

main network structures

VGG16: Top-5 error 9.62, Top-1 error 28.41

```
VGG (
  (features): Sequential (
    (0): Conv2d(3, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): ReLU (inplace)
    (2): Conv2d(64, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (3): ReLU (inplace)
    (4): MaxPool2d (size=(2, 2), stride=(2, 2), dilation=(1, 1))
    (5): Conv2d(64, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (6): ReLU (inplace)
    (7): Conv2d(128, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (8): ReLU (inplace)
    (9): MaxPool2d (size=(2, 2), stride=(2, 2), dilation=(1, 1))
    (10): Conv2d(128, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (11): ReLU (inplace)
    (12): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (13): ReLU (inplace)
    (14): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (15): ReLU (inplace)
    (16): MaxPool2d (size=(2, 2), stride=(2, 2), dilation=(1, 1))
    (17): Conv2d(256, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (18): ReLU (inplace)
    (19): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (20): ReLU (inplace)
    (21): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (22): ReLU (inplace)
    (23): MaxPool2d (size=(2, 2), stride=(2, 2), dilation=(1, 1))
    (24): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (25): ReLU (inplace)
    (26): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (27): ReLU (inplace)
    (28): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (29): ReLU (inplace)
    (30): MaxPool2d (size=(2, 2), stride=(2, 2), dilation=(1, 1))
  )
  (classifier): Sequential (
    (0): Linear (25088 -> 4096)
    (1): ReLU (inplace)
    (2): Dropout (p = 0.5)
    (3): Linear (4096 -> 4096)
    (4): ReLU (inplace)
    (5): Dropout (p = 0.5)
    (6): Linear (4096 -> 1000)
  )
)
```

VGG13 with batch normalization: Top-5 error 10.75, Top-1 error 30.07

```
VGG (
  (features): Sequential (
    (0): Conv2d(3, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True)
    (2): ReLU (inplace)
    (3): Conv2d(64, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
```

```

(4): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True)
(5): ReLU (inplace)
(6): MaxPool2d (size=(2, 2), stride=(2, 2), dilation=(1, 1))
(7): Conv2d(64, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
(8): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True)
(9): ReLU (inplace)
(10): Conv2d(128, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
(11): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True)
(12): ReLU (inplace)
(13): MaxPool2d (size=(2, 2), stride=(2, 2), dilation=(1, 1))
(14): Conv2d(128, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
(15): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True)
(16): ReLU (inplace)
(17): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
(18): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True)
(19): ReLU (inplace)
(20): MaxPool2d (size=(2, 2), stride=(2, 2), dilation=(1, 1))
(21): Conv2d(256, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
(22): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True)
(23): ReLU (inplace)
(24): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
(25): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True)
(26): ReLU (inplace)
(27): MaxPool2d (size=(2, 2), stride=(2, 2), dilation=(1, 1))
(28): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
(29): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True)
(30): ReLU (inplace)
(31): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
(32): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True)
(33): ReLU (inplace)
(34): MaxPool2d (size=(2, 2), stride=(2, 2), dilation=(1, 1))
)
(classifier): Sequential (
  (0): Linear (25088 -> 4096)
  (1): ReLU (inplace)
  (2): Dropout (p = 0.5)
  (3): Linear (4096 -> 4096)
  (4): ReLU (inplace)
  (5): Dropout (p = 0.5)
  (6): Linear (4096 -> 1000)
)
)

```

Resnet50: Top-5 error 7.13, Top-1 error 28.15

```

ResNet (
  (conv1): Conv2d(3, 64, kernel_size=(7, 7), stride=(2, 2), padding=(3, 3), bias=False)
  (bn1): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True)
  (relu): ReLU (inplace)
  (maxpool): MaxPool2d (size=(3, 3), stride=(2, 2), padding=(1, 1), dilation=(1, 1))
  (layer1): Sequential (
    (0): Bottleneck (
      (conv1): Conv2d(64, 64, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn1): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True)
      (conv2): Conv2d(64, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), bias=False)
      (bn2): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True)
      (conv3): Conv2d(64, 256, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn3): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True)
      (relu): ReLU (inplace)
      (downsample): Sequential (
        (0): Conv2d(64, 256, kernel_size=(1, 1), stride=(1, 1), bias=False)
        (1): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True)
      )
    )
  )
)

```

```

(1): Bottleneck (
  (conv1): Conv2d(256, 64, kernel_size=(1, 1), stride=(1, 1), bias=False)
  (bn1): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True)
  (conv2): Conv2d(64, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), bias=False)
  (bn2): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True)
  (conv3): Conv2d(64, 256, kernel_size=(1, 1), stride=(1, 1), bias=False)
  (bn3): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True)
  (relu): ReLU (inplace)
)
(2): Bottleneck (
  (conv1): Conv2d(256, 64, kernel_size=(1, 1), stride=(1, 1), bias=False)
  (bn1): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True)
  (conv2): Conv2d(64, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), bias=False)
  (bn2): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True)
  (conv3): Conv2d(64, 256, kernel_size=(1, 1), stride=(1, 1), bias=False)
  (bn3): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True)
  (relu): ReLU (inplace)
)
)
(layer2): Sequential (
  (0): Bottleneck (
    (conv1): Conv2d(256, 128, kernel_size=(1, 1), stride=(1, 1), bias=False)
    (bn1): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True)
    (conv2): Conv2d(128, 128, kernel_size=(3, 3), stride=(2, 2), padding=(1, 1), bias=False)
    (bn2): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True)
    (conv3): Conv2d(128, 512, kernel_size=(1, 1), stride=(1, 1), bias=False)
    (bn3): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True)
    (relu): ReLU (inplace)
    (downsample): Sequential (
      (0): Conv2d(256, 512, kernel_size=(1, 1), stride=(2, 2), bias=False)
      (1): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True)
    )
  )
  (1): Bottleneck (
    (conv1): Conv2d(512, 128, kernel_size=(1, 1), stride=(1, 1), bias=False)
    (bn1): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True)
    (conv2): Conv2d(128, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), bias=False)
    (bn2): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True)
    (conv3): Conv2d(128, 512, kernel_size=(1, 1), stride=(1, 1), bias=False)
    (bn3): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True)
    (relu): ReLU (inplace)
  )
  (2): Bottleneck (
    (conv1): Conv2d(512, 128, kernel_size=(1, 1), stride=(1, 1), bias=False)
    (bn1): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True)
    (conv2): Conv2d(128, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), bias=False)
    (bn2): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True)
    (conv3): Conv2d(128, 512, kernel_size=(1, 1), stride=(1, 1), bias=False)
    (bn3): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True)
    (relu): ReLU (inplace)
  )
  (3): Bottleneck (
    (conv1): Conv2d(512, 128, kernel_size=(1, 1), stride=(1, 1), bias=False)
    (bn1): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True)
    (conv2): Conv2d(128, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), bias=False)
    (bn2): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True)
    (conv3): Conv2d(128, 512, kernel_size=(1, 1), stride=(1, 1), bias=False)
    (bn3): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True)
    (relu): ReLU (inplace)
  )
)
)
(layer3): Sequential (
  (0): Bottleneck (
    (conv1): Conv2d(512, 256, kernel_size=(1, 1), stride=(1, 1), bias=False)
    (bn1): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True)
    (conv2): Conv2d(256, 256, kernel_size=(3, 3), stride=(2, 2), padding=(1, 1), bias=False)
    (bn2): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True)
    (conv3): Conv2d(256, 1024, kernel_size=(1, 1), stride=(1, 1), bias=False)

```

```

        (bn3): BatchNorm2d(1024, eps=1e-05, momentum=0.1, affine=True)
        (relu): ReLU (inplace)
        (downsample): Sequential (
          (0): Conv2d(512, 1024, kernel_size=(1, 1), stride=(2, 2), bias=False)
          (1): BatchNorm2d(1024, eps=1e-05, momentum=0.1, affine=True)
        )
      )
    (1): Bottleneck (
      (conv1): Conv2d(1024, 256, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn1): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True)
      (conv2): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), bias=False)
      (bn2): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True)
      (conv3): Conv2d(256, 1024, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn3): BatchNorm2d(1024, eps=1e-05, momentum=0.1, affine=True)
      (relu): ReLU (inplace)
    )
    (2): Bottleneck (
      (conv1): Conv2d(1024, 256, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn1): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True)
      (conv2): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), bias=False)
      (bn2): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True)
      (conv3): Conv2d(256, 1024, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn3): BatchNorm2d(1024, eps=1e-05, momentum=0.1, affine=True)
      (relu): ReLU (inplace)
    )
    (3): Bottleneck (
      (conv1): Conv2d(1024, 256, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn1): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True)
      (conv2): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), bias=False)
      (bn2): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True)
      (conv3): Conv2d(256, 1024, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn3): BatchNorm2d(1024, eps=1e-05, momentum=0.1, affine=True)
      (relu): ReLU (inplace)
    )
    (4): Bottleneck (
      (conv1): Conv2d(1024, 256, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn1): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True)
      (conv2): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), bias=False)
      (bn2): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True)
      (conv3): Conv2d(256, 1024, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn3): BatchNorm2d(1024, eps=1e-05, momentum=0.1, affine=True)
      (relu): ReLU (inplace)
    )
    (5): Bottleneck (
      (conv1): Conv2d(1024, 256, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn1): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True)
      (conv2): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), bias=False)
      (bn2): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True)
      (conv3): Conv2d(256, 1024, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn3): BatchNorm2d(1024, eps=1e-05, momentum=0.1, affine=True)
      (relu): ReLU (inplace)
    )
  )
(layer4): Sequential (
  (0): Bottleneck (
    (conv1): Conv2d(1024, 512, kernel_size=(1, 1), stride=(1, 1), bias=False)
    (bn1): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True)
    (conv2): Conv2d(512, 512, kernel_size=(3, 3), stride=(2, 2), padding=(1, 1), bias=False)
    (bn2): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True)
    (conv3): Conv2d(512, 2048, kernel_size=(1, 1), stride=(1, 1), bias=False)
    (bn3): BatchNorm2d(2048, eps=1e-05, momentum=0.1, affine=True)
    (relu): ReLU (inplace)
    (downsample): Sequential (
      (0): Conv2d(1024, 2048, kernel_size=(1, 1), stride=(2, 2), bias=False)
      (1): BatchNorm2d(2048, eps=1e-05, momentum=0.1, affine=True)
    )
  )
  (1): Bottleneck (

```

```

(conv1): Conv2d(2048, 512, kernel_size=(1, 1), stride=(1, 1), bias=False)
(bn1): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True)
(conv2): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), bias=False)
(bn2): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True)
(conv3): Conv2d(512, 2048, kernel_size=(1, 1), stride=(1, 1), bias=False)
(bn3): BatchNorm2d(2048, eps=1e-05, momentum=0.1, affine=True)
(relu): ReLU (inplace)
)
(2): Bottleneck (
(conv1): Conv2d(2048, 512, kernel_size=(1, 1), stride=(1, 1), bias=False)
(bn1): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True)
(conv2): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), bias=False)
(bn2): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True)
(conv3): Conv2d(512, 2048, kernel_size=(1, 1), stride=(1, 1), bias=False)
(bn3): BatchNorm2d(2048, eps=1e-05, momentum=0.1, affine=True)
(relu): ReLU (inplace)
)
)
(avgpool): AvgPool2d (size=7, stride=7, padding=0, ceil_mode=False, count_include_pad=True)
(fc): Linear (2048 -> 1000)
)

```