Q6_change_sampling_rate

April 29, 2018

In [1]:
```
# allow the notebook to access the parent directory so we can import the other modules
# https://stackoverflow.com/a/35273613
import os
import sys
nb_dir = os.path.split(os.getcwd())[0]
if nb_dir not in sys.path:
    sys.path.append(nb_dir)
```

0.1 # Data Preparation

0.1.1 Constants and Folder Paths

In [2]:
```
import os
dataset_folder_path = os.path.join("..", "files", "dataset")
```

0.1.2 Load Data and Split into *Test, Train/Valid*

In [3]:
```
from data.DataSet import DataSet
dataset = DataSet()
dataset.load(dataset_folder_path, test_set_percentage=0, validation_set_percentage=0)
```

In [4]:
```
print(len(dataset.train_data))
print(len(dataset.test_data))
```

```
3600
0
```

0.1.3 Data Preprocessing

In [5]:
```
from utils.preprocessing import *
from functools import partial
dataset.apply(apply_mean_centering)
dataset.apply(apply_unit_distance_normalization)
dataset.expand(reverse_digit_sequence)
```

In [6]:
```
print(len(dataset.train_data))
print(len(dataset.test_data))
```

```
7200
0
```

Test different sample rates and cross validate then compare the results to determine the optimal sampling rate

```
In [15]: NUM_SAMPLES_TO_TRY = [300, 200, 100, 75, 50, 25, 10]
         N_FOLDS = 4
         PARAM_NUM_EPOCHS = 20
         PARAM_BATCH_SIZE = 300

In [16]: import numpy as np
         import pandas as pd
         from utils.evaluation import cross_validate_model
         from models.regularized_deep_gru import NaiveRegularizedDeepGRU

         results = {}

         for num_samples in NUM_SAMPLES_TO_TRY:
             print("\n\n\n--------------------------------")
             print("Evaluating Spline interpolation using %d samples" % num_samples)
             print("--------------------------------")
             # setup copy of data and evaluate its spline with the currently selected number of
             data = dataset.copy()
             data.apply(partial(spline_interpolate_and_resample, num_samples=num_samples))
             x = np.array(data.train_data)
             y = np.array(data.train_labels)
             # setup the model
             mymodel = NaiveRegularizedDeepGRU(x.shape[1:])
             mymodel.batch_size = PARAM_BATCH_SIZE
             mymodel.num_epochs = PARAM_NUM_EPOCHS
             # run cross validation
             scores = cross_validate_model(x, y, mymodel, N_FOLDS)
             results[num_samples] = scores
```

```
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Evaluating Spline interpolation using 300 samples
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...
Cross validation fold [1]
...
```

```
Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 24s 4ms/step - loss: 2.0769 - categorical_accuracy:
Epoch 2/20
5400/5400 [==============================] - 23s 4ms/step - loss: 1.9243 - categorical_accuracy:
Epoch 3/20
5400/5400 [==============================] - 23s 4ms/step - loss: 1.6586 - categorical_accuracy:
Epoch 4/20
5400/5400 [==============================] - 23s 4ms/step - loss: 1.3814 - categorical_accuracy:
Epoch 5/20
5400/5400 [==============================] - 23s 4ms/step - loss: 1.1557 - categorical_accuracy:
Epoch 6/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.8039 - categorical_accuracy:
Epoch 7/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.4666 - categorical_accuracy:
Epoch 8/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.2432 - categorical_accuracy:
Epoch 9/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.1402 - categorical_accuracy:
Epoch 10/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0888 - categorical_accuracy:
Epoch 11/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0717 - categorical_accuracy:
Epoch 12/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0504 - categorical_accuracy:
Epoch 13/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.1462 - categorical_accuracy:
Epoch 14/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0663 - categorical_accuracy:
Epoch 15/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0587 - categorical_accuracy:
Epoch 16/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0424 - categorical_accuracy:
Epoch 17/20
5400/5400 [==============================] - 24s 4ms/step - loss: 0.0282 - categorical_accuracy:
Epoch 18/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0400 - categorical_accuracy:
Epoch 19/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0199 - categorical_accuracy:
Epoch 20/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0102 - categorical_accuracy:
1800/1800 [==============================] - 5s 3ms/step
categorical_accuracy: 95.89%

...
Cross validation fold [2]
...
```

```
Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 24s 4ms/step - loss: 2.1009 - categorical_accuracy:
Epoch 2/20
5400/5400 [==============================] - 23s 4ms/step - loss: 1.8928 - categorical_accuracy:
Epoch 3/20
5400/5400 [==============================] - 23s 4ms/step - loss: 1.6793 - categorical_accuracy:
Epoch 4/20
5400/5400 [==============================] - 23s 4ms/step - loss: 1.4300 - categorical_accuracy:
Epoch 5/20
5400/5400 [==============================] - 23s 4ms/step - loss: 1.1640 - categorical_accuracy:
Epoch 6/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.7743 - categorical_accuracy:
Epoch 7/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.5141 - categorical_accuracy:
Epoch 8/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.2624 - categorical_accuracy:
Epoch 9/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.2494 - categorical_accuracy:
Epoch 10/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.1076 - categorical_accuracy:
Epoch 11/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0755 - categorical_accuracy:
Epoch 12/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0874 - categorical_accuracy:
Epoch 13/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0556 - categorical_accuracy:
Epoch 14/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0325 - categorical_accuracy:
Epoch 15/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0462 - categorical_accuracy:
Epoch 16/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0306 - categorical_accuracy:
Epoch 17/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0713 - categorical_accuracy:
Epoch 18/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0811 - categorical_accuracy:
Epoch 19/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0497 - categorical_accuracy:
Epoch 20/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0344 - categorical_accuracy:
1800/1800 [==============================] - 5s 3ms/step
categorical_accuracy: 95.00%

...
Cross validation fold [3]
...
```

```
Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 24s 4ms/step - loss: 2.0647 - categorical_accuracy:
Epoch 2/20
5400/5400 [==============================] - 23s 4ms/step - loss: 1.8687 - categorical_accuracy:
Epoch 3/20
5400/5400 [==============================] - 23s 4ms/step - loss: 1.5725 - categorical_accuracy:
Epoch 4/20
5400/5400 [==============================] - 23s 4ms/step - loss: 1.2804 - categorical_accuracy:
Epoch 5/20
5400/5400 [==============================] - 23s 4ms/step - loss: 1.0210 - categorical_accuracy:
Epoch 6/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.7550 - categorical_accuracy:
Epoch 7/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.4040 - categorical_accuracy:
Epoch 8/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.2032 - categorical_accuracy:
Epoch 9/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.3197 - categorical_accuracy:
Epoch 10/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.1443 - categorical_accuracy:
Epoch 11/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0953 - categorical_accuracy:
Epoch 12/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.1175 - categorical_accuracy:
Epoch 13/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0969 - categorical_accuracy:
Epoch 14/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0492 - categorical_accuracy:
Epoch 15/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0328 - categorical_accuracy:
Epoch 16/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0903 - categorical_accuracy:
Epoch 17/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0390 - categorical_accuracy:
Epoch 18/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0312 - categorical_accuracy:
Epoch 19/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0336 - categorical_accuracy:
Epoch 20/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0197 - categorical_accuracy:
1800/1800 [==============================] - 5s 3ms/step
categorical_accuracy: 91.72%

...
Cross validation fold [4]
...
```

```
Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 24s 5ms/step - loss: 2.1043 - categorical_accuracy:
Epoch 2/20
5400/5400 [==============================] - 23s 4ms/step - loss: 1.9242 - categorical_accuracy:
Epoch 3/20
5400/5400 [==============================] - 23s 4ms/step - loss: 1.7402 - categorical_accuracy:
Epoch 4/20
5400/5400 [==============================] - 23s 4ms/step - loss: 1.4522 - categorical_accuracy:
Epoch 5/20
5400/5400 [==============================] - 23s 4ms/step - loss: 1.1996 - categorical_accuracy:
Epoch 6/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.8557 - categorical_accuracy:
Epoch 7/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.6604 - categorical_accuracy:
Epoch 8/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.3873 - categorical_accuracy:
Epoch 9/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.2069 - categorical_accuracy:
Epoch 10/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.1612 - categorical_accuracy:
Epoch 11/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.1101 - categorical_accuracy:
Epoch 12/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0936 - categorical_accuracy:
Epoch 13/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.2403 - categorical_accuracy:
Epoch 14/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.1173 - categorical_accuracy:
Epoch 15/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0523 - categorical_accuracy:
Epoch 16/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0388 - categorical_accuracy:
Epoch 17/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0395 - categorical_accuracy:
Epoch 18/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0981 - categorical_accuracy:
Epoch 19/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0345 - categorical_accuracy:
Epoch 20/20
5400/5400 [==============================] - 23s 4ms/step - loss: 0.0259 - categorical_accuracy:
1800/1800 [==============================] - 5s 3ms/step
categorical_accuracy: 97.44%
95.01% (+/- 2.09%)



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```

```
Evaluating Spline interpolation using 200 samples
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...
Cross validation fold [1]
...

Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 15s 3ms/step - loss: 2.0716 - categorical_accuracy:
Epoch 2/20
5400/5400 [==============================] - 14s 3ms/step - loss: 1.8861 - categorical_accuracy:
Epoch 3/20
5400/5400 [==============================] - 14s 3ms/step - loss: 1.6075 - categorical_accuracy:
Epoch 4/20
5400/5400 [==============================] - 14s 3ms/step - loss: 1.3197 - categorical_accuracy:
Epoch 5/20
5400/5400 [==============================] - 14s 3ms/step - loss: 1.1072 - categorical_accuracy:
Epoch 6/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.8432 - categorical_accuracy:
Epoch 7/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.4969 - categorical_accuracy:
Epoch 8/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.2640 - categorical_accuracy:
Epoch 9/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.2192 - categorical_accuracy:
Epoch 10/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.2878 - categorical_accuracy:
Epoch 11/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.5079 - categorical_accuracy:
Epoch 12/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.1216 - categorical_accuracy:
Epoch 13/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0753 - categorical_accuracy:
Epoch 14/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0564 - categorical_accuracy:
Epoch 15/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0543 - categorical_accuracy:
Epoch 16/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0413 - categorical_accuracy:
Epoch 17/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0373 - categorical_accuracy:
Epoch 18/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0841 - categorical_accuracy:
Epoch 19/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0263 - categorical_accuracy:
Epoch 20/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0243 - categorical_accuracy:
```

```
1800/1800 [==============================] - 3s 2ms/step
categorical_accuracy: 96.22%

...
Cross validation fold [2]
...

Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 16s 3ms/step - loss: 2.0773 - categorical_accuracy:
Epoch 2/20
5400/5400 [==============================] - 14s 3ms/step - loss: 1.8982 - categorical_accuracy:
Epoch 3/20
5400/5400 [==============================] - 14s 3ms/step - loss: 1.7270 - categorical_accuracy:
Epoch 4/20
5400/5400 [==============================] - 14s 3ms/step - loss: 1.2975 - categorical_accuracy:
Epoch 5/20
5400/5400 [==============================] - 14s 3ms/step - loss: 1.0199 - categorical_accuracy:
Epoch 6/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.7936 - categorical_accuracy:
Epoch 7/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.4766 - categorical_accuracy:
Epoch 8/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.2674 - categorical_accuracy:
Epoch 9/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.1674 - categorical_accuracy:
Epoch 10/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.1103 - categorical_accuracy:
Epoch 11/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0655 - categorical_accuracy:
Epoch 12/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0729 - categorical_accuracy:
Epoch 13/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0567 - categorical_accuracy:
Epoch 14/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.1827 - categorical_accuracy:
Epoch 15/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0492 - categorical_accuracy:
Epoch 16/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0320 - categorical_accuracy:
Epoch 17/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0277 - categorical_accuracy:
Epoch 18/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0720 - categorical_accuracy:
Epoch 19/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0364 - categorical_accuracy:
Epoch 20/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0164 - categorical_accuracy:
```

```
1800/1800 [==============================] - 3s 2ms/step
categorical_accuracy: 94.06%

...
Cross validation fold [3]
...

Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 16s 3ms/step - loss: 2.0811 - categorical_accuracy:
Epoch 2/20
5400/5400 [==============================] - 14s 3ms/step - loss: 1.9007 - categorical_accuracy:
Epoch 3/20
5400/5400 [==============================] - 14s 3ms/step - loss: 1.6493 - categorical_accuracy:
Epoch 4/20
5400/5400 [==============================] - 14s 3ms/step - loss: 1.3397 - categorical_accuracy:
Epoch 5/20
5400/5400 [==============================] - 14s 3ms/step - loss: 1.0711 - categorical_accuracy:
Epoch 6/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.7590 - categorical_accuracy:
Epoch 7/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.4830 - categorical_accuracy:
Epoch 8/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.2489 - categorical_accuracy:
Epoch 9/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.1596 - categorical_accuracy:
Epoch 10/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0969 - categorical_accuracy:
Epoch 11/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0865 - categorical_accuracy:
Epoch 12/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0616 - categorical_accuracy:
Epoch 13/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0757 - categorical_accuracy:
Epoch 14/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0529 - categorical_accuracy:
Epoch 15/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0892 - categorical_accuracy:
Epoch 16/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0400 - categorical_accuracy:
Epoch 17/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0195 - categorical_accuracy:
Epoch 18/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0432 - categorical_accuracy:
Epoch 19/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.1246 - categorical_accuracy:
Epoch 20/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0381 - categorical_accuracy:
```

```
1800/1800 [==============================] - 3s 2ms/step
categorical_accuracy: 96.83%

...
Cross validation fold [4]
...

Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 16s 3ms/step - loss: 2.0780 - categorical_accuracy:
Epoch 2/20
5400/5400 [==============================] - 14s 3ms/step - loss: 1.8827 - categorical_accuracy:
Epoch 3/20
5400/5400 [==============================] - 14s 3ms/step - loss: 1.6560 - categorical_accuracy:
Epoch 4/20
5400/5400 [==============================] - 14s 3ms/step - loss: 1.4108 - categorical_accuracy:
Epoch 5/20
5400/5400 [==============================] - 14s 3ms/step - loss: 1.0887 - categorical_accuracy:
Epoch 6/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.7164 - categorical_accuracy:
Epoch 7/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.4237 - categorical_accuracy:
Epoch 8/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.2520 - categorical_accuracy:
Epoch 9/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.1247 - categorical_accuracy:
Epoch 10/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.1028 - categorical_accuracy:
Epoch 11/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0924 - categorical_accuracy:
Epoch 12/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.1157 - categorical_accuracy:
Epoch 13/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0543 - categorical_accuracy:
Epoch 14/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0759 - categorical_accuracy:
Epoch 15/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0434 - categorical_accuracy:
Epoch 16/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0219 - categorical_accuracy:
Epoch 17/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0267 - categorical_accuracy:
Epoch 18/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0169 - categorical_accuracy:
Epoch 19/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.1191 - categorical_accuracy:
Epoch 20/20
5400/5400 [==============================] - 14s 3ms/step - loss: 0.0309 - categorical_accuracy:
```

```
1800/1800 [==============================] - 3s 2ms/step
categorical_accuracy: 93.67%
95.19% (+/- 1.36%)



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Evaluating Spline interpolation using 100 samples
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...
Cross validation fold [1]
...

Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 9s 2ms/step - loss: 2.0772 - categorical_accuracy:
Epoch 2/20
5400/5400 [==============================] - 7s 1ms/step - loss: 1.8049 - categorical_accuracy:
Epoch 3/20
5400/5400 [==============================] - 7s 1ms/step - loss: 1.4219 - categorical_accuracy:
Epoch 4/20
5400/5400 [==============================] - 7s 1ms/step - loss: 1.3177 - categorical_accuracy:
Epoch 5/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.7796 - categorical_accuracy:
Epoch 6/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.3320 - categorical_accuracy:
Epoch 7/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.2658 - categorical_accuracy:
Epoch 8/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.1284 - categorical_accuracy:
Epoch 9/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.1033 - categorical_accuracy:
Epoch 10/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0774 - categorical_accuracy:
Epoch 11/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0350 - categorical_accuracy:
Epoch 12/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0365 - categorical_accuracy:
Epoch 13/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0949 - categorical_accuracy:
Epoch 14/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0657 - categorical_accuracy:
Epoch 15/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0516 - categorical_accuracy:
Epoch 16/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.5535 - categorical_accuracy:
Epoch 17/20
```

```
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0869 - categorical_accuracy:
Epoch 18/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0503 - categorical_accuracy:
Epoch 19/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0263 - categorical_accuracy:
Epoch 20/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0201 - categorical_accuracy:
1800/1800 [==============================] - 2s 950us/step
categorical_accuracy: 95.00%

...
Cross validation fold [2]
...

Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 9s 2ms/step - loss: 2.0806 - categorical_accuracy:
Epoch 2/20
5400/5400 [==============================] - 7s 1ms/step - loss: 1.8561 - categorical_accuracy:
Epoch 3/20
5400/5400 [==============================] - 7s 1ms/step - loss: 1.4872 - categorical_accuracy:
Epoch 4/20
5400/5400 [==============================] - 7s 1ms/step - loss: 1.1119 - categorical_accuracy:
Epoch 5/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.6893 - categorical_accuracy:
Epoch 6/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.2856 - categorical_accuracy:
Epoch 7/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.1757 - categorical_accuracy:
Epoch 8/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.1101 - categorical_accuracy:
Epoch 9/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.1103 - categorical_accuracy:
Epoch 10/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0572 - categorical_accuracy:
Epoch 11/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.2294 - categorical_accuracy:
Epoch 12/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.2176 - categorical_accuracy:
Epoch 13/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0652 - categorical_accuracy:
Epoch 14/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0397 - categorical_accuracy:
Epoch 15/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0463 - categorical_accuracy:
Epoch 16/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0266 - categorical_accuracy:
Epoch 17/20
```

```
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0163 - categorical_accuracy:
Epoch 18/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.3862 - categorical_accuracy:
Epoch 19/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.1231 - categorical_accuracy:
Epoch 20/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0417 - categorical_accuracy:
1800/1800 [==============================] - 2s 948us/step
categorical_accuracy: 95.89%

...
Cross validation fold [3]
...

Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 9s 2ms/step - loss: 2.0597 - categorical_accuracy:
Epoch 2/20
5400/5400 [==============================] - 7s 1ms/step - loss: 1.7884 - categorical_accuracy:
Epoch 3/20
5400/5400 [==============================] - 7s 1ms/step - loss: 1.4965 - categorical_accuracy:
Epoch 4/20
5400/5400 [==============================] - 7s 1ms/step - loss: 1.1540 - categorical_accuracy:
Epoch 5/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.7606 - categorical_accuracy:
Epoch 6/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.4335 - categorical_accuracy:
Epoch 7/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.1994 - categorical_accuracy:
Epoch 8/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.1528 - categorical_accuracy:
Epoch 9/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.1143 - categorical_accuracy:
Epoch 10/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.9041 - categorical_accuracy:
Epoch 11/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.2352 - categorical_accuracy:
Epoch 12/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.1101 - categorical_accuracy:
Epoch 13/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.1095 - categorical_accuracy:
Epoch 14/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0656 - categorical_accuracy:
Epoch 15/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0399 - categorical_accuracy:
Epoch 16/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0250 - categorical_accuracy:
Epoch 17/20
```

```
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0605 - categorical_accuracy:
Epoch 18/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.2209 - categorical_accuracy:
Epoch 19/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0401 - categorical_accuracy:
Epoch 20/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0338 - categorical_accuracy:
1800/1800 [==============================] - 2s 945us/step
categorical_accuracy: 95.00%

...
Cross validation fold [4]
...

Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 9s 2ms/step - loss: 2.0665 - categorical_accuracy:
Epoch 2/20
5400/5400 [==============================] - 7s 1ms/step - loss: 1.7632 - categorical_accuracy:
Epoch 3/20
5400/5400 [==============================] - 7s 1ms/step - loss: 1.4974 - categorical_accuracy:
Epoch 4/20
5400/5400 [==============================] - 7s 1ms/step - loss: 1.1529 - categorical_accuracy:
Epoch 5/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.7350 - categorical_accuracy:
Epoch 6/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.4043 - categorical_accuracy:
Epoch 7/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.2006 - categorical_accuracy:
Epoch 8/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.2096 - categorical_accuracy:
Epoch 9/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.1027 - categorical_accuracy:
Epoch 10/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.1528 - categorical_accuracy:
Epoch 11/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.1892 - categorical_accuracy:
Epoch 12/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.1348 - categorical_accuracy:
Epoch 13/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0760 - categorical_accuracy:
Epoch 14/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0458 - categorical_accuracy:
Epoch 15/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0279 - categorical_accuracy:
Epoch 16/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0224 - categorical_accuracy:
Epoch 17/20
```

```
5400/5400 [==============================] - 7s 1ms/step - loss: 0.1366 - categorical_accuracy:
Epoch 18/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.1189 - categorical_accuracy:
Epoch 19/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0321 - categorical_accuracy:
Epoch 20/20
5400/5400 [==============================] - 7s 1ms/step - loss: 0.0191 - categorical_accuracy:
1800/1800 [==============================] - 2s 941us/step
categorical_accuracy: 95.44%
95.33% (+/- 0.37%)



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Evaluating Spline interpolation using 75 samples
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...
Cross validation fold [1]
...

Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 8s 1ms/step - loss: 2.0763 - categorical_accuracy:
Epoch 2/20
5400/5400 [==============================] - 5s 957us/step - loss: 1.7771 - categorical_accuracy
Epoch 3/20
5400/5400 [==============================] - 5s 954us/step - loss: 1.4547 - categorical_accuracy
Epoch 4/20
5400/5400 [==============================] - 5s 955us/step - loss: 0.9475 - categorical_accuracy
Epoch 5/20
5400/5400 [==============================] - 5s 957us/step - loss: 0.6176 - categorical_accuracy
Epoch 6/20
5400/5400 [==============================] - 5s 956us/step - loss: 0.2982 - categorical_accuracy
Epoch 7/20
5400/5400 [==============================] - 5s 957us/step - loss: 0.1988 - categorical_accuracy
Epoch 8/20
5400/5400 [==============================] - 5s 957us/step - loss: 0.1480 - categorical_accuracy
Epoch 9/20
5400/5400 [==============================] - 5s 957us/step - loss: 0.1879 - categorical_accuracy
Epoch 10/20
5400/5400 [==============================] - 5s 955us/step - loss: 0.1681 - categorical_accuracy
Epoch 11/20
5400/5400 [==============================] - 5s 957us/step - loss: 0.4519 - categorical_accuracy
Epoch 12/20
5400/5400 [==============================] - 5s 960us/step - loss: 0.0891 - categorical_accuracy
Epoch 13/20
5400/5400 [==============================] - 5s 963us/step - loss: 0.0528 - categorical_accuracy
```

```
Epoch 14/20
5400/5400 [==============================] - 5s 959us/step - loss: 0.0567 - categorical_accuracy
Epoch 15/20
5400/5400 [==============================] - 5s 958us/step - loss: 0.0420 - categorical_accuracy
Epoch 16/20
5400/5400 [==============================] - 5s 959us/step - loss: 0.0340 - categorical_accuracy
Epoch 17/20
5400/5400 [==============================] - 5s 961us/step - loss: 0.0246 - categorical_accuracy
Epoch 18/20
5400/5400 [==============================] - 5s 959us/step - loss: 0.0179 - categorical_accuracy
Epoch 19/20
5400/5400 [==============================] - 5s 961us/step - loss: 0.1041 - categorical_accuracy
Epoch 20/20
5400/5400 [==============================] - 5s 961us/step - loss: 0.0258 - categorical_accuracy
1800/1800 [==============================] - 1s 729us/step
categorical_accuracy: 95.50%

...
Cross validation fold [2]
...

Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 8s 1ms/step - loss: 2.0509 - categorical_accuracy:
Epoch 2/20
5400/5400 [==============================] - 5s 959us/step - loss: 1.7500 - categorical_accuracy
Epoch 3/20
5400/5400 [==============================] - 5s 960us/step - loss: 1.4475 - categorical_accuracy
Epoch 4/20
5400/5400 [==============================] - 5s 960us/step - loss: 1.0740 - categorical_accuracy
Epoch 5/20
5400/5400 [==============================] - 5s 959us/step - loss: 0.6360 - categorical_accuracy
Epoch 6/20
5400/5400 [==============================] - 5s 959us/step - loss: 0.3441 - categorical_accuracy
Epoch 7/20
5400/5400 [==============================] - 5s 960us/step - loss: 0.1312 - categorical_accuracy
Epoch 8/20
5400/5400 [==============================] - 5s 960us/step - loss: 0.1090 - categorical_accuracy
Epoch 9/20
5400/5400 [==============================] - 5s 961us/step - loss: 0.0940 - categorical_accuracy
Epoch 10/20
5400/5400 [==============================] - 5s 959us/step - loss: 0.6642 - categorical_accuracy
Epoch 11/20
5400/5400 [==============================] - 5s 961us/step - loss: 0.1279 - categorical_accuracy
Epoch 12/20
5400/5400 [==============================] - 5s 960us/step - loss: 0.0697 - categorical_accuracy
Epoch 13/20
5400/5400 [==============================] - 5s 956us/step - loss: 0.0566 - categorical_accuracy
```

```
Epoch 14/20
5400/5400 [==============================] - 5s 957us/step - loss: 0.0952 - categorical_accuracy
Epoch 15/20
5400/5400 [==============================] - 5s 959us/step - loss: 0.0330 - categorical_accuracy
Epoch 16/20
5400/5400 [==============================] - 5s 957us/step - loss: 0.0307 - categorical_accuracy
Epoch 17/20
5400/5400 [==============================] - 5s 957us/step - loss: 0.0136 - categorical_accuracy
Epoch 18/20
5400/5400 [==============================] - 5s 956us/step - loss: 0.0140 - categorical_accuracy
Epoch 19/20
5400/5400 [==============================] - 5s 957us/step - loss: 0.0091 - categorical_accuracy
Epoch 20/20
5400/5400 [==============================] - 5s 957us/step - loss: 0.0073 - categorical_accuracy
1800/1800 [==============================] - 1s 726us/step
categorical_accuracy: 96.50%

...
Cross validation fold [3]
...

Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 8s 1ms/step - loss: 2.0622 - categorical_accuracy:
Epoch 2/20
5400/5400 [==============================] - 5s 955us/step - loss: 1.7443 - categorical_accuracy
Epoch 3/20
5400/5400 [==============================] - 5s 954us/step - loss: 1.4552 - categorical_accuracy
Epoch 4/20
5400/5400 [==============================] - 5s 955us/step - loss: 0.9782 - categorical_accuracy
Epoch 5/20
5400/5400 [==============================] - 5s 956us/step - loss: 0.5758 - categorical_accuracy
Epoch 6/20
5400/5400 [==============================] - 5s 955us/step - loss: 0.3931 - categorical_accuracy
Epoch 7/20
5400/5400 [==============================] - 5s 957us/step - loss: 0.1764 - categorical_accuracy
Epoch 8/20
5400/5400 [==============================] - 5s 955us/step - loss: 0.1352 - categorical_accuracy
Epoch 9/20
5400/5400 [==============================] - 5s 955us/step - loss: 0.1172 - categorical_accuracy
Epoch 10/20
5400/5400 [==============================] - 5s 956us/step - loss: 0.0599 - categorical_accuracy
Epoch 11/20
5400/5400 [==============================] - 5s 957us/step - loss: 0.0492 - categorical_accuracy
Epoch 12/20
5400/5400 [==============================] - 5s 956us/step - loss: 0.0467 - categorical_accuracy
Epoch 13/20
5400/5400 [==============================] - 5s 957us/step - loss: 0.0653 - categorical_accuracy
```

```
Epoch 14/20
5400/5400 [==============================] - 5s 956us/step - loss: 0.0404 - categorical_accuracy
Epoch 15/20
5400/5400 [==============================] - 5s 956us/step - loss: 0.0235 - categorical_accuracy
Epoch 16/20
5400/5400 [==============================] - 5s 956us/step - loss: 0.7966 - categorical_accuracy
Epoch 17/20
5400/5400 [==============================] - 5s 958us/step - loss: 0.7411 - categorical_accuracy
Epoch 18/20
5400/5400 [==============================] - 5s 956us/step - loss: 0.1140 - categorical_accuracy
Epoch 19/20
5400/5400 [==============================] - 5s 957us/step - loss: 0.0971 - categorical_accuracy
Epoch 20/20
5400/5400 [==============================] - 5s 955us/step - loss: 0.0635 - categorical_accuracy
1800/1800 [==============================] - 1s 722us/step
categorical_accuracy: 97.11%

...
Cross validation fold [4]
...

Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 8s 1ms/step - loss: 2.1660 - categorical_accuracy:
Epoch 2/20
5400/5400 [==============================] - 5s 952us/step - loss: 1.7508 - categorical_accuracy
Epoch 3/20
5400/5400 [==============================] - 5s 955us/step - loss: 1.4498 - categorical_accuracy
Epoch 4/20
5400/5400 [==============================] - 5s 954us/step - loss: 1.0640 - categorical_accuracy
Epoch 5/20
5400/5400 [==============================] - 5s 953us/step - loss: 0.5847 - categorical_accuracy
Epoch 6/20
5400/5400 [==============================] - 5s 954us/step - loss: 0.4027 - categorical_accuracy
Epoch 7/20
5400/5400 [==============================] - 5s 954us/step - loss: 0.2009 - categorical_accuracy
Epoch 8/20
5400/5400 [==============================] - 5s 960us/step - loss: 0.1458 - categorical_accuracy
Epoch 9/20
5400/5400 [==============================] - 5s 955us/step - loss: 0.1468 - categorical_accuracy
Epoch 10/20
5400/5400 [==============================] - 5s 954us/step - loss: 0.1319 - categorical_accuracy
Epoch 11/20
5400/5400 [==============================] - 5s 956us/step - loss: 0.0630 - categorical_accuracy
Epoch 12/20
5400/5400 [==============================] - 5s 954us/step - loss: 0.3784 - categorical_accuracy
Epoch 13/20
5400/5400 [==============================] - 5s 956us/step - loss: 0.0741 - categorical_accuracy
```

```
Epoch 14/20
5400/5400 [==============================] - 5s 955us/step - loss: 0.0576 - categorical_accuracy
Epoch 15/20
5400/5400 [==============================] - 5s 954us/step - loss: 0.0391 - categorical_accuracy
Epoch 16/20
5400/5400 [==============================] - 5s 954us/step - loss: 0.0249 - categorical_accuracy
Epoch 17/20
5400/5400 [==============================] - 5s 954us/step - loss: 0.0181 - categorical_accuracy
Epoch 18/20
5400/5400 [==============================] - 5s 953us/step - loss: 0.0136 - categorical_accuracy
Epoch 19/20
5400/5400 [==============================] - 5s 957us/step - loss: 0.0121 - categorical_accuracy
Epoch 20/20
5400/5400 [==============================] - 5s 953us/step - loss: 0.0077 - categorical_accuracy
1800/1800 [==============================] - 1s 722us/step
categorical_accuracy: 91.00%
95.03% (+/- 2.40%)



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Evaluating Spline interpolation using 50 samples
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...
Cross validation fold [1]
...

Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 6s 1ms/step - loss: 2.0664 - categorical_accuracy:
Epoch 2/20
5400/5400 [==============================] - 3s 645us/step - loss: 1.6916 - categorical_accuracy
Epoch 3/20
5400/5400 [==============================] - 3s 646us/step - loss: 1.4581 - categorical_accuracy
Epoch 4/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.9495 - categorical_accuracy
Epoch 5/20
5400/5400 [==============================] - 3s 648us/step - loss: 0.5641 - categorical_accuracy
Epoch 6/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.2645 - categorical_accuracy
Epoch 7/20
5400/5400 [==============================] - 3s 648us/step - loss: 0.1711 - categorical_accuracy
Epoch 8/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.2099 - categorical_accuracy
Epoch 9/20
5400/5400 [==============================] - 3s 645us/step - loss: 0.0915 - categorical_accuracy
Epoch 10/20
```

```
5400/5400 [==============================] - 3s 646us/step - loss: 0.0758 - categorical_accuracy
Epoch 11/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.0545 - categorical_accuracy
Epoch 12/20
5400/5400 [==============================] - 3s 647us/step - loss: 0.0490 - categorical_accuracy
Epoch 13/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.1419 - categorical_accuracy
Epoch 14/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.0332 - categorical_accuracy
Epoch 15/20
5400/5400 [==============================] - 3s 645us/step - loss: 0.0418 - categorical_accuracy
Epoch 16/20
5400/5400 [==============================] - 3s 645us/step - loss: 0.0238 - categorical_accuracy
Epoch 17/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.0204 - categorical_accuracy
Epoch 18/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.0273 - categorical_accuracy
Epoch 19/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.0312 - categorical_accuracy
Epoch 20/20
5400/5400 [==============================] - 3s 648us/step - loss: 0.0125 - categorical_accuracy
1800/1800 [==============================] - 1s 506us/step
categorical_accuracy: 98.56%

...
Cross validation fold [2]
...

Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 7s 1ms/step - loss: 2.0617 - categorical_accuracy:
Epoch 2/20
5400/5400 [==============================] - 3s 646us/step - loss: 1.7332 - categorical_accuracy
Epoch 3/20
5400/5400 [==============================] - 3s 646us/step - loss: 1.3499 - categorical_accuracy
Epoch 4/20
5400/5400 [==============================] - 3s 646us/step - loss: 1.0059 - categorical_accuracy
Epoch 5/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.5456 - categorical_accuracy
Epoch 6/20
5400/5400 [==============================] - 3s 645us/step - loss: 0.3305 - categorical_accuracy
Epoch 7/20
5400/5400 [==============================] - 3s 647us/step - loss: 0.1555 - categorical_accuracy
Epoch 8/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.1113 - categorical_accuracy
Epoch 9/20
5400/5400 [==============================] - 3s 648us/step - loss: 0.1863 - categorical_accuracy
Epoch 10/20
```

```
5400/5400 [==============================] - 3s 646us/step - loss: 0.1649 - categorical_accuracy
Epoch 11/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.1495 - categorical_accuracy
Epoch 12/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.0820 - categorical_accuracy
Epoch 13/20
5400/5400 [==============================] - 4s 649us/step - loss: 0.0458 - categorical_accuracy
Epoch 14/20
5400/5400 [==============================] - 3s 648us/step - loss: 0.0310 - categorical_accuracy
Epoch 15/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.0260 - categorical_accuracy
Epoch 16/20
5400/5400 [==============================] - 3s 647us/step - loss: 0.9057 - categorical_accuracy
Epoch 17/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.1386 - categorical_accuracy
Epoch 18/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.0863 - categorical_accuracy
Epoch 19/20
5400/5400 [==============================] - 3s 645us/step - loss: 0.0416 - categorical_accuracy
Epoch 20/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.0276 - categorical_accuracy
1800/1800 [==============================] - 1s 509us/step
categorical_accuracy: 96.06%

...
Cross validation fold [3]
...

Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 7s 1ms/step - loss: 2.0321 - categorical_accuracy:
Epoch 2/20
5400/5400 [==============================] - 3s 646us/step - loss: 1.6390 - categorical_accuracy
Epoch 3/20
5400/5400 [==============================] - 3s 646us/step - loss: 1.2003 - categorical_accuracy
Epoch 4/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.5589 - categorical_accuracy
Epoch 5/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.9043 - categorical_accuracy
Epoch 6/20
5400/5400 [==============================] - 4s 649us/step - loss: 0.2326 - categorical_accuracy
Epoch 7/20
5400/5400 [==============================] - 3s 647us/step - loss: 0.1338 - categorical_accuracy
Epoch 8/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.2434 - categorical_accuracy
Epoch 9/20
5400/5400 [==============================] - 3s 648us/step - loss: 0.0969 - categorical_accuracy
Epoch 10/20
```

```
5400/5400 [==============================] - 3s 648us/step - loss: 0.0706 - categorical_accuracy
Epoch 11/20
5400/5400 [==============================] - 3s 647us/step - loss: 0.1945 - categorical_accuracy
Epoch 12/20
5400/5400 [==============================] - 4s 648us/step - loss: 0.0430 - categorical_accuracy
Epoch 13/20
5400/5400 [==============================] - 3s 647us/step - loss: 0.0307 - categorical_accuracy
Epoch 14/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.0250 - categorical_accuracy
Epoch 15/20
5400/5400 [==============================] - 3s 645us/step - loss: 0.0179 - categorical_accuracy
Epoch 16/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.0386 - categorical_accuracy
Epoch 17/20
5400/5400 [==============================] - 3s 647us/step - loss: 0.0443 - categorical_accuracy
Epoch 18/20
5400/5400 [==============================] - 3s 645us/step - loss: 0.0156 - categorical_accuracy
Epoch 19/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.0110 - categorical_accuracy
Epoch 20/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.0082 - categorical_accuracy
1800/1800 [==============================] - 1s 507us/step
categorical_accuracy: 93.78%

...
Cross validation fold [4]
...

Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 7s 1ms/step - loss: 2.0131 - categorical_accuracy:
Epoch 2/20
5400/5400 [==============================] - 3s 645us/step - loss: 1.7595 - categorical_accuracy
Epoch 3/20
5400/5400 [==============================] - 3s 645us/step - loss: 1.4193 - categorical_accuracy
Epoch 4/20
5400/5400 [==============================] - 3s 645us/step - loss: 0.9088 - categorical_accuracy
Epoch 5/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.6139 - categorical_accuracy
Epoch 6/20
5400/5400 [==============================] - 3s 645us/step - loss: 0.2410 - categorical_accuracy
Epoch 7/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.1637 - categorical_accuracy
Epoch 8/20
5400/5400 [==============================] - 3s 647us/step - loss: 0.3369 - categorical_accuracy
Epoch 9/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.0890 - categorical_accuracy
Epoch 10/20
```

```
5400/5400 [==============================] - 3s 647us/step - loss: 0.0510 - categorical_accuracy
Epoch 11/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.3013 - categorical_accuracy
Epoch 12/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.6547 - categorical_accuracy
Epoch 13/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.1010 - categorical_accuracy
Epoch 14/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.0590 - categorical_accuracy
Epoch 15/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.0442 - categorical_accuracy
Epoch 16/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.0426 - categorical_accuracy
Epoch 17/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.0259 - categorical_accuracy
Epoch 18/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.0246 - categorical_accuracy
Epoch 19/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.0177 - categorical_accuracy
Epoch 20/20
5400/5400 [==============================] - 3s 646us/step - loss: 0.0160 - categorical_accuracy
1800/1800 [==============================] - 1s 508us/step
categorical_accuracy: 94.33%
95.68% (+/- 1.86%)



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Evaluating Spline interpolation using 25 samples
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...
Cross validation fold [1]
...

Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 5s 993us/step - loss: 2.0076 - categorical_accuracy
Epoch 2/20
5400/5400 [==============================] - 2s 339us/step - loss: 1.3798 - categorical_accuracy
Epoch 3/20
5400/5400 [==============================] - 2s 338us/step - loss: 1.1286 - categorical_accuracy
Epoch 4/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.4955 - categorical_accuracy
Epoch 5/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.2382 - categorical_accuracy
Epoch 6/20
5400/5400 [==============================] - 2s 339us/step - loss: 0.3362 - categorical_accuracy
```

```
Epoch 7/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.1335 - categorical_accuracy
Epoch 8/20
5400/5400 [==============================] - 2s 339us/step - loss: 0.0816 - categorical_accuracy
Epoch 9/20
5400/5400 [==============================] - 2s 339us/step - loss: 0.1724 - categorical_accuracy
Epoch 10/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.2863 - categorical_accuracy
Epoch 11/20
5400/5400 [==============================] - 2s 340us/step - loss: 0.0786 - categorical_accuracy
Epoch 12/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.0573 - categorical_accuracy
Epoch 13/20
5400/5400 [==============================] - 2s 339us/step - loss: 0.0313 - categorical_accuracy
Epoch 14/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.0228 - categorical_accuracy
Epoch 15/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.0144 - categorical_accuracy
Epoch 16/20
5400/5400 [==============================] - 2s 339us/step - loss: 0.1283 - categorical_accuracy
Epoch 17/20
5400/5400 [==============================] - 2s 343us/step - loss: 0.0295 - categorical_accuracy
Epoch 18/20
5400/5400 [==============================] - 2s 340us/step - loss: 0.0156 - categorical_accuracy
Epoch 19/20
5400/5400 [==============================] - 2s 340us/step - loss: 0.0133 - categorical_accuracy
Epoch 20/20
5400/5400 [==============================] - 2s 341us/step - loss: 0.0083 - categorical_accuracy
1800/1800 [==============================] - 1s 291us/step
categorical_accuracy: 97.89%

...
Cross validation fold [2]
...

Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 6s 1ms/step - loss: 2.0259 - categorical_accuracy:
Epoch 2/20
5400/5400 [==============================] - 2s 336us/step - loss: 1.4764 - categorical_accuracy
Epoch 3/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.9337 - categorical_accuracy
Epoch 4/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.6049 - categorical_accuracy
Epoch 5/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.3085 - categorical_accuracy
Epoch 6/20
5400/5400 [==============================] - 2s 336us/step - loss: 0.1509 - categorical_accuracy
```

```
Epoch 7/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.0982 - categorical_accuracy
Epoch 8/20
5400/5400 [==============================] - 2s 337us/step - loss: 0.0854 - categorical_accuracy
Epoch 9/20
5400/5400 [==============================] - 2s 338us/step - loss: 1.0358 - categorical_accuracy
Epoch 10/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.1742 - categorical_accuracy
Epoch 11/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.0985 - categorical_accuracy
Epoch 12/20
5400/5400 [==============================] - 2s 337us/step - loss: 0.0563 - categorical_accuracy
Epoch 13/20
5400/5400 [==============================] - 2s 340us/step - loss: 0.0964 - categorical_accuracy
Epoch 14/20
5400/5400 [==============================] - 2s 339us/step - loss: 0.0459 - categorical_accuracy
Epoch 15/20
5400/5400 [==============================] - 2s 339us/step - loss: 0.0341 - categorical_accuracy
Epoch 16/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.4337 - categorical_accuracy
Epoch 17/20
5400/5400 [==============================] - 2s 337us/step - loss: 0.2725 - categorical_accuracy
Epoch 18/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.0536 - categorical_accuracy
Epoch 19/20
5400/5400 [==============================] - 2s 337us/step - loss: 0.0410 - categorical_accuracy
Epoch 20/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.0286 - categorical_accuracy
1800/1800 [==============================] - 1s 291us/step
categorical_accuracy: 97.28%

...
Cross validation fold [3]
...

Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 6s 1ms/step - loss: 1.9469 - categorical_accuracy:
Epoch 2/20
5400/5400 [==============================] - 2s 337us/step - loss: 1.3120 - categorical_accuracy
Epoch 3/20
5400/5400 [==============================] - 2s 339us/step - loss: 0.7399 - categorical_accuracy
Epoch 4/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.5812 - categorical_accuracy
Epoch 5/20
5400/5400 [==============================] - 2s 339us/step - loss: 0.1865 - categorical_accuracy
Epoch 6/20
5400/5400 [==============================] - 2s 341us/step - loss: 0.1454 - categorical_accuracy
```

```
Epoch 7/20
5400/5400 [==============================] - 2s 339us/step - loss: 0.1028 - categorical_accuracy
Epoch 8/20
5400/5400 [==============================] - 2s 339us/step - loss: 0.0980 - categorical_accuracy
Epoch 9/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.0646 - categorical_accuracy
Epoch 10/20
5400/5400 [==============================] - 2s 339us/step - loss: 0.7927 - categorical_accuracy
Epoch 11/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.6633 - categorical_accuracy
Epoch 12/20
5400/5400 [==============================] - 2s 340us/step - loss: 0.1283 - categorical_accuracy
Epoch 13/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.0778 - categorical_accuracy
Epoch 14/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.0733 - categorical_accuracy
Epoch 15/20
5400/5400 [==============================] - 2s 339us/step - loss: 0.0576 - categorical_accuracy
Epoch 16/20
5400/5400 [==============================] - 2s 339us/step - loss: 0.0337 - categorical_accuracy
Epoch 17/20
5400/5400 [==============================] - 2s 339us/step - loss: 0.0252 - categorical_accuracy
Epoch 18/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.1402 - categorical_accuracy
Epoch 19/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.1794 - categorical_accuracy
Epoch 20/20
5400/5400 [==============================] - 2s 339us/step - loss: 0.0411 - categorical_accuracy
1800/1800 [==============================] - 1s 293us/step
categorical_accuracy: 95.56%

...
Cross validation fold [4]
...

Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 6s 1ms/step - loss: 1.9361 - categorical_accuracy:
Epoch 2/20
5400/5400 [==============================] - 2s 338us/step - loss: 1.3896 - categorical_accuracy
Epoch 3/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.8192 - categorical_accuracy
Epoch 4/20
5400/5400 [==============================] - 2s 340us/step - loss: 0.5943 - categorical_accuracy
Epoch 5/20
5400/5400 [==============================] - 2s 337us/step - loss: 0.2188 - categorical_accuracy
Epoch 6/20
5400/5400 [==============================] - 2s 339us/step - loss: 0.1201 - categorical_accuracy
```

```
Epoch 7/20
5400/5400 [==============================] - 2s 339us/step - loss: 0.0793 - categorical_accuracy
Epoch 8/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.6024 - categorical_accuracy
Epoch 9/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.1543 - categorical_accuracy
Epoch 10/20
5400/5400 [==============================] - 2s 339us/step - loss: 0.0597 - categorical_accuracy
Epoch 11/20
5400/5400 [==============================] - 2s 339us/step - loss: 0.0576 - categorical_accuracy
Epoch 12/20
5400/5400 [==============================] - 2s 340us/step - loss: 0.0330 - categorical_accuracy
Epoch 13/20
5400/5400 [==============================] - 2s 339us/step - loss: 0.0271 - categorical_accuracy
Epoch 14/20
5400/5400 [==============================] - 2s 340us/step - loss: 0.0360 - categorical_accuracy
Epoch 15/20
5400/5400 [==============================] - 2s 340us/step - loss: 0.0176 - categorical_accuracy
Epoch 16/20
5400/5400 [==============================] - 2s 339us/step - loss: 0.2026 - categorical_accuracy
Epoch 17/20
5400/5400 [==============================] - 2s 339us/step - loss: 0.2591 - categorical_accuracy
Epoch 18/20
5400/5400 [==============================] - 2s 341us/step - loss: 0.0444 - categorical_accuracy
Epoch 19/20
5400/5400 [==============================] - 2s 340us/step - loss: 0.0272 - categorical_accuracy
Epoch 20/20
5400/5400 [==============================] - 2s 338us/step - loss: 0.0185 - categorical_accuracy
1800/1800 [==============================] - 1s 290us/step
categorical_accuracy: 93.67%
96.10% (+/- 1.64%)



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Evaluating Spline interpolation using 10 samples
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...
Cross validation fold [1]
...

Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 5s 906us/step - loss: 1.9404 - categorical_accuracy
Epoch 2/20
5400/5400 [==============================] - 1s 151us/step - loss: 1.2312 - categorical_accuracy
Epoch 3/20
```

```
5400/5400 [==============================] - 1s 151us/step - loss: 0.6153 - categorical_accuracy
Epoch 4/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.4432 - categorical_accuracy
Epoch 5/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.2430 - categorical_accuracy
Epoch 6/20
5400/5400 [==============================] - 1s 151us/step - loss: 0.1756 - categorical_accuracy
Epoch 7/20
5400/5400 [==============================] - 1s 151us/step - loss: 0.1809 - categorical_accuracy
Epoch 8/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.1148 - categorical_accuracy
Epoch 9/20
5400/5400 [==============================] - 1s 151us/step - loss: 0.1487 - categorical_accuracy
Epoch 10/20
5400/5400 [==============================] - 1s 151us/step - loss: 0.0711 - categorical_accuracy
Epoch 11/20
5400/5400 [==============================] - 1s 153us/step - loss: 0.1690 - categorical_accuracy
Epoch 12/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.2706 - categorical_accuracy
Epoch 13/20
5400/5400 [==============================] - 1s 151us/step - loss: 0.0777 - categorical_accuracy
Epoch 14/20
5400/5400 [==============================] - 1s 151us/step - loss: 0.0496 - categorical_accuracy
Epoch 15/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.0389 - categorical_accuracy
Epoch 16/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.0316 - categorical_accuracy
Epoch 17/20
5400/5400 [==============================] - 1s 153us/step - loss: 0.0261 - categorical_accuracy
Epoch 18/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.0235 - categorical_accuracy
Epoch 19/20
5400/5400 [==============================] - 1s 151us/step - loss: 0.0194 - categorical_accuracy
Epoch 20/20
5400/5400 [==============================] - 1s 151us/step - loss: 0.1216 - categorical_accuracy
1800/1800 [==============================] - 0s 153us/step
categorical_accuracy: 70.89%

...
Cross validation fold [2]
...

Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 5s 918us/step - loss: 1.9588 - categorical_accuracy
Epoch 2/20
5400/5400 [==============================] - 1s 152us/step - loss: 1.2102 - categorical_accuracy
Epoch 3/20
```

```
5400/5400 [==============================] - 1s 151us/step - loss: 0.7385 - categorical_accuracy
Epoch 4/20
5400/5400 [==============================] - 1s 151us/step - loss: 0.4465 - categorical_accuracy
Epoch 5/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.3019 - categorical_accuracy
Epoch 6/20
5400/5400 [==============================] - 1s 151us/step - loss: 0.1770 - categorical_accuracy
Epoch 7/20
5400/5400 [==============================] - 1s 153us/step - loss: 0.1864 - categorical_accuracy
Epoch 8/20
5400/5400 [==============================] - 1s 151us/step - loss: 0.1053 - categorical_accuracy
Epoch 9/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.1069 - categorical_accuracy
Epoch 10/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.0864 - categorical_accuracy
Epoch 11/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.0683 - categorical_accuracy
Epoch 12/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.7518 - categorical_accuracy
Epoch 13/20
5400/5400 [==============================] - 1s 151us/step - loss: 0.1310 - categorical_accuracy
Epoch 14/20
5400/5400 [==============================] - 1s 151us/step - loss: 0.0700 - categorical_accuracy
Epoch 15/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.0527 - categorical_accuracy
Epoch 16/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.0351 - categorical_accuracy
Epoch 17/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.0371 - categorical_accuracy
Epoch 18/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.0256 - categorical_accuracy
Epoch 19/20
5400/5400 [==============================] - 1s 151us/step - loss: 0.0267 - categorical_accuracy
Epoch 20/20
5400/5400 [==============================] - 1s 151us/step - loss: 0.0165 - categorical_accuracy
1800/1800 [==============================] - 0s 154us/step
categorical_accuracy: 95.78%

...
Cross validation fold [3]
...

Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 5s 947us/step - loss: 1.9591 - categorical_accuracy
Epoch 2/20
5400/5400 [==============================] - 1s 153us/step - loss: 1.3037 - categorical_accuracy
Epoch 3/20
```

```
5400/5400 [==============================] - 1s 152us/step - loss: 0.7331 - categorical_accuracy
Epoch 4/20
5400/5400 [==============================] - 1s 151us/step - loss: 0.3396 - categorical_accuracy
Epoch 5/20
5400/5400 [==============================] - 1s 151us/step - loss: 0.2839 - categorical_accuracy
Epoch 6/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.1768 - categorical_accuracy
Epoch 7/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.1410 - categorical_accuracy
Epoch 8/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.1135 - categorical_accuracy
Epoch 9/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.1312 - categorical_accuracy
Epoch 10/20
5400/5400 [==============================] - 1s 153us/step - loss: 0.0695 - categorical_accuracy
Epoch 11/20
5400/5400 [==============================] - 1s 151us/step - loss: 0.0592 - categorical_accuracy
Epoch 12/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.0497 - categorical_accuracy
Epoch 13/20
5400/5400 [==============================] - 1s 151us/step - loss: 0.5232 - categorical_accuracy
Epoch 14/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.1966 - categorical_accuracy
Epoch 15/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.0635 - categorical_accuracy
Epoch 16/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.0403 - categorical_accuracy
Epoch 17/20
5400/5400 [==============================] - 1s 151us/step - loss: 0.0300 - categorical_accuracy
Epoch 18/20
5400/5400 [==============================] - 1s 151us/step - loss: 0.0319 - categorical_accuracy
Epoch 19/20
5400/5400 [==============================] - 1s 151us/step - loss: 0.0154 - categorical_accuracy
Epoch 20/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.0119 - categorical_accuracy
1800/1800 [==============================] - 0s 157us/step
categorical_accuracy: 95.72%

...
Cross validation fold [4]
...

Train on 5400 samples, validate on 1800 samples
Epoch 1/20
5400/5400 [==============================] - 5s 964us/step - loss: 1.9405 - categorical_accuracy
Epoch 2/20
5400/5400 [==============================] - 1s 152us/step - loss: 1.1499 - categorical_accuracy
Epoch 3/20
```

```
5400/5400 [==============================] - 1s 152us/step - loss: 0.6106 - categorical_accuracy
Epoch 4/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.3857 - categorical_accuracy
Epoch 5/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.2344 - categorical_accuracy
Epoch 6/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.2584 - categorical_accuracy
Epoch 7/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.1275 - categorical_accuracy
Epoch 8/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.1127 - categorical_accuracy
Epoch 9/20
5400/5400 [==============================] - 1s 151us/step - loss: 0.0874 - categorical_accuracy
Epoch 10/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.0717 - categorical_accuracy
Epoch 11/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.0700 - categorical_accuracy
Epoch 12/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.2282 - categorical_accuracy
Epoch 13/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.0597 - categorical_accuracy
Epoch 14/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.0433 - categorical_accuracy
Epoch 15/20
5400/5400 [==============================] - 1s 153us/step - loss: 0.0293 - categorical_accuracy
Epoch 16/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.0608 - categorical_accuracy
Epoch 17/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.3195 - categorical_accuracy
Epoch 18/20
5400/5400 [==============================] - 1s 151us/step - loss: 0.0581 - categorical_accuracy
Epoch 19/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.0471 - categorical_accuracy
Epoch 20/20
5400/5400 [==============================] - 1s 152us/step - loss: 0.0275 - categorical_accuracy
1800/1800 [==============================] - 0s 168us/step
categorical_accuracy: 91.22%
88.40% (+/- 10.28%)
```

```
In [17]: results_df = pd.DataFrame([[key, np.mean(res), np.std(res)] for key,res in list(results
         results_df
```

Out[17]:

	Number of Samples	Categorical Accuracy	Std Deviation
0	300	95.013889	2.092157
1	200	95.194444	1.357705
2	100	95.333333	0.368514
3	75	95.027778	2.395501

4	50	95.680556	1.860230
5	25	96.097222	1.643532
6	10	88.402778	10.279232