



GENESILK:AN INTELLIGENT SYSTEM FOR SUSTAINABLE BIO-SILK INNOVATION

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Abstract:

GeneSilk is an intelligent system developed to transform sustainable bio-silk production using advanced biotechnology and artificial intelligence. The project integrates genetic engineering techniques to enhance silk protein strength, durability, and yield by identifying optimal gene combinations. Machine learning algorithms analyze biological and environmental data to predict performance outcomes and improve production efficiency. The system reduces reliance on traditional silkworm farming, promoting cruelty-free and ethical textile manufacturing. It minimizes environmental impact by optimizing water usage, reducing chemical consumption, and ensuring eco-friendly production practices. Real-time monitoring and data-driven analysis maintain consistent quality and scalable manufacturing processes. By combining biotechnology, AI, and smart environmental management, GeneSilk provides an innovative, sustainable, and future-ready solution for next-generation bio-silk production.

Keywords: Bio-Silk Production,Genetic Engineering, Artificial Intelligence, Machine Learning, Gene Optimization,Sustainable Textiles, Environmental Monitoring,Data-Driven Prediction, Eco-Friendly Manufacturing, Smart Production System.

1. Introduction

GeneSilk is an innovative project developed to improve sustainable bio-silk production using biotechnology and artificial intelligence. Traditional silk production relies heavily on silkworm farming, which consumes significant resources and impacts the environment. To overcome these limitations, GeneSilk applies genetic engineering techniques to optimize silk-producing genes for enhanced strength, durability, and yield. The system integrates machine learning algorithms to analyze gene and environmental data, enabling accurate predictions and better production decisions. It also maintains structured databases for gene records, prediction results, production batches, and environmental monitoring. By reducing water usage, minimizing chemical consumption, and ensuring controlled production conditions, GeneSilk promotes eco-friendly and ethical textile manufacturing. Overall, the project combines smart technology and biological innovation to create a scalable, efficient, and sustainable solution for next-generation bio-silk production.

2. Literature Review

The field of biotechnology has significantly advanced the production of bio-based materials, including silk proteins. Researchers have explored recombinant DNA technology to produce silk proteins using genetically modified bacteria, yeast, and other microorganisms. These studies demonstrate that engineered biological systems can replicate natural silk properties while offering better control over strength, elasticity, and durability. Such innovations reduce dependence on traditional sericulture and open new possibilities for large-scale, sustainable silk production.

In recent years, artificial intelligence and machine learning have been widely applied in biological data analysis. Several studies show that machine learning algorithms can analyze gene sequences, identify patterns, and predict protein structures with high accuracy. These predictive models help optimize gene combinations and improve material properties before actual production. The use of AI in biotechnology reduces experimental time, cost, and resource consumption, making the process more efficient and reliable.

Sustainability research in the textile industry emphasizes reducing environmental impact through eco-friendly production methods. Studies highlight the importance of minimizing water usage, chemical treatments, and carbon emissions during manufacturing. Environmental monitoring systems have been introduced to track temperature, humidity, and resource consumption in real time, ensuring controlled and optimized production conditions. Such systems improve quality control while supporting sustainable development goals.

However, most existing research focuses either on genetic engineering, AI-based prediction, or environmental management separately. There is limited integration of these components into a single intelligent system. The GeneSilk project builds upon previous studies by combining gene optimization, machine learning prediction, structured data management, production tracking, and environmental monitoring into one unified platform. This integrated approach enhances efficiency, sustainability, and scalability in next-generation bio-silk production.

3. Case and Methodology

The GeneSilk project is based on the case of improving traditional silk production through a smart and sustainable technological approach. In conventional sericulture, silk quality depends on natural silkworm breeding, environmental conditions, and manual monitoring, which can lead to inconsistent fiber strength and high resource consumption. To address these challenges, the proposed system considers a bioengineered production model where silk-producing genes are optimized using biotechnology and analyzed using artificial intelligence. The case focuses on enhancing silk strength, durability, and yield while reducing environmental impact such as water usage and chemical consumption. By implementing a structured database and predictive analytics, the system ensures better quality control, efficient batch management, and sustainable manufacturing practices.

The methodology of GeneSilk follows a systematic and data-driven approach. First, gene data related to silk protein production is collected and stored in a structured database. Genetic engineering techniques are applied to modify and optimize gene sequences for improved performance. Next, machine learning algorithms are used to analyze gene characteristics and predict outcomes such as strength factor, durability index, and yield rate. The predicted results guide production decisions and batch planning. During the production phase, environmental parameters like temperature, humidity, water usage, and chemical consumption are monitored in real time. All data is continuously recorded and analyzed to ensure quality control and sustainability. Finally, performance evaluation is conducted to compare predicted results with actual production outcomes, improving the system's accuracy and efficiency over time.

4. Results & Analysis

The results of the GeneSilk project show clear improvements in silk strength, durability, and overall production efficiency compared to traditional methods. The machine learning model successfully predicted performance factors such as strength, durability, and yield rate with high accuracy, reducing trial-and-error experiments and saving time and resources. The structured database system improved data management and batch tracking, ensuring better quality control and consistency in output. Real-time environmental monitoring helped maintain optimal production conditions, which enhanced fiber quality and reduced resource wastage. Additionally, the system minimized water usage and chemical consumption, supporting sustainable and eco-friendly manufacturing. Overall, the analysis confirms that integrating biotechnology, artificial intelligence, and smart monitoring significantly improves scalability, productivity, and environmental responsibility in bio-silk production.

5. Conclusion

In conclusion, the GeneSilk project successfully demonstrates how biotechnology and artificial intelligence can be integrated to transform traditional silk production into a smart and sustainable system. By optimizing silk-producing genes and applying machine learning for performance prediction, the system improves fiber strength, durability, and yield while reducing experimental costs and production errors. The inclusion of structured data management and real-time environmental monitoring ensures consistent quality, efficient batch tracking, and eco-friendly manufacturing practices. The project also minimizes water usage and chemical consumption, supporting sustainable development in the textile industry. Overall, GeneSilk provides a scalable, efficient, and future-ready solution for next-generation bio-silk production, bridging the gap between biological research and intelligent manufacturing systems.

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