

Modelling and communicating geographic relevance in a digitally transformed world using a digital twin

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Abstract:

The importance of filtering and representing geographic information according to its relevance to mobile users in a specific context has long been claimed (Reichenbacher, 2005; 2009). To avoid information overload in mobile maps, the concept of geographic relevance (GR) has emerged in GIScience (Reichenbacher 2005, Raper 2007; Reichenbacher and De Sabbata 2011). GR includes spatiotemporal and place-oriented accessibility, considers a user's activities and argues that spatial proximity alone is insufficient to consider a geographic object relevant (De Sabbata, 2013). Almost ten years later, we can argue that the GR model is even more a crucial tool for GIScience and mobile cartography. Smartphones, tablets, and smartwatches have become pervasive in modern life. Not only do most people use mobile map apps as their primary source of geographic information for navigating, spatial decision-making, and problem-solving, but the extensive usage of these tools provides rich contextual information sensed from device sensors (e.g., positioning, temperature).

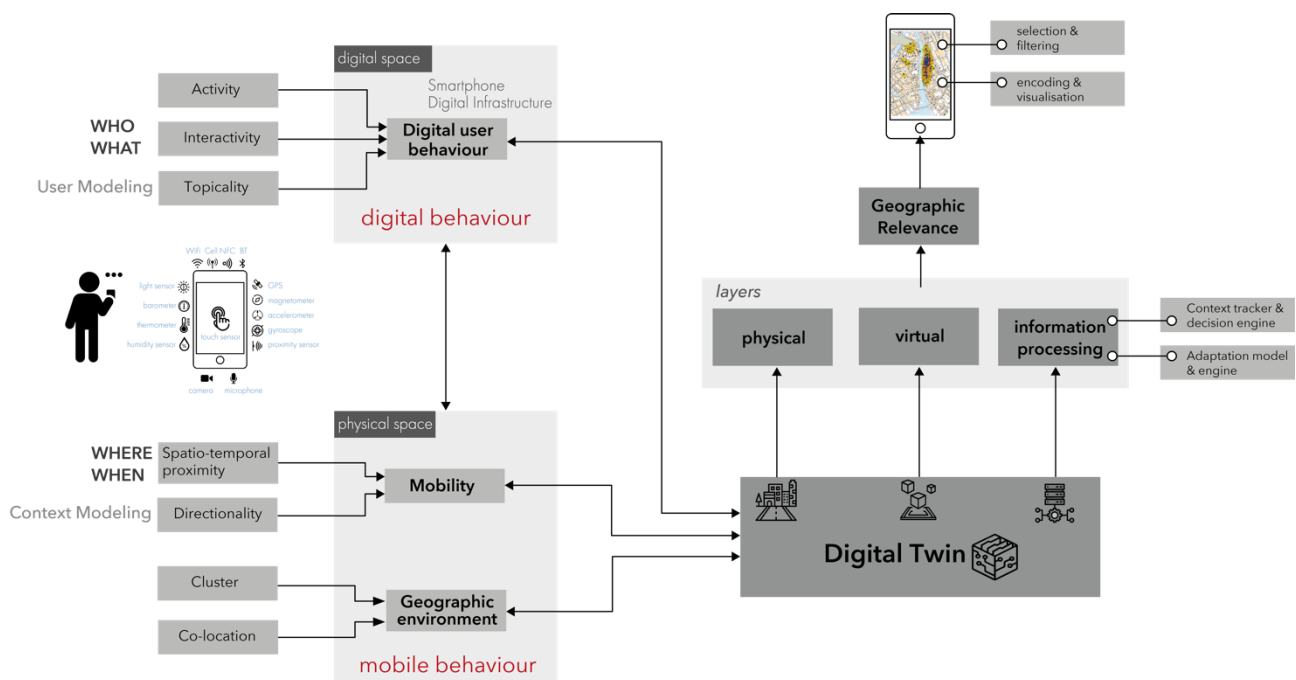


Figure 1. A conceptual model of geographic relevance based on a digital twin.

Nonetheless, while technological advancements accelerate, GR as a user-centred mobility notion of relevance is still lagging in finding its application in the new digital era. Therefore, the concept and modelling of GR need to be revised and extended to be successfully applied to the digitally transformed environment. Indeed, numerous disruptive technologies, such as the Internet of Things (IoT), big data, and cloud computing, are evolving rapidly (Kaur et al., 2020). Moreover, mobile broadband communication networks, as the 5G, create a prevalence of real-time data and services. Taken together, these new generation technologies (Tao and Qi, 2017) converge into the crucial concept of the Digital Twin (DT), initially developed in 2003 by (Grievies, 2014) as the “digital equivalent to a physical product”. The core concept of DT consists of physical, virtual, and information processing layers. The latter is crucial to set bi-directional

processing, which feeds data from the physical to the virtual representation and processes from the virtual representation to the physical (Zheng et al., 2019). A new line of research has recently suggested using the digital twin for humans, opening new research prospects on human DT (Shengli, 2021).

In line with the DT core concepts, we propose a possible DT application to display geographically relevant information in real-time that changes dynamically on map apps based on the continuous exchange of data derived from direct and indirect interaction with one's smartphone (see Fig. 1). With this novel approach, we aim to include users' activity and behaviour, extending the previous GR model to more accurately predict and retrieve geographically relevant information of users, based on their context, now easily accessible with new generation technologies. Our conceptual approach resides between the DT and the human DT, considering not only the context parameters derived from the physical world, collected by the smartphone's sensors, but also the user's interaction with the digital and physical world mediated by the smartphone. In that sense, the human element of our DT is the user behaviour in the physical and digital space, which becomes an essential part of modelling and assessing GR, and eventually visualise relevance-filtered and relevance-encoded information in mobile map apps. We argue that smartphones, available to most users, possess sufficient processing power, high-speed transmission, and sensors. They are in between the physical and digital world allowing the user to access digital information and relate it to the physical world. As such, smartphones are a crucial source for sensing and collecting data from the physical environment and behavioural data where geographic information behaviour could be derived and modelled into its virtual counterpart. They are also the ideal platform to create and host an individual digital twin. Thus, the virtual component is a computational model where GR is sourced and fed from the geographic environment, mobility, and digital user behaviour. Finally, bi-directional data connections and processing, continuously coming from the digital and physical models, can provide a real-time GR visualisation that changes instantaneously considering the user's experience interacting with the world. Apart from filtering, feature relevance can also be visually encoded in the mobile map app. The DT allows to model GR and can also include an adaptive component in the information processing layer that tracks context information and decides about the necessity of adapting the GR visualisation through a decision engine (see Fig. 1). The GR of map features is eventually adapted through an engine that implements rules and methods based on an adaptation model. Such adaptation would mostly be a filtering and ranking of content, and ultimately changing the visual encoding of degrees of relevance. Although the adaptation could be fully autonomous, the user always has full control and could stop or override adaptive behaviour of the system. Our proposed DT model could be implemented in a mobile map app to improve the display of relevant geographical information in real-time smartphone-based interaction.

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