Research on the Cultivation of Talent in the Application of Blockchain and Artificial Intelligence Technologies in Smart Expressway Management

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Abstract: There is a severe shortage of inter-disciplinary talents in higher vocational education who possess knowledge of expressway management alongside expertise in blockchain and AI (artificial intelligence) technologies, which constrains the further advancement of intelligent transportation. To address these issues in this paper, firstly an in-depth analysis of the revolutionary impact brought by blockchain technology in areas such as trusted evidence storage and data traceability is conducted, as well as AI technology in intelligent perception and assisted decision-making for expressway management. Subsequently, the current state of talent cultivation in higher vocational education in this field is examined systematically, and a multi-dimensional talent cultivation system centered on "industry-education integration and collaborative education" is proposed, encompassing training objectives, curriculum design, practical teaching, faculty development, and evaluation mechanisms. Finally, specific implementation pathways and support recommendations are proposed to provide high-quality interdisciplinary talents for expressway management in China.

Keywords: Intelligent Transportation; Blockchain; Artificial Intelligence; Interdisciplinary Talents

1. Introduction

The expressway system plays a crucial role in the national economy, and the level of its operational management level directly affects the efficiency of the national economy [1]. The growing number and diversity of motor vehicles, the expansion of data modalities, the complexity of traffic incidents, and the rapid increase in multi-faceted services and demands have made conventional technical solutions increasingly inadequate. In response, new-generation information technologies, with blockchain and AI as their representatives, provide potent solutions to those issues [2].

Leveraging features such as consensus algorithm, distributed storage, data immutability, and traceability, blockchain technology provides a credible data foundation for expressway management [3]. It addresses pain points such as data silos and low process transparency. With its powerful capabilities in intelligent perception, learning, reasoning, and decision-making, AI demonstrates significant potential in fields such as route planning, traffic flow prediction, and toll auditing [4]. The deep integration of those two technologies will establish a credible and intelligent high way management system [5].

The practical application and scaling of any advanced technology rely on a substantial workforce of relevant vocational professionals. However, there is currently a severe lack of deep integration within high way management and the academic disciplines of blockchain and AI. A critical shortage of cross-disciplinary and innovative talent—capable of understanding business pain points and utilizing specialized technology to design solutions—has become a bottleneck constraining the high-quality development of the transportation industry. It is precisely within this context that this paper researches and explores training models and pathways for "Blockchain + AI" application talent oriented towards high way management.

2. Application of Blockchain and AI Technologies in Expressway Management

To clarify the direction of talent cultivation, the analysis of the application of technology in specific scenarios and the corresponding literacy requirements for professionals should be carried out firstly.

Blockchain, based on its consensus algorithm, endows on-chain data with characteristics such

as immutability, traceability, and trustworthiness. This enables data to remain within the domain while allowing value to circulate, promoting data sharing and utilization while safeguarding the privacy and security of all parties' data. For instance, by leveraging blockchain technology, a trusted billing and clearing system can be established to enhance fund management efficiency and effectively address issues such as expressway toll evasion [6]. In the logistics industry, shipping documents and payment vouchers can be stored on the blockchain for certification, providing the sector with a full-lifecycle "trusted digital waybill" that enhances logistics transparency and adds value through supply chain services [7]. In engineering construction and maintenance, information such as the design, construction, materials, and maintenance records of assets like roads, bridges, and tunnels can be recorded on the blockchain, creating a legally effective "digital archive" that serves as critical evidence for quality traceability and liability determination [8]. In traffic rescue incidents, key information such as rescue dispatch, traffic control, and on-site handling processes can be stored on the blockchain for auditing, serving as a basis for reviewing accidents or emergencies and determining liability [9].

AI technology has been extensively implemented in transportation. Leveraging technologies such as computer vision, deep learning, intelligent sensing and so on, it enables accurate recognition of license plates and vehicle types, supports cross-camera tracking, and precisely identifies fraudulent activities like license plate cloning and toll evasion. By mining and analyzing vast amounts of traffic data, it accurately identifies vehicle trajectories, density, and speed in real time, providing a decision-making basis for dynamic traffic control. It also detects hazardous events such as abnormal parking, pedestrian intrusions, and wrong-way driving in real time, triggering automatic alarms and coordinating with roadside message signs to quickly generate emergency plans [10]. Additionally, it automatically identifies road surface defects like cracks and potholes and, by integrating historical maintenance data with real-time monitoring information, utilizes predictive maintenance models to scientifically formulate maintenance plans [11].

The integration of blockchain and AI technologies will generate a significant multiplier effect. From one perspective, blockchain provides a trustworthy data source for AI model training, faithfully recording model versions, parameters, and decision-making processes. This enhances reliability and addresses prominent issues such as "garbage data", "fake data", and "hallucinations". From another perspective, AI possesses the potential to optimize blockchain consensus algorithm and to extract deeper insights from the value of credible data. For instance, the integration of blockchain and AI recognition technologies permits toll management platforms to achieve seamless vehicle payment and accurate route tracing. The automated execution of fee calculation and settlement distribution via smart contracts substantially improves operational efficiency, lowers overhead, mitigates against revenue leakage, and provides a foundation for precise and credible inter-provincial and multi-operator clearing.

3. An Analysis of the Current State and Challenges in Cultivating "Blockchain + AI" Application Professionals

The effective management of smart expressways demands not mere technical engineers, but interdisciplinary talents who can master the intricate "business-technology" nexus. Nevertheless, the talent development framework in China for this domain remains underdeveloped and is confronted with a multitude of challenges.

3.1 Mismatch Between Talent Cultivation and Industry Needs

The computer science and AI curricula in higher education institutions tend to overemphasize universal theories and algorithms while lacking industry-specific case studies and practical components tailored to transportation. Consequently, students remain unfamiliar with concrete operational scenarios—such as toll collection, road maintenance, and safety management in expressways—leading to a phenomenon where they “grasp technology but misunderstand its practical application,” thereby hindering effective problem-solving with technical expertise.

3.2 Insufficient Depth in Cross-Disciplinary Integration

"Blockchain + AI + Transportation" represents a typical interdisciplinary field. However, university structures maintain rigid departmental boundaries currently. There is a lack of effective mechanisms for curriculum sharing, faculty interaction, and research collaboration among the schools of computer science, software engineering, and transportation engineering. This prevents students from systematically acquiring interdisciplinary knowledge and cognitive frameworks.

3.3 Inadequate Resources for Experiential Learning

Blockchain and AI are technologies requiring substantial practical experience. However, universities generally lack access to real-world expressway operational data (due to security and privacy constraints), high-fidelity simulation platforms, and deployable blockchain networks for student testing. This results in weak hands-on skills among students, whose understanding of the technologies remains largely theoretical. However, there is a widespread lack of expressway operational data in real-world, high-fidelity simulation platforms, and deployable blockchain networks for student use in higher education institutions. Consequently, students exhibit weak practical skills, and their understanding of the technology remains theoretical.

3.4 A Scarcity of Practitioner-Instructors with High-Caliber

Teachers qualified to deliver such interdisciplinary instruction must possess both deep theoretical knowledge in AI and blockchain, as well as a thorough understanding of expressway operations management. In reality, however, most teachers are academically oriented and lack hands-on industry experience. Conversely, while industry professionals possess extensive practical knowledge, they typically lack the pedagogical training required for structured teaching.

3.5 A Single Criterion for Talent Evaluation

The prevailing talent evaluation system predominantly emphasizes theoretical learning and examination performance, while demonstrating critical deficiencies in assessing students' capacity for interdisciplinary knowledge integration, complex problem-solving in engineering contexts, and innovative practical application. This fundamental inadequacy fails to provide effective guidance or motivation for students to develop into multidisciplinary professionals.

4. Priorities in Talent Development for Blockchain and AI Applications in Expressway Management

This paper presents an integrated framework for developing applied talent, designed to meet the advancing needs of the expressway management sector. With "industry-education integration and collaborative cultivation" as its guiding philosophy, the framework is supported by a structured approach encompassing five dimensions: goal-setting, curriculum, practical experience, faculty, and evaluation.

4.1 Toward an Industry-Oriented Applied Workforce

Talent development must be strategically aligned with industrial applications and specific job requirements. Focusing on the expressway management sector within the transportation industry, the goal is to cultivate high-caliber, interdisciplinary professionals for the new era. These individuals will master blockchain and AI technologies with practical application skills, understand expressway management operations, and possess strong practical and innovative capabilities.

4.2 Developing an Interdisciplinary and Integrated Curriculum

Blockchain and AI technologies form the backbone of the curriculum, which breaks down traditional disciplinary boundaries to design a modular system comprising "foundational knowledge + technical core + industry application + frontier exploration". The foundational knowledge module encompasses mathematics, programming, and data structures. The technical core module comprises principles of blockchain, smart contract development, machine learning, computer vision, big data mining and analytics. The industry application module is pivotal for achieving curricular integration. It incorporates high-practicality components such as intelligent traffic management, integrated application development, along with authentic case studies sourced directly from expressway management corporations. The frontier exploration module

incorporates cutting-edge domains such as vehicle-infrastructure cooperation and digital tokens, strategically designed to broaden students' perspectives. The instructional focus on in-depth exploration of core concepts including hash algorithms, consensus mechanisms, artificial neural networks, and semantic segmentation. It ensures students achieve mastery of both the fundamental principles and practical application techniques of the technologies. Emphasis must be placed on highlighting the integrated application of blockchain and AI technologies within the transportation industry, with particular focus on analytical applications in expressway management scenarios.

For instance, smart contracts can automatically execute corresponding operations according to predefined conditions. These conditions are provided by data collected through AI technology, with execution results fed back to refine the predefined conditions and optimize the automated execution mechanism. Additionally, blockchain can provide a platform for data sharing and exchange, enabling trusted interoperability of traffic data among different departments. Meanwhile, AI can leverage the vast amounts of data stored on the blockchain for deep learning and pattern recognition, thereby achieving more accurate and reliable data analysis and forecasting for expressway management. Moreover, skill instruction must integrate traditional programming courses. For instance, students can use Solidity for smart contract development and Python for AI applications, ultimately achieving cross-platform compilation, integration, and invocation. This approach enables comprehensive program development and deployment in integrated application scenarios, breaking through the limitations of standalone single-language applications.

4.3 Establishing a Progressive Practical Sequence

Practical training serves as the cornerstone for cultivating interdisciplinary talent. An integrated three-tier system comprising foundational training, project practice, and workplace internships, should be established to ensure progressive skill development.

Foundational training is conducted in on-campus laboratories, where students utilize simulation platforms and sandbox environments to complete fundamental exercises such as smart contract programming/deployment and model training.

Project practice, as the core component, involves collaboration between the university and enterprises in the expressway industry to establish shared practical training bases. Based on anonymized business data, a series of comprehensive and design-oriented course projects and practical training programs are established. For instance, taking the intelligent application of BeiDou Navigation as an example, students are guided in project practice to utilize the domestic mainstream blockchain development platform FISCO BCOS for smart contract construction, design of longitude and latitude trajectory traceability systems, and development of computer vision-based expressway anomaly detection systems.

During the workplace internship, students are assigned to expressway management departments or smart transportation technology companies for six-month placements. Through these internships, they acquire skills in blockchain network deployment and maintenance—covering node configuration, on-chain data management, and consensus mechanism optimization—thereby deepening their knowledge and honing their skills in real-world working environments while completing their graduation projects.

4.4 Bridging the Gap Between Industry and Academia in Faculty Development

Higher education institutions should take the initiative to establish connections with enterprises, staying updated on industry practices and technological advancements. They should arrange for young teachers to undertake temporary positions at partner companies, where they can participate in actual research and development projects to gain industry experience. Additionally, technical and managerial professionals from enterprises should be invited to serve as industry mentors or part-time lecturers, regularly visiting campuses to deliver lectures, mentor student projects, and co-teach courses. The formation of joint research teams consisting of academic faculty and industry experts should be encouraged, collaborating on research proposals and projects. Furthermore, research outcomes should be integrated back into teaching materials, creating a synergistic cycle where research and education

mutually enhance each other.

4.5 Establishing a Competency-Oriented Multifaceted Evaluation Mechanism

The current examination-oriented assessment model must be reformed through the establishment of a diversified evaluation framework. Process-based evaluation should form the foundation, with increased weighting for practical exercises, seminar participation, skill development initiatives, and teamwork in overall student assessment. Outcome-based evaluation serves as the driving force, prioritizing tangible deliverables such as software systems, algorithmic models, technical solutions, and contributions to patents or academic papers as primary assessment criteria. Enterprise participation provides crucial support by involving industry mentors in project defenses and graduation thesis reviews, enabling industry-informed evaluation of project value and enhancing career readiness for students.

5. Implementation Pathways and Measures for the Talent Development Framework

Institutions should proactively engage in multi-party collaboration to ensure the effective implementation of the cultivation system and provide robust support for the development of specialized talent, should promote the development of interdisciplinary programs, establish dedicated funding mechanisms, and create industry-academy colleges. Within industry-academy colleges, simulated expressway environments should be established, integrating AI computing platforms, blockchain test networks, and vehicle-infrastructure cooperative equipment to support industry-education integration projects in intelligence transportation. An Industry-Education Integration Alliance shall be established with joint participation from institutions and enterprises, dedicated to co-developing curriculum resources, sharing practical training platforms, and collaborative faculty development. Interdisciplinary and cross-institutional teams of experts will be organized to compile high-quality teaching materials and case libraries, while simultaneously developing corresponding massive open online courses. Non-degree training programs will be offered for industry professionals to facilitate knowledge structure modernization and technical skill enhancement, thereby supporting the transformation and upgrading of existing industry talent.

6. Conclusion

The development of smart expressways constitutes a critical component of the national strategy to build China into a leading transportation power. Progress is inextricably linked to talent development, yet the cultivation system for interdisciplinary applied professionals in blockchain and AI tailored to expressway management remains in its nascent stage. This paper proposes a multidimensional talent development system centered on the principle of industry-education integration and collaborative education. This systematically addresses the aforementioned challenges by defining interdisciplinary competency objectives, restructuring cross-integrated curricula, enhancing progressive practical training, developing high-level "dual-qualified" faculty, and establishing competency-oriented evaluation mechanisms.

With the continuous evolution of new-generation information technologies and the ongoing intensification of industry demands, the applied talent cultivation system must undergo synchronous dynamic adjustments and continuous optimization. Through the collective efforts of all stakeholders, we will be able to cultivate a large cohort of high-quality interdisciplinary talents who can lead the development of smart transportation. This will provide a continuous stream of new momentum for the high-quality development of China's smart expressways and the advancement of its transportation power strategy.

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