Academic Education Publishing House
-AEPH-

Higher Education and Practice Vol. 1 No. 7, 2024

Enhancing Remote Sensing Education: A Progressive-Guided Experimental Teaching System Integrating Industry, Academia, and Research

Lifeng Liang[1,2], Xiujuan Liu[1,*], Ruihang Ling[1]
[1]*School of Geographical Sciences, Lingnan Normal University, Zhanjiang, Guangdong, China*
[2]*Mangrove Institute, Lingnan Normal University, Zhanjiang, Guangdong, China*
[*]*Corresponding Author.*

Abstract: Remote sensing technology, as an interdisciplinary and versatile field, is widely applied in geographic information science, environmental monitoring, agricultural management, and disaster response. However, the practical component of remote sensing education is currently underdeveloped, leading to deficiencies in students' hands-on skills and innovative thinking. To address this issue, this paper proposes an experimental teaching system that integrates industry, academia, and research, focusing on a deep integration of theoretical knowledge and practical application. A "progressive-guided" experimental teaching method is designed as the core of this approach. Instructors not only demonstrate software operations based on video content, but also provide in-depth explanations on topics beyond the scope of the videos, drawing from extensive project experience. This method helps students quickly integrate the principles, basic methods, core operations, and advanced project applications of remote sensing, thereby improving their practical skills and overall competence. Furthermore, through collaborations with research institutions and enterprises, the experimental content is enriched, fostering students' creativity and problem-solving abilities. The proposed teaching model enhances the quality of remote sensing education and provides new pathways for cultivating highly skilled remote sensing professionals. Looking ahead, the integration of emerging technologies such as virtual reality (VR) and augmented reality (AR) will further enhance remote sensing education, promoting the development of talent and driving educational reform in this field.

Keywords: Remote Sensing Technology; Educational Reform; Industry-Academia Collaboration; Practical Application; Innovative Thinking

1. Introduction

Remote sensing technology is an interdisciplinary and comprehensive field, widely applied in geographic information science, environmental science, agriculture, and disaster monitoring [1]. However, current remote sensing education is hindered by the underdevelopment of practical training, which has resulted in students lacking hands-on abilities and innovative thinking. To cultivate interest in remote sensing technology and strengthen practical skills, this paper examines the state of remote sensing education and explores educational reforms aimed at establishing an integrated experimental teaching system that combines industry, academia, and research, thereby better meeting the demand for skilled professionals in modern remote sensing.

Since its inception in the early 20th century, remote sensing technology has undergone multiple revolutions. From the early days of aerial remote sensing to satellite-based systems and the now widely used drone technology, remote sensing has continually pushed technical boundaries, becoming more precise and diversified [1]. Particularly in the field of data processing, rapid advancements in computing have transformed remote sensing into a comprehensive tool that integrates data acquisition, processing, analysis, and decision-making support. In recent years, the convergence of remote sensing with big data, artificial intelligence, and machine learning has significantly improved the accuracy and efficiency of image analysis [2-3]. This integration has led to broader applications in fields such as climate change monitoring, urban planning, and precision agriculture, demonstrating its indispensable value.

As remote sensing applications continue to expand, the need for educational reform has become inevitable [4,5]. To address these evolving needs, this paper introduces an innovative approach that combines experimental teaching with theoretical instruction. Through educational reform, remote sensing education is made more relevant to students' daily lives. The course design emphasizes the integration of theory and practice, especially through collaboration with research institutes and enterprises, which brings real-world application cases into the classroom. This enriched teaching content helps further develop students' comprehensive capabilities, not only deepening their theoretical knowledge but also enhancing their practical skills and ability to solve real-world problems.

The focus of this paper is on implementing a "progressive-guided" experimental teaching model, gradually achieving a deeper integration of theory and practice in remote sensing education, ultimately promoting the optimization and innovation of talent cultivation.

2. The Current Status and Challenges in Remote Sensing Education

2.1 Issues in Practical Training

Traditional remote sensing education has been largely theoretical, with experimental teaching often limited to basic data preprocessing and simple image analysis. It lacks exposure to complex scenarios and real-world applications [6,7]. As a result, student engagement is low, and they lack the exploratory and innovative spirit necessary for problem-solving. Furthermore, experimental procedures are often rigidly structured by the instructor, offering little room for students to develop their own insights or propose creative solutions. These limitations in practical teaching make it difficult for students to address complex remote sensing applications after graduation, particularly when they are faced with real-world problems that require hands-on and innovative skills.

2.2 Disconnect Between Theory and Practice

In the current curriculum, a significant disconnect exists between theoretical instruction and practical application. While students learn the theories and methods of remote sensing data processing in class, the lack of practical training prevents them from applying these theories to solve real-world problems. This gap between theory and practice not only hinders students' understanding of remote sensing technology but also diminishes their enthusiasm for learning. As a highly practice-driven field, remote sensing education urgently requires reform to integrate theoretical learning with hands-on practice, thereby enhancing students' overall capabilities.

3. Design and Implementation of the General Course "Remote Sensing and Life"

To bridge the gap between theory and practice, the general education course "Remote Sensing and Life" was introduced. This course is designed to provide non-specialist students with foundational knowledge of remote sensing while demonstrating the relevance of remote sensing in everyday life through real-world application cases. The course design places special emphasis on experimental teaching, combining instructional videos with hands-on activities to guide students in progressively mastering the skills necessary for remote sensing data processing.

3.1 Course Content Design

The "Remote Sensing and Life" course is structured into two major modules: a theory module and an experimental module. In the theory module, students are introduced to the basic principles of remote sensing, the processes for acquiring and processing remote sensing images, and typical applications across various fields, such as urban planning and environmental monitoring. In the experimental module, students watch video demonstrations and progressively learn to download, preprocess, and classify remote sensing data. Each step is demonstrated in detail, enabling students to independently complete tasks in the classroom or laboratory, thereby deepening their understanding of remote sensing technology.

The experimental module is designed with student interests in mind. For example, case studies include the analysis of urban heat islands and monitoring vegetation cover changes. These relatable examples allow students to appreciate the important role of remote sensing technology in environmental protection and urban development. The course also introduces real-world research projects, such as "Drone-Based Monitoring of Mangrove Ecosystems and Blue Carbon Resource Estimation," combining cutting-edge technologies with fundamental experimental work to enhance the course's practical and forward-looking nature.

3.2 Teaching Cases and Practical Applications

A series of real-world teaching cases has been designed to help students understand the applications of remote sensing technology. For instance, in the urban heat island case, remote sensing imagery is used to analyze temperature changes across different urban areas. Students then explore the relationship between urban greening and the heat island effect through hands-on exercises. Similarly, the case of "Drone-Based Monitoring of Mangrove Ecosystems" helps students understand how remote sensing technology can be used to monitor ecological changes.

These practical cases not only increase student interest in remote sensing technology but also help cultivate their data analysis skills and problem-solving abilities. Students learn to operate remote sensing software, handling tasks from data downloading and image preprocessing to thematic map creation, thus gaining valuable experience in remote sensing data analysis.

The design of these experimental cases also emphasizes the real-world applications of remote sensing technology. For example, in the urban heat island analysis, students first learn how to download remote sensing imagery from open data platforms, followed by geometric and radiometric corrections. Then, thermal infrared bands are used to invert temperature data, generating an urban temperature distribution map. The key takeaway from this experiment is to assess the impact of the heat island effect by analyzing temperature differences across regions and proposing mitigation strategies based on greening conditions. In another case, students use drone data to monitor changes in mangrove ecosystems and estimate blue carbon resources using remote sensing technology. These practical cases provide students with a deeper understanding of how remote sensing contributes to environmental protection.

4. Remote Sensing Experimental Teaching Reform Through Industry-Academia-Research Integration

To further improve the quality of remote sensing education, the introduction of an industry-academia-research integration model was adopted. By collaborating with research institutions and enterprises, students have the opportunity to engage in experimental projects that meet industry needs. This collaboration not only provides students with more diverse experimental data and case studies but also exposes them to the latest developments in remote sensing technology [8-10].

Such collaborations go beyond data sharing, extending to joint development of research projects and the cultivation of students' practical skills. For example, through cooperation with Wuhan University, the latest research results from the State Key Laboratory of Information Engineering in Surveying, Mapping, and Remote Sensing were introduced. Students participated in real-world research projects, such as global impervious surface extraction. Industry mentors and leading academic institutions provided regular technical training and online guidance, equipping students with the skills to use enterprise-level software and gain practical project experience. This multi-faceted approach to collaboration has effectively enhanced students' learning outcomes and fostered the development of industry-ready professionals.

The industry-academia-research integration approach has also enriched the experimental content, overcoming the limitations of traditional experiments, such as resource scarcity and lack of variety. By leveraging collaborations with Wuhan University's State Key Laboratory, students were able to work with high-resolution remote sensing images to address complex issues, such as analyzing impervious surface changes. This sharing of resources injected new energy into students' learning experiences in remote sensing.

In the new experimental teaching model, the "1+3+X" menu-style remote sensing internship teaching model was proposed. "1" represents basic experimental tasks, "3" refers to guidance from university teachers, industry mentors, and research institute mentors, and "X" represents experimental projects chosen by students based on their interests. Students can select the projects that best suit their interests and academic needs for in-depth research.

This model shifts away from the traditional "injection-style" teaching method, stimulating students' independent learning abilities and encouraging them to propose problems and actively seek solutions during experiments. Through this teaching model, students can combine theory and practice and apply what they have learned to solve real-world problems, thereby enhancing their innovative and practical abilities.

To better evaluate students' performance in experiments, a multidimensional evaluation system based on "knowledge + skills + qualities" was introduced. This system integrates students' experimental operation skills, innovation capabilities, and daily performance, focusing not only on their mastery of knowledge but also on their problem-solving abilities during the experiments. For example, in the remote sensing impervious surface extraction experiment, students must not only complete data processing but also write analysis reports based on the results and propose feasible suggestions. This multidimensional evaluation method comprehensively reflects students' overall abilities, motivating them to remain proactive and creative throughout the experimental process.

5. "Progressive-Guided" Remote Sensing Experimental Teaching Method Based on Instructional Videos

To address the complexity of remote sensing experiments and the difficulties students may encounter, a "progressive-guided" instructional video teaching method was adopted. This approach presents experimental steps to students in a step-by-step manner, allowing them to visually understand the remote sensing data processing flow and complete experimental tasks by following the video guidance.

5.1 Design of Instructional Videos

The instructional videos are designed progressively, from basic to complex, covering all aspects of remote sensing data downloading, preprocessing, and classification analysis. For example, one video demonstrates how to download remote sensing images and use remote sensing software for geometric correction and radiometric correction. The video then explains how to classify remote sensing images and generate thematic maps. Students can watch and follow the video instructions repeatedly until they master the related skills.

5.2 Advantages of the Teaching Method

The "progressive-guided" teaching method offers significant advantages. First, the step-by-step video demonstrations provide detailed operational guidance, reducing students' apprehension about the complexity of remote sensing experiments. Second, students can control the video playback according to their learning pace, ensuring the accuracy and completeness of experimental operations. Lastly, this teaching method integrates theory with practice, helping students translate abstract remote sensing knowledge into concrete experimental operations. During the teaching process, instructors not only re-demonstrate software operations based on video content but also provide in-depth explanations on topics not covered in the videos. These additional insights come from the instructors' years of accumulated project experience. This approach enables students to better understand the applications of remote sensing technology and further improve their practical skills and overall competency.

6. Conclusion and Outlook

Through educational reform and innovation, remote sensing courses have achieved an organic combination of theory and practice. The deep integration of industry, academia, and research provides students with rich experimental resources and application cases, while video-guided experimental teaching methods help students better master remote sensing technology, improving their hands-on skills and innovative abilities.

With the development of virtual reality (VR) and augmented reality (AR) technologies, the application of virtual simulation laboratories in remote sensing education has become a possibility. Virtual laboratories allow students to break through time and space limitations and complete complex remote sensing data processing and experimental operations in a virtual environment. Virtual laboratories can simulate real operational scenarios, such as drone flights and field data collection, and provide interactive experiences that deepen students' understanding of complex concepts. In the future, virtual laboratories will become a core component of remote sensing education, offering students richer learning resources and practical opportunities.

Future educational reforms will focus on the integration of remote sensing technology with emerging technologies such as artificial intelligence and big data. By introducing these cutting-edge technologies, students will not only master basic remote sensing data processing skills but also learn how to use new technologies to solve complex social and environmental issues, thereby laying a solid foundation for cultivating high-quality remote sensing professionals.

Acknowledgments

This research was supported by the Teaching Reform Projects at Lingnan Normal University: (1) "Exploration and Practice of Talent Development Pathways for Geographic Information Science Undergraduate Programs at Local Universities Without Master's Programs—In Collaboration with Wuhan University"; and (2) "Comprehensive Reform and Innovation of Remote Sensing Internship Practices through Deep Integration of Industry, Academia, and Research." Additionally, support was provided by the College Student Innovation and Entrepreneurship Training Program at Lingnan Normal University (Project Numbers: X202210579002, X202410579042).

References

[1] LI Deren, WANG Mi, SHEN Xin, DONG Zhipeng, et al. From Earth Observation Satellite to Earth Observation Brain. Geomatics and Information Science of Wuhan University, 2017, 42(2): 143-149. DOI:10.13203/j.whugis20160526.

[2] GONG Jianya. Chances and Challenges for Development of Surveying and Remote Sensing in the Age of Artificial Intelligence. Geomatics and Information Science of Wuhan University, 2018, 43(12): 1788-1796. DOI:10.13203/j.whugis20180082.

[3] CHEN Jie, DENG Min, HOU Dongyang. Reform and exploration of the practical teaching mode of remote sensing course in the era of big data and artificial intelligence. Bulletin of Surveying and Mapping, 2023(6): 176-179. DOI:10.13474/j.cnki.11-2246.2023.0190.

[4] LI Gang, WAN Youchuan. Innovatory Experiment Teaching Demonstration on Course Design of Remote Sensing Principles and Applications Based on CDIO. Bulletin of Surveying and Mapping, 2015, (1): 134-136. DOI:10.13474/j.cnki.11-2246.2015.0028.

[5] LI Gang, QIN Kun, WAN Youchuan. CDIO-OBE mode reformation of remote sensing experiment teaching under the background of emerging engineering. Bulletin of Surveying and Mapping, 2019, (6): 140-145. DOI:10.13474/j.cnki.11-2246.2019.0203.

[6] SHAO Zhenfeng, XU Xiaodi, WU Wenfu,et al. Reform and Practice of Urban Remote Sensing Teaching Driven by Frontier Scientific Research and Curriculum Thought and Politics. Journal of Geomatics, 2024, 49(2): 135-138. DOI:10.14188/j.2095-6045.2021904.

[7] Shao Zhenfeng, Li Deren, Hu Bin, et al. Teaching Reform Mode Exploration of Reciprocation of Remote Sensing Frontier Research to Undergraduate Courses. Journal of Geomatics, 2021, 46(5): 172-175. DOI:10.14188/j.2095-6045.2021523.

[8] Wang ZH, Yang X M, Zhou C H. Geographic knowledge graph for remote sensing big data. Journal of Geo-information Science, 2021, 23(1): 16-28. DOI:10.12082/dqxxkx.2021.200632.

[9] ZHANG Yongjun, ZHANG Zuxun, GONG Jianya. Generalized photogrammetry of spaceborne, airborne and terrestrial multi source remote sensing datasets. Acta Geodaetica et Cartographica Sinica, 2021, 50(1): 1-11. DOI:10.11947/j.AGCS.2021.20200245.

[10] FU Dongjie, XIAO Han, SU Fenzhen, et

al. Remote sensing cloud computing platform development and Earth science application. National Remote Sensing Bulletin, 2021, 25(1): 220-230. DOI:10.11834/jrs.20210447.