




Editorial

# Applications of Machine Learning in National Territory Spatial Planning

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## 1. Introduction

National territory spatial planning guides national spatial development and the spatial blueprint of sustainable development [1,2]. It is the basis for a variety of development, protection, and construction activities, and it is of great significance in solving problems such as the prominent human–land conflict, a lack of spatial resources, and the imbalance of regional development in the process of rapid urbanization, industrialization, and modernization [3,4]. National territory spatial planning integrates multiple spatial plans, including main functional area planning as well as land use planning and urban and rural planning, and opens a new era of integrated territorial governance [5,6]. Integrated territorial governance is the theoretical interpretation of the direction of national territory spatial governance. Eradicating the conflicts among multiple spatial plans is the basic premise of the reconstruction of a national territory spatial planning system. Supporting the construction of ecological civilization is an important mission of national territory spatial governance for the current age [7]. Machine learning technology is a multi-disciplinary field, involving probability theory, statistics, approximation theory, convex analysis, algorithm complexity theory, and other disciplines, which specializes in determining how computers simulate or realize human learning behavior in order to acquire new knowledge or skills and reorganizing existing knowledge structures to continuously improve its own performance. At present, the methodologies of national territory spatial planning are continuously and closely linked to machine learning. However, there is still a lack of further exploration of spatial data set mining, multi-domain monitoring, and national territory spatial planning the use of machine learning [8]. Thus, the latest application achievements and advanced technologies of machine learning in the theory and practice of national territory spatial planning need to be summarized, explored, and integrated, and, simultaneously, further relevant study should be promoted and encouraged.

To this end, we organized the Special Issue “Applications of Machine Learning in National Territory Spatial Planning”, which received nearly 14k views up to November 2023, thus showing the broad interest of scholars and readers in this research topic. This Special Issue focuses on the latest research advances in machine learning technologies and their applications for national territory spatial planning. We focused on new advanced methodological approaches or frameworks toward “national food security and agricultural spatial patterns”, “improving the quality of human settlements and community life cycles”, and so on. We expect these academic papers to systematically summarize and divide the methods of national territory spatial planning, determine the technical problems that exist in national territory spatial planning in its current f, and provide reference technical



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guidance for theoretical research and the practice of national territory spatial planning in the future. Following our call for papers during the period of 2022 to 2023, we published seven papers from 37 authors as a part of this Special Issue, with them highlighting some current research discoveries and study progress in “big-data-driven urban spatial environmental monitoring and infrastructure service capability measurement” (contributions 1 and 7), “the interdisciplinary perspective of food security, agricultural development spatial planning, and machine learning” (contributions 2 and 4), and “methodological innovation and system development of the integration of machine learning and national territorial spatial planning” (contributions 3, 5, and 6). In the following section, we will summarize the key contributions of this Special Issue and then present a summary and the future directions.

## 2. Materials and Methods

### 2.1. *Big-Data-Driven Urban Spatial Environmental Monitoring and Infrastructure Service Capability Measurement*

With the continuous advancement of machine learning, positioning, navigation, and remote sensing technology, the construction of a “Smart City” provides data acquisition methods for space–time sensing big data, such as satellite and drone remote sensing, mobile sensing, social sensing, and crowdsourced sensing data, thus providing a new way to analyze urban dynamics such as urban space, human behavior, and the interaction between them [9] and explore the three-dimensional, comprehensive, and multi-dimensional nature of urban space [10]. Of the papers included in our Special Issue, two research teams attempted to use new types of big data combined with machine learning technologies to innovate research methodologies for different urban spatial issues, such as urban spatial environmental monitoring and infrastructure service capability measurement. Elvas et al. (contribution 1) provide a novel approach for analyzing nocturnal urban noise patterns and identifying distinct zones using mobile phone data and audio recordings from city sensors, which utilize machine learning techniques to extract noise features indicative of different sound sources and intensities and create comprehensive city noise maps during nighttime hours. In order to evaluate the service capacity of public health facilities more accurately, Fu et al. (contribution 7) take the integrated population and spatial elements into consideration and compensate for the lack of a relevant evaluation model and data collection method based on the perspective of geographic system analysis by using point of interest (POI) big data. These methodologies have a profound impact on government decision-making intention, the processes involved, and the efficiency level at which it operates. However, there are also a number of research fields not involved in this area of interest that are worthy of further study, such as national rural revitalization and urban–rural integrated development, new infrastructure construction, and so on.

### 2.2. *The Interdisciplinary Perspective of Food Security, Agricultural Development Spatial Planning, and Machine Learning*

Food security and agricultural development are major issues related to the national economy and people’s livelihoods, which are crucial for maintaining social stability and economic development, building ecological barriers, and safeguarding national security [11]. Research on crop classification, food security monitoring and early warning systems, and other relevant fields based on machine learning methods is of great practical significance for ensuring regional food security and ecological security [12]. Recently, a number of scholars have presented an interdisciplinary perspective between food security, agricultural development spatial planning, and machine learning and have achieved notable results in the research fields of food security monitoring, food security early warning, and the simulation application of machine learning technology. However, existing research still lacks a comprehensive integrated system model, data mining, and visualization technology in food security through the use of machine learning technologies to establish and perfect them [13]. As a part of our Special Issue, two research teams have made efforts to tackle this issue. Ren et al. (contribution 2) introduce the concept of resilience and explore the impact of NGCL on agricultural development resilience (ADR) in the main grain-producing area

of northeast China based on the threshold effect model and the spatial lag model. Martinho et al. (contribution 4) summarize and show that new technologies in Industry 4.0 (drones and sensors, big data, the Internet of Things, and machine learning) and their application through climate-smart agriculture approaches play a key role in sustainable businesses (economically, socially, and environmentally) and food supply. In the future, we should further strengthen the integration of machine learning, food security, and agricultural development to better respond to the major challenges of the new environment caused by global disasters such as climate change, global warming, the COVID-19 pandemic, and the Russia–Ukraine conflict.

### *2.3. Methodological Innovation and the System Development of Machine Learning and National Territorial Spatial Planning Integration*

The rapid development of new technologies has promoted the emergence of the “Smart Society”, and the rise of the smart society has provided a new environment and new requirements for current territorial spatial planning and governance [14]. In recent years, scholars have used artificial intelligence, machine learning, and other territorial spatial computing technology methods to dynamically simulate and evaluate regional space structure [15], urban growth [16], land use change [17], transportation networks [18], and landscape ecology [19], providing support for planning decision-making [20,21]. At present, considerable exploration has been carried out with many practices at the technical level on territorial spatial planning. However, due to a lack of multi-source data and methods, there is less comprehensive thinking and systematic research on the application of new technologies in territorial spatial planning. Informatization is the core power of empowerment to national territorial spatial planning; however, the current level of technological progress needed not only includes new information and communication technology but also the integrated application of innovative technology [22]. In the papers included in our Special Issue, three teams use machine learning technology to research different fields in national territorial spatial planning from different perspectives, involving land carrying capacity, house price prediction, and the identification of urbanized and non-urbanized areas. Yu et al. (contribution 3) develop a multi-dimensional evaluation index system for land comprehensive carrying capacity (LCCC) using a normal cloud model, which brings the fuzziness and randomness of the evaluation index and its results into consideration. McCord et al. (contribution 5) use the more transparent supervised regularized regression technique and integrate it with the eigenvector spatial filter (ESF) approach to more accurately account for spatial auto-correlation and enhance the prediction accuracy of house prices whilst also improving the explanation ability needed for mass appraisal exercises. Machine learning technologies also promote the development of the dynamic simulation of urban space. For example, Fiorini et al. (contribution 6) present a standardized and automatic approach aimed at analyzing the performance of clustering methods to identify if an area is urban.

### **3. Summary and Future Directions**

As a part of this Special Issue, the seven contributions summarized above describe this frontier topic from the three aforementioned aspects to some extent, and the national territory spatial planning research methodologies linked to machine learning are also diverse, ranging from big data technology, drones, and sensors, the Internet of Things, different types of mathematical models, spatial models, and physical models to other types of remote sensing spatiotemporal analysis technology. However, we also note that there are still many challenges and difficulties that need to be overcome in the future, including but not limited to (1) strengthening research on data mining and machine learning methods, optimizing data processing methods, creating new data types, improving data resolution, and fully exploring the relevant information in combination with machine learning; (2) strengthening research on a small scale, such as studies involving villages and courtyards, creating more accurate spatial data sets, establishing multi-scale analysis

systems at different time or spatial scales, and realizing innovative and comprehensive research on multi-dimensional national territorial spatial planning within human and natural ecosystems; and (3) strengthening practical cases of local territory spatial development innovation continuously, developing territorial space life cycle assessment in specific regions, and improving the quality of production-living-ecological spaces.

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