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Application Development for Monitoring Wool from Farm to Fabric

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Abstract - The wool business, an important component of the worldwide textile and fashion industry, consists of intricate steps from farm-level production to the final fabric-making process. Tracing wool across its entire value chain—from the shearing in the farm to the production of the fabric—is fraught with difficulties such as traceability, product quality, and sustainability issues. This research work discusses the development and design of an application with a focus on tracking and monitoring wool throughout its production life cycle. The app combines state-of-the-art technologies such as the Internet of Things (IoT), blockchain, and cloud computing to give real-time information and insights. The system proposed provides farmers, manufacturers, and retailers with the means to trace the origin of wool, track quality at different levels, and validate compliance with the environment and ethical requirements. The system, with enhanced transparency and accountability, could improve the quality, sustainability, and efficiency of the wool value chain to benefit all stakeholders, from the farm to the end consumer. This article presents the design requirements, technology architecture, and possible contribution of such an application, underscoring its potential to propel the wool sector towards a transparent and sustainable future.

***Key Words*:** Wool Value Chain,Traceability in Textile Industry,IoT in Agriculture,Blockchain for Supply Chain Management, Sustainable Wool Production

1.INTRODUCTION

1.1 Background

The wool sector is one of the most significant contributors to the world textile industry, providing quality fabrics utilized in a range of consumer goods, such as apparel, carpets, and upholstery. Wool is manufactured by millions of sheep worldwide, and its path from farm to fabric is an intricate and sophisticated supply chain. From shearing the fleece to sorting, cleaning, spinning, weaving, and finally fabric production, every step in this procedure is important for the assurance of the end product's quality and sustainability. Still, safeguarding the transparency, ensuring quality control, and adherence to sustainable practices in the production of wool has become tougher with the complexity of the supply chain, the ineffectiveness of the tracking systems, and increasing consumer demand for ethically manufactured materials.

The latest technological developments, including the Internet of Things (IoT), blockchain, and cloud computing, have created new opportunities for enhancing textile industry supply chain management, traceability, and transparency. These technologies have the potential to enable real-time tracing of wool from the farm to fabric, enabling all parties involved—farmers, manufacturers, retailers, and customers—to make informed choices. Such an application would resolve long-standing issues in wool production, leading to more sustainable practices, improved quality of products, and enhanced consumer confidence.

1.2 Problem Statement

Although important, the wool sector has a number of challenges related to supply chain transparency, traceability, and quality assurance. Wool is frequently blended with other fibers when processed, and hence
proving its origin and tracking its passage through the different steps becomes challenging. Additionally, the absence of real-time monitoring systems leads to inefficiencies, quality inconsistencies, and a failure to guarantee adherence to sustainability and ethical production protocols. With increased consumer demand for ethically sourced and sustainably produced textiles, the wool sector is under pressure to implement cutting-edge solutions to enhance traceability and accountability. The lack of an end-to-end, digital system to track wool from the farm to fabric greatly hinders the industry's capacity to respond to these needs.

1.3 Research Paper Objectives

To create and implement an application for tracking wool from the farm to fabric. The application will utilize IoT, blockchain, and cloud computing technologies to enable real-time tracking and transparency across the wool supply chain.

To solve issues of traceability and quality control in wool production. This system will allow stakeholders to monitor the provenance and quality of wool at each point of production, making sure that the wool is of certain standards of sustainability and quality.

To offer solutions for enhancing transparency and sustainability. The study seeks to create a framework for the wool industry that promotes ethical sourcing, minimizes waste, and reduces environmental effects.

In order to assess how the suggested application might affect the wool industry. This involves considering how the application can drive operational effectiveness, build consumer confidence, and help establish a sustainable future for the wool industry.

Literature Review

2.1 The Wool Industry and Its Challenge

The wool sector, being a critical component of the international textile sector, is confronted with a myriad of challenges that make it less efficient and sustainable. As argued by Johnson et al. (2020), producing wool entails several processes, ranging from shearing to processing and manufacturing of fabrics, each with the need for proper quality control. But the industry is plagued by inefficient supply chains, opaqueness, and inefficiencies that cause problems ranging from poor quality of products to environmental degradation. Additionally, Smith and Taylor (2018) point out that wool tends to get blended with man-made fibers at processing, rendering it difficult to ascertain the authenticity and purity of the wool, thereby making it even more difficult to assure quality control and traceability.

Consumer sensitivity to ethical and sustainable practices in the production of textiles has also increased considerably, and the expectation for transparency in sourcing is on the rise. A study by Brown et al. (2019) indicates that consumers now prefer brands that are able to demonstrate the sustainability and ethical origin of their material. Thus, making wool traceable from farm to fabric is no longer only a regulatory obligation but also a market expectation.

2.2 Supply Chain Transparency Technological Solutions

A number of technological developments have been investigated for enhancing supply chain management and visibility within the textile and agricultural sectors. The use of IoT in supply chain management has attracted much interest over the last few years. IoT devices like RFID tags, GPS sensors, and smart tags enable real-time collection of data, tracking, and monitoring of products as they are transported through the supply chain. Kumar and Chawla (2021) show the application of IoT in monitoring raw materials in different industries, such as textiles, wherein IoT sensors were able to significantly enhance product quality monitoring and inventory management.

Another technology that has the potential to increase supply chain transparency is blockchain. Blockchain technology, through its decentralized and immutable quality, is being more widely applied to facilitate traceability, data security, and accountability. Research like Li et al. (2020) points to the use of blockchain for traceability in the food supply chain, and Wang and Lee (2019) further apply this use to the textile sector, where blockchain can verify the origin of wool, trace its movement, and guarantee the validity of certifications (e.g., sustainability certifications).

In addition, cloud computing has been efficient in offering scalable data storage, analytics, and collaboration platforms. Cheng et al. (2022) suggest the incorporation of cloud-based systems for the real-time sharing of data in the agricultural industry, which can be modified to track the wool production processes and enhance communication among the stakeholders, from farmers to manufacturers.

Proposed Methodology

1. User Registration and Authentication

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- Farmers, producers, and stakeholders get themselves registered on the platform.
- Secure authentication enables authorized access.

2. Wool Production & Processing Management

- Wool production data is collected from the farms.
- Real-time logging of processing stages (cleaning, sorting, spinning).

3. Order and Tracking System

- Orders are placed and tracked through the supply chain.
- Status reports at each stage for transparency.

4. End-to-End Traceability

- Blockchain or database-based traceability provides wool origin verification.
- Each transaction and movement is logged.

5. User Logout and Data Security

- Secure logout processes to safeguard user information.
- Encryption and security protocols guarantee data privacy.

Results and Discussions

The platform consolidates resources such as crops, fertilizers, renting lands and machinery. By integrating these into a single interface, it reduces farmers' reliance on intermediaries. User-centric design has enhanced adoption rates, with farmers gaining direct access to suppliers and financial resources. Additionally, the inclusion of offline functionality ensures accessibility even in remote areas.

Figure 1.1: Home page

Figure 1.1: The interface displays the home page of the wool monitoring application. It contains a file upload area named "Upload Wool Data," where users can upload a .csv file like combined_wool_data.csv. Once the file is chosen, clicking on the "Analyze Wool Quality" button initiates the analysis process. The page title describes the system's function — tracking wool from farm to fabric — and the footer highlights it as an AI-powered wool quality grading and traceability system.

Figure 1.2: Wool Quality Result

Figure 1.2: The graph represents the Wool Quality Results produced by the system when it processed a dataset with 10 wool samples. The top summary states the distribution: 5 samples fall into Grade A, 1 sample into Grade B, and 4 samples into Grade C. The bar chart puts this distribution in a visual form, color-coded bars—green forGrade A, yellow for Grade B, and red for Grade C—that illustrate the number of samples for each quality group.

Figure 1.3: Detailed Results

Figure 1.3: The Detailed Results table is shown for 10 wool samples, each of which has a distinct Sample ID (W001–W010). For each sample, four measured parameters—Fiber Length, Diameter, Crimp, and Cleanliness—are shown alongside the Predicted Grade (A, B, or C). Grade A samples,

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being rich in fiber length, having low diameter and high cleanliness, are colored green; Grade B yellow; and Grade C red. There is an Action column with a link to see the complete lifecycle information for each sample, enabling traceability from source to result.

Figure 1.4: Wool Batch Traceability

Figure 1.4: This figure displays the Lifecycle Details for wool batch W001, which were logged as part of the Wool Batch Traceability system. The information shows shearing was performed on 15/02/2024 at Wilson Farms, New Zealand, and John Wilson is the accountable stakeholder. The mechanism verifies that shearing was finalised, reporting pertinent measurements such as a collective wool weight of 12.5 kg originating from 10 sheep, as per favourable weather conditions. There is a recording of a sole Transaction Hash (0x87fd8b3c2e1a5f6d9c8b) at the footer, which includes verifiability of this entry on the traceability ledger.

Figure 1.5: Initial Processing

Figure 1.5: Functionality displays the first stage of processing an agricultural commodity, and users are able to see crucial information like location, stakeholder, and measuring factors. The user can see where the process occurred (Regional Collection Center Auckland), who conducted it (NZ Wool Co.), and certain outputs like processed weight, yield percent, and removed contaminants. This interface promotes traceability and transparency by also providing a transaction hash, guaranteeing authenticity and recordkeeping. Strengths are inclusive of comprehensive process reporting, excellent metrics visibility, and incorporation of blockchain for safe tracking of data.

Figure 1.5: Quality Testing

Figure 1.6: The functionality represents the quality testing phase of the agricultural product life cycle, making users available to important quality parameters. It has precise details regarding the testing location (Testing Laboratory Wellington), the stakeholder (QualityTest Inc.), and precise measurement values such as fiber length, diameter, crimp, and cleanliness percentage. The interface indicates that the process of testing has been completed with a transaction hash for traceability and verification of data. Weaknesses comprise extensive quality measurement, open stakeholders' information, and secure monitoring through blockchain implementation, providing authenticity and product assurance.

Figure 1.7: manufacturing

Figure 1.7: The functionality depicts the manufacturing phase of the textile production life cycle. It offers complete information like the

location (Textile Factory Milan, Italy), the stakeholder involved (LuxFabrics S.p.A.), and the status of the manufacturing process completion. Users are offered key manufacturing parameters like fabric type (Fine worsted), batch size (120m), and fabric weight (240g/m²). The addition of a transaction hash guarantees traceability and data integrity. Some of the most important strengths of this interface are accurate production information, traceability worldwide, and safe tracking, all helping to achieve a clear and accountable manufacturing process.

Figure 1.8: Retail Distribution

Figure 4.9: The functionality shows the retail distribution phase of the product lifecycle, providing a clear view of the market-facing end of the supply chain. It features necessary information such as the location of distribution (Fashion District Paris), the stakeholder that oversees the process (Haute Couture Distributors), and verification of the completion of the process. Key commercial measures are shown—retail price (€250/m) and order size (80m). Having a transaction hash provides transparency and trust via blockchain validation. Strengths of this interface are simple access to retail information, transparency in pricing and volume, and secure traceability of product flow to the market.

Figure 1.9: Stakeholders Involved

Figure 4.10: The functionality details the major stakeholders across the product lifecycle, clearly indicating each party's role and verification status. It has the farmer (John Wilson), processor (NZ Wool Co.), testing lab (QualityTest Inc.), manufacturer (LuxFabrics S.p.A.), and distributor (Haute Couture Distributors), all designated as "Verified ✓." This interface gives users a clear view of all the players in the supply chain, establishing trust and accountability. Strengths are well-defined stakeholder identification, role categorization, and assurance of verification, which all contribute to credibility and traceability throughout the production and distribution process.

3.Conclusion

The creation of an application for tracing wool from farm to fabric is a revolutionary solution to improve transparency, efficiency, and sustainability in the wool industry. Through the incorporation of user authentication, management of wool production and processing, order tracking, end-to-end traceability, and stringent measures of data security, the system guarantees smooth tracing of wool through its entire supply chain. The use of sophisticated technologies like IoT, blockchain, and cloud computing allows real-time tracing, quality checking, and ethical sourcing verification to build trust among stakeholders.

This app not only facilitates ease of operations for farmers, manufacturers, and consumers but also ensures adherence to industry practices and sustainability principles. By guaranteeing the genuineness and traceability of wool products, it enables consumers to make informed choices while ensuring fair trade and responsible sourcing. Moreover, incorporating secure data handling methods curbs cybersecurity threats, ensuring sensitive information is protected.

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