Convolutional Neural Network (CNN)

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INTRODUCTION

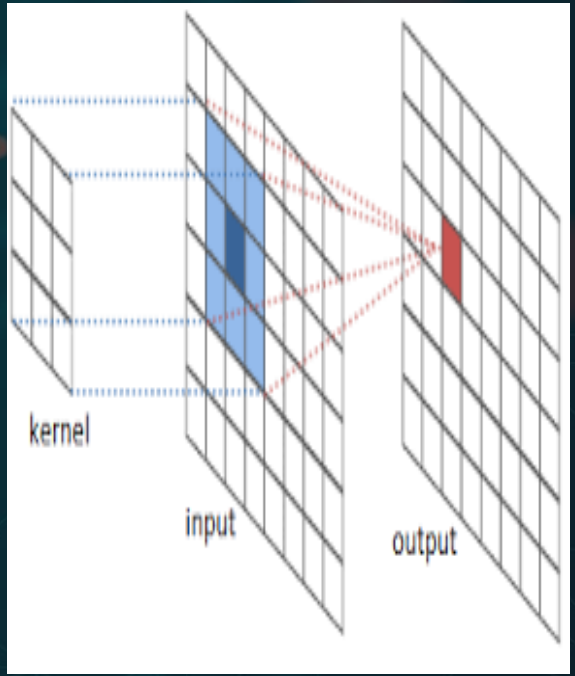
- A Convolutional Neural Network (CNN) is a type of artificial neural network designed for processing structured grid data, such as images and videos.
- The primary purpose of a CNN is to efficiently and automatically learn hierarchical representations of features from input data.
- In the context of image processing, CNNs excel at tasks like image classification, object detection, and image segmentation
- Popular CNN architectures include LeNet, AlexNet, VGGNet, GoogLeNet, DenseNet, MobileNet ,and ResNet.

Characteristics of CNN

1. Convolutional Layers
2. Pooling Layers
3. Fully Connected Layer
4. Activation Functions
5. Weight Sharing
6. Stride
7. Padding
8. Feature Maps
9. Dropout
10. Loss Function
11. Optimization Algorithms
12. Softmax

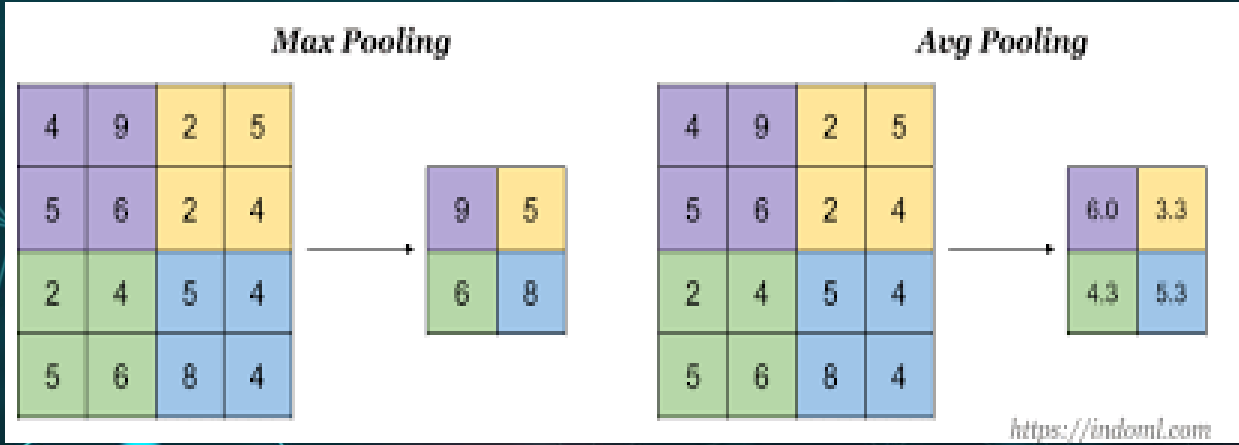
CONVOLUTIONAL LAYERS

- CNNs use convolutional layers to scan an input image or feature map using small, learnable filters (kernels).
- These filters slide over the input data, applying convolution operations to detect patterns and features.
- Convolutional layers are responsible for feature extraction.



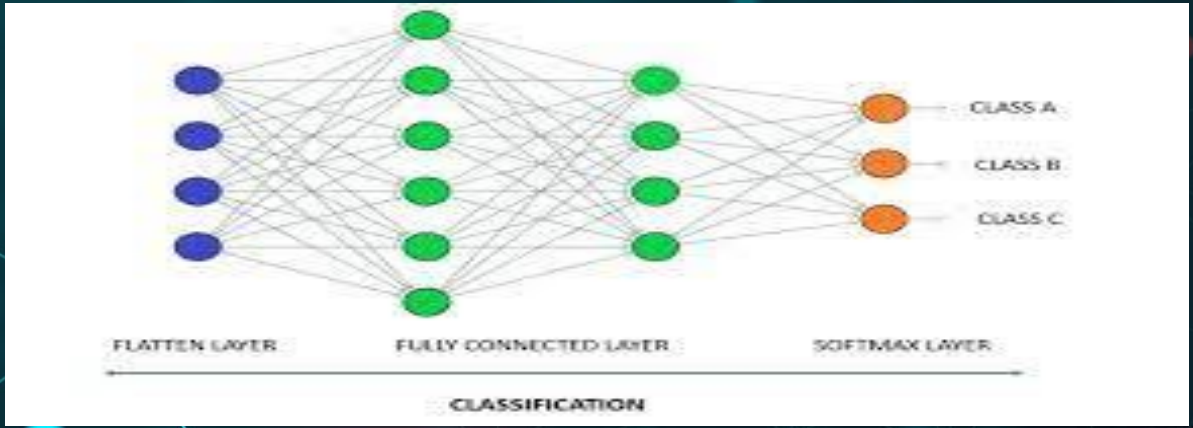
POOLING LAYERS

- The main purpose of pooling layer is to progressively reduce the spatial size of the input image, so that number of computations in the network are reduced.
- Pooling performs down sampling by reducing the size and sends only the important data to next layers in CNN.



FULLY CONNECTED LAYERS

- Fully connected layers are used to perform high-level reasoning and classification.
- These layers take the output from the previous layers and map it to the desired output, such as class probabilities.

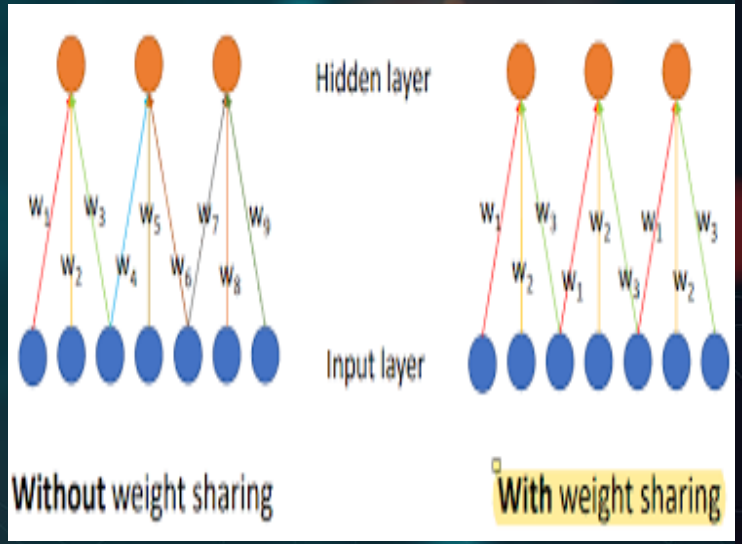


ACTIVATION FUNCTIONS

- An activation function is a mathematical operation applied to each neuron's output in a neural network layer.
- Activation functions introduce non-linearities to the network, allowing it to learn complex patterns and relationships in the data.

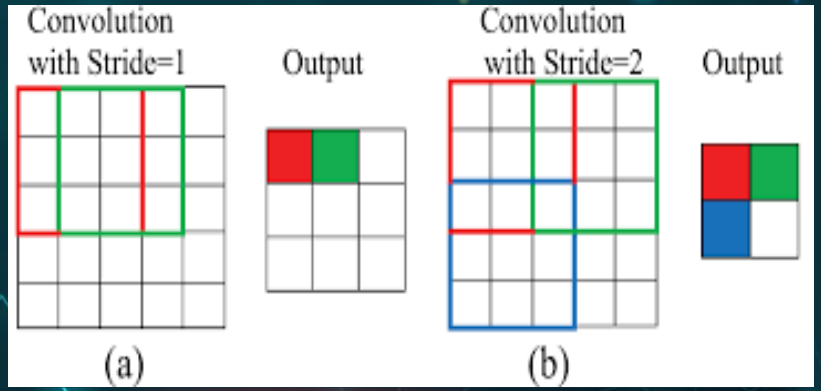
WEIGHT SHARING

- Weight sharing is a way to reduce the number of parameters while allowing for more robust feature detection.
- This property enables the network to recognize patterns anywhere in the image.



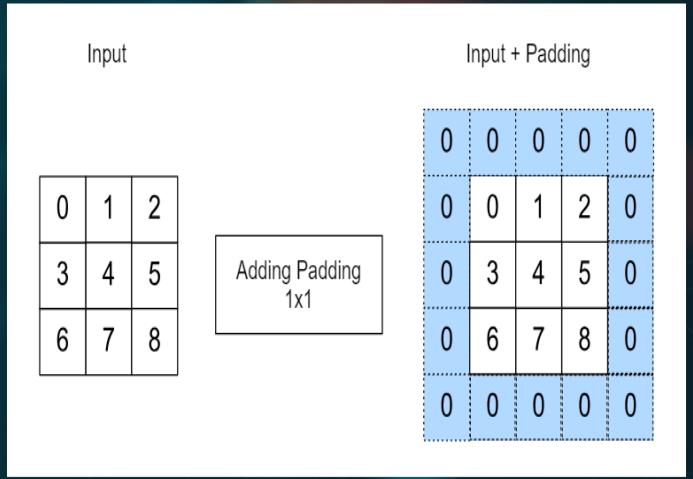
STRIDE

- Stride is the number of pixels shifts over the input matrix. When the stride is 1 then we move the filters to 1 pixel at a time.
- When the stride is 2 then we move the filters to 2 pixels at a time and so on.



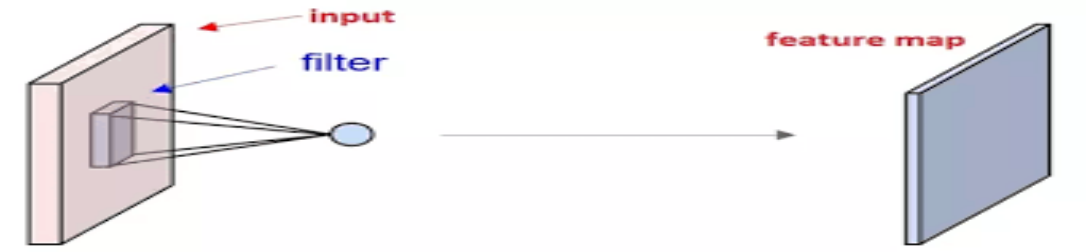
PADDING

- Padding in CNN refers to the addition of extra pixels around the borders of the input images or feature map.
- Adding padding to an image processed by a CNN allows for more accurate analysis of images.

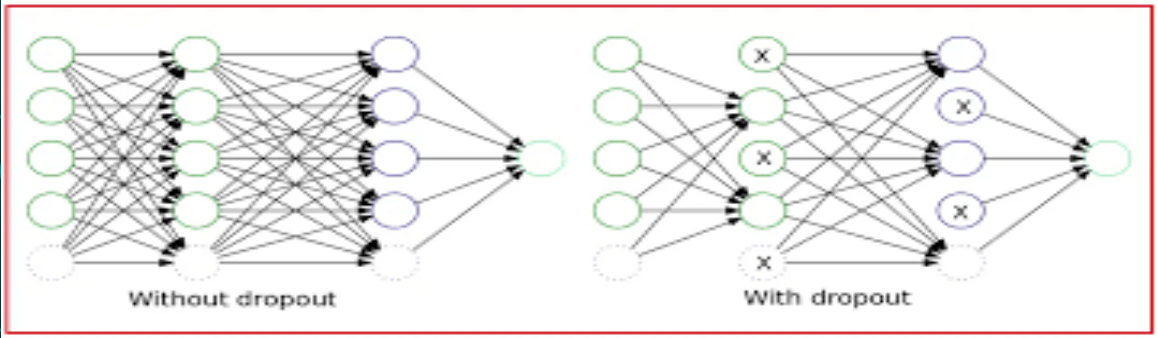


FEATURE MAPS AND DROPOUT

Feature mapping involves selecting or designing a set of functions that map the original data to a new set of features.

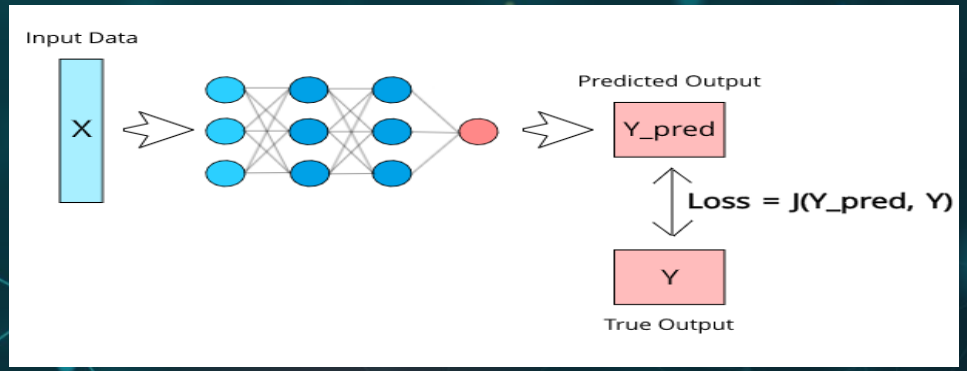


Dropout layers are sometimes used to prevent overfitting.



LOSS FUNCTION

- CNNs are typically trained using a loss function that measures the difference between predicted and actual values (to prevent over fitting).
- It measures the model's performance and guides the optimization process by providing feedback on how well it fits the data.

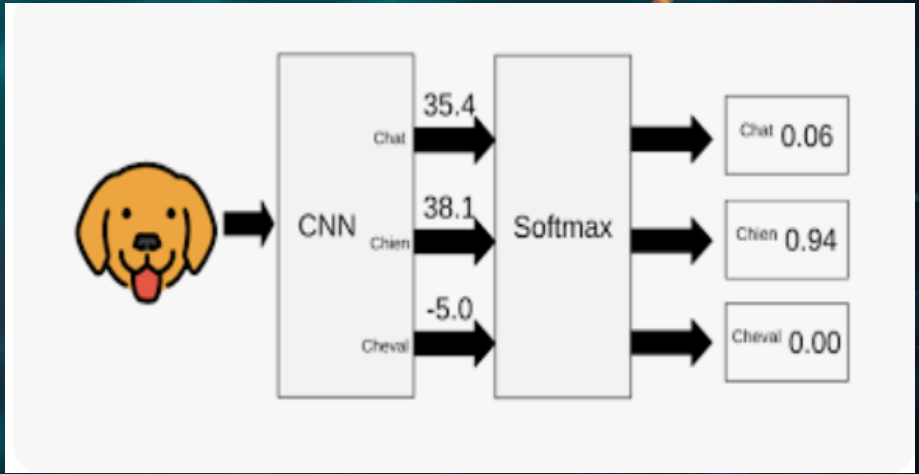


OPTIMIZATION ALGORITHMS

- In deep learning, optimizers are algorithms that adjust the model's parameters during training to minimize a loss function.
- They enable neural networks to learn from data by iteratively updating weights and biases.
- Common optimizers include Stochastic Gradient Descent (SGD) and Adam.

SOFTMAX

- The softmax function is commonly used in the output layer to generate class probabilities for multiclass classification problems.
- It is usually placed as the last layer in the CNN model.



LIMITATIONS OF CNN

- Limited Understanding of Global Context
- Data Dependency and Overfitting
- Computational Intensity
- Lack of Interpretability
- Not Universally Applicable
- Vulnerability to Adversarial Attacks
- Large Memory Requirements
- Difficulty in Handling Sequential Data

APPLICATIONS OF CNN

- Image Classification
- Facial Recognition
- Natural Language Processing (NLP)
- Video Analysis
- Gesture Recognition
- Document Analysis

- Object Detection
- Medical Imaging
- Biometric Security
- Emotion Recognition
- Financial Fraud Detection
- Human Pose Estimation

- Speech Recognition
- Healthcare Informatics
- Social Media Content Analysis
- Handwriting Recognition

DROWSINESS DETECTION USING CNN

Classification Report:

	precision	recall	f1-score	support
Closed_Eyes	0.99	0.99	0.99	422
Open_Eyes	0.99	0.98	0.99	378
accuracy			0.99	800
macro avg	0.99	0.99	0.99	800
weighted avg	0.99	0.99	0.99	800

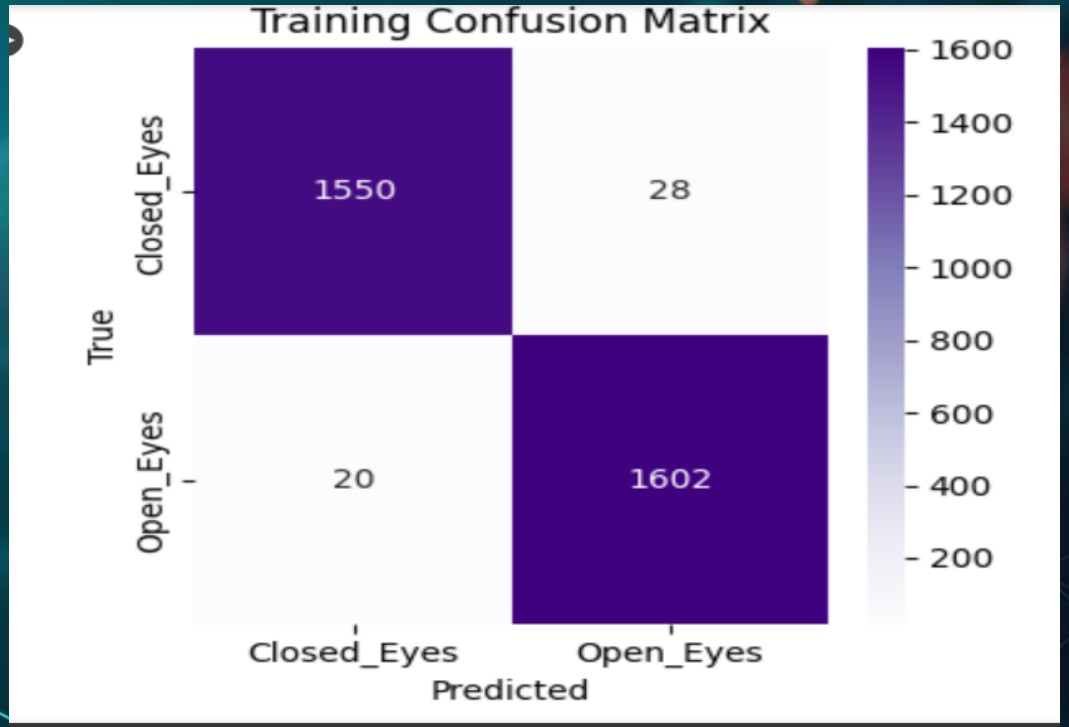
SCORES

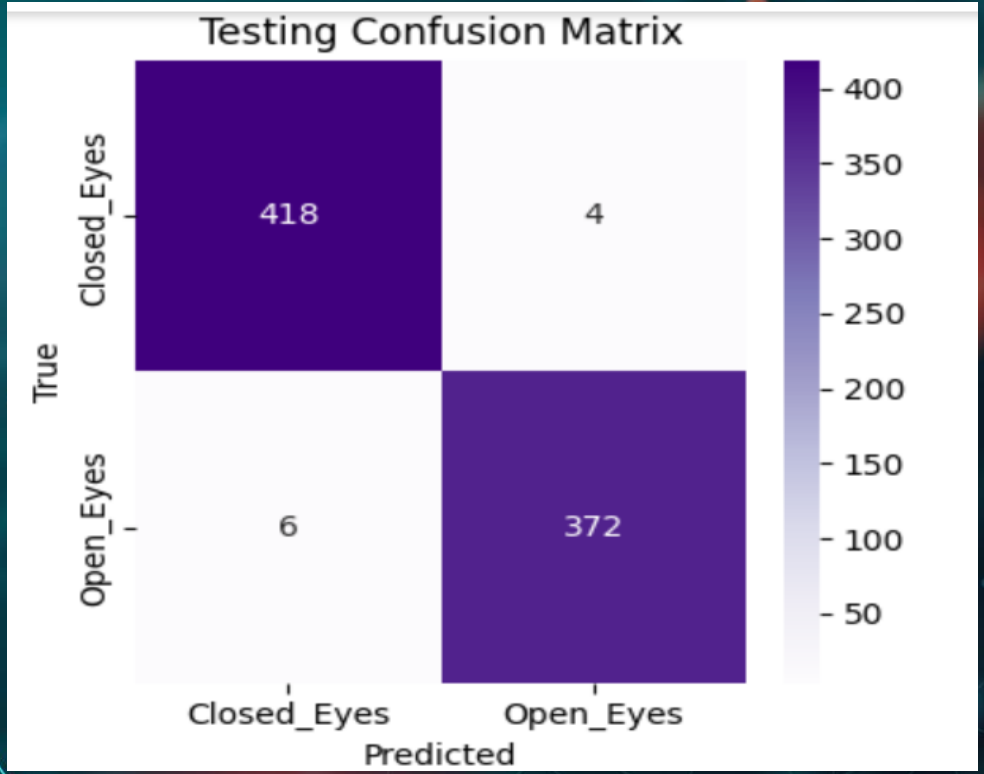
$$Precision = \frac{TP}{TP+FP}$$

$$Recall = \frac{TP}{TP+FN}$$

$$F1 = 2 \times \frac{\text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}$$

$$\text{Accuracy} = \frac{\text{TP} + \text{TN}}{\text{TP} + \text{TN} + \text{FP} + \text{FN}}$$


Training Confusion Matrix
1550
28
20
1602
Closed_Eyes
Open_Eyes
True
Closed_Eyes
Open_Eyes
Predicted
1600
1400
1200
1000
800
600
400
200


Testing Confusion Matrix
418
4
6
372
Closed_Eyes
Open_Eyes
True
Closed_Eyes
Open_Eyes
Predicted
400
350
300
250
200
150
100
50


Thank
you