Position paper submitted to the **User Experience Design for Mobile Cartography: Setting the Agenda**

3D User interfaces, human factors and augmented-and-mixed reality as maps: Re-establishing the link between cartography and photogrammetry

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As the smart phones have become computationally 'strong enough' to run augmented reality (AR) and mixed reality (MR) applications in recent years, it seems inevitable that these technologies move towards becoming mainstream (e.g., [1][2]). While the mobile phones may not be the AR/MR media, arguably they will be the devices to enable AR/MR towards everyday relevance until we have glasses and wearable headsets that are light, high-functioning and cheap enough.

Confirming AR/MR's short- to mid-term relevance, in a talk I recently attended, MagicLeap's Judith Wiesinger said "spatial computing has arrived" [3]. When people (outside the geographic information science and related domains) say *spatial computing*, they mean using the space around us *as the interface* to interact with information, thus they refer precisely to the technologies such as virtual, augmented and mixed reality displays [4].[1] When we examine the narratives in this discourse, we see that spatial computing, not surprisingly, embeds some fundamental concepts and approaches from spatial sciences: Specifically, cartography and photogrammetry, especially when AR/MR approaches are used in navigation assistance (as in [1] and [2]).

Given the experience the cartographers and photogrammetrists have in processing and representing space from both technology and human factors angles, we should (more systematically) investigate the links between them and 'spatial computing' in AR/MR with the goal to improve interaction and interface design in what might be *the* next generation displays. In the context of AR and MR, the entire physical world becomes a part of the user interface (UI), thus the UI paradigms as we know them for 2D have to be re-considered for the 3D space. Importantly, visualization essentially becomes the *only* interface (i.e., hardware is no longer the way we interact with information). In cartography and geovisualization domains the paradigm 'visualization as an interface (to information)' has been understood, because space-variant information is *mapped* on the different parts of the visualization. As such, examining the expertise in geospatial domains to benefit the AR/MR developments would be worth exploring, given that we can critically think of our understanding of 2D user interfaces, combine them with our understanding of 3D space and representations in photogrammetry, and translate these to 3DUIs (e.g., [8], [9]).

[1] It is not entirely clear if people in geographic information science and related domains use the term 'spatial computing' consistently. Many authors use it to broadly mean the use of spatial algorithms of any kind, including any and all 2D spatial analyses, and I would argue that this is the dominant use/understanding of the term in GIScience (e.g., see [5], [6] and [7]).

[1] Mapbox (2019). Location-based AR Platform. https://www.mapbox.com/augmented-reality/

[2] Schroeder, S. (2019). Google's augmented reality Maps are live for some users https://mashable.com/article/google-ar-maps/#gUFiFnvg1sq3. February 11th, 2019

[3] Wiesinger, J. (2018). "Spatial computing has arrived" https://twitter.com/acolt/status/1072913844308246529

[4] Agulhom, V. (2016). What is spatial computing? https://medium.com/@victoragulhon/what-is-spatial-computing-777fae84a499

[5] Adam, N. R., Shafiq, B., & Staffin, R. (2012). Spatial computing and social media in the context of disaster management. *IEEE Intelligent Systems*, *27*(6), 90-96.

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[8] Rautenbach, V., Coetzee, S., Schiewe, J., & Çöltekin, A. (2015). An assessment of visual variables for the cartographic design of 3D informal settlement models. In *Proceedings of the 27th International Cartographic Conference, Rio de Janeiro, Brazil* (pp. 23-28).

[9] Halik L (2012). The analysis of visual variables for use in the cartographic design of point symbols for mobile Augmented Reality applications. Geodesy and Cartography, 61(1):19–30.