LECTURE 18

WINTER 2021
APPLIED MACHINE LEARNING
CIHANG XIE

SLIDE CREDIT:
NARGES NOROUZI

GROUP ACTIVITIES

- Week 9 is the last week that you need to turn in your files
- Most groups are doing extremely great

CLASS PARTICIPATION

IF you submitted all polling questions:

you are good 😀

ELSEIF #(zoom participations less than 1hr) < 3

you are good 😀

ELSE

you may lose participation credit

Come to my next Tuesday office hour

-- send me an email for booking this appointment

EXTRA CREDITS

Course Feedback

Student Experience of Teaching Surveys - Spring 2021 for CSE-144-01-64331-Applied ML

Medium	Online
Timing	Scheduled

- Start Date 2021-05-24 08:00
- End Date 2021-06-06 23:59

Response Rate

	Responded	Invited	% Rate
Students	20	102	19.61%

60+ responded --- everyone get 1pt

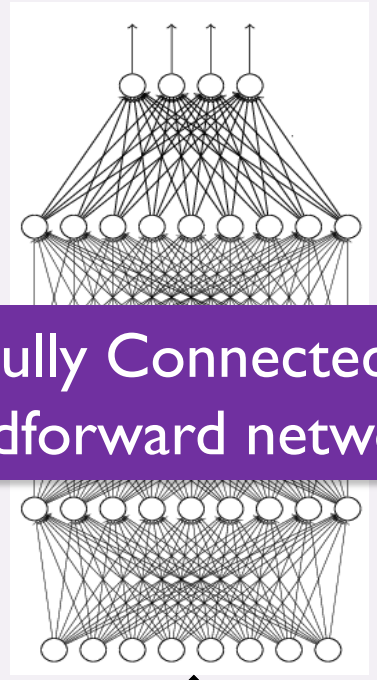
80+ responded --- everyone get 2pts

All responded --- everyone get 3pts

TODAY

- Convolutional Neural Network
  - TensorFlow implementation
- Transfer Learning
- Other Training Considerations
  - Batch normalization
  - Proper weight initialization

THE WHOLE CNN



cat dog ……

Fully Connected Feedforward network

Flatten

Convolution

Max Pooling

Convolution

Max Pooling

Can repeat many times

THE WHOLE CNN

Input

7	3	5	2
8	7	1	6
4	9	3	9
0	8	4	5

maxpool

Output

8	6
9	9

Property 1

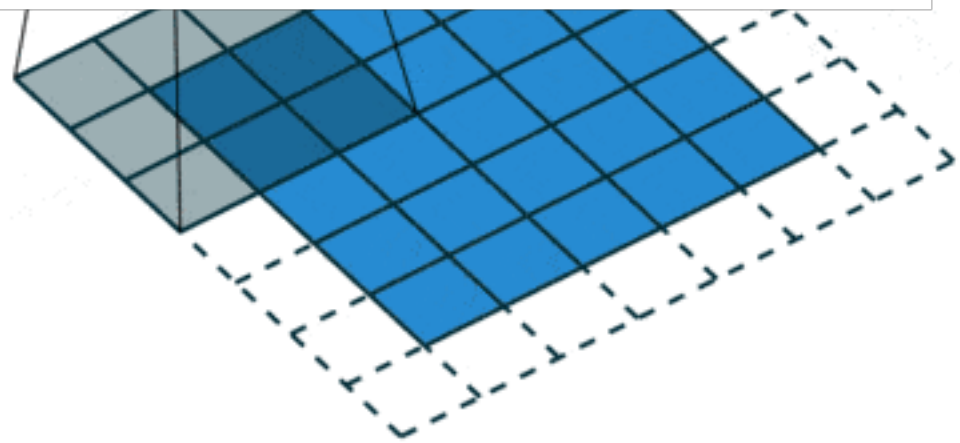
- Some pat
  smaller th

Property 2

- The same
  different r

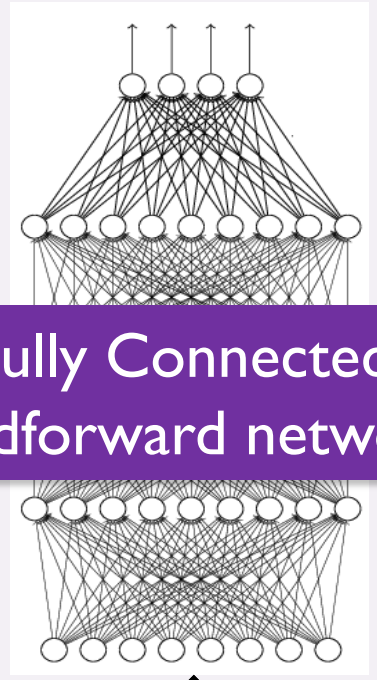
Property 3

- Subsampling the pixels will not change the object



Flatten

THE WHOLE CNN



cat dog ……

Fully Connected Feedforward network

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Convolution

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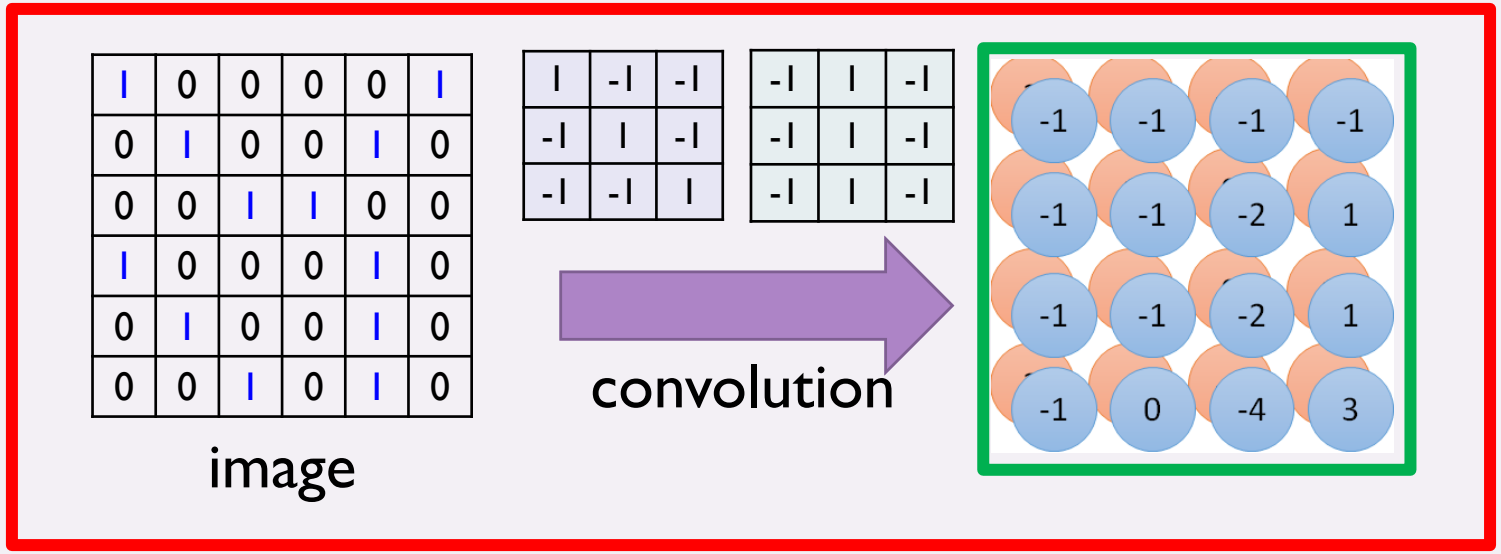
Convolution

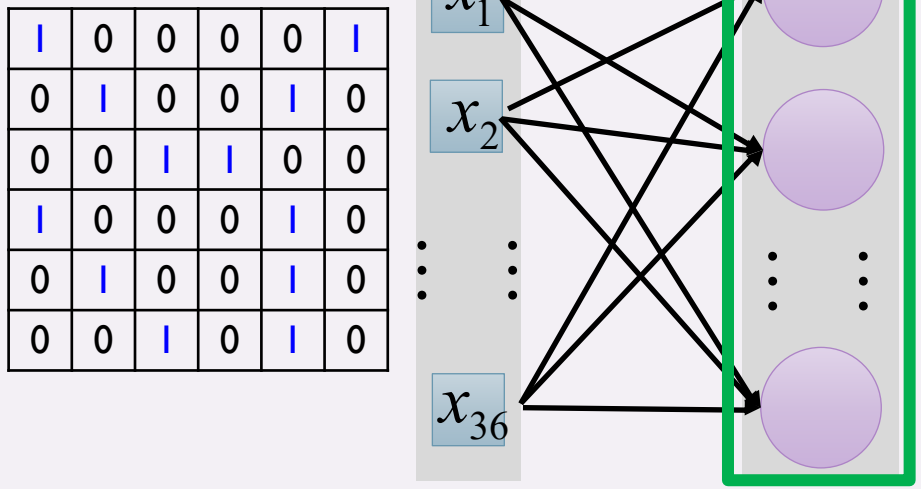
Max Pooling

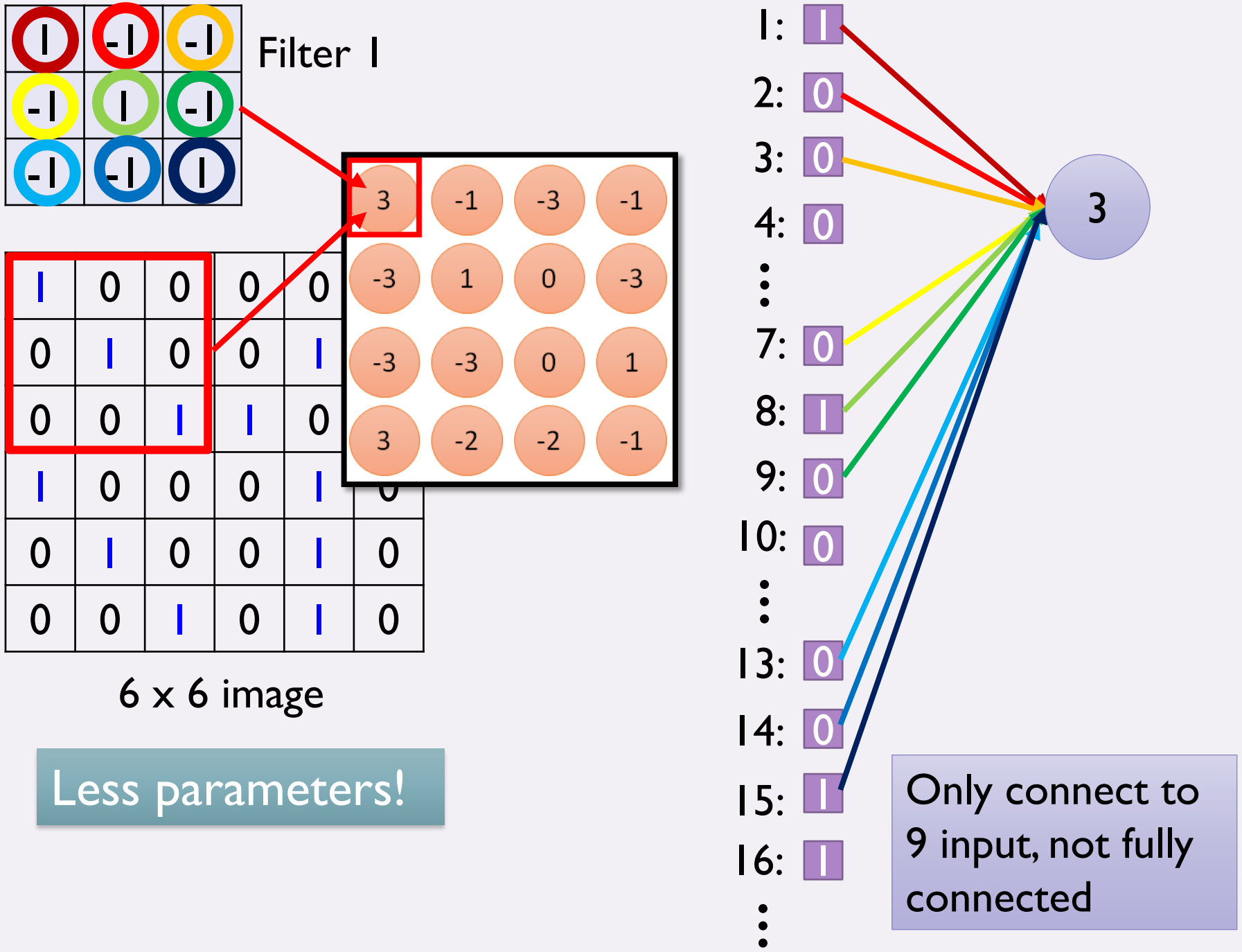
Can repeat many times

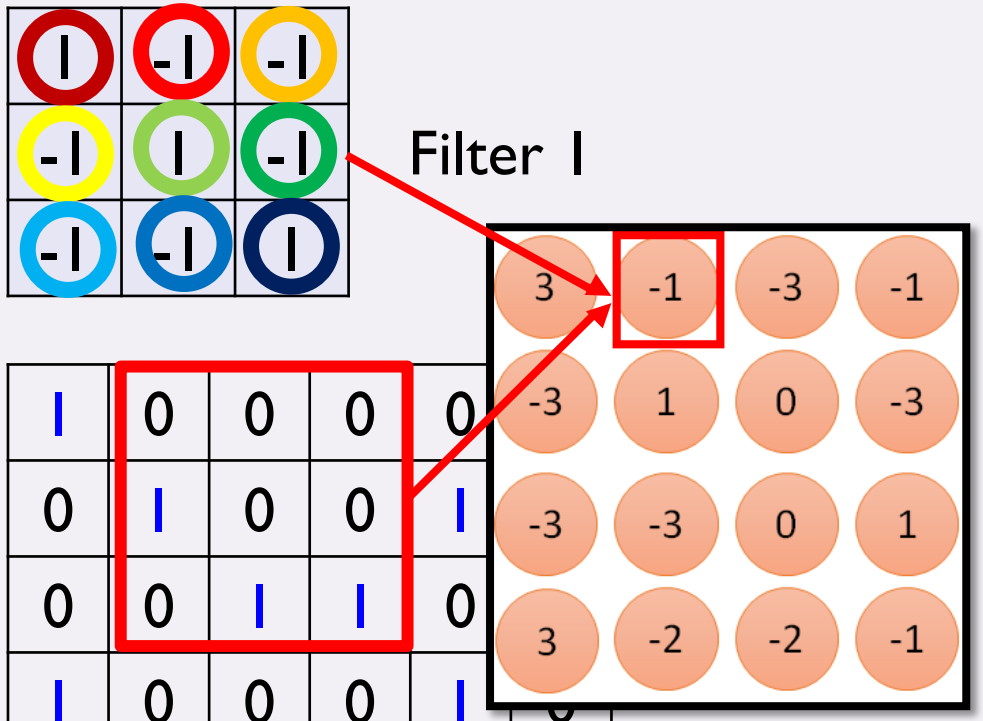
CONVOLUTION VS FULLY-CONNECTED



Fully-connected

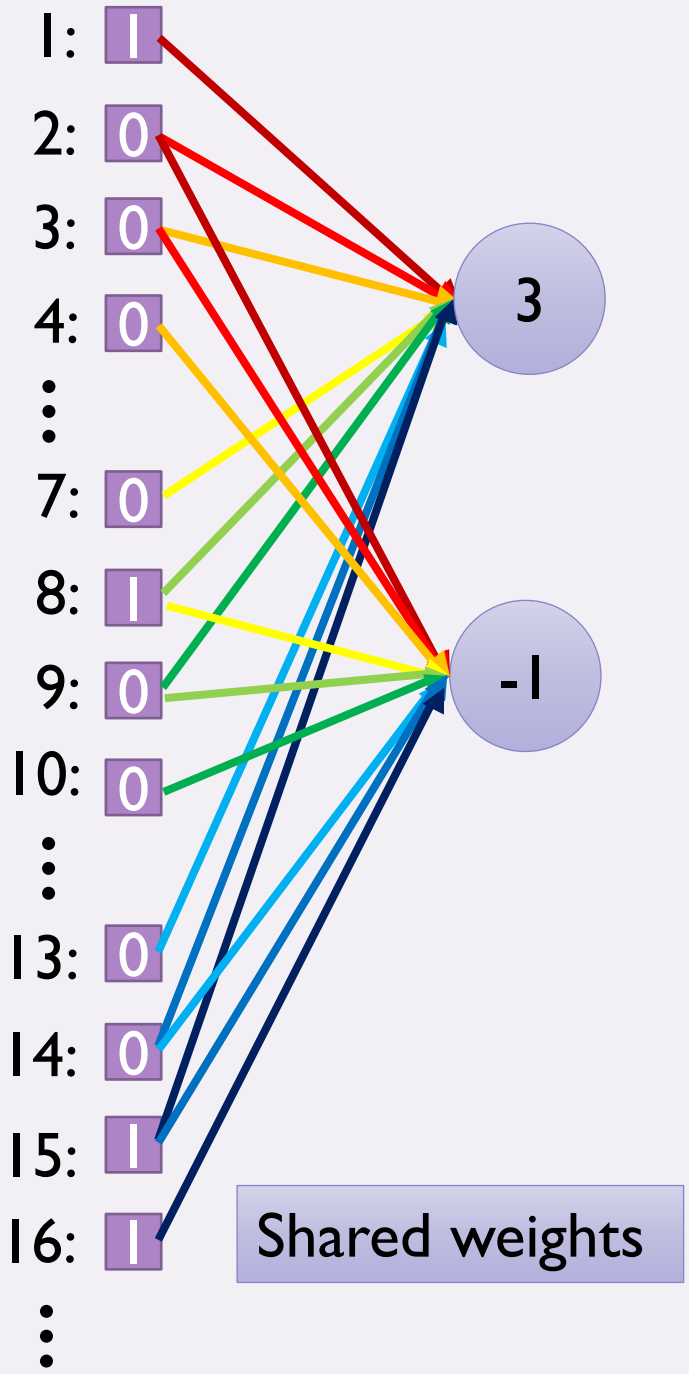



1 -1 -1
-1 1 -1
-1 -1 1
Filter 1
3 -1 -3 -1
-3 1 0 -3
-3 -3 0 1
3 -2 -2 -1
1 0 0 0 0
0 1 0 0 1
0 0 1 1 0
1 0 0 0 1 0
0 1 0 0 1 0
0 0 1 0 1 0
6 x 6 image
Less parameters!
1:
2:
3:
4:
7:
8:
9:
10:
13:
14:
15:
16:
3
Only connect to 9 input, not fully connected

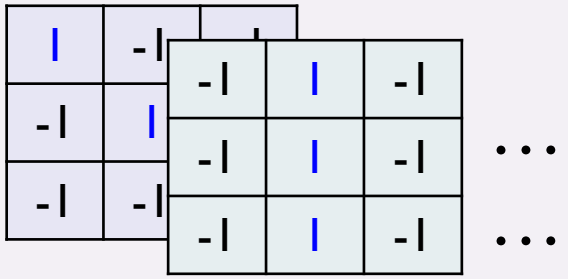


Less parameters!

Even less parameters!



```
model.add(Conv2D(filters = 25,
kernel_size = (3, 3),
padding = 'same',
activation = 'relu',
input_shape = (28, 28, 1)))
```

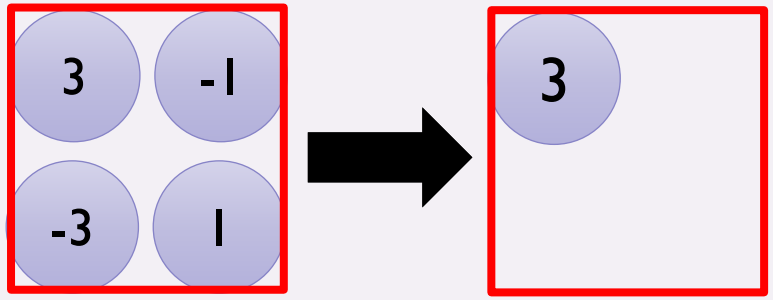


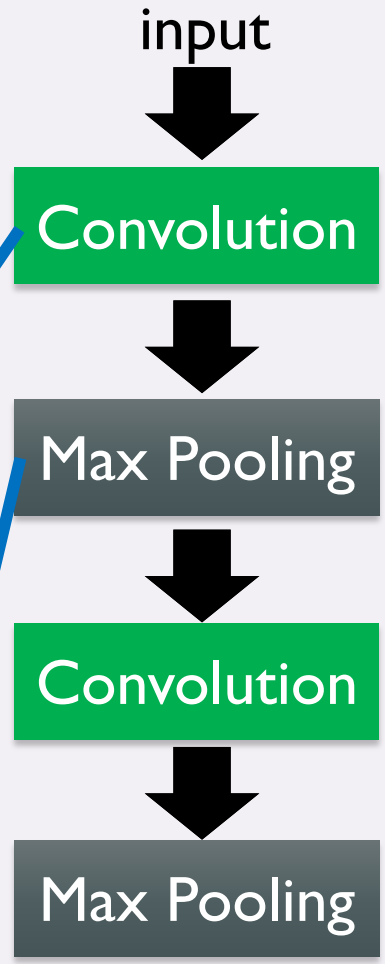
...

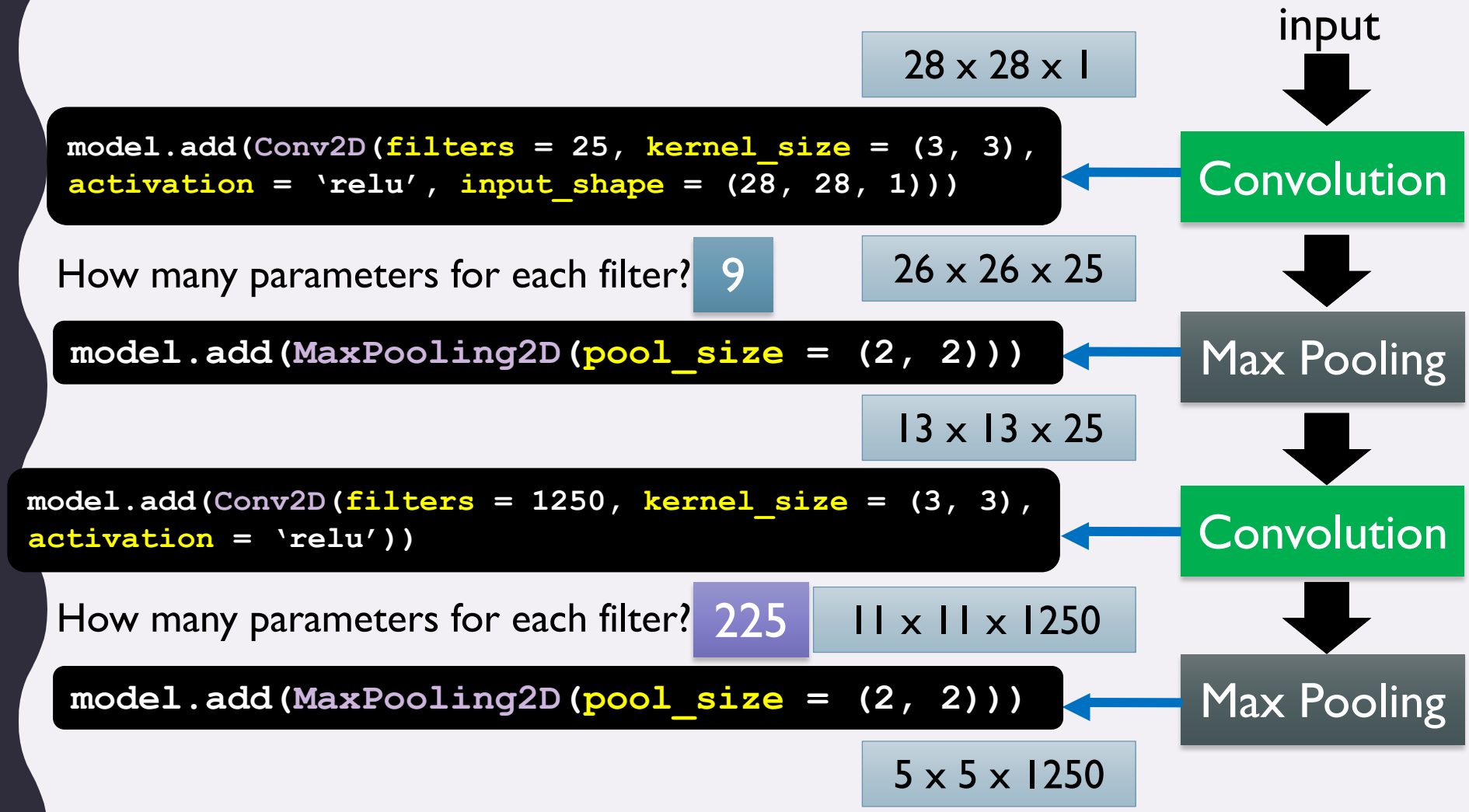
...

There are 25 3x3 filters.

```
model.add(MaxPooling2D(pool_size = (2, 2)))
```






input
28 x 28 x 1
model.add(Conv2D(filters = 25, kernel_size = (3, 3), activation = 'relu', input_shape = (28, 28, 1)))
Convolution
How many parameters for each filter?
9
26 x 26 x 25
model.add(MaxPooling2D(pool_size = (2, 2)))
Max Pooling
13 x 13 x 25
model.add(Conv2D(filters = 1250, kernel_size = (3, 3), activation = 'relu'))
Convolution
How many parameters for each filter?
225
11 x 11 x 1250
model.add(MaxPooling2D(pool_size = (2, 2)))
Max Pooling
5 x 5 x 1250

input

28 x 28 x 1

Convolution

26 x 26 x 25

Max Pooling

13 x 13 x 25

Convolution

11 x 11 x 1250

Max Pooling

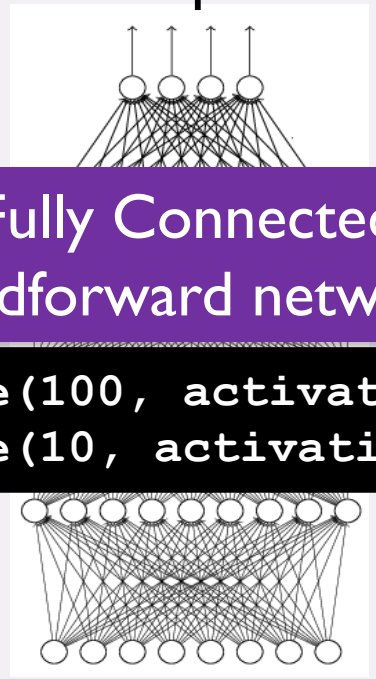
5 x 5 x 1250

```
model.add(Flatten())
```

Flatten

31250

output



Fully Connected Feedforward network

```
model.add(Dense(100, activation='relu'))
model.add(Dense(10, activation='softmax'))
```

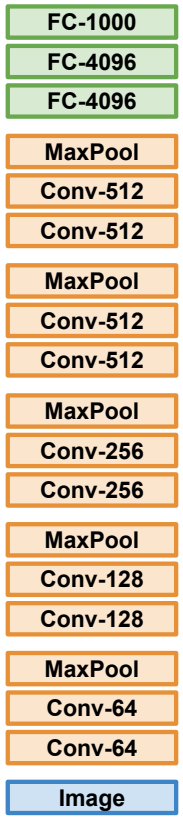
TRANSFER LEARNING

TRANSFER LEARNING

- A shortcut in training neural networks for recognition tasks
- The idea is to start with a fully trained image recognition neural network, off the shelf with trained weights.
- We can repurpose the trained network for our particular recognition task.
- What was learned by the neural network in it's early layers are useful features in recognizing various things in images.
- Keras even has pretrained models built in for this purpose:
  - Xception, VGG16, VGG19, ResNet, InceptionV3, InceptionResNetV2, MobileNet, DenseNet, NASNet

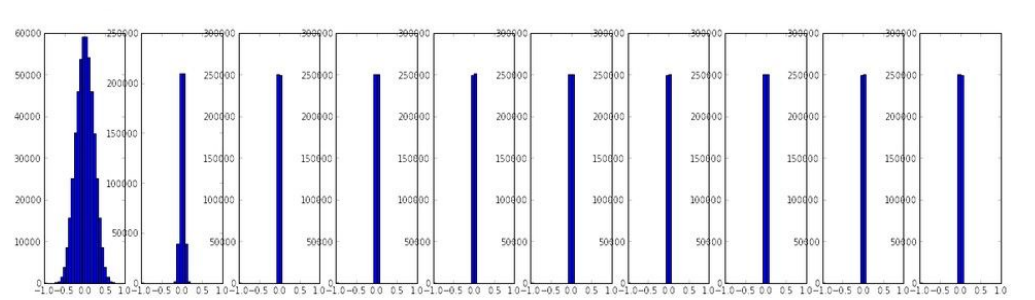
TRANSFER LEARNING WITH CNN

1. Train on Imagenet



OTHER TRAINING CONSIDERATIONS

PROPER WIGHT INITIALIZATION



- **Initialization too small**: Activations go to zero, gradients also zero → No learning

```
# Usage in a Keras layer:
initializer = tf.keras.initializers.HeNormal()
layer = tf.keras.layers.Dense(3, kernel_initializer=initializer)
```

Delving Deep into Rectifiers:
Surpassing Human-Level Performance on ImageNet Classification

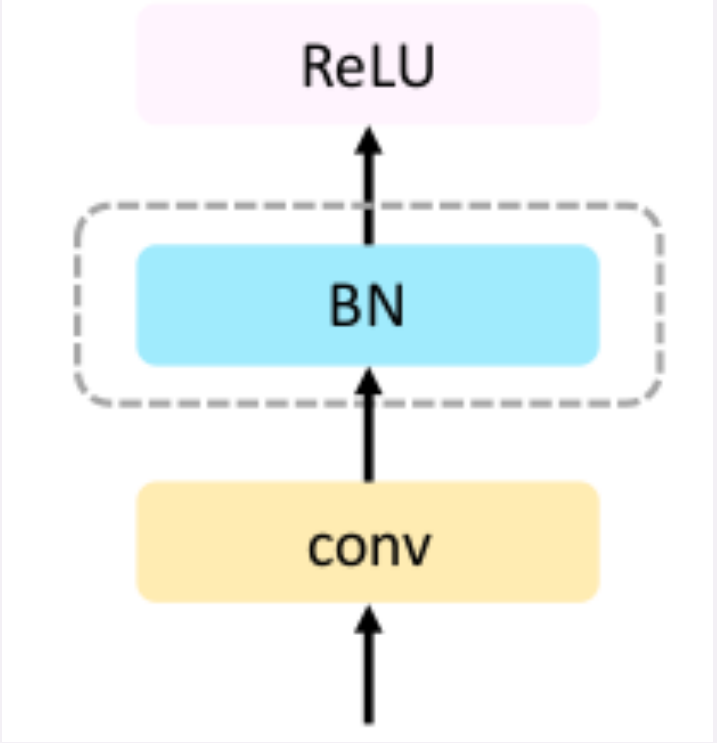
Kaiming He Xiangyu Zhang Shaoqing Ren Jian Sun

Microsoft Research

{kahe, v-xiangz, v-shren, jiansun}@microsoft.com

BATCH NORMALIZATION

- Distribution of each layer's input changes during training, as parameters of previous layers change → Internal covariate shift
- We try to fix this problem by normalization:
  - Input x: $N \times D$
  - Learnable Parameters γ, β: D
  - Intermediates μ, σ: D
  - $\hat{x}$: $N \times D$
  - Output y: $N \times D$



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EXERCISE

HTTPS://BIT.LY/2RKUDRQ

QUESTIONS?