# An Introduction to Convolutional Neural Network

Neural Networks and Learning Systems - 1

Indian Institute of Science

#### Motivation

Computer Vision: Image Classification



# Suppose we had a set of classes : cat, truck, boat.

#### Motivation

Computer Vision: Image Classification



# Suppose we had a set of classes : cat, truck, boat.



#### Problem: The semantic gap

Images are represented as 3D arrays of numbers, with integers between [0,255].



# Image classifier



# CIFAR-10 dataset

10 classes50,000 training images10,000 testing images $32 \times 32$  image size



#### Multilayer Perceptron



### Multilayer Perceptron

Steps in training a neural network:

- 1. Forward propagation: Feed image and obtain loss function.
- 2. Back propagation : Calculate the gradients with respect to loss.
- 3. Update parameters: Update using the gradient.

## Neural Network



Say 100 hidden neurons.

Size of image =  $32 \times 32 \times 3 = 3072$ . Number of parameters = 3,07,200.

### Neural Network



Say 100 hidden neurons.

- Size of image =  $32 \times 32 \times 3 = 3072$ . Number of parameters = 3,07,200.
- Size of image = 960 × 720 × 3 = 20, 73, 600.
  Number of parameters = 20, 73, 60, 000.

# Visual Cortex

**Hubel and Weisel:** Feature identification using low, mid and high level features.<sup>1</sup>



<sup>&</sup>lt;sup>1</sup>Hubel, David H., and Torsten N. Wiesel. "Receptive fields, binocular interaction and functional architecture in the cat's visual cortex." The Journal of physiology 160.1 (1962): 106-154.

Identifying features : Convolution
 Bringing invariance : Pooling

 $32 \times 32 \times 3$  image



 $32 \times 32 \times 3$  image



A single value is obtained by taking the dot product of filter and a  $5 \times 5 \times 3$  portion of image.



Convolving the filter over the image, we obtain a map of size  $28 \times 28 \times 1$ .

If we have six  $5 \times 5$  filters, we will get 6 maps.



This forms the new input of size  $28 \times 28 \times 6$ .



Depth of filters increases as the layers increase.

# Pooling

MAX POOLING - Downsamples the input by 2 along the width and height by performing pooling over  $2 \times 2$  with a stride of 2. Discards 75% of the activations.



