The Power of Transfer Learning in Artist Identification

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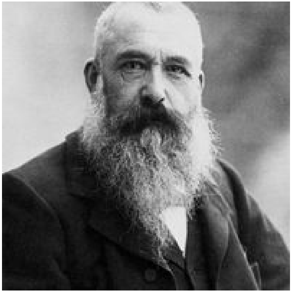
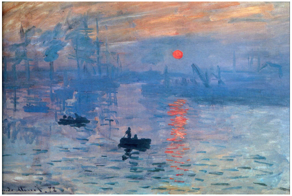
Warm Up



Claude Monet

Vincent Van Gogh

Try it yourself



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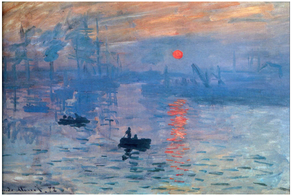

Claude Monet

Vincent Van Gogh

Try it yourself

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Claude Monet

Vincent Van Gogh

Can we solve it with machine learning?

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Let's try it

Data set

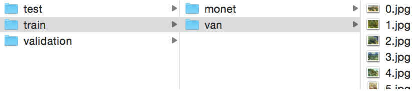
WIKIART

VISUAL ART ENCYCLOPEDIA

Data set

WIKIART
VISUAL ART ENCYCLOPEDIA

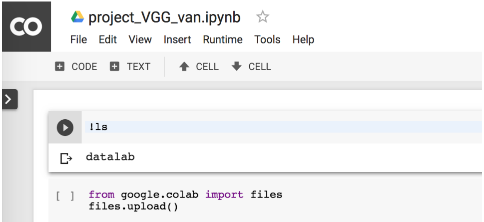
- We collect 300 images for *each* artist.
- We split into 240 for training, 30 for validation and 30 for testing.
- Folder structure:



Platform

Platform

- We use Keras with tensorflow backend to support neural networks.
- We use *Google Colaboratory* as our computing engine.
  - Free Tesla K80 GPU!
  - It is similar to Jupyter notebook:

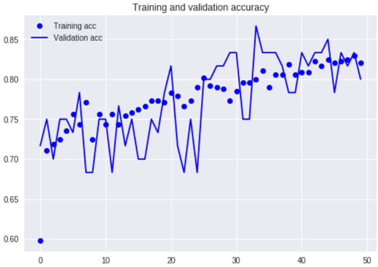


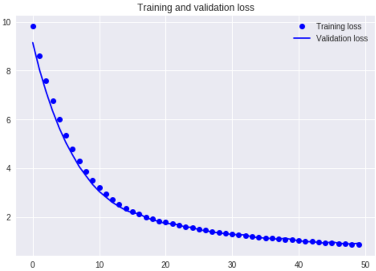
Baseline CNN

```
model.summary()
```

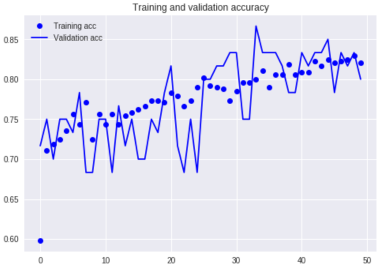
```
________________________________________________________________
Layer (type)                 Output Shape              Param #
================================================================
conv2d_1 (Conv2D)            (None, 222, 222, 32)      896
________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 111, 111, 32)      0
________________________________________________________________
conv2d_2 (Conv2D)            (None, 109, 109, 64)      18496
________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 54, 54, 64)        0
________________________________________________________________
conv2d_3 (Conv2D)            (None, 52, 52, 128)       73856
________________________________________________________________
max_pooling2d_3 (MaxPooling2 (None, 26, 26, 128)       0
________________________________________________________________
conv2d_4 (Conv2D)            (None, 24, 24, 128)       147584
________________________________________________________________
max_pooling2d_4 (MaxPooling2 (None, 12, 12, 128)       0
________________________________________________________________
flatten_1 (Flatten)          (None, 18432)             0
________________________________________________________________
dropout_1 (Dropout)          (None, 18432)             0
________________________________________________________________
dense_1 (Dense)              (None, 512)               9437696
________________________________________________________________
dense_2 (Dense)              (None, 1)                 513
================================================================
Total params: 9,679,041
Trainable params: 9,679,041
Non-trainable params: 0
________________________________________________________________
```

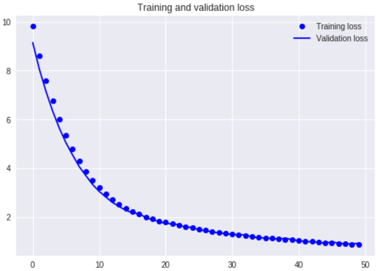
Baseline CNN





Baseline CNN

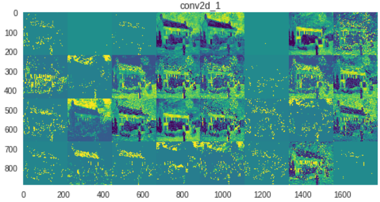




Test Accuracy: 83.3%

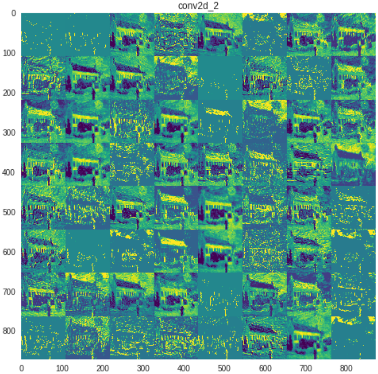
```
Found 60 images belonging to 2 classes.
test acc: 0.8333333233992258
```

Activations Visualization

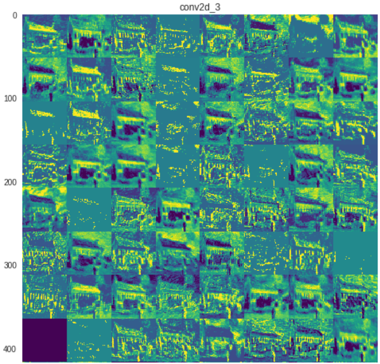


First layer: it keeps almost all of the information in the initial image.

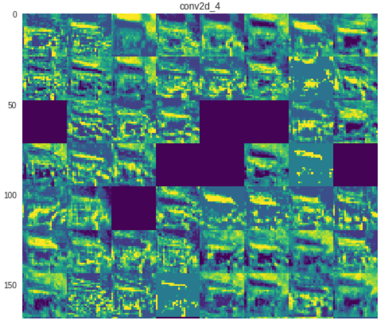
Activations Visualization



Activations Visualization



Activations Visualization



Higher layers:

- activations become *abstract*, less information about the visual contents.
- the sparsity of the activations increases.

Well, the result is okay, but definitely not perfect, is it?

Well, the result is okay, but definitely not perfect, is it?

I agree, let's improve it!

Transfer Learning

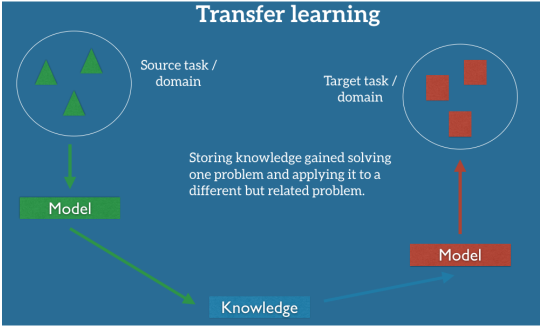


Figure: Transfer learning setup[1]

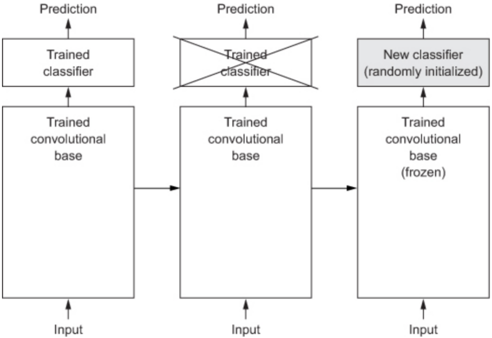
Source:

- Task: ImageNet
- Model: VGG16

Target:

- Task: Artist identification
- Model: Softmax classifier

Transfer learning



In our case:

- Trained convolutional base: VGG16
- New classifier: Softmax.

Transfer learning with VGG16

- Load pre-trained VGG16 model as base.

```
[ ]  from keras.applications import VGG16

     conv_base = VGG16(weights='imagenet',
                       include_top=False,
                       input_shape=(224, 224, 3))
```

- Extract features

```
[ ]  train_features = np.reshape(train_features, (480, 7 * 7 * 512))
     validation_features = np.reshape(validation_features, (60, 7 * 7 * 512))
     test_features = np.reshape(test_features, (60, 7 * 7 * 512))
```

```
[ ]  np.shape(train_features)
```

```
(480, 25088)
```

- Add densely connected classifier

```
from keras import models
from keras import layers
from keras import optimizers
from keras import regularizers

model = models.Sequential()
model.add(layers.Dense(256, kernel_regularizer=regularizers.l2(5e-5),
                       activation='relu', input_dim=7 * 7 * 512))
model.add(layers.Dropout(0.5))
model.add(layers.Dense(1, activation='sigmoid'))
```

Before we start...

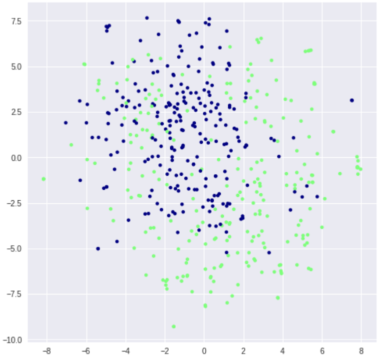
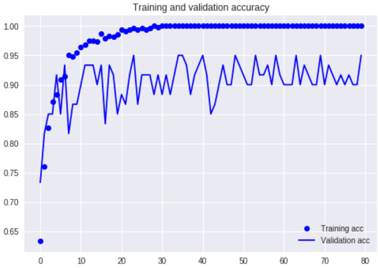
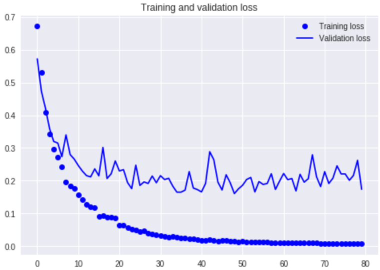


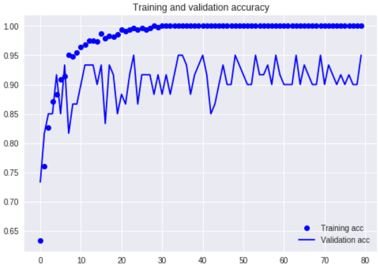
Figure: Bottleneck features visualization, created by *tsne*

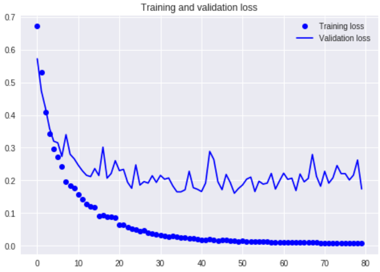
Now, let's train it...





Now, let's train it...





Test Accuracy: 94.6%

Nice result, but, shall we be satisfied with it?

Nice result, but, shall we be satisfied with it?

No, let's further improve it!

Fine tuning

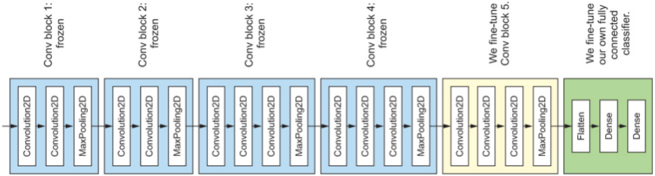
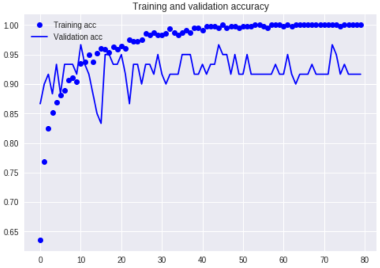
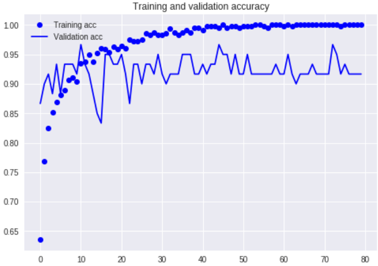


Figure: Frozen certain layers and fine tuning certain blocks only.

Show me the result...



Show me the result...

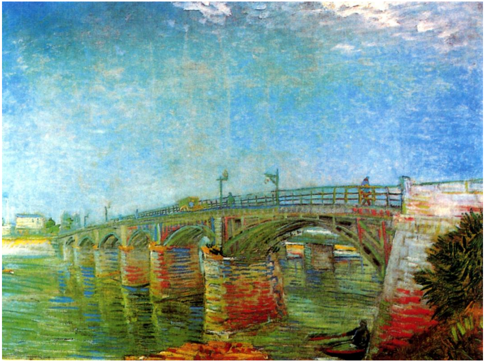


Test Accuracy: 98.3% (make mistake on just one image) 

```
test_generator = test_datagen.flow_from_directory(
        test_dir,
        target_size=(224, 224),
        batch_size=10,
        class_mode='binary')
test_loss, test_acc = model.evaluate_generator(test_generator,steps = 6)
test_acc
```

```
Found 60 images belonging to 2 classes.
0.9833333293596903
```

The missing one...



Does it really learn?

Some technicals

- Use data processing and augmentation.
- Batch size is 10.
- Training for 80 epochs.
- Optimizer is RMSprop with learning rate $2e^{-5}$.
- Activation is ReLu.
- L2 regularization of $1e^{-5}$.
- Dropout with probability 0.5.

Really nice, but, wait a minute...can you distinguish which column is Monet's works?

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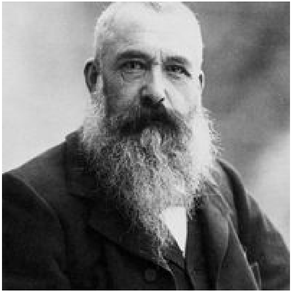
Claude Monet

Alfred Sisley

A harder problem...



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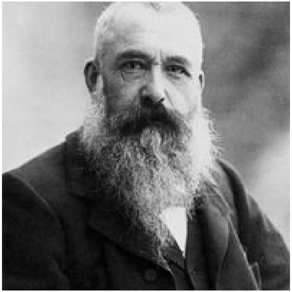


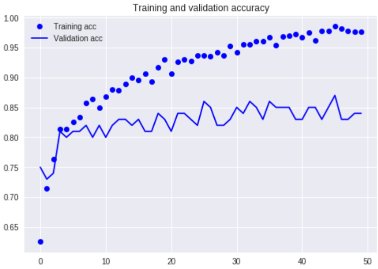
Claude Monet

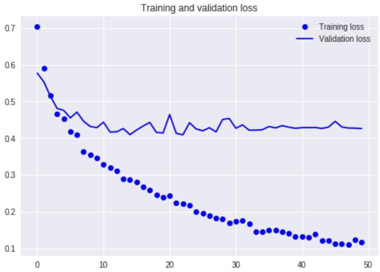
Alfred Sisley

- Exactly the same period.
- Nearly the same style.
- Almost the same scenarios.

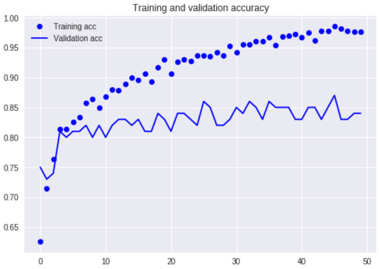
Is it possible?

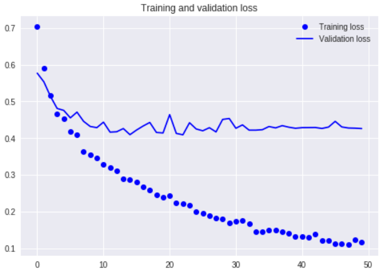
Show me the result...





Show me the result...





Test Accuracy: 86.6%

Future direction:

- Try model ensemble.
- Try batch normalization.
- Try dynamical rate adjustment.
- Try other pre-trained models (tried ResNet, not successful.)

Take-away

- Transfer learning is powerful.
- VGG16 is very easy to train (maybe your first choice).
- Go try the Google colab (too good to be true).
- Keras maybe your first choice, easy and effective.

Learn more about the details and code:

`xingyuzhou.org/blog`