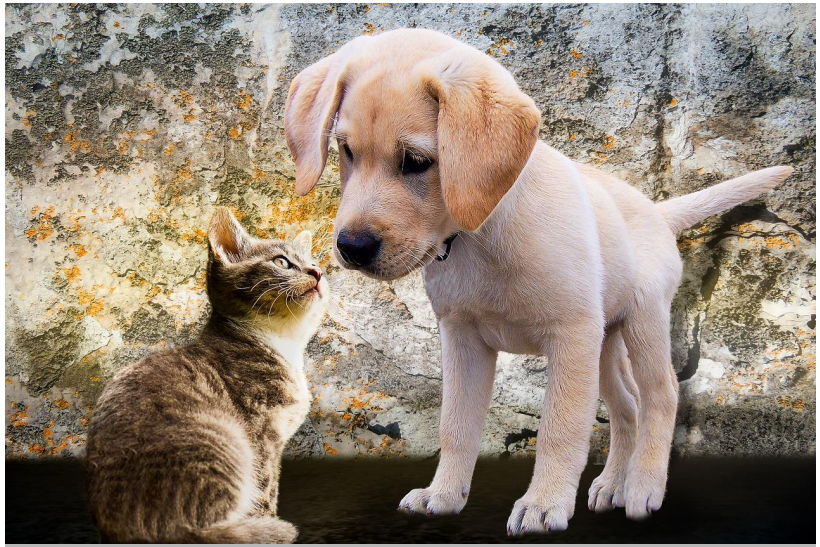
Image Classification

- Multi-class Classification
  - Binary Classification (Subset of the problem)
- Multi-label Classification

Image Classification

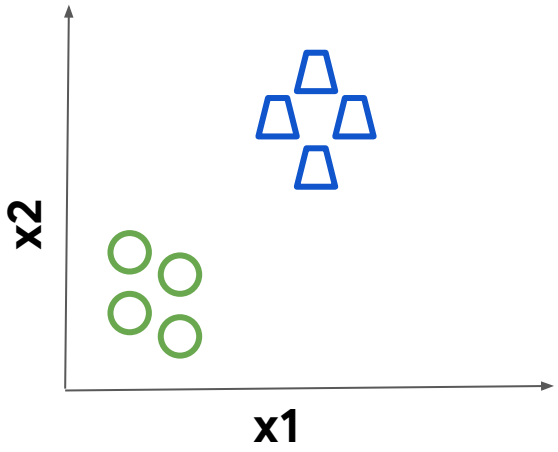
CAT

Multi-label Classification



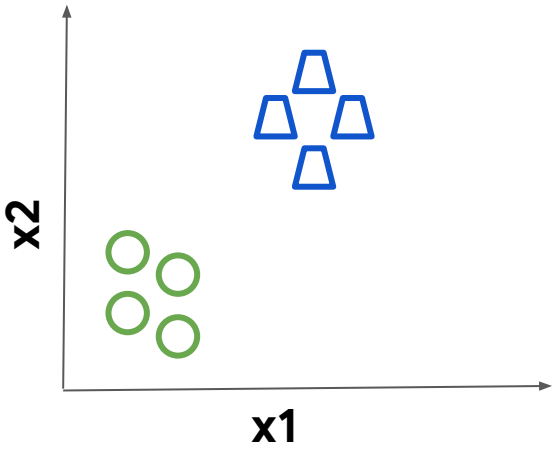
CAT, DOG

Binary vs. Multi Class Classification

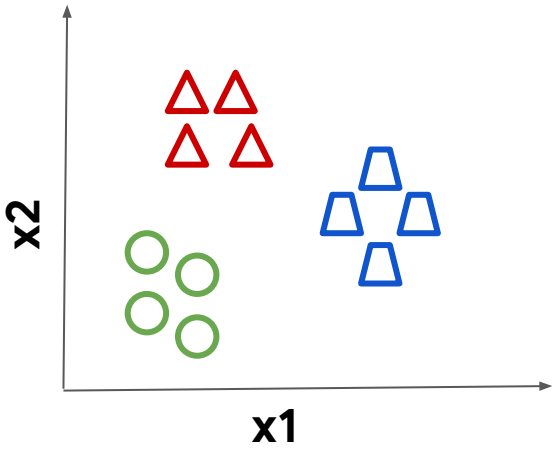


Binary Classification

Binary vs. Multi Class Classification

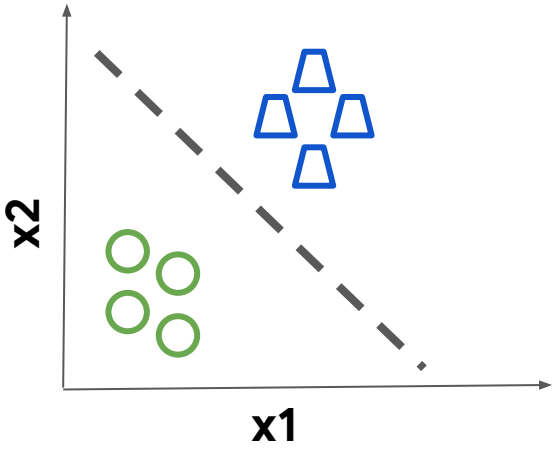


Binary Classification

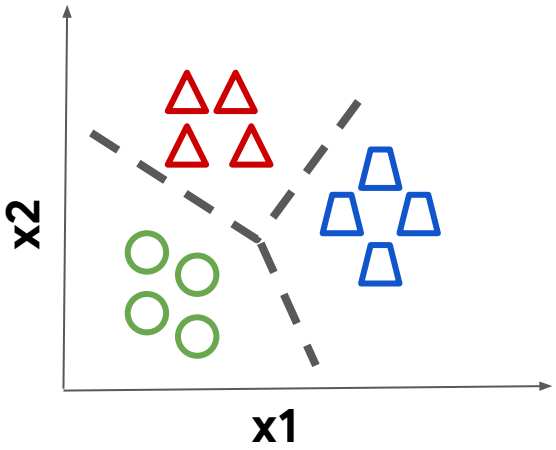


Multi-class Classification

Binary vs. Multi Class Classification

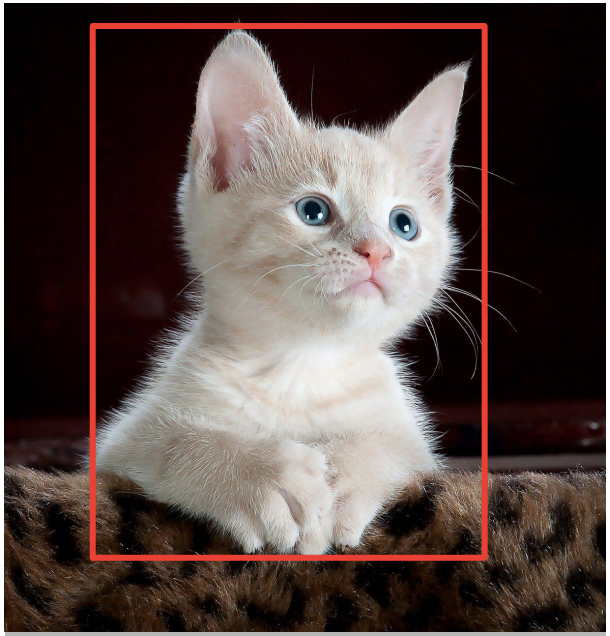


Binary Classification



Multi-class Classification

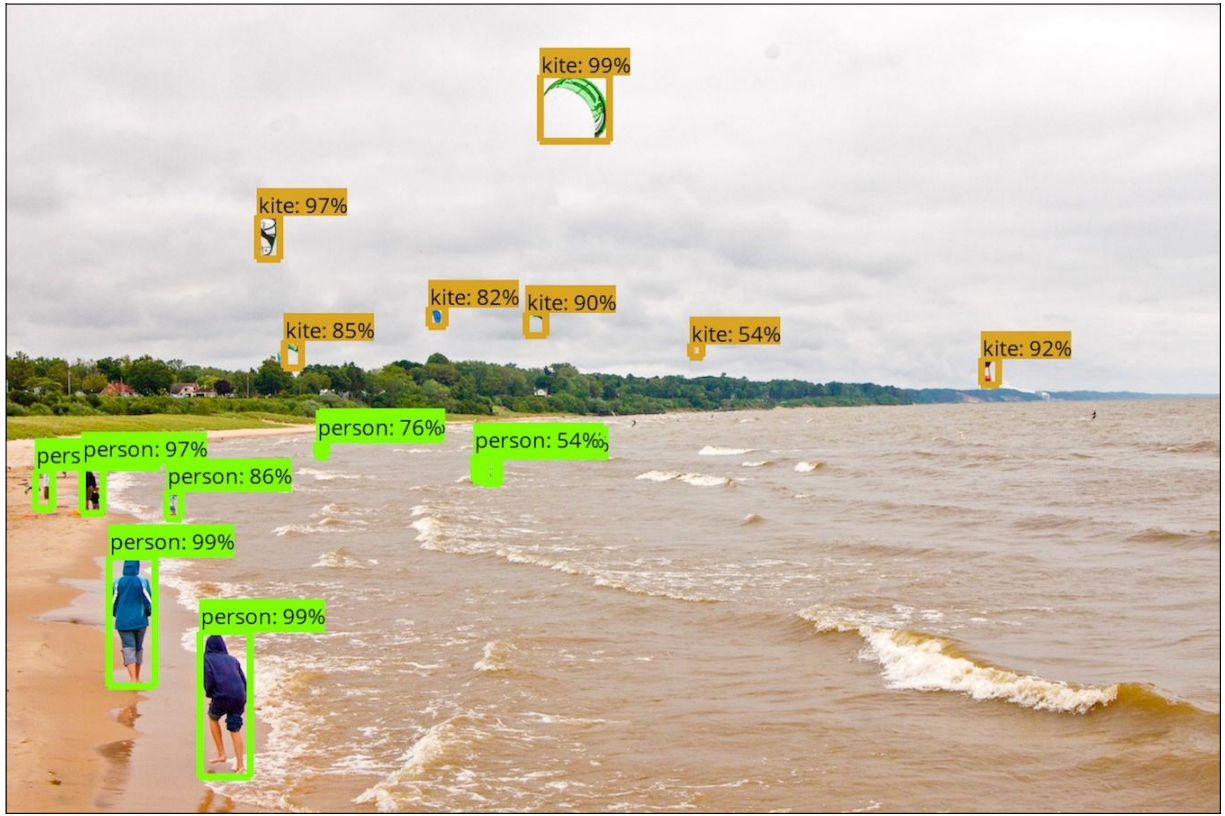
Object Localization



CAT

https://pixabay.com/photos/kitty-cat-kitten-pet-animal-cute-551554/

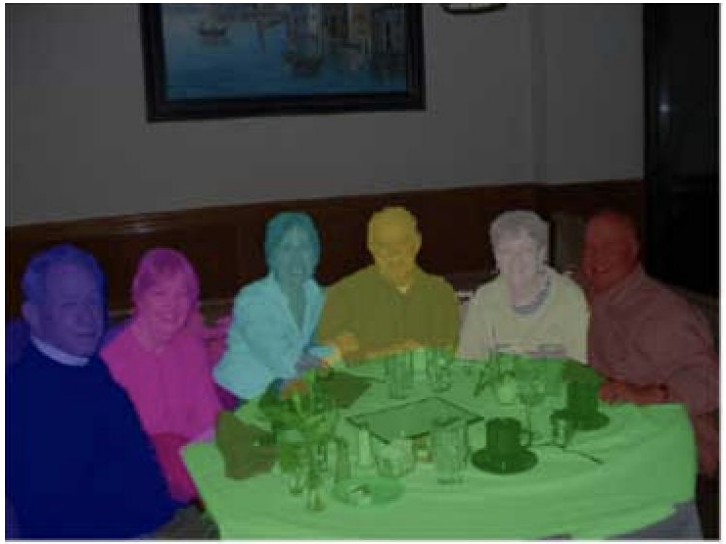
Object Detection



Object Detection

- For each object:
  - confidence scores
  - bounding boxes.
- Popular algorithms
  - R-CNN
  - Faster-RCNN
  - YOLO
  - SSD

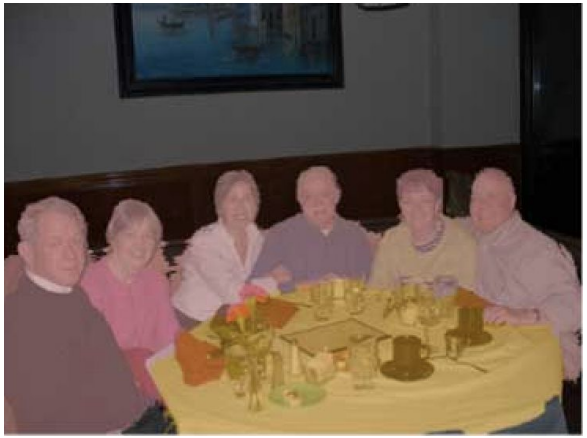
Image Segmentation



source

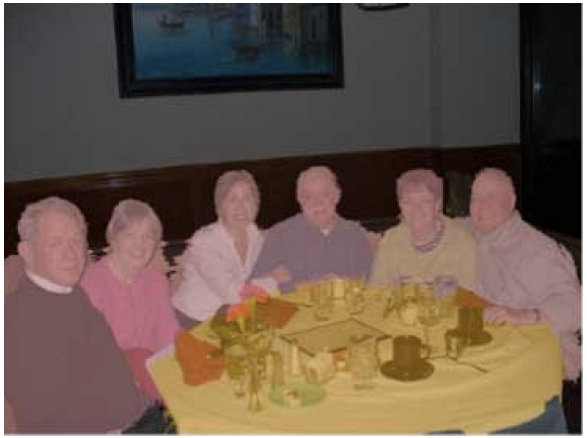
Semantic vs. Instance Segmentation

Semantic vs. Instance Segmentation



Semantic Segmentation

Semantic vs. Instance Segmentation



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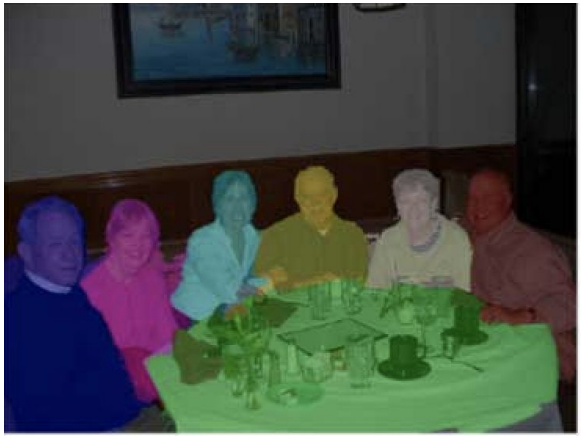

Instance Segmentation

Semantic Segmentation

- Same class → one segment.

Semantic Segmentation

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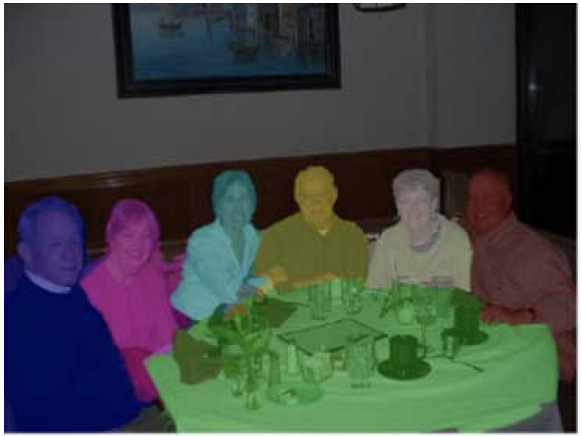
  - All person(s) in an image are treated as one segment

Semantic Segmentation

- Same class → one segment.
- Each pixel is associated with one class.
  - All person(s) in an image are treated as one segment
- Popular models are Fully Convolutional Neural Networks, U-Net, DeepLab

Instance Segmentation

- Multiple “instances” of same class are separate segments.



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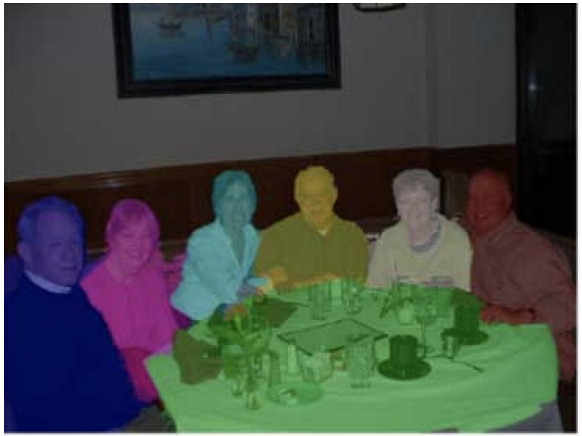
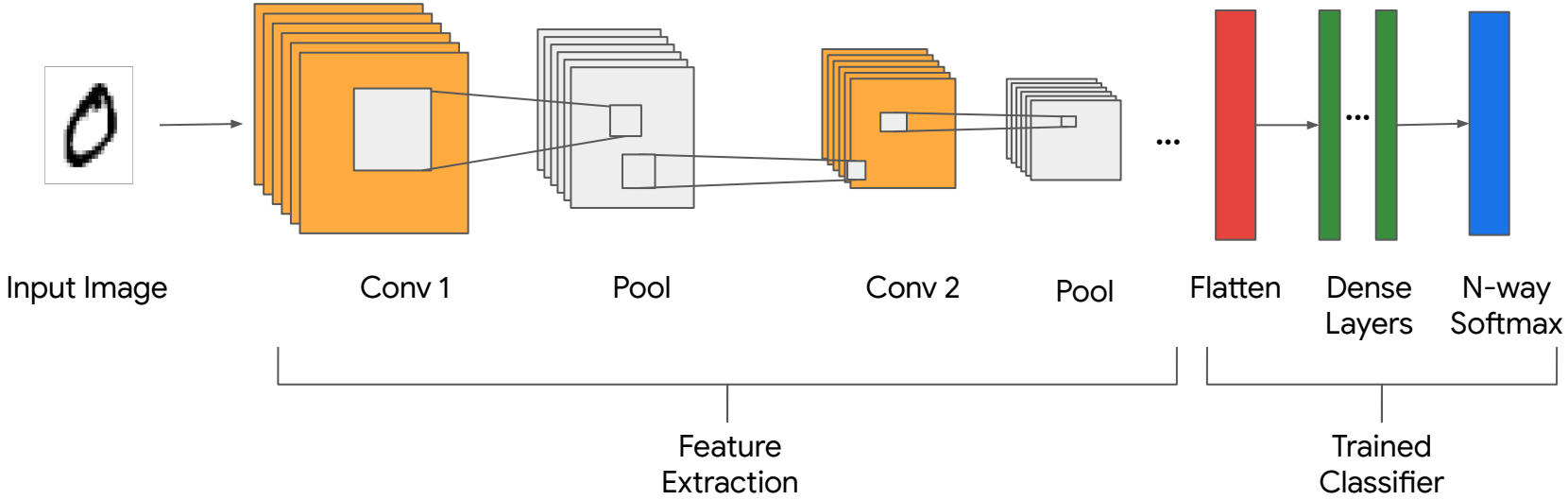
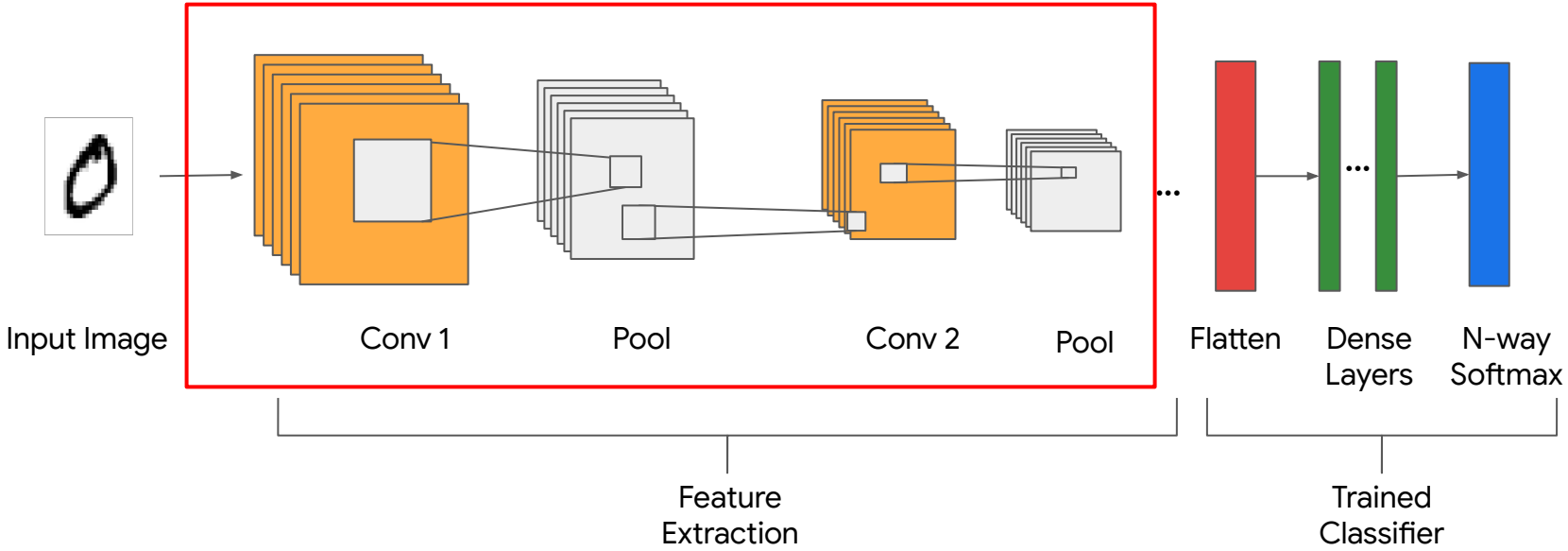


- Popular algorithms are Mask R-CNN.

Convolutional Neural Networks Architecture



Convolutional Neural Networks Architecture



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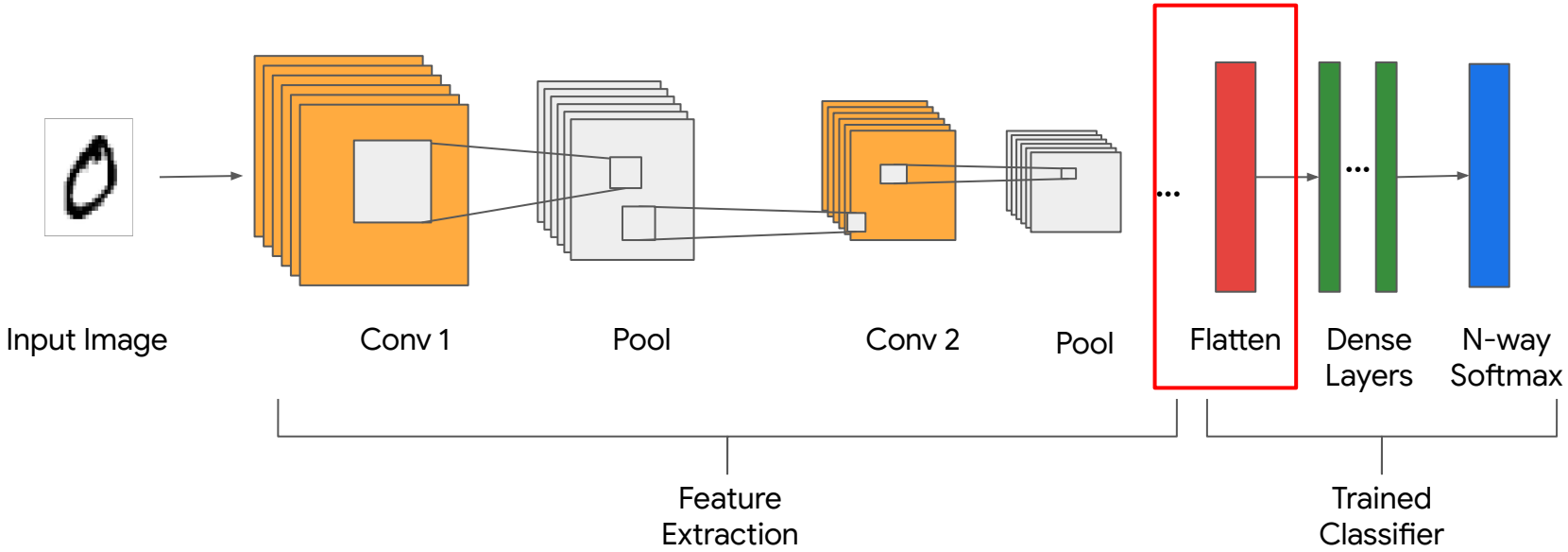

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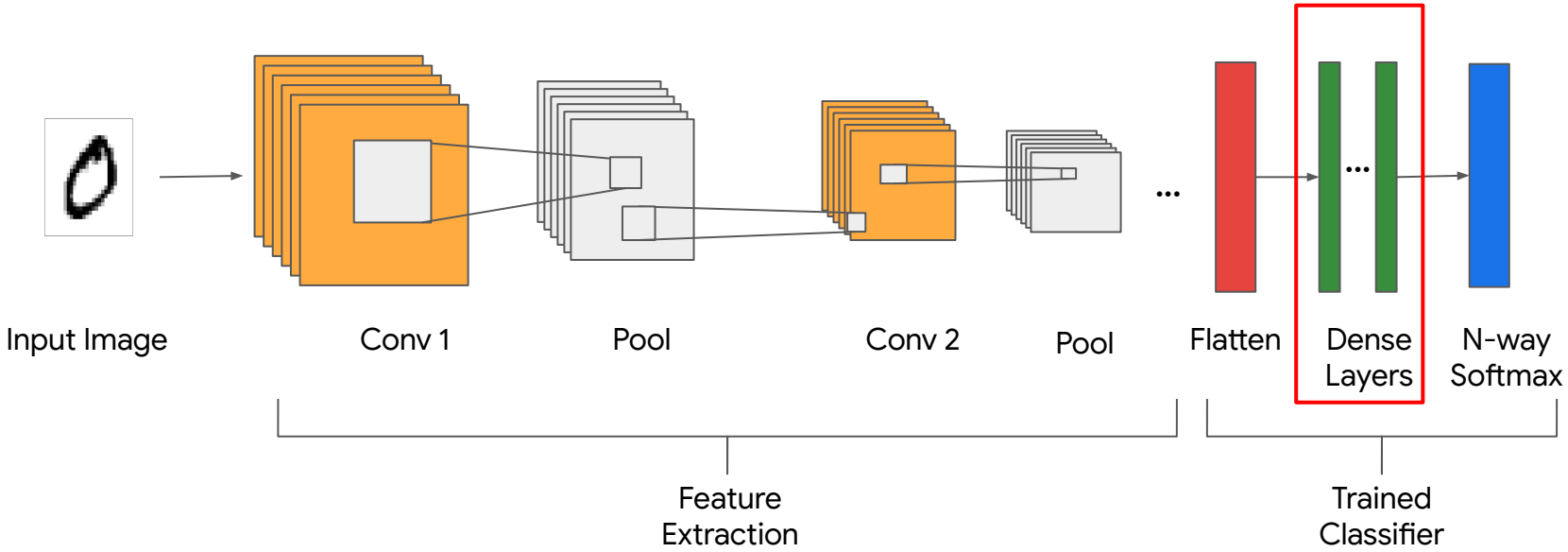

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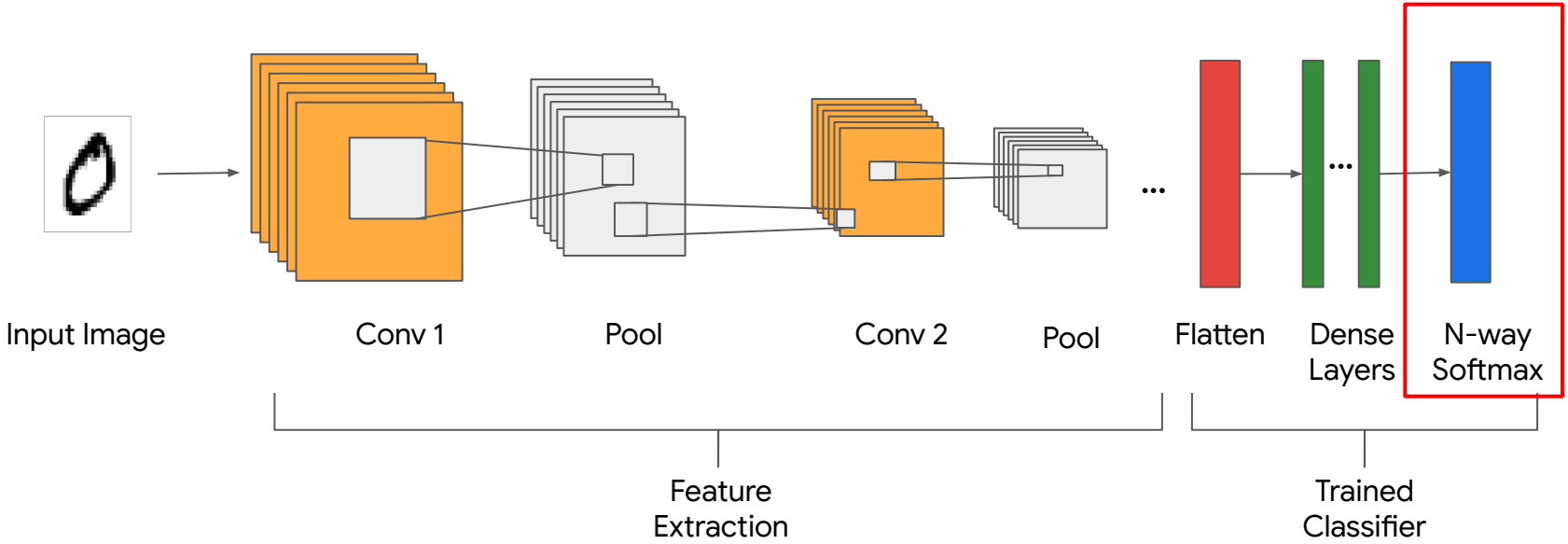
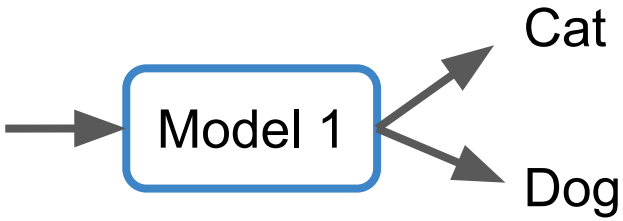


Without Transfer Learning



Without Transfer Learning

Model 1

Cat

Dog

Model 2

cow

horse

Re-use past learning

Pre-train

Model 1

Cat

Dog

Train on downstream task

Model 2

cow

horse

What is Transfer Learning?

- Pre trained model reused for solving another task.
- Reuse weights and layers.
- Example: pre-trained MobileNetV2 → cats vs dog classifier.

What is Transfer Learning?

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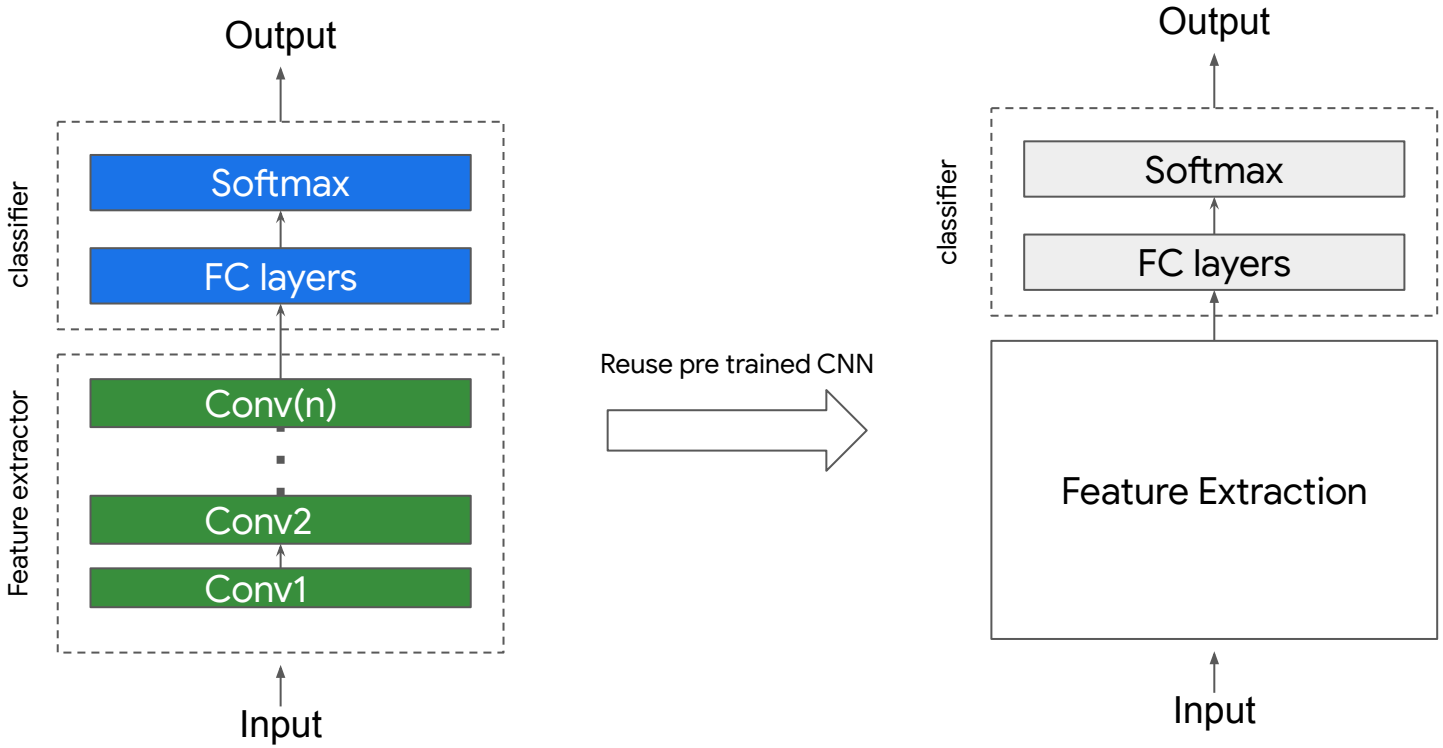

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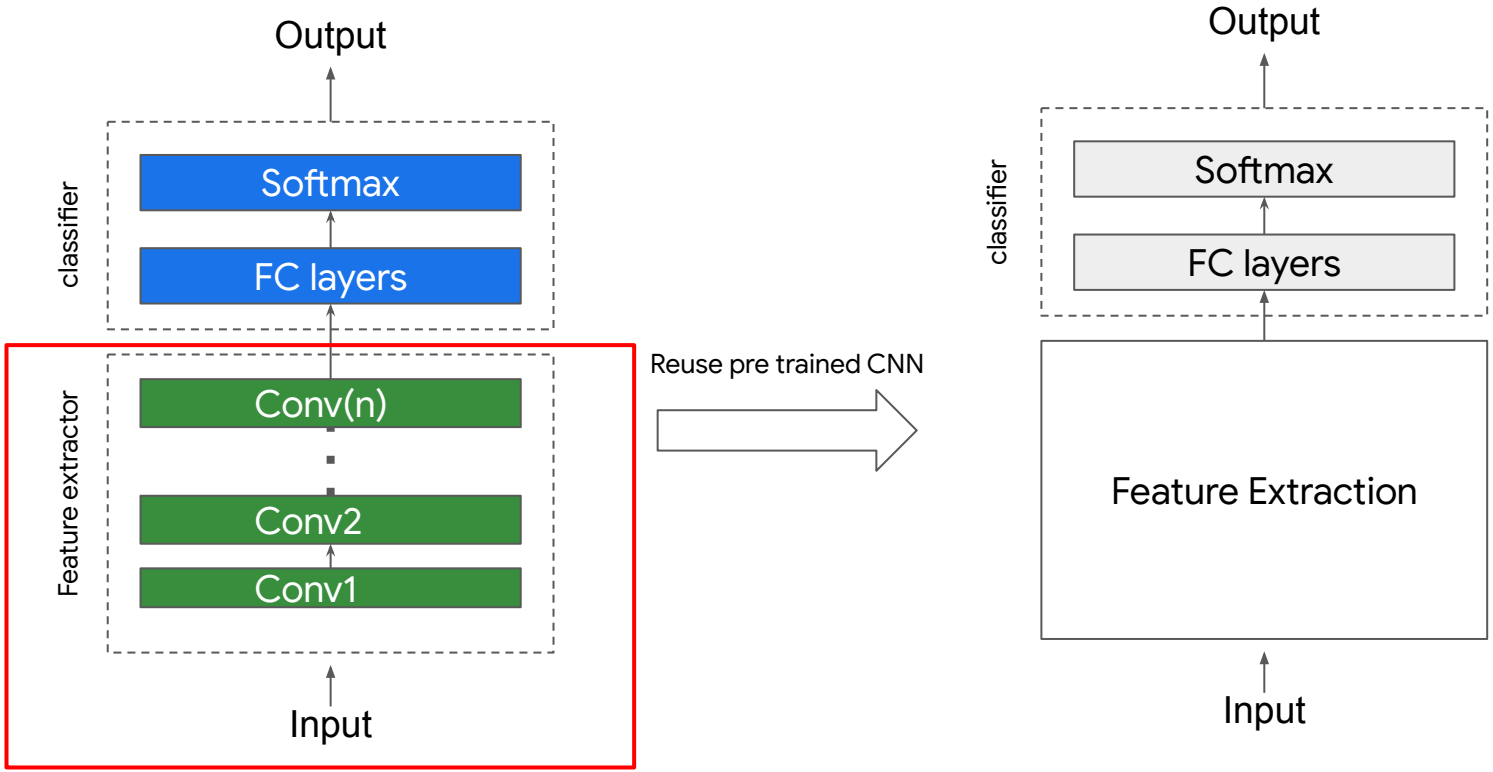

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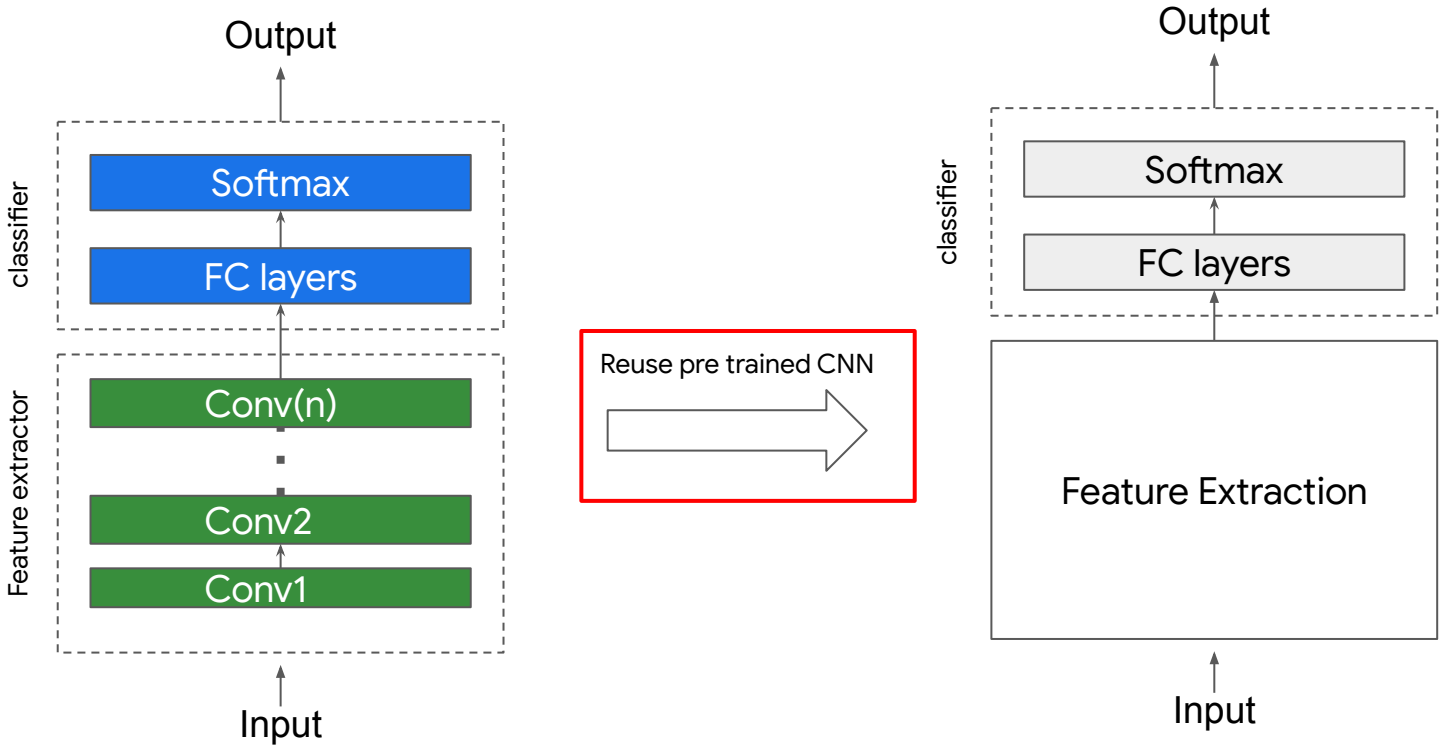

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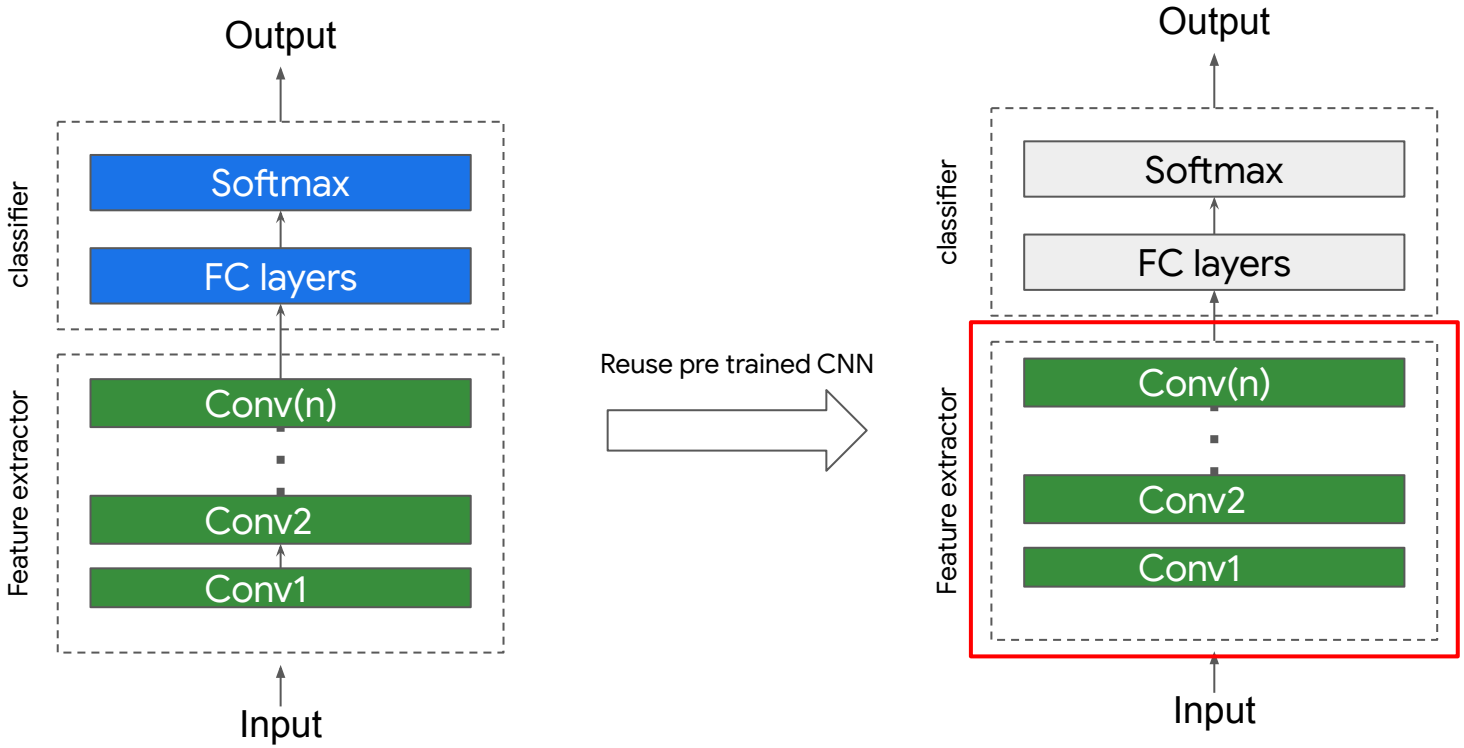
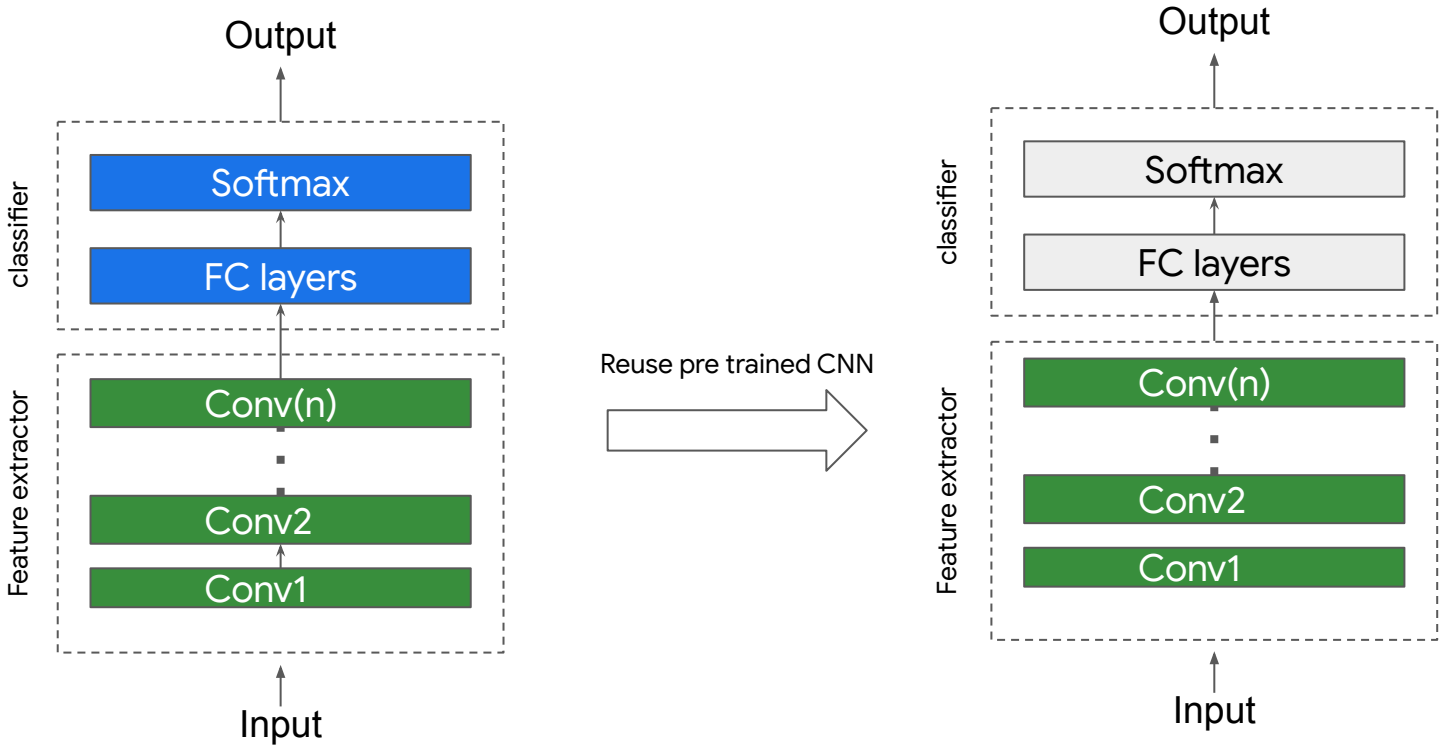


Freeze the Weights



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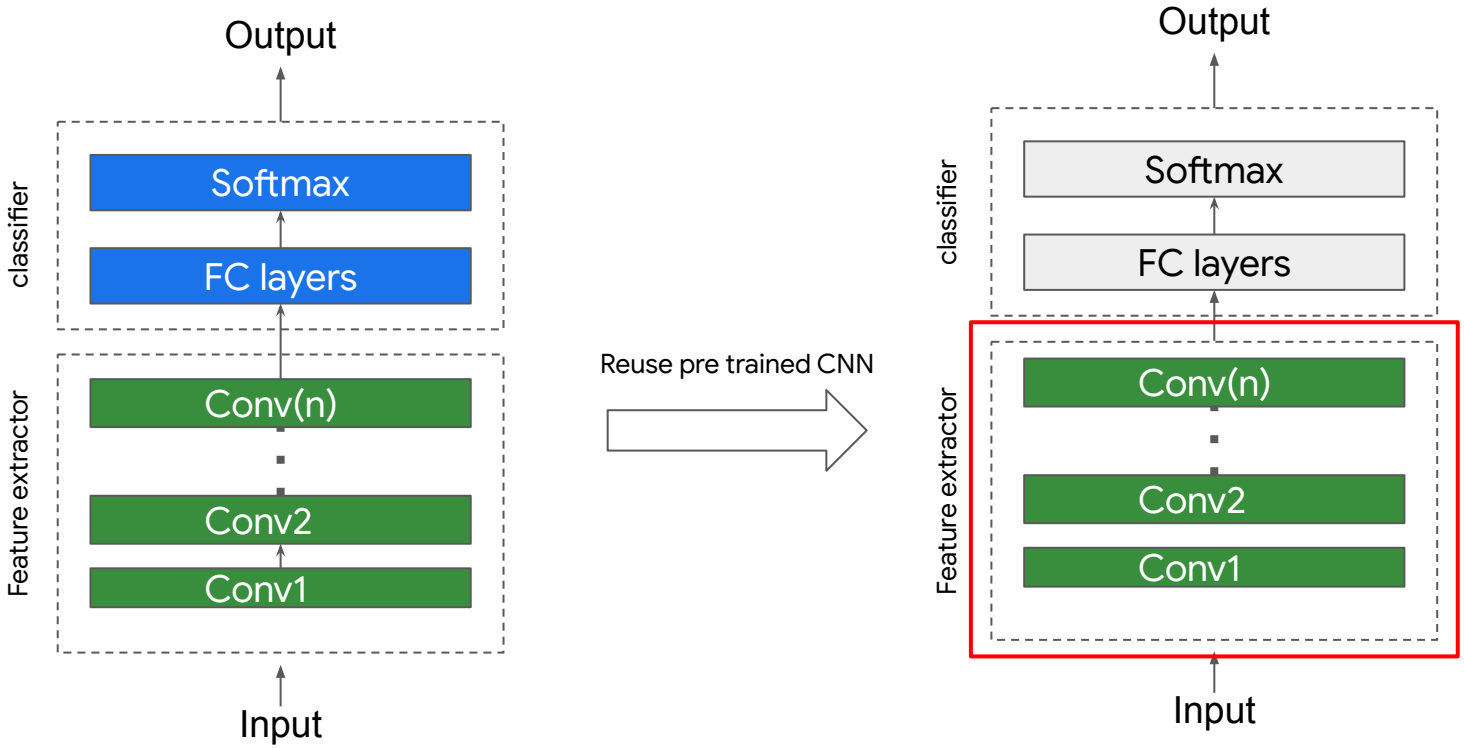

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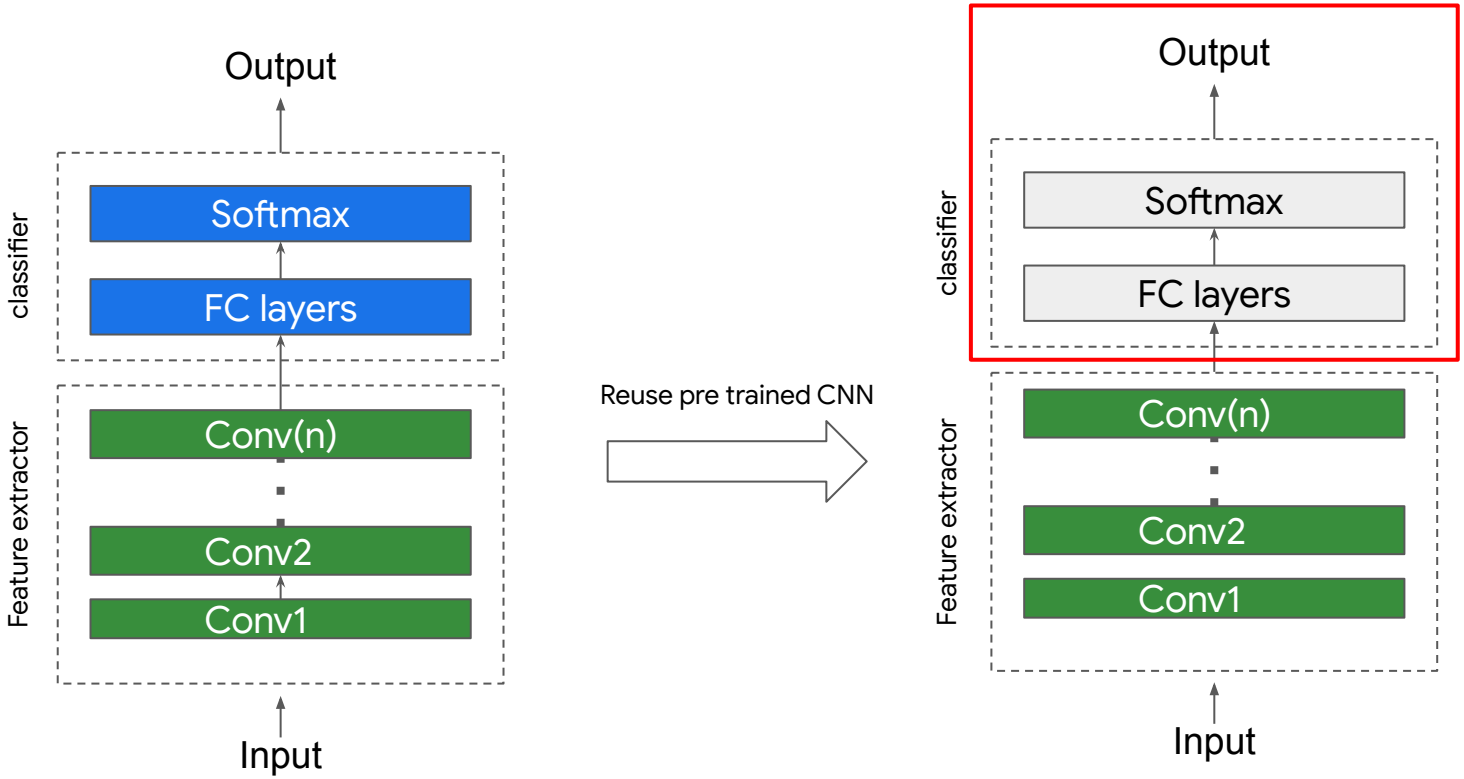
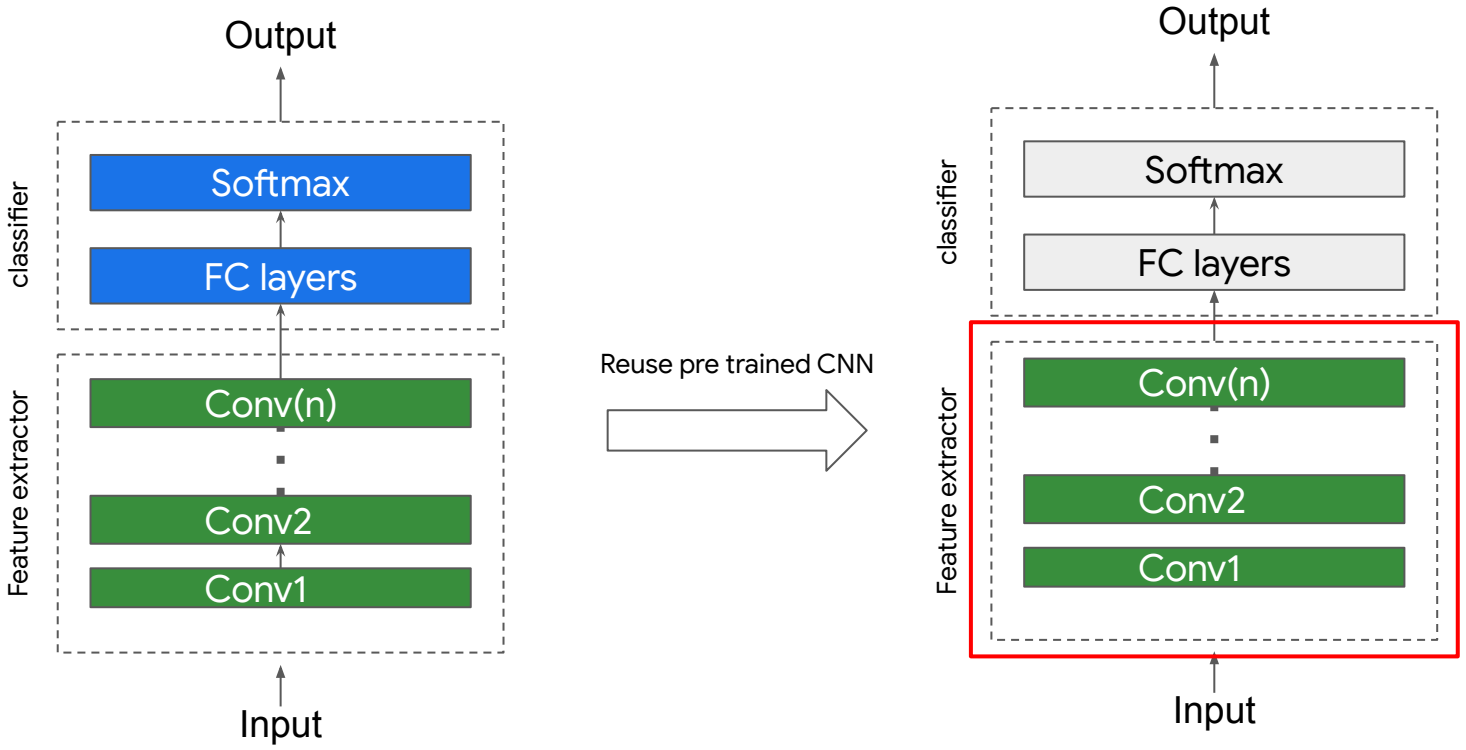


Train with learned values as default



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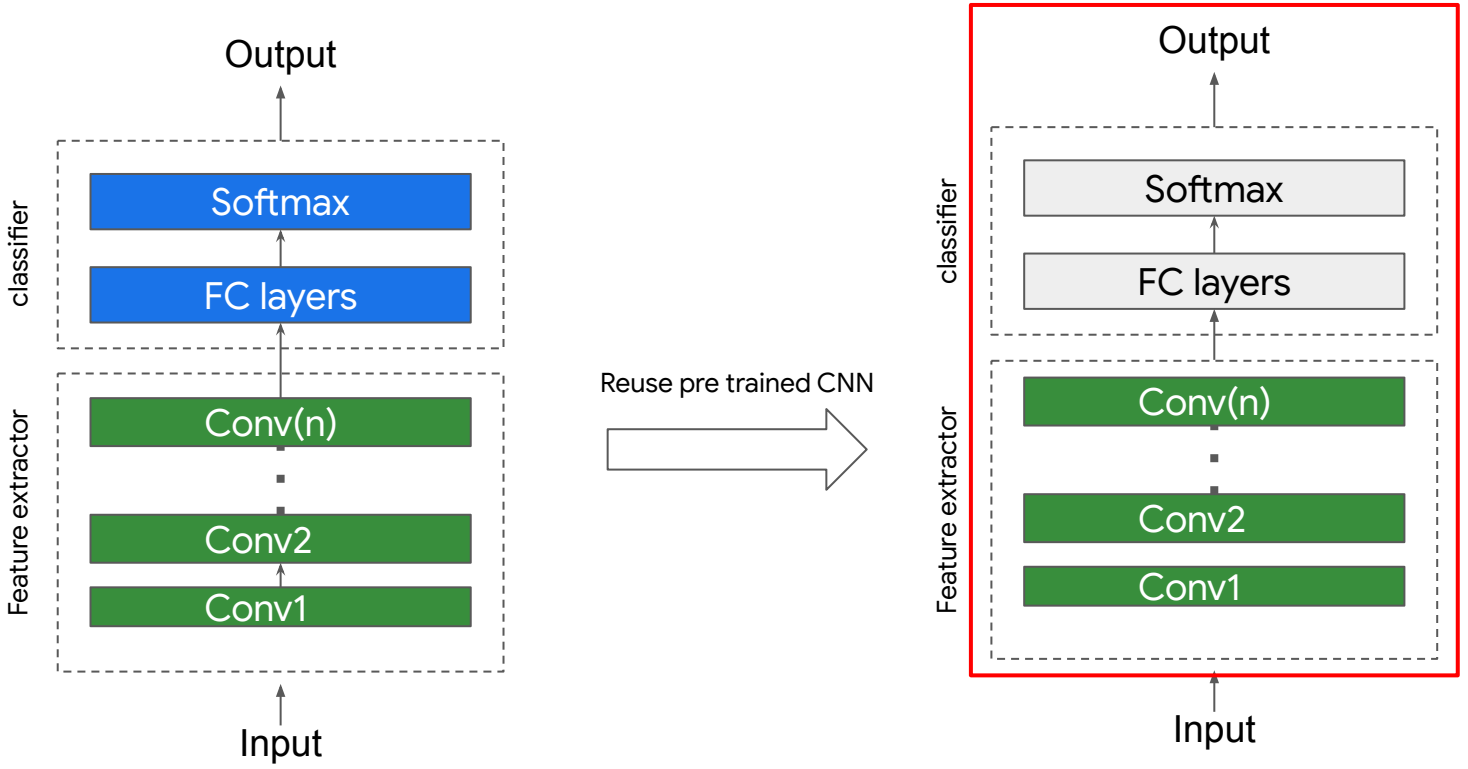
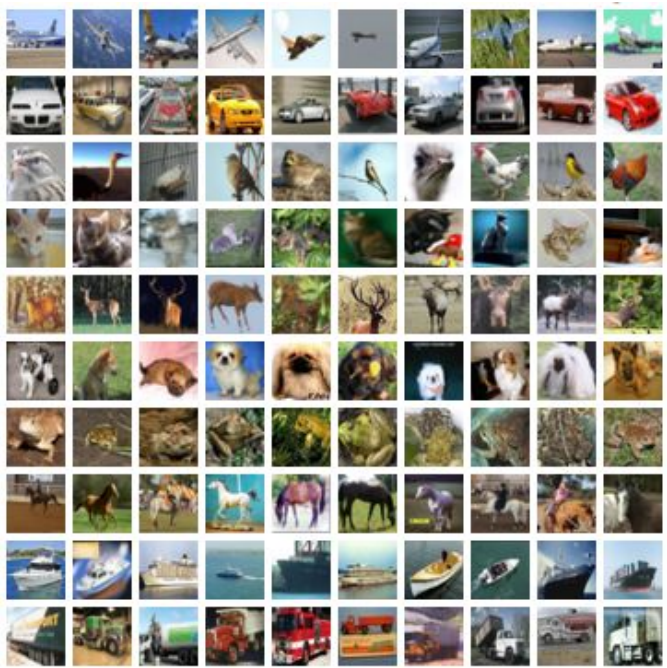


CIFAR - 10 Dataset

10

- airplane
- automobile
- bird
- cat
- deer
- dog
- frog
- horse
- ship
- truck



https://www.cs.toronto.edu/~kriz/cifar.html

~6,000

...

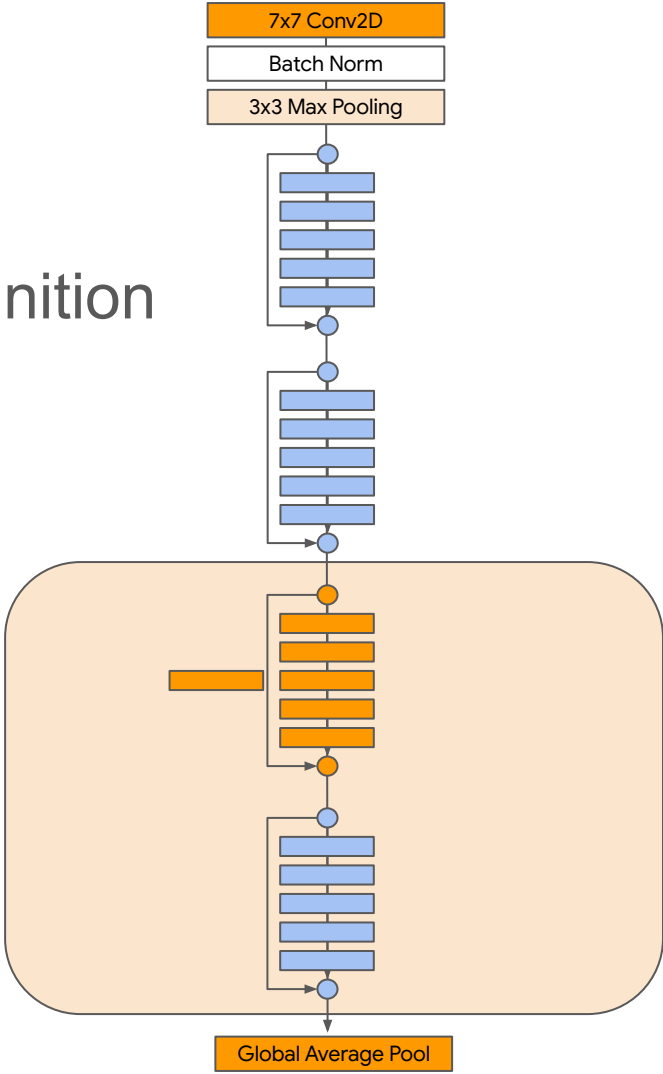
~6,000

= 60,000

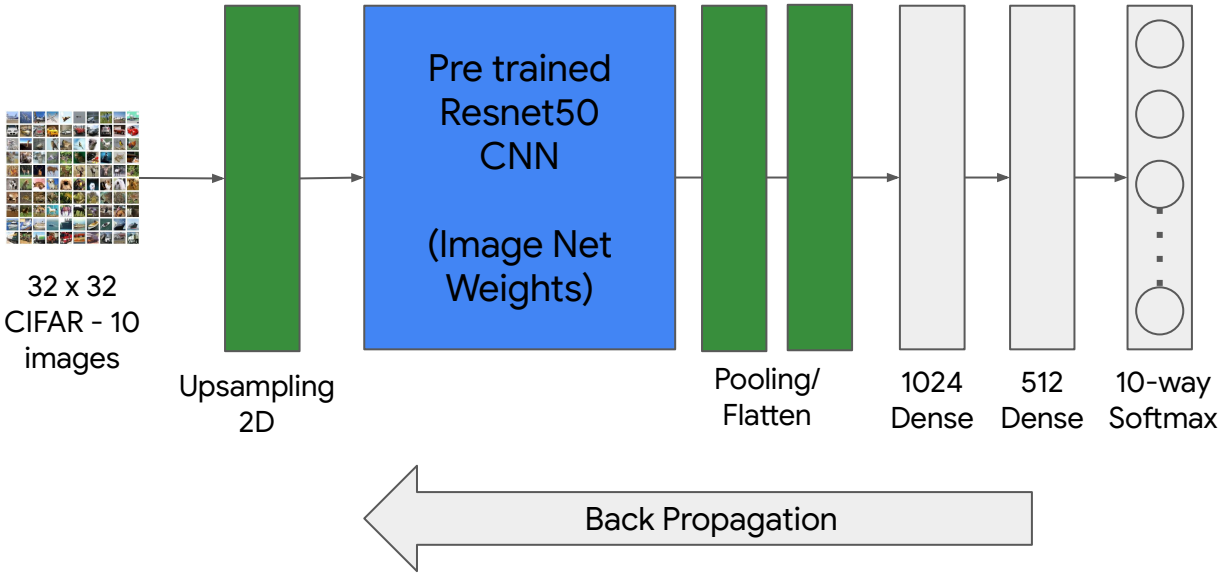
ResNet 50

Deep Residual Learning for Image Recognition

https://arxiv.org/abs/1512.03385



Network Architecture



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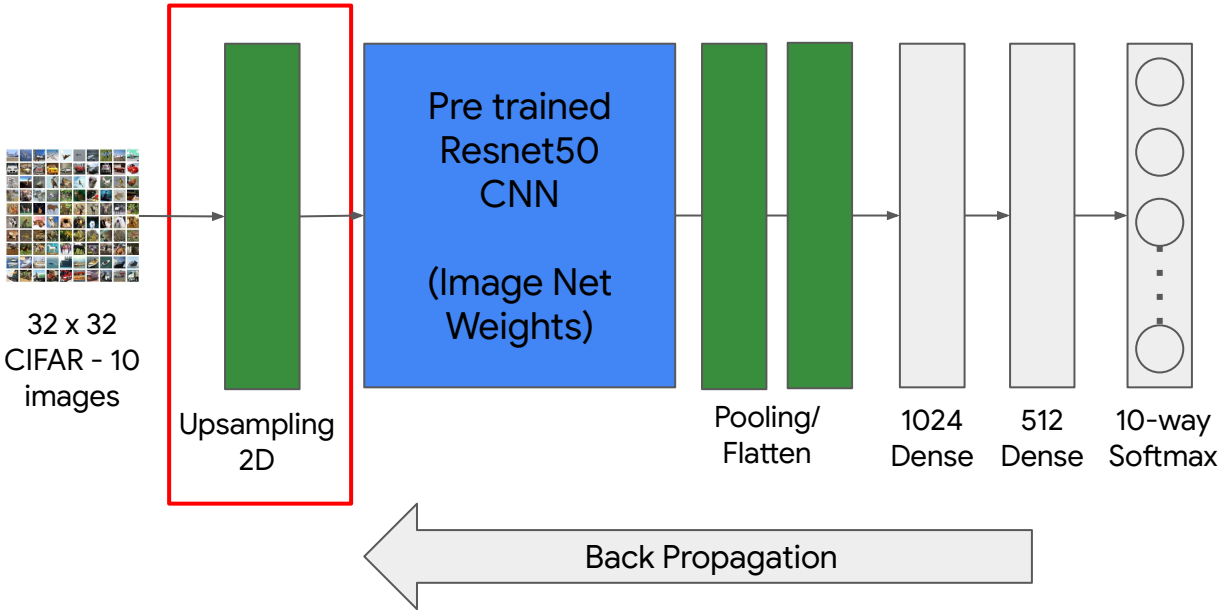

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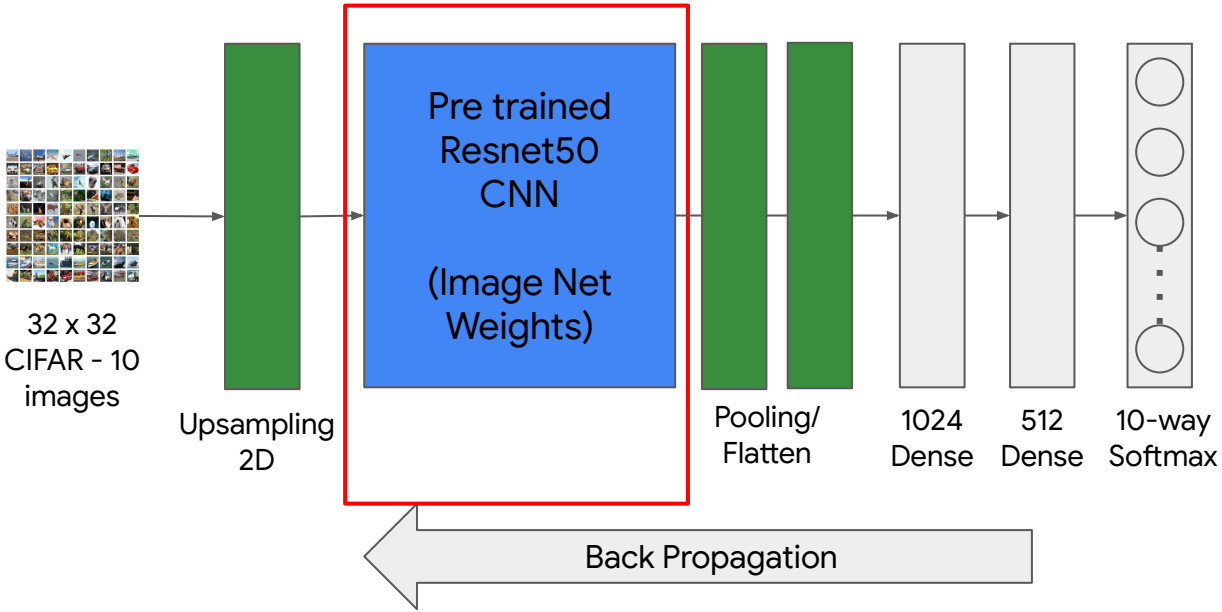

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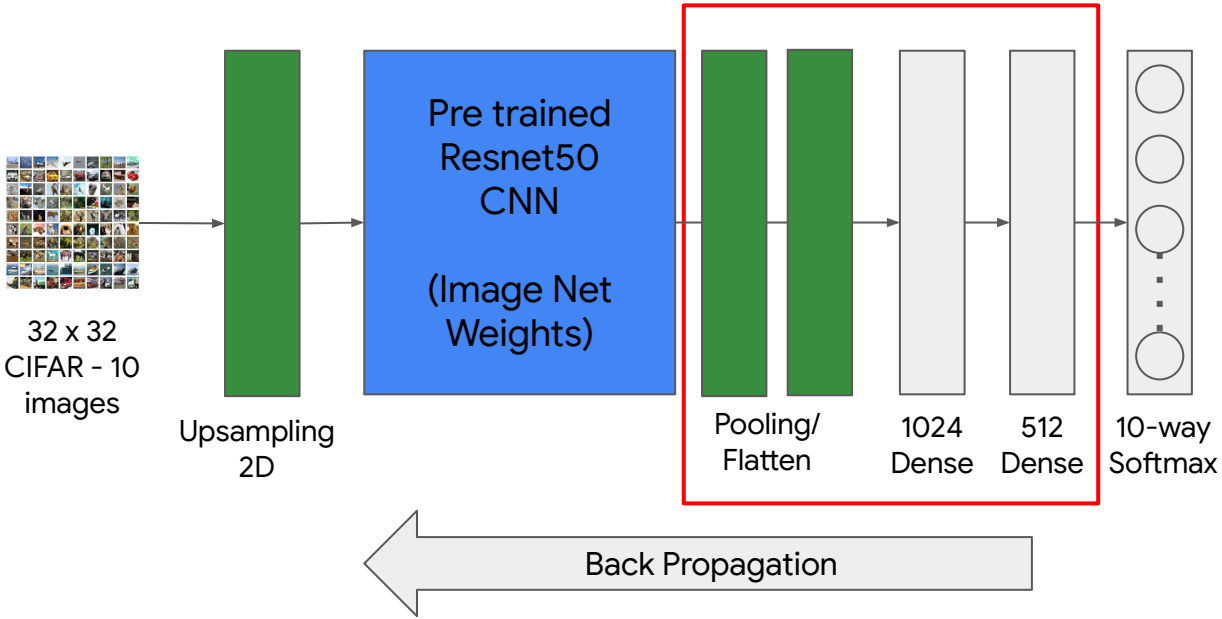

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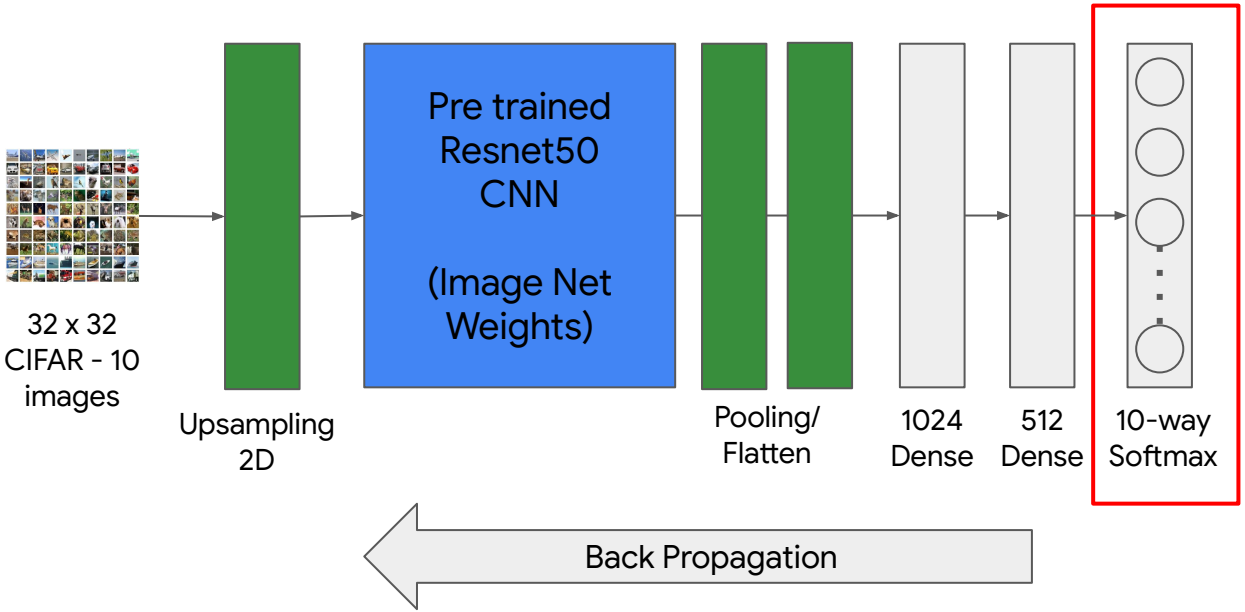

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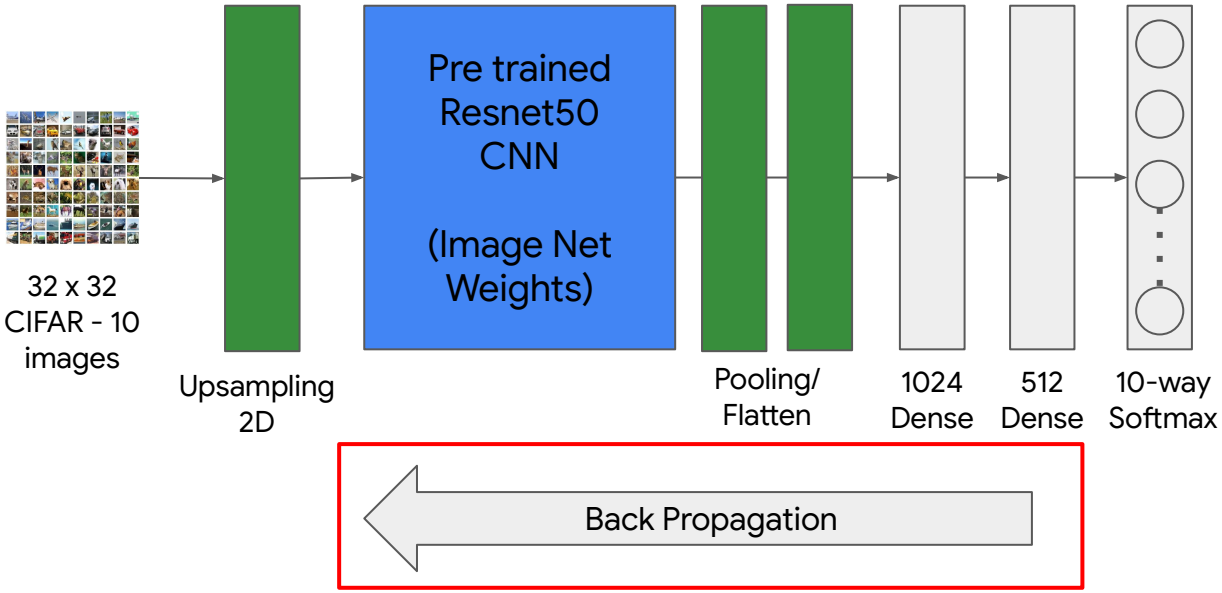

Define Feature Extraction

Pre trained Resnet50 CNN

(Image Net Weights)

```
def feature_extractor(inputs):
  feature_extractor_layer = tf.keras.applications.resnet.ResNet50(
      input_shape=(224, 224, 3),
      include_top=False,
      weights='imagenet')(inputs)

  return feature_extractor_layer
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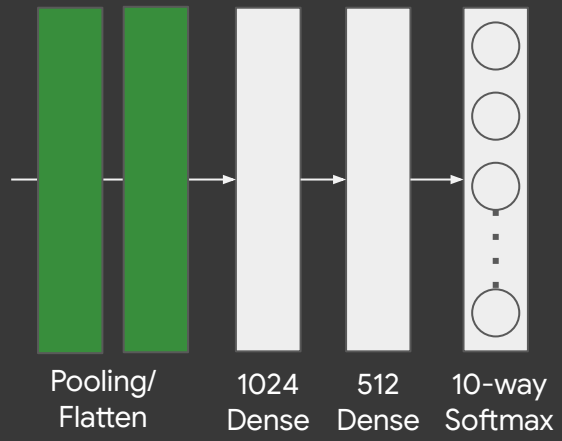
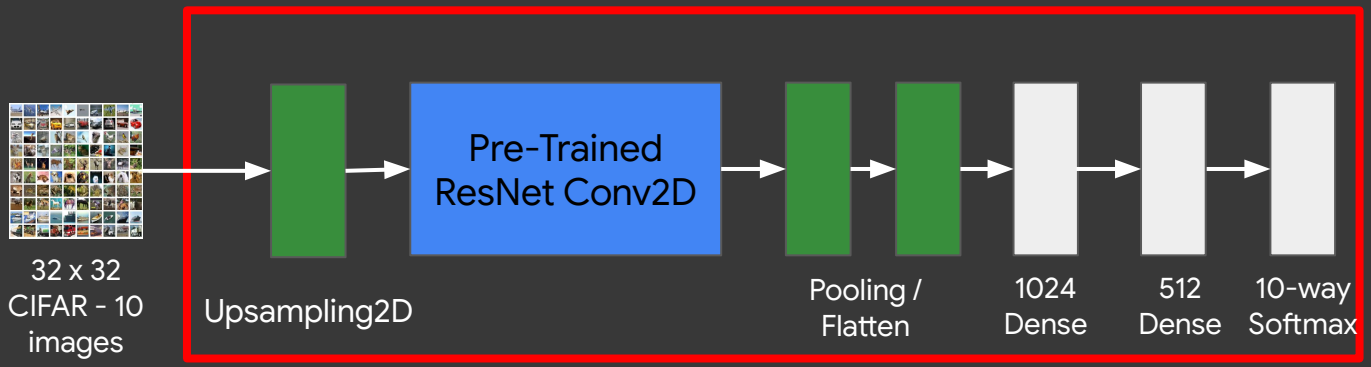
Define Classifier




```
def classifier(inputs):
    x = tf.keras.layers.GlobalAveragePooling2D()(inputs)
    x = tf.keras.layers.Flatten()(x)
    x = tf.keras.layers.Dense(1024, activation="relu")(x)
    x = tf.keras.layers.Dense(512, activation="relu")(x)
    x = tf.keras.layers.Dense(10, activation="softmax", name="classification")(x)
    return x
```

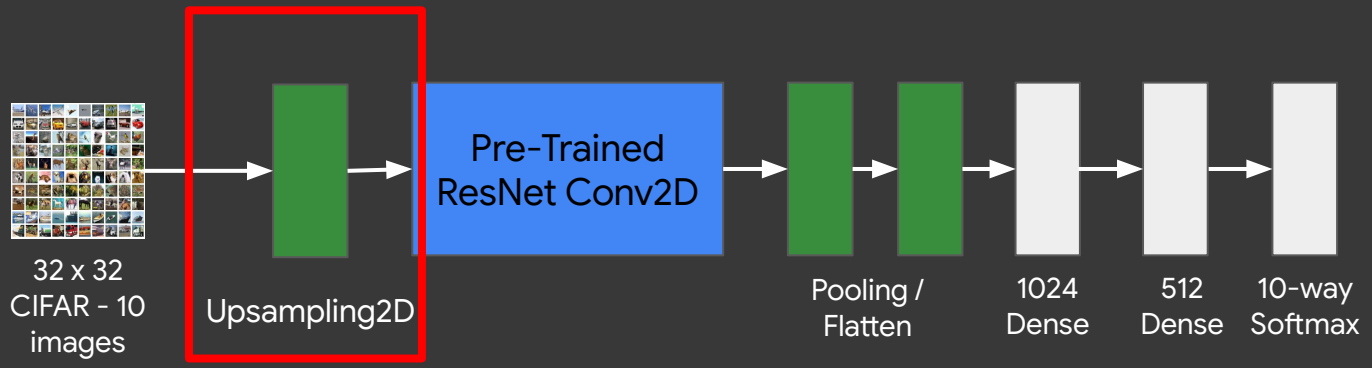
Finalize Model

```
def final_model(inputs):
...
```



Define Inputs and Outputs

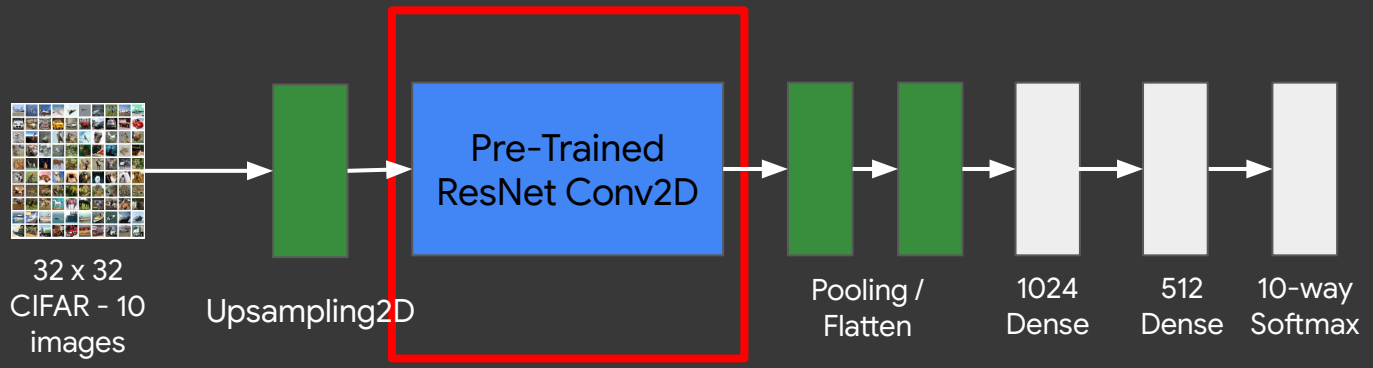
```
def final_model(inputs):
    resize = tf.keras.layers.UpSampling2D(size=(7,7))(inputs)
```



Define Inputs and Outputs

```
def final_model(inputs):
    resize = tf.keras.layers.UpSampling2D(size=(7,7))(inputs)

    resnet_feature_extractor = feature_extractor(resize)
```



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def final_model(inputs):
    resize = tf.keras.layers.UpSampling2D(size=(7,7))(inputs)

    resnet_feature_extractor = feature_extractor(resize)
    classification_output = classifier(resnet_feature_extractor)

    return classification_output
```
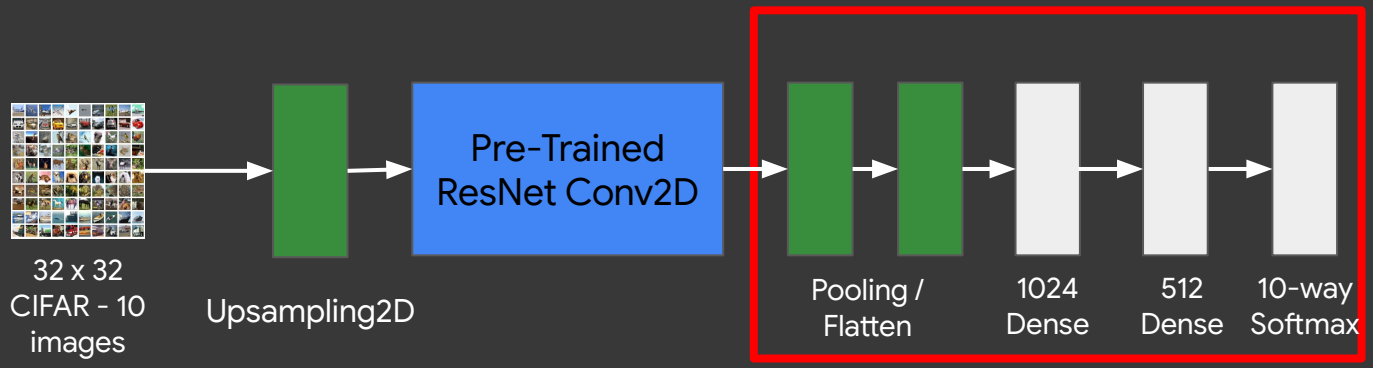
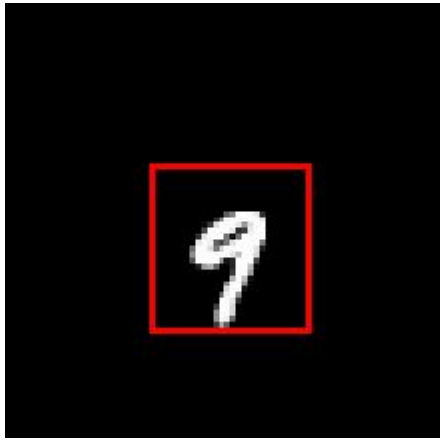



Augmenting MNIST for Object Localization

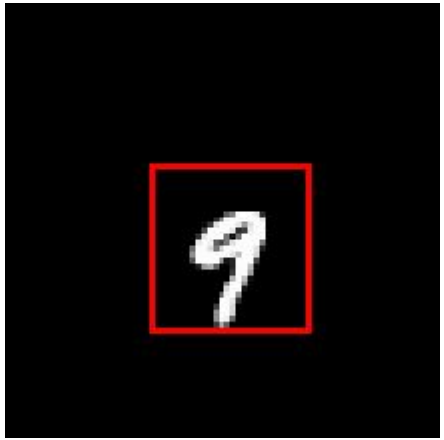
A sample from MNIST



Sample pasted on a 75 x 75 black canvas

Augmenting MNIST for Object Localization

A sample from MNIST



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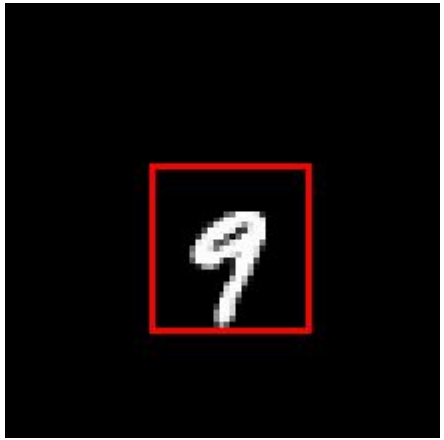

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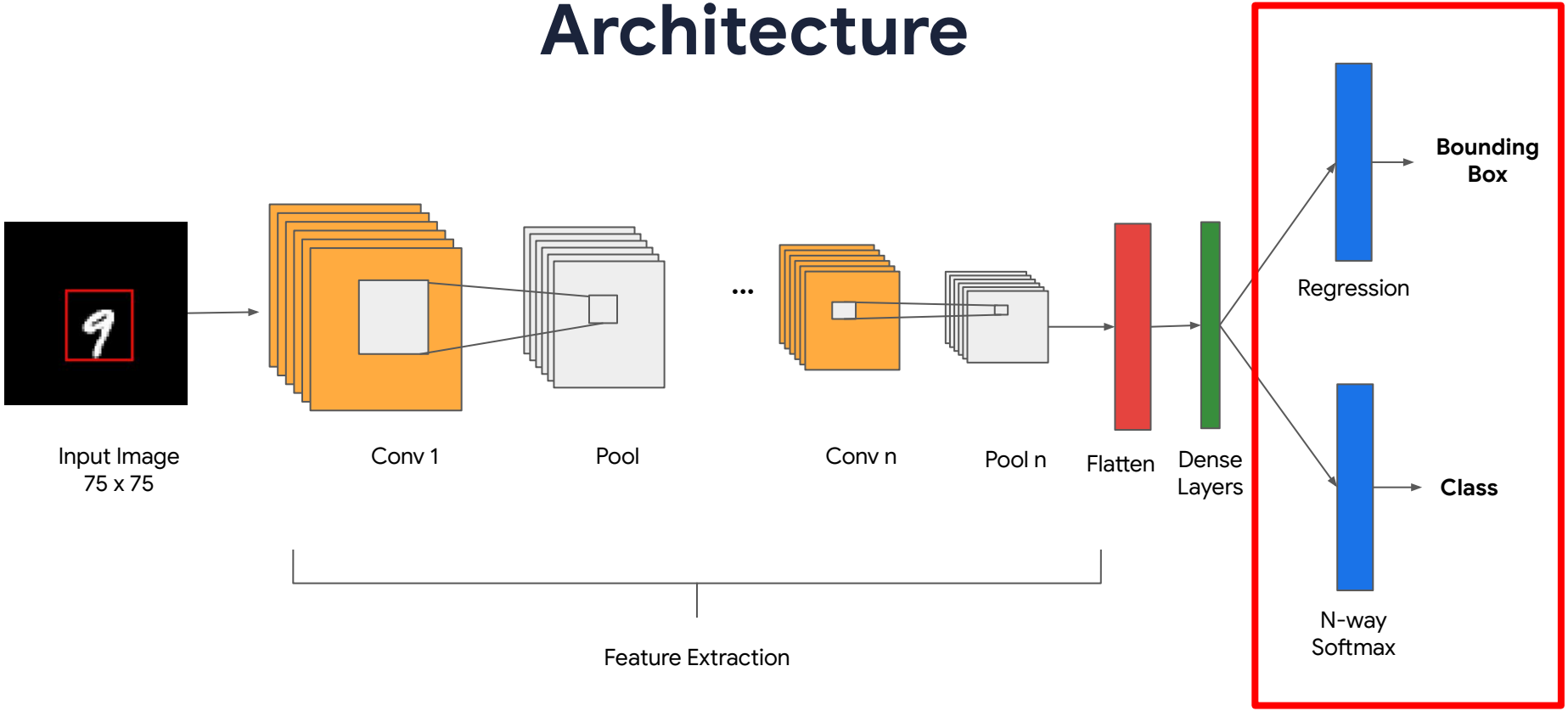

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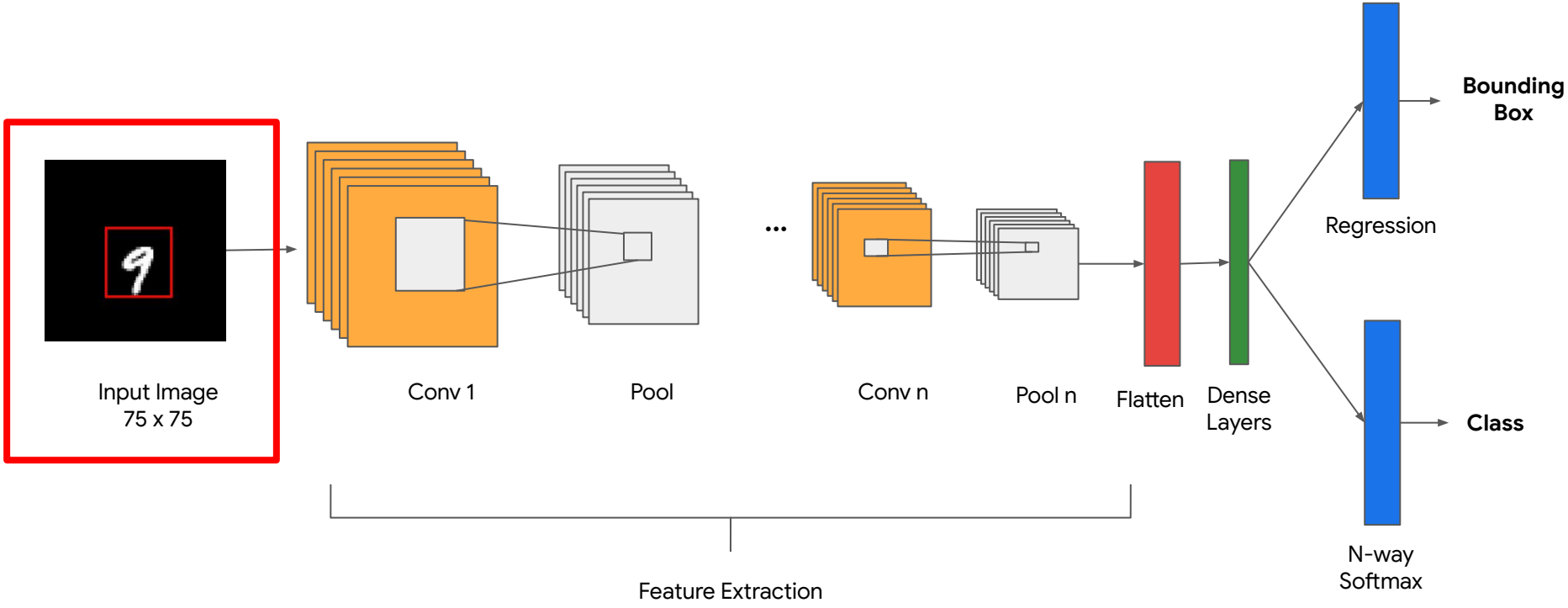
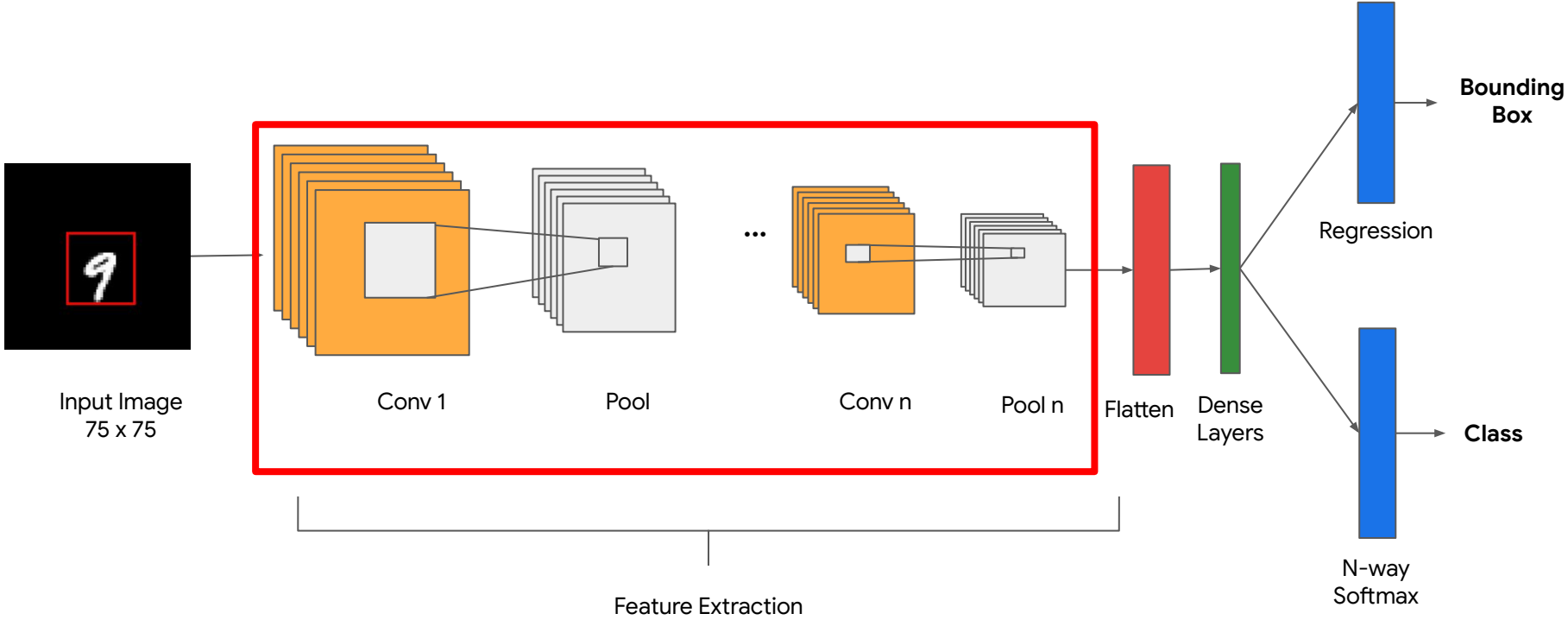
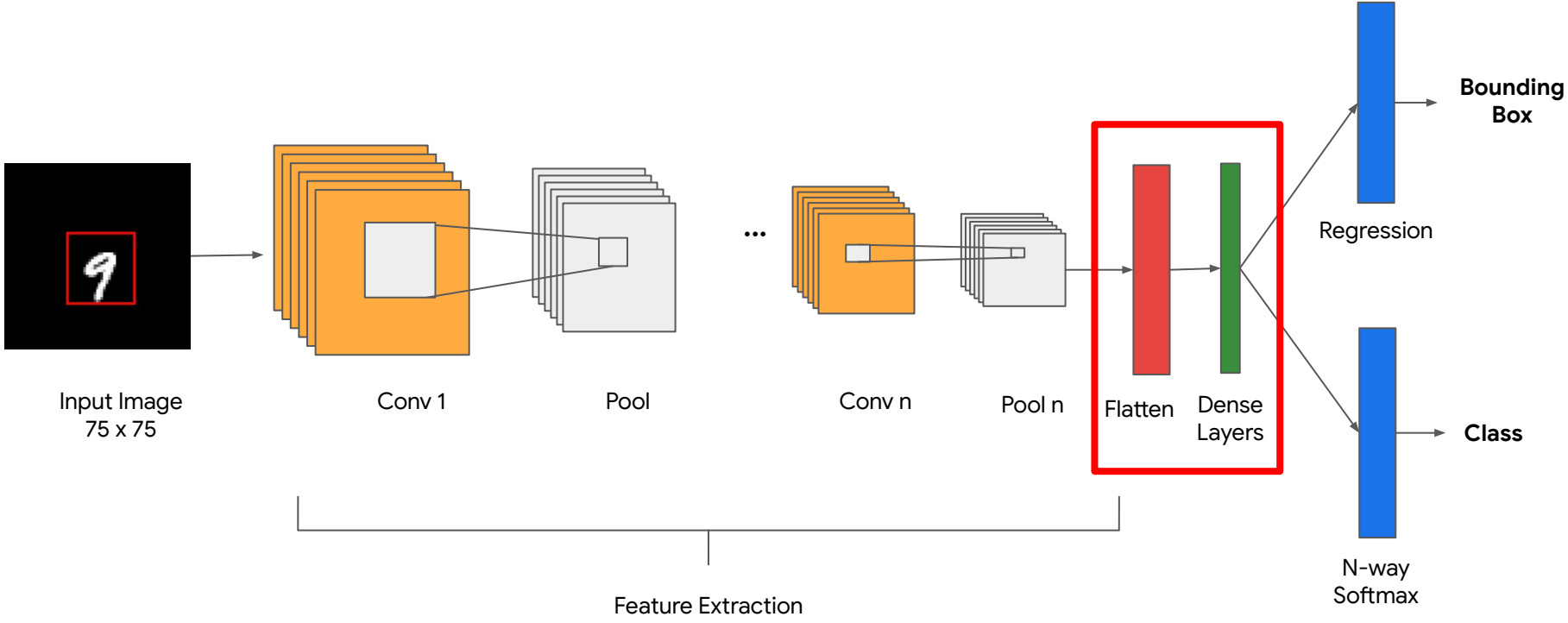


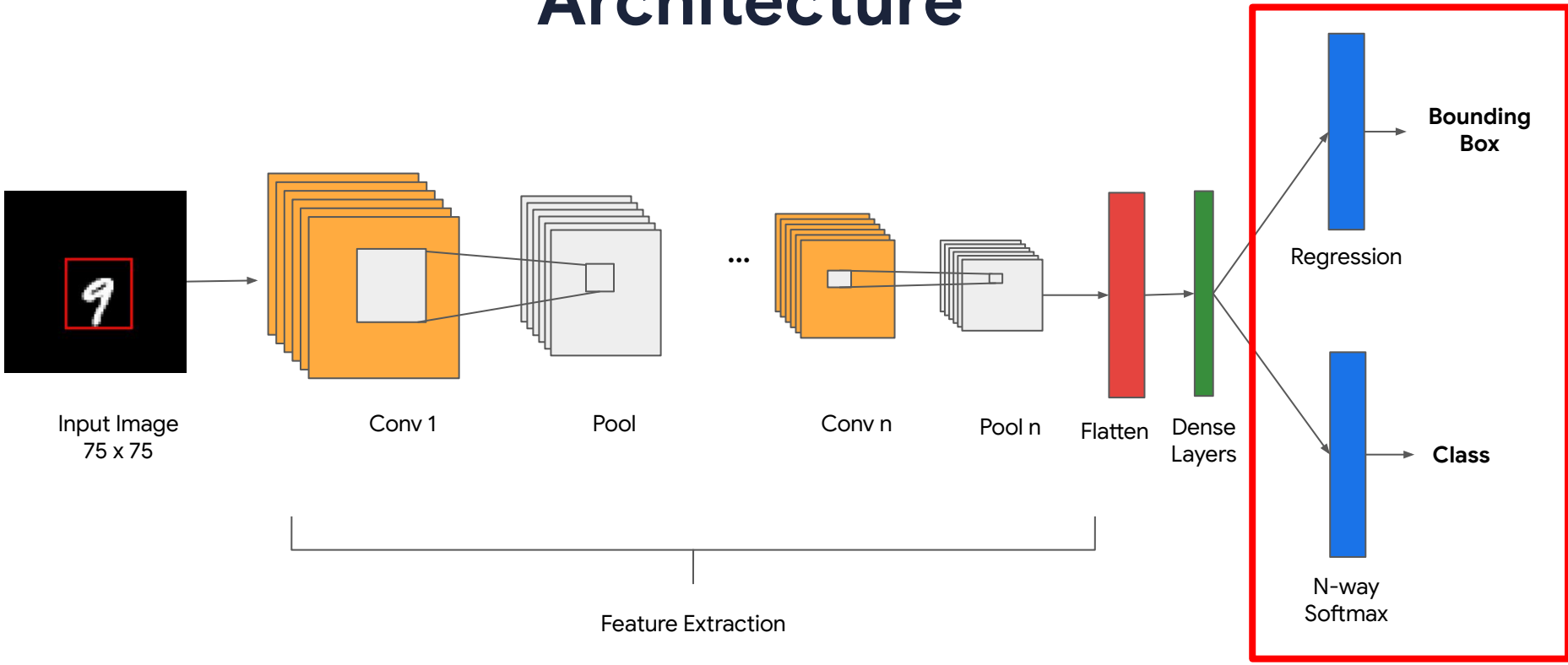
Convolutional Neural Networks Architecture



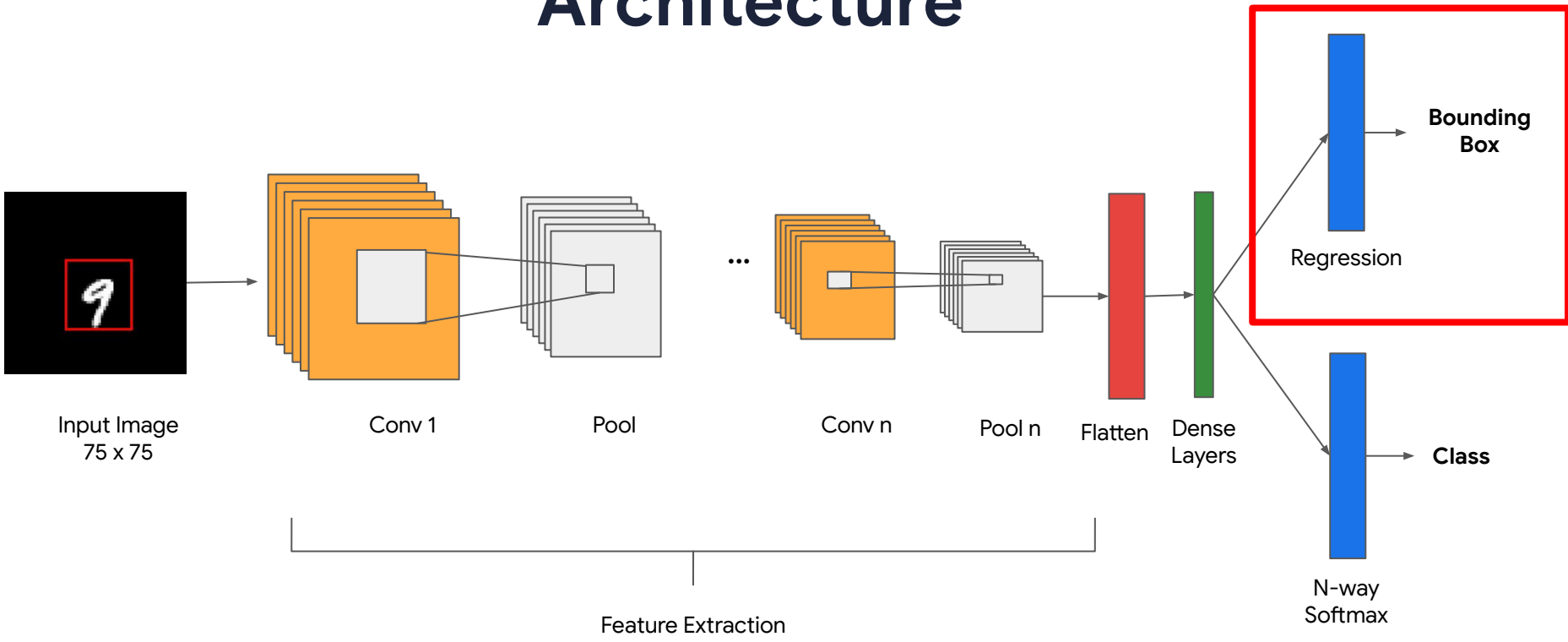
Convolutional Neural Networks Architecture



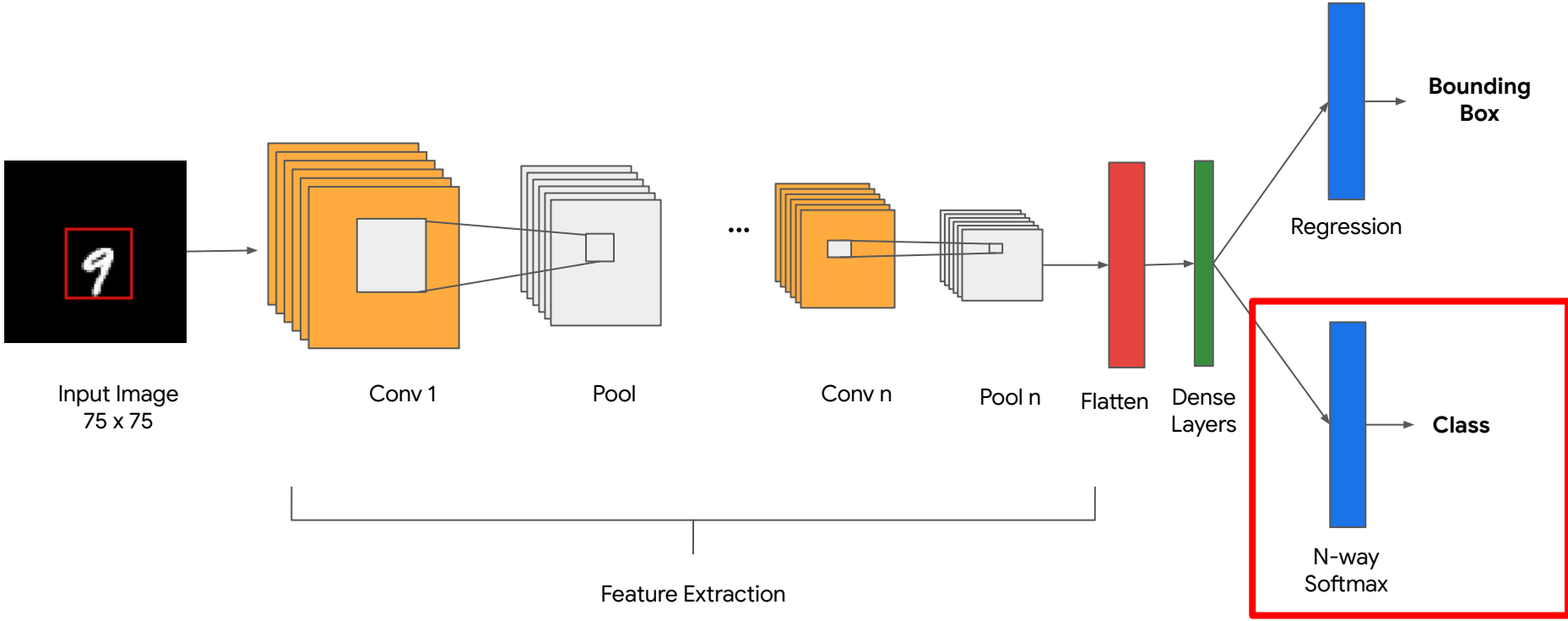
Convolutional Neural Networks Architecture

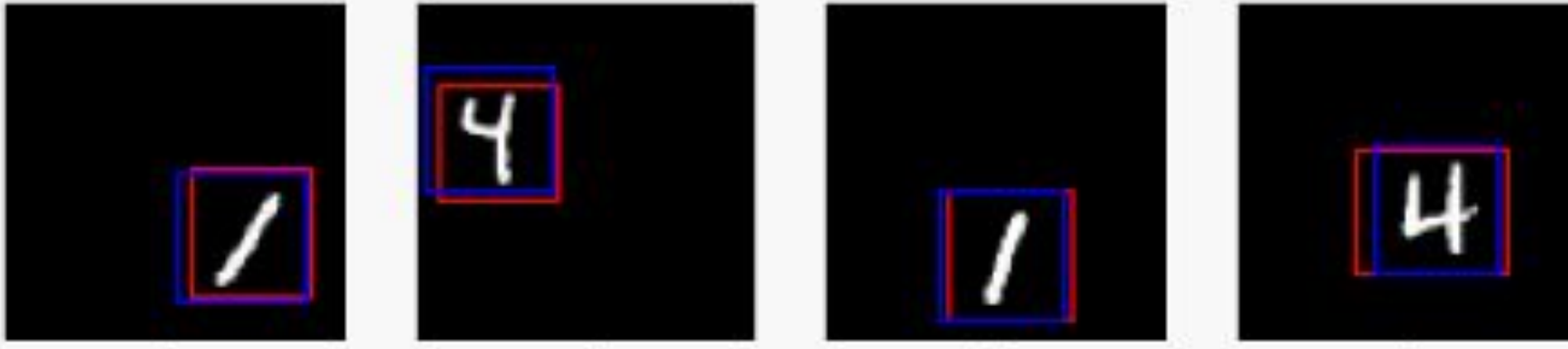


Convolutional Neural Networks Architecture



Convolutional Neural Networks Architecture





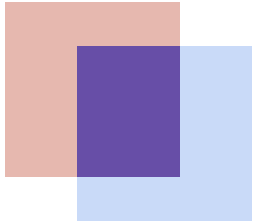
1 iou: 0.90866166

4 iou: 1.1792105

1 iou: 1.2664019

4 iou: 1.0059167

Intersection Over Union



$$\text{IOU} = \frac{\text{Intersection}}{\text{Union}}$$

Intersection Over Union

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