NC STATE UNIVERSITY

22-263 Development of Deep Learning Based Nonwoven Uniformity Analysis

Mingwei Gao[1], Eunkyuong Shim[2], Mengmeng Zhu[2]

College of Engineering, NC State University[1]; Willson College of Textile, NC State University[2]

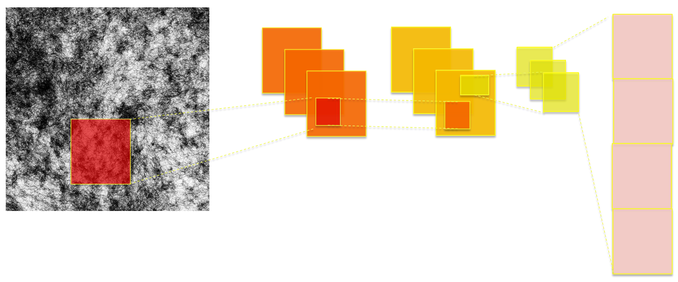
Motivition and Objective

- Nonwoven fabric quality depends on uniformity, but most assessment methods are limited to defect detection.
- CNN-based deep learning offers new possibilities for improving detection.

Objective: Build a robust deep learning framework for comprehensive nonwoven uniformity assessment.

Objective for this reporting period: To review the development of CNNs, as well as key algorithms and frameworks.

CNN Overview



Original Image

Convolutional Layer
Extract features

Active Layer
Determine whether neurons are activated;
Add non-linear factors

Pooling Layer
Reduce spatial dimensions and computation;
Increase robustness

Full Connectionl Layer
Feature combination; Final decision-making

Milstones of CNN

- **Neocognitron 1980** — The first computer vision model based on animal vision
- **LeCun 1989** — Applied the backpropagation algorithm to train a multi-layer neural network
- **LeNet 1998** — The foundation for modern CNNs
- **AlexNet 2012** — Marked a milestone in transitioning CNNs from academic models to commercial applications.
- **ZFNet 2013** — Improved performance over AlexNet; Reduced the first convolutional layer's filter size
- **VGG Series 2014** — Deeper network structures; Smaller convolutional kernels
- **GoogLeNet Series 2014** — Introduced the Inception module; Balancing network depth and width while improving
- **ResNet 2015** — Introduced the residual connections; Solved the vanishing gradient problem
- **R-CNN series 2015** — Introduced the region proposal network; Promoted feature reuse; Reduced the number of parameters
- **DenseNet 2017** — Denser layer connections; Promoted feature reuse; Reduced the number of parameters
- **MobileNet 2017** — Introduced depthwise separable convolution; Reduced the number of parameters
- **Deformable Convolutional Networks 2017** — Allowed convolution kernels to dynamically adjust sampling positions; Improved the network's ability to detect irregular objects
- **EfficientNet 2019** — Proposed compound scaling; Optimized the depth, width, and resolution of the network simultaneously

Next Step

- Expand dataset to include nonwoven uniformity images (both electronic and synthetic)
- Explore advanced architectures (RNNs, Transformers)

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