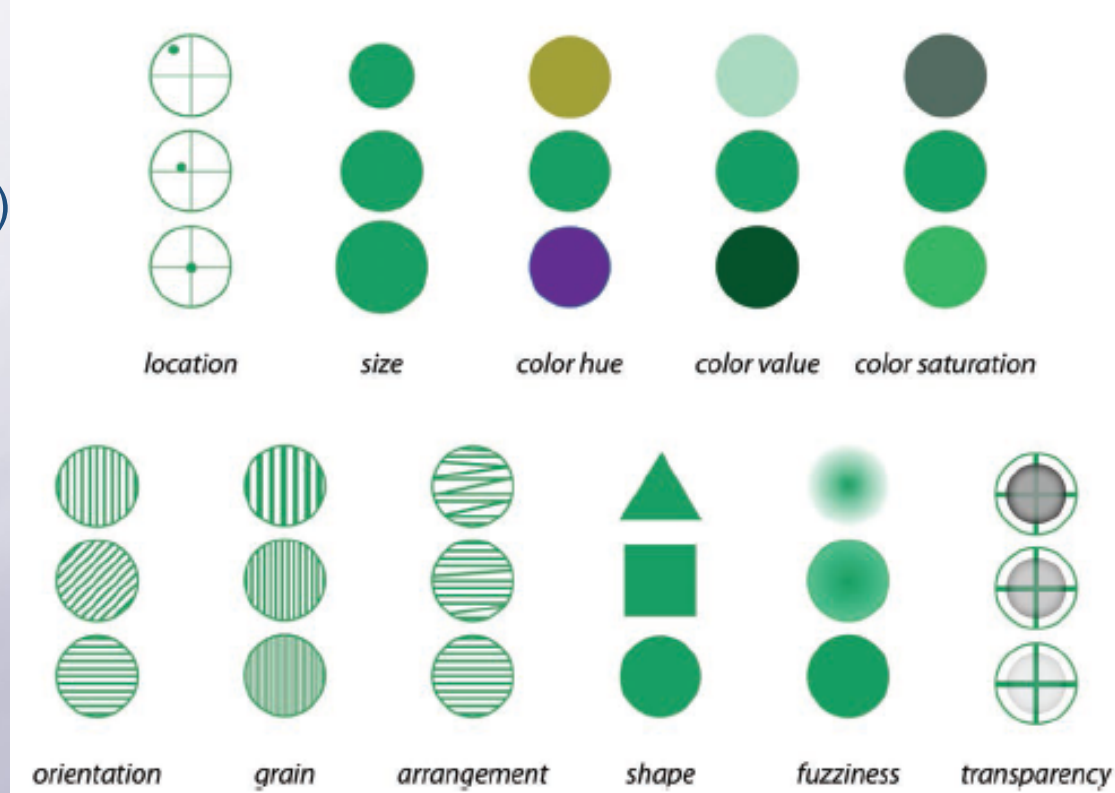
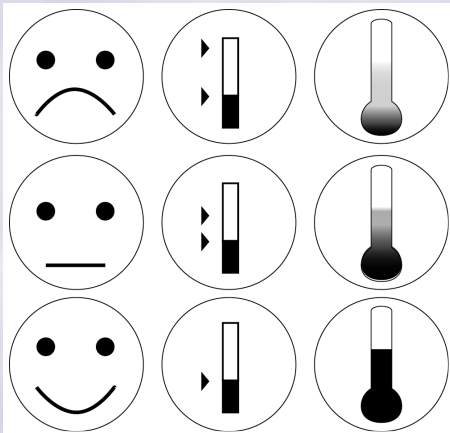
Category	Space	Time	Attributes
Accuracy/ error	coordinates., buildings	+/- 1 day	counts, magnitudes
Precision	1 degree	once per day	nearest 1000
Completeness	20% cloud cover	5 samples for 100	75% reporting
Consistency	from / for a place	5 say M; 2 say T	multiple classifiers
Lineage	# of input sources	# of steps	transformation- tions
Currency/ timing	age of maps	$C = T_{\text{present}} - T_{\text{info}}$	census data
Credibility	knowledge of place	reliability of model	U.S. analyst vs. informant
Subjectivity	local \leftrightarrow outsider	expert \leftrightarrow trainee	fact \leftrightarrow guess
Interrelatedness	source proximity	time proximity	same author

MacEachren et al., Visual semiotics and uncertainty visualization: An empirical study , 2012

Related work – Spatial Uncertainty Visualization

3 levels of confidence

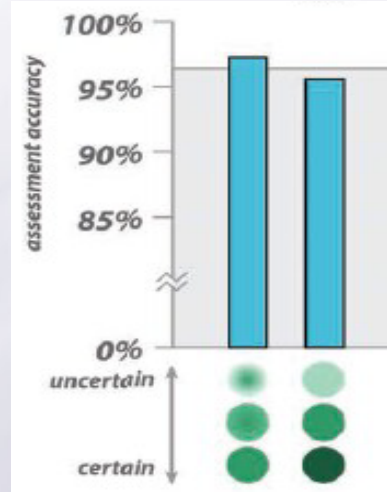
-  Low (uncertain)
-  Medium (moderately certain)
-  High (certain)



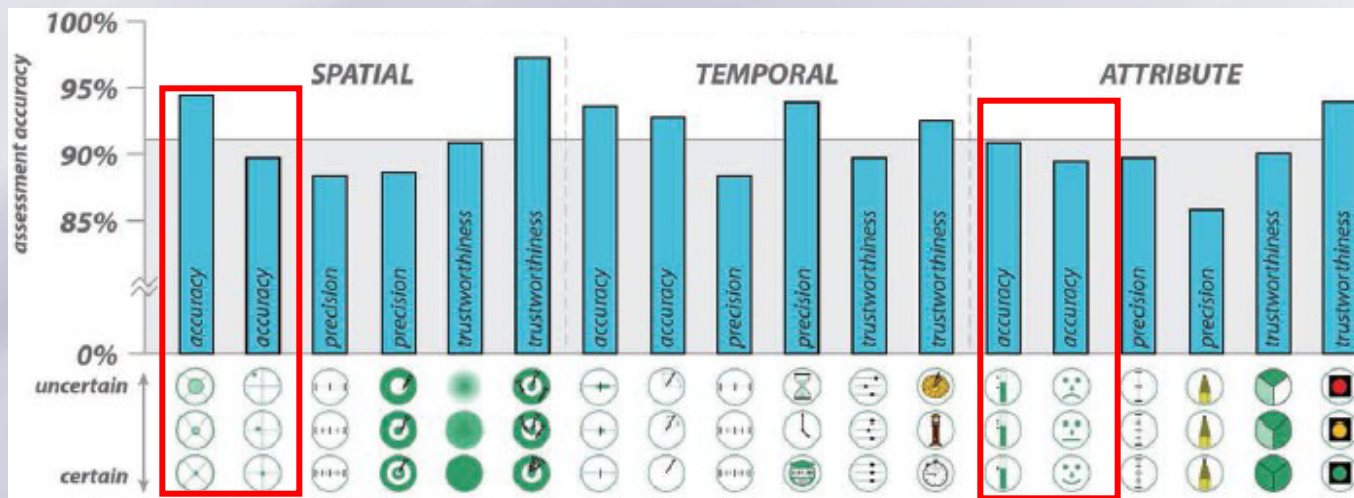
Abstract symbols (Morrison 1974, Bertin 1983, MacEachern 1995)

Iconic symbols (MacEachren et al., Visual semiotics and uncertainty visualization: An empirical study , 2012)

Related work – Spatial Uncertainty Visualization



Most abstract relevant visual variables for uncertainty generally (MacEachren & al. 2012)



Most relevant visual variables for each component in some categories (MacEachren & al. 2012)

Plan

- ≡ Introduction
- ≡ Related Work
- ≡ **Representing Uncertainty**

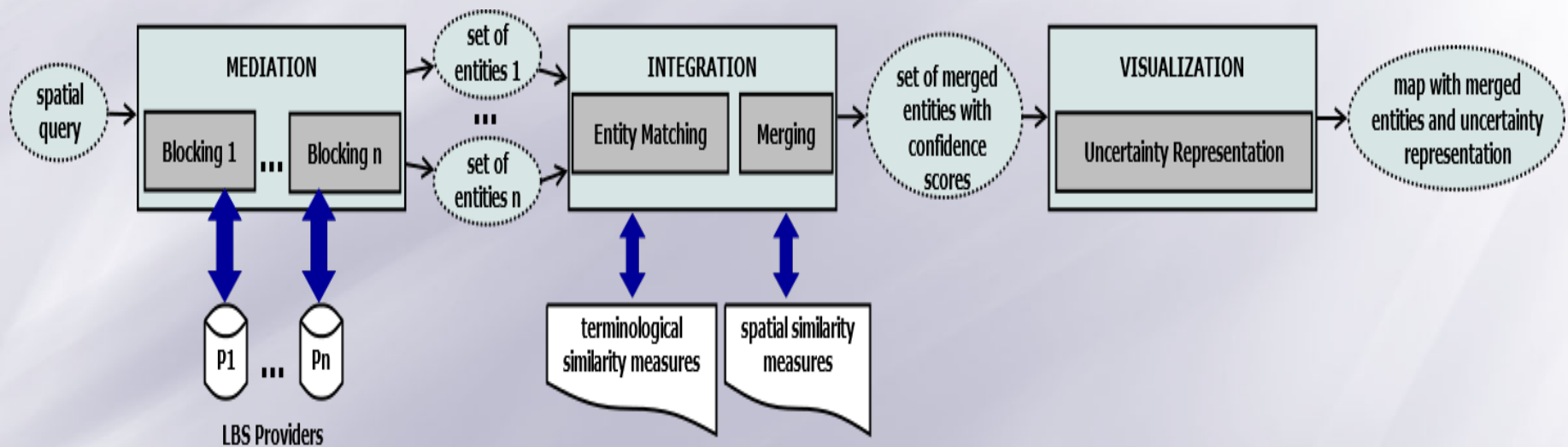
- ≡ Approach Overview
- ≡ Integration and Uncertainty Computation
- ≡ Visualization of Uncertainty

- ≡ **Experimental Validation**
- ≡ **Conclusion and Future Work**

Representing Uncertainty





Approach Overview

- Mediation process
- Integration process
- Visualization process






Representing Uncertainty – Integration Process

Integration Process

-  Spatial similarity based on Euclidian distance
-  Terminological similarity based on Levenshtein distance
-  Global similarity ☐ combining spatial and terminological similarity
-  Entities with highest global score are considered as similar




3 Geographical Dimensions

-  Confidence level of spatial attributes
-  Confidence level of terminological attributes
-  Global confidence level






Representing Uncertainty - Integration Process

Confidence Scores

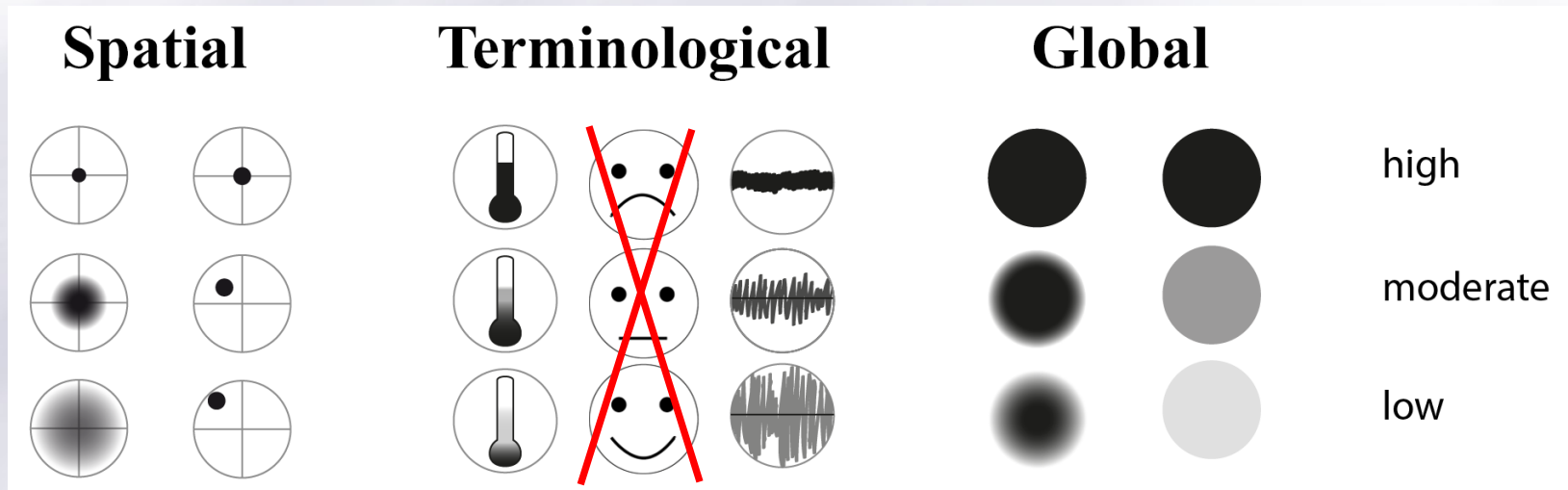
-  Spatial confidence score \square spatial similarity score
-  Terminological confidence score \square average of similarity scores of all terminological attributes
-  Global confidence score \square combining the spatial and terminological confidence scores

Confidence Levels

-  Low (uncertain) \square confidence score \square $[0,0.5]$
-  Medium (moderate certainty) \square confidence score \square $]0.5,0.75]$
-  High (certain) \square confidence score \square $]0.75,1]$

Representing Uncertainty on the Map

Selected visual variables

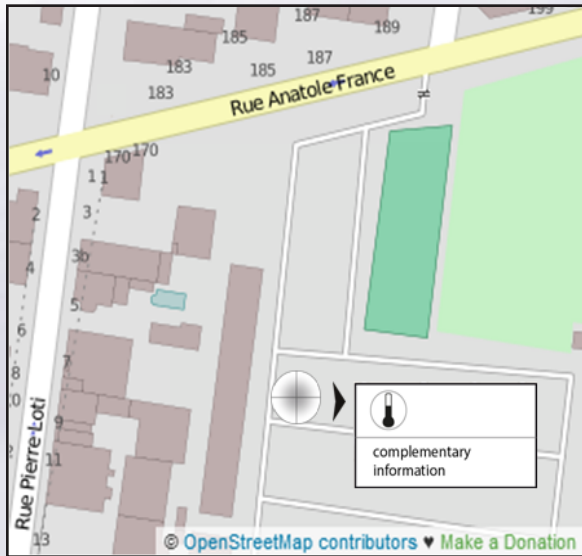


2 ways to portray a visual variable

- Directly on the map (on the POI location)
- In a tool-tip (above the terminological information)

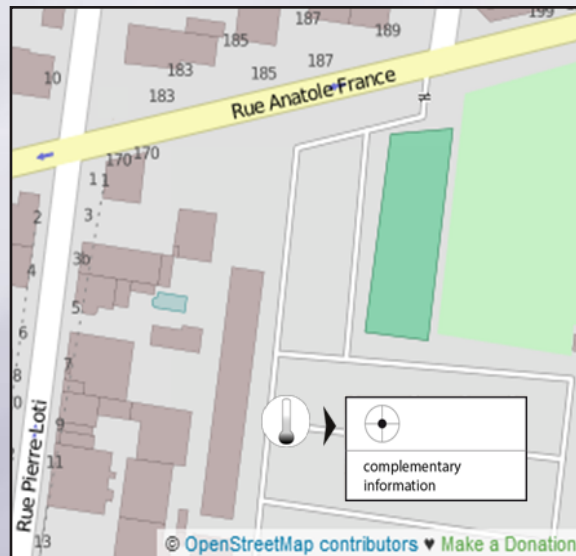
Representing Uncertainty on the Map - Proposals

Spatial and terminological confidences



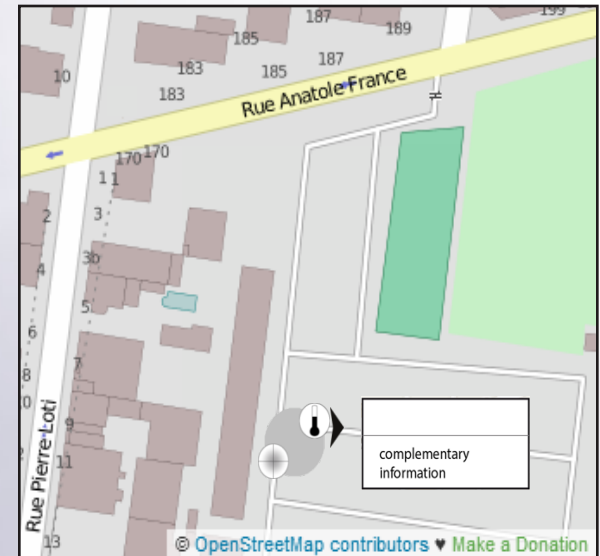
Proposal 1

- Spatial on map
- Terminological in tool-tip



Proposal 2

- Terminological on map
- Spatial in tool-tip

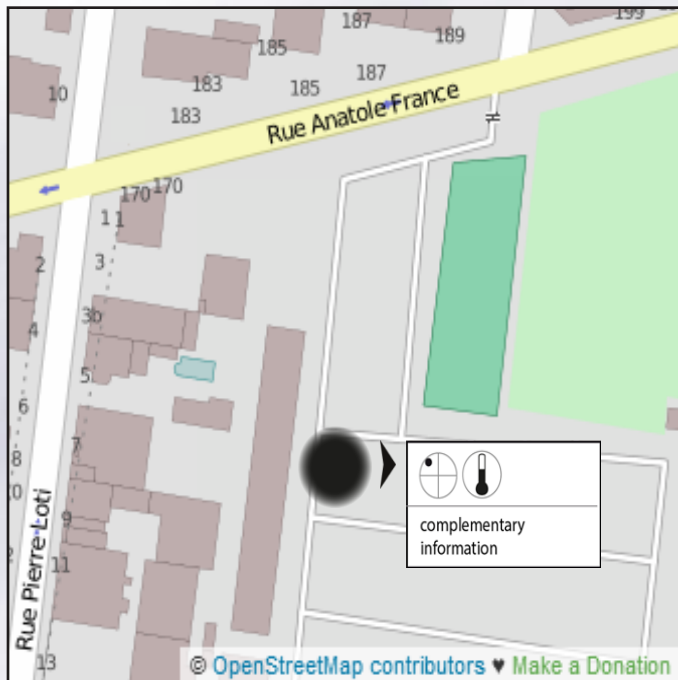


Proposal 3

- Terminological and spatial on map

Representing Uncertainty on the Map - Proposals

Global, spatial and terminological confidences



Proposal 4

- Global on map
- Spatial and terminological in tool-tip



Proposal 5

- Global, terminological and spatial on map

Plan

- ≡ Introduction
- ≡ Related Work
- ≡ **Representing Uncertainty**

- ≡ Approach Overview
- ≡ Integration and Uncertainty Computation
- ≡ Visualization of Uncertainty

- ≡ **Experimental Validation**
- ≡ **Conclusion and Future Work**

Experimental Validation

- POIs are the result of the integration of POIs from several LBS providers
- Representing uncertainty based on Proposal 4
 - Global □ Color value
 - Spatial □ Location associated to fuzziness and size
 - Terminological □ Thermometer
- Search for POIs by their types
- Dynamic map




Experimental Validation

POI Type:




- ☐ Random ☐ Hotel ☐ Museum
☐ Bus Station ☐ Park

Legend:




Global confidence:

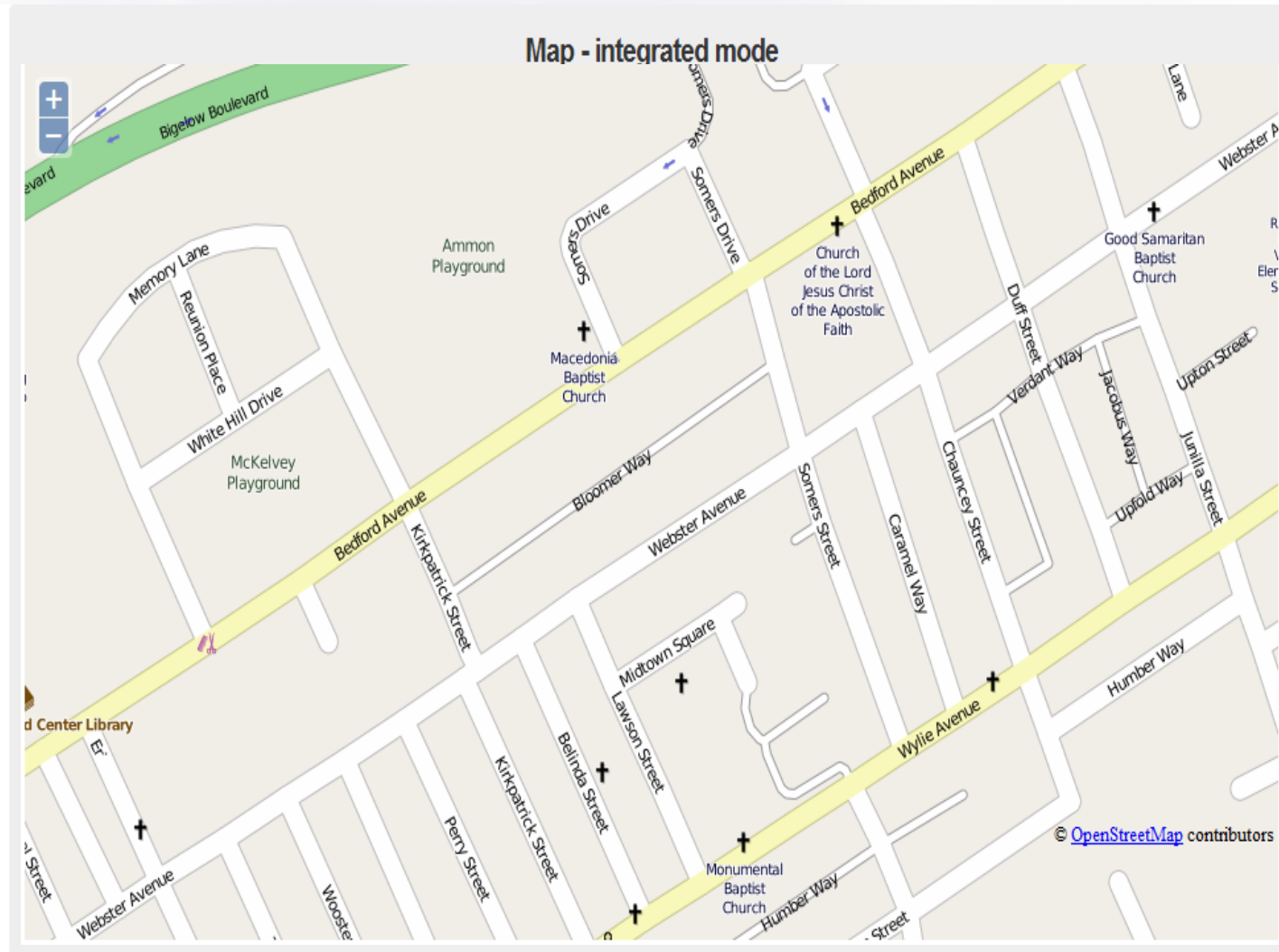
-  High
 Moderate
 Low

Spatial confidence:

-  High
 Moderate
 Low

Terminological confidence:

-  High
 Moderate
 Low






Experimental Validation

POI Type:




- ☒ Random ☐ Hotel ☐ Musuem
☐ Bus Station ☐ Park

Legend:




Global confidence:

-  High
 Moderate
 Low

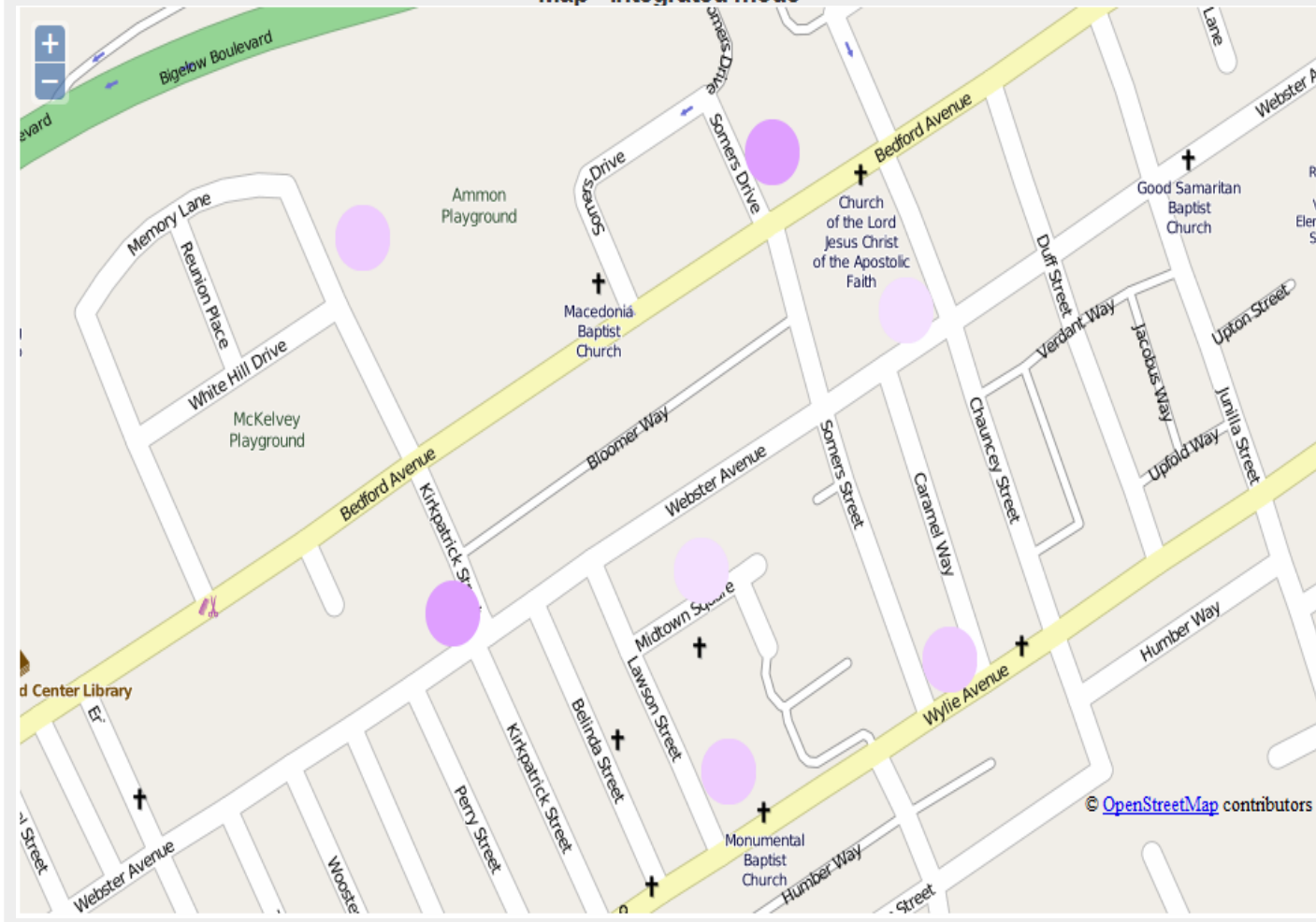
Spatial confidence:

-  High
 Moderate
 Low

Terminological confidence:

-  High
 Moderate
 Low

Map - integrated mode






Experimental Validation

POI Type:




- ☒ Random ☐ Hotel ☐ Musuem
☐ Bus Station ☐ Park

Legend:




Global confidence:

-  High
 Moderate
 Low

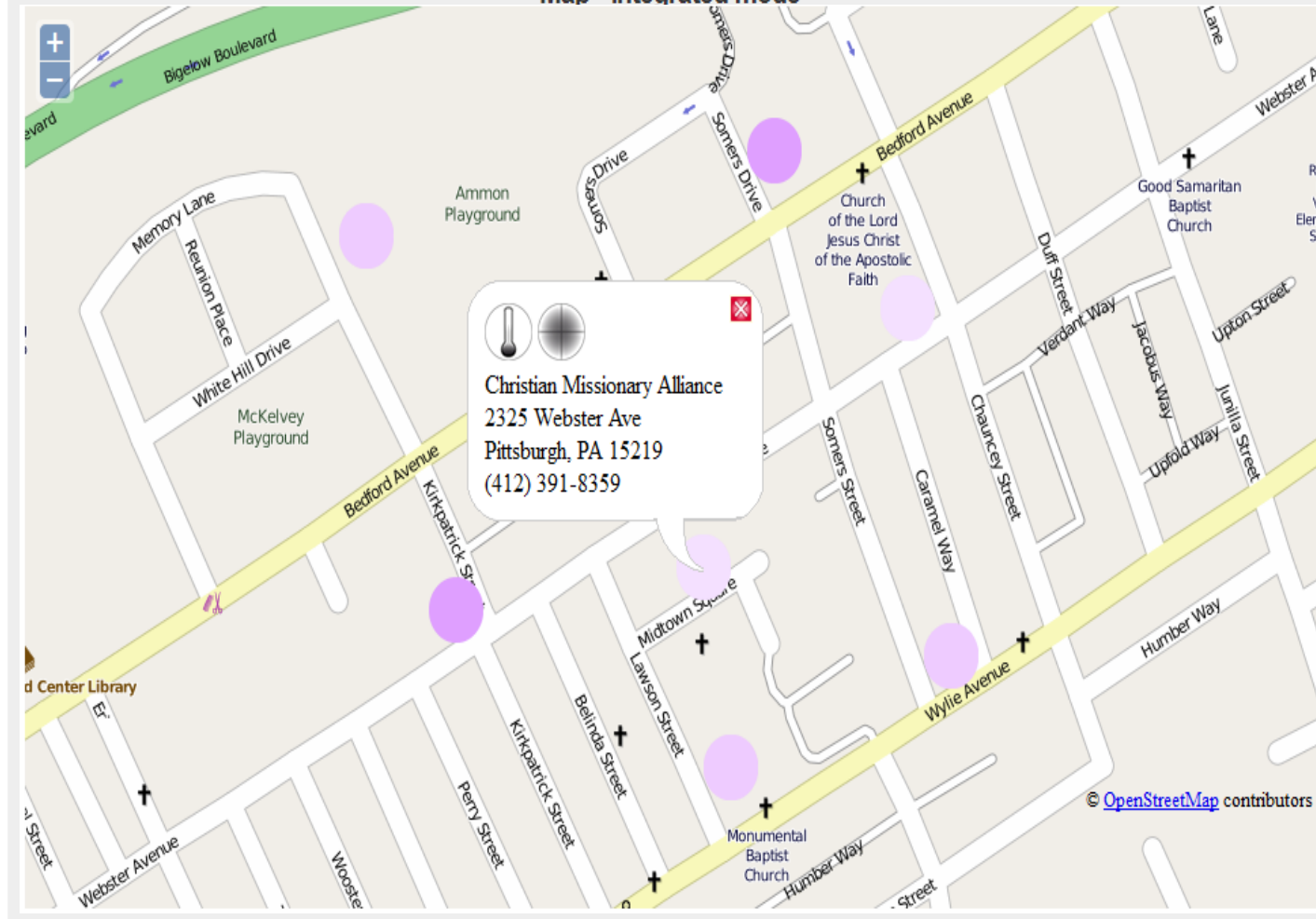
Spatial confidence:

-  High
 Moderate
 Low

Terminological confidence:

-  High
 Moderate
 Low

Map - integrated mode



Plan

- ≡ Introduction
- ≡ Related Work
- ≡ **Representing Uncertainty**

- ≡ Approach Overview
- ≡ Integration and Uncertainty Computation
- ≡ Visualization of Uncertainty

- ≡ **Experimental Validation**
- ≡ **Conclusion and Future Work**






Conclusion and Future Work

Conclusion

Representing the uncertainty of integrated POIs in a spatial context

Future Work

-  Find the most efficient visual variables for each dimension of geographic information
-  Evaluate alternative solutions and explore how end-users navigate with interactive maps
-  Customize the visual representation and the navigation process according to user profiles

Thank you Questions?

bilal.berjawi@liris.cnrs.fr
<http://unimap.liris.cnrs.fr>

Experimental validation – 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

References

- Ruiz & al., Digital map conflation: a review of the process and a proposal for classification, 2011.
- Beeri & al., “Finding corresponding objects when integrating several geospatial datasets,” 2005.
- Safra & al., Location-based algorithms for finding sets of corresponding objects over several geo-spatial data sets,” 2010.
- Olteanu, A multi-criteria fusion approach for geographical data matching,” 2007.
- Karam & al., Integration of similar location based services proposed by several providers, 2010.
- Sehgal & al., Entity resolution in geospatial data integration, 2006.
- Safra & al., Integrating data from maps on the world-wide web, 2006.
- Kang & al., Geoddupe: A novel interface for interactive entity resolution in geospatial data, 2007.
- MacEachren & al. Visual semiotics and uncertainty visualization: An empirical study, 2012.
- Bertin ,Semiology of graphics: diagrams, networks, maps, 1983.
- Morrison, A theoretical framework for cartographic generalization with the emphasis on the process of symbolization, 1974.