ASU Arizona State University

# CSE 575: Statistical Machine Learning

## Project Part 3 – Classification Using Neural Networks and Deep Learning

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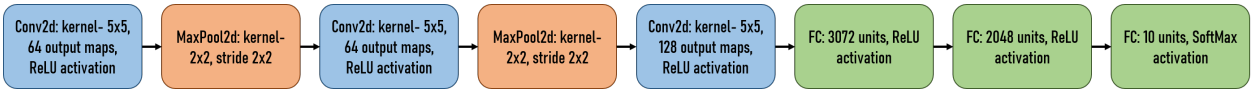
We used the SVHN dataset to build and train a small convolutional neural network for the classification task.

The CNN architecture was followed as:




The output:

```
2022-07-04 16:58:01.509698: I tensorflow/core/platform/cpu_feature_guard.cc:193] This TensorFlow binary is optimized with oneAPI Deep Neural Network Library (oneDNN) to use the following CPU instructions in performance-critical operations
:  AVX2 FMA
To enable them in other operations, rebuild TensorFlow with the appropriate compiler flags.
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 32, 32, 64)        4864

 max_pooling2d (MaxPooling2D  (None, 16, 16, 64)       0
 )

 conv2d_1 (Conv2D)           (None, 16, 16, 64)        102464

 max_pooling2d_1 (MaxPooling  (None, 8, 8, 64)         0
 2D)

 conv2d_2 (Conv2D)           (None, 8, 8, 128)         204928

 flatten (Flatten)           (None, 8192)              0

 dense (Dense)               (None, 3072)              25168896

 dense_1 (Dense)             (None, 2048)              6293504

 dense_2 (Dense)             (None, 10)                20490

=================================================================
Total params: 31,795,146
Trainable params: 31,795,146
Non-trainable params: 0
_________________________________________________________________
Epoch 1/20
2290/2290 [==============================] - 730s 318ms/step - loss: 1.8405 - accuracy: 0.3617 - val_loss: 1.0620 - val_accuracy: 0.6572
Epoch 2/20
2290/2290 [==============================] - 787s 344ms/step - loss: 0.6148 - accuracy: 0.8203 - val_loss: 0.5131 - val_accuracy: 0.8531
Epoch 3/20
2290/2290 [==============================] - 723s 316ms/step - loss: 0.4282 - accuracy: 0.8760 - val_loss: 0.4707 - val_accuracy: 0.8652
Epoch 4/20
2290/2290 [==============================] - 828s 362ms/step - loss: 0.3473 - accuracy: 0.8989 - val_loss: 0.4602 - val_accuracy: 0.8656
Epoch 5/20
2290/2290 [==============================] - 793s 346ms/step - loss: 0.2932 - accuracy: 0.9148 - val_loss: 0.4291 - val_accuracy: 0.8813
Epoch 6/20
2290/2290 [==============================] - 789s 344ms/step - loss: 0.2479 - accuracy: 0.9281 - val_loss: 0.3696 - val_accuracy: 0.8955
Epoch 7/20
2290/2290 [==============================] - 784s 342ms/step - loss: 0.2097 - accuracy: 0.9396 - val_loss: 0.4201 - val_accuracy: 0.8831
Epoch 8/20
2290/2290 [==============================] - 779s 340ms/step - loss: 0.1756 - accuracy: 0.9495 - val_loss: 0.3646 - val_accuracy: 0.9025
Epoch 9/20
2290/2290 [==============================] - 808s 353ms/step - loss: 0.1436 - accuracy: 0.9592 - val_loss: 0.3803 - val_accuracy: 0.8963
Epoch 10/20
2290/2290 [==============================] - 694s 303ms/step - loss: 0.1140 - accuracy: 0.9676 - val_loss: 0.4192 - val_accuracy: 0.8928
Epoch 11/20
2290/2290 [==============================] - 645s 282ms/step - loss: 0.0891 - accuracy: 0.9750 - val_loss: 0.4133 - val_accuracy: 0.9016
Epoch 12/20
2290/2290 [==============================] - 652s 285ms/step - loss: 0.0659 - accuracy: 0.9819 - val_loss: 0.4666 - val_accuracy: 0.8987
Epoch 13/20
2290/2290 [==============================] - 636s 278ms/step - loss: 0.0489 - accuracy: 0.9862 - val_loss: 0.4772 - val_accuracy: 0.9037
Epoch 14/20
2290/2290 [==============================] - 778s 340ms/step - loss: 0.0323 - accuracy: 0.9921 - val_loss: 0.5034 - val_accuracy: 0.9010
Epoch 15/20
2290/2290 [==============================] - 786s 343ms/step - loss: 0.0227 - accuracy: 0.9947 - val_loss: 0.5174 - val_accuracy: 0.9062
Epoch 16/20
2290/2290 [==============================] - 646s 282ms/step - loss: 0.0158 - accuracy: 0.9965 - val_loss: 0.5559 - val_accuracy: 0.9008
Epoch 17/20
2290/2290 [==============================] - 635s 277ms/step - loss: 0.0104 - accuracy: 0.9981 - val_loss: 0.5719 - val_accuracy: 0.9051
Epoch 18/20
2290/2290 [==============================] - 670s 292ms/step - loss: 0.0087 - accuracy: 0.9981 - val_loss: 0.5747 - val_accuracy: 0.9015
Epoch 19/20
2290/2290 [==============================] - 646s 282ms/step - loss: 0.0073 - accuracy: 0.9989 - val_loss: 0.6071 - val_accuracy: 0.8973
Epoch 20/20
2290/2290 [==============================] - 645s 282ms/step - loss: 0.0095 - accuracy: 0.9980 - val_loss: 0.6288 - val_accuracy: 0.9068
```

The Graph plot of testing and training curves as a function of the epochs.