

# Data Modeling and Processing in Location Based Services: A Collaborative Research Agenda

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## Abstract:

We are living in a mobile information era when (mobile) information communication technologies are fundamentally changing science and society. *Location Based Services* (LBS), which are computer applications (especially mobile computing applications) deliver information tailored to the location and context of the device and the user, play a key role in this mobile information era (Raper et al. 2007). Recent years have seen rapid advances in LBS with the continuous evolution of mobile devices, communication technologies, internet of things, and location-based big data (LocBigData). More and more LBS are entering into general public's daily lives, with many application fields, such as navigation and mobility, emergency and disaster management, infotainment (e.g., gaming and social networking), healthcare, tracking and assistive technologies (Huang, 2022). As a result, LBS have attracted significant research attention from the disciplines of Cartography and Geographic Information Science (GIScience), as well as many related disciplines.

To ensure good usability, LBS should be context-aware, i.e., adapting the information and services according to the user's context, such as his/her location, tasks, preferences, and the underlying geo-social environment. At a high-level, the essential question for the data modelling and processing in LBS is: *How can relevant information that best matches a user's cognitive capacity for their task/activity and context be identified?* Here, a user is usually a human, but can be expanded to an intelligent agent, e.g., in the context of autonomous cars and artificial intelligence. We propose a research agenda to comprehensively address this essential question. The research challenges can be classified into 4 groups (Figure 1): "modelling of the geo-social environment", "modelling of the mobile user", "context-aware adaptation", and "ethical data modelling and processing". For each group, a series of research opportunities that address the corresponding leading research challenge is outlined and presented in Table 1.

This research agenda (Huang et al. forthcoming) together with another two ones on cognitive issues (Griffin et al. forthcoming) and map design (Roth et al. forthcoming) form a special issue of the *Journal of Location Based Services* on user experience design for mobile cartography.

We hope that the research agenda presented in this paper motivates the LBS research community and beyond to join forces to enable the 4A vision ("anytime", "anywhere", "for anyone" and "anything" services) and fulfil the 5R ("right" information, in the "right" presentation, at the "right" time, in the "right" place, to the "right" person) requirements of LBS.

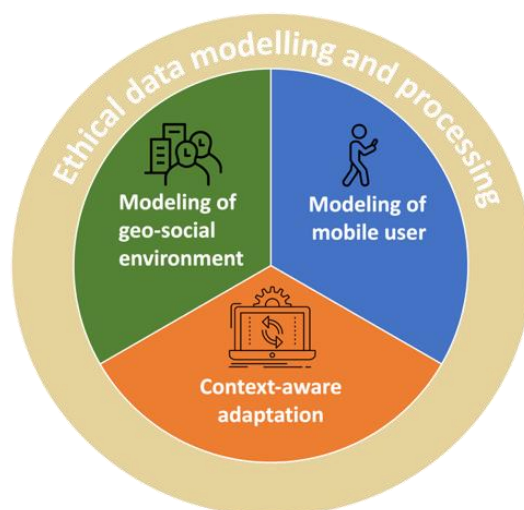


Figure 1. The “key research challenges” regarding data modelling and processing in LBS.

Open research challenges	Research opportunities addressing each challenge
Modelling of the geo-social environment	<ul style="list-style-type: none"> <li>• Indoor/outdoor seamless spatial modelling (high definition and 3D)</li> <li>• Social sensing</li> </ul>
Modelling of the mobile user	<ul style="list-style-type: none"> <li>• Ubiquitous positioning</li> <li>• Semantic enrichment of location</li> <li>• User modelling and task modelling</li> <li>• Modelling of context and its dynamics</li> </ul>
Context-aware adaptation	<ul style="list-style-type: none"> <li>• Conceptualizing and modelling relevance in LBS</li> <li>• Techniques of context-aware adaptation</li> <li>• Level of automation in the context-aware adaptation process</li> <li>• Optimized distribution of data and processing among the mobile device and the cloud</li> </ul>
Ethical data modelling and processing	<ul style="list-style-type: none"> <li>• Privacy and ethical issues in LBS</li> <li>• Modelling the trade-off between service quality and (geo)privacy</li> <li>• Techniques of privacy-preserving data modelling and processing</li> <li>• Governance and regulation on privacy-preserving data processing</li> </ul>

Table 1. Research challenges and opportunities regarding data modelling and processing in LBS

## References

- Griffin, A. L., T. Reichenbacher, H. Liao, W. Wang, and Y. Cao. under review. Cognitive issues of mobile map design and use. *Journal of Location Based Services*.
- Huang, H., Y. Cheng, W. Dong, G. Gartner, J. Krisp, and L. Meng. under review. Context modeling and processing in location based services: Research challenges and opportunities. *Journal of Location Based Services*.
- Huang, H., 2022. Location-Based Services. In W. Kresse & D. M. Danko (Eds.), *Springer Handbook of Geographic Information*. Springer. <https://doi.org/10.1007/978-3-030-53124-9>
- Raper, J., G. Gartner, H. Karimi, and C. Rizos., 2007. A Critical Evaluation of Location Based Services and Their Potential. *Journal of Location Based Services*, 1 (1), pp. 5–45. doi:10.1080/17489720701584069.
- Roth, R. E., A. Çöltekin, L. Delazari, B. Denney, A. Mendonça, J. Shen, Z. Stachoň, and M. Wu. forthcoming. Making maps & visualizations for mobile devices: Challenges for mobile-first and responsive cartographic design. *Journal of Location Based Services*.