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Digital twins for understanding territorial dynamics: A case study of the Moria Camp, Lesvos, Greece

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Abstract:

Territory is a widely used concept in geography, urban planning and social sciences. For political geography this concept describes not only the physical and national space but also the relations presiding in an area of interest (Carter-White & Minca, 2025). Sack defined human territoriality as “the attempt to affect, influence, or control actions and interactions (of people, things, and relationships) by asserting and attempting to enforce control over a geographic area” (Sack, 1983). Access to and practices of land use, and how these are shaped through social and political practices is crucial in this field (Gottmann, 1973). Conventional methods of spatial visualization, however, such as 2D maps, offer limited insights into land use change and spatiotemporal evolution (Fitzpatrick & Hedley, 2023). In contrast, 3D models, which are considered modern visualization techniques in digital environments, virtual reality and digital twins, can contribute towards enhancing the understanding of spatial phenomena (Mihai et al., 2022). The interactive nature of these visualization techniques offers an efficient method for knowledge extraction (Ağca, 2023).

This paper discusses and assesses a digital twin of the Moria Camp, Lesvos Island, Greece, which represents the spatial evolution of land use changes over the period from 2017 to 2026. The digital twin was designed primarily as an educational aid towards the understanding of the concepts of Territory, Camp and borders, through a tangible example, for the benefit of the undergraduate and postgraduate students. The Moria Camp was chosen on account of its characteristics as national and EU border, its multiple land uses, as well as the intense spatial and social dynamics it had presented in the last decade. In addition, the coexistence of multiple control and access regimes made it a representative case study for the conceptualization of the territory. A crucial step in the development of this educational tool is the creation of a photorealistic 3D model. The 3D model was created by utilizing 3D mapping and image based 3D modeling processing methods. In particular, the area was mapped using Unmanned Aerial Vehicles (UAV) following a specially designed flight plan. The flight plan was designed to conduct at a flight altitude of 70 m with 85% front and 75% side overlap. In addition, a 360° panorama was captured, which was used to enhance the perception of the wider landscape and the geographical location of the Moria Camp. The data collected using UAV, were processed with photogrammetric algorithms leading to the creation of a photorealistic 3D model of the area in its’ current state. The digital twin camp reconstruction for the years 2017, 2019, 2024 and 2026 was achieved through Twinmotion, a game engine software. In the period ranging between 2012 to 2020 (i.e. the period of operation of the Moria Camp), the actual Camp site as well as the surrounding area changed significantly in physical and political terms. Initially, the area expanded considerably beyond its predetermined boundaries. At the same time, changes in terms of its functional and social dimensions took place. The representation of these changes highlighted the transition from, initially, limited reception system to an extensive and very complex camp with differentiated zones of use and levels of control. One of the challenges faced during the implementation of this study was the limited availability of reliable and systematic data from earlier stages of the camp. To address this limitation, aerial photographs from journalistic sources were used as a guide for assessing the spatial layout and density of infrastructure. Information regarding the country of origin, daily practices and accommodation access was obtained from interviews with camp residents. 3D models in the form of a thematic layer, allow an accurate representation of the space. The digital twin was then developed into a virtual reality application software with the aim of creating an immersive application. This specific application allowed the user to navigate the space to explore the spatial layouts at different time periods and observe the spatiotemporal change of the territory at the camp scale (Figure 1.). The user experience was enhanced by the 360° panorama which contributed to the understanding of the geographical space surrounding the structure. In conclusion, the development of digital twin highlights the potential of interactive 3D visualizations as a tool for understanding complex spatial concepts. The combined use of geometric and qualitative data allows a multiscale approach to the conceptualization of territory. The

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proposed educational approach aims to enhance experiential learning and a deeper understanding of spatial transformations. Finally, the application is to be deployed to undergraduate and postgraduate university students, as well as to be evaluated using specially designed questionnaires both in terms of its usefulness and usability, as well as in terms of its effectiveness in the understanding of concept of territory. Future research should focus on integrating political and social layers within 3D digital twins to analyze how evolving governance structures and administrative boundaries shape the perception and management of territory, highlighting interactions between authority, access, and spatial practices.

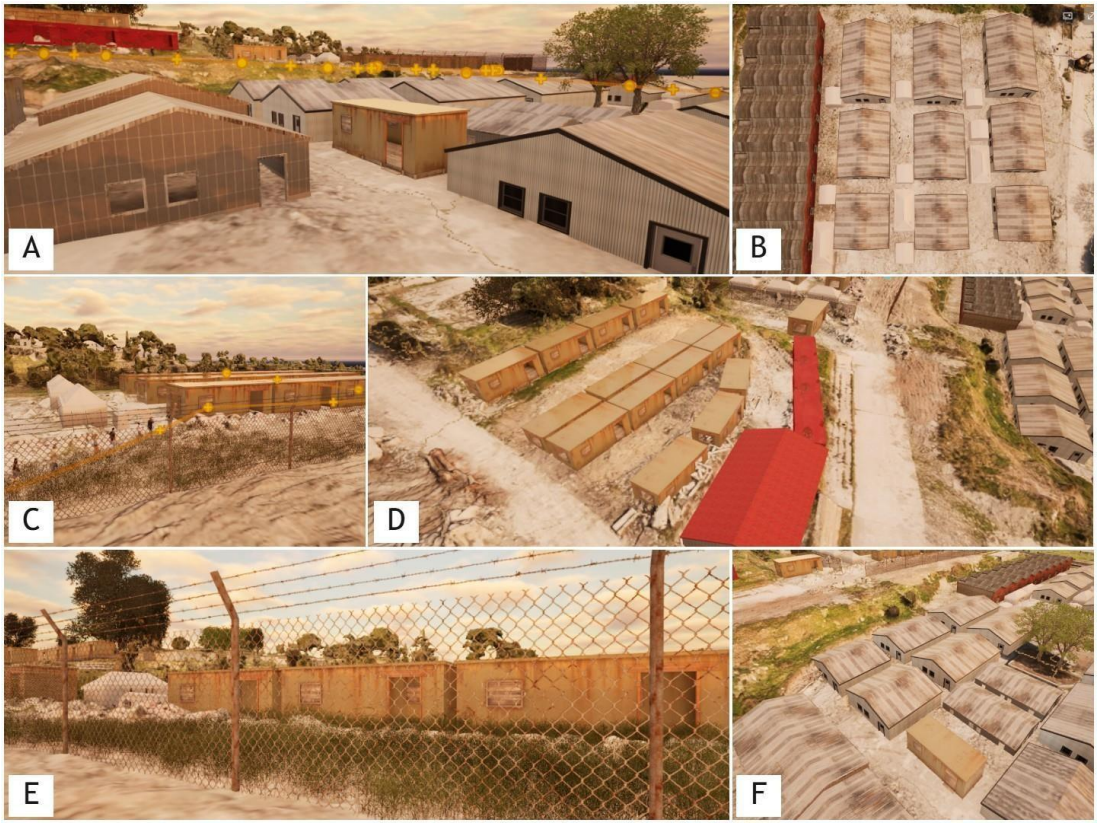

Figure 1. 3D model of the Moria camp 2017: A&F) aerial view of central area, B) vertical aerial view of section ,C&E) pedestrian view of North – east area and D) aerial view of South – East area.

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