Experiments - Plots and models

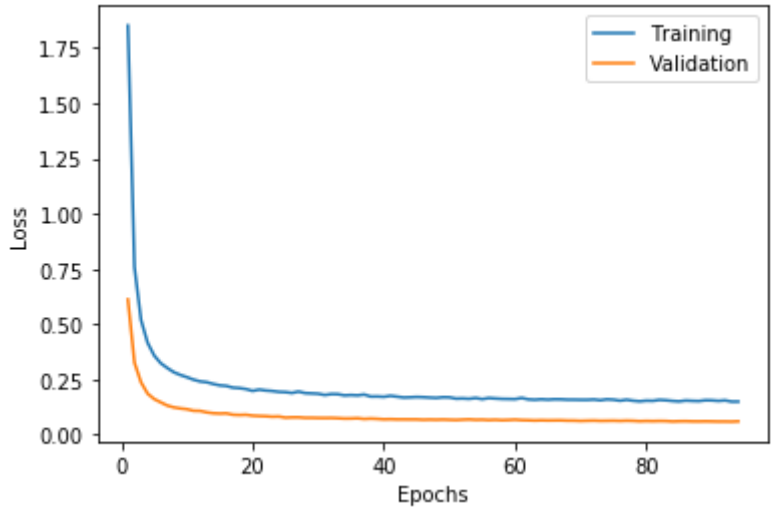
EXP1

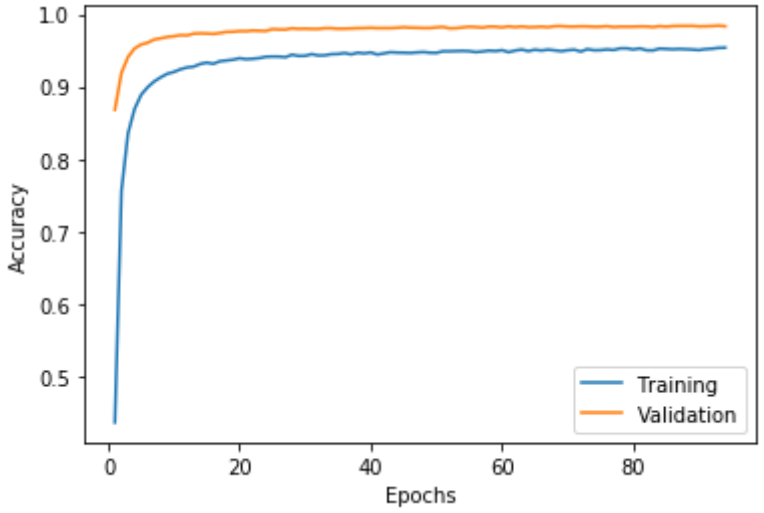
Standardized input

```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_1 (Conv2D)            (None, 26, 26, 4)         40
_________________________________________________________________
activation_1 (Activation)    (None, 26, 26, 4)         0
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 13, 13, 4)         0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 11, 11, 8)         296
_________________________________________________________________
activation_2 (Activation)    (None, 11, 11, 8)         0
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 5, 5, 8)           0
_________________________________________________________________
flatten_1 (Flatten)          (None, 200)               0
_________________________________________________________________
dropout_1 (Dropout)          (None, 200)               0
_________________________________________________________________
dense_1 (Dense)              (None, 10)                2010
=================================================================
Total params: 2,346
Trainable params: 2,346
Non-trainable params: 0
Dropout: 0.3

Epoch 94/100
48000/48000 [==============================] - 2s 32us/step - loss:
0.1500 - acc: 0.9537 - val_loss: 0.0607 - val_acc: 0.9833
```

	precision	recall	f1-score	support
0	0.99	0.99	0.99	1189
1	0.99	0.99	0.99	1372
2	0.97	0.97	0.97	1146
3	0.99	0.98	0.98	1235
4	0.98	0.98	0.98	1185
5	0.98	0.98	0.98	1107
6	0.98	0.99	0.99	1191
7	0.97	0.98	0.97	1212

```
           8       0.97      0.97      0.97      1160
           9       0.97      0.96      0.97      1203

    accuracy                           0.98     12000
   macro avg       0.98      0.98      0.98     12000
weighted avg       0.98      0.98      0.98     12000
```





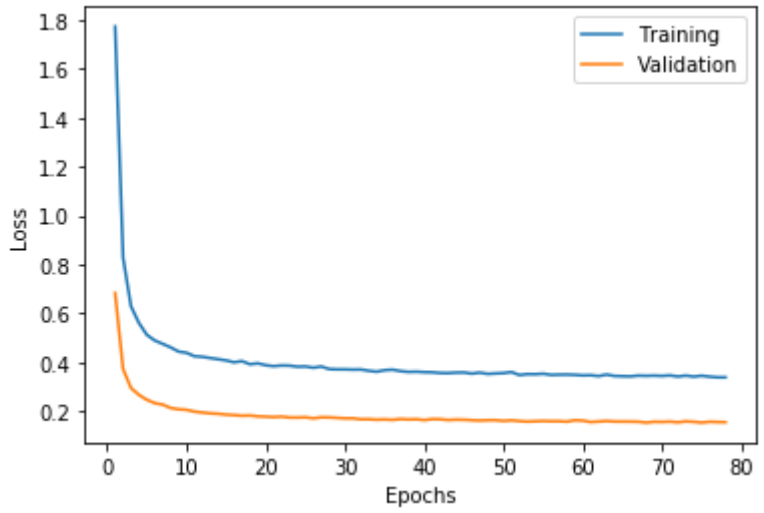
EXP2

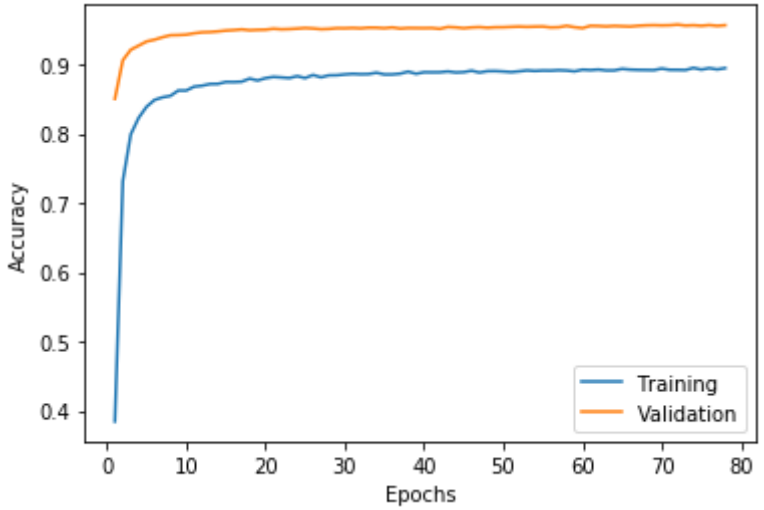
Standardized input

```
Model: "sequential_3"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_5 (Conv2D)            (None, 26, 26, 2)         20
_________________________________________________________________
activation_5 (Activation)    (None, 26, 26, 2)         0
_________________________________________________________________
```

```
max_pooling2d_5 (MaxPooling2 (None, 13, 13, 2)         0
_________________________________________________________________
conv2d_6 (Conv2D)            (None, 11, 11, 4)         76
_________________________________________________________________
activation_6 (Activation)    (None, 11, 11, 4)         0
_________________________________________________________________
max_pooling2d_6 (MaxPooling2 (None, 5, 5, 4)           0
_________________________________________________________________
flatten_3 (Flatten)          (None, 100)               0
_________________________________________________________________
dropout_3 (Dropout)          (None, 100)               0
_________________________________________________________________
dense_3 (Dense)              (None, 10)                1010
=================================================================
Total params: 1,106
Trainable params: 1,106
Non-trainable params: 0
Dropout: 0.3

Epoch 78/100
48000/48000 [==============================] - 1s 30us/step - loss:
0.3387 - acc: 0.8945 - val_loss: 0.1551 - val_acc: 0.9563
```

	precision	recall	f1-score	support
0	0.97	0.98	0.98	1189
1	0.97	0.97	0.97	1372
2	0.94	0.96	0.95	1146
3	0.97	0.94	0.96	1235
4	0.96	0.96	0.96	1185
5	0.96	0.98	0.97	1107
6	0.98	0.97	0.98	1191
7	0.95	0.94	0.95	1212
8	0.93	0.92	0.92	1160
9	0.93	0.94	0.93	1203
accuracy			0.96	12000
macro avg	0.96	0.96	0.96	12000
weighted avg	0.96	0.96	0.96	12000





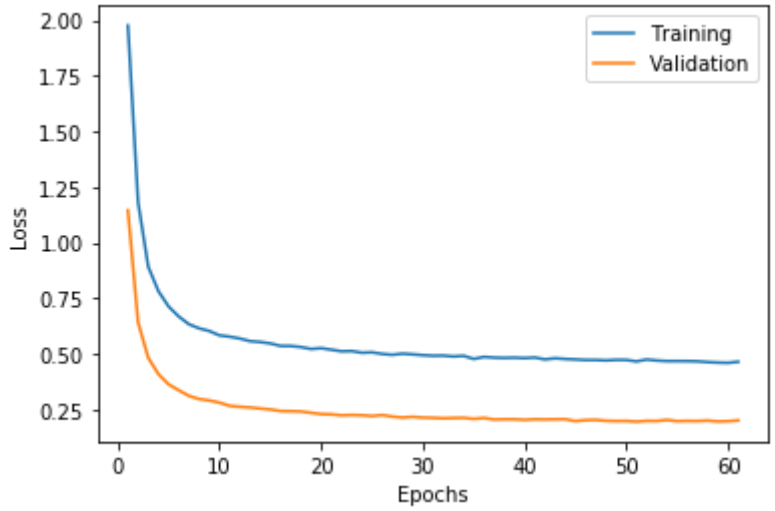
EXP3

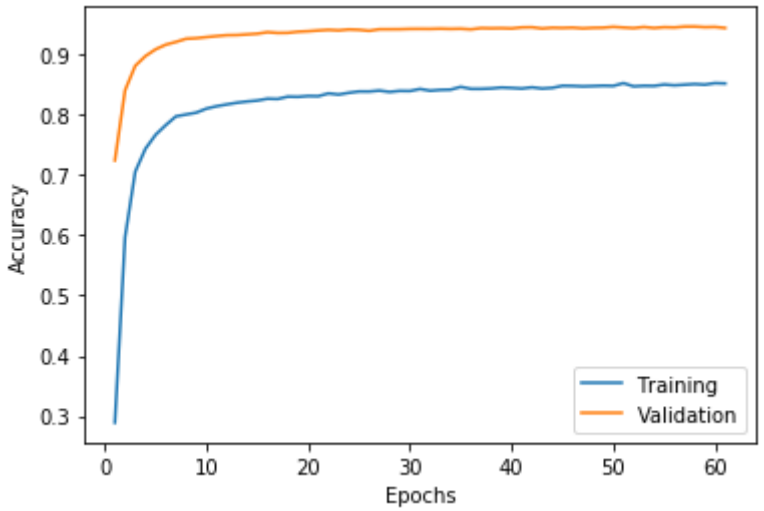
Standardized input

```
Model: "sequential_12"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_28 (Conv2D)           (None, 13, 13, 4)         40
_________________________________________________________________
activation_28 (Activation)   (None, 13, 13, 4)         0
_________________________________________________________________
conv2d_29 (Conv2D)           (None, 6, 6, 8)           296
_________________________________________________________________
activation_29 (Activation)   (None, 6, 6, 8)           0
_________________________________________________________________
max_pooling2d_12 (MaxPooling (None, 3, 3, 8)           0
_________________________________________________________________
flatten_11 (Flatten)         (None, 72)                0
```

```
_________________________________________________________________
dropout_11 (Dropout)         (None, 72)                0
_________________________________________________________________
dense_14 (Dense)             (None, 10)                730
=================================================================
Total params: 1,066
Trainable params: 1,066
Non-trainable params: 0
Dropout: 0.3

Epoch 61/100
48000/48000 [==============================] - 1s 27us/step - loss:
0.4649 - acc: 0.8512 - val_loss: 0.2013 - val_acc: 0.9432
```

	precision	recall	f1-score	support
0	0.96	0.97	0.97	1189
1	0.96	0.97	0.97	1372
2	0.95	0.93	0.94	1146
3	0.94	0.94	0.94	1235
4	0.94	0.95	0.95	1185
5	0.94	0.94	0.94	1107
6	0.97	0.96	0.96	1191
7	0.96	0.95	0.95	1212
8	0.91	0.89	0.90	1160
9	0.91	0.93	0.92	1203
accuracy			0.94	12000
macro avg	0.94	0.94	0.94	12000
weighted avg	0.94	0.94	0.94	12000





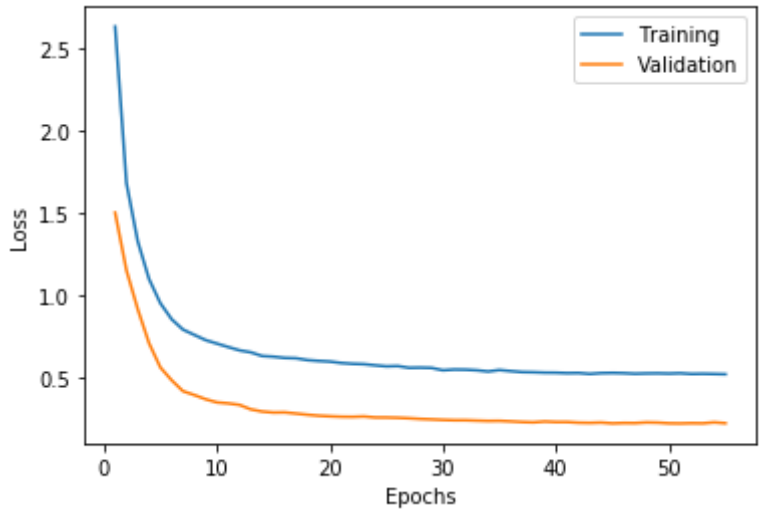
EXP4

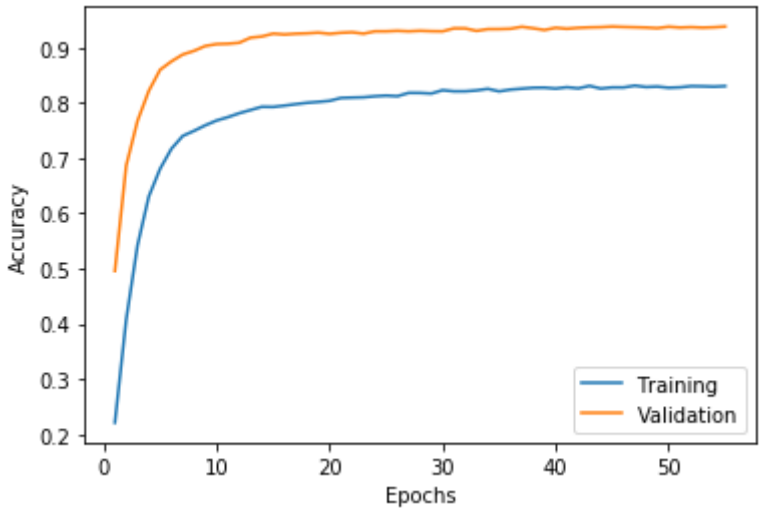
Standardized input

```
Model: "sequential_14"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_32 (Conv2D)           (None, 13, 13, 8)         80
_________________________________________________________________
activation_32 (Activation)   (None, 13, 13, 8)         0
_________________________________________________________________
batch_normalization_1 (Batch (None, 13, 13, 8)         32
_________________________________________________________________
conv2d_33 (Conv2D)           (None, 6, 6, 4)           292
_________________________________________________________________
activation_33 (Activation)   (None, 6, 6, 4)           0
_________________________________________________________________
batch_normalization_2 (Batch (None, 6, 6, 4)           16
_________________________________________________________________
max_pooling2d_14 (MaxPooling (None, 3, 3, 4)           0
_________________________________________________________________
flatten_13 (Flatten)         (None, 36)                0
_________________________________________________________________
dropout_13 (Dropout)         (None, 36)                0
_________________________________________________________________
dense_16 (Dense)             (None, 10)                370
=================================================================
Total params: 790
Trainable params: 766
Non-trainable params: 24
Dropout: 0.3
```

```
Epoch 55/100
48000/48000 [==============================] - 2s 35us/step - loss:
0.5175 - acc: 0.8302 - val_loss: 0.2187 - val_acc: 0.9381
```

	precision	recall	f1-score	support
0	0.96	0.97	0.97	1189
1	0.97	0.97	0.97	1372
2	0.93	0.92	0.93	1146
3	0.94	0.93	0.94	1235
4	0.95	0.96	0.95	1185
5	0.92	0.95	0.93	1107
6	0.95	0.98	0.96	1191
7	0.96	0.90	0.93	1212
8	0.89	0.89	0.89	1160
9	0.89	0.92	0.91	1203
accuracy			0.94	12000
macro avg	0.94	0.94	0.94	12000
weighted avg	0.94	0.94	0.94	12000



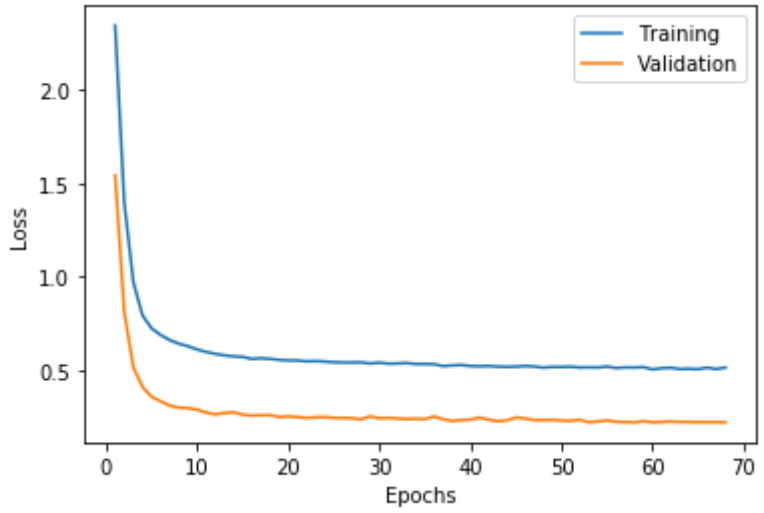


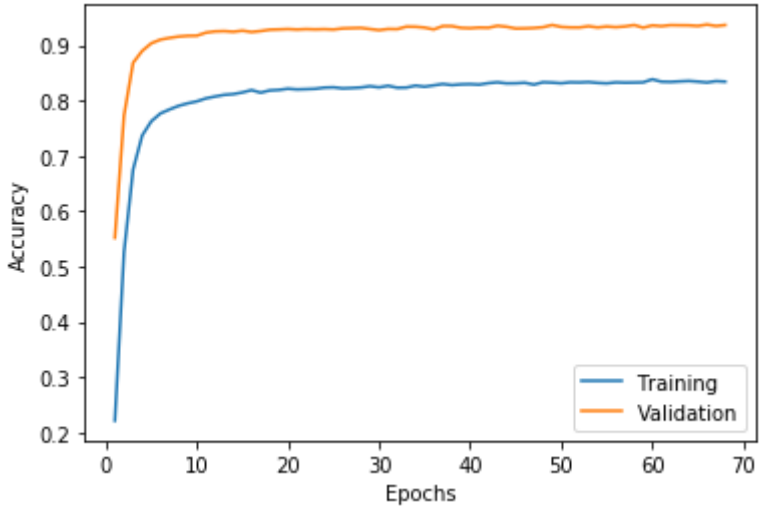
EXP5

Standardized input

```
Model: "sequential_17"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_39 (Conv2D)           (None, 13, 13, 16)        160
_________________________________________________________________
activation_37 (Activation)   (None, 13, 13, 16)        0
_________________________________________________________________
batch_normalization_7 (Batch (None, 13, 13, 16)        64
_________________________________________________________________
conv2d_40 (Conv2D)           (None, 6, 6, 4)           580
_________________________________________________________________
max_pooling2d_17 (MaxPooling (None, 3, 3, 4)           0
_________________________________________________________________
flatten_16 (Flatten)         (None, 36)                0
_________________________________________________________________
dropout_16 (Dropout)         (None, 36)                0
_________________________________________________________________
dense_19 (Dense)             (None, 10)                370
=================================================================
Total params: 1,174
Trainable params: 1,142
Non-trainable params: 32

Epoch 68/100
48000/48000 [==============================] - 2s 35us/step - loss:
0.5120 - acc: 0.8341 - val_loss: 0.2178 - val_acc: 0.9363

              precision    recall  f1-score   support
```

0	0.95	0.97	0.96	1189
1	0.97	0.98	0.97	1372
2	0.94	0.92	0.93	1146
3	0.90	0.95	0.93	1235
4	0.95	0.94	0.95	1185
5	0.93	0.93	0.93	1107
6	0.95	0.96	0.95	1191
7	0.96	0.92	0.94	1212
8	0.94	0.86	0.90	1160
9	0.88	0.93	0.91	1203
accuracy			0.94	12000
macro avg	0.94	0.94	0.94	12000
weighted avg	0.94	0.94	0.94	12000





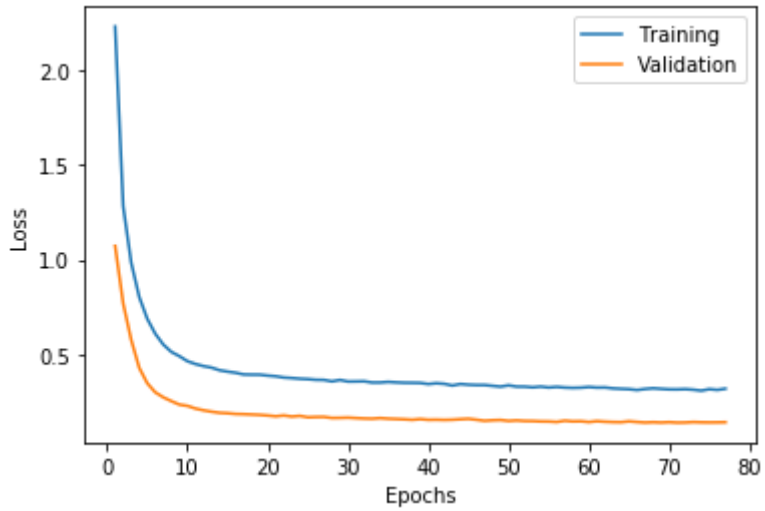
EXP6

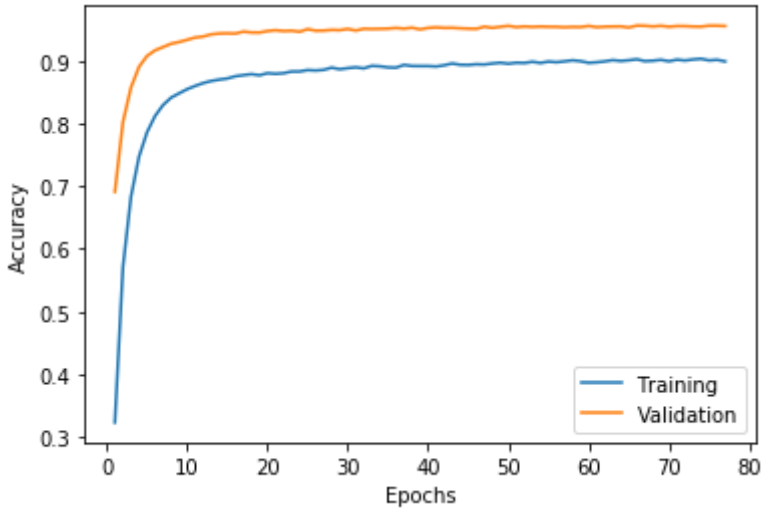
Standardized input

```
Model: "sequential_22"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_53 (Conv2D)           (None, 13, 13, 4)         40
_________________________________________________________________
activation_48 (Activation)   (None, 13, 13, 4)         0
_________________________________________________________________
batch_normalization_16 (Batc (None, 13, 13, 4)         16
_________________________________________________________________
conv2d_54 (Conv2D)           (None, 6, 6, 8)           296
_________________________________________________________________
activation_49 (Activation)   (None, 6, 6, 8)           0
_________________________________________________________________
batch_normalization_17 (Batc (None, 6, 6, 8)           32
_________________________________________________________________
conv2d_55 (Conv2D)           (None, 2, 2, 16)          1168
_________________________________________________________________
activation_50 (Activation)   (None, 2, 2, 16)          0
_________________________________________________________________
batch_normalization_18 (Batc (None, 2, 2, 16)          64
_________________________________________________________________
max_pooling2d_21 (MaxPooling (None, 1, 1, 16)          0
_________________________________________________________________
flatten_21 (Flatten)         (None, 16)                0
_________________________________________________________________
dropout_21 (Dropout)         (None, 16)                0
_________________________________________________________________
dense_24 (Dense)             (None, 10)                170
=================================================================
Total params: 1,786
Trainable params: 1,730
Non-trainable params: 56
Dropout: 0.3

Epoch 77/100
48000/48000 [==============================] - 2s 42us/step - loss:
0.3185 - acc: 0.8988 - val_loss: 0.1416 - val_acc: 0.9553
```

	precision	recall	f1-score	support
0	0.97	0.98	0.97	1189
1	0.98	0.97	0.97	1372
2	0.93	0.95	0.94	1146
3	0.95	0.95	0.95	1235
4	0.96	0.95	0.96	1185
5	0.97	0.96	0.96	1107

```
              6       0.96      0.96      0.96      1191
              7       0.96      0.96      0.96      1212
              8       0.95      0.94      0.94      1160
              9       0.93      0.94      0.93      1203

       accuracy                           0.96     12000
      macro avg       0.96      0.96      0.96     12000
   weighted avg       0.96      0.96      0.96     12000
```





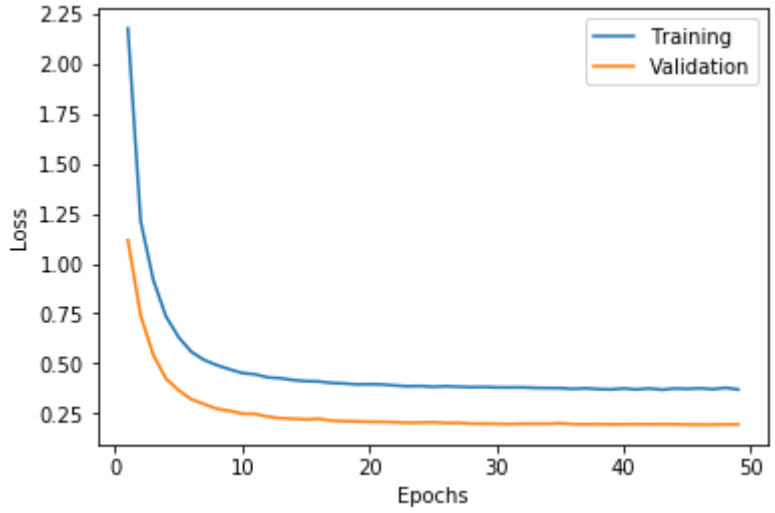
EXP7

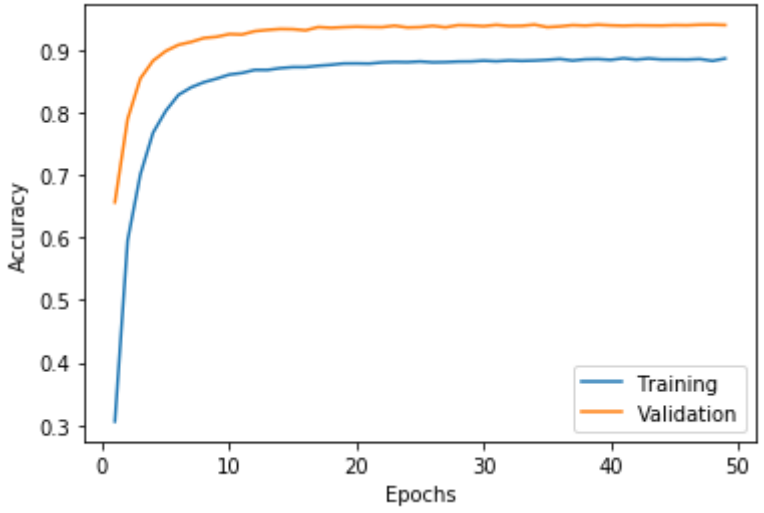
Standardized input

```
Model: "sequential_26"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_65 (Conv2D)           (None, 13, 13, 2)         20
_________________________________________________________________
```

```
activation_60 (Activation)   (None, 13, 13, 2)         0
_________________________________________________________________
batch_normalization_28 (Batc (None, 13, 13, 2)         8
_________________________________________________________________
conv2d_66 (Conv2D)           (None, 6, 6, 4)           76
_________________________________________________________________
activation_61 (Activation)   (None, 6, 6, 4)           0
_________________________________________________________________
batch_normalization_29 (Batc (None, 6, 6, 4)           16
_________________________________________________________________
conv2d_67 (Conv2D)           (None, 2, 2, 8)           296
_________________________________________________________________
activation_62 (Activation)   (None, 2, 2, 8)           0
_________________________________________________________________
batch_normalization_30 (Batc (None, 2, 2, 8)           32
_________________________________________________________________
flatten_25 (Flatten)         (None, 32)                0
_________________________________________________________________
dropout_25 (Dropout)         (None, 32)                0
_________________________________________________________________
dense_28 (Dense)             (None, 10)                330
=================================================================
Total params: 778
Trainable params: 750
Non-trainable params: 28

Epoch 49/100
48000/48000 [==============================] - 2s 41us/step - loss:
0.3696 - acc: 0.8858 - val_loss: 0.1947 - val_acc: 0.9393
```

	precision	recall	f1-score	support
0	0.97	0.98	0.97	1189
1	0.95	0.98	0.97	1372
2	0.92	0.92	0.92	1146
3	0.95	0.91	0.93	1235
4	0.94	0.95	0.95	1185
5	0.93	0.94	0.93	1107
6	0.95	0.96	0.96	1191
7	0.95	0.93	0.94	1212
8	0.91	0.91	0.91	1160
9	0.92	0.91	0.92	1203
accuracy			0.94	12000
macro avg	0.94	0.94	0.94	12000
weighted avg	0.94	0.94	0.94	12000





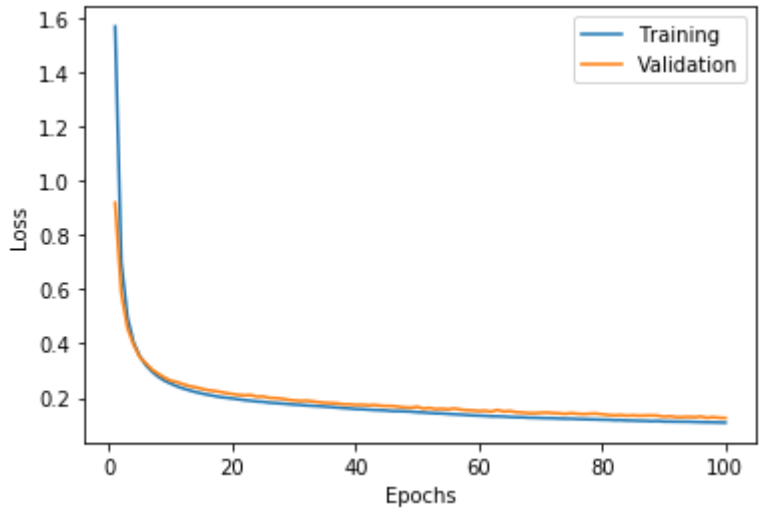
EXP8

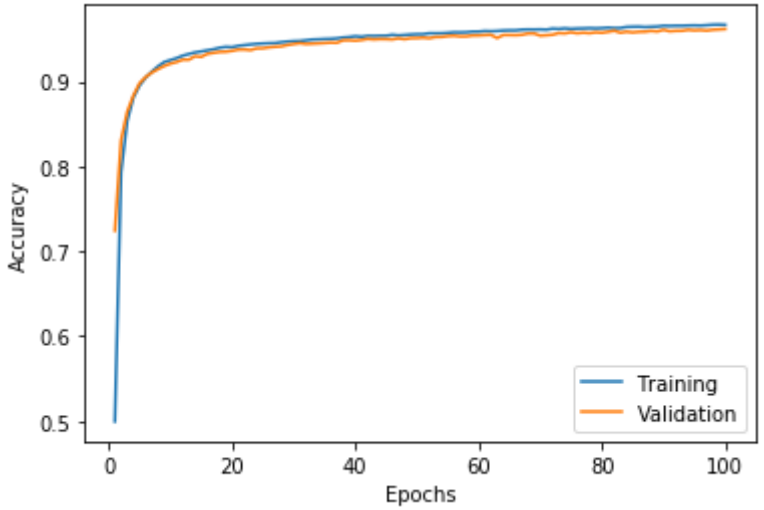
Standardized input

```
Model: "sequential_27"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_68 (Conv2D)           (None, 13, 13, 2)         20
_________________________________________________________________
activation_63 (Activation)   (None, 13, 13, 2)         0
_________________________________________________________________
batch_normalization_31 (Batc (None, 13, 13, 2)         8
_________________________________________________________________
conv2d_69 (Conv2D)           (None, 6, 6, 4)           76
_________________________________________________________________
activation_64 (Activation)   (None, 6, 6, 4)           0
_________________________________________________________________
batch_normalization_32 (Batc (None, 6, 6, 4)           16
```

```
_________________________________________________________________
conv2d_70 (Conv2D)           (None, 2, 2, 8)           296
_________________________________________________________________
activation_65 (Activation)   (None, 2, 2, 8)           0
_________________________________________________________________
batch_normalization_33 (Batc (None, 2, 2, 8)           32
_________________________________________________________________
flatten_26 (Flatten)         (None, 32)                0
_________________________________________________________________
dense_29 (Dense)             (None, 10)                330
=================================================================
Total params: 778
Trainable params: 750
Non-trainable params: 28

Epoch 100/100
48000/48000 [==============================] - 2s 41us/step - loss:
0.1089 - acc: 0.9665 - val_loss: 0.1260 - val_acc: 0.9616
```

	precision	recall	f1-score	support
0	0.98	0.98	0.98	1189
1	0.98	0.98	0.98	1372
2	0.96	0.95	0.96	1146
3	0.96	0.95	0.95	1235
4	0.96	0.96	0.96	1185
5	0.96	0.96	0.96	1107
6	0.96	0.98	0.97	1191
7	0.96	0.96	0.96	1212
8	0.95	0.94	0.95	1160
9	0.94	0.95	0.95	1203
accuracy			0.96	12000
macro avg	0.96	0.96	0.96	12000
weighted avg	0.96	0.96	0.96	12000





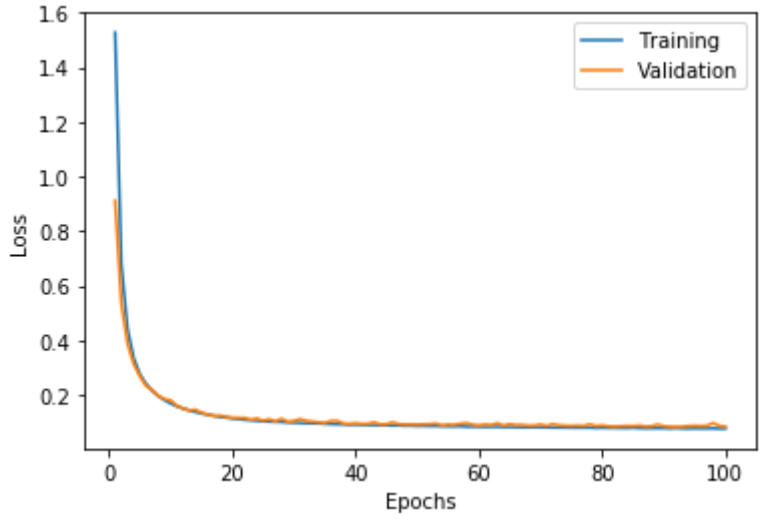
EXP9

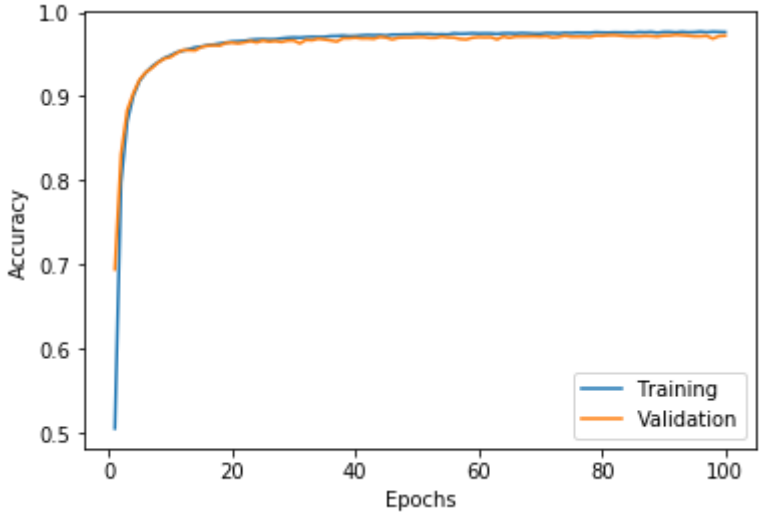
Standardized input

```
Model: "sequential_32"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_84 (Conv2D)           (None, 13, 13, 8)         80
_________________________________________________________________
activation_79 (Activation)   (None, 13, 13, 8)         0
_________________________________________________________________
batch_normalization_45 (Batc (None, 13, 13, 8)         32
_________________________________________________________________
conv2d_85 (Conv2D)           (None, 6, 6, 4)           292
_________________________________________________________________
activation_80 (Activation)   (None, 6, 6, 4)           0
_________________________________________________________________
batch_normalization_46 (Batc (None, 6, 6, 4)           16
```

```
_________________________________________________________________
conv2d_86 (Conv2D)           (None, 4, 4, 2)           74
_________________________________________________________________
activation_81 (Activation)   (None, 4, 4, 2)           0
_________________________________________________________________
batch_normalization_47 (Batc (None, 4, 4, 2)           8
_________________________________________________________________
flatten_31 (Flatten)         (None, 32)                0
_________________________________________________________________
dense_34 (Dense)             (None, 10)                330
=================================================================
Total params: 832
Trainable params: 804
Non-trainable params: 28

Epoch 100/100
48000/48000 [==============================] - 2s 42us/step - loss:
0.0764 - acc: 0.9764 - val_loss: 0.0836 - val_acc: 0.9721
```

	precision	recall	f1-score	support
0	0.98	0.98	0.98	1189
1	0.98	0.99	0.98	1372
2	0.96	0.97	0.96	1146
3	0.97	0.97	0.97	1235
4	0.98	0.97	0.97	1185
5	0.97	0.98	0.98	1107
6	0.98	0.99	0.98	1191
7	0.96	0.97	0.97	1212
8	0.98	0.95	0.96	1160
9	0.96	0.96	0.96	1203
accuracy			0.97	12000
macro avg	0.97	0.97	0.97	12000
weighted avg	0.97	0.97	0.97	12000





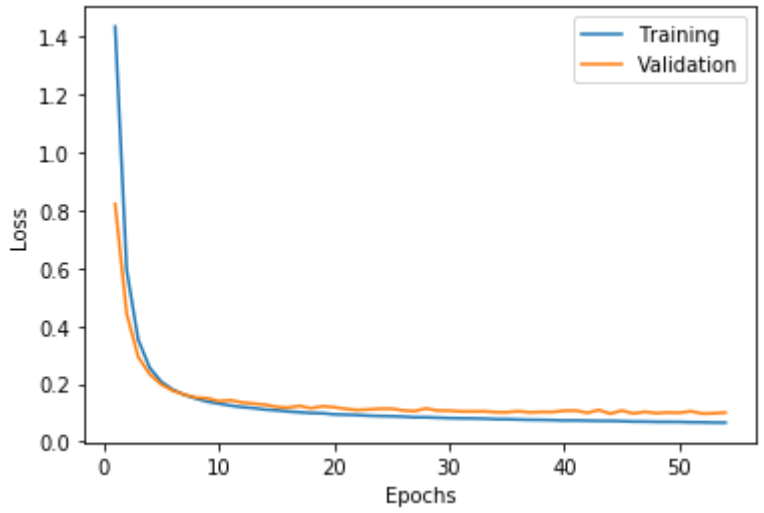
EXP10

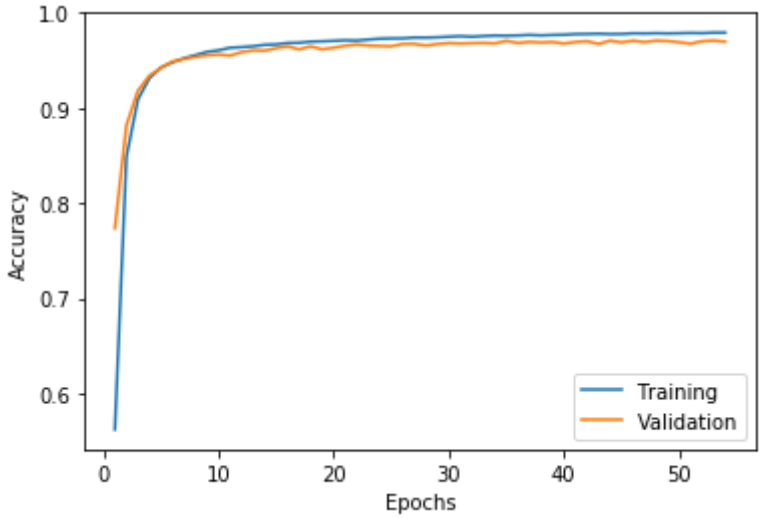
Standardized input

```
Model: "sequential_35"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_93 (Conv2D)           (None, 13, 13, 16)        160
_________________________________________________________________
activation_88 (Activation)   (None, 13, 13, 16)        0
_________________________________________________________________
batch_normalization_54 (Batc (None, 13, 13, 16)        64
_________________________________________________________________
conv2d_94 (Conv2D)           (None, 6, 6, 8)           1160
_________________________________________________________________
activation_89 (Activation)   (None, 6, 6, 8)           0
_________________________________________________________________
```

```
batch_normalization_55 (Batc (None, 6, 6, 8)           32
_________________________________________________________________
conv2d_95 (Conv2D)           (None, 2, 2, 4)           292
_________________________________________________________________
activation_90 (Activation)   (None, 2, 2, 4)           0
_________________________________________________________________
batch_normalization_56 (Batc (None, 2, 2, 4)           16
_________________________________________________________________
flatten_34 (Flatten)         (None, 16)                0
_________________________________________________________________
dense_37 (Dense)             (None, 10)                170
=================================================================
Total params: 1,894
Trainable params: 1,838
Non-trainable params: 56

Epoch 54/100
48000/48000 [==============================] - 2s 45us/step - loss:
0.0661 - acc: 0.9792 - val_loss: 0.1008 - val_acc: 0.9698
```

	precision	recall	f1-score	support
0	0.98	0.98	0.98	1189
1	0.99	0.99	0.99	1372
2	0.95	0.97	0.96	1146
3	0.98	0.96	0.97	1235
4	0.97	0.96	0.97	1185
5	0.96	0.98	0.97	1107
6	0.97	0.98	0.98	1191
7	0.96	0.97	0.96	1212
8	0.97	0.95	0.96	1160
9	0.96	0.96	0.96	1203
accuracy			0.97	12000
macro avg	0.97	0.97	0.97	12000
weighted avg	0.97	0.97	0.97	12000





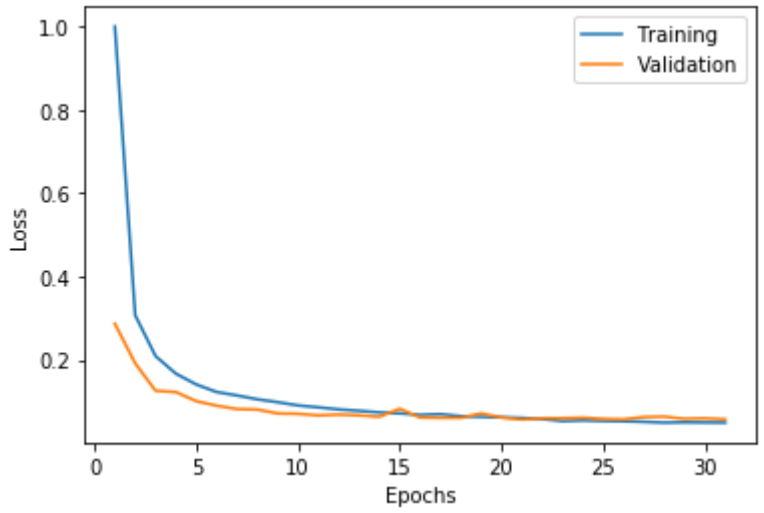
EXP11

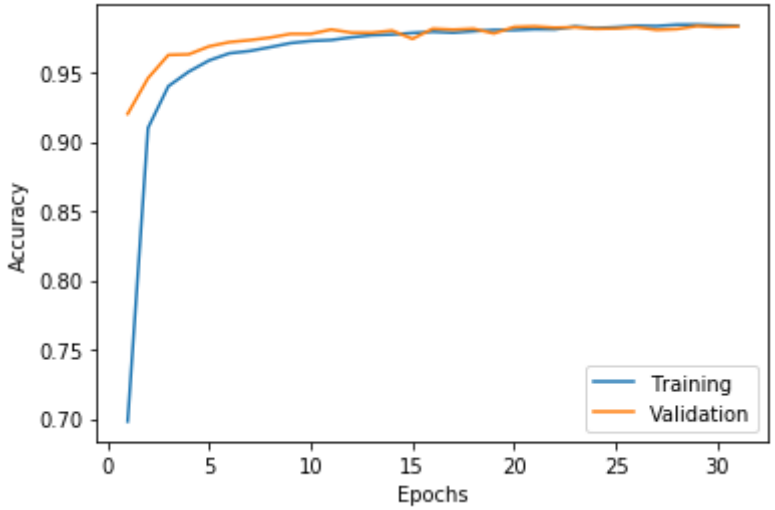
Un-standardized input

```
Model: "sequential_20"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_56 (Conv2D)           (None, 26, 26, 8)         80
_________________________________________________________________
activation_56 (Activation)   (None, 26, 26, 8)         0
_________________________________________________________________
batch_normalization_56 (Batc (None, 26, 26, 8)         32
_________________________________________________________________
max_pooling2d_8 (MaxPooling2 (None, 13, 13, 8)         0
_________________________________________________________________
conv2d_57 (Conv2D)           (None, 11, 11, 16)        1168
_________________________________________________________________
activation_57 (Activation)   (None, 11, 11, 16)        0
```

```
_________________________________________________________________
batch_normalization_57 (Batc (None, 11, 11, 16)        64
_________________________________________________________________
max_pooling2d_9 (MaxPooling2 (None, 5, 5, 16)          0
_________________________________________________________________
conv2d_58 (Conv2D)           (None, 3, 3, 32)          4640
_________________________________________________________________
activation_58 (Activation)   (None, 3, 3, 32)          0
_________________________________________________________________
batch_normalization_58 (Batc (None, 3, 3, 32)          128
_________________________________________________________________
max_pooling2d_10 (MaxPooling (None, 1, 1, 32)          0
_________________________________________________________________
flatten_20 (Flatten)         (None, 32)                0
_________________________________________________________________
dropout_6 (Dropout)          (None, 32)                0
_________________________________________________________________
dense_25 (Dense)             (None, 10)                330
=================================================================
Total params: 6,442
Trainable params: 6,330
Non-trainable params: 112
Dropout: 0.3

Epoch 31/200
48000/48000 [==============================] - 3s 58us/step - loss:
0.0497 - acc: 0.9836 - val_loss: 0.0577 - val_acc: 0.9830
```

	precision	recall	f1-score	support
0	0.99	0.99	0.99	1179
1	0.99	0.99	0.99	1377
2	0.98	0.97	0.98	1234
3	0.98	0.98	0.98	1166
4	0.98	0.99	0.98	1184
5	0.99	0.99	0.99	1085
6	0.98	0.99	0.99	1191
7	0.98	0.97	0.98	1234
8	0.98	0.97	0.98	1143
9	0.98	0.98	0.98	1207
accuracy			0.98	12000
macro avg	0.98	0.98	0.98	12000
weighted avg	0.98	0.98	0.98	12000





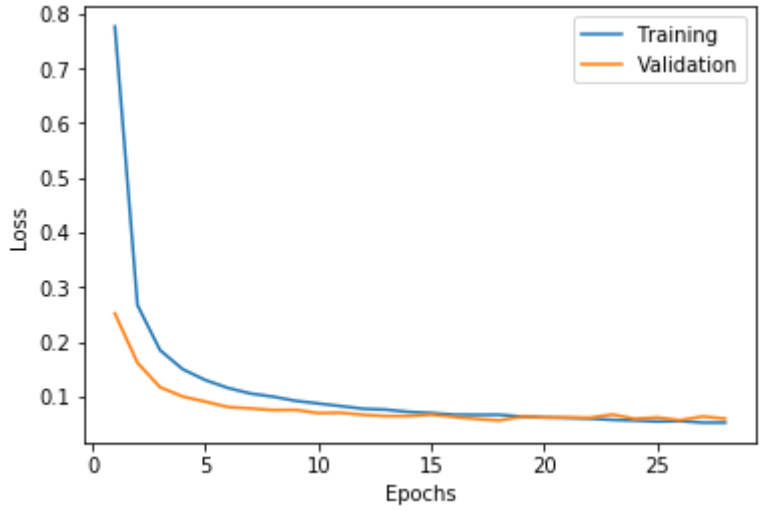
EXP12

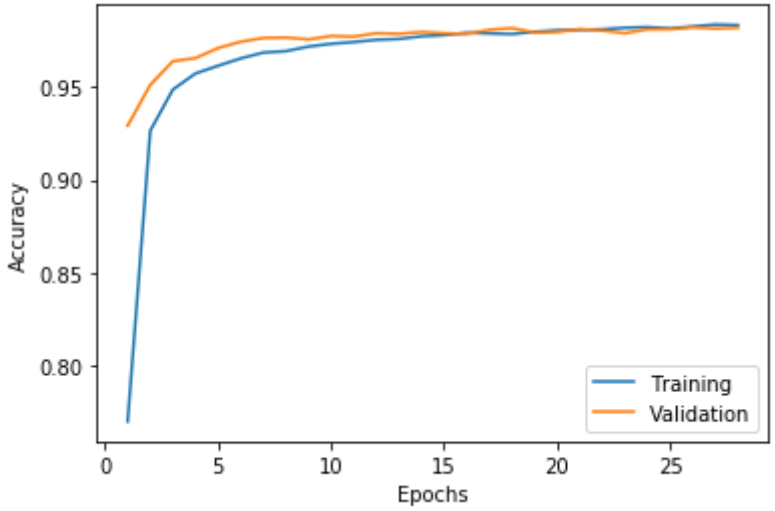
Standardized input

```
Model: "sequential_23"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_65 (Conv2D)           (None, 26, 26, 8)         80
_________________________________________________________________
activation_65 (Activation)   (None, 26, 26, 8)         0
_________________________________________________________________
max_pooling2d_17 (MaxPooling (None, 13, 13, 8)         0
_________________________________________________________________
batch_normalization_65 (Batc (None, 13, 13, 8)         32
_________________________________________________________________
conv2d_66 (Conv2D)           (None, 11, 11, 16)        1168
_________________________________________________________________
activation_66 (Activation)   (None, 11, 11, 16)        0
```

```
_________________________________________________________________
max_pooling2d_18 (MaxPooling (None, 5, 5, 16)          0
_________________________________________________________________
batch_normalization_66 (Batc (None, 5, 5, 16)          64
_________________________________________________________________
conv2d_67 (Conv2D)           (None, 3, 3, 32)          4640
_________________________________________________________________
activation_67 (Activation)   (None, 3, 3, 32)          0
_________________________________________________________________
max_pooling2d_19 (MaxPooling (None, 1, 1, 32)          0
_________________________________________________________________
batch_normalization_67 (Batc (None, 1, 1, 32)          128
_________________________________________________________________
flatten_23 (Flatten)         (None, 32)                0
_________________________________________________________________
dropout_8 (Dropout)          (None, 32)                0
_________________________________________________________________
dense_28 (Dense)             (None, 10)                330
=================================================================
Total params: 6,442
Trainable params: 6,330
Non-trainable params: 112

Epoch 28/200
48000/48000 [==============================] - 3s 60us/step - loss:
0.0527 - acc: 0.9834 - val_loss: 0.0599 - val_acc: 0.9819
```

	precision	recall	f1-score	support
0	0.98	0.99	0.99	1219
1	0.99	0.99	0.99	1342
2	0.97	0.97	0.97	1173
3	0.99	0.98	0.98	1281
4	0.98	0.98	0.98	1150
5	0.98	0.98	0.98	1092
6	0.99	0.98	0.99	1186
7	0.98	0.98	0.98	1223
8	0.98	0.98	0.98	1155
9	0.98	0.98	0.98	1179
accuracy			0.98	12000
macro avg	0.98	0.98	0.98	12000
weighted avg	0.98	0.98	0.98	12000





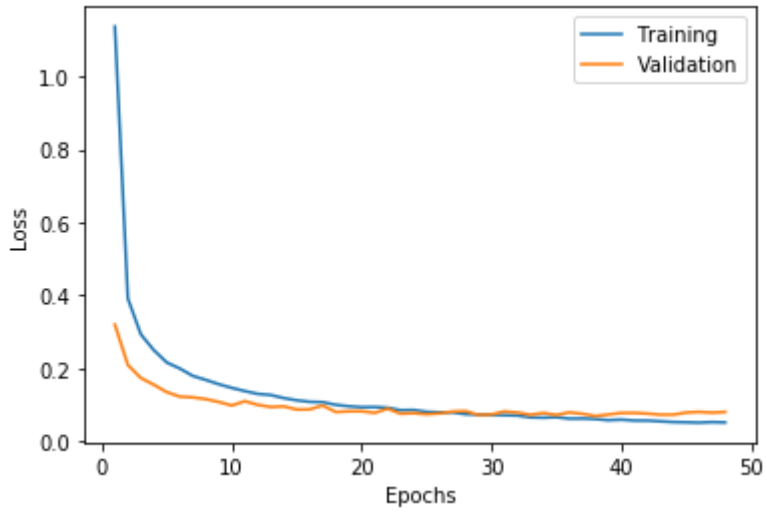
EXP13

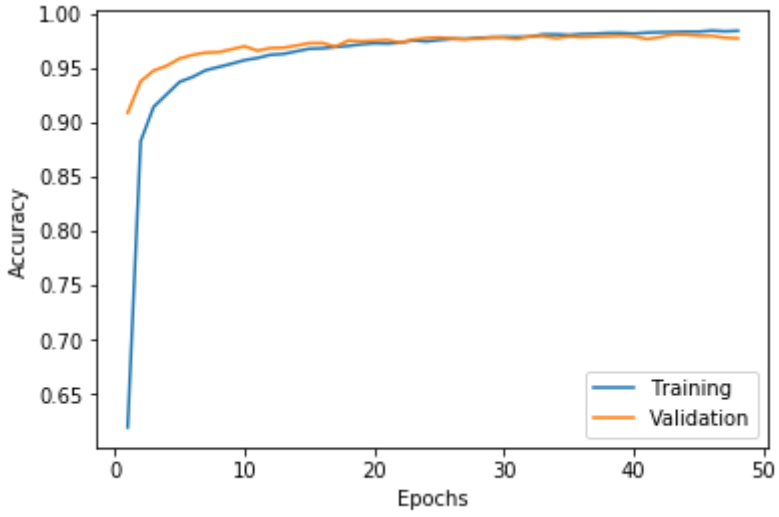
Model: "sequential_45"

Layer (type)	Output Shape	Param #
conv2d_131 (Conv2D)	(None, 26, 26, 8)	80
activation_131 (Activation)	(None, 26, 26, 8)	0
max_pooling2d_50 (MaxPooling	(None, 13, 13, 8)	0
conv2d_132 (Conv2D)	(None, 11, 11, 16)	1168
activation_132 (Activation)	(None, 11, 11, 16)	0
max_pooling2d_51 (MaxPooling	(None, 5, 5, 16)	0
conv2d_133 (Conv2D)	(None, 3, 3, 32)	4640

```
_________________________________________________________________
activation_133 (Activation)  (None, 3, 3, 32)          0
_________________________________________________________________
max_pooling2d_52 (MaxPooling (None, 1, 1, 32)          0
_________________________________________________________________
flatten_44 (Flatten)         (None, 32)                0
_________________________________________________________________
dense_57 (Dense)             (None, 32)                1056
_________________________________________________________________
dropout_29 (Dropout)         (None, 32)                0
_________________________________________________________________
dense_58 (Dense)             (None, 10)                330
=================================================================
Total params: 7,274
Trainable params: 7,274
Non-trainable params: 0
Dropout: 0.3

Epoch 48/200
48000/48000 [==============================] - 2s 51us/step - loss:
0.0521 - acc: 0.9839 - val_loss: 0.0809 - val_acc: 0.9770
```

	precision	recall	f1-score	support
0	0.99	0.99	0.99	1219
1	0.99	0.99	0.99	1342
2	0.96	0.97	0.97	1173
3	0.98	0.97	0.98	1281
4	0.98	0.98	0.98	1150
5	0.98	0.98	0.98	1092
6	0.99	0.99	0.99	1186
7	0.97	0.98	0.97	1223
8	0.98	0.98	0.98	1155
9	0.97	0.97	0.97	1179
accuracy			0.98	12000
macro avg	0.98	0.98	0.98	12000
weighted avg	0.98	0.98	0.98	12000





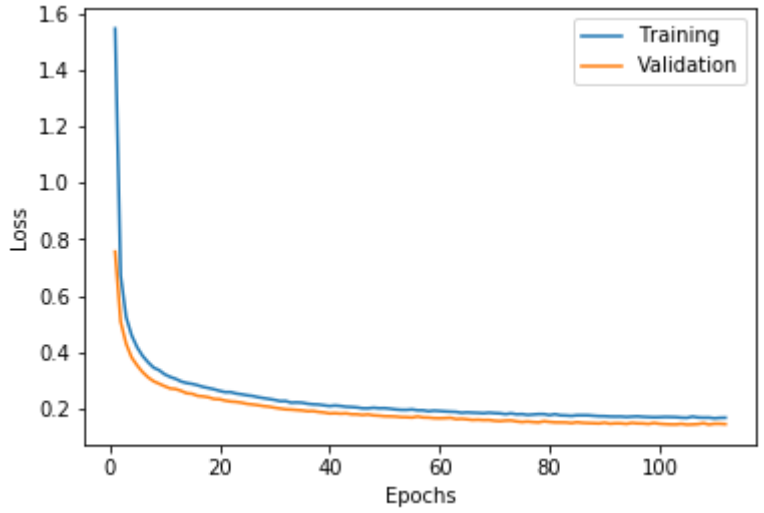
EXP14

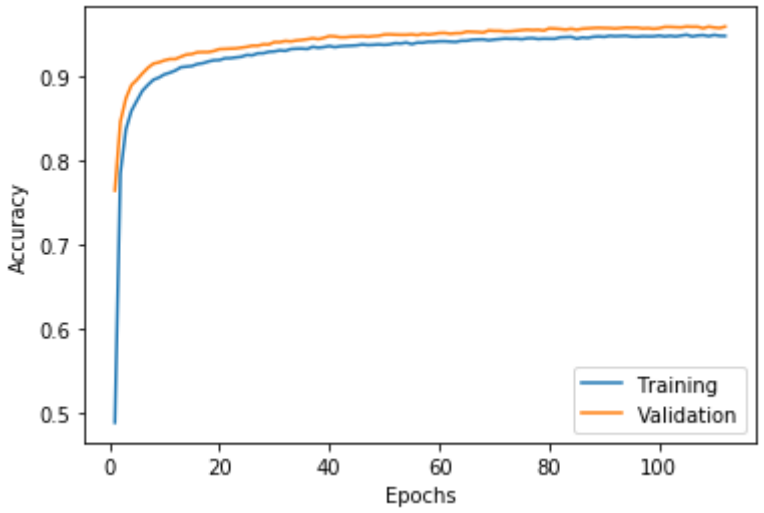
Standardized input

```
Model: "sequential_7"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_20 (Conv2D)           (None, 13, 13, 2)         20
_________________________________________________________________
activation_19 (Activation)   (None, 13, 13, 2)         0
_________________________________________________________________
conv2d_21 (Conv2D)           (None, 6, 6, 4)           76
_________________________________________________________________
activation_20 (Activation)   (None, 6, 6, 4)           0
_________________________________________________________________
conv2d_22 (Conv2D)           (None, 2, 2, 8)           296
_________________________________________________________________
```

```
activation_21 (Activation)   (None, 2, 2, 8)           0
_________________________________________________________________
flatten_6 (Flatten)          (None, 32)                0
_________________________________________________________________
dropout_5 (Dropout)          (None, 32)                0
_________________________________________________________________
dense_6 (Dense)              (None, 10)                330
=================================================================
Total params: 722
Trainable params: 722
Non-trainable params: 0
Dropout: 0.05

Epoch 112/200
48000/48000 [==============================] - 1s 28us/step - loss:
0.1660 - acc: 0.9474 - val_loss: 0.1432 - val_acc: 0.9585
```

	precision	recall	f1-score	support
0	0.97	0.98	0.98	1199
1	0.97	0.99	0.98	1349
2	0.97	0.94	0.95	1235
3	0.96	0.95	0.95	1250
4	0.96	0.94	0.95	1138
5	0.96	0.95	0.95	1108
6	0.96	0.97	0.97	1149
7	0.95	0.96	0.96	1264
8	0.95	0.93	0.94	1121
9	0.93	0.96	0.95	1187
accuracy			0.96	12000
macro avg	0.96	0.96	0.96	12000
weighted avg	0.96	0.96	0.96	12000

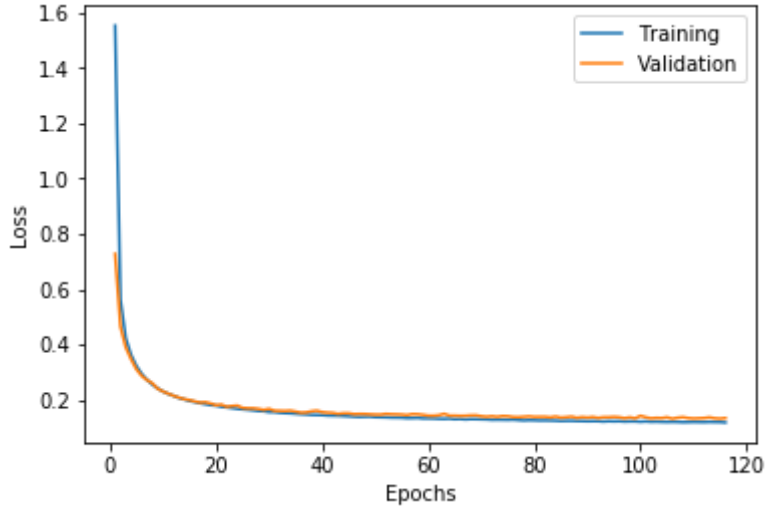


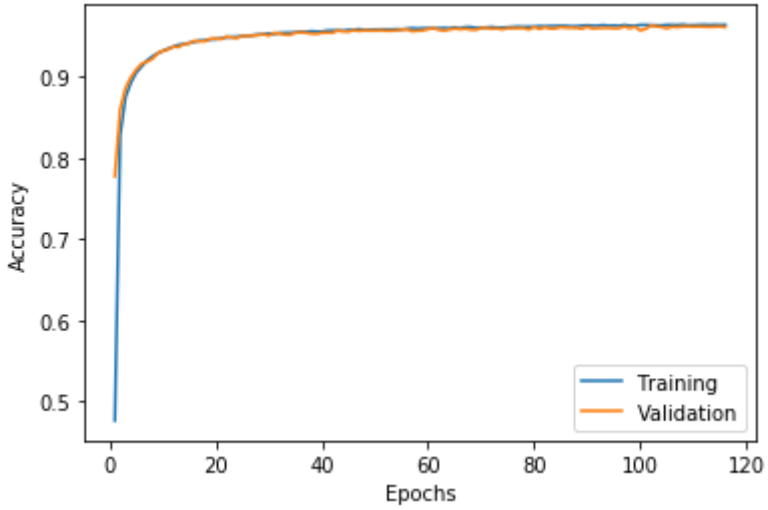


EXP15

```
Model: "sequential_9"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_26 (Conv2D)           (None, 13, 13, 2)         20
_________________________________________________________________
activation_25 (Activation)   (None, 13, 13, 2)         0
_________________________________________________________________
conv2d_27 (Conv2D)           (None, 6, 6, 4)           76
_________________________________________________________________
activation_26 (Activation)   (None, 6, 6, 4)           0
_________________________________________________________________
conv2d_28 (Conv2D)           (None, 2, 2, 8)           296
_________________________________________________________________
activation_27 (Activation)   (None, 2, 2, 8)           0
_________________________________________________________________
flatten_8 (Flatten)          (None, 32)                0
_________________________________________________________________
dense_8 (Dense)              (None, 10)                330
=================================================================
Total params: 722
Trainable params: 722
Non-trainable params: 0

Epoch 116/200
48000/48000 [==============================] - 1s 27us/step - loss:
0.1174 - acc: 0.9638 - val_loss: 0.1332 - val_acc: 0.9608

              precision    recall  f1-score   support

           0       0.97      0.98      0.98      1199
```

1	0.97	0.99	0.98	1349
2	0.96	0.95	0.96	1235
3	0.97	0.94	0.95	1250
4	0.97	0.96	0.96	1138
5	0.96	0.96	0.96	1108
6	0.97	0.97	0.97	1149
7	0.95	0.96	0.96	1264
8	0.94	0.94	0.94	1121
9	0.95	0.95	0.95	1187
accuracy			0.96	12000
macro avg	0.96	0.96	0.96	12000
weighted avg	0.96	0.96	0.96	12000

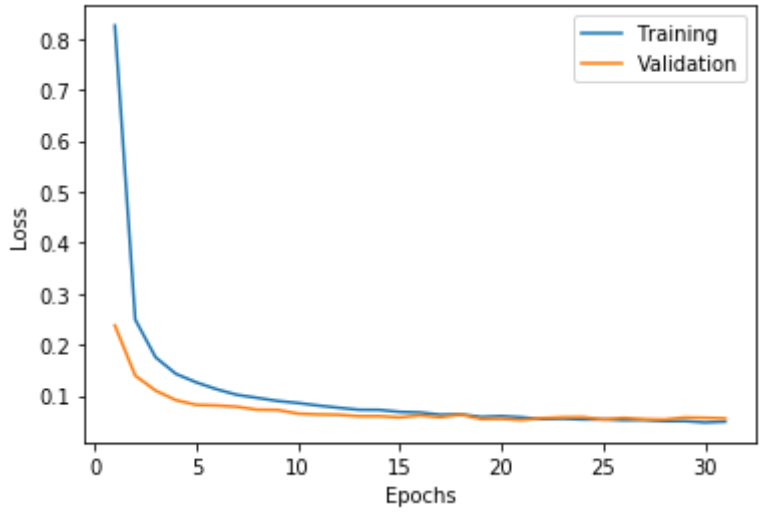


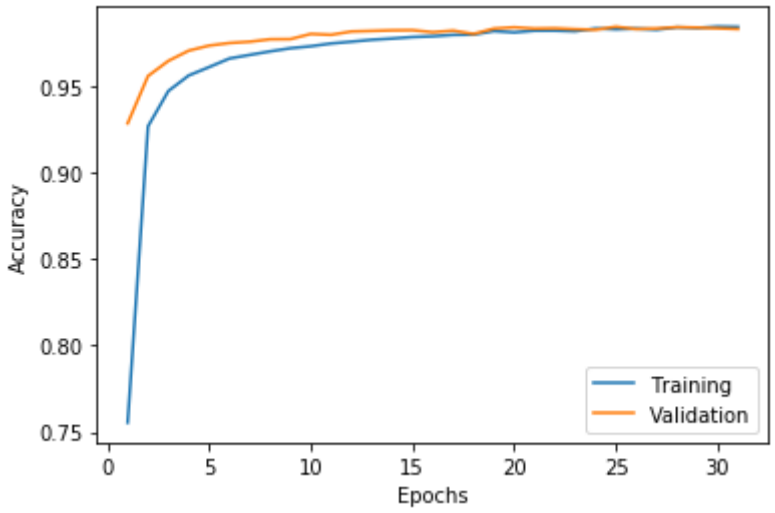


EXP16

```
Model: "sequential_38"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_111 (Conv2D)          (None, 26, 26, 8)         80
_________________________________________________________________
activation_111 (Activation)  (None, 26, 26, 8)         0
_________________________________________________________________
max_pooling2d_110 (MaxPoolin (None, 13, 13, 8)         0
_________________________________________________________________
batch_normalization_22 (Batc (None, 13, 13, 8)         32
_________________________________________________________________
conv2d_112 (Conv2D)          (None, 11, 11, 16)        1168
_________________________________________________________________
activation_112 (Activation)  (None, 11, 11, 16)        0
_________________________________________________________________
max_pooling2d_111 (MaxPoolin (None, 5, 5, 16)          0
_________________________________________________________________
batch_normalization_23 (Batc (None, 5, 5, 16)          64
_________________________________________________________________
conv2d_113 (Conv2D)          (None, 3, 3, 32)          4640
_________________________________________________________________
activation_113 (Activation)  (None, 3, 3, 32)          0
_________________________________________________________________
max_pooling2d_112 (MaxPoolin (None, 1, 1, 32)          0
_________________________________________________________________
batch_normalization_24 (Batc (None, 1, 1, 32)          128
_________________________________________________________________
flatten_38 (Flatten)         (None, 32)                0
_________________________________________________________________
dropout_9 (Dropout)          (None, 32)                0
_________________________________________________________________
dense_77 (Dense)             (None, 32)                1056
_________________________________________________________________
dense_78 (Dense)             (None, 10)                330
=================================================================
Total params: 7,498
Trainable params: 7,386
Non-trainable params: 112
Dropout: 0.3

Epoch 31/200
48000/48000 [==============================] - 3s 68us/step - loss:
0.0491 - acc: 0.9842 - val_loss: 0.0554 - val_acc: 0.9829
```

	precision	recall	f1-score	support
0	0.98	0.99	0.99	1199
1	0.99	0.99	0.99	1349
2	0.97	0.98	0.98	1235
3	0.99	0.98	0.99	1250
4	0.99	0.97	0.98	1138
5	0.99	0.99	0.99	1108
6	0.99	0.99	0.99	1149
7	0.98	0.98	0.98	1264
8	0.97	0.98	0.98	1121
9	0.97	0.98	0.98	1187
accuracy			0.98	12000
macro avg	0.98	0.98	0.98	12000
weighted avg	0.98	0.98	0.98	12000





RESULTS

- **Modello EXP16**

  10000/10000 [==============================] - 1s 116us/step
  [0.05155884924988641, 0.9863]

	precision	recall	f1-score	support
0	0.99	0.99	0.99	980
1	0.99	1.00	0.99	1135
2	0.98	0.98	0.98	1032
3	0.99	0.99	0.99	1010
4	0.99	0.98	0.99	982
5	0.99	0.98	0.98	892
6	0.99	0.98	0.98	958
7	0.98	0.98	0.98	1028
8	0.99	0.99	0.99	974
9	0.98	0.98	0.98	1009
accuracy			0.99	10000
macro avg	0.99	0.99	0.99	10000
weighted avg	0.99	0.99	0.99	10000

- **Modello EXP15**

  10000/10000 [==============================] - 2s 201us/step
  [0.11605910385809838, 0.9645]

	precision	recall	f1-score	support
0	0.97	0.98	0.97	980
1	0.98	0.99	0.98	1135
2	0.97	0.96	0.97	1032
3	0.96	0.96	0.96	1010
4	0.97	0.97	0.97	982
5	0.97	0.96	0.96	892
6	0.97	0.98	0.98	958
7	0.94	0.96	0.95	1028
8	0.95	0.95	0.95	974
9	0.96	0.94	0.95	1009
accuracy			0.96	10000
macro avg	0.96	0.96	0.96	10000
weighted avg	0.96	0.96	0.96	10000