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Convolutional Neural Networks

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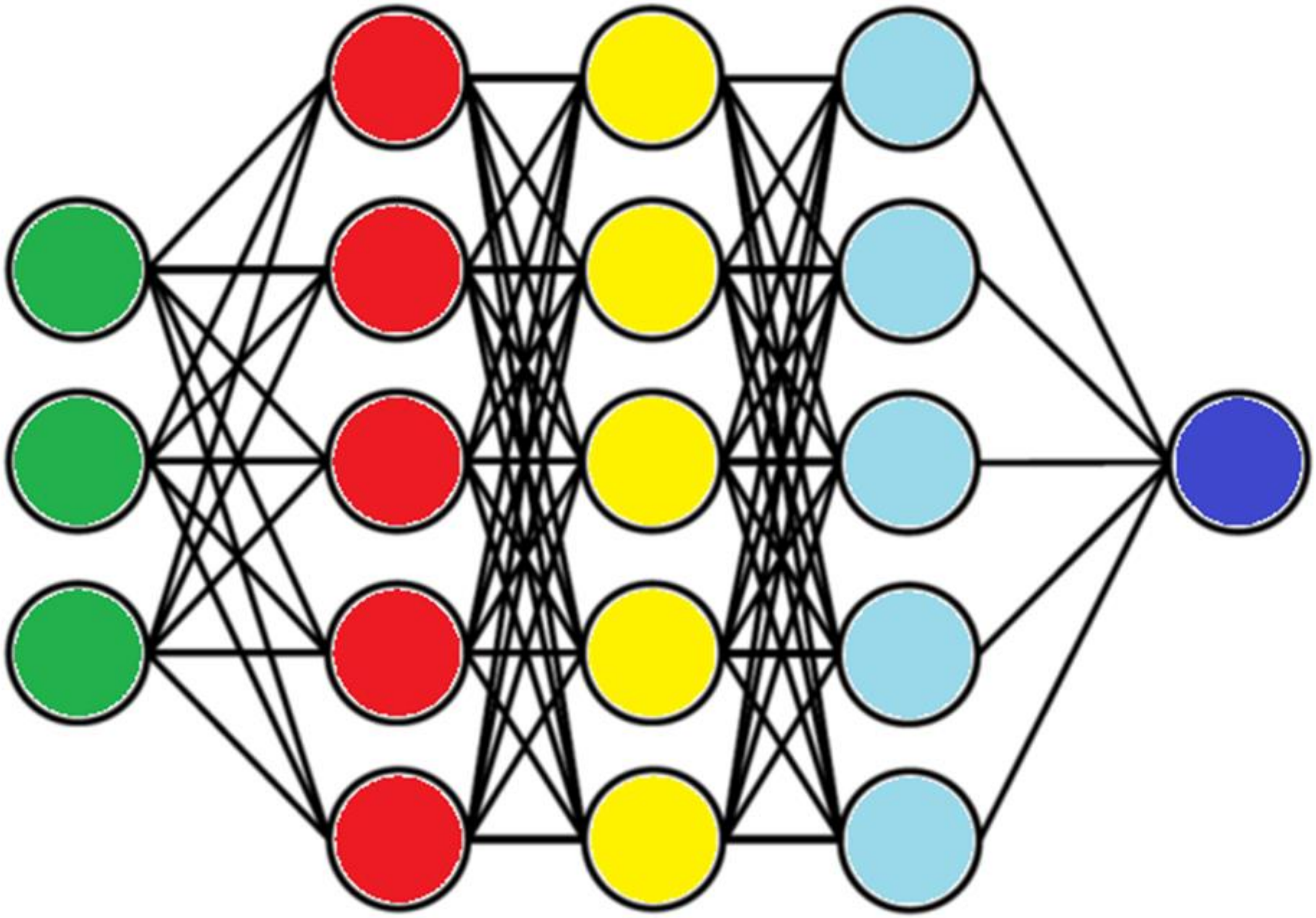
Fully Connected Neural Networks



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Fully Connected Neural Networks

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_6 (Dense)              (None, 800)               628000
_________________________________________________________________
dense_7 (Dense)              (None, 10)                8010
=================================================================
Total params: 636,010
Trainable params: 636,010
```

Convolutional Neural Network Principals

- Local perception
- Shared weights
- Dimensionality Reduction

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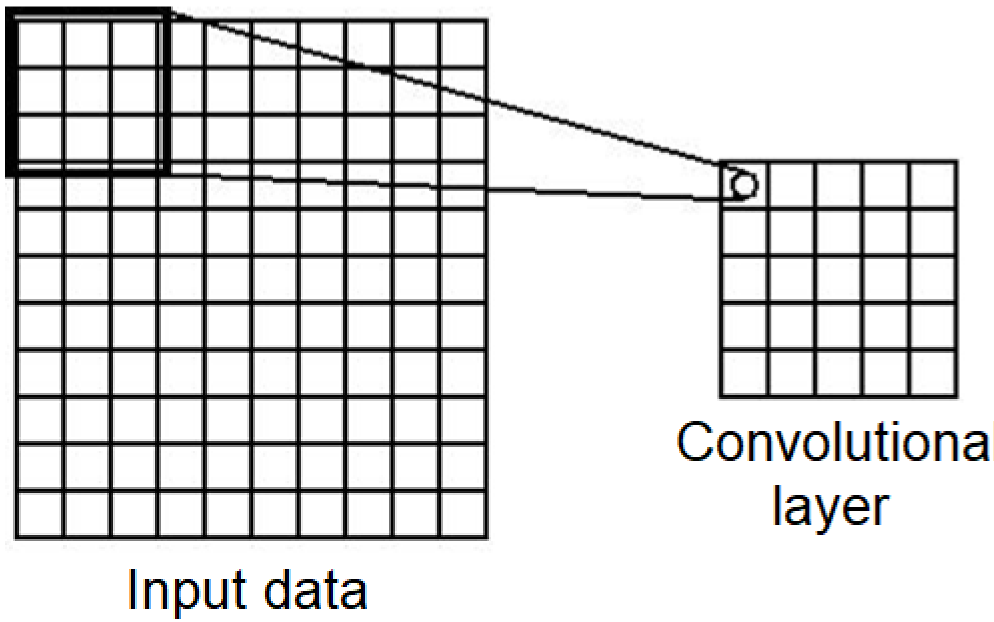
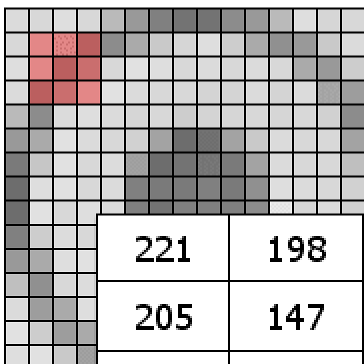
Local Perception



Convolution



221	198	149
205	147	173
149	170	222

Kernel

-1	0	1
-2	0	2
-1	0	1

N(x,y) = 221 * (-1) +
198 * 0 +
149 * 1 +
205 * (-2) +
147 * 0 +
173 * 2 +
149 * (-1) +
170 * 0 +
222 * 1 = - 63

Convolutional Kernels

Blurring

1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

Edge Detection

0	-1	0
-1	4	-1
0	-1	0

Sharpening

0	-1	0
-1	5	-1
0	-1	0

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Convolutional Kernels

Blurring

1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

Edge Detection

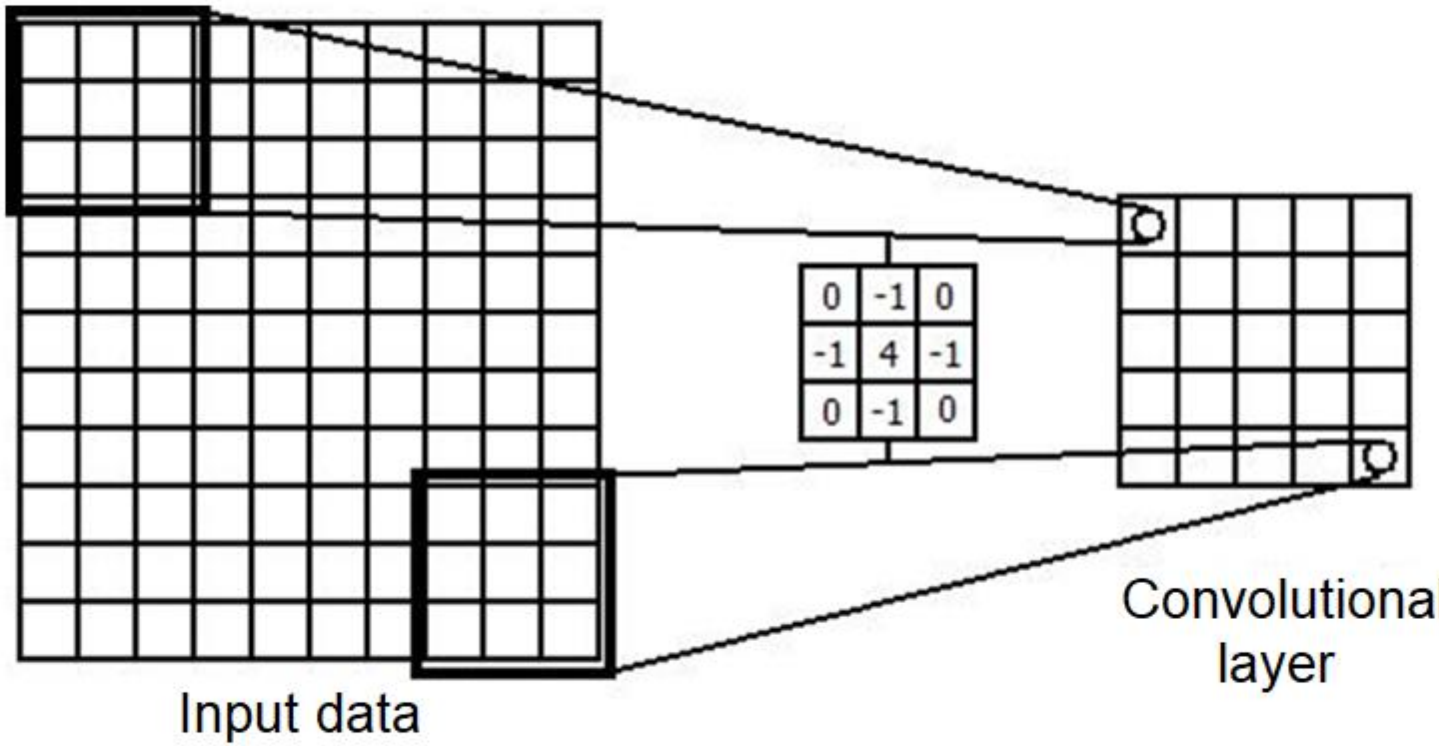
0	-1	0
-1	4	-1
0	-1	0

Sharpening

0	-1	0
-1	5	-1
0	-1	0

In convolutional neural network kernels are learned during training.

Shared weights



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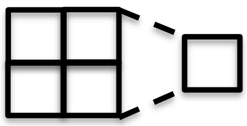
Dimensionality Reduction

- Recognition of objects with various sizes
- Presence of some feature is more important than the position of the feature in the image
- Subsampling layer:
  - Average
  - Max Pooling



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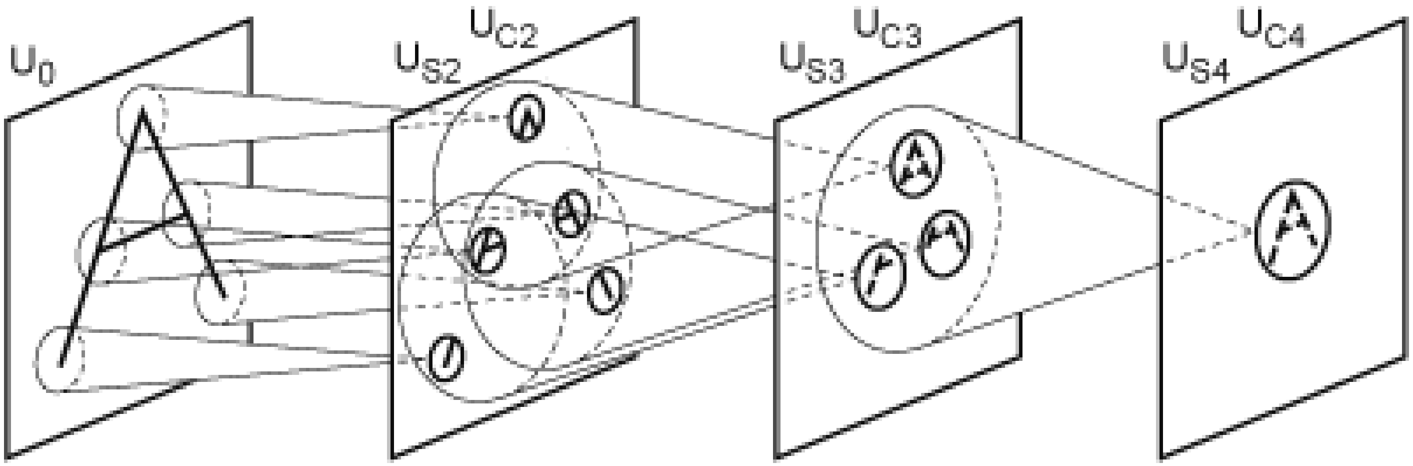
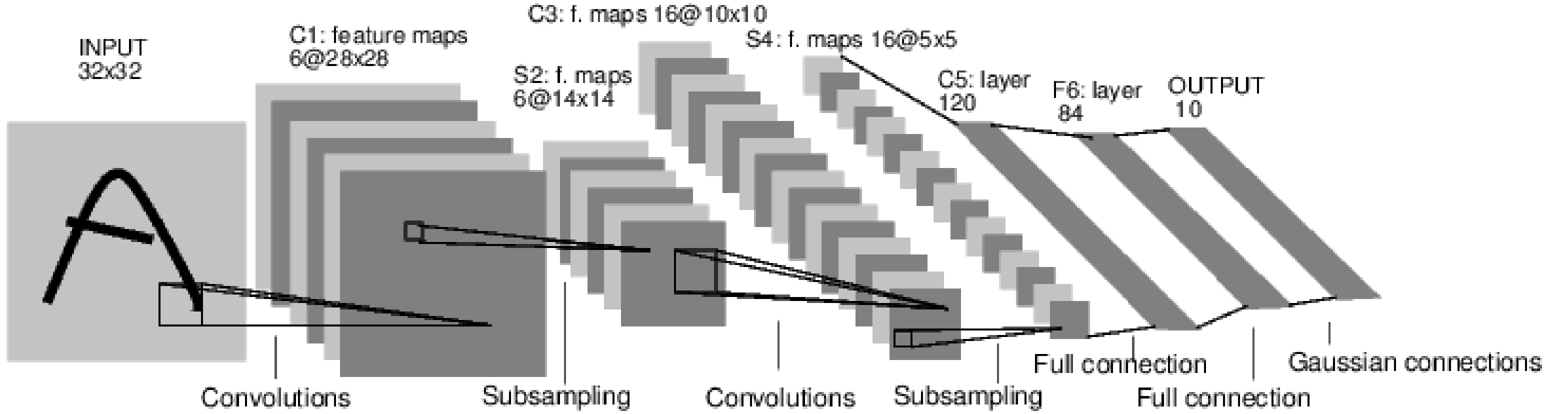
Architecture of CNN



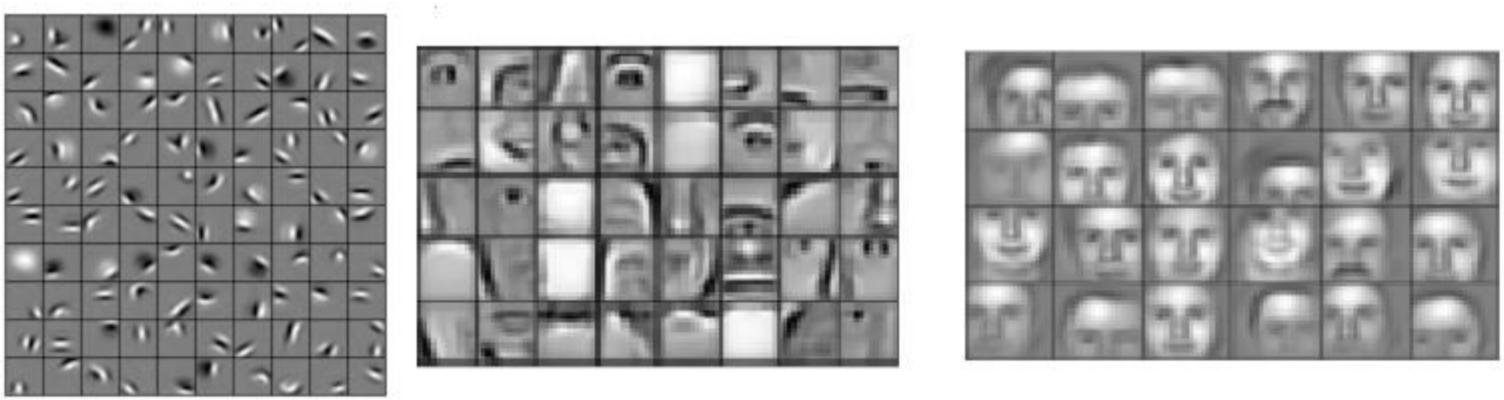
Kunihiko Fukushima. Neocognitron

Lenet-5



Back-Propagation Applied to Handwritten Zip Code Recognition / *Y. LeCun, B. Boser, J. S. Denker et al*. 1989

How layers of CNN work



Honglak Lee, Roger Grosse, Rajesh Ranganath, and Andrew Y. Ng.
Unsupervised Learning of Hierarchical Representations with
Convolutional Deep Belief Networks (2011)

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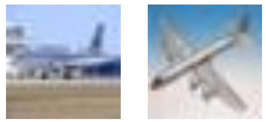
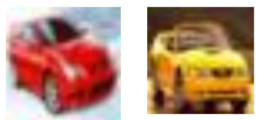
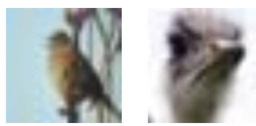
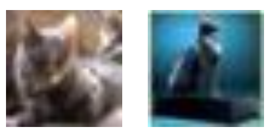
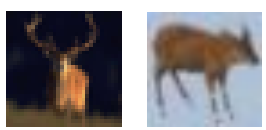
CIFAR-10 Dataset

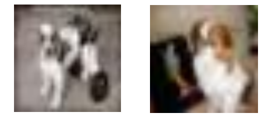
airplane 

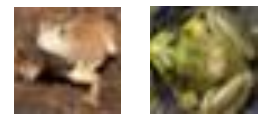
automobile 

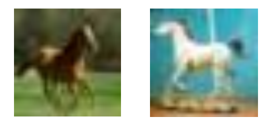
bird 

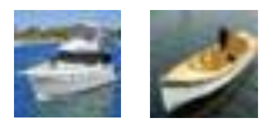
cat 

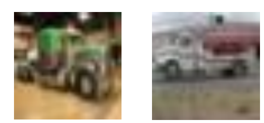
deer 

dog 

frog 

horse 

ship 

truck 

CIFAR-10 Dataset

- Open dataset
  - https://www.cs.toronto.edu/~kriz/cifar.html
  - Alex Krizhevsky, Learning Multiple Layers of Features from Tiny Images, 2009.
- Images in CIFAR-10
  - Size 32x32
  - Color (RGB)
  - Training dataset – 50 000 images (5 000 for each class)
  - Test dataset – 10 000 images
  - Every image has only one object
  - Object belongs to only one class

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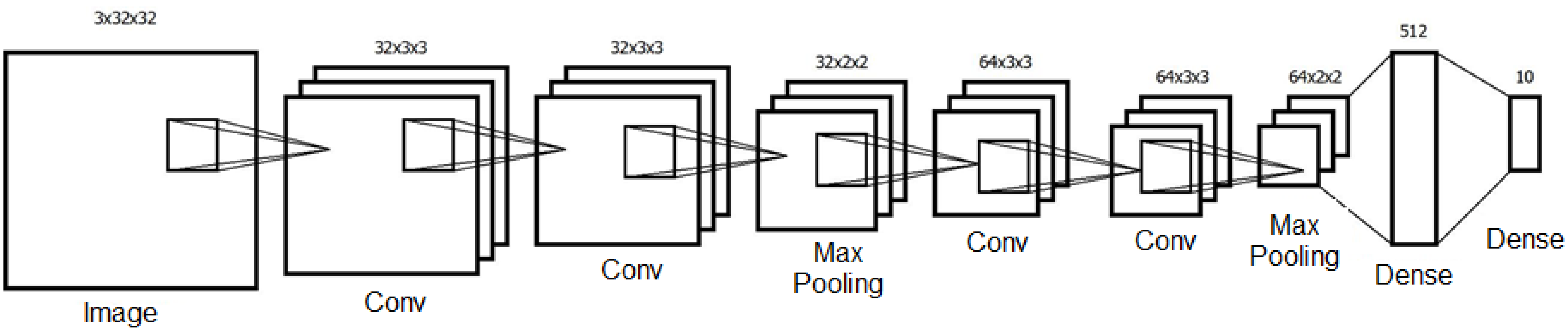
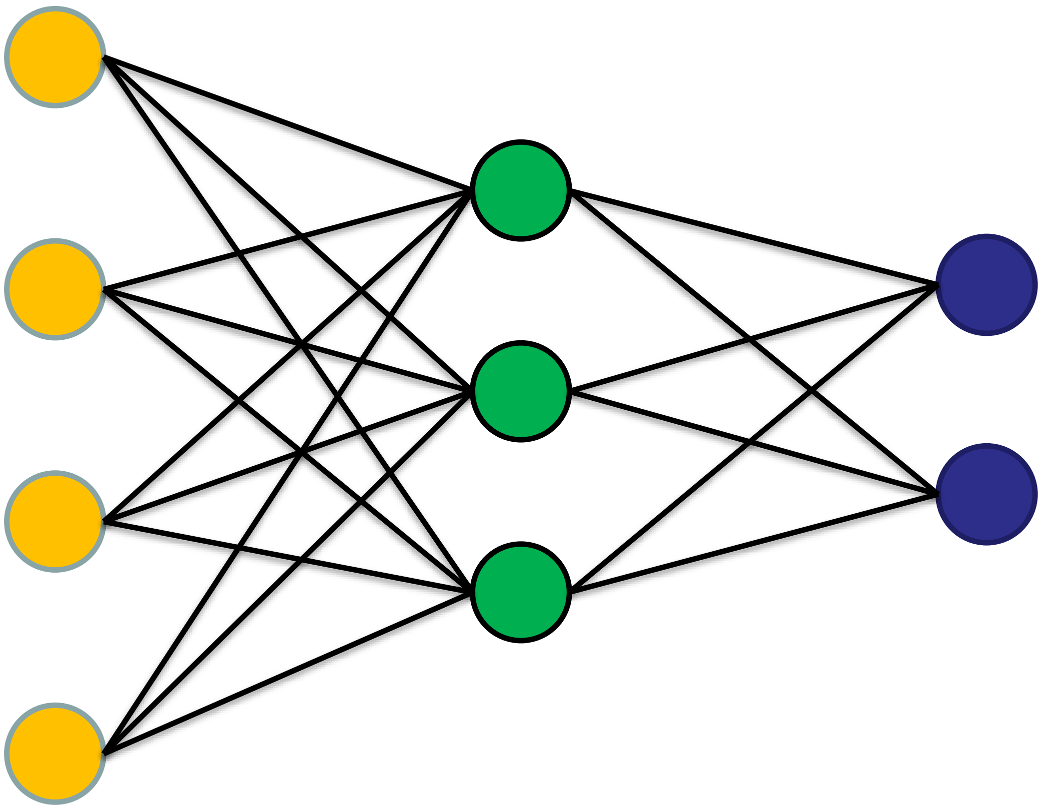
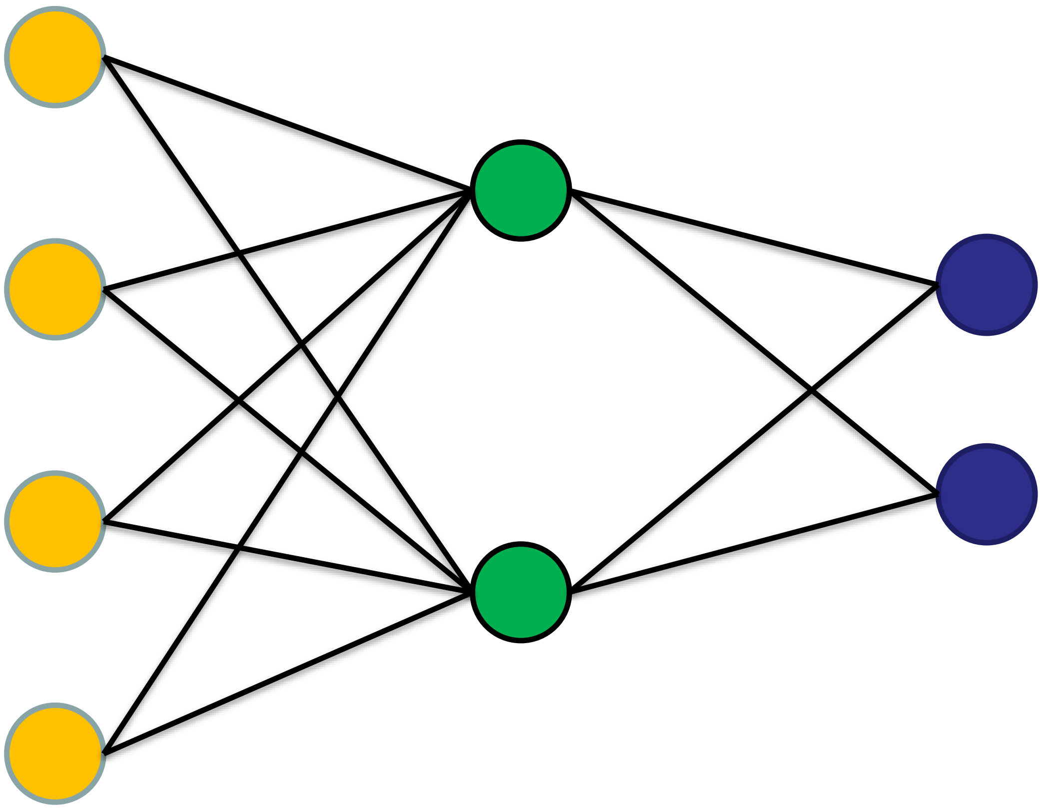
CNN for CIFAR-10



Dropout



Dropout



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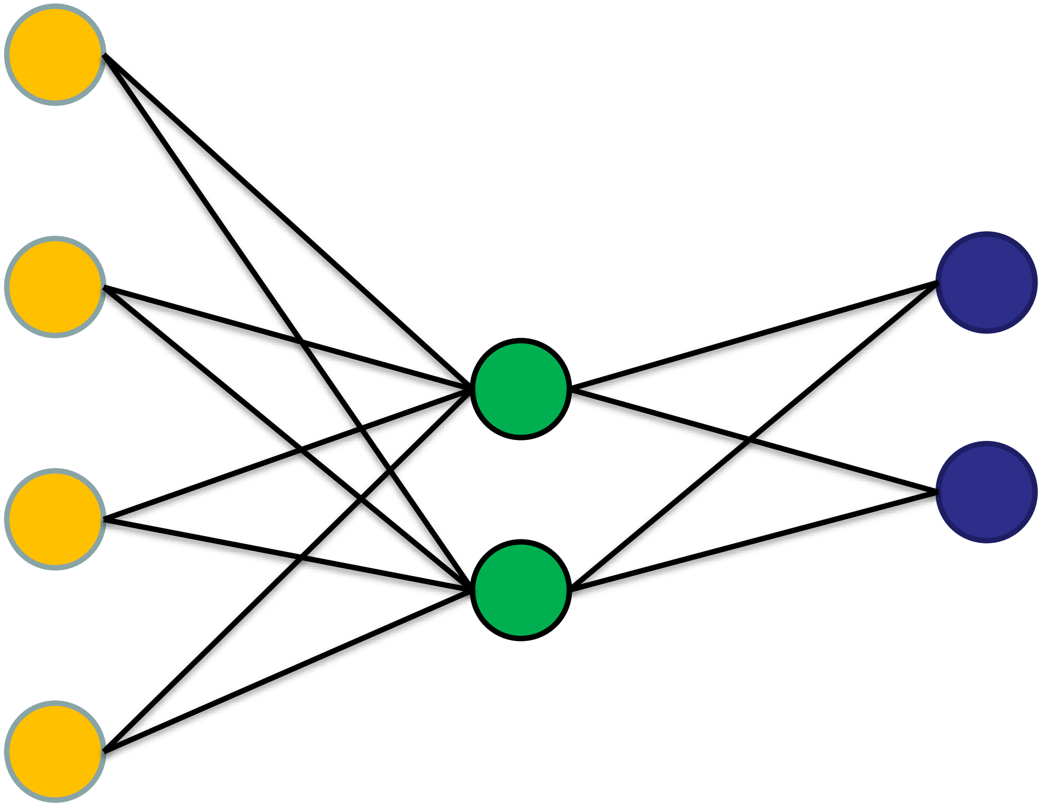
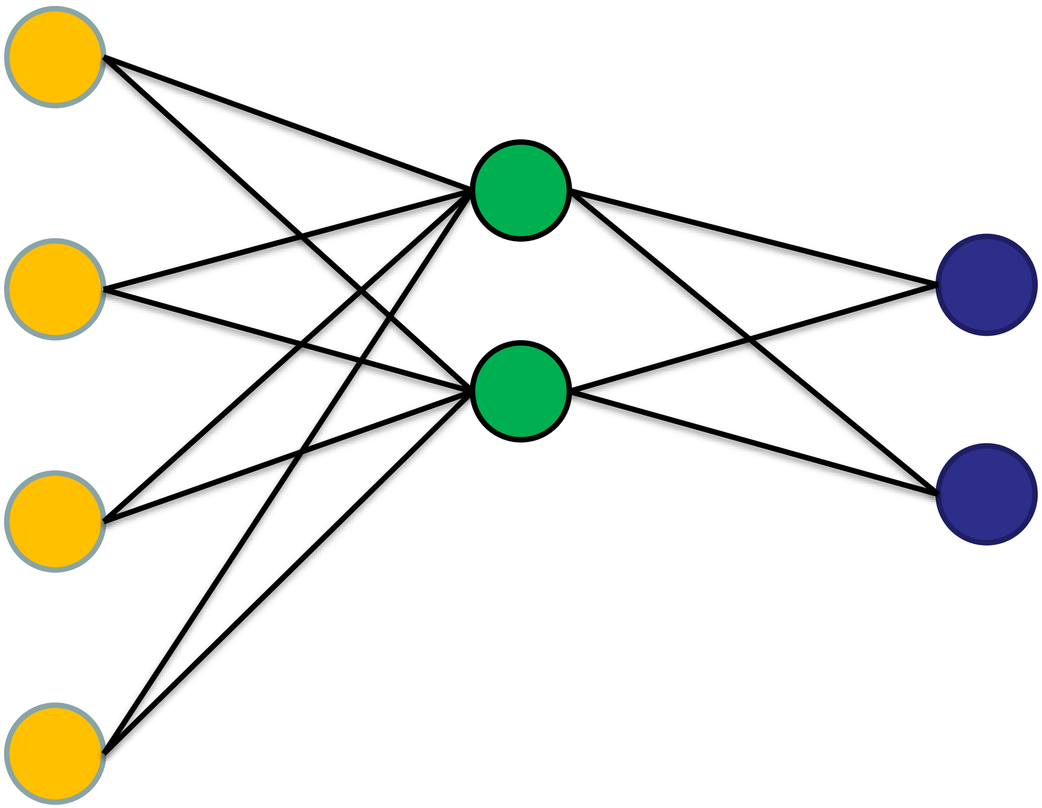
Dropout



Dropout



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Dropout in Keras

```
# Input Dense Layer
model.add(Dense(800, input_dim=784,
                activation="relu"))
# Dropout
model.add(Dropout(0.5))
# Output Dense layer
model.add(Dense(10,
                activation="softmax"))
```

Dimensionality Reduction

- A paper with the full description of Dropout:
  - Dropout: A Simple Way to Prevent Neural Networks from Overfitting. http://www.jmlr.org/papers/volume15/srivastava14a/srivastava14a.pdf
- How to prevent overfitting:
  - 3 datasets: training, validation, testing
  - Dropout
  - Regularization
  - BatchNormalization

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Thank you!