MNIST Training Example

Test Document Author

Contents

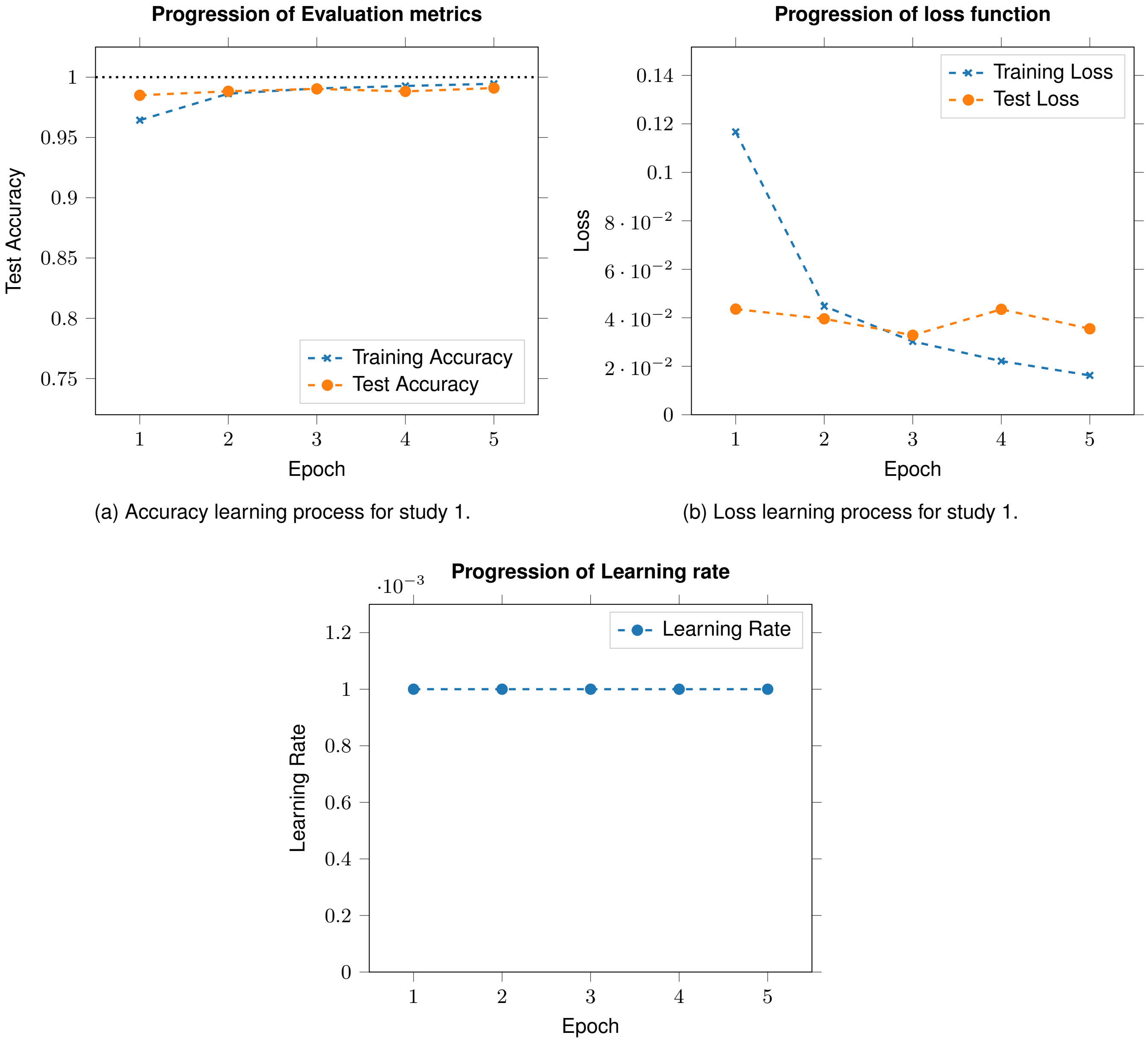
1 Summary

№	Study name	Model	#Parameters	#Epochs	Batch size	Test Acc.	Training Acc.
1	ConvNet	ConvNet2layers	1 199 882	5	16	99.1 %	99.45 %
2	Two layer MLP	MLP2layers	669 706	5	16	90.78 %	89.63 %
3	Five layer MLP	MLP5layers	1 457 674	5	16	91.84 %	91.38 %

2 Training reports

2.1 Model 1: ConvNet

Training history See Figure 1.



(a) Accuracy learning process for study 1.

(b) Loss learning process for study 1.

(c) Learning rate per epoch for study 1.

Figure 1: Training and evaluation metrics for study 1.

Link to model: `https://keras.io/examples/mnist_cnn/`

Dataset

Name MNIST

Train-Test-Dev split: *Training set:* 60000, *Test set:* 10000, *Dev set:* 0,

Image size [28, 28]

Training

Number of epochs 5

Optimizer Adam (Kingma et al., 2015)

Learning Rate	0.0010000000474974513
Beta 1	0.8999999761581421
Beta 2	0.9990000128746033
Decay	0.0
Epsilon	1e-07
Amsgrad	False

Loss Categorical crossentropy

Batch size 16

Shuffle Yes

Training time 2 min 42 sec

Platform

Weights exported to path weights\ConvNet2layers_5ep_MNIST.h5

Device used GPU (GeForce GTX 1060 6GB)

CPU Intel(R) Xeon(R) CPU E3-1245 v5 @ 3.50GHz, X86_64

Python Version 3.7.2.final.0 (64 bit)

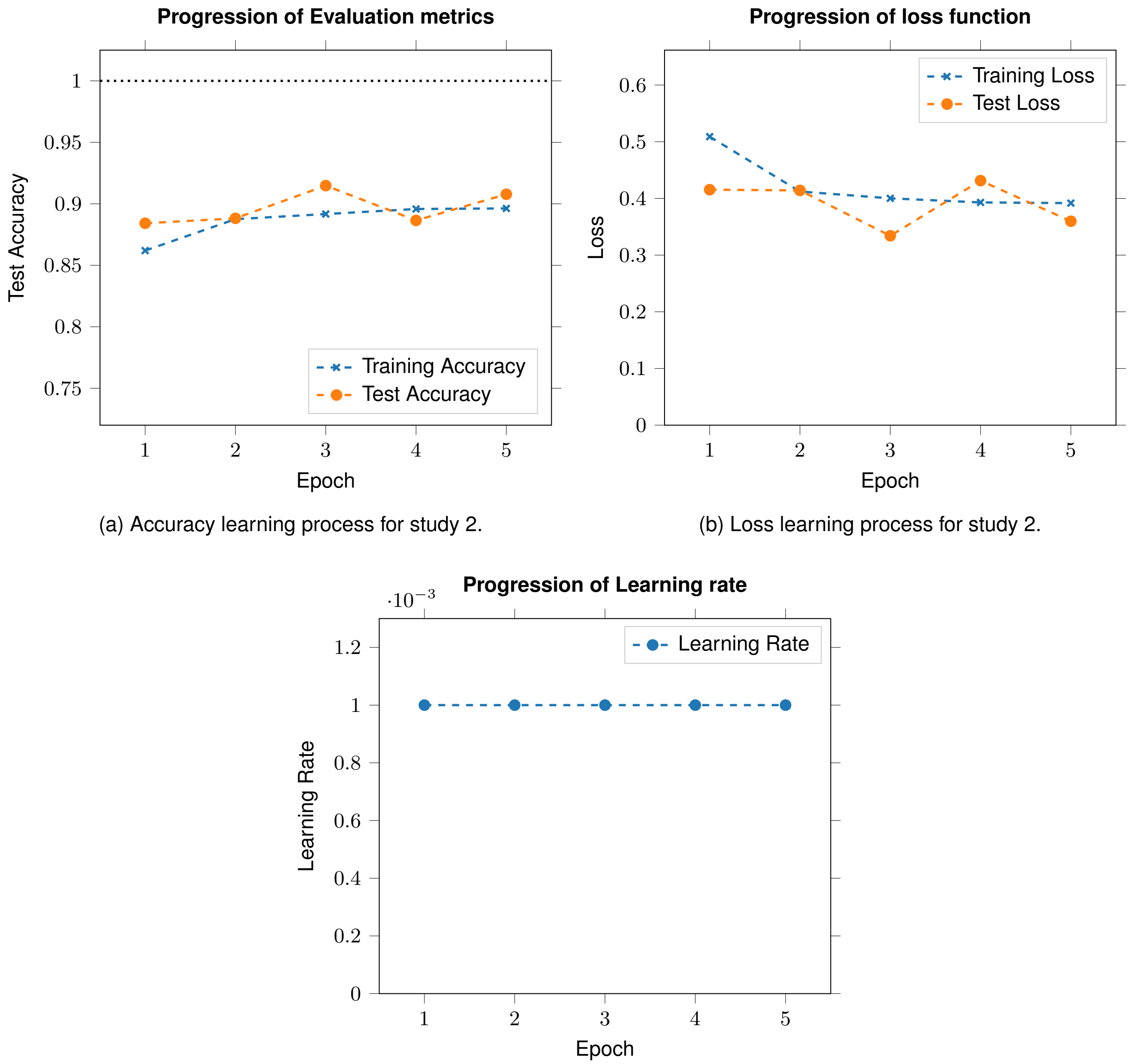
Keras Version 2.2.5 (Backend: tensorflow)

Tensorflow Version 1.14.0

Timestamp 26.09.2019 at 13:50

2.2 Model 2: Two layer MLP

Training history See Figure 2.



(a) Accuracy learning process for study 2.

(b) Loss learning process for study 2.

(c) Learning rate per epoch for study 2.

Figure 2: Training and evaluation metrics for study 2.

Link to model: `https://keras.io/examples/mnist_mlp/`

Dataset

Name MNIST

Train-Test-Dev split: *Training set:* 60000, *Test set:* 10000, *Dev set:* 0,

Image size [28, 28]

Training

Number of epochs 5

Optimizer RMSProp (Hinton et al. 2014)

Learning Rate	0.00010000000474974513
Rho	0.8999999761581421
Decay	0.0
Epsilon	1e-07

Loss Categorical crossentropy

Batch size 16

Shuffle Yes

Training time 1 min 51 sec

Platform

Weights exported to path weights\MLP2layers_5ep_MNIST.h5

Device used GPU (GeForce GTX 1060 6GB)

CPU Intel(R) Xeon(R) CPU E3-1245 v5 @ 3.50GHz, X86_64

Python Version 3.7.2.final.0 (64 bit)

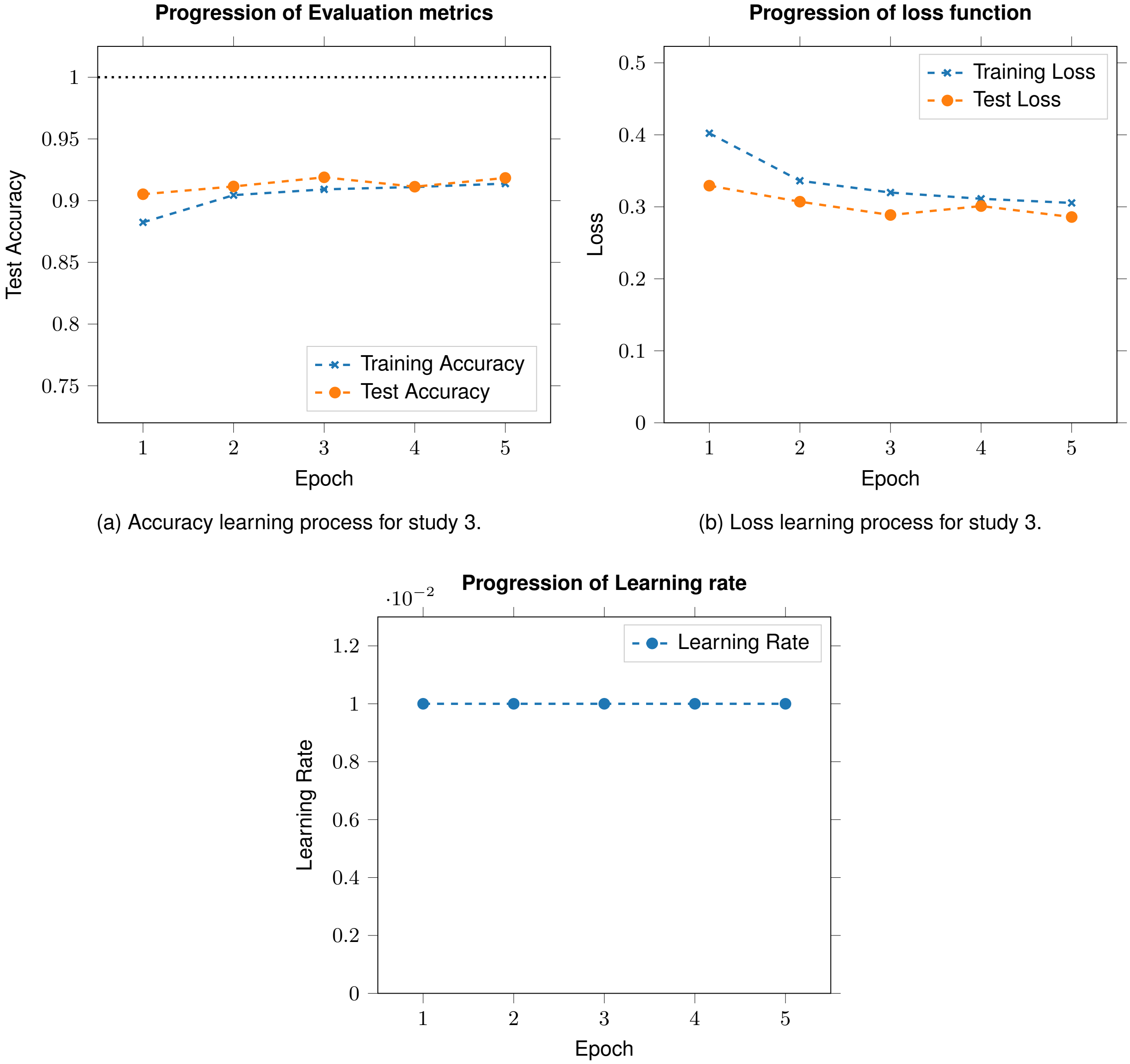
Keras Version 2.2.5 (Backend: tensorflow)

Tensorflow Version 1.14.0

Timestamp 26.09.2019 at 13:52

2.3 Model 3: Five layer MLP

Training history See Figure 3.



(a) Accuracy learning process for study 3.

(b) Loss learning process for study 3.

(c) Learning rate per epoch for study 3.

Figure 3: Training and evaluation metrics for study 3.

Dataset

Name MNIST

Train-Test-Dev split: *Training set:* 60000, *Test set:* 10000, *Dev set:* 0,

Image size [28, 28]

Training

Number of epochs 5

Optimizer Stochastic Gradient Descent

Learning Rate	0.0009999999310821295
Momentum	0.0
Decay	0.0
Nesterov	False

Loss Categorical crossentropy

Batch size 16

Shuffle Yes

Training time 2 min 5 sec

Platform

Weights exported to path weights\MLP5layers_5ep_MNIST.h5

Device used GPU (GeForce GTX 1060 6GB)

CPU Intel(R) Xeon(R) CPU E3-1245 v5 @ 3.50GHz, X86_64

Python Version 3.7.2.final.0 (64 bit)

Keras Version 2.2.5 (Backend: tensorflow)

Tensorflow Version 1.14.0

Timestamp 26.09.2019 at 13:54

3 Model Architectures

3.1 Model architecture of ConvNet2layers

Used in study №: 3

Model summary:

№	Layer (Type)	Output shape	Config	#Parameters	Inbound layers
0	input_1 (InputLayer)	(28, 28, 1)		0	
1	conv2d_1 (Conv2D)	(26, 26, 32)	**Activation:** relu **Kernel Size:** [3, 3] **Stride:** [1, 1] **Dilation:** [1, 1] **Padding:** valid	320	input_1
2	conv2d_2 (Conv2D)	(24, 24, 64)	**Activation:** relu **Kernel Size:** [3, 3] **Stride:** [1, 1] **Dilation:** [1, 1] **Padding:** valid	18 496	conv2d_1
3	max_pooling2d_1 (MaxPooling2D)	(12, 12, 64)	**Pool size:** [2, 2] **Strides:** [2, 2] **Padding:** valid	0	conv2d_2
4	dropout_1 (Dropout)	(12, 12, 64)	**Dropout Rate:** 0.0	0	max_pooling2d_1
5	flatten_1 (Flatten)	(9216,)		0	dropout_1
6	dense_1 (Dense)	(128,)	**#Neurons:** 128 **Activation:** relu	1 179 776	flatten_1
7	dropout_2 (Dropout)	(128,)	**Dropout Rate:** 0.2	0	dense_1
8	dense_2 (Dense)	(10,)	**#Neurons:** 10 **Activation:** softmax	1290	dropout_2

3.2 Model architecture of MLP5layers

Used in study №: 3

Model summary:

№	Layer (Type)	Output shape	Config	#Parameters	Inbound layers
0	input_3 (InputLayer)	(28, 28, 1)		0	
1	flatten_3 (Flatten)	(784,)		0	input_3
2	dense_6 (Dense)	(512,)	**#Neurons:** 512 **Activation:** linear	401 920	flatten_3
3	dropout_5 (Dropout)	(512,)	**Dropout Rate:** 0.0	0	dense_6
4	dense_7 (Dense)	(512,)	**#Neurons:** 512 **Activation:** linear	262 656	dropout_5
5	dropout_6 (Dropout)	(512,)	**Dropout Rate:** 0.0	0	dense_7
6	dense_8 (Dense)	(512,)	**#Neurons:** 512 **Activation:** linear	262 656	dropout_6
7	dropout_7 (Dropout)	(512,)	**Dropout Rate:** 0.0	0	dense_8
8	dense_9 (Dense)	(512,)	**#Neurons:** 512 **Activation:** linear	262 656	dropout_7
9	dropout_8 (Dropout)	(512,)	**Dropout Rate:** 0.2	0	dense_9
10	dense_10 (Dense)	(512,)	**#Neurons:** 512 **Activation:** linear	262 656	dropout_8
11	dropout_9 (Dropout)	(512,)	**Dropout Rate:** 0.2	0	dense_10
12	dense_11 (Dense)	(10,)	**#Neurons:** 10 **Activation:** softmax	5130	dropout_9

3.3 Model architecture of MLP2layers

Used in study №: 3

Model summary:

№	Layer (Type)	Output shape	Config	#Parameters	Inbound layers
0	input_2 (InputLayer)	(28, 28, 1)		0	
1	flatten_2 (Flatten)	(784,)		0	input_2
2	dense_3 (Dense)	(512,)	**#Neurons:** 512 **Activation:** linear	401 920	flatten_2
3	dropout_3 (Dropout)	(512,)	**Dropout Rate:** 0.0	0	dense_3
4	dense_4 (Dense)	(512,)	**#Neurons:** 512 **Activation:** linear	262 656	dropout_3
5	dropout_4 (Dropout)	(512,)	**Dropout Rate:** 0.2	0	dense_4
6	dense_5 (Dense)	(10,)	**#Neurons:** 10 **Activation:** softmax	5130	dropout_4