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The Preliminary Exploration of Teaching "Modern Optoelectronic Imaging Technology and Applications" in Graduate Courses

Gao Meijing[a,*], Sun Lei[b]

National Demonstration Center for Experimental Electrotechnics & Electronics Education, College of Integrated Circuits and Electronics, Beijing Institute of Technology, Beijing, 100081, China
[a]gaomj@bit.edu.cn, [b]Sunlei@bit.edu.cn
[*]Corresponding author

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Abstract: To provide students with comprehensive and systematic knowledge in the field of optoelectronic imaging, enhance their understanding of the overall technological structure of optoelectronic imaging systems, improve their problem-solving skills, and foster an innovative mindset, we have newly introduced the course "Modern Optoelectronic Imaging Technology and Applications." The course covers a wide range of topics and has witnessed rapid advancements in both theory and technology. Given the students' foundational knowledge and their future learning and work requirements, it is particularly important to appropriately structure the teaching content and design assessment components. This paper first outlines the background of the course's establishment, followed by a description of the main content and chapter organization. It then discusses the integration of ideological into the course. Finally, the paper presents the specific assessment methods, student evaluation of teaching, and the subsequent reform directions for the course.

1. Introduction

Obtaining image information is a fundamental requirement for the survival and development of human civilization, with the human eye accounting for over 80% of the total amount of information. However, the human eye has many limitations, so humans need to rely on science and devices to overcome their own limitations and meet various needs. As a result, optoelectronic imaging technology has emerged and developed rapidly. Optoelectronic imaging is a comprehensive discipline that uses photons and photoelectrons as information carriers to study the physical processes of image capture, conversion, enhancement, processing, display, transmission, and storage. Optoelectronic imaging technology can expand human visual sensitivity, expand visual spectral domain, expand human visual ability to see details, and expand spatial and temporal limitations [1].

Modern optoelectronic imaging technology can fully utilize modern optical, optoelectronic, microelectronic, and computer technologies to visually reproduce the spatial-temporal characteristics of objects of interest (targets) on the user monitoring platform through optical-electronic techniques [2]. This is a visual technology that can be used to capture and display the spatial-temporal characteristics distribution of targets (object-side distribution), and reproduce it on the spatial-temporal characteristics distribution of the monitoring platform (image-side distribution). In essence, modern optoelectronic imaging technology utilizes high-sensitivity, high-resolution, wide-spectral, fast-response, and large-dynamic-range optoelectronic imaging devices and systems specially designed and manufactured to overcome or compensate for the visual limitations of the human eye in terms of space, time, sensitivity, and response bands. This allows weak light, infrared light, additional light, X-rays, and other forms of static and dynamic scenes formed by electromagnetic radiation to be transformed into visible images that become an important high-tech tool for humans to obtain over 80% of external information today[3]. With the development of modern optoelectronic imaging technology, it has been widely applied in today's information society, providing powerful technological support for the progress of human spiritual and material civilization [4].

We have introduced the elective course "Modern Optoelectronic Imaging Technology and Applications" as a graduate elective course in September 2022. The course objectives are as follows: Through the course, students will be able to grasp the classification, composition, and basic imaging principles of optical imaging devices, gain a general understanding of the latest optical imaging devices, and master the development trends and applications of optical imaging devices today. They will also be able to understand commonly used modern optical image processing methods, focusing on helping students understand optical imaging system design and embedded real-time system development, etc. The course aims to provide students with a comprehensive and systematic knowledge of optical imaging, enhance their understanding of the overall technological structure of optical imaging systems, improve their problem-solving and analytical skills, foster their innovative and scientific research spirit, and lay a foundation for their future work and research. Below, we will introduce the course from the perspective of teaching content arrangement and course assessment.

2. Organization of teaching content

Optical imaging technology covers a wide range of content and involves various knowledge and technologies. Specifically, it involves (1) the visual characteristics of the human eye; (2) Various radiation sources, targets, and background characteristics; (3) The influence of atmospheric optical properties on radiation transfer; (4) Imaging optical system; (5) Light radiation detectors and refrigerators; (6) Electronic processing of signals; (7) Display of images[5-6]. Therefore, if all content is taught in its entirety, 32 hours are far from sufficient. Moreover, students who enroll in this course are not limited to optical engineering majors, which makes them unexposed to some basic knowledge. Considering the above factors, the course has carefully designed the teaching content. The overall content includes the following parts: an overview of modern optical imaging systems, CCD fundamentals and applications, several typical optical imaging technologies using light sources, modern optical image processing techniques, real-time image processing techniques for optical imaging, and case studies for optical imaging system design and development. Specifically, there are 9 chapters totaling 32 hours, as shown in Table 1. From the course setting shown in Table 1, it can be seen that this course closely follows recent advances in optical imaging, tracks the latest theories and technologies, and helps students effectively broaden their horizons and understand the frontiers of science. Some content in chapters 7-9 and development cases are research achievements obtained by the research group. In particular, Chapter 9 "Design and Development Cases of Optical Imaging Systems" brings together projects covering land, sea, and air domains, which will give students a fresh perspective and fully activate students' learning enthusiasm. Some teaching content, such as "Super-resolution optical micro-scanning dual-light fusion microscopy imaging systems," have received funding from national and provincial natural science foundations and have won second-class technical inventions at the provincial level.

Table 1: Organization of course chapters

Chapter and title	**Contents of each chapter**
Chapter 1: Overview of modern photoelectric imaging technology	1.1 Generation and development of photoelectric imaging technology 1.2 Classification and Characteristics of Photoelectric Imaging Systems 1.2 Application scope of photoelectric imaging technology 1.3 Characteristic Parameters of Photoelectric Imaging Devices
Chapter 2: Fundamentals of Photoelectric Imaging Technology	2.1 Photoelectric imaging of the CCD foundation 2.2 CCD basic principles and performance parameters
Chapter 3: CCD Application Overview	3.1 Introduction to conventional CCD technology 3.2 Civilian CCD applications 3.3 Military CCD Applications
Chapter 4: Light sources for photoelectric imaging	4.1 Natural light source and artificial light source 4.2 Basic characteristic parameters of light sources and selection of light sources
Chapter 5: Infrared and microlight night vision technology	5.1 Basic Principles of Infrared and Microlight Night Vision Imaging 5.2 Infrared and Microlight Night Vision Technology Advances and Applications
Chapter 6: Terahertz and Ultraviolet Imaging Technology	6.1 Basic Principles of Terahertz and Ultraviolet Imaging Technology 6.2 Progress and Applications of Terahertz and Ultraviolet Imaging Technology
Chapter 7: modern photoelectric image processing technology	7.1 Overview of Optical Image Processing Technology 7.2 Error Correction Theory for Microscan Imaging Systems 7.3 Super-resolution Image Processing Technology 7.4 Deep Learning Based Target Recognition Detection Techniques
Chapter 8: Real-Time Image Processing Techniques for Photovoltaic Imaging	8.1 Approaches to real-time image processing 8.2 Developments in real-time image processing technology 8.3 Examples of real-time imaging system development
Chapter 9: Optical imaging system design and development cases	9.1 UAV-Based Ocean Hyperspectral Remote Sensing Image Processing and Stitching Technology 9.2 Super-resolution optical micro-scanning dual-optical fusion micro-imaging system 9.3 Research on Jellyfish Detection and Identification System Based on Underwater Polarized Photoelectric Imaging and Deep Learning Theory

Figure 1: Gondola & Mountain

If we were to liken the learning of this course to mountain climbing, then the teacher would be like the cable car shown in Figure 1, guiding the students on a journey to easily complete the course in 32 hours. Through this journey, students will gain a general understanding of modern optoelectronic imaging theory and technology. In the future, if students need the content of this course for their studies or work, they can use the knowledge acquired from this course as a foundation to climb mountains with their own hands and feet, delve deep into the necessary optoelectronic imaging knowledge, and propel themselves forward on their research path.

3. Course assessment and student feedback

Based on the teaching target and course content arrangement, the assessment method for this course is set as examinations. The total score for this course is 100 points, with examination including a literature review on the forefront and optoelectronic imaging system design topics, specified by the teacher. These topics are designed with consideration of military and civilian requirements. Student performance is primarily evaluated in two aspects: essay writing contributes to 60% of the total score, while the defense presentation PPT accounts for 40%. Teachers follow the school's guidelines for writing master's theses and have formulated a course template based on the course situation.

Teachers will designate the topics for the course essays. The enrollment for this course is limited to 30 students, and typically the teacher will propose around 50 essay topics covering both comprehensive review topics and design topics. Students can choose topics based on their research direction, major, interests, and hobbies, or they can propose their own topics. The teacher has established the assessment criteria for the course.

4. Conclusion

The course was launched in September 2022 and is taught once per academic year, completing two teaching cycles to date. Based on student evaluations, students are quite satisfied with this course, with teaching evaluations scores of 97.24 and 98.25 in the past two years. Students have expressed that they gained significant benefits from taking this course and found the course content meaningful. The assessment system is also considered unique, indicating the successful achievement of the course's educational objectives. In order to further cultivate students' abilities and meet the demands of the times, the course is planning to make improvements to the assessment components starting in September 2024. Specifically, the plan is to remove comprehensive reports and introduce topics related to algorithm design and implementation in optoelectronic imaging systems. For example, topics may include deep learning for object detection and recognition, deep learning-based super-resolution image processing, infrared and visible light fusion algorithms, underwater image enhancement algorithm, and design of shared bicycle parking detection systems. This approach aims to broaden students' knowledge base, enhance their programming skills through practical application, foster innovation, boost confidence, and lay a solid foundation for their future learning.

The teaching exploration of this course has just begun, and we will continue to improve, rectify issues promptly, update teaching content continuously, and stay up-to-date with the latest theories and technologies in the field of optoelectronic imaging. We strive to achieve the best objectives with the best intentions and the utmost effort on the journey ahead.

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