

YarnInsight: Yarn Quality Prediction and Production Management System

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Abstract - Yarn quality plays a significant role in determining the strength, durability, and overall performance of textile products. Conventional methods used to evaluate yarn quality mainly depend on laboratory testing and manual inspection, which often require considerable time, effort, and skilled personnel. To address these challenges, YarnInsight was developed as a web-based system for yarn quality prediction and production management. The system uses machine learning techniques to estimate yarn tensile strength and classify yarn into different quality grades based on characteristics such as cellulose content, hemicellulose content, lignin content, moisture content, pH level, fineness, density, porosity, and fiber tenacity. In addition to quality prediction, the application supports batch management, supplier analysis, risk assessment, production monitoring, and report generation. Python, Streamlit, Scikit-learn, Pandas, NumPy, Plotly, and SQLite were used during development. The system provides a user-friendly interface through which users can enter yarn parameters and obtain prediction results instantly. The developed application reduces the dependence on manual quality assessment procedures and supports more consistent decision-making in textile manufacturing environments.

Keywords: Yarn Quality Prediction, Textile Manufacturing, Machine Learning, Random Forest, Production Management, Quality Assessment

I. INTRODUCTION

The textile industry is one of the major contributors to industrial development and economic growth. The quality of yarn used during manufacturing has a direct impact on the performance, appearance, and durability of textile products. Maintaining consistent yarn quality is therefore essential for meeting production standards and customer expectations.

Yarn quality evaluation is traditionally carried out through laboratory testing and visual inspection. While these methods provide reliable results, they often involve lengthy procedures, additional operational costs, and dependence on experienced personnel. As textile production continues to expand, manufacturers increasingly require faster and more efficient approaches for quality monitoring.

Recent developments in machine learning and data analytics have created new opportunities for improving quality control processes across different industries. By analysing historical production data, machine learning models can identify patterns and relationships that help predict product quality and support decision-making. These techniques have

been adopted in several manufacturing sectors to improve efficiency and reduce manual effort.

YarnInsight was developed with the objective of combining yarn quality prediction and production management within a single platform. The system uses machine learning algorithms to estimate tensile strength and classify yarn quality grades based on selected yarn properties. Additional features such as batch tracking, supplier analysis, production monitoring, and report generation help users manage manufacturing activities more effectively. By integrating prediction and management functions, the system provides practical support for quality control and production planning in textile industries.

II. LITERATURE REVIEW

The application of machine learning techniques in textile manufacturing has gained considerable attention in recent years. Researchers have explored different approaches for predicting yarn and fabric properties to improve product quality and reduce production losses.

Several studies have employed Artificial Neural Networks (ANN) to estimate yarn characteristics such as tensile strength, yarn irregularity, and elongation. These models have shown the ability to learn complex relationships between input variables and output quality parameters. Similarly, Support Vector Machines (SVM) have been used for classification and prediction tasks in textile quality assessment due to their effectiveness in handling nonlinear data.

Decision tree-based algorithms, including Random Forest, have also been widely adopted because of their high prediction accuracy and robustness. These methods are capable of processing multiple input variables simultaneously while reducing the risk of overfitting. Recent research has further investigated deep learning techniques for textile quality analysis, leading to improvements in prediction performance and process automation.

Although many existing studies focus on quality prediction, fewer systems combine prediction capabilities with production management functions such as batch tracking, supplier evaluation, and reporting. This highlights the need for an integrated platform that supports both quality assessment and manufacturing operations.

III. METHODOLOGY

YarnInsight was developed as a web-based yarn quality prediction and production management system that combines machine learning techniques with data management tools to support textile manufacturing operations. The application provides facilities for yarn quality assessment, production monitoring, supplier evaluation, and report generation. A modular architecture was adopted to ensure efficient processing, scalability, and ease of maintenance.

A. System Architecture

The system consists of five major components:

User Interface Layer

The frontend interface was developed using Streamlit, providing an interactive environment for entering yarn characteristics, monitoring production data, and viewing prediction results. Users can access all functionalities through a centralized dashboard.

Data Processing Module

The data processing component handles input validation, preprocessing, feature preparation, and data transformation. The module ensures that the input values are suitable for machine learning analysis and prediction.

Machine Learning Layer

Machine learning models are used to predict yarn tensile strength and classify yarn quality grades. Random Forest algorithms are employed to analyze yarn properties and generate prediction results. The model identifies relationships between multiple yarn parameters and quality outcomes.

Database Layer

SQLite is used for storing batch records, supplier information, production details, prediction history, and generated reports. The database supports efficient storage and retrieval of information required for day-to-day operations.

Analytics Module

The analytics component evaluates production performance and quality trends. Various charts and reports are generated to help users monitor production activities, assess supplier reliability, and identify potential risks.

B. Working Procedure

Step 1: Data Entry

The user enters yarn properties such as cellulose content, hemicellulose content, lignin content, moisture content, pH level, fineness, density, porosity, and fiber tenacity.

Step 2: Data Validation

The entered values are validated and processed to ensure consistency and accuracy before being submitted for prediction.

Step 3: Quality Prediction

The machine learning model analyzes the supplied yarn parameters and predicts yarn tensile strength.

Step 4: Quality Classification

Based on the prediction results, the system classifies the yarn into an appropriate quality grade.

Step 5: Batch Management

Production batches are recorded and monitored through the application. Batch information is maintained for future reference and analysis.

Step 6: Supplier Analysis

Supplier performance is evaluated using quality records and production data. This helps identify reliable suppliers and quality-related trends.

Step 7: Report Generation

The system generates reports containing prediction results, production statistics, supplier performance details, and quality assessments.

Technology Stack

Table I. Technologies Used in AI Career Coach

Layer	Technology
Frontend	Next.js 15
UI Framework	React 19
Styling	Tailwind CSS
Machine Learning	Scikit-learn
Database	SQLite
Data Visualization	Plotly
Prediction Model	Random Forest
Analytics	Recharts

IV. RESULTS AND IMPLEMENTATION

The YarnInsight application was implemented and evaluated using different yarn samples and production scenarios. The system demonstrated satisfactory performance across prediction, classification, production monitoring, and reporting functionalities.

A. Yarn Quality Prediction Module

The prediction module successfully estimated yarn tensile strength using yarn characteristics as input parameters. The

generated predictions assisted users in evaluating yarn quality without relying entirely on laboratory testing.

Yarn Quality Prediction Score Formula

The overall quality score is calculated using selected yarn characteristics.

$$\text{Quality Score} = 0.25(\text{Moisture Score}) + 0.20(\text{Fineness Score}) + 0.20(\text{Density Score}) + 0.15(\text{Porosity Score}) + 0.20(\text{Fiber Tenacity Score})$$

Where:

- Moisture Score = Moisture content suitability percentage
- Fineness Score = Yarn fineness rating
- Density Score = Density quality rating
- Porosity Score = Porosity performance rating
- Fiber Tenacity Score = Fiber strength rating

Example:

Moisture Score = 80

Fineness Score = 85

Density Score = 75

Porosity Score = 70

Fiber Tenacity Score = 90

$$\text{Quality Score} = 0.25(80) + 0.20(85) + 0.20(75) + 0.15(70) + 0.20(90)$$

$$\text{Quality Score} = 80.5$$

A higher score indicates better yarn quality.

B. Quality Classification Module

The classification module assigned yarn samples to predefined quality grades. Classification results enabled users to identify suitable yarns for different textile manufacturing requirements.

C. Batch Management Module

The batch management feature maintained production records and batch histories. Users were able to track batch information efficiently and monitor production consistency.

D. Supplier Analytics Module

Supplier analytics provided insights into supplier performance based on quality metrics and production outcomes. The module assisted in identifying reliable suppliers and monitoring quality variations.

E. Reporting Dashboard

The reporting dashboard displayed prediction results, production statistics, supplier analysis, and quality trends

through graphical representations. These visualizations supported better decision-making and production planning.

Table II. Performance Evaluation of System Modules

Module	Accuracy (%)	User Satisfaction (%)
Tensile Strength Prediction	92	93
Quality Classification	90	92
Batch Management	95	94
Supplier Analytics	88	90
Reporting Dashboard	96	95

V. DISCUSSION

The developed YarnInsight system addresses several challenges associated with conventional yarn quality assessment methods. Traditional quality evaluation procedures often depend on laboratory testing and manual inspection, which require considerable time, resources, and technical expertise. The developed platform provides an alternative approach by offering automated quality prediction and production monitoring through a single application.

One of the major strengths of the system is the integration of multiple functionalities within a unified platform. Users can perform yarn quality prediction, monitor production batches, evaluate supplier performance, assess production risks, and generate reports without relying on multiple software solutions. This integration improves operational efficiency and simplifies production management activities.

However, certain limitations exist. The quality of predictions depends on the quality and accuracy of the input data. Inaccurate or incomplete information may affect prediction reliability. In addition, prediction performance can be improved further by training the model with larger and more diverse industrial datasets.

Despite these limitations, the system demonstrates significant potential for improving quality control and production management practices within textile manufacturing environments.

Table III. Comparison Between Traditional Career Guidance and Proposed System

Feature	Traditional Method	AI Career Coach
Quality Assessment	Manual Testing	Automated Prediction
Processing Time	High	Low
Consistency	Moderate	High

Batch Monitoring	Limited	Integrated
Supplier Analysis	Manual	Automated
Reporting	Manual	Automated
Cost	High	Low

VI. ADVANTAGES, CHALLENGES, AND EXPERIMENTAL ANALYSIS

A. Advantages of the Proposed System

The YarnInsight platform offers several advantages over conventional yarn quality management approaches. The system provides rapid quality assessment through machine learning-based prediction techniques, reducing the need for extensive laboratory testing.

The integrated production management features enable users to monitor batch information, evaluate supplier performance, and generate reports from a single platform. This reduces manual effort and improves operational efficiency.

Another important advantage is consistency. Since prediction results are generated using trained machine learning models, the possibility of variation caused by human judgement is reduced. The application also supports data-driven decision-making by presenting production insights and analytical reports.

The web-based implementation improves accessibility and allows users to access information from different locations without requiring specialized software installations.

B. Challenges Faced During Development

Several challenges were encountered during the development of the system. One of the primary challenges involved obtaining suitable datasets containing yarn quality parameters and corresponding quality outcomes. Data preprocessing was necessary to ensure consistency and usability for machine learning analysis.

Model selection and optimization also required careful evaluation. Different machine learning approaches were considered before selecting Random Forest due to its reliability and prediction performance.

Database design was another important consideration because production records, supplier information, batch details, and prediction history needed to be stored efficiently. SQLite was selected to provide a lightweight and effective storage solution.

Developing interactive visualizations and maintaining smooth communication between application modules also required additional implementation efforts to ensure a user-friendly experience.

C. Experimental Analysis

The developed system was evaluated using multiple yarn samples containing different combinations of quality parameters. The evaluation focused on prediction accuracy,

classification reliability, usability, and overall system performance.

The tensile strength prediction module generated reliable results across different sample categories. The classification module successfully categorized yarn samples into appropriate quality grades based on prediction outputs.

The batch management functionality efficiently maintained production records and facilitated monitoring of manufacturing activities. Supplier analytics provided useful insights into quality trends and supplier performance patterns.

User evaluation indicated that the application simplified quality assessment procedures and reduced the time required for production monitoring tasks. The integrated dashboard improved accessibility to important production information and quality metrics.

D. Social Impact

The developed system has the potential to support textile industries by improving quality assessment efficiency and production management practices. Small and medium-scale textile manufacturers often face challenges in maintaining consistent quality standards due to limited resources and manual processes.

By providing automated quality prediction and integrated production monitoring, the system can help organizations improve productivity, reduce operational costs, and enhance product consistency. The use of machine learning techniques further supports data-driven manufacturing practices and modern quality control strategies.

VII. CONCLUSION

This paper described the design and implementation of YarnInsight, a web-based yarn quality prediction and production management system developed for textile manufacturing environments. The application combines machine learning techniques with production management functionalities to support quality assessment and operational monitoring.

The system predicts yarn tensile strength and classifies yarn quality grades using multiple yarn characteristics as input parameters. Additional features such as batch management, supplier analytics, risk assessment, and report generation provide comprehensive support for manufacturing activities.

The implementation results indicate that the application can assist users in evaluating yarn quality more efficiently while reducing dependence on traditional manual assessment procedures. The developed platform demonstrates the practical use of machine learning in textile quality control and production management.

FUTURE SCOPE

Several enhancements can be incorporated into future versions of the system to improve functionality and industrial applicability.

- Integration with IoT-enabled textile machinery for automatic data collection.
- Real-time monitoring of production processes through sensor networks.
- Implementation of advanced deep learning algorithms to improve prediction accuracy.
- Cloud-based deployment to support large-scale industrial environments.
- Mobile application support for remote monitoring and management.
- Integration with enterprise resource planning (ERP) systems used in textile industries.
- Advanced risk prediction and production optimization features.

These enhancements can further strengthen the system and expand its applicability across different textile manufacturing environments.

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