Title Page:

Analysis and performance of ResNet to detect synthetic fiber defects in textiles in comparison with EfficientNet.

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Keywords: defects, detection, dimensional irregularities,EfficientNet, fabric,financial loss, ResNet, synthetic fiber,textile,weaving.

ABSTRACT

Aim: The research aims to enhance the better performance of ResNet,prior to EfficientNet in detection of synthetic fiber defects in textiles. **Materials and Methods:**Two groups, ResNet and EfficientNet, both consisting of 20 samples, were employed in the comparative analysis. Sample size calculations were conducted with an alpha value of 0.05 and 80% of G-power using Clinicalc.com. To assess performance, dimensional irregularities and weaving errors are involved altering the ResNet and EfficientNet materials in the analysis of synthetic fiber defect detection in textiles.**Results:**Compared to the EfficientNet classifier,which achieved an accuracy of 73.64%, the ResNet model was able to achieve a maximum accuracy of 92.73% for the ResNet classifier.Between the groups,there is a statistical analysis of Independent T-test significant difference with a p-value of 0.011($p<0.05$).**Conclusion:**In conclusion,the ResNet approach performs significantly better in both sample groups than the EfficientNet technique, given the constraints of the available resources and data sources.

Keywords: defects, detection, dimensional irregularities,EfficientNet, fabric,financial loss, ResNet, synthetic fiber,textile,weaving.

INTRODUCTION

The textile industry, a pivotal sector in manufacturing, encounters inherent challenges when detecting defects in synthetic fibers.Identifying defects in textiles, such as dimensional irregularities and weaving inconsistencies(Jing et al. 2020), remains critical for quality assurance.These flaws, which can range in size from tiny flaws to large inconsistencies(Zhang et al. 2022), can have a big effect on the fabric's overall performance,structural integrity, and quality(Ho, Chou, and Su 2021).In order to identify defects accurately and efficiently,sophisticated technical solutions are typically required because traditional approaches are inadequate in detecting small differences(Li et al. 2023).This exploration seeks to refine how the industry identifies and addresses flaws in synthetic fiber production, potentially curbing financial losses attributed to faulty textile manufacturing processes(Kahraman and Durmuşoğlu 2022).

Over the past few years, extensive research has concentrated on enhancing the detection of synthetic fiber defects in textiles(Thakur et al. 2022).After a thorough search of the Scopus database,such as IEEE Xplore,Springers and Elsevier it was discovered that there have been 1468 publications in Science Direct and over 229 articles on Google Scholar regarding detection.The textile industry categorizes synthetic fibers based on their quality and flaws, distinguishing between first-grade fabric without significant flaws and second-grade fabric with noticeable defects(Kai et al. 2023).These flaws lead to substantial financial losses,with undetected defects contributing to over half of second-grade fabric production. Traditional manual inspection methods are prone to human error and fatigue(Priya et al. 2023), achieving only 60%–75% accuracy rates. Delayed flaw discovery and manual inspection also create production bottlenecks. However, advancements in computer science and machine vision have paved the way for automated fabric inspections, promising enhanced quality control(Jun et al. 2020) and reliability in the manufacturing process. This exploration focuses on optimizing algorithms to detect dimensional irregularities and weaving flaws in synthetic fibers(Ouyang et al. n.d.2019), significantly impacting defect detection and enhancing fabric quality in textile manufacturing.

Textile defect detection requires various methodologies,statistical approaches,machine learning,deep learning techniques and leveraging advancements in computer vision(Feng et al. 2019).Despite of the existing EfficientNet,the introduction of ResNet helps to develop a robust detection model, aiming to improve accuracy in detecting synthetic fiber flaws, weaving irregularities(Sudha and Sujatha n.d.2021), addressing financial losses in fabric materials offering a solution to this issue. ResNet's precision in detecting dimensional irregularities and defects within synthetic fiber textile materials, particularly in weaving and fabric, showcases its superiority over EfficientNet, mitigating financial loss.

MATERIALS AND METHODS

This investigation was conducted at the Data Analytics lab in the Saveetha School of Engineering,Saveetha Institute of Medical and Technical Sciences,Chennai,India. In the lab, an extremely adjustable system allows for thorough research and precise results. There were 20 participants in all, divided into two two groups(Çelik et al. 2022):the ResNet group and the EfficientNet group.Maintaining a power level of 0.8 (beta), significance level of 0.05 (alpha) and a 95% confidence level and the research's statistical power was upheld with an 80 percent G-Power value.

The primary goal of this research is to analyze the synthetic fiber defect detection in textiles using the images folder structured "AITEX Fabric Image Database" dataset. The information includes variables like broken end,broken yarn,broken pick,warp ball,weft crack,Nep,Knots to improve detection accuracy(He Y et al. 2021).The preprocessed dataset with these various features is used for training and testing of the ResNet algorithm in order to analyze the performance of defect detection.There are 245 photos of seven distinct fabrics in the textile fabric database.Twenty photos for each type of cloth out of 140 are free of defects.There are 105 pictures with various kinds of flaws.A picture's dimensions are 4096 x 256 pixels.

The approach presented in this research was applied to a specific dataset, and the outcomes were contrasted with those of the well-known EfficientNet algorithm. The dataset is set up in this case as an image dataset, which holds a range of data values.To perform a comprehensive examination and comparison(Fang et al. n.d.2022), the dataset was subjected to a detailed analysis of the records using the algorithms presented in this research.The gear setup for this work was an Intel dual-core processor with 8 GB of RAM. Utilizing Jupyter Notebook, Python, and a MySQL database, the software configuration offered a stable platform for executing the algorithm and doing the comparative analysis.

ResNet

ResNet, denoting Residual Networks, stands as a pioneering architecture with its innovative skip connections addressing the vanishing gradient problem in deep learning. This attribute allows ResNet to delve into intricate patterns within textile images, making it a robust choice for detecting defects in synthetic fiber textiles. By integrating dense layers and leveraging its understanding of complex correlations, ResNet is adept at recognizing dimensional irregularities and flaws in fabric weaves. Trained using fabric image databases and employing loss functions like mean squared error, the model undergoes rigorous evaluation on independent datasets to ensure its accuracy and effectiveness in identifying textile faults and potential financial losses due to defective fabric production.

EfficientNet

EfficientNet, with its novel scaling technique, offers a balanced network design, optimizing depth, width, and resolution, ensuring both efficiency and accuracy in identifying defects within textile materials. This methodical approach, using compound scaling, facilitates enhanced computational efficiency while maintaining robust performance in pinpointing dimensional irregularities and flaws in synthetic fiber weaves. Trained on fabric image datasets and guided by mean squared error as a fitting loss function, EfficientNet's efficacy is thoroughly scrutinized across distinct datasets, gauging its capacity to detect defects and mitigate potential financial losses in the textile industry. This algorithmic model, enriched with dense layers, adeptly learns complex fabric structures, ensuring a meticulous analysis of defects and a high level of accuracy in fault identification within textile imagery.

Statistical Analysis

SPSS(Statistical Product and Service Solutions)version 26 generates graphs using accuracy data. Regression analysis, t-tests,mean comparisons, group statistics,including accuracy counts (N), mean,standard error,and standard mean error(Meng et al. 2022),were obtained from T-tests of the two groups,ResNet and EfficientNet.Results comprised tables for mean equality tests,Levene's variance equality tests, and an accuracy bar graph have analyzed ResNet is the dependent variable, while EfficientNet serves as the independent variable making the efficacy and performance of the comparative analysis.The Y-axis displayed mean accuracy, and the X-axis represented different algorithm parameters.

RESULTS

The accuracy raw data table for both ResNet and EfficientNet is displayed in Table 1 with sample sizes of 20.Table 2, which displays Std.Deviation as 2.14472 and 23.12153,Std.Error Mean as .67822 and 7.31167 and has a mean accuracy values of 92.7380% and 73.6420% for ResNet and EfficientNet approach respectively of N=20.

Table 3 displays the T-test results for mean equality, with a two-tailed independent test conducted and displays the "F" value as 8.149 with equal variances assumed.The 95% confidence intervals of the differences, assuming equal variances and without that assumption, show a range of 34.52319 to 35.66442 in the upper case and 3.66881 to 2.52358 in the lower case.The bar graph displayed in Figure 1 is the result of plotting groups on the X-axis and mean accuracy on the Y-axis. The graph clearly shows that ResNet is more accurate than EfficientNet by a value of 0.011($p<0.05$)for single-tailed.

DISCUSSION

The research observations reveal that detecting synthetic fiber defects in textiles has examined the mean accuracy for the EfficientNet as 73.6420%,whereas the ResNet classifier has a 92.7380% accuracy rate. This suggests that in comparison to EfficientNet,ResNet performs better with utilizing an Independent T-test,and obtains a p-value of 0.011($p<0.05$).

The dataset consisting of dimensional irregularities,weaving defect images of textiles and clean fabrics provides a comprehensive set of columns detailing textile flaws, particularly in synthetic fibers, encompassing texture, color changes, tensile strength, and surface imperfections(An et al. n.d.2020). This dataset aims to bridge the gap between textile stakeholders and decision-makers in production and investment strategies(Saberi Ronaghi, Ren, and El-Gindy 2023). In the analysis of synthetic fiber defect detection, ResNet and EfficientNet, two powerful deep learning methods, play crucial roles. ResNet, known for its deep-layered networks and skip connections, excels in identifying complex patterns(Çıklaçandır, Utku, and Özdemir 2021), making it highly effective in recognizing flaws like dimensional irregularities and weaving defects in fabric(Yang et al. 2020).Despite EfficientNet's scaling advantages, ResNet's robustness and superior accuracy with 92.7380% compared to 73.6420% for EfficientNet in position as the optimal choice for challenging visual tasks in synthetic fiber defect detection in textiles, minimizing financial losses associated with subpar fabric production.

In assessing both ResNet and EfficientNet, limitations were evident in EfficientNet, primarily linked to model effectiveness concerning defect diversity, uncertain generalization across fabric types, and the demand for extensive labeled data. Additionally, computational complexities for deployment and unexplored scenarios surfaced. Despite this, ResNet consistently showcased superiority in detecting defects within synthetic fiber textiles, affirming its potential as a more dependable choice in addressing accuracy, defects, and dimensional irregularities, particularly in the textile and weaving industry, ultimately minimizing financial losses.

CONCLUSION

In conclusion,ResNet outperformed EfficientNet in synthetic fiber defect identification, as shown by the analysis and performance evaluation of the two networks.ResNet is statistically better than EfficientNet,achieving a mean accuracy of 92.7380% compared to 73.6420%, showcasing superior synthetic fiber defect identification capabilities due to its advanced feature extraction and deeper architecture with 0.011($p<0.05$).

DECLARATION

Conflict of Interest

This paper contains no declared conflicts of interest. To maintain our commitment to academic integrity and prevent any inadvertent participation with concerns related to academic dishonesty, we carefully checked that our work is original.

Authors Contribution

Author KNP was facilitated in the data collection,data analysis, and manuscript writing.On the other hand, Author PA made a significant contribution to the research idea, conceptualization, and offered wise criticism throughout the manuscript review procedure.

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REFERENCES

An, Meng, Shiyu Wang, Liaomo Zheng, and Xinjun Liu. n.d. "Fabric Defect Detection Using Deep Learning: An Improved Faster R-Approach." Accessed January 10, 2024. https://ieeexplore.ieee.org/abstract/document/9270434.

Çelik, Halil İbrahim, Lale Canan Dülger, Burak Öztaş, Mehmet Kertmen, and Elif Gültekin. 2022. "A Novel Industrial Application of CNN Approach: Real Time Fabric Inspection and Defect Classification on Circular Knitting Machine." Textile and Apparel 32 (4): 344–52.

Çıklaçandır, Fatma Günseli Yaşar, Semih Utku, and Hakan Özdemir. 2021. "Fabric Defect Classification Using Combination of Deep Learning and Machine Learning." Journal of Artificial Intelligence and Data Science 1 (1): 22–27.

Fang, Bin, Xingming Long, Fuchun Sun, Huaping Liu, Shixin Zhang, and Cheng Fang. n.d. "Tactile-Based Fabric Defect Detection Using Convolutional Neural Network With Attention Mechanism." Accessed January 10, 2024. https://ieeexplore.ieee.org/abstract/document/9772441.

Feng, Zunlei, Weixin Liang, Daocheng Tao, Li Sun, Anxiang Zeng, and Mingli Song. 2019. "CU-Net: Component Unmixing Network for Textile Fiber Identification." International Journal of Computer Vision 127 (10): 1443–54.

He, Yuan. 2021. "Fabric Defect Detection Based on Improved Faster RCNN," July. https://papers.ssrn.com/abstract=3939685.

Ho, Chao-Ching, Wei-Chi Chou, and Eugene Su. 2021. "Deep Convolutional Neural Network Optimization for Defect Detection in Fabric Inspection." Sensors 21 (21): 7074.

Jing, Junfeng, Zhen Wang, Matthias Rätsch, and Huanhuan Zhang. 2020. "Mobile-Unet: An Efficient Convolutional Neural Network for Fabric Defect Detection." Textile Research Journal, May. https://doi.org/10.1177/0040517520928604.

Jun, Xiang, Jingan Wang, Jian Zhou, Shuo Meng, Ruru Pan, and Weidong Gao. 2020. "Fabric Defect Detection Based on a Deep Convolutional Neural Network Using a Two-Stage Strategy." Textile Research Journal, June. https://doi.org/10.1177/0040517520935984.

Kahraman, Yavuz, and Alptekin Durmuşoğlu. 2022. "Deep Learning-Based Fabric Defect Detection: A Review." Textile Research Journal, October. https://doi.org/10.1177/00405175221130773.

Kai, Y. U., L. Y. U. Wentao, Y. U. Xuyi, G. U. O. Qing, X. U. Weiqiang, and Lu Zhang. 2023. "FA-YOLO: A High-Precision and Efficient Method for Fabric Defect Detection in Textile Industry." IEICE Transactions on Fundamentals of Electronics, Communications and Computer Sciences, September, 2023EAP1030.

Li, Long, Qi Li, Zhiyuan Liu, and Lin Xue. 2023. "Effective Fabric Defect Detection Model for High-Resolution Images." NATO Advanced Science Institutes Series E: Applied Sciences 13 (18): 10500.

Meng, Shuo, Ruru Pan, Weidong Gao, Benchao Yan, and Yangyang Peng. 2022. "Automatic Recognition of Woven Fabric Structural Parameters: A Review." Artificial Intelligence Review 55 (8): 6345–87.

Ouyang, Wenbin, Bugao Xu, Jue Hou, and Xiaohui Yuan. n.d. "Fabric Defect Detection Using Activation Layer Embedded Convolutional Neural Network." Accessed January 10, 2024. https://ieeexplore.ieee.org/abstract/document/8701450.

Priya, D. Karthika, B. Sathya Bama, M. P. Ramkumar, and S. Mohamed Mansoor Roomi. 2023. "STD-Net: Saree Texture Detection via Deep Learning Framework for E-Commerce Applications." Journal of VLSI Signal Processing Systems for Signal, Image, and Video

Technology, September, 1–9.
Saberi Ronaghi, Alireza, Jing Ren, and Moustafa El-Gindy. 2023. “Defect Detection Methods for Industrial Products Using Deep Learning Techniques: A Review.” Algorithms 16 (2): 95.
Sudha, K. K., and P. Sujatha. n.d. “Robust and Rapid Fabric Defect Detection Using EGNet.” Accessed January 10, 2024. https://ieeexplore.ieee.org/abstract/document/9711875.
Thakur, Rashmi, Deepak Panghal, Prabir Jana, Rajan, and Ankit Prasad. 2022. “Automated Fabric Inspection through Convolutional Neural Network: An Approach.” Neural Computing & Applications 35 (5): 3805–23.
Yang, Jing, Shaobo Li, Zheng Wang, Hao Dong, Jun Wang, and Shihao Tang. 2020. “Using Deep Learning to Detect Defects in Manufacturing: A Comprehensive Survey and Current Challenges.” Materials 13 (24): 5755.
Zhang, Hongwei, Guanhua Qiao, Shuai Lu, Le Yao, and Xia Chen. 2022. “Attention-Based Feature Fusion Generative Adversarial Network for Yarn-Dyed Fabric Defect Detection.” Textile Research Journal, October. https://doi.org/10.1177/00405175221129654.

TABLES AND FIGURES

Table 1: Representing the ResNet's accuracy of 92.7380% and the EfficientNet algorithms' accuracy of 73.6420%. In terms of accuracy, the ResNet Algorithm outperforms the EfficientNet Algorithm.

SAMPLE NO.	RESNET(%)	EFFICIENT NET(%)
1.	91.11	85.93
2.	88.15	53.33
3.	91.11	14.07
4.	94.81	84.44
5.	94.07	85.19
6.	92.59	79.26
7.	94.81	80.12
8.	92.59	85.93
9.	93.33	82.22
10.	94.81	85.93
11.	91.11	85.96
12.	88.15	85.14
13.	91.11	84.48
14.	92.59	53.32
15.	94.07	14.05
16.	94.81	85.91
17.	94.81	82.24
18.	93.33	79.29
19.	92.59	80.09
20.	94.81	85.93
Average	**92.7380**	**73.6420**

Table 2: Group Statistics Results: EfficientNet has a mean accuracy of 73.6480% and a St. Deviation of 23.12153, whereas ResNet has a mean accuracy of 92.7380% and a St. Deviation of 2.14472.

Group Statistics					
Accuracy	**Group**	**N**	**Mean**	**Std.Deviation**	**Std.Error Mean**
	ResNet	20	92.7380	2.14472	0.67822
	EfficientNet	20	73.6420	23.12153	7.31167

Table 3:T-test for independent Results from samples were conducted for the two accuracy groups. The table below displays the results of the t-test for equality of means and the Levene's test for equality of variances (F=16.041,sig=0.01).

Independent Samples test										
		Levene's Test for Equality of Variances		**T-test for Equality of means**						
		F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95%Confidence Interval of the Difference**	
									Lower	**Upper**
ACCURACY	**Equal variances assumed**	8.149	.011	2.601	18	.018	19.09600	7.34306	3.66881	34.52319
	Equal variances not assumed			2.601	9.155	.028	19.09600	7.34306	2.52758	35.66442

Statistical Bar Graph

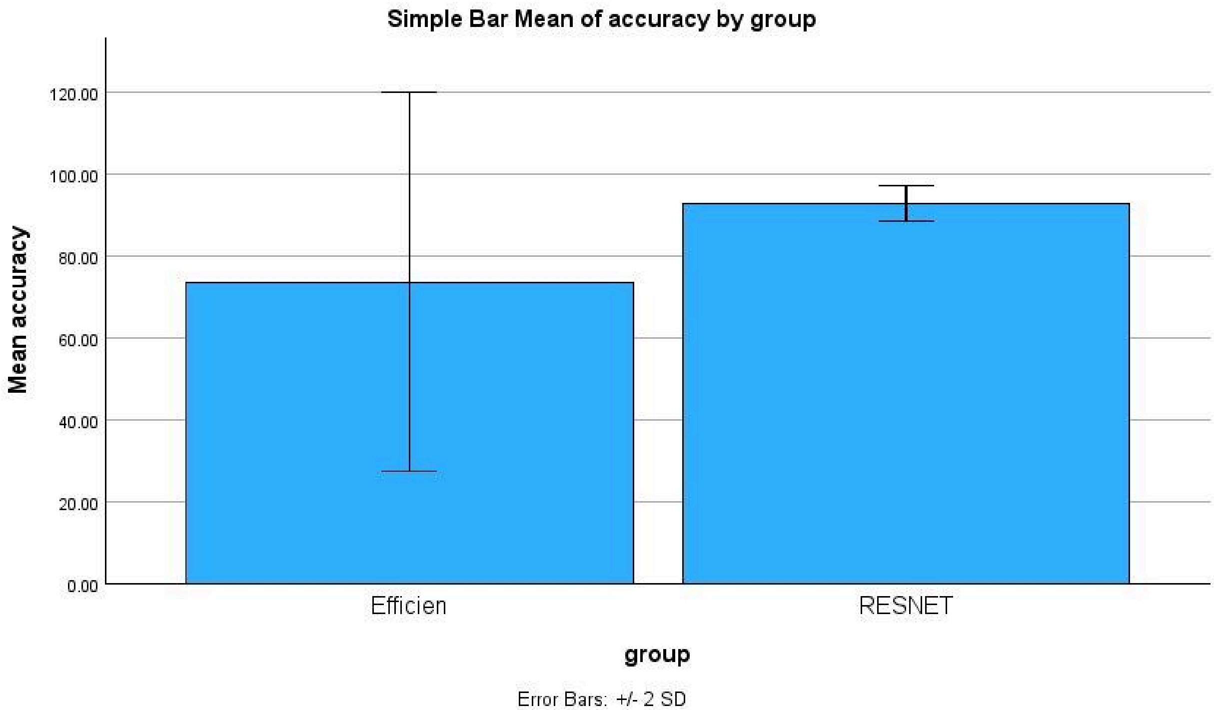

Fig 1:A bar graph comparing ResNet and EfficientNet as parameters indicates a noteworthy difference.ResNet exhibits a substantially higher mean compared to those based on EfficientNet. The X-axis portrays ResNet and EfficientNet,while the Y-axis represents mean with a variance of ± 1 standard deviation.