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Editorial

Geomatics in the Era of Citizen Science

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Geomatics has long been recognized as an information-technology-oriented discipline whose objective is to integrate and deliver multiple sources of geolocated data to a wide range of environmental and urban sciences [1]. The range of sensor-based technologies involved in geomatics is continuously expanding thanks to the emergence of high-resolution satellites, 3D radars, airborne laser and camera systems, unmanned aerial systems, underwater acoustic systems and intelligent location-based sensors. Parallel to these substantial technological advances, the digital age expands the access to and engagement with spatial data to new and diverse user communities, which then play an increasing participating role. This encourages novel interactions and exchanges between user communities, scientists and policymakers. Citizen scientists have long existed in many areas such as the natural sciences, where human observations are crucial. The difference is that the current widespread availability of interactive, real-time, affordable and geolocated platforms, together with the global availability and ubiquity of the Internet, offers many opportunities for citizen scientists to collaborate with scientific programs and studies [2]. Beyond spatial data collection processes, citizen scientists can contribute to data curation, synthesis, analysis and, finally, to a new form of public engagement. In exchange, they can take on an active role in the dissemination of the study's outcomes to a broad community [3].

Over the past decades, applications of citizen science to the spatial domain have rapidly expanded and encompass very diverse application areas and levels of interactions, from data collection to close involvement in the studies [4]. A landmark example is the collaborative and volunteer-based OpenStreetMap project that involves millions of registered users, including hundreds of thousands of contributors, which has proven its effectiveness in many environmental and humanitarian operations. A high diversity of experiments and innovations are under development, from web- and location-based projects that engage citizens in collecting the data of wildlife observations [5], to the integration of augmented reality interfaces for the promotion of biodiversity education [6] and the combination of citizens' reporting of public, geographical and remote sensing data to evaluate the forest tree decline [7]. Specific attention is paid to the identification and study of the different levels of citizen engagement [6] and to the integration of spatial and temporal dimensions as discriminating criteria [8].

While the effects of citizen science on the geomatics community and society are largely positive, there are still a series of research, technological and social challenges to overcome. First, while citizen science offers novel possibilities for observational data, potential errors and biases, as well as consistency across data collection tasks, are typical issues that are inherent to the diversity of actors that require appropriate data sampling and validation protocols. There is also a clear need to design citizen science methodologies that are closely associated with geomatics technologies, as well as training procedures and best practices, that will extend the range of advanced capabilities offered to the participants. Next, since a wide range of citizen- and volunteer-based geomatics applications are under development at an unprecedented scale, distributed citizen science infrastructures

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and applications should be developed and standardized; socio-cultural differences and practices to ensure the effective implementation of geomatics applications should also be considered. Although there is a profusion of open-source Volunteered Geographic Information (VGI) toolkits, communication and messaging resources with similar purposes for data collection, they are not always user-friendly and easy to install, not designed under some normalized principles, and often require adaptation to the specific needs of the application. Well-designed human–computer interfaces still need to be developed to leverage and facilitate user interactions, rating systems and feedback, and accelerate learning processes and capacity building. Geographical artificial intelligence has the potential to enhance citizens' participation by suggesting and prioritizing activities based on the citizens' interests, location and previous engagement [9]. Additionally, it simplifies the validation process for citizens' contributions, paving the way for major innovations in this area [9]. Using gamification and rewards as motivational and engaging factors, which were proven to be effective in fields like remote sensing, are promising approaches to attract new categories of citizens, particularly in validating land cover classifications [10]. Privacy issues and consent should be addressed to professionalize citizen science and secure long-term participation. Moreover, maintaining transparency becomes crucial, particularly when incorporating artificial intelligence into citizen science initiatives [11]. Despite the availability of several citizen science and geomatics applications, "geomaticians" are sometimes hesitant to accept this form of data collection. Instead, they continue to favor common data acquisition approaches that are exclusively carried out by experts. While we acknowledge the vital role of surveyors in geomatics data acquisition, advancements in technology have introduced novel opportunities for cheaper and easier methods of data collection, which can be used by volunteers. For instance, the development of recent smartphones made it possible for citizens to collect LiDAR data. Consequently, it is possible to establish a balance between expert- and citizen-driven data collection in the field of geomatics, which increases opportunities to make collaborative efforts with citizens. Overall, theoretical, methodological and practical challenges remain, and require close collaboration between social and engineering sciences and the geomatics community. The development of citizen science applications in the geomatics world will provide mutual benefits and a novel pathway between open science and society. Citizens clearly aspire to participate in sustainable development practices and global transitions offered by these novel approaches. With the increasing importance of environmental and health concerns, there will undoubtedly be many innovative applications in which geomatics and citizen science can be combined to create effective solutions.

Conflicts of Interest: The authors declare no conflict of interest.

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