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Artificial Intelligence in the New Era of Sericulture

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Sericulture, the cultivation of silkworms for silk production, remains an important agro-based industry supporting rural livelihoods and textile economies worldwide. However, traditional sericulture practices face multiple challenges, including climate variability, disease outbreaks, labor shortages, and inconsistent productivity. The integration of Artificial Intelligence (AI) into sericulture systems marks a transformative shift toward precision, automation, and sustainability. AI-driven tools such as machine learning algorithms, computer vision systems, predictive analytics, and IoT-based monitoring platforms are being applied across mulberry cultivation, silkworm rearing, disease diagnosis, environmental control, and silk quality assessment. This review explores the role of AI in modernizing sericulture, highlighting technological advancements, practical applications, benefits, and future prospects. The adoption of AI in sericulture represents a critical step toward enhancing productivity, quality, and resilience in the silk industry.

Introduction

Sericulture is a labor-intensive agro-industry that integrates mulberry cultivation, silkworm rearing, cocoon production, and silk reeling. Countries such as India, China, and Brazil depend heavily on sericulture for rural employment and economic growth. Despite its socio-economic importance, the sector continues to rely largely on traditional knowledge and manual management practices. Modern challenges such as unpredictable climate patterns, disease incidence, fluctuating leaf quality, and rising labor costs necessitate technological intervention. Artificial Intelligence (AI), defined as the simulation of human intelligence processes by machines, offers data-driven solutions that enhance decision-making and operational efficiency. In agriculture and allied sectors, AI has already demonstrated significant success in crop management, pest detection, yield forecasting, and resource optimization. The extension of AI technologies to sericulture opens new opportunities for precision management and sustainable growth.

AI in Mulberry Cultivation

Mulberry leaves form the primary feed source for silkworms, making leaf quality and yield critical determinants of silk productivity. AI-based precision agriculture tools enable farmers to monitor soil conditions, nutrient levels, irrigation requirements, and pest incidence. Machine learning models can analyze historical climate and soil data to predict optimal planting times and fertilizer requirements. Remote sensing technologies integrated with AI algorithms allow detection of nutrient deficiencies and pest infestations through image analysis. Drone-based imaging combined with computer vision can assess leaf health, biomass distribution, and crop stress at early stages, enabling timely interventions. By optimizing irrigation schedules and fertilizer application through predictive analytics, AI reduces resource wastage while improving mulberry yield and nutritional quality.

Smart Silkworm Rearing Systems

Silkworm growth is highly sensitive to environmental conditions such as temperature, humidity, ventilation, and light intensity. Traditionally, farmers manually monitor these parameters, which may lead to fluctuations affecting larval development. AI-integrated Internet of Things (IoT) systems enable real-time monitoring of environmental parameters within rearing houses. Sensors continuously collect data on temperature, humidity, and carbon dioxide levels, which are analyzed using AI algorithms to maintain optimal rearing conditions automatically. Smart control systems adjust ventilation, heating, and humidification to ensure uniform growth. Predictive models can forecast larval growth stages and feeding requirements, helping farmers optimize leaf distribution and reduce feed wastage. Such automation improves survival rate, cocoon uniformity, and overall productivity.

Disease Detection and Management

Disease outbreaks, including grasserie, flacherie, muscardine, and pebrine, significantly reduce cocoon yield and quality. Early detection is crucial to prevent large-scale losses. Computer vision systems trained on image datasets of infected larvae and diseased leaves can identify symptoms at early stages with high accuracy. AI-powered diagnostic tools can differentiate between bacterial, viral, and fungal infections based on visual patterns and environmental data. Machine learning algorithms also analyze historical outbreak data and environmental conditions to predict disease risk levels. This enables preventive measures such as improved sanitation, disinfection, and optimized environmental control. Early warning systems enhance biosecurity and minimize economic losses.

AI in Cocoon Quality Assessment

Cocoon quality determines silk yield and thread strength. Traditional grading relies on manual inspection, which can be subjective and inconsistent. AI-driven image processing systems can evaluate cocoon size, shape, weight, and shell thickness with greater precision. Automated grading machines equipped with machine vision ensure uniform quality assessment, improving market transparency and pricing accuracy. Predictive analytics can also correlate rearing conditions with cocoon characteristics, helping farmers refine management practices for enhanced silk quality.

Data Analytics and Decision Support Systems

The integration of AI into sericulture generates large volumes of data related to crop growth, environmental conditions, disease patterns, and production output. Decision support systems (DSS) use this data to provide actionable recommendations to farmers. AI-based mobile applications can guide farmers on optimal feeding schedules, environmental adjustments, and disease management strategies. Such platforms bridge the knowledge gap between research institutions and field-level practitioners, empowering farmers with real-time scientific guidance. In regions where sericulture is practiced by smallholder farmers, AI-enabled advisory systems can significantly enhance productivity and reduce risk.

Economic and Sustainability Implications

AI adoption in sericulture enhances productivity, reduces input costs, and minimizes losses due to disease and environmental stress. Efficient resource management contributes to environmental sustainability by optimizing water use, reducing chemical inputs, and improving energy efficiency. Automation also addresses labor shortages, a growing concern in rural sectors. While initial investment costs for AI infrastructure may be substantial, long-term gains in yield, quality, and operational efficiency justify adoption. Furthermore, improved quality control strengthens global competitiveness of silk products in international markets.

Challenges and Future Directions

Despite its potential, AI integration in sericulture faces challenges including limited digital literacy among farmers, high initial investment costs, and lack of standardized datasets for algorithm training. Infrastructure limitations such as poor internet connectivity in rural areas may also hinder implementation. Future research should focus on developing cost-effective AI solutions tailored to small-scale farmers. Collaborative efforts between agricultural scientists, computer engineers, and policymakers are essential to create accessible and scalable AI platforms. Advancements in edge computing, affordable sensors, and cloud-based analytics will likely accelerate adoption. Integration of AI with blockchain technology could also enhance traceability and transparency in silk supply chains.

Conclusion

Artificial Intelligence is redefining the future of sericulture by transforming traditional practices into data-driven, precision-based systems. From mulberry cultivation and silkworm rearing to disease detection and cocoon grading, AI enhances productivity, quality, and sustainability. Although challenges remain in terms of cost and infrastructure, the long-term benefits of improved efficiency, reduced losses, and enhanced competitiveness position AI as a cornerstone of the new era of sericulture. Continued innovation and inclusive technological adoption will ensure that sericulture evolves into a smart, resilient, and sustainable agro-industry.

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