Faculty of Science

Classifying dog and cat images with Keras

Final project

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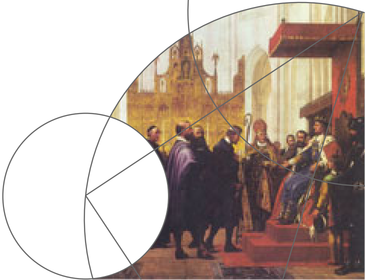
All group members have contributed evenly to this project

Niels Bohr Institute



Data

From Kaggle: 25,000 images of cats and dogs, half of each

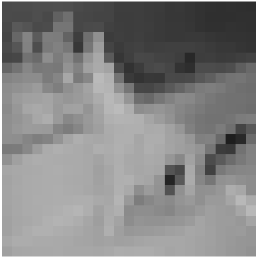
Goal: train an algorithm to classify whether images are cats or dogs

Preprocessing

Before

After, 100x100 pixels

After, 50x50 pixels



After, 25x25 pixels

Convolutional neural network

Models are built using Keras.

```
model = Sequential()
model.add(Conv2D(16, (3,3), input_shape=(IMG_SIZE, IMG_SIZE, 1), activation='relu'))
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Conv2D(32, (3,3), activation='relu'))
model.add(MaxPooling2D(pool_size=(2,2)))
model.add(Dropout(0.1))
model.add(Flatten())
model.add(Dense(128, activation='relu'))
model.add(Dense(num_classes, activation='sigmoid'))
my_adam = keras.optimizers.Adam(lr=0.001, beta_1=0.9, beta_2=0.999, epsilon=None, decay=0.0, amsgrad=False)
model.compile(loss='binary_crossentropy', optimizer=my_adam, metrics=['accuracy'])
```

Figure: Model 2 structure

```
Epoch 1/15
9000/9000 [==============================] - 27s 3ms/step - loss: 0.7162 - acc: 0.4990 - val_loss: 0.6851 - val_acc: 0.5190
Epoch 2/15
9000/9000 [==============================] - 24s 3ms/step - loss: 0.6818 - acc: 0.5597 - val_loss: 0.6742 - val_acc: 0.5410
Epoch 3/15
9000/9000 [==============================] - 24s 3ms/step - loss: 0.6646 - acc: 0.6176 - val_loss: 0.6526 - val_acc: 0.6090
Epoch 4/15
9000/9000 [==============================] - 24s 3ms/step - loss: 0.6416 - acc: 0.6650 - val_loss: 0.6324 - val_acc: 0.6500
```

Figure: Training a model

Keras models

Four different architectures:

Model 1	: C M F D D	Accuracy $(71.8 \pm 0.6)\%$
Model 2	: C M C M Dr F D D	Accuracy $(75.6 \pm 0.3)\%$
Model 2.1	: C C M Dr F D Dr D	Accuracy $(70.7 \pm 0.4)\%$
Model 3	: C M Dr C M Dr C M Dr F D D	Accuracy $(79.3 \pm 0.7)\%$

Trained on 10,000 images using 15 epochs

C = convolutional, M = max pooling, F = flatten,
D = dense, Dr = dropout

Hyperparameter optimization

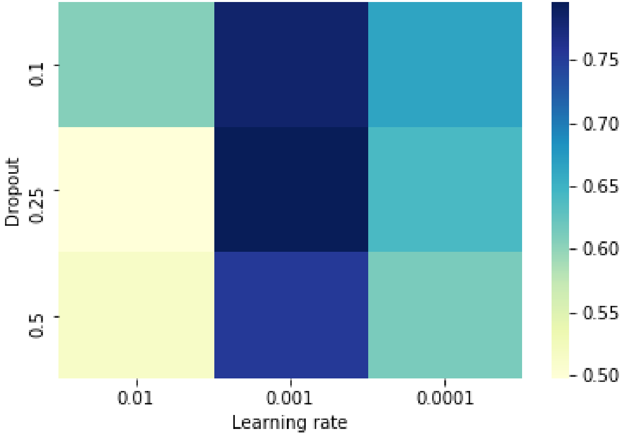


Figure: Validation accuracy as a function of dropout and learning rate.

Hyperparameter optimization

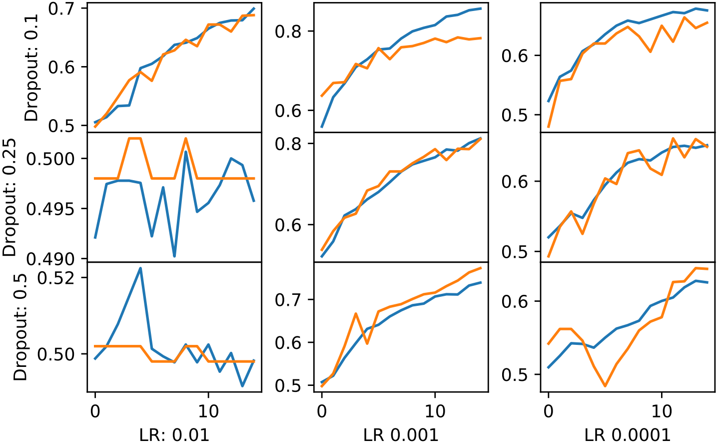


Figure: Accuracy as a function of epoch.
Blue = training accuracy, orange = validation accuracy

Finding the best optimizer

Optimizer	Optimal Epochs	Validation Accuracy
Adam	20	$81.2 \pm 0.6\%$
Adadelta	25	$75.7 \pm 0.9\%$
SGD	400+	$\sim 73\%$
AdaGrad	25	$79 \pm 1\%$

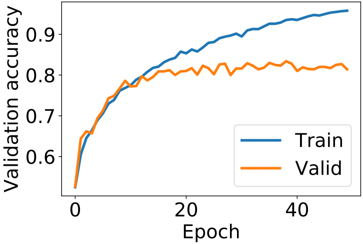


Figure: 10,000 pictures. Optimizer: Adam. LR: 0.001. Dropout: 0.25.

Results

Accuracy: $(85.3 \pm 0.5)\%$ after 30 epochs training on all 25,000 images.

Predict \ Truth	Cat	Dog	Total
Cat	1023	135	1158
Dog	201	1141	1342
Total	1224	1276	2500

Pretrained models can achieve an accuracy of up to 97%

Evaluation of the model

Examples of the images that the model guesses correctly with highest probability.

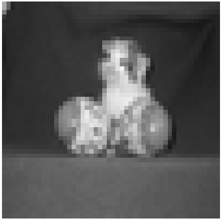
Prob: 99.99%

Prob: 99.99%

Prob: 99.99%

Evaluation of the model

Examples of images which the model guesses wrong.



Prob: 98% dog

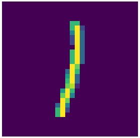
Prob: 97% cat

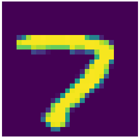
Prob: 66% dog

Prob: 97% dog

Testing the model on MNIST digit data

Test our best model on ones and sevens from the MNIST database.





Accuracy for cats & dogs: $(85.3 \pm 0.5)\%$
Accuracy for digits: $(99.84 \pm 0.03)\%$

References

Data: Kaggle
Model 1: Here
Model 2: Here (with modifications)
Model 2.1: Chollet's Architecture
Model 3: Malireddi's Architecture
General knowledge:
CNN and Image Classification
Developing a CNN
Hyperparameter Optimization with Keras
Guide to Hyperparameter Search
97 Percent Accuracy
MNIST digit: Dataset

Appendix

```
model = Sequential()
model.add(Conv2D(32, (3,3), input_shape=(IMG_SIZE, IMG_SIZE, 1), activation='relu'))
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Flatten())
model.add(Dense(128, activation='relu'))
model.add(Dense(num_classes, activation='softmax'))
my_adam = keras.optimizers.Adam(lr=0.001, beta_1=0.9, beta_2=0.999, epsilon=None, decay=0.0, amsgrad=False)
model.compile(loss='binary_crossentropy', optimizer=my_adam, metrics=['accuracy'])
```

Figure: Model 1 structure

```
numOfFilters_1 = 16
numOfFilters_2 = 32
filterSize = 3
dropout = 0.1
numberOfDense = 128
lr = 0.001

model = Sequential()
model.add(Conv2D(numOfFilters_1, (filterSize,filterSize), input_shape=(IMG_SIZE, IMG_SIZE, 1), activation='relu'))
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Conv2D(numOfFilters_2, (filterSize,filterSize), activation='relu'))
model.add(MaxPooling2D(pool_size=(2,2)))
model.add(Dropout(dropout))
model.add(Flatten())
model.add(Dense(numberOfDense, activation='relu'))
model.add(Dense(num_classes, activation='sigmoid'))
my_adam = keras.optimizers.Adam(lr=lr, beta_1=0.9, beta_2=0.999, epsilon=None, decay=0.0, amsgrad=False)
model.compile(loss='binary_crossentropy', optimizer=my_adam, metrics=['accuracy'])
```

Figure: Model 2 structure

Appendix

```
dropout = 0.11127488091320181
filtersize = 3
lr= 0.0022693120181
numOfDense = 112
numOfFilters= 37
filterSize = 3

model_c = Sequential()
model_c.add(Conv2D(numOfFilters, (filterSize, filterSize), input_shape=(IMG_SIZE, IMG_SIZE, 1), activation='relu'))
model_c.add(Conv2D(numOfFilters, (filterSize, filterSize), activation='relu'))
model_c.add(MaxPooling2D(pool_size=(2, 2)))
model_c.add(Dropout(dropout))
model_c.add(Flatten())
model_c.add(Dense(numOfDense, activation='relu'))
model_c.add(Dropout(dropout))
model_c.add(Dense(num_classes, activation='softmax'))
my_adam = keras.optimizers.Adam(lr=lr, beta_1=0.9, beta_2=0.999, epsilon=None, decay=0.0, amsgrad=False)
model_c.compile(loss='binary_crossentropy', optimizer=my_adam, metrics=['accuracy'])
```

Figure: Model 2.1 structure

Appendix

```
model_m = Sequential()
model_m.add(Conv2D(32, (3, 3), input_shape=(IMG_SIZE, IMG_SIZE, 1), activation='relu'))
model_m.add(MaxPooling2D(pool_size=(2, 2)))
model_m.add(Dropout(0.25))

model_m.add(Conv2D(64, (3, 3), activation='relu'))
model_m.add(MaxPooling2D(pool_size=(2, 2)))
model_m.add(Dropout(0.25))

model_m.add(Conv2D(128, (3, 3), activation='relu'))
model_m.add(MaxPooling2D(pool_size=(2, 2)))
model_m.add(Dropout(0.25))

model_m.add(Flatten())
model_m.add(Dense(64, activation='relu'))
model_m.add(Dense(num_classes, activation='sigmoid'))
print(model_m.summary())

my_adam = keras.optimizers.Adam(lr=0.001, beta_1=0.9, beta_2=0.999, epsilon=None, decay=0.0, amsgrad=False)
model_m.compile(loss='binary_crossentropy', optimizer=my_adam, metrics=['accuracy'])
```

Figure: Model 3 structure

Appendix

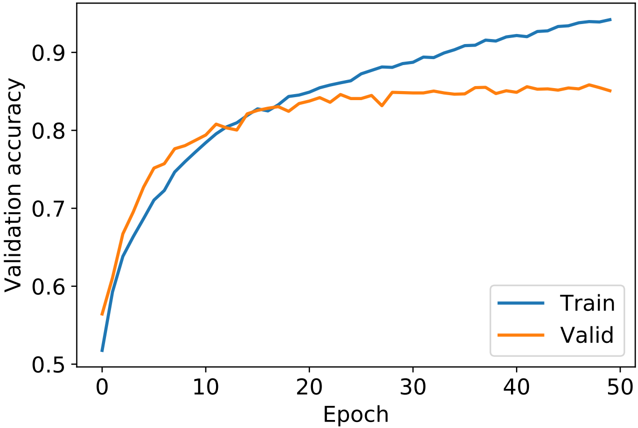


Figure: Model 3 with the Adam optimizer, learning rate 0.001, dropout rate 0.25 and run on all 25,000 pictures for 50 epochs.

Appendix

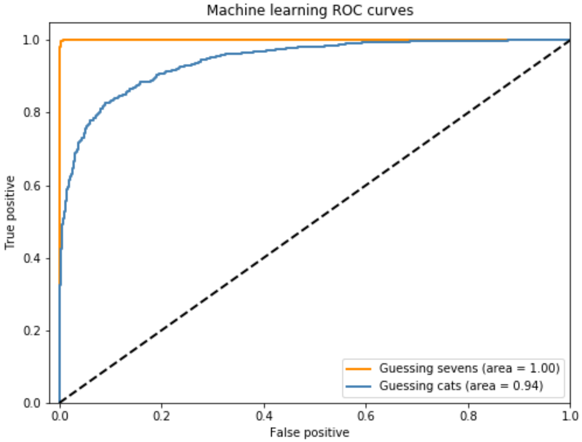


Figure: Roc curves for Model 3 using the cats/dogs dataset and the MNIST handwritten dataset.