

Research on the Application of Artificial Intelligence-driven Smart Lighting Technology in the Electrical Optics Major of Technical Education

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Abstract: With the continuous in-depth development of artificial intelligence technology, smart lighting technology is reshaping the technical framework and application scenarios of the optoelectronic industry. Within the technical education system, the electrical optics major undertakes the vital function of cultivating frontline application-oriented technical talents. At present, some technical colleges still adopt curriculum systems centered on basic electric light sources and simple circuits, and their experimental equipment is limited to traditional lighting devices, which cannot reflect the dynamic response and adaptive regulation mechanisms of smart lighting systems. On this basis, this paper aims to break the integration barriers between artificial intelligence technology and electrical optics education, reconstruct talent training models adapted to the development trend of intelligent manufacturing, and provide replicable and promotable practical paradigms for technical colleges to realize major upgrading under the background of a new round of technological revolution.

Keywords: Artificial intelligence; Smart lighting technology; Technical education; Electrical optics major

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1. Application background of AI-driven smart lighting technology in the electrical optics major of technical education

1.1. Evolution trend and industrial implementation status of smart lighting technology

Early lighting systems relied on manual operation or simple time sequence control, featuring single functions and low energy efficiency^[1]. With the maturity of sensor technology and Internet of Things (IoT) architecture, lighting equipment has gradually realized remote regulation and environmental perception, forming a preliminary automatic response mechanism. In recent years, breakthroughs in artificial intelligence in image recognition, behavior prediction, and adaptive adjustment have pushed lighting systems toward the direction of independent decision-making. Modern smart lighting technology can dynamically adjust light intensity based on multi-dimensional data such as illumination intensity and pedestrian flow, and configure personalized

scenarios combined with user habits, so as to improve energy efficiency and user experience.

In terms of industrial application, smart lighting has been widely applied in urban infrastructure, commercial spaces, industrial plants and household environments. For example, in smart city construction projects, intelligent street lamp systems integrate video monitoring, air quality detection and wireless communication modules, serving as multi-functional public information nodes ^[2]. Some high-end manufacturing workshops have introduced adaptive light environment systems to optimize production conditions through precise light parameter regulation, reduce visual fatigue and improve work efficiency. In the household market, smart lamps compatible with voice assistants and mobile terminals maintain growing sales volume, and consumers' acceptance of concepts such as scenario lighting and healthy circadian lighting keeps rising. In general, smart lighting has shifted from single-point innovation to system integration with an increasingly mature industrial ecosystem, providing practical references and implementation foundations for integrating relevant technologies into vocational education scenarios.

1.2. Policy orientation and strategic demands for digital transformation of technical education

At the national level, continuous efforts have been made to promote high-quality development of vocational education and emphasize in-depth integration of information technology with teaching, which has issued clear policy guidance for the digital transformation of technical education ^[3]. On this basis, the *Action Plan for Educational Informatization 2.0* further proposes building a new "Internet + Education" ecosystem, requiring the construction of intelligent teaching environments and improvement of teachers' and students' digital literacy and technical application capabilities.

With the rapid development of emerging fields such as intelligent manufacturing and smart cities, traditional optoelectronic posts are undergoing structural adjustment. Enterprises have a sharply rising demand for technical workers equipped with AI algorithm understanding, intelligent hardware operation and data analysis thinking. Smart lighting integrates multiple technical elements, including sensor control, network communication, machine learning, and light environment design, and its engineering implementation requires compound talents who master both optical principles and intelligent systems. Existing training models fail to keep up with such changes, so curriculum reconstruction and teaching upgrading must be carried out to update talent cultivation goals synchronously ^[4].

The gradual improvement of industrial standard systems provides a basis for setting majors related to smart lighting. The *Three-Year Action Guide for the Intelligent Sensor Industry* issued by the Ministry of Industry and Information Technology and the specifications for urban smart pole construction promoted by the Ministry of Housing and Urban-Rural Development both cover requirements for the installation, commissioning, operation and maintenance of intelligent lighting systems. Incorporating these standards into teaching content can help students develop awareness of operation procedures in line with industrial norms, enhance employability, and form a talent supply chain linking industry and education.

2. Difficulties in applying AI-driven smart lighting technology to the electrical optics major of technical education

2.1. Outdated experimental equipment lags behind the iteration rhythm of intelligent lighting hardware

At present, experimental devices in some technical colleges remain limited to traditional lighting control

and basic photometry measurement, relying on analog dimming systems connected by fixed circuits and independent sensor modules. They lack intelligent components supporting adaptive regulation, environmental perception and data interaction, making it difficult for students to understand networking logic and remote management mechanisms in real working scenarios. On the one hand, though some colleges have introduced network-enabled lighting nodes, their software and hardware architectures are closed with restricted development interfaces, limiting secondary development and algorithm debugging and reducing students' hands-on opportunities for AI model training and optimization ^[5]. On the other hand, long equipment procurement cycles and complicated approval procedures further widen the technical gap. It usually takes more than one year from project initiation to acceptance, during which intelligent lighting hardware has gone through several rounds of iteration. Meanwhile, fund allocation tends to guarantee basic teaching operations, with cautious investment in high-cost AI-integrated experimental platforms, leading to low-level repeated construction of some laboratories.

2.2. Fragmented curriculum contents separate AI and optoelectronic professional knowledge

In terms of curriculum arrangement, contents such as optical principles, circuit control, sensor technology and machine learning are scattered across different semesters and courses without logical connection and knowledge linkage. Students cannot form a cognitive chain of “illumination perception — data processing — decision output” in intelligent dimming systems ^[6]. In addition, practical courses further fragment knowledge. Most experimental projects are limited to verification operations such as LED characteristic tests and simple PWM dimming circuit construction. Even a small number of colleges offering comprehensive training face problems of inconsistent equipment interfaces and closed software platforms, separating artificial intelligence technology from lighting hardware in operation. Students can only operate them separately and cannot experience the closed-loop process from data collection to intelligent response. Such a broken knowledge structure weakens the professional adaptability of trained talents and hinders the effective application and continuous innovation of smart lighting technology in industrial frontlines ^[7].

2.3. Teachers lack interdisciplinary practical ability and project-driven teaching experience

Smart lighting technology integrates optical design, embedded control, IoT communication and machine learning algorithms, placing higher requirements on teachers' knowledge breadth and practical depth. However, most professional teaching staff currently have backgrounds in traditional optoelectronics or electronic engineering, lacking practical experience in AI model training and big data analysis. Their teaching stays at the conceptual level and cannot guide students to complete the full process from data collection to intelligent decision-making ^[8]. Meanwhile, under the project-driven teaching mode, teachers need the capability to integrate software and hardware resources and design real engineering tasks. In reality, many teachers have long been confined to textbook teaching without corporate practice experience, making it hard to design teaching projects matching industrial demands. For instance, when simulating energy optimization tasks for commercial space intelligent lighting, some teachers only set idealized parameters while ignoring practical variables such as ambient light interference and uncertain user behaviors, weakening training in students' engineering thinking. In addition, the proportion of dual-qualified teachers with industry-education integration backgrounds in teaching teams is low, restricting the construction and implementation of high-level practical courses.

3. Application paths of AI-driven smart lighting technology in the electrical optics major of technical education

3.1. Construct a virtual-real integrated smart lighting teaching and experimental platform

Restricted by traditional teaching concepts, most optoelectronic experiments rely on physical light sources and fixed circuit systems, which can hardly simulate complex AI control logic and dynamic light environment changes. The deep integration of virtual simulation technology and physical experimental equipment provides a new practical carrier for smart lighting teaching^[9]. For example, after introducing the digital twin architecture, teachers can restore LED characteristics, sensor response curves and neural network algorithm operation processes in virtual spaces. Students configure lighting strategies via graphical programming interfaces and observe real-time impacts of different parameters on energy efficiency ratio, color rendering index and human health indicators, independently completing full-process training from scheme design to commissioning and optimization.

The smart lighting teaching experimental platform embeds templates of various typical application scenarios, including adaptive classroom lighting, traffic-sensing road dimming, and plant factory light formula management. Each scenario is equipped with standard data interfaces and evaluation indicator systems to facilitate comparative research. Teachers can open specific functional permissions according to teaching progress and guide students to master key technical points such as illumination prediction model training and fuzzy PID parameter tuning. The system records all operation logs and performance feedback to form personalized learning track files as the basis for process evaluation. The virtual-real linkage platform also embeds a fault injection module to simulate common industrial problems such as gateway offline, sensor failure and abnormal algorithm convergence under safe and controllable conditions. Students can locate fault sources and propose repair schemes combined with system alarms, historical data trends and topological diagrams, breaking the boundary between in-class and after-class learning and promoting the development of ubiquitous and immersive learning modes^[10].

3.2. Implement dual-qualified teacher competency improvement plan through school-enterprise collaboration

Teachers of electrical optics majors in technical colleges generally possess solid optical theories and traditional lighting teaching experience, yet they have obvious shortcomings in practical capabilities for emerging technologies such as AI algorithm deployment and IoT communication protocols. Frontline enterprise engineers are familiar with R&D and engineering implementation of intelligent lighting products but lack systematic teaching design ability and understanding of vocational education rules. The complementary competence of both sides lays a practical foundation for cooperative training^[11].

First, establish a rotational training system. Colleges can arrange professional teachers to participate in real project development at leading smart lighting enterprises, focusing on mastering operation procedures of core technical links such as AI dimming model training and sensor data fusion processing. Enterprises provide typical scenario cases and technical documents to help teachers understand the complete chain from demand analysis to product delivery^[12]. Meanwhile, colleges invite enterprise technical backbones to serve as part-time lecturers, deeply participating in curriculum construction and practical training guidance, and improving their expression ability and educational cognition through teaching practice. Second, build joint teaching and research teams. Carry out collective lesson preparation and teaching research around typical smart lighting topics to effectively link theoretical knowledge and engineering practice. Technical colleges set special

research projects focusing on cutting-edge directions such as computer vision application in illumination detection and deep learning-driven energy consumption optimization, and promote continuous learning via workshops and technical salons. Third, formulate a scientific competency evaluation system. Schools and enterprises sign long-term cooperation agreements to clarify the division of rights, responsibilities, and resource input mechanisms and guarantee the continuity and effectiveness of teacher training. Colleges incorporate participation in corporate projects, technology transformation achievements, and the quality of student project guidance into assessment indicators to motivate teachers to update knowledge actively. Through systematic design, teachers can continuously accumulate experience in real industrial environments and translate the latest technical trends into teachable content, improving the matching degree between classroom teaching and industrial demands ^[13].

3.3. Design stepwise project training system based on real production line problems

With the continuous advancement of the “Intelligence + Education” model, technical colleges shall build a stepwise project training system relying on frontline industrial demands, convert real enterprise production scenarios into teachable task modules, and form a progressive practical path from basic skill training to comprehensive innovation cultivation. Project design shall center on the full development process of smart lighting products, including demand analysis, system architecture design, sensor integration, algorithm deployment, energy optimization, and user experience ^[14].

The primary stage focuses on the installation, commissioning and operation maintenance of typical smart lighting systems. Students simulate factory workshops, commercial spaces and urban road lighting environments to master implementation principles of functions such as illumination detection and human body induction, establishing basic cognition of intelligent control logic. The intermediate stage introduces machine learning model applications in illumination behavior prediction and adaptive dimming. Students use Python to complete data preprocessing, feature extraction and simple regression model training, and embed models into embedded control units to realize personalized lighting services based on historical usage habits ^[15]. The advanced stage is driven by real enterprise production line problems. Teachers set challenging tasks such as complex fault diagnosis, multi-source heterogeneous data fusion and edge computing deployment, including optimizing response delay of large-scale lamp clusters and improving stability of outdoor lighting systems under severe weather. Students work in teams to complete the full process of project demonstration, scheme design, prototype development, testing and result presentation, exercising systematic thinking and collaboration capabilities. This training system breaks the limitations of traditional verification experiments and enables students to realize knowledge transfer and ability upgrading by solving real engineering problems, providing practical support for cultivating high-skilled optoelectronic talents close to industrial frontiers.

4. Conclusion

In summary, AI-driven smart lighting technology is gradually penetrating urban infrastructure, industrial production, and daily life, putting forward brand-new requirements for the knowledge structure and practical abilities of technically skilled talents. At present, some colleges have introduced courses and experiments related to smart lighting, yet common problems including slow equipment renewal, fragmented curriculum content, and weak teaching staff still exist. Therefore, teaching model reform oriented by industrial demands and centered on technology integration can not only improve students’ employability, but also guarantee the

supply of practical technical talents for the smart lighting industrial chain. In the future, with the continuous evolution of edge computing and 5G communication, the intelligence level of smart lighting systems will be further improved. Technical education shall maintain dynamic updating and a forward-looking layout of teaching contents to ensure talent cultivation keeps pace with technological development trends.

Disclosure statement

The author declares no conflict of interest.

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