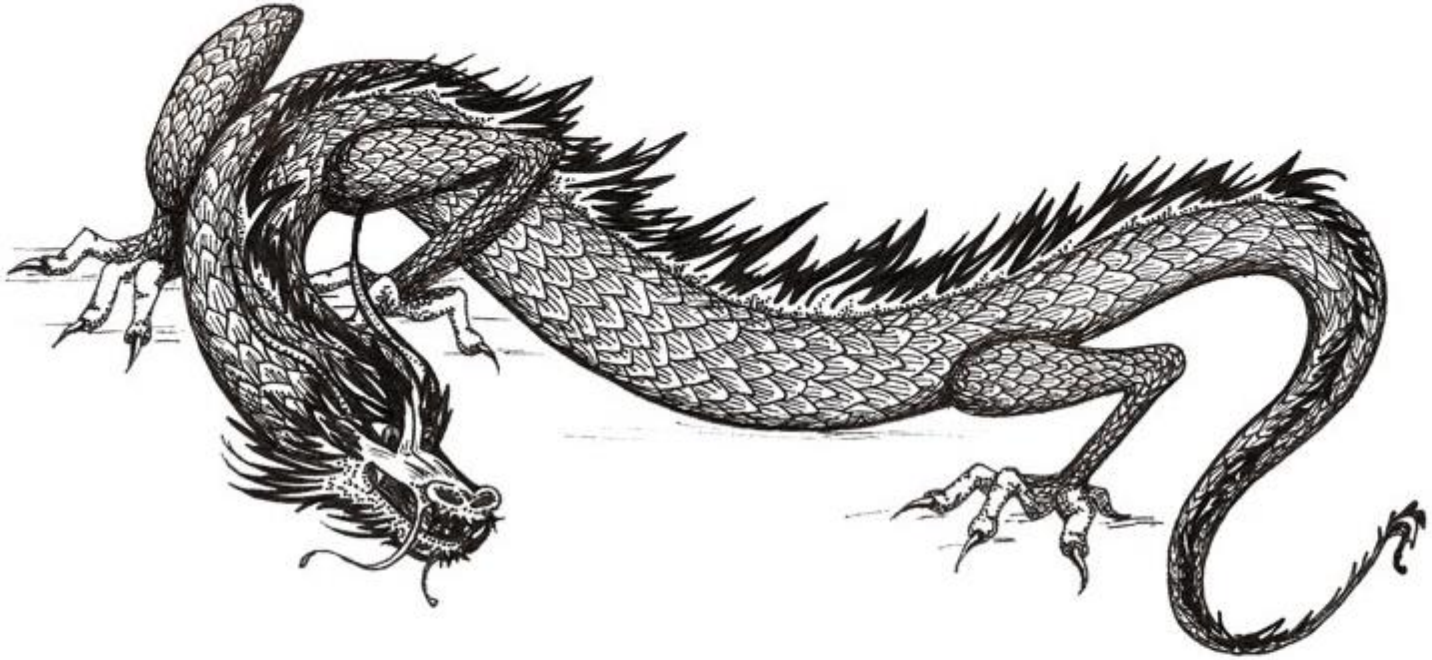
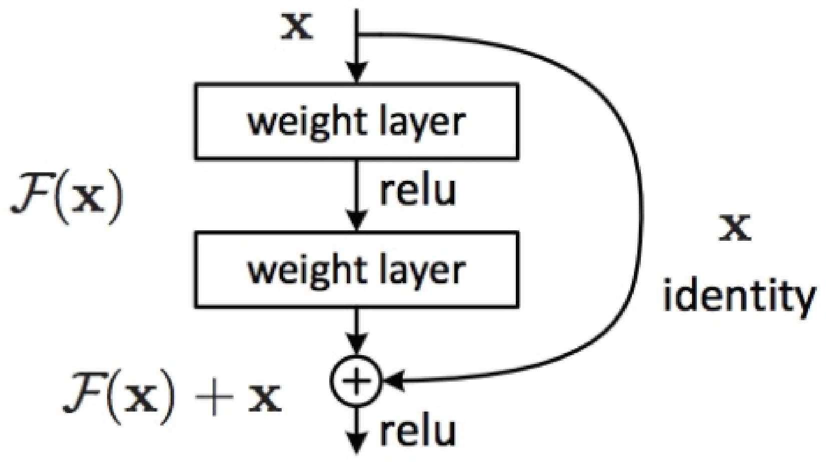


ResNet 与 DenseNet

主讲：龙良曲

ResNet

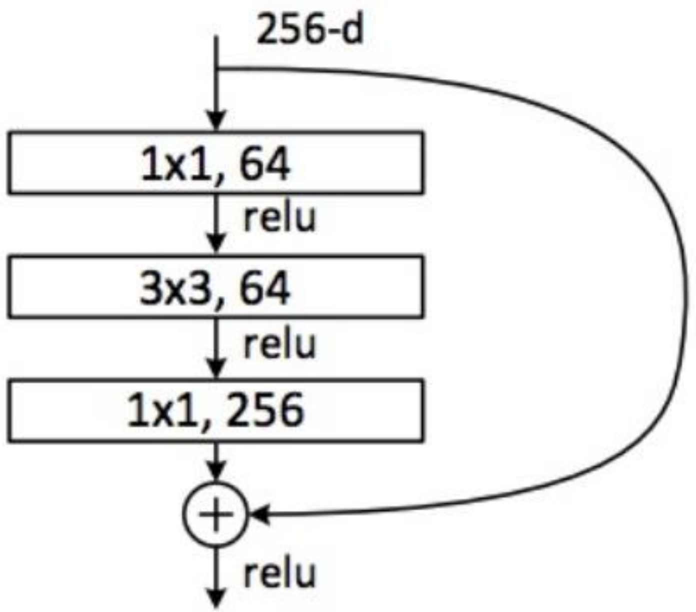
- The residual module
  - Introduce *skip* or *shortcut* connections (existing before in various forms in literature)
  - Make it easy for network layers to represent the identity mapping
  - For some reason, need to skip at least two layers



Kaiming He, Xiangyu Zhang, Shaoqing Ren, and Jian Sun,
Deep Residual Learning for Image Recognition, CVPR 2016 (Best Paper)

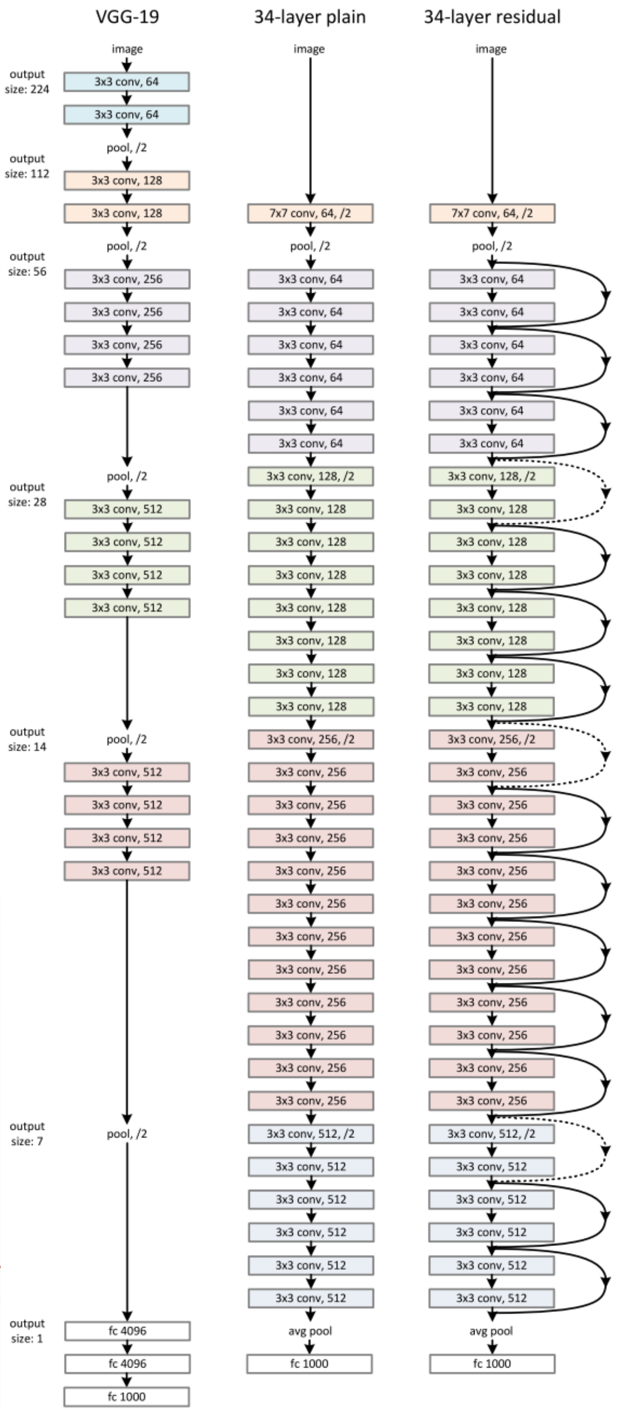
ResNet

Deeper residual module (bottleneck)



- Directly performing 3x3 convolutions with 256 feature maps at input and output:
  256 x 256 x 3 x 3 ~ 600K
  operations
- Using 1x1 convolutions to reduce 256 to 64 feature maps, followed by 3x3 convolutions, followed by 1x1 convolutions to expand back to 256 maps:
  256 x 64 x 1 x 1 ~ 16K
  64 x 64 x 3 x 3 ~ 36K
  64 x 256 x 1 x 1 ~ 16K
  Total: ~70K

Kaiming He, Xiangyu Zhang, Shaoqing Ren, and Jian Sun,
Deep Residual Learning for Image Recognition, CVPR 2016 (Best Paper)

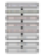

VGG-19
34-layer plain
34-layer residual
output size: 224
output size: 112
output size: 56
output size: 28
output size: 14
output size: 7
output size: 1
image
3x3 conv, 64
3x3 conv, 64
pool, /2
3x3 conv, 128
3x3 conv, 128
pool, /2
3x3 conv, 256
3x3 conv, 256
3x3 conv, 256
3x3 conv, 256
pool, /2
3x3 conv, 512
3x3 conv, 512
3x3 conv, 512
3x3 conv, 512
pool, /2
3x3 conv, 512
3x3 conv, 512
3x3 conv, 512
3x3 conv, 512
pool, /2
fc 4096
fc 4096
fc 1000
image
7x7 conv, 64, /2
pool, /2
3x3 conv, 64
3x3 conv, 64
3x3 conv, 64
3x3 conv, 64
3x3 conv, 64
3x3 conv, 64
3x3 conv, 128, /2
3x3 conv, 128
3x3 conv, 128
3x3 conv, 128
3x3 conv, 128
3x3 conv, 128
3x3 conv, 128
3x3 conv, 128
3x3 conv, 256, /2
3x3 conv, 256
3x3 conv, 256
3x3 conv, 256
3x3 conv, 256
3x3 conv, 256
3x3 conv, 256
3x3 conv, 256
3x3 conv, 256
3x3 conv, 256
3x3 conv, 256
3x3 conv, 256
3x3 conv, 512, /2
3x3 conv, 512
3x3 conv, 512
3x3 conv, 512
3x3 conv, 512
3x3 conv, 512
avg pool
fc 1000
image
7x7 conv, 64, /2
pool, /2
3x3 conv, 64
3x3 conv, 64
3x3 conv, 64
3x3 conv, 64
3x3 conv, 64
3x3 conv, 64
3x3 conv, 128, /2
3x3 conv, 128
3x3 conv, 128
3x3 conv, 128
3x3 conv, 128
3x3 conv, 128
3x3 conv, 128
3x3 conv, 128
3x3 conv, 256, /2
3x3 conv, 256
3x3 conv, 256
3x3 conv, 256
3x3 conv, 256
3x3 conv, 256
3x3 conv, 256
3x3 conv, 256
3x3 conv, 256
3x3 conv, 256
3x3 conv, 256
3x3 conv, 256
3x3 conv, 512, /2
3x3 conv, 512
3x3 conv, 512
3x3 conv, 512
3x3 conv, 512
3x3 conv, 512
avg pool
fc 1000


I WAS WINNING IMAGENET
UNTIL A DEEPER MODEL CAME ALONG
imgflip.com

ResNet: ILSVRC 2015 winner

Revolution of Depth

AlexNet, 8 layers
(ILSVRC 2012)

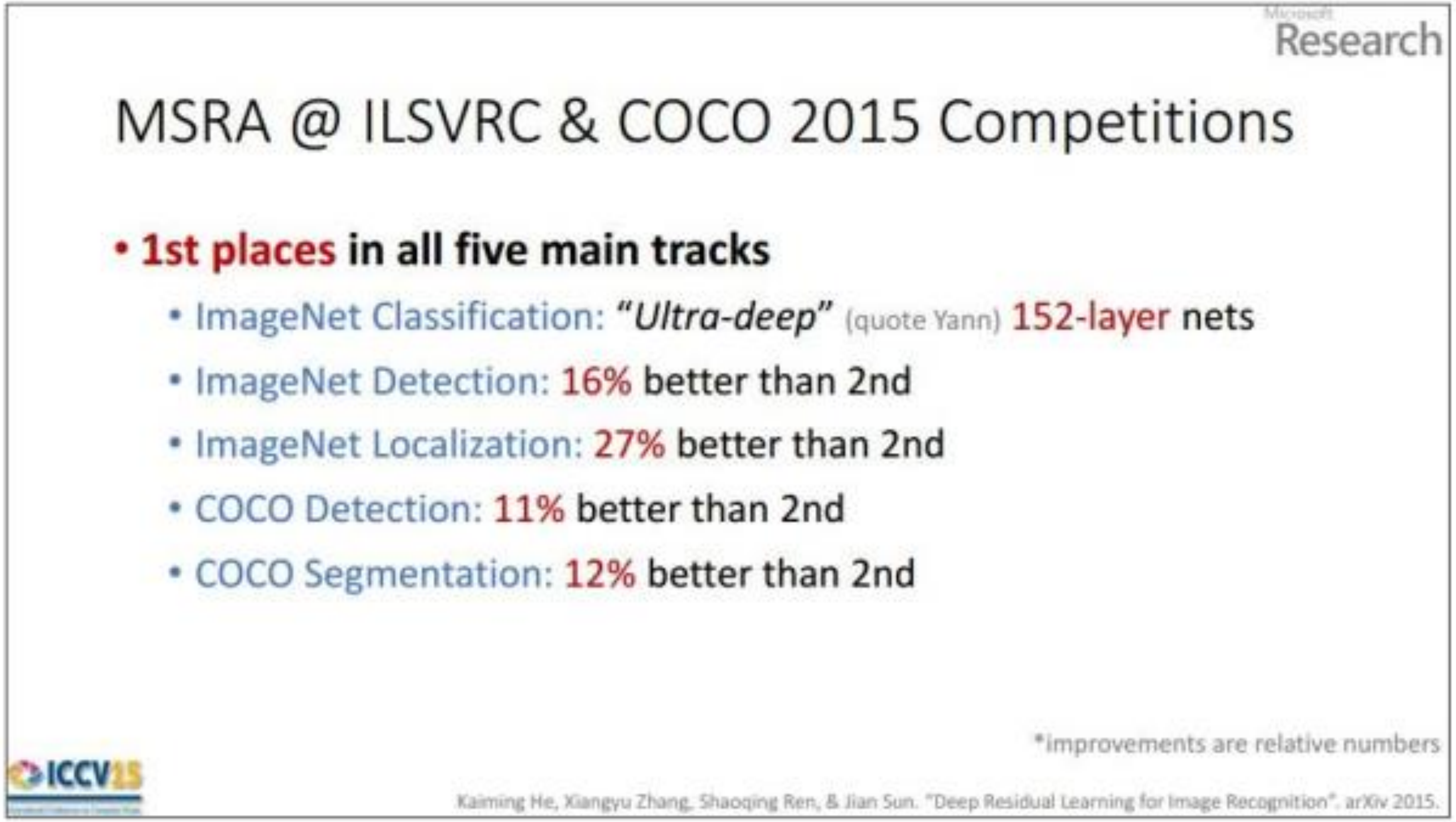


VGG, 19 layers
(ILSVRC 2014)

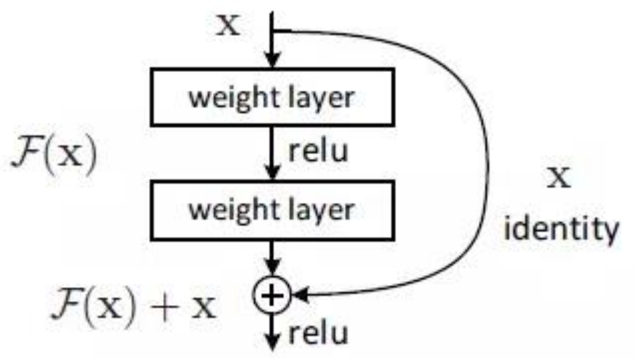
ResNet, 152 layers
(ILSVRC 2015)

Kaiming He, Xiangyu Zhang, Shaoqing Ren, and Jian Sun,
[Deep Residual Learning for Image Recognition](), CVPR 2016

BOOM!


Research
MSRA @ ILSVRC & COCO 2015 Competitions
• 1st places in all five main tracks
• ImageNet Classification: "Ultra-deep" (quote Yann) 152-layer nets
• ImageNet Detection: 16% better than 2nd
• ImageNet Localization: 27% better than 2nd
• COCO Detection: 11% better than 2nd
• COCO Segmentation: 12% better than 2nd
*improvements are relative numbers
ICCV15
Kaiming He, Xiangyu Zhang, Shaoqing Ren, & Jian Sun. "Deep Residual Learning for Image Recognition". arXiv 2015.

Why call Residual?

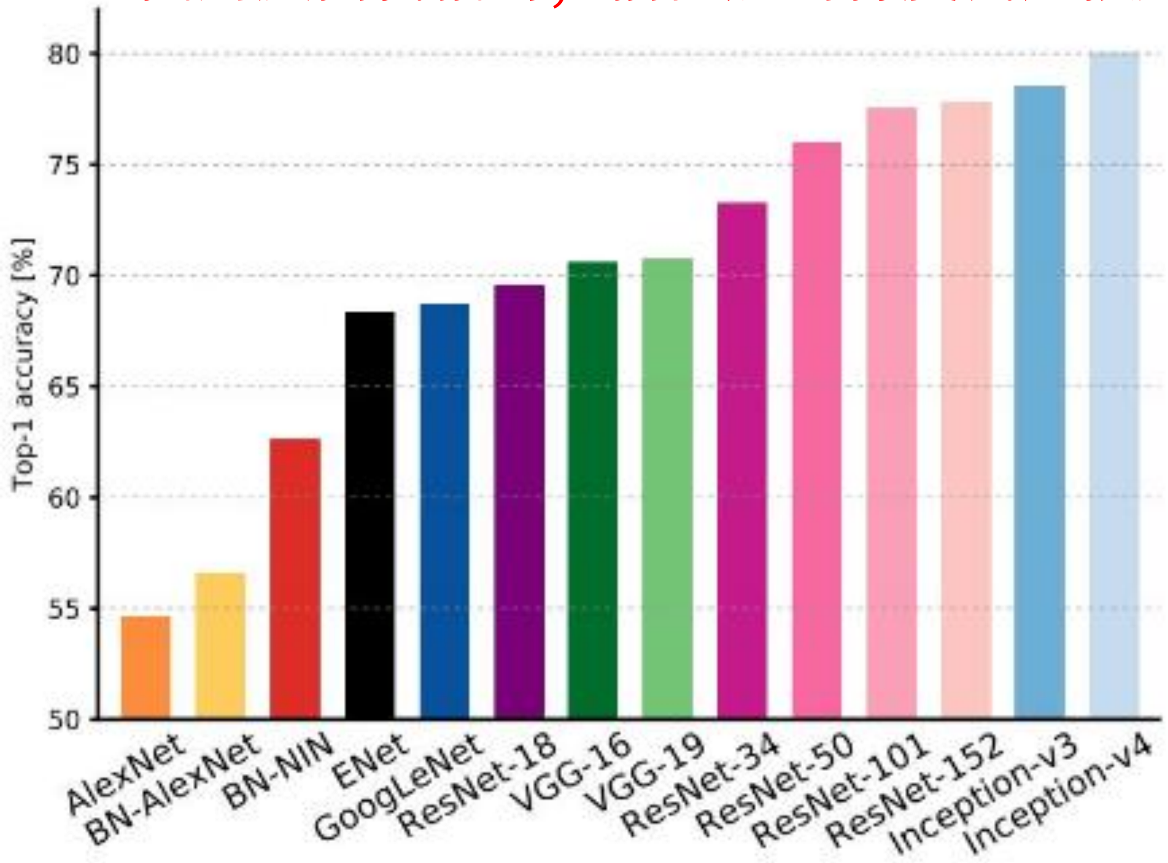


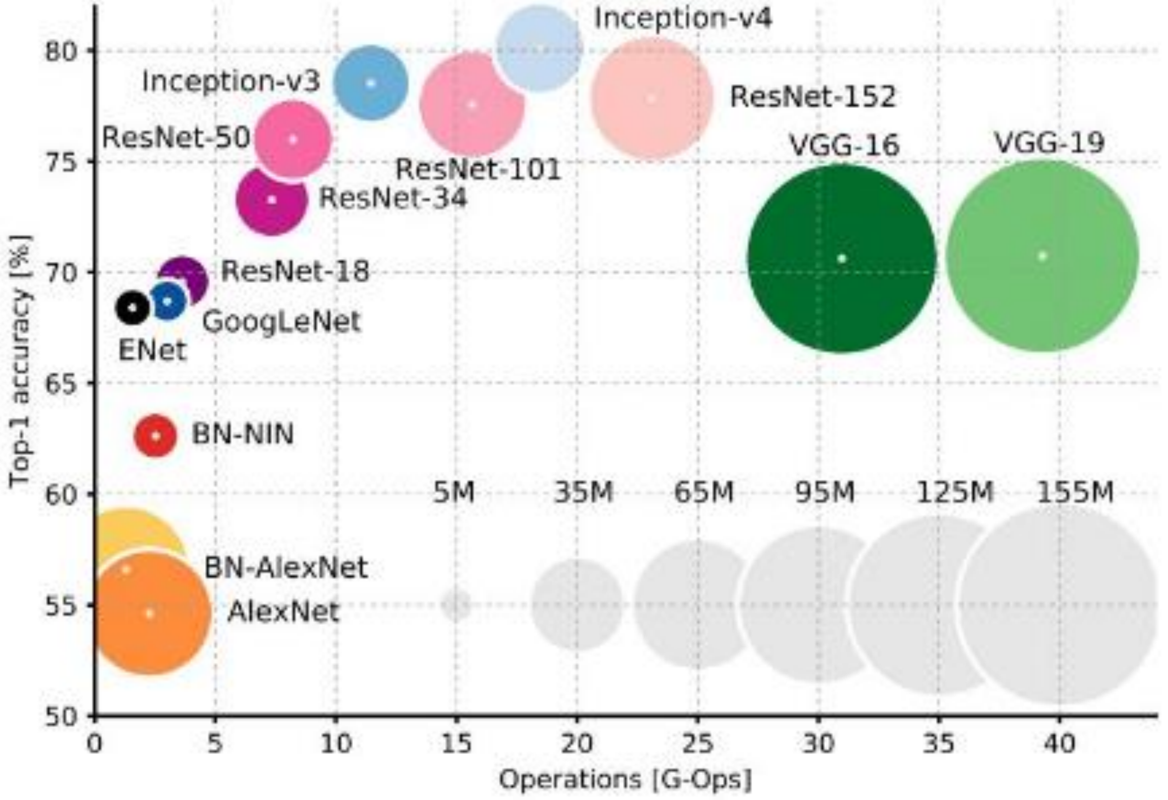
$$\mathcal{F}(\mathrm{x}) := \mathcal{H}(\mathrm{x}) - \mathrm{x}$$

残差

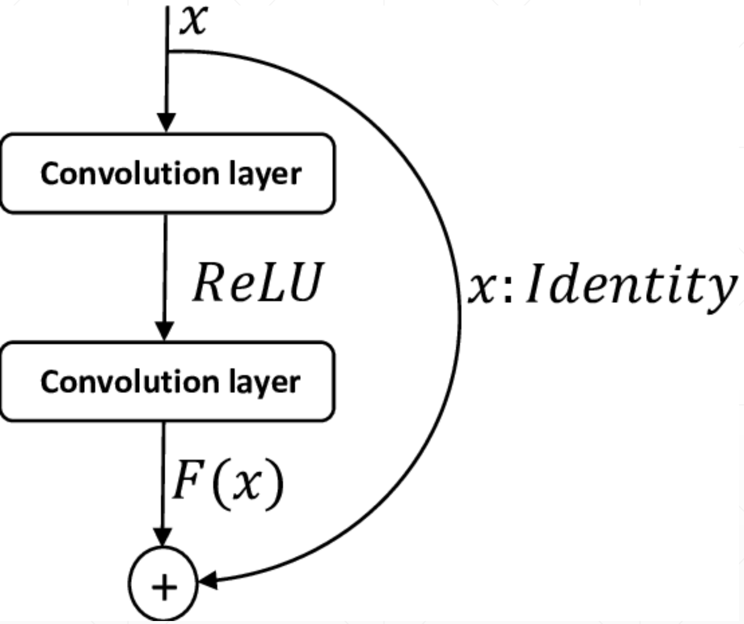
https://www.jianshu.com/p/a71f0085157c

20层以后，层数的简单堆叠对结果帮助不大
因为反向传播时，前面层的梯度会近似为0



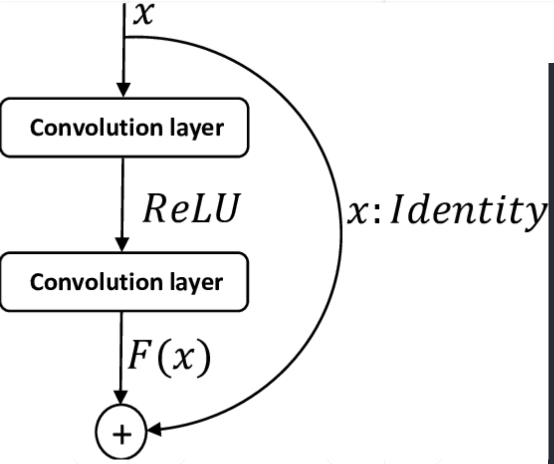


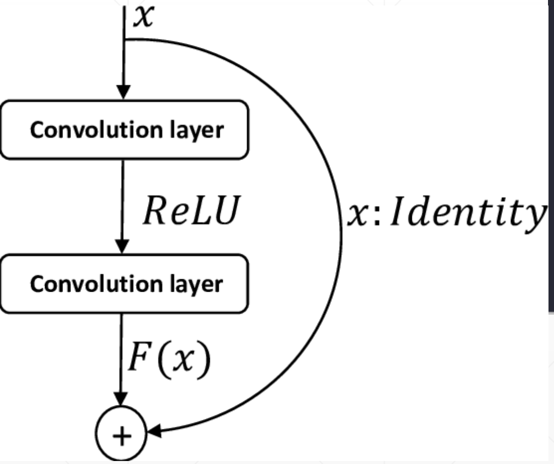
Basic Block




```python
class BasicBlock(layers.Layer):
    def __init__(self, filter_num, stride=1):
        super(BasicBlock, self).__init__()

        self.conv1 = layers.Conv2D(filter_num, (3, 3), strides=stride, padding='same')
        self.bn1 = layers.BatchNormalization()
        self.relu = layers.Activation('relu')
        self.conv2 = layers.Conv2D(filter_num, (3, 3), strides=1, padding='same')
        self.bn2 = layers.BatchNormalization()
        if stride != 1:
            self.downsample = Sequential()
            self.downsample.add(layers.Conv2D(filter_num, (1, 1), strides=stride))
            self.downsample.add(layers.BatchNormalization())
        else:
            self.downsample = lambda x: x

        self.stride = stride

    def call(self, inputs, training=None):
        residual = self.downsample(inputs)

        conv1 = self.conv1(inputs)
        bn1 = self.bn1(conv1)
        relu1 = self.relu(bn1)
        conv2 = self.conv2(relu1)
        bn2 = self.bn2(conv2)

        add = layers.add([bn2, residual])
        out = self.relu(add)
        return out
```

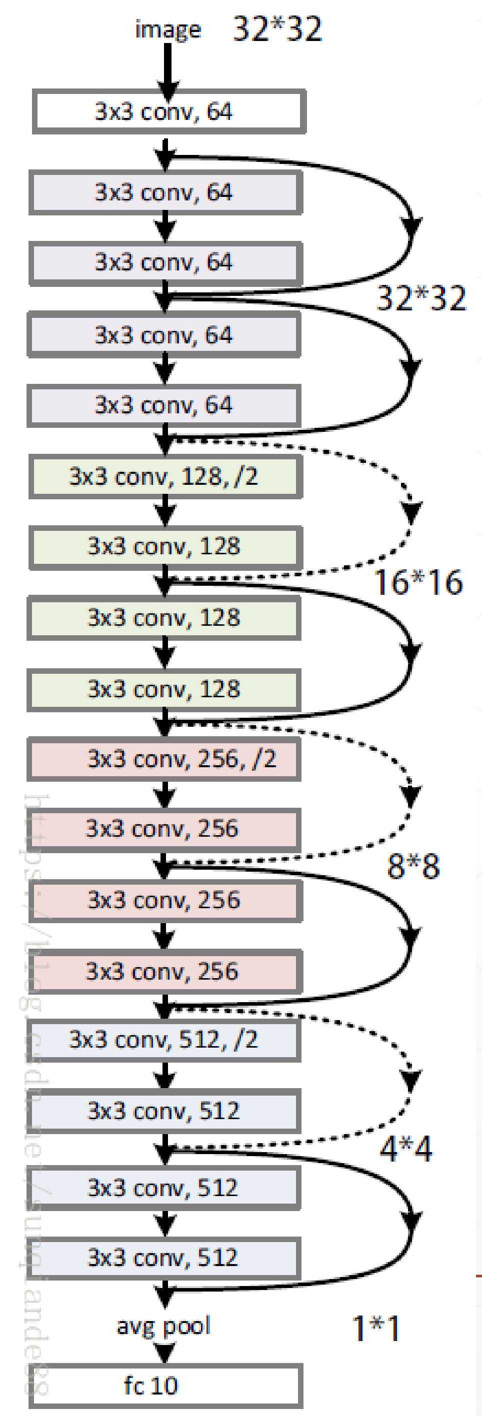
Res Block





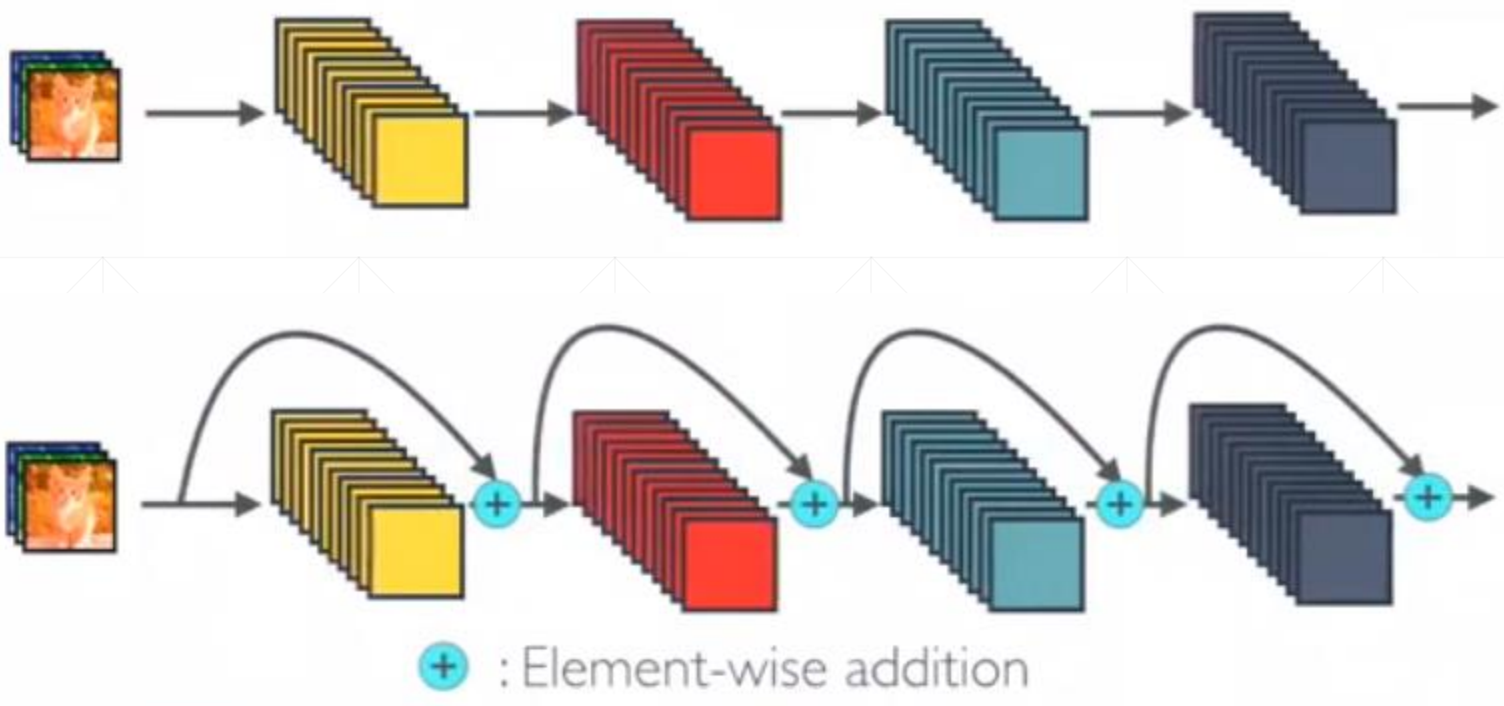

```python
def _build_resblock(self, block, filter_num, blocks, stride=1):

    res_blocks = keras.Sequential()
    res_blocks.add(block(filter_num, stride))

    for _ in range(1, blocks):
        res_blocks.add(block(filter_num, stride=1))

    return res_blocks
```

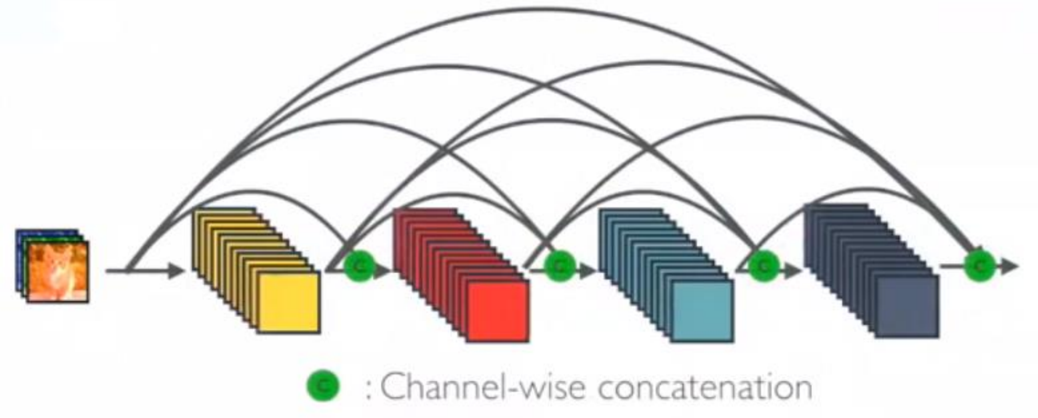
ResNet-18



https://hackernoon.com/traffic-sign-classification-6e7113d9c4d5

DenseNet





后面层与前面每一层都有机会短接

下一课时

ResNet实战

Thank You.