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INTEGRATING ARTIFICIAL INTELLIGENCE AND TIME-SERIES FORECASTING FOR SMART TEXTILE PRODUCTION: TRENDS, CHALLENGES, AND OPPORTUNITIES IN THE INDUSTRY 4.0 ERA

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Abstract

The increasing complexity of textile manufacturing in the industry 4.0 era has intensified the need for forecasting systems that can adapt to dynamic demand patterns, interconnected production networks, and heterogeneous data environments. This article provides a comprehensive review of how Artificial Intelligence (AI) and time-series forecasting techniques are being integrated to enhance operational intelligence within smart textile production. It synthesizes the strengths and limitations of classical statistical models, modern machine-learning architectures, and emerging hybrid approaches that combine linear decomposition with nonlinear learning. The review highlights how interconnected data ecosystems enabled by IoT sensors, RFID tracking, MES/ERP systems, edge–cloud architectures, and digital twins form the backbone of real-time predictive capabilities in contemporary textile factories. In examining recent research and industrial applications, the study identifies key opportunities for sustainability alignment, adaptive learning, and autonomous decision support, alongside persistent challenges related to data quality, interoperability, computational demands, and SME adoption barriers. Finally, the article outlines actionable future directions, including reinforcement-learning-driven forecasting, federated learning, lightweight edge analytics, standardized benchmarks, and sustainability-aware predictive models. By consolidating methodological advances and practical considerations, this review offers a grounded roadmap for deploying intelligent, responsive, and resilient forecasting systems within the evolving landscape of smart textile manufacturing.

Keywords: Smart Textile Manufacturing**,** AI-Driven Time-Series Forecasting**,** Industry 4.0 and Digital Transformation**,** Hybrid Forecasting Models**,** IoT and Edge-Cloud Data Ecosystems

1. Introduction

1.1 Background of Textile Production and Forecasting

The textile sector is among the most dynamic and globally competitive manufacturing industries, characterized by pronounced seasonality, short product life cycles, and volatile consumer demand, factors that complicate planning and forecasting (Kačmáry & Lörincz, 2023; Lorente-Leyva et al., 2020). Precise production forecasting therefore underpins supply-demand alignment, resource optimization, inventory reduction, and on-time fulfillment; empirical and case studies in textile operations and just-in-time (JIT) systems