Title Page:

Detection of synthetic fiber defects in textiles using ResNet for accurate prediction in comparison with LSTM(Long Short-Term Memory).

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Keywords: accuracy, defects, detection, dimensional irregularities, fabric, financial loss, LSTM(Long Short-Term Memory), ResNet, synthetic fiber, textile, weaving.

ABSTRACT

Aim: The objective is to advance ResNet's efficacy over LSTM(Long Short-Term Memory)in detecting defects in synthetic fiber within textile materials.**Materials and Methods:**Two sets, ResNet and LSTM, each encompassing 20 samples, were utilized for the comparative investigation. Sample size computations were performed, considering an alpha value of 0.05 and 80% G-power.The analysis focused on assessing accuracy, detecting defects, and identifying dimensional irregularities and weaving errors in ResNet and LSTM materials for detecting synthetic fiber defects in textile materials.**Results:**In contrast to the 70.6660% accuracy attained by the LSTM classifier, the ResNet model demonstrated a superior accuracy rate,reaching a maximum of 92.7380%.The comparison between these groups indicated a statistically significant variance via an Independent T-test analysis, displaying a p-value of 0.011 ($p<0.05$).**Conclusion:**Conclusively, given the resource and data constraints, ResNet demonstrates notably better performance across both sample groups in comparison to the LSTM(Long Short-Term Memory) approach.

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INTRODUCTION

The textile industry faces a persistent struggle in identifying imperfections within synthetic fiber materials, a critical aspect affecting the overall quality of products(Xie and Xu 2023). Detecting flaws such as dimensional irregularities and weaving inconsistencies holds immense significance in ensuring the integrity and performance of textiles(Li et al. 2023). These defects, ranging from minor irregularities to larger inconsistencies(Guo et al. n.d.2019), wield substantial influence over fabric quality and structural robustness. Traditional methods often fall short in capturing these nuanced differences(Silenzi et al. 2023), demanding advanced technical solutions for accurate defect identification. This research endeavors to revolutionize the identification of defects in synthetic fiber production(Feng et al. 2019), potentially alleviating financial losses linked to flawed processes in textile manufacturing.

Over recent years, substantial research has concentrated on refining the detection methods for synthetic fiber defects within textile materials(Ren et al. 2021).Upon thorough exploration of databases like IEEE Xplore, Springer, and Elsevier, an abundance of publications 1171 articles on Science Direct and over 289 pieces on Google Scholar have been dedicated to this facet of detection. The textile industry's classification of synthetic fibers hinges on quality gradation(Zhao et al. 2022), distinguishing between first-grade fabric free of substantial defects and second-grade fabric bearing noticeable flaws. These imperfections account for considerable financial losses, with more than half of second-grade fabric production attributable to undetected flaws. Manual inspection methods, prone to human error and fatigue, manage to achieve only moderate accuracy rates ranging between 60% and 75%(Bhatt et al. 2021). Delayed flaw identification and manual inspection further impede production efficiency. Nonetheless, strides in computer science and machine vision have ushered in automated fabric inspection(Gao et al. 2023), heralding improved quality control. This inquiry focuses on fine-tuning algorithms for detecting dimensional irregularities and weaving flaws within synthetic fibers(Mao et al. 2023), significantly influencing defect identification and elevating fabric quality in textile manufacturing.

In the grand performance of textile defect detection, ResNet emerges as the leading virtuoso, surpassing even the captivating LSTM(Long Short-Term Memory) in its pursuit of flawless fabrics. While both deep learning techniques gracefully pirouette across the stage(Chaupal, Rohit, and Rajendran 2023), ResNet's unique ability to learn intricate patterns and capture long-range dependencies within fabric structures proves to be a showstopper. Its unparalleled precision in identifying dimensional irregularities and weaving flaws within synthetic fibers, especially in complex weaves and intricate patterns(Jaber et al. 2023), cements ResNet's standing ovation. As a result, the textile industry applauds ResNet's superior accuracy and financial savings, recognizing it as the true star of textile defect detection.

MATERIALS AND METHODS

This investigation unfolded within the Data Analytics lab of Saveetha School of Engineering,Saveetha Institute of Medical and Technical Sciences,Chennai, India, where a highly flexible system empowers precise research and meticulous results. Twenty participants formed the study's core, evenly split into two ensembles: the ResNet group and the LSTM group. Stringent statistical rigor was upheld, ensuring a power level of 0.8 (beta), significance level of 0.05 (alpha), and a 95% confidence level. Moreover, the study's statistical potency was bolstered by an 80% G-Power value.With this robust framework in place, the researchers aimed to determine whether ResNet's prowess in pattern recognition(Zoph et al. 2018), and its ability to capture long-range dependencies within fabric structures, could eclipse the capabilities of LSTM in detecting textile defects.

The core objective of this investigation is to evaluate synthetic fiber defect detection within textile images sourced from the "AITEX Fabric Image Database" dataset. This dataset encapsulates crucial variables such as broken end, broken yarn, broken pick, warp ball, weft crack, Nep, and Knots, aimed at enhancing detection accuracy. Leveraging the preprocessed dataset, featuring these diverse characteristics(Jiang et al. 2019), the ResNet algorithm is employed for defect detection analysis. The dataset encompasses 245 images of seven unique fabric types, including 20 defect-free images for each fabric type out of 140, while the remaining

105 images exhibit various flaws. These images are sized at 4096 x 256 pixels, forming the basis for evaluating defect detection in synthetic fiber textiles.

The research methodology adopted here involved working with a specific dataset, evaluating its outcomes in contrast to the widely acknowledged EfficientNet algorithm. This dataset, structured as an image dataset, houses a diverse array of data values. To ensure a comprehensive analysis and comparison, the dataset underwent meticulous scrutiny utilizing the algorithms outlined in this research(Demir et al. 2022). The hardware setup comprised an Intel dual-core processor equipped with 8 GB of RAM. Employing Jupyter Notebook, Python, and a MySQL database, the software environment provided a stable framework for executing the algorithm and facilitating the comparative analysis.

ResNet

ResNet, or Residual Networks, signifies a breakthrough in convolutional neural network (CNN) architectures, offering substantial depth while alleviating the vanishing gradient problem. Its innovative skip connections, or residual connections, enable the passing of information across layers, allowing the network to learn complex features more effectively. In textile defect detection, ResNet's capability to handle intricate patterns within fabric images is crucial. Its deep-layered architecture, with the incorporation of residual blocks, empowers the model to capture fine details, such as dimensional irregularities and weaving flaws, enhancing its accuracy in identifying defects. Trained on extensive fabric image datasets, ResNet undergoes comprehensive evaluations, utilizing loss functions like mean squared error, to precisely detect faults and prevent potential financial losses in the textile manufacturing process. The robustness of ResNet in synthetic fiber defect detection positions it as a vital tool in ensuring fabric quality and minimizing production-related losses in the textile industry.

LSTM(Long Short-Term Memory)

Long Short-Term Memory (LSTM), a type of recurrent neural network (RNN), specializes in processing and analyzing sequential data, making it valuable for time-series analysis and pattern recognition in various domains, including textile defect detection. Unlike traditional neural networks, LSTMs are equipped with memory cells that enable the retention of information over extended sequences, addressing the vanishing gradient problem faced by standard RNNs. In the context of detecting synthetic fiber defects in textiles, LSTM models excel in capturing temporal dependencies, allowing them to discern intricate irregularities and patterns within fabric images.
For the analysis of textile defects, LSTM networks can interpret and learn from sequential fabric image data, identifying subtle dimensional irregularities, weaving flaws, or defects within synthetic fiber materials. The ability of LSTM to retain and utilize information over extended sequences allows it to detect nuanced irregularities that might be crucial in ensuring fabric

quality. By training on extensive textile image datasets and employing sophisticated learning techniques, LSTM models are adept at detecting anomalies or deviations that could indicate defects, contributing to improved accuracy in defect detection.

Statistical Analysis

In the comparison between ResNet and LSTM (Long Short-Term Memory), the role of ResNet is defined as the dependent variable, while LSTM is established as the independent variable. This setup remains consistent throughout the assessment of their efficacy and performance. Within the analytical process, SPSS(Statistical Product and Service Solutions) version 26 generates graphs and facilitates regression analysis, t-tests, mean comparisons, and group statistics, focusing on parameters like accuracy counts, mean values, standard error, and standard mean error(Parida et al. 2022). The analysis includes tables for mean equality tests, Levene's variance equality tests, and an accuracy bar graph. On the visual representation, the Y-axis denotes mean accuracy, while the X-axis exhibits diverse algorithm parameters.

RESULTS

The accuracy of raw data for both ResNet and LSTM(Long Short-Term Memory) is exhibited in Table 1,each containing 20 samples.Table 2 presents standard deviations of 2.14472 and 19.39023,standard error mean values of 0.67822 and 6.13173,and mean accuracy rates of 92.7380% and 70.6660% for ResNet and LSTM, respectively, with a N of 20.

Table 3 demonstrates the T-test outcomes for mean equality, conducting a two-tailed independent test, showcasing an "F" value of 8.074 assuming equal variances. The 95% confidence intervals, assuming equal variances and without that assumption, reveal ranges of 35.03284 to 35.97689 in the upper case and 9.11116 to 8.16711 in the lower case. Figure 1 illustrates a bar graph plotting groups on the X-axis and mean accuracy on the Y-axis, distinctly showing ResNet's superiority over LSTM with a value of 0.011 ($p<0.05$) for single-tailed analysis.

DISCUSSION

The findings of the research signify that in detecting synthetic fiber defects, the mean accuracy of the LSTM(Long Short-Term Memory) model reaches 70.6660%, whereas the ResNet classifier achieves a higher accuracy rate of 92.7380%. This highlights ResNet's superior performance compared to LSTM in synthetic fiber defect detection. Employing an Independent T-test, the obtained p-value of 0.011 ($p<0.05$) further emphasizes ResNet's enhanced efficacy over LSTM in accurately identifying defects in textile materials.
The dataset encompasses a comprehensive range of textile flaws, addressing dimensional irregularities and weaving defects in synthetic fibers, offering insights into texture, color

variations, tensile strength(Anu and Bibal Benifa 2024), and surface imperfections. This dataset strives to bridge the gap between textile stakeholders and decision-makers, aiding production and investment strategies in the industry . ResNet and LSTM, as powerful deep learning approaches, are pivotal in synthetic fiber defect detection. ResNet's architecture, characterized by deep-layered networks and skip connections, excels in capturing intricate patterns, particularly in identifying flaws like dimensional irregularities and weaving defects(Durairaj et al. 2023). Although EfficientNet boasts scaling advantages, ResNet's robustness and superior accuracy, reaching 92.7380% compared to EfficientNet's 70.6660%, establish it as the preferred choice for intricate visual tasks in detecting synthetic fiber defects, thereby curbing potential financial losses associated with substandard fabric production.

Limitations in the assessment were observed in LSTM(Long Short-Term Memory), particularly concerning model efficacy in dealing with defect diversity, uncertain adaptability across fabric types, and the substantial need for abundant labeled data. Moreover, complexities in deployment and unexplored scenarios emerged as challenges. However, throughout these limitations, ResNet consistently demonstrated superiority in synthetic fiber defect detection, positioning it as a more reliable choice in addressing accuracy, defects, and dimensional irregularities in the textile and weaving sector, thereby mitigating potential financial losses.

CONCLUSION

In summary, the comparison between ResNet and LSTM(Long Short-Term Memory) in identifying synthetic fiber defects indicates ResNet's superiority over LSTM. ResNet achieved a mean accuracy of 92.7380%, outperforming LSTM's 70.6660%. This outcome underscores ResNet's advanced feature extraction and deeper architecture with 0.011($p<0.05$) in accurately detecting synthetic fiber defects, reinforcing its position as a robust solution for addressing accuracy, defects, and dimensional irregularities in textile and weaving contexts, with a significant performance and a better impact on minimizing financial losses.

DECLARATION

Conflict of Interest

This document asserts the absence of any disclosed conflicts of interest. To uphold our dedication to academic honesty and avoid any unintentional involvement in issues concerning academic integrity, we rigorously ensured the originality of our work.

Authors Contribution

Author KNP contributed to data collection, data analysis, and manuscript writing. Meanwhile, Author PA significantly contributed to the research idea, conceptualization, and provided valuable critique throughout the manuscript review process.

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TABLES AND FIGURES

Table 1: The ResNet algorithm achieves an accuracy of 92.7380%, surpassing the LSTM(Long Short-Term Memory) algorithm, which attains 70.6660% accuracy. In accuracy terms, ResNet outperforms LSTM.

SAMPLE NO.	**RESNET(%)**	**LSTM(%)**
1.	91.11	75.56
2.	88.15	49.63
3.	91.11	25.93
4.	94.81	85.93
5.	94.07	71.11
6.	92.59	68.89
7.	94.81	80.19
8.	92.59	72.59
9.	93.33	85.91
10.	94.81	85.92
11.	91.11	85.96
12.	88.15	85.87
13.	91.11	72.52
14.	92.59	85.19
15.	94.07	68.89
16.	94.81	75.51
17.	94.81	49.68
18.	93.33	85.94
19.	92.59	25.96
20.	94.81	71.13
Average	**92.7380**	**70.6660**

Table 2: The mean accuracy for LSTM stands at 70.6660% with a standard deviation of 19.39023, while ResNet shows a mean accuracy of 92.7380% and a standard deviation of 2.14472.

Group Statistics					
Accuracy	**Group**	**N**	**Mean**	**Std.Deviation**	**Std.Error Mean**
	ResNet	20	92.7380	2.14472	0.67822
	LSTM	20	70.6660	19.39023	6.13173

Table 3: The independent samples T-test was performed to compare the accuracy groups. The results, shown in the table, indicate the t-test for equality of means and Levene's test for equality of variances (F=8.074, sig=0.01).

Independent Samples test											
		Levene's Test for Equality of Variances		**T-test for Equality of means**							
		F	**Sig.**	**t**	**df**	**Significance**		**Mean Difference**	**Std. Error Difference**	**95%Confidence Interval of the Difference**	
						1-sided p	**2-sided p**			**Lower**	**Upper**
ACCURACY	**Equal variances assumed**	8.074	.011	3.578	18	.001	.002	22.07200	6.16912	9.11116	35.03284
	Equal variances not assumed			3.578	9.220	.003	.006	22.07200	6.16912	8.16711	35.97689

Statistical Bar Graph

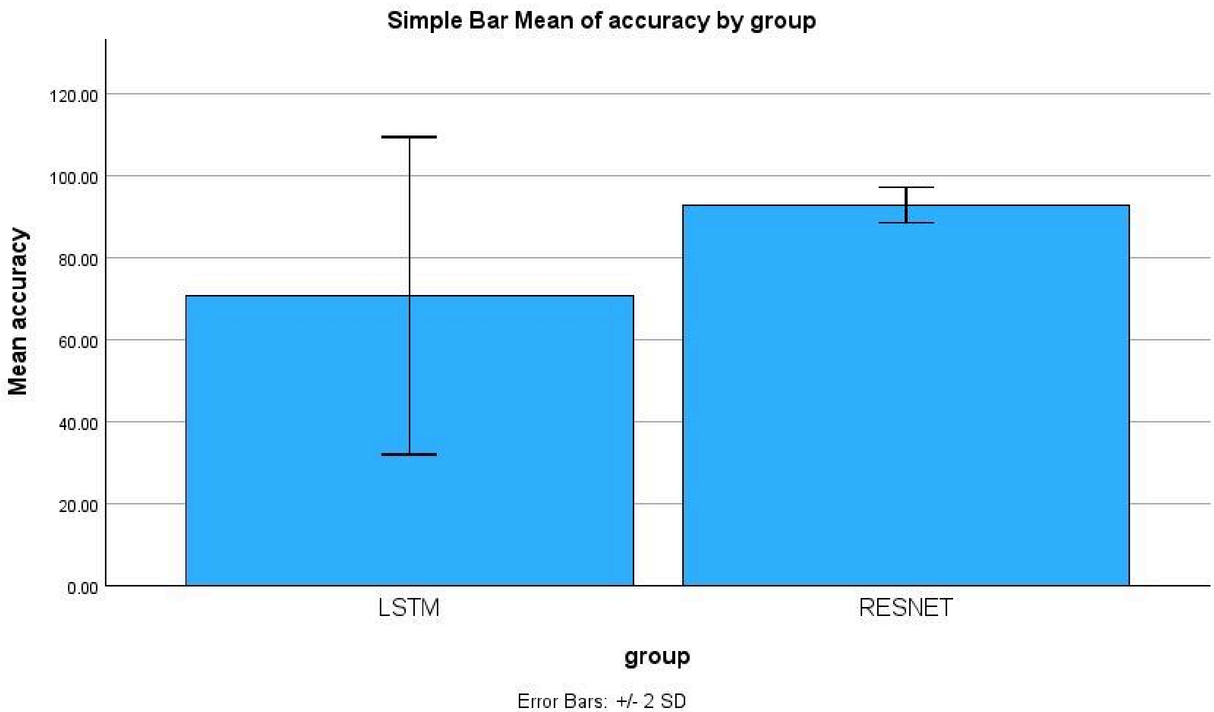

Fig 1:A notable distinction is evident in the bar graph comparing ResNet and LSTM(Long Short-Term Memory). The X-axis represents ResNet and LSTM(Long Short-Term Memory), while the Y-axis illustrates the mean with a variance of ± 1 standard deviation. ResNet notably displays a significantly higher mean compared to the values associated with LSTM.