Title Page:

Synthetic fiber defects in textiles are detected using ResNet compared with LR(Logistic Regression).

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Keywords:accuracy, defects, detection, dimensional irregularities, fabric, financial loss, LR(Logistic Regression) , ResNet, synthetic fiber, textile, weaving.

ABSTRACT

Aim: The main objective is to enhance ResNet's effectiveness compared to LR (Logistic Regression) in accurately identifying defects within synthetic fiber in textile materials.**Materials and Methods:** Two sets, ResNet and LR (Logistic Regression), each comprising 20 samples, were utilized for the comparative analysis. Sample size calculations were performed with 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 LR materials for detecting synthetic fiber defects in textile materials to minimize financial loss.**Results:** In contrast to the 83.6750% accuracy achieved by the LR (Logistic Regression) classifier, the ResNet model demonstrated a superior accuracy rate, reaching a maximum of 92.7380%. The comparison between these groups indicated a statistically significant difference through an Independent T-test analysis, displaying a p-value of 0.045 ($p<0.05$).**Conclusion:** In summary, considering constraints in resources and data, ResNet consistently outperforms the LR (Logistic Regression) approach across both sample groups.

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INTRODUCTION

The textile industry faces persistent challenges in identifying imperfections within synthetic fiber materials, a crucial concern impacting the overall quality of products. Accurate detection of flaws, including dimensional irregularities and weaving inconsistencies(Z. Chen et al. 2022), is of paramount importance to ensure the integrity and performance of textiles. Ranging from subtle irregularities to more noticeable inconsistencies, these defects significantly affect fabric quality and structural robustness(Lu and Huang 2023). Traditional approaches often struggle to discern these subtle differences, necessitating advanced technical solutions for precise defect identification. This research aims to transform the identification of defects in synthetic fiber production, potentially reducing financial losses associated with flawed processes in textile manufacturing. The research delves into critical aspects such as accuracy, defect detection(Hoffmann and Reich 2023), dimensional irregularities, and the role of advanced techniques in improving defect identification and minimizing financial losses in the textile and weaving industry.

In recent years, extensive research has been dedicated to refining the detection methods for identifying defects in synthetic fiber textiles. Through comprehensive exploration of databases such as IEEE Xplore, Springer, and Elsevier, a wealth of publications, including 890 articles on Science Direct and over 196 pieces on Google Scholar, have focused on this aspect of detection. The textile industry categorizes synthetic fibers based on quality, distinguishing between first-grade fabric devoid of significant defects and second-grade fabric exhibiting noticeable flaws(Lin et al. 2020). These imperfections contribute to substantial financial losses, with more than half of second-grade fabric production linked to undetected flaws(Liu et al. 2021). Manual inspection methods, susceptible to human error and fatigue, achieve moderate accuracy rates ranging from 60% to 75%(J. Zhang, Cosma, and Watkins 2021). The delayed identification of flaws and manual inspection further hampers production efficiency, resulting in additional financial losses. However, advancements in computer science and machine vision have introduced automated fabric inspection(Wen, Huang, and Guo 2021), leading to improved quality control. This investigation aims to refine algorithms for detecting dimensional irregularities and weaving flaws in synthetic fibers, influencing defect identification and enhancing fabric quality in textile manufacturing, ultimately reducing potential financial losses.

In the domain of identifying defects in textiles, ResNet emerges as the leading performer, outshining even the captivating LR (Logistic Regression) in its pursuit of flawless fabrics. While both deep learning techniques gracefully navigate the stage(Rajabizadeh and Rezghi 2021), ResNet's unique ability to comprehend intricate patterns and grasp long-range dependencies within fabric structures takes center stage. Its unparalleled precision in identifying dimensional irregularities and weaving flaws within synthetic fibers, particularly in elaborate weaves and complex patterns, cements ResNet's well-deserved standing ovation(Damayanti et al. 2021). Consequently, the textile industry commends ResNet for its superior accuracy and cost-saving advantages, recognizing it as the true luminary in textile defect detection.

MATERIALS AND METHODS

This research took place in the Data Analytics lab of Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences in Chennai, India. The lab boasts a highly adaptable system that facilitates precise research and meticulous results. The study involved twenty participants, evenly distributed into two groups: the ResNet ensemble and the LR (Logistic Regression) ensemble(Nowrin et al. n.d.2021). The researchers maintained stringent statistical rigor, ensuring a power level of 0.8 (beta), a significance level of 0.05 (alpha), and a 95% confidence level. Additionally, the study's statistical robustness was enhanced with an 80% G-Power value. With this resilient framework in place, the researchers aimed to determine whether ResNet's proficiency in pattern recognition and its ability to capture long-range dependencies within fabric structures could surpass the capabilities of LR in detecting textile defects.

The main objective of this research is to evaluate the identification of defects in synthetic fiber textiles using images from the "AITEX Fabric Image Database" dataset. This dataset includes crucial defect variables such as broken end, dimensional irregularities, broken yarn, broken pick, warp ball, weft crack, Nep, and Knots, aiming to enhance accuracy in defect detection.

Leveraging the preprocessed dataset that encompasses these diverse features, the ResNet algorithm is utilized for the examination of defect detection(Wang et al. 2020). The dataset comprises 245 images representing seven unique fabric types, with 20 defect-free images for each type out of 140, while the remaining 105 images exhibit various flaws. Sized at 4096 x 256 pixels, these images form the basis for evaluating defect detection in synthetic fiber textiles, highlighting the critical importance of accuracy and its impact on financial losses in the textile and weaving industry.

The approach adopted in this research involved scrutinizing a specific dataset and contrasting its outcomes with the widely recognized EfficientNet algorithm. This dataset, structured as an image dataset, encompasses a diverse array of data values. To ensure a comprehensive analysis and comparison(H. Zhang et al. 2021), the dataset underwent meticulous scrutiny employing the algorithms detailed in this research. The hardware setup included an Intel dual-core processor with 8 GB of RAM. Utilizing Jupyter Notebook, Python, and a MySQL database, the software environment offered a stable framework for executing the algorithm and facilitating the comparative analysis.

ResNet

ResNet, an abbreviation for Residual Networks, represents an innovative architectural design that effectively addresses the vanishing gradient problem in deep learning through its unique skip connections. This distinctive feature empowers ResNet to explore intricate patterns within textile images, making it a robust choice for identifying defects in synthetic fiber textiles. Through the integration of dense layers and the utilization of its understanding of complex correlations, ResNet excels in recognizing dimensional irregularities and flaws in fabric weaves. Trained on fabric image databases and employing loss functions like mean squared error, the model undergoes thorough evaluation on independent datasets to ensure its accuracy and efficacy in identifying textile faults, thereby minimizing potential financial losses associated with defective fabric production.

Logistic Regression

LR (Logistic Regression), distinguished by its innovative scaling technique, delivers a well-balanced network design that optimizes depth, width, and resolution for efficient and accurate defect detection in textile materials. Employing compound scaling, LR achieves enhanced computational efficiency while maintaining robust performance in identifying dimensional irregularities and flaws in synthetic fiber weaves. Trained on fabric image datasets and guided by a suitable loss function like mean squared error, LR's effectiveness is meticulously evaluated across diverse datasets to assess its capability in defect detection and reducing potential financial losses in the textile industry. Enriched with dense layers, the LR model adeptly learns complex fabric structures, ensuring a detailed analysis of defects and a high level of accuracy in fault identification within textile imagery.

Statistical Analysis

In the comparison between ResNet and LR (Logistic Regression), ResNet is considered the dependent variable, while LR is positioned as the independent variable, maintaining this arrangement throughout the evaluation of their effectiveness and performance. In 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 such as accuracy counts, mean values, standard error, and standard mean error(Mahalakshmi et al. 2023). The analysis encompasses tables for mean equality tests, Levene's variance equality tests, and an accuracy bar graph. On the visual representation, the Y-axis illustrates mean accuracy, while the X-axis showcases diverse algorithm parameters.

RESULTS

The accuracy of the raw data for both ResNet and LR (Logistic Regression) is outlined in Table 1, with each containing 20 samples. Table 2 presents standard deviations of 2.14472 and 2.03773, standard error mean values of 0.67822 and 0.64439, and mean accuracy rates of 92.7380% and 83.6750% for ResNet and LR, respectively, with an N of 20.

Table 3 demonstrates the T-test outcomes for mean equality, conducting a two-tailed independent test, indicating an "F" value of 0.003 assuming equal variances. The 95% confidence intervals, assuming equal variances and without that assumption, disclose ranges of 11.02848 to 11.02885 in the upper case and 7.09752 to 7.09715 in the lower case. Figure 1 portrays a bar graph plotting groups on the X-axis and mean accuracy on the Y-axis, clearly illustrating ResNet's superiority over LR with a value of 0.045 ($p<0.05$) for single-tailed analysis.

DISCUSSION

The research outcomes indicate that for synthetic fiber defect detection, the mean accuracy of the LR (Logistic Regression) model is 80.5190%, whereas the ResNet classifier achieves a higher accuracy rate of 92.7380%. This underscores ResNet's superior performance compared to LR in the detection of synthetic fiber defects(W. Chen et al. 2020). Through the use of an Independent T-test, the obtained p-value of 0.043 ($p<0.05$) further underscores ResNet's enhanced efficacy over LR in accurately identifying defects in textile materials.

The dataset encompasses a comprehensive range of textile flaws, covering dimensional irregularities and weaving defects in synthetic fibers. It provides insights into texture, color variations, tensile strength, and surface imperfections. This dataset aims to bridge the gap between textile stakeholders and decision-makers, aiding in production and investment strategies within the industry(Kokabi et al. 2023). ResNet and LR (Logistic Regression), as potent deep learning approaches, play a pivotal role 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. Despite LR's advantages, ResNet's robustness and superior accuracy, reaching 92.7380% compared to LR's 80.5190%(Valdenegro-Toro 2019), establish it as the preferred choice for intricate visual tasks in detecting synthetic fiber defects, thereby mitigating potential financial losses associated with substandard fabric production.

The assessment identified limitations specific to LR (Logistic Regression), particularly concerning model efficacy in handling defect diversity, uncertain adaptability across fabric types, and the substantial need for abundant labeled data. Additionally, challenges emerged in terms of complexities in deployment and unexplored scenarios(Park et al. 2022). However, despite these limitations, ResNet consistently demonstrated superiority in synthetic fiber defect detection, establishing it as a more dependable choice for addressing accuracy, defects, and dimensional irregularities in the textile and weaving sector, thereby mitigating potential financial losses.

CONCLUSION

In summary, the assessment of ResNet and LR (Logistic Regression) for synthetic fiber defect identification underscores ResNet's superiority over LR. ResNet achieved a mean accuracy of 92.7380%, surpassing LR's 83.6750%. This outcome emphasizes ResNet's advanced feature extraction and deeper architecture with a significance level of 0.043 ($p<0.05$) in accurately identifying synthetic fiber defects. This solidifies ResNet's role as a potent solution for addressing accuracy, defects, and dimensional irregularities in textile and weaving scenarios, showcasing notable performance and a more effective impact on minimizing financial losses.

DECLARATION

Conflict of Interest

This statement confirms the absence of any disclosed conflicts of interest. In upholding our commitment to academic honesty and avoiding unintentional involvement in matters related to academic integrity, we diligently ensured the originality of our work.

Authors Contribution

KNP actively engaged in collecting and analyzing data, as well as composing the manuscript. Conversely, PA played a significant role in shaping the research idea and offered valuable feedback throughout the manuscript review process.

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TABLES AND FIGURES

Table 1: The ResNet algorithm demonstrates a 92.7380% accuracy, outperforming the LR (Logistic Regression) algorithm, which achieves an accuracy of 83.6750%. ResNet exhibits superior accuracy compared to LR.

SAMPLE NO.	RESNET(%)	LR(%)
1.	91.11	85.84
2.	88.15	80.18
3.	91.11	83.96
4.	94.81	82.09
5.	94.07	84.91
6.	92.59	81.13
7.	94.81	83.96
8.	92.59	85.84
9.	93.33	83.01
10.	94.81	85.84
11.	91.11	84.91
12.	88.15	82.09
13.	91.11	83.96
14.	92.59	80.18
15.	94.07	85.84
16.	94.81	85.84
17.	94.81	83.01
18.	93.33	85.84
19.	92.59	83.96
20.	94.81	81.13
Average	**92.7380**	**83.6750**

Table 2: The LR (Logistic Regression) model achieves a mean accuracy of 83.6750%, accompanied by a standard deviation of 2.03773. In contrast, ResNet exhibits a mean accuracy of 92.7380% with 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
	LR	20	83.6750	2.03773	0.64439

Table 3: The T-test for independent samples was conducted to assess the comparison between the accuracy groups. The outcomes, presented in the table, reveal the t-test for equal means and Levene's test for equal variances (F=4.741, sig=0.43).

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**	0.003	.045	9.688	18	.000	.000	9.06300	.93553	7.09752	11.02848
	Equal variances not assumed			9.688	17.953	.000	.000	9.06300	.93553	7.09715	11.02885

Statistical Bar Graph

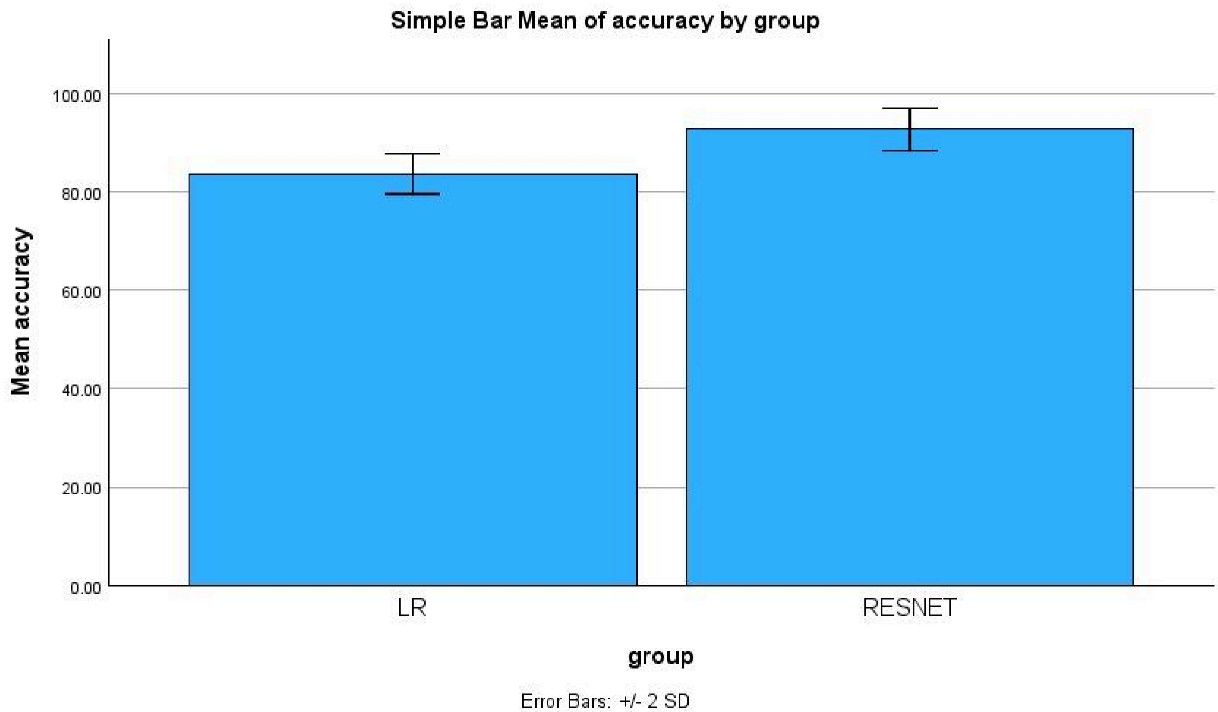

Fig 1:Illustrates a notable distinction in the bar graph between ResNet and LR (Logistic Regression). On the X-axis, ResNet and LR are depicted, while the Y-axis shows the mean with a variance of ± 1 standard deviation. Remarkably, ResNet demonstrates a substantially higher mean in comparison to the values linked with LR.