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Research on the Development of Cotton Quality and the Innovation of Testing Technology under the New Era

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***Abstract*—*Amid the transformation of China's cotton industry from a focus on quantity to an emphasis on quality, this paper integrates five recent domestic studies to comprehensively examine the challenges and technical paths of cotton quality improvement in the new era. Focusing on fiber quality standards, AI-based testing methods, short fiber rate metrics, industrial status, and pest detection, the study identifies key strategies to enhance cotton quality and competitiveness: optimizing evaluation systems, introducing intelligent detection algorithms, advancing digital industrial management, and strengthening short fiber rate control and smart pest recognition. Furthermore, it proposes constructing a unified national cotton data platform and upgrading calibration standards and equipment, aiming to support the industry's high-quality development with theoretical and practical guidance.*

Keywords*—*cotton quality; artificial intelligence testing; short fiber rate; industrial digitalization; YOLOv8; fiber standards

I. Introduction

As a vital strategic crop in China, cotton serves as an indispensable raw material for the national economy and the textile industry. In recent years, under strong policy support and technological advancements, China's cotton yield and cultivation techniques have steadily improved. However, rising expectations for fiber quality, coupled with changes in the global cotton trade and the advancement of carbon neutrality and green development strategies, have shifted the development model from scale expansion to quality enhancement. Scientific evaluation, efficient testing, intelligent pest detection, and optimized industrial coordination have become pressing issues in managing cotton quality across its entire lifecycle.

II. Current Evaluation System of Cotton Quality and Its Optimization

As a bridge between raw cotton production and textile consumption, the scientific and adaptable quality evaluation system directly influences the efficiency of the entire supply chain. Currently, national standards are primarily based on key indicators such as fiber length, uniformity, micronaire, breaking strength, color, and trash content [1]. However, challenges remain due to limited coverage, incompatibility across standards, and elastic classification rules. To build an internationally aligned, market-responsive system, the following directions are recommended: incorporating advanced indicators such as short fiber rate and elongation at break; refining classification criteria for premium cotton to establish quality-based pricing incentives; and synchronizing quality and equipment standards to enhance end-to-end compatibility.

III. Development and Application of Intelligent Testing Technologies

Driven by big data and AI, cotton quality testing is rapidly evolving toward automation and intelligence. The subjectivity, inefficiency, and inconsistent application of conventional visual inspection methods make them difficult to use. Recently, deep learning models such as YOLO, ResNet, and MobileNet have been widely applied in fiber length recognition, color grading, and impurity removal. These models use image recognition and object detection to extract key features from complex environments and enable high-precision classification. For instance, YOLOv8 integrates attention mechanisms and lightweight architectures to support high-frame-rate, real-time detection on edge devices. Challenges remain in terms of limited high-quality, diverse datasets, deployment constraints in low-resource environments, and the need for seamless integration with ginning and textile processes to create a unified intelligent quality inspection system from detection to control and traceability.

IV. Inclusion of Short Fiber Rate Indicator and Improvement of Testing Methods

As an essential indicator introduced in the 2023 revision of the National Cotton Quality Standard, the short fiber rate reflects spinning performance, impacting yarn evenness, tensile strength, and material loss. While advanced tools such as the AFIS fiber analyzer and optical imaging systems provide strong detection capabilities, high costs, technical complexity, and measurement variability limit their adoption among SMEs. Therefore, it is recommended to: develop domestic instruments to reduce cost; establish unified calibration standards and sample systems to improve cross-device comparability; and introduce AI algorithms for automatic labeling and interpretation of optical images to minimize human intervention.

V. Current Situation of Cotton Processing Industry and Digital Upgrading

As of 2024, China maintains around 1,100 cotton

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processing enterprises, with over 92% located in Xinjiang [2]. Powered by digital technologies, platforms such as 'iCottonNet' are enabling transparency and standardization across the supply chain from planting to processing. The proliferation of digital platforms not only enhances governmental oversight but also enables enterprises to establish real-time quality control and precision marketing systems. However, SMEs still face challenges in equipment integration, data uploading, and understanding standards, which affects overall efficiency and quality. It is recommended to build regional demonstration zones to support digital transformation through standard promotion, data hosting, and shared services.

VI. Progress in Intelligent Identification of Cotton Pests and Diseases

Early detection and scientific management are crucial because pests and diseases provide a major danger to the yield and quality of cotton. Manual inspections are increasingly insufficient for large-scale operations. YOLOv8n-based detection models, enhanced with SE attention mechanisms and SCConv lightweight convolution modules, significantly improve robustness and real-time performance in natural field environments. Experiments show that the improved model increases mean average precision (mAP) by 4% and boosts detection frame rate by approximately 10 FPS across seven common disease categories. Future work should focus on expanding data sources and integrating multimodal sensor technologies, such as infrared, thermal, and multispectral imaging, to enable continuous, all-weather field monitoring.

VII. Conclusion and Outlook

In the new era of high-quality cotton development, key priorities include constructing scientific evaluation systems, upgrading intelligent technologies, and integrating digitalized industrial structures. Based on five recent studies, this paper systematically reviewed existing achievements and challenges in fiber quality standards, AI testing models, short fiber measurement, pest identification, and digital processing. The following directions are proposed for future research: promoting interdisciplinary collaboration among research, industry, and policymakers; building a unified evaluation platform that integrates standards, data, and models to support nationwide quality monitoring; and integrating agriculture with cutting-edge technologies such as AI and IoT to develop an intelligent quality control system across the cotton lifecycle [3]—ensuring excellence in cultivation, management, utilization, and marketability.

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