exercise_5

November 9, 2025

1 Exercise-5: Deeper CNN Training on SVHN

Train a controlled deep convolutional neural network (CNN) on a subset of the SVHN dataset. Set random seeds to 42. Load and preprocess SVHN. Build the network using the following configuration:

Data Preparation - Load SVHN and normalize pixel values to [0, 1] - Use only the first 2000 training samples and first 500 test samples - Input shape: 32 × 32 × 3

CNN Architecture - Conv2D: 32 filters, 3×3 kernel, ReLU activation - Conv2D: 32 filters, 3×3 kernel, ReLU activation - MaxPooling2D: 2×2 - Conv2D: 64 filters, 3×3 kernel, ReLU activation - Conv2D: 64 filters, 3×3 kernel, ReLU activation - MaxPooling2D: 2×2 - Flatten - Dense: 256 neurons, ReLU activation - Dropout: 0.3 - Output layer: 10 neurons with softmax activation

Training Configuration - Optimizer: Adam, with learning rate = 0.001 - Loss: sparse_categorical_crossentropy - Epochs: 15 - Batch size: 32

1.1 Data Preparation

1.1.1 The Street View House Numbers (SVHN) Dataset

- Contains over 600,000 labeled digits from real-world images
- 10 classes (digits 0-9), 0 has label 10 from tensorflow.keras.datasets import svhn

[29]:

```
# load SVHN dataset
import numpy as np
import tensorflow as tf
import tensorflow_datasets as tfds

# Set random seeds for reproducibility
np.random.seed(42)
tf.random.set_seed(42)

# Construct a tf.data.Dataset, load only the first 2000 training and 500 test␣
 ↪examples
ds_train, info = tfds.load('svhn_cropped', split='train[:2000]',␣
 ↪as_supervised=True, with_info=True)
# Check the number of examples in the training dataset
print("Number of training examples:", ds_train.cardinality().numpy())
print(info)
```

```python
ds_test = tfds.load('svhn_cropped', split='test[:500]', as_supervised=True)
print("Number of test examples:", ds_test.cardinality().numpy())
# print the class names
print("Class names:", info.features['label'].names)

# Display some examples from the dataset
tfds.show_examples(ds_train, info, rows=3, cols=3);

def preprocess(image, label):
    image = tf.cast(image, tf.float32) / 255.0  # Normalize to [0, 1]
    return image, label
ds_train = ds_train.map(preprocess).batch(32).prefetch(tf.data.AUTOTUNE)
ds_test = ds_test.map(preprocess).batch(32).prefetch(tf.data.AUTOTUNE)

# Build the CNN model
model = tf.keras.Sequential([
    tf.keras.layers.Input(shape=(32, 32, 3)),
    tf.keras.layers.Conv2D(32, (3, 3), activation='relu'),
    tf.keras.layers.Conv2D(32, (3, 3), activation='relu'),
    tf.keras.layers.MaxPooling2D((2, 2)),
    tf.keras.layers.Conv2D(64, (3, 3), activation='relu'),
    tf.keras.layers.Conv2D(64, (3, 3), activation='relu'),
    tf.keras.layers.MaxPooling2D((2, 2)),
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(256, activation='relu'),
    tf.keras.layers.Dropout(0.3),
    tf.keras.layers.Dense(10, activation='softmax')]
)

# Compile the model
model.compile(optimizer='adam',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

# early stopping callback
early_stopping = tf.keras.callbacks.EarlyStopping(monitor='val_loss',␣
 ↪patience=5, restore_best_weights=True)

# Train the model
history = model.fit(ds_train, epochs=15,batch_size=32, validation_data=ds_test,␣
 ↪callbacks=[early_stopping])

# Evaluate the model
test_loss, test_accuracy = model.evaluate(ds_test)
print(f'Test accuracy: {test_accuracy:.4f}')
```

```
Number of training examples: 2000
```

```
tfds.core.DatasetInfo(
    name='svhn_cropped',
    full_name='svhn_cropped/3.1.0',
    description="""
    The Street View House Numbers (SVHN) Dataset is an image digit recognition
    dataset of over 600,000 digit images coming from real world data. Images are
    cropped to 32x32.
    """,
    homepage='http://ufldl.stanford.edu/housenumbers/',
    data_dir='/Users/arthurborgerthorkildsen/tensorflow_datasets/svhn_cropped/3.
1.0',
    file_format=tfrecord,
    download_size=1.47 GiB,
    dataset_size=1.09 GiB,
    features=FeaturesDict({
        'id': Text(shape=(), dtype=string),
        'image': Image(shape=(32, 32, 3), dtype=uint8),
        'label': ClassLabel(shape=(), dtype=int64, num_classes=10),
    }),
    supervised_keys=('image', 'label'),
    disable_shuffling=False,
    nondeterministic_order=False,
    splits={
        'extra': <SplitInfo num_examples=531131, num_shards=8>,
        'test': <SplitInfo num_examples=26032, num_shards=1>,
        'train': <SplitInfo num_examples=73257, num_shards=1>,
    },
    citation=""""""Street View House Numbers (SVHN) Dataset, cropped version."""

    @article{Netzer2011,
    author = {Netzer, Yuval and Wang, Tao and Coates, Adam and Bissacco,
Alessandro and Wu, Bo and Ng, Andrew Y},
    booktitle = {Advances in Neural Information Processing Systems ({NIPS})},
    title = {Reading Digits in Natural Images with Unsupervised Feature
Learning},
    year = {2011}
    }""",
)
Number of test examples: 500
Class names: ['0', '1', '2', '3', '4', '5', '6', '7', '8', '9']
```

4 (4) 8 (8) 7 (7)

2 (2) 6 (6) 3 (3)

0 (0) 8 (8) 5 (5)

```
Epoch 1/15
63/63            2s 18ms/step -
accuracy: 0.1865 - loss: 2.2650 - val_accuracy: 0.1840 - val_loss: 2.2519
Epoch 2/15
63/63            1s 16ms/step -
accuracy: 0.1955 - loss: 2.2457 - val_accuracy: 0.1840 - val_loss: 2.2439
Epoch 3/15
63/63            1s 17ms/step -
accuracy: 0.2375 - loss: 2.1446 - val_accuracy: 0.3200 - val_loss: 1.9490
Epoch 4/15
63/63            1s 17ms/step -
accuracy: 0.4325 - loss: 1.6924 - val_accuracy: 0.4860 - val_loss: 1.5737
Epoch 5/15
```

```
63/63              1s 17ms/step -
accuracy: 0.6280 - loss: 1.1726 - val_accuracy: 0.6640 - val_loss: 1.1407
Epoch 6/15
63/63              1s 17ms/step -
accuracy: 0.7160 - loss: 0.8877 - val_accuracy: 0.7140 - val_loss: 0.9804
Epoch 7/15
63/63              1s 17ms/step -
accuracy: 0.7625 - loss: 0.7431 - val_accuracy: 0.7200 - val_loss: 0.9261
Epoch 8/15
63/63              1s 17ms/step -
accuracy: 0.7905 - loss: 0.6275 - val_accuracy: 0.7040 - val_loss: 1.0225
Epoch 9/15
63/63              1s 17ms/step -
accuracy: 0.8395 - loss: 0.5266 - val_accuracy: 0.7380 - val_loss: 0.9450
Epoch 10/15
63/63              1s 17ms/step -
accuracy: 0.8400 - loss: 0.4595 - val_accuracy: 0.7440 - val_loss: 1.0717
Epoch 11/15
63/63              1s 17ms/step -
accuracy: 0.8855 - loss: 0.3610 - val_accuracy: 0.7420 - val_loss: 1.1081
Epoch 12/15
63/63              1s 17ms/step -
accuracy: 0.8860 - loss: 0.3451 - val_accuracy: 0.7440 - val_loss: 1.0906
16/16              0s 6ms/step -
accuracy: 0.7200 - loss: 0.9261
Test accuracy: 0.7200
```

[33]:

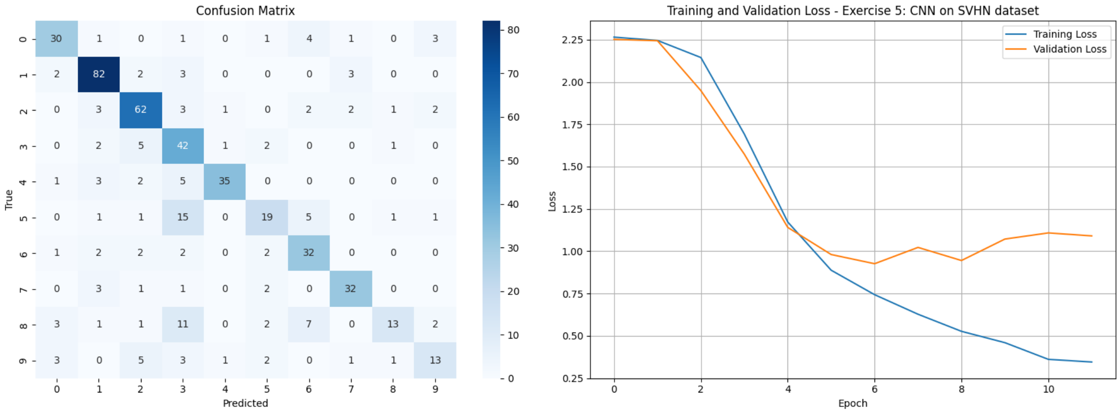
```python
from helper import plot_model_evaluation
import numpy as np

# Extract x_test and y_test as numpy arrays from the dataset
x_test_list = []
y_test_list = []
for images, labels in ds_test:
    x_test_list.append(images.numpy())
    y_test_list.append(labels.numpy())

x_test = np.concatenate(x_test_list, axis=0)
y_test = np.concatenate(y_test_list, axis=0)

plot_model_evaluation(model, x_test, y_test, history, exercise_title='Exercise␣
 ↪5: CNN on SVHN dataset')
```

```
16/16              0s 4ms/step
```


Confusion Matrix
True
Predicted
0 1 2 3 4 5 6 7 8 9
0: 30 1 0 1 0 1 4 1 0 3
1: 2 82 2 3 0 0 0 3 0 0
2: 0 3 62 3 1 0 2 2 1 2
3: 0 2 5 42 1 2 0 0 1 0
4: 1 3 2 5 35 0 0 0 0 0
5: 0 1 1 15 0 19 5 0 1 1
6: 1 2 2 2 0 2 32 0 0 0
7: 0 3 1 1 0 2 0 32 0 0
8: 3 1 1 11 0 2 7 0 13 2
9: 3 0 5 3 1 2 0 1 1 13
80
70
60
50
40
30
20
10
0
Training and Validation Loss - Exercise 5: CNN on SVHN dataset
Training Loss
Validation Loss
Loss
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
Epoch
0
2
4
6
8
10

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