CONVOLUTIONAL NEURAL NETWORK (CNN) FOR HANDWRITTEN DIGITS RECOGNITION

DEEP LEARNING

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Summary

In the last notebook, we built a Multilayer Perceptron for recognizing hand-written digits from the MNIST data-set. The best achieved accuracy on testing data was about 97%, but modern implementations of Convolutional Neural Networks whould surpass that mark.

In this notebook, we will build, train and optimize in TensorFlow one of the early Convolutional Neural Networks, **LeNet-5**, and push it beyond 99% accuracy.

1. A first NeuralNetwork model in TensorFlow

1.1 Import Modules & Load MNIST Data in TensorFlow

```
In [117]:  import tensorflow as tf
           from tensorflow.examples.tutorials.mnist import input_data
           from tensorflow.contrib.layers import flatten
           from __future__ import print_function
           from numpy import array
           import numpy as np
           import time
```

```
In [190]:  mnist = input_data.read_data_sets("MNIST_data/", one_hot=True)
           X_train, y_train           = mnist.train.images, mnist.train.labels
           X_validation, y_validation = mnist.validation.images, mnist.validation.l
           abels
           X_test, y_test             = mnist.test.images, mnist.test.labels
           print("Image Shape: {}".format(X_train[0].shape[0]))
           print("Training Set:   {} samples".format(len(X_train)))
           print("Validation Set: {} samples".format(len(X_validation)))
           print("Test Set:       {} samples".format(len(X_test)))
```

```
           Extracting MNIST_data/train-images-idx3-ubyte.gz
           Extracting MNIST_data/train-labels-idx1-ubyte.gz
           Extracting MNIST_data/t10k-images-idx3-ubyte.gz
           Extracting MNIST_data/t10k-labels-idx1-ubyte.gz
           Image Shape: 784
           Training Set:   55000 samples
           Validation Set: 5000 samples
           Test Set:       10000 samples
```

Before starting with CNN, let's train and test in TensorFlow a simple example : **y=softmax(Wx+b)**

This model should reach an accuracy of about 92 %.

1.2 Coding the Graph and Training

In [2]:
```python
#GRAPH DEFINITION

# Parameters
learning_rate = 0.01
training_epochs = 100
batch_size = 128
display_step = 1
logs_path = 'log_files/'  # useful for tensorboard

# tf Graph Input:  mnist data image of shape 28*28=784
x = tf.placeholder(tf.float32, [None, 784], name='InputData')
# 0-9 digits recognition,  10 classes
y = tf.placeholder(tf.float32, [None, 10], name='LabelData')

# Set model weights
W = tf.Variable(tf.zeros([784, 10]), name='Weights')
b = tf.Variable(tf.zeros([10]), name='Bias')

# Construct model and encapsulating all ops into scopes,
#  making Tensorboard's Graph visualization more convenient
with tf.name_scope('Model'):
    # Model
    pred = tf.nn.softmax(tf.matmul(x, W) + b) # Softmax
with tf.name_scope('Loss'):
    # Minimize error using cross entropy
    cost = tf.reduce_mean(-tf.reduce_sum(y*tf.log(pred), reduction_indic
es=1))
with tf.name_scope('SGD'):
    # Gradient Descent
    optimizer = tf.train.GradientDescentOptimizer(learning_rate).minimiz
e(cost)
with tf.name_scope('Accuracy'):
    # Accuracy
    acc = tf.equal(tf.argmax(pred, 1), tf.argmax(y, 1))
    acc = tf.reduce_mean(tf.cast(acc, tf.float32))

# Initializing the variables
init = tf.global_variables_initializer()
# Create a summary to monitor cost tensor
tf.summary.scalar("TrainingLoss", cost)
# Create a summary to monitor accuracy tensor
tf.summary.scalar("TrainingAccuracy", acc)
# Merge all summaries into a single op
merged_summary_op = tf.summary.merge_all()


#TRAINING


# Launch the graph for training
with tf.Session() as sess:
    sess.run(init)
```

```python
    # op to write logs to Tensorboard
    summary_writer = tf.summary.FileWriter(logs_path, graph=tf.get_defau
lt_graph())
    # Training cycle
    for epoch in range(training_epochs):
        avg_cost = 0.
        total_batch = int(mnist.train.num_examples/batch_size)
        # Loop over all batches
        for i in range(total_batch):
            batch_xs, batch_ys = mnist.train.next_batch(batch_size, shuf
fle=True)
            # Run optimization op (backprop), cost op (to get loss value
)
            # and summary nodes
            _, c, summary = sess.run([optimizer, cost, merged_summary_op
],
                                     feed_dict={x: batch_xs, y: batch_ys
})
            # Write logs at every iteration
            summary_writer.add_summary(summary, epoch * total_batch + i)
            # Compute average loss
            avg_cost += c / total_batch
        # Display logs per epoch step
        if (epoch+1) % display_step == 0:
            print("Epoch: ", '%02d' % (epoch+1), "  =====> Loss=",
                  "{:.9f}".format(avg_cost))

    print("Optimization Finished!")

    # Test model
    # Calculate accuracy
    print("Accuracy:", acc.eval({x: mnist.test.images, y: mnist.test.lab
els}))
```

```
Epoch:  01   =====> Loss= 1.286880517
Epoch:  02   =====> Loss= 0.732314337
Epoch:  03   =====> Loss= 0.600182705
Epoch:  04   =====> Loss= 0.536474698
Epoch:  05   =====> Loss= 0.497743477
Epoch:  06   =====> Loss= 0.471044735
Epoch:  07   =====> Loss= 0.451285015
Epoch:  08   =====> Loss= 0.435486047
Epoch:  09   =====> Loss= 0.423485379
Epoch:  10   =====> Loss= 0.413127333
Epoch:  11   =====> Loss= 0.404424905
Epoch:  12   =====> Loss= 0.396875077
Epoch:  13   =====> Loss= 0.390122826
Epoch:  14   =====> Loss= 0.384438272
Epoch:  15   =====> Loss= 0.379063723
Epoch:  16   =====> Loss= 0.374401041
Epoch:  17   =====> Loss= 0.370427270
Epoch:  18   =====> Loss= 0.366561572
Epoch:  19   =====> Loss= 0.362732460
Epoch:  20   =====> Loss= 0.359670188
Epoch:  21   =====> Loss= 0.356530713
Epoch:  22   =====> Loss= 0.353755475
Epoch:  23   =====> Loss= 0.351379176
Epoch:  24   =====> Loss= 0.348841268
Epoch:  25   =====> Loss= 0.346291858
Epoch:  26   =====> Loss= 0.344263495
Epoch:  27   =====> Loss= 0.342145607
```

```
           Epoch:   28   =====> Loss=  0.340279845
           Epoch:   29   =====> Loss=  0.338280311
           Epoch:   30   =====> Loss=  0.336593690
           Epoch:   31   =====> Loss=  0.334856931
           Epoch:   32   =====> Loss=  0.333555910
           Epoch:   33   =====> Loss=  0.331999466
           Epoch:   34   =====> Loss=  0.330438348
           Epoch:   35   =====> Loss=  0.329235198
           Epoch:   36   =====> Loss=  0.327769872
           Epoch:   37   =====> Loss=  0.326818192
           Epoch:   38   =====> Loss=  0.325353872
           Epoch:   39   =====> Loss=  0.324172505
           Epoch:   40   =====> Loss=  0.323176802
           Epoch:   41   =====> Loss=  0.321943087
           Epoch:   42   =====> Loss=  0.320741635
           Epoch:   43   =====> Loss=  0.319880484
           Epoch:   44   =====> Loss=  0.318746548
           Epoch:   45   =====> Loss=  0.318128876
           Epoch:   46   =====> Loss=  0.317128404
           Epoch:   47   =====> Loss=  0.316180597
           Epoch:   48   =====> Loss=  0.315200540
           Epoch:   49   =====> Loss=  0.314626362
           Epoch:   50   =====> Loss=  0.313644664
           Epoch:   51   =====> Loss=  0.313065712
           Epoch:   52   =====> Loss=  0.312324699
           Epoch:   53   =====> Loss=  0.311312480
           Epoch:   54   =====> Loss=  0.310184292
           Epoch:   55   =====> Loss=  0.309985134
           Epoch:   56   =====> Loss=  0.309305577
           Epoch:   57   =====> Loss=  0.308584504
           Epoch:   58   =====> Loss=  0.307975754
           Epoch:   59   =====> Loss=  0.307369640
           Epoch:   60   =====> Loss=  0.306651877
           Epoch:   61   =====> Loss=  0.306076956
           Epoch:   62   =====> Loss=  0.305529022
           Epoch:   63   =====> Loss=  0.304919904
           Epoch:   64   =====> Loss=  0.304308251
           Epoch:   65   =====> Loss=  0.303945196
           Epoch:   66   =====> Loss=  0.303266914
           Epoch:   67   =====> Loss=  0.302906753
           Epoch:   68   =====> Loss=  0.302573205
           Epoch:   69   =====> Loss=  0.301829170
           Epoch:   70   =====> Loss=  0.301280140
           Epoch:   71   =====> Loss=  0.300879078
           Epoch:   72   =====> Loss=  0.300337700
           Epoch:   73   =====> Loss=  0.299630875
           Epoch:   74   =====> Loss=  0.299276637
           Epoch:   75   =====> Loss=  0.299070879
           Epoch:   76   =====> Loss=  0.298232197
           Epoch:   77   =====> Loss=  0.298021811
           Epoch:   78   =====> Loss=  0.297795259
           Epoch:   79   =====> Loss=  0.297131211
           Epoch:   80   =====> Loss=  0.296873052
           Epoch:   81   =====> Loss=  0.296567148
           Epoch:   82   =====> Loss=  0.295779722
           Epoch:   83   =====> Loss=  0.295447144
           Epoch:   84   =====> Loss=  0.295448288
           Epoch:   85   =====> Loss=  0.295106368
           Epoch:   86   =====> Loss=  0.294550212
           Epoch:   87   =====> Loss=  0.294151047
           Epoch:   88   =====> Loss=  0.294116553
```

```
Epoch:  89   =====> Loss= 0.293291785
Epoch:  90   =====> Loss= 0.293069592
Epoch:  91   =====> Loss= 0.292543515
Epoch:  92   =====> Loss= 0.292532154
Epoch:  93   =====> Loss= 0.292028785
Epoch:  94   =====> Loss= 0.291817178
Epoch:  95   =====> Loss= 0.291677481
Epoch:  96   =====> Loss= 0.291299572
Epoch:  97   =====> Loss= 0.290715999
Epoch:  98   =====> Loss= 0.290480864
Epoch:  99   =====> Loss= 0.290369174
Epoch:  100   =====> Loss= 0.289843813
Optimization Finished!
Accuracy: 0.92
```

1.3 Visualization with Tensorboard

Using Tensorboard, we can now visualize the created graph, giving us an overview of the architecture and how all of the major components are connected. You can also visalize and analyse the learning curves.

In order to launch tensorBoard we follow these steps:

- Open a Terminal and run the command line **"tensorboard --logdir=log_files/"**, it will generate an http link ,ex http://666.6.6.6:6006,
- Copy this link into a web browser
- Display the images!

<img src="MNIST_99_Challenge_Figures/Screenshot from 2017-05-26 17:53:17.png",width="800" height="600" align="center">

Figure 1: Tensorboard visualization

2. The 99% MNIST Challenge using CNNs

2.1 LeNet5 Implementation

Now that we are familiar with familar with **tensorFlow** and **tensorBoard**, we are going to build, train and test the baseline LeNet-5 model for the MNIST digits recognition problem.

Further ahead we will make some optimizations to surpass 99% of accuracy. The best model so far achieved over 99.7% accuracy (List of Results)

<img src="lenet.png",width="800" height="600" align="center">

Figure 2: Lenet 5

The LeNet architecture accepts a 32x32xC image as input, where C is the number of color channels. Since MNIST images are grayscale, C is 1 in this case.

---

1. Layer 1: Convolutional. The output shape should be 28x28x6 Activation. sigmoid Pooling. The output shape

should be 14x14x6.

1. **Layer 2: Convolutional.** The output shape should be 10x10x16. **Activation.** sigmoid
   Pooling. The output shape should be 5x5x16.
2. **Flatten.** Flatten the output shape of the final pooling layer such that it's 1D instead of 3D.
   You may need to use *flatten* from tensorflow.contrib.layers import flatten
3. **Layer 3: Fully Connected.** This should have 120 outputs. **Activation.** sigmoid
4. **Layer 4: Fully Connected.** This should have 84 outputs. **Activation.** sigmoid
5. **Layer 5: Fully Connected.** This should have 10 outputs. **Activation.** softmax

2.1.1 LeNet5 model Implementation [Question 2.1.1]

The implementation draws classes and functions from the [Tensorflow API](#).

```python
In [317]:  # LeNet5 variables init
def weight_variable(shape):
    initial = tf.truncated_normal(shape, stddev=0.01)
    return tf.Variable(initial)

def bias_variable(shape):
    initial = tf.constant(0.1, shape=shape)
    return tf.Variable(initial)
```

> **COMMENT:**
> These functions are used for weigths and bias initilization. The standard deviation in the weights can be tuned in case we find any strange behaviour in the CNN.

```python
In [304]:  # LeNet5 convolutional and max pool layers
def conv2d(x, W,pad='SAME'):
    return tf.nn.conv2d(x, W, strides=[1, 1, 1, 1], padding=pad)

def max_pool_2x2(x,pad='VALID'):
    return tf.nn.max_pool(x, ksize=[1, 2, 2, 1],
                          strides=[1, 2, 2, 1], padding=pad)
```

> **COMMENT:**
> The stride of value 1x1 in the convolutional will yield a same size feature map when used with padding 'SAME', which adds padding to ensure that the proportion stays equal after the convolution.
>
> Using a stride of 2x2 in the max pool ensures reducing the features in half, which is why padding 'VALID' is used (equivalent to no padding).

```python
In [338]:  def LeNet5_Model(data, keep_pr=1, activFunc=tf.nn.sigmoid):
    input_data = tf.reshape(data,[-1,28,28,1])

    # ------------------------------------------------
    # ------------------VARIABLES------------------
```

```python
# ------------------------------------------------
# Convolutional layer 1 variables
W_conv1 = weight_variable([5,5,1,6])
b_conv1 = bias_variable([6])

# Convolutional layer 2 variables
W_conv2 = weight_variable([5,5,6,16])
b_conv2 = bias_variable([16])

# Fully connected layer 1 param
W_fc1 = weight_variable([400, 120])
b_fc1 = bias_variable([120])

# Fully connected layer 2 param
W_fc2 = weight_variable([120, 84])
b_fc2 = bias_variable([84])

# Fully connected layer 3 param
W_fc3 = weight_variable([84, 10])
b_fc3 = bias_variable([10])


# -------------------------------------------------------
# -------------------COMPUTATIONS-------------------
# -------------------------------------------------------
# Convolutional layer 1 & max pooling
h_conv1 = activFunc(conv2d(input_data,W_conv1)+ b_conv1)
h_pool1 = max_pool_2x2(h_conv1)

# Convolutional layer 2 & max pooling
h_conv2 = activFunc(conv2d(h_pool1,W_conv2, pad='VALID')+ b_conv2)
h_pool2 = max_pool_2x2(h_conv2)

# Flattening
h_pool2_flat = tf.contrib.layers.flatten(h_pool2)

# Fully connected layer 1, sigmoid activation
h_fc1 = activFunc(tf.matmul(h_pool2_flat, W_fc1) + b_fc1)
drop_fc1 = tf.nn.dropout(h_fc1, keep_pr)

# Fully connected layer 2, sigmoid activation
h_fc2 = activFunc(tf.matmul(drop_fc1, W_fc2) + b_fc2)
drop_fc2 = tf.nn.dropout(h_fc2, keep_pr)

# Fully connected layer 3, softmax activation
predicted = tf.nn.softmax(tf.matmul(drop_fc2, W_fc3) + b_fc3)

return predicted
```

COMMENT:
First we define all the variables, then we compute all the activations using the functions defined above. We included a dropout in the fully connected layers, but is set off (with keep_p=1) by default.

2.1.2 Number of parameters in LeNet5 [Question 2.1.2]

```
In [306]: NParameters_LeNet5 = \
          2*(5*5*1*6) + \
          2*(5*5*6*16) + \
          400*120 + \
          120 + \
          120*84 + \
          84 + \
          84*10 + \
          10


          print('Mumber of parameters in LeNet5: %d'%NParameters_LeNet5)
```

Mumber of parameters in LeNet5: 64234

> **COMMENT:**
>
> - Weights and biases for convolutional layer 1 = 2 x (5 x 5 x 1 x 6)
> - Weights and biases for convolutional layer 2 = 2 x (5 x 5 x 6 x 16)
> - Weights for fully connected layer 1 = 400 x 120
> - Biases for fully connected layer 1 = 120
> - Weights for fully connected layer 2 = 120 x 84
> - Biases for fully connected layer 2 = 84
> - Weights for fully connected layer 3 = 84 x 10
> - Biases for fully connected layer 3 = 10
>
> TOTAL: 64234

2.1.3 CNNet: Tensorflow graph creation [Question 2.1.3]

The initial training will be using the parameters cited below:

```
Learning rate =0.1
Loss Function : Cross entropy
Optimisateur: SGD
Number of training iterations= 10000
The batch size =128
```

```
In [339]: def CNNet ( modelName,
                    learning_rate = 0.1,
                    training_epochs = 100,
                    batch_size = 128,
                    display_step = 1,
                    keep_p = 1,
                    activationFunc = tf.nn.sigmoid,
                    optimFunc = tf.train.GradientDescentOptimizer,
                    X_train=mnist.train.images,
                    y_train=mnist.train.labels,
                    X_val=mnist.validation.images,
                    y_val=mnist.validation.labels,
                    X_test= mnist.test.images,
                    y_test=mnist.test.labels,
                    loadModel=None
```

```python
            ):

        # ---------- DESCRIPTION OF DATASET ----------
        InputSize = X_train[0].shape[0]
        OutputSize = y_train[0].shape[0]
        TrainingSetSize = len(X_train)
        ValidationSetSize = len(X_validation)
        TestSetSize = len(X_test)

        # ---------- OUTPUT FOLDERS ----------
        logsFolder = 'log_files/' # useful for tensorboard
        saveFolder = 'Models/'    # useful to restore the model

        # ---------- RESET GRAPH ----------
        tf.reset_default_graph()

        # ---------- DEFINE VARIABLES ----------
        # tf Graph Input:  mnist data image of shape 28*28*1
        x = tf.placeholder(tf.float32, [None,InputSize], name='InputData')
        # 0-9 digits recognition,  10 classes
        y = tf.placeholder(tf.float32, [None,OutputSize], name='LabelData')
        # Dropout
        keep_prob = tf.placeholder(tf.float32, name='DropoutKeepProbability'
)

        # ---------- DEFINE GRAPH NODES ----------
        with tf.name_scope('Model'):
            # Model
            model = LeNet5_Model(x, keep_prob, activFunc=activationFunc)

        with tf.name_scope('Loss'):
            # Minimize error using cross entropy
            cost = tf.reduce_mean(-tf.reduce_sum(y*tf.log(model+1e-9), reduc
tion_indices=1))
            #cost = tf.nn.softmax_cross_entropy_with_logits(model, tf.one_ho
t(y, 10))
        with tf.name_scope('Optimizer'):
            #Optimization, using cost reduction
            optimizer = optimFunc(learning_rate).minimize(cost)

        with tf.name_scope('Accuracy'):
            # Accuracies
            acc = CNNetAccuracy(model, y)


        # ---------- INITIALIZE VARIABLES ----------
        init = tf.global_variables_initializer()


        # ---------- TRACK BATCH LOSS AND ACCURACY ----------
        # Create a summary to monitor cost tensor
        tf.summary.scalar("BatchLoss", cost)
        # Create a summary to monitor batch accuracy tensor
        tf.summary.scalar("BatchAccuracy", acc)
        # Merge all summaries into a single op
        merged_summary_op = tf.summary.merge_all()

        # ---------- TRAIN MODEL ----------
        CNNtrain(model, cost, optimizer, acc,
                 x, y, keep_prob, TrainingSetSize,
                 X_train, y_train, X_val, y_val, X_test, y_test,
```

```
                     init, merged_summary_op,
                     modelName, saveFolder,logsFolder,
                     learning_rate, training_epochs, batch_size, display_step ,
keep_p,
                     loadModel
                    )
```

> **COMMENT:**
> The CNNet function creates the whole graph from scratch (Nodes, Variables, Summaries)
> and calls the function CNNTrain, which will be in charge of creating a session and running
> the graph.

2.1.4 CNNet: Accuracy [Question 2.1.4]

Here we implement the evaluation function for accuracy computation:

```
In [308]:  def CNNetAccuracy(model, y):
               accuracy = tf.reduce_mean(
                           tf.cast( tf.equal( tf.argmax(model, 1),
                                              tf.argmax(y, 1)), tf.float32))
               return accuracy
```

> **COMMENT:**
> We've opted for defining the computation the way it should be set inside a Tensorflow graph.
> However, in order to execute it and obtain a value, we need to create the rest of the graph
> and use a session to perform the computation (it will be called in the training function)

2.1.5 CNNet Training [Question 2.1.5]

Here we implement training pipeline and run the training data through it to train the model. Other
steps to consider are:

- Before each epoch, shuffling the training set.
- Printing the loss per mini batch and the training/validation accuracy per epoch. (Display
  results every 100 epochs)
- Saving the model after training
- Printing after training the final testing accuracy

```
In [340]:  def read_my_file_format(filename_queue):
               reader = tf.SomeReader()
               key, record_string = reader.read(filename_queue)
               example, label = tf.some_decoder(record_string)
               processed_example = some_processing(example)
               return processed_example, label

           def input_pipeline(filenames, batch_size, num_epochs=None):
               filename_queue = tf.train.string_input_producer(
```

```
        filenames, num_epochs=num_epochs, shuffle=True)
    example, label = read_my_file_format(filename_queue)
    # min_after_dequeue defines how big a buffer we will randomly sample
    #   from -- bigger means better shuffling but slower start up and mo
re
    #   memory used.
    # capacity must be larger than min_after_dequeue and the amount larg
er
    #   determines the maximum we will prefetch.  Recommendation:
    #   min_after_dequeue + (num_threads + a small safety margin) * batc
h_size
    min_after_dequeue = 10000
    capacity = min_after_dequeue + 3 * batch_size
    example_batch, label_batch = tf.train.shuffle_batch(
        [example, label], batch_size=batch_size, capacity=capacity,
        min_after_dequeue=min_after_dequeue)
    return example_batch, label_batch
```

> **COMMENT:**
> We import the pipeline functions that come from tensorflow:
> https://www.tensorflow.org/programmers_guide/reading_data

```python
In [336]: def CNNtrain(model, cost, optimizer, acc,
                  x, y, keep_prob, TrainingSetSize,
                  X_train, y_train, X_val, y_val, X_test, y_test,
                  init, merged_summary_op,
                  modelName, saveFolder, logsFolder,
                  learning_rate, training_epochs, batch_size, display_step, k
eep_p,
                  loadModel, dataFileName=None
                  ):

    # Initial model print
    print("*Model [", modelName,"] {l_r: %.4f; n_iter: %d; batch: %d}"%\
            (learning_rate, training_epochs, batch_size))

    # Start a tensorflow session
    with tf.Session() as sess:
        print ("   Start Training!")
        sess.run(init)

        # Load model if the parameter loadModel is not empty
        saver = tf.train.Saver()
        if(loadModel):
            saver.restore(sess=sess,save_path='Models/'+loadModel)

        # op to write logs to Tensorboard
        summary_writer = tf.summary.FileWriter(logsFolder,
                                                    graph=tf.get_default_grap
h())

        # Training cycle
        t0 = time.time()
        for epoch in range(training_epochs):
            avg_cost = 0.
            total_batch = int(mnist.train.num_examples/batch_size)
```

```python
            # Loop over all batches
            for i in range(total_batch):

                batch_xs, batch_ys = mnist.train.next_batch(batch_size,
shuffle=True)
                # batch_xs,batch_ys = input_pipeline(filenames=dataFileN
ame,
                                                     batch_size=batch_siz
e,
                                                     num_epochs=total_bat
ch)
                # Run optimization op (backprop), cost op (to get loss v
alue)
                # and summary nodes
                _, c, summary = sess.run([optimizer, cost, merged_summar
y_op],
                                         feed_dict={x: batch_xs,
                                                    y: batch_ys,
                                                    keep_prob: keep_p})
                # Write logs at every iteration
                summary_writer.add_summary(summary, epoch * total_batch
+ i)

                # Compute average loss
                avg_cost += c / total_batch

            # Display logs per epoch step
            if (epoch+1) % display_step == 0:
                tr_acc = acc.eval({x: X_train, y: y_train, keep_prob: 1}
)
                vl_acc = acc.eval({x: X_val, y: y_val, keep_prob: 1})
                print("   Epoch: %02d | Loss=%.9f | TrainAcc=%.3f %% | V
alAcc=%.3f %%"%
                      (epoch+1, avg_cost, tr_acc*100, vl_acc*100));


        print ("   Training Finished in %.1f seconds."%(time.time()-t0))

        # Evaluating model with the accuracies
        print ("   Final accuracies:")
        print ("   ~ TrainAcc: %.3f %%"%(100*acc.eval({x: X_train, y: y_
train, keep_prob: 1})))
        print ("   ~ ValAcc: %.3f %%"%(100*acc.eval({x: X_val, y: y_val,
 keep_prob: 1})))
        print ("   ~ TestAcc: %.3f %%"%(100*acc.eval({x: X_test, y: y_te
st, keep_prob: 1})))

        # Saving Model
        saver.save(sess=sess,save_path=saveFolder+modelName)
        print ("   Saving model in file: %s"%(saveFolder+modelName))
```

COMMENT:

This function implements the session, and using and input pipeline, it fetches batches of data to the graph and runs it in order to obtain results.

The model is evaluated in the end, and we have added a possibility to load previous models as well as saving it. The training and validation accuracies are calculated on every epoch, while test accuracy is only calculated in the end.

In order to keep the original version available, we have commented the original batch function from the mnist dataset.

```
In [299]: # Training our first model!
          CNNet ('lenet5-model',
                    learning_rate = 0.1,
                    training_epochs = 100,
                    batch_size = 128,
                )
```

```
*Model [ lenet5-model ] {l_r: 0.1000; n_iter: 100; batch: 128}
  Start Training!
  Epoch: 01 | Loss=2.306631047 | TrainAcc=10.391 %| ValAcc=11.000 %
  Epoch: 02 | Loss=2.305539821 | TrainAcc=10.251 %| ValAcc=9.860 %
  Epoch: 03 | Loss=2.304715242 | TrainAcc=11.235 %| ValAcc=11.260 %
  Epoch: 04 | Loss=2.304092920 | TrainAcc=9.945 %| ValAcc=9.760 %
  Epoch: 05 | Loss=2.303851811 | TrainAcc=10.391 %| ValAcc=11.000 %
  Epoch: 06 | Loss=2.302999963 | TrainAcc=10.391 %| ValAcc=11.000 %
  Epoch: 07 | Loss=2.301510114 | TrainAcc=9.945 %| ValAcc=9.760 %
  Epoch: 08 | Loss=2.298957096 | TrainAcc=9.945 %| ValAcc=9.760 %
  Epoch: 09 | Loss=2.290840972 | TrainAcc=23.744 %| ValAcc=23.080 %
  Epoch: 10 | Loss=2.217125939 | TrainAcc=45.135 %| ValAcc=45.980 %
  Epoch: 11 | Loss=1.557864240 | TrainAcc=63.400 %| ValAcc=63.560 %
  Epoch: 12 | Loss=0.869937158 | TrainAcc=79.955 %| ValAcc=80.900 %
  Epoch: 13 | Loss=0.587728509 | TrainAcc=85.653 %| ValAcc=86.280 %
  Epoch: 14 | Loss=0.442426659 | TrainAcc=89.376 %| ValAcc=89.680 %
  Epoch: 15 | Loss=0.339899377 | TrainAcc=91.262 %| ValAcc=91.840 %
  Epoch: 16 | Loss=0.284057041 | TrainAcc=92.544 %| ValAcc=93.500 %
  Epoch: 17 | Loss=0.246779823 | TrainAcc=93.407 %| ValAcc=94.320 %
  Epoch: 18 | Loss=0.213511055 | TrainAcc=94.040 %| ValAcc=94.680 %
  Epoch: 19 | Loss=0.193927778 | TrainAcc=94.685 %| ValAcc=95.140 %
  Epoch: 20 | Loss=0.175255372 | TrainAcc=95.049 %| ValAcc=95.460 %
  Epoch: 21 | Loss=0.162582722 | TrainAcc=95.522 %| ValAcc=95.720 %
  Epoch: 22 | Loss=0.147062424 | TrainAcc=95.782 %| ValAcc=95.960 %
  Epoch: 23 | Loss=0.143401140 | TrainAcc=96.045 %| ValAcc=96.360 %
  Epoch: 24 | Loss=0.127880746 | TrainAcc=96.325 %| ValAcc=96.600 %
  Epoch: 25 | Loss=0.122923835 | TrainAcc=96.569 %| ValAcc=96.640 %
  Epoch: 26 | Loss=0.116992221 | TrainAcc=96.664 %| ValAcc=96.680 %
  Epoch: 27 | Loss=0.110676361 | TrainAcc=96.887 %| ValAcc=96.880 %
  Epoch: 28 | Loss=0.105750041 | TrainAcc=97.038 %| ValAcc=97.160 %
  Epoch: 29 | Loss=0.100782192 | TrainAcc=97.111 %| ValAcc=97.120 %
  Epoch: 30 | Loss=0.093881377 | TrainAcc=97.255 %| ValAcc=97.500 %
  Epoch: 31 | Loss=0.094529159 | TrainAcc=97.355 %| ValAcc=97.440 %
  Epoch: 32 | Loss=0.086472801 | TrainAcc=97.460 %| ValAcc=97.480 %
  Epoch: 33 | Loss=0.086841481 | TrainAcc=97.507 %| ValAcc=97.500 %
  Epoch: 34 | Loss=0.082052249 | TrainAcc=97.651 %| ValAcc=97.620 %
  Epoch: 35 | Loss=0.081445980 | TrainAcc=97.756 %| ValAcc=97.800 %
  Epoch: 36 | Loss=0.076425658 | TrainAcc=97.789 %| ValAcc=97.880 %
  Epoch: 37 | Loss=0.075406765 | TrainAcc=97.831 %| ValAcc=97.620 %
  Epoch: 38 | Loss=0.071945635 | TrainAcc=97.787 %| ValAcc=97.760 %
  Epoch: 39 | Loss=0.072156838 | TrainAcc=97.987 %| ValAcc=97.880 %
  Epoch: 40 | Loss=0.067399871 | TrainAcc=97.975 %| ValAcc=97.860 %
  Epoch: 41 | Loss=0.066895949 | TrainAcc=98.065 %| ValAcc=98.080 %
  Epoch: 42 | Loss=0.065822107 | TrainAcc=98.071 %| ValAcc=98.020 %
  Epoch: 43 | Loss=0.064373688 | TrainAcc=98.178 %| ValAcc=97.900 %
  Epoch: 44 | Loss=0.061473853 | TrainAcc=98.116 %| ValAcc=97.740 %
  Epoch: 45 | Loss=0.060343402 | TrainAcc=98.195 %| ValAcc=97.940 %
  Epoch: 46 | Loss=0.060677404 | TrainAcc=98.275 %| ValAcc=98.060 %
```

```
Epoch: 47 | Loss=0.057433997 | TrainAcc=98.316 %| ValAcc=98.180 %
Epoch: 48 | Loss=0.058747132 | TrainAcc=98.244 %| ValAcc=97.800 %
Epoch: 49 | Loss=0.055160534 | TrainAcc=98.387 %| ValAcc=98.120 %
Epoch: 50 | Loss=0.053796961 | TrainAcc=98.433 %| ValAcc=98.200 %
Epoch: 51 | Loss=0.054843310 | TrainAcc=98.427 %| ValAcc=98.340 %
Epoch: 52 | Loss=0.052881928 | TrainAcc=98.502 %| ValAcc=98.280 %
Epoch: 53 | Loss=0.052524625 | TrainAcc=98.473 %| ValAcc=98.400 %
Epoch: 54 | Loss=0.049642457 | TrainAcc=98.575 %| ValAcc=98.280 %
Epoch: 55 | Loss=0.051047719 | TrainAcc=98.582 %| ValAcc=98.420 %
Epoch: 56 | Loss=0.049000237 | TrainAcc=98.565 %| ValAcc=98.320 %
Epoch: 57 | Loss=0.047842143 | TrainAcc=98.600 %| ValAcc=98.420 %
Epoch: 58 | Loss=0.048208271 | TrainAcc=98.585 %| ValAcc=98.240 %
Epoch: 59 | Loss=0.048406639 | TrainAcc=98.675 %| ValAcc=98.480 %
Epoch: 60 | Loss=0.045644873 | TrainAcc=98.705 %| ValAcc=98.520 %
Epoch: 61 | Loss=0.045256516 | TrainAcc=98.651 %| ValAcc=98.340 %
Epoch: 62 | Loss=0.043868340 | TrainAcc=98.722 %| ValAcc=98.440 %
Epoch: 63 | Loss=0.043714555 | TrainAcc=98.736 %| ValAcc=98.620 %
Epoch: 64 | Loss=0.044404055 | TrainAcc=98.707 %| ValAcc=98.420 %
Epoch: 65 | Loss=0.042454557 | TrainAcc=98.800 %| ValAcc=98.560 %
Epoch: 66 | Loss=0.041678178 | TrainAcc=98.791 %| ValAcc=98.480 %
Epoch: 67 | Loss=0.040897159 | TrainAcc=98.847 %| ValAcc=98.620 %
Epoch: 68 | Loss=0.041794721 | TrainAcc=98.893 %| ValAcc=98.660 %
Epoch: 69 | Loss=0.040252054 | TrainAcc=98.867 %| ValAcc=98.600 %
Epoch: 70 | Loss=0.039880601 | TrainAcc=98.742 %| ValAcc=98.500 %
Epoch: 71 | Loss=0.039827537 | TrainAcc=98.927 %| ValAcc=98.580 %
Epoch: 72 | Loss=0.038584120 | TrainAcc=98.904 %| ValAcc=98.660 %
Epoch: 73 | Loss=0.038074038 | TrainAcc=98.947 %| ValAcc=98.640 %
Epoch: 74 | Loss=0.037141427 | TrainAcc=98.858 %| ValAcc=98.620 %
Epoch: 75 | Loss=0.037215871 | TrainAcc=98.940 %| ValAcc=98.660 %
Epoch: 76 | Loss=0.037616341 | TrainAcc=98.987 %| ValAcc=98.660 %
Epoch: 77 | Loss=0.034986995 | TrainAcc=98.984 %| ValAcc=98.580 %
Epoch: 78 | Loss=0.036369161 | TrainAcc=98.938 %| ValAcc=98.580 %
Epoch: 79 | Loss=0.035246240 | TrainAcc=98.980 %| ValAcc=98.580 %
Epoch: 80 | Loss=0.034594428 | TrainAcc=99.025 %| ValAcc=98.640 %
Epoch: 81 | Loss=0.034820716 | TrainAcc=99.036 %| ValAcc=98.640 %
Epoch: 82 | Loss=0.033643226 | TrainAcc=99.095 %| ValAcc=98.640 %
Epoch: 83 | Loss=0.034329354 | TrainAcc=99.065 %| ValAcc=98.740 %
Epoch: 84 | Loss=0.033407850 | TrainAcc=99.085 %| ValAcc=98.740 %
Epoch: 85 | Loss=0.032714229 | TrainAcc=99.109 %| ValAcc=98.660 %
Epoch: 86 | Loss=0.033154654 | TrainAcc=99.122 %| ValAcc=98.700 %
Epoch: 87 | Loss=0.030976301 | TrainAcc=99.104 %| ValAcc=98.720 %
Epoch: 88 | Loss=0.031782167 | TrainAcc=99.144 %| ValAcc=98.660 %
Epoch: 89 | Loss=0.031738917 | TrainAcc=99.125 %| ValAcc=98.660 %
Epoch: 90 | Loss=0.030860026 | TrainAcc=99.165 %| ValAcc=98.700 %
Epoch: 91 | Loss=0.031554804 | TrainAcc=99.138 %| ValAcc=98.740 %
Epoch: 92 | Loss=0.028973189 | TrainAcc=99.189 %| ValAcc=98.760 %
Epoch: 93 | Loss=0.030849772 | TrainAcc=99.131 %| ValAcc=98.720 %
Epoch: 94 | Loss=0.029520935 | TrainAcc=99.236 %| ValAcc=98.740 %
Epoch: 95 | Loss=0.030010340 | TrainAcc=99.144 %| ValAcc=98.740 %
Epoch: 96 | Loss=0.029015477 | TrainAcc=99.231 %| ValAcc=98.640 %
Epoch: 97 | Loss=0.027510516 | TrainAcc=99.211 %| ValAcc=98.700 %
Epoch: 98 | Loss=0.028949183 | TrainAcc=99.269 %| ValAcc=98.760 %
Epoch: 99 | Loss=0.026873244 | TrainAcc=99.182 %| ValAcc=98.740 %
Epoch: 100 | Loss=0.028509810 | TrainAcc=99.273 %| ValAcc=98.760 %
Training Finished in 2687.3 seconds.
Final accuracies:
~ TrainAcc: 99.273 %
~ ValAcc: 98.760 %
~ TestAcc: 98.760 %
Saving model in file: Models/lenet5-model
```

> **COMMENT:**
> First accuracy obtained is 98.76%! very close to the objective of 99%.

2.1.6 Visualization of results with Tensorboard [Question 2.1.6]

We use tensorBoard to visualise and save the LeNet5 Graph and all learning curves. The data is then converted into CSV using the GUI drom tensorboard and is then plotted using Excel. The resulting figures are:

<img src="MNIST_99_Challenge_Figures/LeNet5_graph.png",width="800" height="600" align="center">

Figure 3: LeNet5 Graph

Figure 4: LeNet5 Training

> **COMMENT:**
> There is an initial step of search for a steep surface in the loss function, and in the epoch 8-9 it starts converging fast, completely stabilizing after epoch 50.

2.2 LeNet5 Optimization

2.2.1 Parameter Tuning [Question 2.2.1]

We change the sigmoid function to a Relu and perform the next steps:

- Retrain the network with SGD and AdamOptimizer. Compare them with the best parameters:

Optimizer	Gradient Descent	AdamOptimizer
Validation Accuracy	98.760 %	99.080 %
Testing Accuracy	98.670 %	99.110 %
Training Time	8048 s	2670 s

- Try with different learning rates for each Optimizer (0.0001 and 0.001) and different Batch sizes (50 and 128) for 10000 Epochs.
- For each optimizer, plot (on the same curve) the **testing accuracies** function to **(learning rate, batch size)**

- Did you reach the 99% accuracy ? What are the optimal parametres that gave you the best results?

<img src="MNIST_99_Challenge_Figures/ParameterTuning.png",width="800" height="600" align="center">
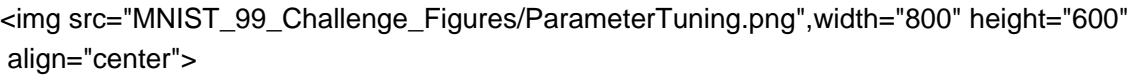
Figure 5: Parameter Tuning

> **COMMENT:**
> Clearly the Adam Optimizer is better than the SGD, and in much less time.
>
> We tried with several parameters and thebest combination we found is **AdamOptimizer, lr=0.001 bs=128**.
>
> Also, we achieved the desired accuracy of 99%!

```
In [297]:  # Trying parameters with SGD
           setOfParams = [ [0.001, 250, 50, 'lenet5-model_relu_lr0001_bs50'],
                           [0.001, 100, 128, 'lenet5-model_relu_lr0001_bs128'],
                           [0.0001, 250, 50, 'lenet5-model_relu_lr00001_bs50'],
                           [0.0001, 100, 128, 'lenet5-model_relu_lr00001_bs128'],

           ]
           for p in setOfParams:
               CNNet (modelName=p[3],
                      learning_rate = p[0],
                      training_epochs = p[1],
                      batch_size = p[2],
                      activationFunc=tf.nn.relu,
                  )
```

```
*Model [ lenet5-model_relu_lr0001_bs50 ] {l_r: 0.0010; n_iter: 250; batch: 50}
   Start Training!
   Epoch: 01 | Loss=2.285461369 | TrainAcc=32.773 %| ValAcc=32.020 %
   Epoch: 02 | Loss=2.132812783 | TrainAcc=59.864 %| ValAcc=59.840 %
   Epoch: 03 | Loss=1.361398856 | TrainAcc=81.147 %| ValAcc=82.020 %
   Epoch: 04 | Loss=0.553005308 | TrainAcc=87.944 %| ValAcc=88.600 %
   Epoch: 05 | Loss=0.384707743 | TrainAcc=89.689 %| ValAcc=90.440 %
   Epoch: 06 | Loss=0.323377239 | TrainAcc=90.982 %| ValAcc=92.000 %
   Epoch: 07 | Loss=0.287973725 | TrainAcc=91.936 %| ValAcc=92.680 %
   Epoch: 08 | Loss=0.263154375 | TrainAcc=92.489 %| ValAcc=93.280 %
   Epoch: 09 | Loss=0.239348642 | TrainAcc=93.165 %| ValAcc=93.920 %
   Epoch: 10 | Loss=0.222846294 | TrainAcc=93.533 %| ValAcc=94.260 %
   Epoch: 11 | Loss=0.211532476 | TrainAcc=93.960 %| ValAcc=94.620 %
   Epoch: 12 | Loss=0.196222519 | TrainAcc=94.267 %| ValAcc=94.860 %
   Epoch: 13 | Loss=0.184968149 | TrainAcc=94.775 %| ValAcc=95.500 %
   Epoch: 14 | Loss=0.171088510 | TrainAcc=95.025 %| ValAcc=95.720 %
   Epoch: 15 | Loss=0.165861866 | TrainAcc=95.309 %| ValAcc=95.800 %
   Epoch: 16 | Loss=0.160169858 | TrainAcc=95.518 %| ValAcc=95.960 %
   Epoch: 17 | Loss=0.149477239 | TrainAcc=95.689 %| ValAcc=96.140 %
   Epoch: 18 | Loss=0.144087977 | TrainAcc=95.689 %| ValAcc=96.160 %
   Epoch: 19 | Loss=0.137406570 | TrainAcc=96.029 %| ValAcc=96.480 %
   Epoch: 20 | Loss=0.133413623 | TrainAcc=96.204 %| ValAcc=96.540 %
   Epoch: 21 | Loss=0.128573287 | TrainAcc=96.293 %| ValAcc=96.600 %
   Epoch: 22 | Loss=0.123372656 | TrainAcc=96.427 %| ValAcc=96.900 %
   Epoch: 23 | Loss=0.119049564 | TrainAcc=96.502 %| ValAcc=96.880 %
   Epoch: 24 | Loss=0.116334625 | TrainAcc=96.631 %| ValAcc=96.940 %
   Epoch: 25 | Loss=0.109801858 | TrainAcc=96.707 %| ValAcc=97.060 %
```

```
Epoch:  26  |  Loss=0.112535800  |  TrainAcc=96.818 %|  ValAcc=97.120 %
Epoch:  27  |  Loss=0.105374946  |  TrainAcc=96.898 %|  ValAcc=97.300 %
Epoch:  28  |  Loss=0.104557877  |  TrainAcc=96.958 %|  ValAcc=97.060 %
Epoch:  29  |  Loss=0.102630379  |  TrainAcc=97.067 %|  ValAcc=97.260 %
Epoch:  30  |  Loss=0.096915770  |  TrainAcc=97.085 %|  ValAcc=97.220 %
Epoch:  31  |  Loss=0.098936162  |  TrainAcc=97.173 %|  ValAcc=97.340 %
Epoch:  32  |  Loss=0.094192208  |  TrainAcc=97.093 %|  ValAcc=97.240 %
Epoch:  33  |  Loss=0.091378372  |  TrainAcc=97.285 %|  ValAcc=97.400 %
Epoch:  34  |  Loss=0.093414419  |  TrainAcc=97.318 %|  ValAcc=97.420 %
Epoch:  35  |  Loss=0.087457429  |  TrainAcc=97.405 %|  ValAcc=97.540 %
Epoch:  36  |  Loss=0.086215350  |  TrainAcc=97.445 %|  ValAcc=97.520 %
Epoch:  37  |  Loss=0.087351593  |  TrainAcc=97.484 %|  ValAcc=97.520 %
Epoch:  38  |  Loss=0.082163252  |  TrainAcc=97.529 %|  ValAcc=97.600 %
Epoch:  39  |  Loss=0.083657361  |  TrainAcc=97.480 %|  ValAcc=97.560 %
Epoch:  40  |  Loss=0.082037196  |  TrainAcc=97.611 %|  ValAcc=97.560 %
Epoch:  41  |  Loss=0.078911429  |  TrainAcc=97.616 %|  ValAcc=97.580 %
Epoch:  42  |  Loss=0.079888741  |  TrainAcc=97.665 %|  ValAcc=97.680 %
Epoch:  43  |  Loss=0.078120012  |  TrainAcc=97.729 %|  ValAcc=97.640 %
Epoch:  44  |  Loss=0.077282885  |  TrainAcc=97.662 %|  ValAcc=97.820 %
Epoch:  45  |  Loss=0.075211456  |  TrainAcc=97.747 %|  ValAcc=97.620 %
Epoch:  46  |  Loss=0.071960739  |  TrainAcc=97.744 %|  ValAcc=97.840 %
Epoch:  47  |  Loss=0.072970361  |  TrainAcc=97.776 %|  ValAcc=97.780 %
Epoch:  48  |  Loss=0.073176821  |  TrainAcc=97.858 %|  ValAcc=97.720 %
Epoch:  49  |  Loss=0.070212999  |  TrainAcc=97.876 %|  ValAcc=97.860 %
Epoch:  50  |  Loss=0.072299475  |  TrainAcc=97.918 %|  ValAcc=97.840 %
Epoch:  51  |  Loss=0.069322755  |  TrainAcc=97.820 %|  ValAcc=97.720 %
Epoch:  52  |  Loss=0.067632132  |  TrainAcc=97.909 %|  ValAcc=97.680 %
Epoch:  53  |  Loss=0.068068573  |  TrainAcc=98.020 %|  ValAcc=97.820 %
Epoch:  54  |  Loss=0.068350828  |  TrainAcc=98.036 %|  ValAcc=97.780 %
Epoch:  55  |  Loss=0.064534768  |  TrainAcc=98.053 %|  ValAcc=97.860 %
Epoch:  56  |  Loss=0.065155246  |  TrainAcc=98.064 %|  ValAcc=97.820 %
Epoch:  57  |  Loss=0.063375496  |  TrainAcc=98.115 %|  ValAcc=97.780 %
Epoch:  58  |  Loss=0.064139586  |  TrainAcc=98.060 %|  ValAcc=97.860 %
Epoch:  59  |  Loss=0.063935661  |  TrainAcc=98.135 %|  ValAcc=97.920 %
Epoch:  60  |  Loss=0.061815903  |  TrainAcc=98.067 %|  ValAcc=97.720 %
Epoch:  61  |  Loss=0.060524897  |  TrainAcc=98.156 %|  ValAcc=97.840 %
Epoch:  62  |  Loss=0.059319592  |  TrainAcc=98.153 %|  ValAcc=97.860 %
Epoch:  63  |  Loss=0.062925885  |  TrainAcc=98.082 %|  ValAcc=97.820 %
Epoch:  64  |  Loss=0.058194372  |  TrainAcc=98.218 %|  ValAcc=97.900 %
Epoch:  65  |  Loss=0.058804354  |  TrainAcc=98.224 %|  ValAcc=97.860 %
Epoch:  66  |  Loss=0.058604298  |  TrainAcc=98.304 %|  ValAcc=97.940 %
Epoch:  67  |  Loss=0.058870856  |  TrainAcc=98.309 %|  ValAcc=98.120 %
Epoch:  68  |  Loss=0.057657476  |  TrainAcc=98.300 %|  ValAcc=97.980 %
Epoch:  69  |  Loss=0.056509917  |  TrainAcc=98.324 %|  ValAcc=98.160 %
Epoch:  70  |  Loss=0.055091935  |  TrainAcc=98.316 %|  ValAcc=97.960 %
Epoch:  71  |  Loss=0.056100632  |  TrainAcc=98.365 %|  ValAcc=98.000 %
Epoch:  72  |  Loss=0.054292002  |  TrainAcc=98.365 %|  ValAcc=97.960 %
Epoch:  73  |  Loss=0.053274232  |  TrainAcc=98.420 %|  ValAcc=98.020 %
Epoch:  74  |  Loss=0.056076834  |  TrainAcc=98.375 %|  ValAcc=98.120 %
Epoch:  75  |  Loss=0.053387047  |  TrainAcc=98.358 %|  ValAcc=98.200 %
Epoch:  76  |  Loss=0.051661383  |  TrainAcc=98.380 %|  ValAcc=98.200 %
Epoch:  77  |  Loss=0.053674746  |  TrainAcc=98.436 %|  ValAcc=98.160 %
Epoch:  78  |  Loss=0.052451015  |  TrainAcc=98.429 %|  ValAcc=98.040 %
Epoch:  79  |  Loss=0.051703369  |  TrainAcc=98.464 %|  ValAcc=98.000 %
Epoch:  80  |  Loss=0.051153506  |  TrainAcc=98.413 %|  ValAcc=98.020 %
Epoch:  81  |  Loss=0.049609337  |  TrainAcc=98.518 %|  ValAcc=98.260 %
Epoch:  82  |  Loss=0.050663759  |  TrainAcc=98.507 %|  ValAcc=98.200 %
Epoch:  83  |  Loss=0.049329799  |  TrainAcc=98.458 %|  ValAcc=98.020 %
Epoch:  84  |  Loss=0.050106153  |  TrainAcc=98.518 %|  ValAcc=98.100 %
Epoch:  85  |  Loss=0.048873586  |  TrainAcc=98.484 %|  ValAcc=98.120 %
Epoch:  86  |  Loss=0.047096422  |  TrainAcc=98.465 %|  ValAcc=98.140 %
```

```
Epoch:  87 | Loss=0.049887148 | TrainAcc=98.575 %| ValAcc=98.180 %
Epoch:  88 | Loss=0.046943648 | TrainAcc=98.585 %| ValAcc=98.120 %
Epoch:  89 | Loss=0.045796685 | TrainAcc=98.591 %| ValAcc=98.200 %
Epoch:  90 | Loss=0.048680889 | TrainAcc=98.595 %| ValAcc=98.140 %
Epoch:  91 | Loss=0.045938718 | TrainAcc=98.689 %| ValAcc=98.260 %
Epoch:  92 | Loss=0.047030030 | TrainAcc=98.622 %| ValAcc=98.120 %
Epoch:  93 | Loss=0.044578014 | TrainAcc=98.716 %| ValAcc=98.240 %
Epoch:  94 | Loss=0.046290484 | TrainAcc=98.729 %| ValAcc=98.300 %
Epoch:  95 | Loss=0.045873421 | TrainAcc=98.649 %| ValAcc=98.380 %
Epoch:  96 | Loss=0.043261532 | TrainAcc=98.718 %| ValAcc=98.280 %
Epoch:  97 | Loss=0.045893035 | TrainAcc=98.740 %| ValAcc=98.320 %
Epoch:  98 | Loss=0.043294866 | TrainAcc=98.582 %| ValAcc=98.180 %
Epoch:  99 | Loss=0.045202967 | TrainAcc=98.749 %| ValAcc=98.240 %
Epoch: 100 | Loss=0.043704280 | TrainAcc=98.782 %| ValAcc=98.300 %
Epoch: 101 | Loss=0.041505274 | TrainAcc=98.711 %| ValAcc=98.320 %
Epoch: 102 | Loss=0.043946795 | TrainAcc=98.698 %| ValAcc=98.380 %
Epoch: 103 | Loss=0.040998889 | TrainAcc=98.736 %| ValAcc=98.340 %
Epoch: 104 | Loss=0.042414350 | TrainAcc=98.773 %| ValAcc=98.440 %
Epoch: 105 | Loss=0.040338580 | TrainAcc=98.689 %| ValAcc=98.320 %
Epoch: 106 | Loss=0.042805888 | TrainAcc=98.705 %| ValAcc=98.240 %
Epoch: 107 | Loss=0.039416220 | TrainAcc=98.745 %| ValAcc=98.400 %
Epoch: 108 | Loss=0.041300113 | TrainAcc=98.891 %| ValAcc=98.380 %
Epoch: 109 | Loss=0.040174271 | TrainAcc=98.707 %| ValAcc=98.220 %
Epoch: 110 | Loss=0.040036633 | TrainAcc=98.896 %| ValAcc=98.440 %
Epoch: 111 | Loss=0.040614730 | TrainAcc=98.816 %| ValAcc=98.420 %
Epoch: 112 | Loss=0.038078927 | TrainAcc=98.887 %| ValAcc=98.540 %
Epoch: 113 | Loss=0.040605902 | TrainAcc=98.776 %| ValAcc=98.340 %
Epoch: 114 | Loss=0.038576678 | TrainAcc=98.913 %| ValAcc=98.500 %
Epoch: 115 | Loss=0.039944093 | TrainAcc=98.780 %| ValAcc=98.380 %
Epoch: 116 | Loss=0.038215257 | TrainAcc=98.891 %| ValAcc=98.460 %
Epoch: 117 | Loss=0.038546574 | TrainAcc=98.893 %| ValAcc=98.220 %
Epoch: 118 | Loss=0.037203973 | TrainAcc=98.984 %| ValAcc=98.520 %
Epoch: 119 | Loss=0.038822611 | TrainAcc=98.964 %| ValAcc=98.420 %
Epoch: 120 | Loss=0.035974897 | TrainAcc=98.936 %| ValAcc=98.380 %
Epoch: 121 | Loss=0.038453726 | TrainAcc=98.958 %| ValAcc=98.600 %
Epoch: 122 | Loss=0.036388228 | TrainAcc=98.969 %| ValAcc=98.580 %
Epoch: 123 | Loss=0.037233435 | TrainAcc=98.985 %| ValAcc=98.600 %
Epoch: 124 | Loss=0.035949366 | TrainAcc=98.969 %| ValAcc=98.500 %
Epoch: 125 | Loss=0.035691601 | TrainAcc=98.891 %| ValAcc=98.460 %
Epoch: 126 | Loss=0.036916094 | TrainAcc=98.864 %| ValAcc=98.440 %
Epoch: 127 | Loss=0.036189874 | TrainAcc=98.976 %| ValAcc=98.540 %
Epoch: 128 | Loss=0.035201176 | TrainAcc=98.873 %| ValAcc=98.280 %
Epoch: 129 | Loss=0.035285351 | TrainAcc=98.960 %| ValAcc=98.420 %
Epoch: 130 | Loss=0.034165581 | TrainAcc=98.985 %| ValAcc=98.540 %
Epoch: 131 | Loss=0.035110146 | TrainAcc=99.062 %| ValAcc=98.500 %
Epoch: 132 | Loss=0.035466153 | TrainAcc=99.007 %| ValAcc=98.480 %
Epoch: 133 | Loss=0.034104754 | TrainAcc=98.984 %| ValAcc=98.480 %
Epoch: 134 | Loss=0.032952479 | TrainAcc=98.996 %| ValAcc=98.560 %
Epoch: 135 | Loss=0.034341251 | TrainAcc=99.053 %| ValAcc=98.380 %
Epoch: 136 | Loss=0.034164459 | TrainAcc=99.009 %| ValAcc=98.480 %
Epoch: 137 | Loss=0.031646022 | TrainAcc=99.100 %| ValAcc=98.700 %
Epoch: 138 | Loss=0.034897388 | TrainAcc=99.062 %| ValAcc=98.440 %
Epoch: 139 | Loss=0.031209846 | TrainAcc=99.067 %| ValAcc=98.540 %
Epoch: 140 | Loss=0.034334577 | TrainAcc=99.035 %| ValAcc=98.500 %
Epoch: 141 | Loss=0.030958260 | TrainAcc=99.080 %| ValAcc=98.580 %
Epoch: 142 | Loss=0.033168876 | TrainAcc=99.111 %| ValAcc=98.560 %
Epoch: 143 | Loss=0.031770934 | TrainAcc=99.138 %| ValAcc=98.640 %
Epoch: 144 | Loss=0.030609913 | TrainAcc=99.122 %| ValAcc=98.580 %
Epoch: 145 | Loss=0.031782280 | TrainAcc=98.956 %| ValAcc=98.380 %
Epoch: 146 | Loss=0.030870964 | TrainAcc=99.056 %| ValAcc=98.460 %
Epoch: 147 | Loss=0.032422362 | TrainAcc=99.131 %| ValAcc=98.520 %
```

```
Epoch:  148  |  Loss=0.030325894  |  TrainAcc=99.064 %|  ValAcc=98.640 %
Epoch:  149  |  Loss=0.029634164  |  TrainAcc=98.924 %|  ValAcc=98.400 %
Epoch:  150  |  Loss=0.032134254  |  TrainAcc=99.211 %|  ValAcc=98.560 %
Epoch:  151  |  Loss=0.029420324  |  TrainAcc=99.178 %|  ValAcc=98.500 %
Epoch:  152  |  Loss=0.030842710  |  TrainAcc=99.144 %|  ValAcc=98.580 %
Epoch:  153  |  Loss=0.029855028  |  TrainAcc=99.200 %|  ValAcc=98.720 %
Epoch:  154  |  Loss=0.030333675  |  TrainAcc=99.182 %|  ValAcc=98.600 %
Epoch:  155  |  Loss=0.028160731  |  TrainAcc=99.216 %|  ValAcc=98.580 %
Epoch:  156  |  Loss=0.030038591  |  TrainAcc=99.140 %|  ValAcc=98.580 %
Epoch:  157  |  Loss=0.028323901  |  TrainAcc=99.222 %|  ValAcc=98.600 %
Epoch:  158  |  Loss=0.029973145  |  TrainAcc=99.098 %|  ValAcc=98.600 %
Epoch:  159  |  Loss=0.028062839  |  TrainAcc=99.109 %|  ValAcc=98.420 %
Epoch:  160  |  Loss=0.030644112  |  TrainAcc=99.200 %|  ValAcc=98.680 %
Epoch:  161  |  Loss=0.027604050  |  TrainAcc=99.235 %|  ValAcc=98.540 %
Epoch:  162  |  Loss=0.027658464  |  TrainAcc=99.189 %|  ValAcc=98.580 %
Epoch:  163  |  Loss=0.028571386  |  TrainAcc=99.207 %|  ValAcc=98.500 %
Epoch:  164  |  Loss=0.029378573  |  TrainAcc=99.247 %|  ValAcc=98.580 %
Epoch:  165  |  Loss=0.026748579  |  TrainAcc=99.267 %|  ValAcc=98.640 %
Epoch:  166  |  Loss=0.027414794  |  TrainAcc=99.236 %|  ValAcc=98.440 %
Epoch:  167  |  Loss=0.027102780  |  TrainAcc=99.311 %|  ValAcc=98.620 %
Epoch:  168  |  Loss=0.027056465  |  TrainAcc=99.213 %|  ValAcc=98.540 %
Epoch:  169  |  Loss=0.027199734  |  TrainAcc=99.065 %|  ValAcc=98.380 %
Epoch:  170  |  Loss=0.027188095  |  TrainAcc=99.247 %|  ValAcc=98.680 %
Epoch:  171  |  Loss=0.026980946  |  TrainAcc=99.224 %|  ValAcc=98.440 %
Epoch:  172  |  Loss=0.025870041  |  TrainAcc=99.213 %|  ValAcc=98.640 %
Epoch:  173  |  Loss=0.026671702  |  TrainAcc=99.245 %|  ValAcc=98.600 %
Epoch:  174  |  Loss=0.026486101  |  TrainAcc=99.180 %|  ValAcc=98.500 %
Epoch:  175  |  Loss=0.026025766  |  TrainAcc=99.349 %|  ValAcc=98.680 %
Epoch:  176  |  Loss=0.026300980  |  TrainAcc=99.280 %|  ValAcc=98.540 %
Epoch:  177  |  Loss=0.025519698  |  TrainAcc=99.267 %|  ValAcc=98.540 %
Epoch:  178  |  Loss=0.024657348  |  TrainAcc=99.356 %|  ValAcc=98.580 %
Epoch:  179  |  Loss=0.025053132  |  TrainAcc=99.358 %|  ValAcc=98.540 %
Epoch:  180  |  Loss=0.026010278  |  TrainAcc=99.340 %|  ValAcc=98.720 %
Epoch:  181  |  Loss=0.025944371  |  TrainAcc=99.282 %|  ValAcc=98.560 %
Epoch:  182  |  Loss=0.023953962  |  TrainAcc=99.338 %|  ValAcc=98.580 %
Epoch:  183  |  Loss=0.025965131  |  TrainAcc=99.342 %|  ValAcc=98.680 %
Epoch:  184  |  Loss=0.023646340  |  TrainAcc=99.305 %|  ValAcc=98.500 %
Epoch:  185  |  Loss=0.025258801  |  TrainAcc=99.362 %|  ValAcc=98.700 %
Epoch:  186  |  Loss=0.023754590  |  TrainAcc=99.329 %|  ValAcc=98.620 %
Epoch:  187  |  Loss=0.025041964  |  TrainAcc=99.315 %|  ValAcc=98.520 %
Epoch:  188  |  Loss=0.023527632  |  TrainAcc=99.342 %|  ValAcc=98.600 %
Epoch:  189  |  Loss=0.023989654  |  TrainAcc=99.407 %|  ValAcc=98.700 %
Epoch:  190  |  Loss=0.022928843  |  TrainAcc=99.349 %|  ValAcc=98.620 %
Epoch:  191  |  Loss=0.024109010  |  TrainAcc=99.304 %|  ValAcc=98.680 %
Epoch:  192  |  Loss=0.025049035  |  TrainAcc=99.329 %|  ValAcc=98.400 %
Epoch:  193  |  Loss=0.023319230  |  TrainAcc=99.429 %|  ValAcc=98.640 %
Epoch:  194  |  Loss=0.021342231  |  TrainAcc=99.340 %|  ValAcc=98.400 %
Epoch:  195  |  Loss=0.024970745  |  TrainAcc=99.391 %|  ValAcc=98.460 %
Epoch:  196  |  Loss=0.021880959  |  TrainAcc=99.362 %|  ValAcc=98.600 %
Epoch:  197  |  Loss=0.022764517  |  TrainAcc=99.400 %|  ValAcc=98.660 %
Epoch:  198  |  Loss=0.022771413  |  TrainAcc=99.445 %|  ValAcc=98.660 %
Epoch:  199  |  Loss=0.022161808  |  TrainAcc=99.382 %|  ValAcc=98.600 %
Epoch:  200  |  Loss=0.023144943  |  TrainAcc=99.424 %|  ValAcc=98.580 %
Epoch:  201  |  Loss=0.021443361  |  TrainAcc=99.442 %|  ValAcc=98.600 %
Epoch:  202  |  Loss=0.023033988  |  TrainAcc=99.422 %|  ValAcc=98.460 %
Epoch:  203  |  Loss=0.021147883  |  TrainAcc=99.405 %|  ValAcc=98.560 %
Epoch:  204  |  Loss=0.022433182  |  TrainAcc=99.447 %|  ValAcc=98.580 %
Epoch:  205  |  Loss=0.022052104  |  TrainAcc=99.384 %|  ValAcc=98.540 %
Epoch:  206  |  Loss=0.020684697  |  TrainAcc=99.500 %|  ValAcc=98.680 %
Epoch:  207  |  Loss=0.022343690  |  TrainAcc=99.464 %|  ValAcc=98.680 %
Epoch:  208  |  Loss=0.021391985  |  TrainAcc=99.431 %|  ValAcc=98.680 %
```

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Epoch: 209 | Loss=0.020406419 | TrainAcc=99.367 %| ValAcc=98.460 %
Epoch: 210 | Loss=0.021115260 | TrainAcc=99.476 %| ValAcc=98.740 %
Epoch: 211 | Loss=0.021083723 | TrainAcc=99.382 %| ValAcc=98.640 %
Epoch: 212 | Loss=0.021272094 | TrainAcc=99.462 %| ValAcc=98.600 %
Epoch: 213 | Loss=0.019890089 | TrainAcc=99.495 %| ValAcc=98.720 %
Epoch: 214 | Loss=0.020367526 | TrainAcc=99.513 %| ValAcc=98.660 %
Epoch: 215 | Loss=0.021144189 | TrainAcc=99.485 %| ValAcc=98.580 %
Epoch: 216 | Loss=0.020042413 | TrainAcc=99.493 %| ValAcc=98.740 %
Epoch: 217 | Loss=0.020319316 | TrainAcc=99.480 %| ValAcc=98.540 %
Epoch: 218 | Loss=0.020316104 | TrainAcc=99.511 %| ValAcc=98.680 %
Epoch: 219 | Loss=0.018853393 | TrainAcc=99.380 %| ValAcc=98.600 %
Epoch: 220 | Loss=0.020540637 | TrainAcc=99.524 %| ValAcc=98.780 %
Epoch: 221 | Loss=0.020118519 | TrainAcc=99.478 %| ValAcc=98.680 %
Epoch: 222 | Loss=0.018931521 | TrainAcc=99.467 %| ValAcc=98.600 %
Epoch: 223 | Loss=0.019585990 | TrainAcc=99.476 %| ValAcc=98.640 %
Epoch: 224 | Loss=0.020097468 | TrainAcc=99.455 %| ValAcc=98.640 %
Epoch: 225 | Loss=0.017883253 | TrainAcc=99.482 %| ValAcc=98.660 %
Epoch: 226 | Loss=0.019998586 | TrainAcc=99.520 %| ValAcc=98.780 %
Epoch: 227 | Loss=0.019607758 | TrainAcc=99.347 %| ValAcc=98.460 %
Epoch: 228 | Loss=0.017962221 | TrainAcc=99.465 %| ValAcc=98.800 %
Epoch: 229 | Loss=0.019619857 | TrainAcc=99.540 %| ValAcc=98.640 %
Epoch: 230 | Loss=0.018274406 | TrainAcc=99.445 %| ValAcc=98.620 %
Epoch: 231 | Loss=0.019043442 | TrainAcc=99.520 %| ValAcc=98.720 %
Epoch: 232 | Loss=0.018268231 | TrainAcc=99.513 %| ValAcc=98.640 %
Epoch: 233 | Loss=0.018206333 | TrainAcc=99.553 %| ValAcc=98.700 %
Epoch: 234 | Loss=0.018864286 | TrainAcc=99.578 %| ValAcc=98.680 %
Epoch: 235 | Loss=0.018296132 | TrainAcc=99.549 %| ValAcc=98.780 %
Epoch: 236 | Loss=0.018326587 | TrainAcc=99.513 %| ValAcc=98.740 %
Epoch: 237 | Loss=0.017348832 | TrainAcc=99.527 %| ValAcc=98.700 %
Epoch: 238 | Loss=0.017273919 | TrainAcc=99.575 %| ValAcc=98.720 %
Epoch: 239 | Loss=0.018349680 | TrainAcc=99.484 %| ValAcc=98.560 %
Epoch: 240 | Loss=0.017956691 | TrainAcc=99.558 %| ValAcc=98.740 %
Epoch: 241 | Loss=0.016142235 | TrainAcc=99.567 %| ValAcc=98.680 %
Epoch: 242 | Loss=0.018590857 | TrainAcc=99.593 %| ValAcc=98.680 %
Epoch: 243 | Loss=0.016355724 | TrainAcc=99.591 %| ValAcc=98.660 %
Epoch: 244 | Loss=0.018008449 | TrainAcc=99.611 %| ValAcc=98.760 %
Epoch: 245 | Loss=0.016973843 | TrainAcc=99.533 %| ValAcc=98.740 %
Epoch: 246 | Loss=0.016064819 | TrainAcc=99.580 %| ValAcc=98.700 %
Epoch: 247 | Loss=0.016608465 | TrainAcc=99.560 %| ValAcc=98.740 %
Epoch: 248 | Loss=0.018074080 | TrainAcc=99.533 %| ValAcc=98.600 %
Epoch: 249 | Loss=0.016987511 | TrainAcc=99.555 %| ValAcc=98.600 %
Epoch: 250 | Loss=0.016613258 | TrainAcc=99.613 %| ValAcc=98.760 %
Training Finished in 8048.2 seconds.
Final accuracies:
~ TrainAcc: 99.613 %
~ ValAcc: 98.760 %
~ TestAcc: 98.670 %
Saving model in file: Models/lenet5-model_relu_lr0001_bs50
*Model [ lenet5-model_relu_lr0001_bs128 ] {l_r: 0.0010; n_iter: 100; bat
ch: 128}
Start Training!
Epoch: 01 | Loss=2.293035556 | TrainAcc=22.165 %| ValAcc=20.940 %
Epoch: 02 | Loss=2.246666034 | TrainAcc=33.467 %| ValAcc=32.760 %
Epoch: 03 | Loss=2.186070200 | TrainAcc=39.667 %| ValAcc=39.200 %
Epoch: 04 | Loss=2.063561223 | TrainAcc=49.151 %| ValAcc=49.440 %
Epoch: 05 | Loss=1.768198797 | TrainAcc=66.075 %| ValAcc=66.360 %
Epoch: 06 | Loss=1.249351058 | TrainAcc=75.558 %| ValAcc=75.660 %
Epoch: 07 | Loss=0.835257401 | TrainAcc=80.755 %| ValAcc=81.040 %
Epoch: 08 | Loss=0.636793443 | TrainAcc=83.851 %| ValAcc=84.720 %
Epoch: 09 | Loss=0.538231127 | TrainAcc=85.818 %| ValAcc=86.540 %
Epoch: 10 | Loss=0.471492427 | TrainAcc=87.236 %| ValAcc=88.120 %
```

```
Epoch: 11 | Loss=0.426160102 | TrainAcc=88.271 %| ValAcc=89.260 %
Epoch: 12 | Loss=0.394364733 | TrainAcc=89.120 %| ValAcc=90.080 %
Epoch: 13 | Loss=0.359810770 | TrainAcc=89.545 %| ValAcc=90.800 %
Epoch: 14 | Loss=0.346231685 | TrainAcc=90.260 %| ValAcc=91.380 %
Epoch: 15 | Loss=0.326311756 | TrainAcc=90.700 %| ValAcc=91.700 %
Epoch: 16 | Loss=0.308703201 | TrainAcc=90.993 %| ValAcc=91.920 %
Epoch: 17 | Loss=0.294904229 | TrainAcc=91.429 %| ValAcc=92.340 %
Epoch: 18 | Loss=0.280363275 | TrainAcc=91.718 %| ValAcc=92.460 %
Epoch: 19 | Loss=0.274616572 | TrainAcc=92.102 %| ValAcc=92.640 %
Epoch: 20 | Loss=0.261235427 | TrainAcc=92.400 %| ValAcc=92.780 %
Epoch: 21 | Loss=0.250474909 | TrainAcc=92.624 %| ValAcc=92.940 %
Epoch: 22 | Loss=0.244036376 | TrainAcc=92.858 %| ValAcc=93.200 %
Epoch: 23 | Loss=0.236118098 | TrainAcc=93.002 %| ValAcc=93.500 %
Epoch: 24 | Loss=0.230162490 | TrainAcc=93.293 %| ValAcc=93.440 %
Epoch: 25 | Loss=0.220249829 | TrainAcc=93.547 %| ValAcc=94.100 %
Epoch: 26 | Loss=0.214611463 | TrainAcc=93.645 %| ValAcc=94.060 %
Epoch: 27 | Loss=0.209055034 | TrainAcc=93.971 %| ValAcc=94.100 %
Epoch: 28 | Loss=0.206053230 | TrainAcc=94.131 %| ValAcc=94.520 %
Epoch: 29 | Loss=0.196894795 | TrainAcc=94.269 %| ValAcc=94.820 %
Epoch: 30 | Loss=0.192198141 | TrainAcc=94.369 %| ValAcc=94.860 %
Epoch: 31 | Loss=0.189277246 | TrainAcc=94.558 %| ValAcc=94.960 %
Epoch: 32 | Loss=0.184327742 | TrainAcc=94.756 %| ValAcc=95.180 %
Epoch: 33 | Loss=0.180260290 | TrainAcc=94.795 %| ValAcc=95.200 %
Epoch: 34 | Loss=0.173474034 | TrainAcc=94.889 %| ValAcc=95.180 %
Epoch: 35 | Loss=0.174056324 | TrainAcc=95.004 %| ValAcc=95.320 %
Epoch: 36 | Loss=0.165283750 | TrainAcc=95.075 %| ValAcc=95.380 %
Epoch: 37 | Loss=0.166025882 | TrainAcc=95.175 %| ValAcc=95.720 %
Epoch: 38 | Loss=0.159386282 | TrainAcc=95.285 %| ValAcc=95.620 %
Epoch: 39 | Loss=0.158759687 | TrainAcc=95.453 %| ValAcc=95.820 %
Epoch: 40 | Loss=0.157157082 | TrainAcc=95.471 %| ValAcc=95.800 %
Epoch: 41 | Loss=0.148359736 | TrainAcc=95.591 %| ValAcc=95.940 %
Epoch: 42 | Loss=0.149188039 | TrainAcc=95.664 %| ValAcc=95.940 %
Epoch: 43 | Loss=0.146598287 | TrainAcc=95.765 %| ValAcc=95.960 %
Epoch: 44 | Loss=0.145838529 | TrainAcc=95.838 %| ValAcc=96.060 %
Epoch: 45 | Loss=0.139487645 | TrainAcc=95.871 %| ValAcc=96.140 %
Epoch: 46 | Loss=0.140147173 | TrainAcc=95.933 %| ValAcc=96.180 %
Epoch: 47 | Loss=0.134008562 | TrainAcc=96.053 %| ValAcc=96.240 %
Epoch: 48 | Loss=0.136843647 | TrainAcc=96.058 %| ValAcc=96.420 %
Epoch: 49 | Loss=0.129832151 | TrainAcc=96.145 %| ValAcc=96.320 %
Epoch: 50 | Loss=0.129506139 | TrainAcc=96.235 %| ValAcc=96.440 %
Epoch: 51 | Loss=0.129012275 | TrainAcc=96.322 %| ValAcc=96.460 %
Epoch: 52 | Loss=0.125390068 | TrainAcc=96.322 %| ValAcc=96.420 %
Epoch: 53 | Loss=0.124851513 | TrainAcc=96.373 %| ValAcc=96.580 %
Epoch: 54 | Loss=0.122864547 | TrainAcc=96.396 %| ValAcc=96.540 %
Epoch: 55 | Loss=0.120778402 | TrainAcc=96.480 %| ValAcc=96.580 %
Epoch: 56 | Loss=0.117437502 | TrainAcc=96.536 %| ValAcc=96.600 %
Epoch: 57 | Loss=0.118215633 | TrainAcc=96.611 %| ValAcc=96.700 %
Epoch: 58 | Loss=0.115738848 | TrainAcc=96.598 %| ValAcc=96.840 %
Epoch: 59 | Loss=0.118387058 | TrainAcc=96.675 %| ValAcc=96.720 %
Epoch: 60 | Loss=0.110518392 | TrainAcc=96.685 %| ValAcc=96.940 %
Epoch: 61 | Loss=0.113898398 | TrainAcc=96.758 %| ValAcc=96.820 %
Epoch: 62 | Loss=0.109593702 | TrainAcc=96.815 %| ValAcc=96.940 %
Epoch: 63 | Loss=0.109178530 | TrainAcc=96.889 %| ValAcc=96.980 %
Epoch: 64 | Loss=0.107544898 | TrainAcc=96.825 %| ValAcc=96.800 %
Epoch: 65 | Loss=0.109088464 | TrainAcc=96.878 %| ValAcc=96.980 %
Epoch: 66 | Loss=0.104567428 | TrainAcc=96.978 %| ValAcc=97.040 %
Epoch: 67 | Loss=0.104195407 | TrainAcc=96.945 %| ValAcc=97.040 %
Epoch: 68 | Loss=0.103226814 | TrainAcc=96.989 %| ValAcc=97.320 %
Epoch: 69 | Loss=0.103489420 | TrainAcc=97.002 %| ValAcc=97.060 %
Epoch: 70 | Loss=0.098616219 | TrainAcc=97.045 %| ValAcc=97.160 %
Epoch: 71 | Loss=0.101540734 | TrainAcc=97.080 %| ValAcc=97.300 %
```

```
        Epoch: 72 | Loss=0.096985124 | TrainAcc=97.125 %| ValAcc=97.160 %
        Epoch: 73 | Loss=0.101444842 | TrainAcc=97.135 %| ValAcc=97.140 %
        Epoch: 74 | Loss=0.094289097 | TrainAcc=97.135 %| ValAcc=97.240 %
        Epoch: 75 | Loss=0.097983516 | TrainAcc=97.196 %| ValAcc=97.240 %
        Epoch: 76 | Loss=0.094324127 | TrainAcc=97.187 %| ValAcc=97.320 %
        Epoch: 77 | Loss=0.095838315 | TrainAcc=97.256 %| ValAcc=97.340 %
        Epoch: 78 | Loss=0.092501018 | TrainAcc=97.211 %| ValAcc=97.320 %
        Epoch: 79 | Loss=0.094569027 | TrainAcc=97.275 %| ValAcc=97.280 %
        Epoch: 80 | Loss=0.093161546 | TrainAcc=97.309 %| ValAcc=97.440 %
        Epoch: 81 | Loss=0.090951208 | TrainAcc=97.325 %| ValAcc=97.360 %
        Epoch: 82 | Loss=0.089560234 | TrainAcc=97.280 %| ValAcc=97.220 %
        Epoch: 83 | Loss=0.088428938 | TrainAcc=97.349 %| ValAcc=97.440 %
        Epoch: 84 | Loss=0.089073880 | TrainAcc=97.431 %| ValAcc=97.360 %
        Epoch: 85 | Loss=0.090287475 | TrainAcc=97.376 %| ValAcc=97.520 %
        Epoch: 86 | Loss=0.085439353 | TrainAcc=97.427 %| ValAcc=97.480 %
        Epoch: 87 | Loss=0.087864276 | TrainAcc=97.418 %| ValAcc=97.500 %
        Epoch: 88 | Loss=0.086936165 | TrainAcc=97.536 %| ValAcc=97.660 %
        Epoch: 89 | Loss=0.084366638 | TrainAcc=97.476 %| ValAcc=97.580 %
        Epoch: 90 | Loss=0.085125366 | TrainAcc=97.465 %| ValAcc=97.520 %
        Epoch: 91 | Loss=0.084454491 | TrainAcc=97.562 %| ValAcc=97.600 %
        Epoch: 92 | Loss=0.083359959 | TrainAcc=97.613 %| ValAcc=97.680 %
        Epoch: 93 | Loss=0.084190196 | TrainAcc=97.569 %| ValAcc=97.720 %
        Epoch: 94 | Loss=0.080908084 | TrainAcc=97.616 %| ValAcc=97.720 %
        Epoch: 95 | Loss=0.080281464 | TrainAcc=97.613 %| ValAcc=97.720 %
        Epoch: 96 | Loss=0.084289883 | TrainAcc=97.655 %| ValAcc=97.600 %
        Epoch: 97 | Loss=0.080252835 | TrainAcc=97.591 %| ValAcc=97.620 %
        Epoch: 98 | Loss=0.080035667 | TrainAcc=97.704 %| ValAcc=97.680 %
        Epoch: 99 | Loss=0.078600037 | TrainAcc=97.704 %| ValAcc=97.640 %
        Epoch: 100 | Loss=0.079353372 | TrainAcc=97.702 %| ValAcc=97.700 %
        Training Finished in 2677.6 seconds.
        Final accuracies:
        ~ TrainAcc: 97.702 %
        ~ ValAcc: 97.700 %
        ~ TestAcc: 97.840 %
        Saving model in file: Models/lenet5-model_relu_lr0001_bs128
    *Model [ lenet5-model_relu_lr00001_bs50 ] {l_r: 0.0001; n_iter: 250; bat
    ch: 50}
        Start Training!
        Epoch: 01 | Loss=2.314985525 | TrainAcc=13.107 %| ValAcc=12.480 %
        Epoch: 02 | Loss=2.303570949 | TrainAcc=13.627 %| ValAcc=13.160 %
        Epoch: 03 | Loss=2.292266892 | TrainAcc=14.485 %| ValAcc=13.900 %
        Epoch: 04 | Loss=2.285166473 | TrainAcc=14.902 %| ValAcc=14.720 %
        Epoch: 05 | Loss=2.277670279 | TrainAcc=16.085 %| ValAcc=15.640 %
        Epoch: 06 | Loss=2.270431685 | TrainAcc=18.344 %| ValAcc=18.180 %
        Epoch: 07 | Loss=2.264070818 | TrainAcc=22.576 %| ValAcc=23.360 %
        Epoch: 08 | Loss=2.257355559 | TrainAcc=25.198 %| ValAcc=25.940 %
        Epoch: 09 | Loss=2.248916448 | TrainAcc=26.504 %| ValAcc=27.640 %
        Epoch: 10 | Loss=2.240554862 | TrainAcc=27.687 %| ValAcc=28.720 %
        Epoch: 11 | Loss=2.231804672 | TrainAcc=30.158 %| ValAcc=31.280 %
        Epoch: 12 | Loss=2.221249664 | TrainAcc=33.098 %| ValAcc=34.840 %
        Epoch: 13 | Loss=2.208500127 | TrainAcc=35.562 %| ValAcc=37.460 %
        Epoch: 14 | Loss=2.195690938 | TrainAcc=38.247 %| ValAcc=39.840 %
        Epoch: 15 | Loss=2.180523416 | TrainAcc=40.696 %| ValAcc=41.840 %
        Epoch: 16 | Loss=2.160457633 | TrainAcc=42.620 %| ValAcc=43.420 %
        Epoch: 17 | Loss=2.140027166 | TrainAcc=44.605 %| ValAcc=45.340 %
        Epoch: 18 | Loss=2.114254781 | TrainAcc=45.973 %| ValAcc=47.000 %
        Epoch: 19 | Loss=2.084103340 | TrainAcc=47.140 %| ValAcc=48.080 %
        Epoch: 20 | Loss=2.044793764 | TrainAcc=48.322 %| ValAcc=49.400 %
        Epoch: 21 | Loss=2.000263449 | TrainAcc=49.625 %| ValAcc=50.620 %
        Epoch: 22 | Loss=1.942387450 | TrainAcc=50.569 %| ValAcc=51.180 %
        Epoch: 23 | Loss=1.878377276 | TrainAcc=52.702 %| ValAcc=53.340 %
```

```
Epoch:  24  | Loss=1.798259903  | TrainAcc=55.024 %| ValAcc=55.580 %
Epoch:  25  | Loss=1.703164416  | TrainAcc=57.811 %| ValAcc=58.360 %
Epoch:  26  | Loss=1.599884366  | TrainAcc=60.725 %| ValAcc=61.460 %
Epoch:  27  | Loss=1.484770735  | TrainAcc=64.509 %| ValAcc=65.320 %
Epoch:  28  | Loss=1.361039547  | TrainAcc=68.000 %| ValAcc=68.680 %
Epoch:  29  | Loss=1.238242439  | TrainAcc=70.680 %| ValAcc=71.940 %
Epoch:  30  | Loss=1.121098438  | TrainAcc=73.080 %| ValAcc=74.700 %
Epoch:  31  | Loss=1.012906806  | TrainAcc=75.709 %| ValAcc=77.280 %
Epoch:  32  | Loss=0.910597260  | TrainAcc=77.449 %| ValAcc=79.000 %
Epoch:  33  | Loss=0.829403715  | TrainAcc=78.985 %| ValAcc=80.560 %
Epoch:  34  | Loss=0.765381871  | TrainAcc=80.380 %| ValAcc=81.680 %
Epoch:  35  | Loss=0.701467588  | TrainAcc=81.458 %| ValAcc=82.740 %
Epoch:  36  | Loss=0.658902448  | TrainAcc=82.411 %| ValAcc=83.740 %
Epoch:  37  | Loss=0.614492829  | TrainAcc=83.358 %| ValAcc=84.520 %
Epoch:  38  | Loss=0.582584663  | TrainAcc=83.955 %| ValAcc=85.340 %
Epoch:  39  | Loss=0.554420969  | TrainAcc=84.642 %| ValAcc=86.080 %
Epoch:  40  | Loss=0.528286731  | TrainAcc=85.160 %| ValAcc=86.700 %
Epoch:  41  | Loss=0.508263771  | TrainAcc=85.685 %| ValAcc=87.320 %
Epoch:  42  | Loss=0.486846848  | TrainAcc=86.045 %| ValAcc=87.680 %
Epoch:  43  | Loss=0.476681690  | TrainAcc=86.593 %| ValAcc=88.260 %
Epoch:  44  | Loss=0.452750813  | TrainAcc=86.904 %| ValAcc=88.520 %
Epoch:  45  | Loss=0.443897470  | TrainAcc=87.298 %| ValAcc=88.620 %
Epoch:  46  | Loss=0.431029184  | TrainAcc=87.633 %| ValAcc=89.200 %
Epoch:  47  | Loss=0.418487607  | TrainAcc=87.933 %| ValAcc=89.380 %
Epoch:  48  | Loss=0.410564729  | TrainAcc=88.151 %| ValAcc=89.520 %
Epoch:  49  | Loss=0.400064718  | TrainAcc=88.304 %| ValAcc=89.940 %
Epoch:  50  | Loss=0.392947442  | TrainAcc=88.645 %| ValAcc=90.020 %
Epoch:  51  | Loss=0.384895758  | TrainAcc=88.780 %| ValAcc=90.120 %
Epoch:  52  | Loss=0.375271516  | TrainAcc=88.982 %| ValAcc=90.120 %
Epoch:  53  | Loss=0.369290199  | TrainAcc=89.196 %| ValAcc=90.360 %
Epoch:  54  | Loss=0.364940785  | TrainAcc=89.367 %| ValAcc=90.580 %
Epoch:  55  | Loss=0.360273867  | TrainAcc=89.542 %| ValAcc=90.660 %
Epoch:  56  | Loss=0.352652895  | TrainAcc=89.627 %| ValAcc=90.800 %
Epoch:  57  | Loss=0.342446766  | TrainAcc=89.736 %| ValAcc=90.880 %
Epoch:  58  | Loss=0.344311007  | TrainAcc=89.860 %| ValAcc=90.940 %
Epoch:  59  | Loss=0.336488790  | TrainAcc=90.051 %| ValAcc=91.060 %
Epoch:  60  | Loss=0.334706277  | TrainAcc=90.204 %| ValAcc=91.180 %
Epoch:  61  | Loss=0.327295696  | TrainAcc=90.285 %| ValAcc=91.280 %
Epoch:  62  | Loss=0.326029734  | TrainAcc=90.393 %| ValAcc=91.300 %
Epoch:  63  | Loss=0.317943900  | TrainAcc=90.516 %| ValAcc=91.400 %
Epoch:  64  | Loss=0.317915915  | TrainAcc=90.653 %| ValAcc=91.460 %
Epoch:  65  | Loss=0.312686075  | TrainAcc=90.765 %| ValAcc=91.440 %
Epoch:  66  | Loss=0.307838891  | TrainAcc=90.842 %| ValAcc=91.620 %
Epoch:  67  | Loss=0.306942262  | TrainAcc=90.949 %| ValAcc=91.620 %
Epoch:  68  | Loss=0.299314241  | TrainAcc=91.071 %| ValAcc=91.720 %
Epoch:  69  | Loss=0.302386993  | TrainAcc=91.127 %| ValAcc=91.740 %
Epoch:  70  | Loss=0.294664326  | TrainAcc=91.256 %| ValAcc=91.960 %
Epoch:  71  | Loss=0.292771967  | TrainAcc=91.335 %| ValAcc=92.060 %
Epoch:  72  | Loss=0.292249043  | TrainAcc=91.435 %| ValAcc=92.060 %
Epoch:  73  | Loss=0.283415456  | TrainAcc=91.513 %| ValAcc=92.160 %
Epoch:  74  | Loss=0.284900427  | TrainAcc=91.591 %| ValAcc=92.280 %
Epoch:  75  | Loss=0.283456304  | TrainAcc=91.682 %| ValAcc=92.260 %
Epoch:  76  | Loss=0.275268862  | TrainAcc=91.811 %| ValAcc=92.400 %
Epoch:  77  | Loss=0.279007617  | TrainAcc=91.831 %| ValAcc=92.500 %
Epoch:  78  | Loss=0.274047177  | TrainAcc=91.924 %| ValAcc=92.500 %
Epoch:  79  | Loss=0.269300972  | TrainAcc=91.987 %| ValAcc=92.460 %
Epoch:  80  | Loss=0.269824231  | TrainAcc=92.009 %| ValAcc=92.640 %
Epoch:  81  | Loss=0.265518033  | TrainAcc=92.118 %| ValAcc=92.640 %
Epoch:  82  | Loss=0.266615008  | TrainAcc=92.207 %| ValAcc=92.700 %
Epoch:  83  | Loss=0.260461711  | TrainAcc=92.280 %| ValAcc=92.740 %
Epoch:  84  | Loss=0.260167850  | TrainAcc=92.344 %| ValAcc=92.780 %
```

```
Epoch:  85 | Loss=0.255841624 | TrainAcc=92.400 %| ValAcc=92.880 %
Epoch:  86 | Loss=0.257598835 | TrainAcc=92.409 %| ValAcc=92.880 %
Epoch:  87 | Loss=0.250511190 | TrainAcc=92.556 %| ValAcc=92.880 %
Epoch:  88 | Loss=0.253187975 | TrainAcc=92.624 %| ValAcc=92.900 %
Epoch:  89 | Loss=0.247921524 | TrainAcc=92.635 %| ValAcc=93.100 %
Epoch:  90 | Loss=0.246428853 | TrainAcc=92.696 %| ValAcc=93.080 %
Epoch:  91 | Loss=0.245834942 | TrainAcc=92.778 %| ValAcc=93.060 %
Epoch:  92 | Loss=0.241439298 | TrainAcc=92.805 %| ValAcc=93.200 %
Epoch:  93 | Loss=0.242251254 | TrainAcc=92.895 %| ValAcc=93.340 %
Epoch:  94 | Loss=0.240581569 | TrainAcc=92.962 %| ValAcc=93.380 %
Epoch:  95 | Loss=0.241351764 | TrainAcc=92.964 %| ValAcc=93.360 %
Epoch:  96 | Loss=0.233245014 | TrainAcc=93.042 %| ValAcc=93.400 %
Epoch:  97 | Loss=0.232896858 | TrainAcc=93.087 %| ValAcc=93.540 %
Epoch:  98 | Loss=0.232641541 | TrainAcc=93.162 %| ValAcc=93.580 %
Epoch:  99 | Loss=0.232187252 | TrainAcc=93.218 %| ValAcc=93.700 %
Epoch: 100 | Loss=0.231109739 | TrainAcc=93.249 %| ValAcc=93.620 %
Epoch: 101 | Loss=0.224595334 | TrainAcc=93.311 %| ValAcc=93.660 %
Epoch: 102 | Loss=0.227438581 | TrainAcc=93.340 %| ValAcc=93.760 %
Epoch: 103 | Loss=0.225614956 | TrainAcc=93.369 %| ValAcc=93.740 %
Epoch: 104 | Loss=0.223620215 | TrainAcc=93.425 %| ValAcc=93.820 %
Epoch: 105 | Loss=0.223429890 | TrainAcc=93.498 %| ValAcc=93.900 %
Epoch: 106 | Loss=0.213946659 | TrainAcc=93.496 %| ValAcc=93.880 %
Epoch: 107 | Loss=0.220411039 | TrainAcc=93.573 %| ValAcc=93.940 %
Epoch: 108 | Loss=0.218172389 | TrainAcc=93.624 %| ValAcc=94.020 %
Epoch: 109 | Loss=0.217589823 | TrainAcc=93.676 %| ValAcc=94.120 %
Epoch: 110 | Loss=0.212281138 | TrainAcc=93.691 %| ValAcc=94.100 %
Epoch: 111 | Loss=0.213533433 | TrainAcc=93.745 %| ValAcc=94.200 %
Epoch: 112 | Loss=0.211532881 | TrainAcc=93.762 %| ValAcc=94.140 %
Epoch: 113 | Loss=0.207521766 | TrainAcc=93.811 %| ValAcc=94.100 %
Epoch: 114 | Loss=0.210219757 | TrainAcc=93.889 %| ValAcc=94.160 %
Epoch: 115 | Loss=0.207966589 | TrainAcc=93.853 %| ValAcc=94.360 %
Epoch: 116 | Loss=0.206663887 | TrainAcc=93.933 %| ValAcc=94.340 %
Epoch: 117 | Loss=0.203593924 | TrainAcc=93.927 %| ValAcc=94.260 %
Epoch: 118 | Loss=0.204824897 | TrainAcc=94.020 %| ValAcc=94.420 %
Epoch: 119 | Loss=0.201984227 | TrainAcc=94.035 %| ValAcc=94.320 %
Epoch: 120 | Loss=0.203079267 | TrainAcc=94.065 %| ValAcc=94.440 %
Epoch: 121 | Loss=0.198841196 | TrainAcc=94.115 %| ValAcc=94.440 %
Epoch: 122 | Loss=0.198597782 | TrainAcc=94.113 %| ValAcc=94.540 %
Epoch: 123 | Loss=0.193577027 | TrainAcc=94.187 %| ValAcc=94.540 %
Epoch: 124 | Loss=0.199845902 | TrainAcc=94.224 %| ValAcc=94.520 %
Epoch: 125 | Loss=0.194908778 | TrainAcc=94.253 %| ValAcc=94.660 %
Epoch: 126 | Loss=0.195411178 | TrainAcc=94.284 %| ValAcc=94.600 %
Epoch: 127 | Loss=0.191325981 | TrainAcc=94.309 %| ValAcc=94.740 %
Epoch: 128 | Loss=0.193564938 | TrainAcc=94.375 %| ValAcc=94.720 %
Epoch: 129 | Loss=0.190541065 | TrainAcc=94.398 %| ValAcc=94.680 %
Epoch: 130 | Loss=0.186756333 | TrainAcc=94.453 %| ValAcc=94.620 %
Epoch: 131 | Loss=0.191649404 | TrainAcc=94.451 %| ValAcc=94.760 %
Epoch: 132 | Loss=0.186383875 | TrainAcc=94.495 %| ValAcc=94.700 %
Epoch: 133 | Loss=0.184948635 | TrainAcc=94.520 %| ValAcc=94.680 %
Epoch: 134 | Loss=0.188199030 | TrainAcc=94.545 %| ValAcc=94.820 %
Epoch: 135 | Loss=0.187691669 | TrainAcc=94.595 %| ValAcc=94.880 %
Epoch: 136 | Loss=0.181240232 | TrainAcc=94.591 %| ValAcc=94.940 %
Epoch: 137 | Loss=0.185310067 | TrainAcc=94.625 %| ValAcc=95.020 %
Epoch: 138 | Loss=0.178128529 | TrainAcc=94.629 %| ValAcc=95.000 %
Epoch: 139 | Loss=0.181835335 | TrainAcc=94.662 %| ValAcc=95.000 %
Epoch: 140 | Loss=0.180046309 | TrainAcc=94.698 %| ValAcc=95.080 %
Epoch: 141 | Loss=0.178251870 | TrainAcc=94.742 %| ValAcc=95.060 %
Epoch: 142 | Loss=0.180386245 | TrainAcc=94.789 %| ValAcc=95.120 %
Epoch: 143 | Loss=0.173250497 | TrainAcc=94.775 %| ValAcc=95.160 %
Epoch: 144 | Loss=0.175348180 | TrainAcc=94.809 %| ValAcc=95.180 %
Epoch: 145 | Loss=0.178705334 | TrainAcc=94.875 %| ValAcc=95.160 %
```

```
Epoch:  146  |  Loss=0.172555403  |  TrainAcc=94.878 %|  ValAcc=95.280 %
Epoch:  147  |  Loss=0.171959419  |  TrainAcc=94.909 %|  ValAcc=95.260 %
Epoch:  148  |  Loss=0.172236921  |  TrainAcc=94.911 %|  ValAcc=95.300 %
Epoch:  149  |  Loss=0.172518645  |  TrainAcc=94.915 %|  ValAcc=95.300 %
Epoch:  150  |  Loss=0.172821536  |  TrainAcc=94.971 %|  ValAcc=95.200 %
Epoch:  151  |  Loss=0.168204195  |  TrainAcc=95.011 %|  ValAcc=95.320 %
Epoch:  152  |  Loss=0.171667507  |  TrainAcc=95.042 %|  ValAcc=95.380 %
Epoch:  153  |  Loss=0.166490953  |  TrainAcc=95.078 %|  ValAcc=95.380 %
Epoch:  154  |  Loss=0.168979874  |  TrainAcc=95.107 %|  ValAcc=95.520 %
Epoch:  155  |  Loss=0.164047803  |  TrainAcc=95.098 %|  ValAcc=95.380 %
Epoch:  156  |  Loss=0.168692682  |  TrainAcc=95.131 %|  ValAcc=95.480 %
Epoch:  157  |  Loss=0.163266546  |  TrainAcc=95.160 %|  ValAcc=95.380 %
Epoch:  158  |  Loss=0.168262320  |  TrainAcc=95.182 %|  ValAcc=95.520 %
Epoch:  159  |  Loss=0.160446556  |  TrainAcc=95.216 %|  ValAcc=95.480 %
Epoch:  160  |  Loss=0.162422763  |  TrainAcc=95.247 %|  ValAcc=95.500 %
Epoch:  161  |  Loss=0.163621631  |  TrainAcc=95.253 %|  ValAcc=95.440 %
Epoch:  162  |  Loss=0.160800652  |  TrainAcc=95.269 %|  ValAcc=95.580 %
Epoch:  163  |  Loss=0.161992428  |  TrainAcc=95.307 %|  ValAcc=95.520 %
Epoch:  164  |  Loss=0.159300671  |  TrainAcc=95.338 %|  ValAcc=95.640 %
Epoch:  165  |  Loss=0.160127863  |  TrainAcc=95.302 %|  ValAcc=95.720 %
Epoch:  166  |  Loss=0.156826847  |  TrainAcc=95.373 %|  ValAcc=95.620 %
Epoch:  167  |  Loss=0.158739888  |  TrainAcc=95.409 %|  ValAcc=95.680 %
Epoch:  168  |  Loss=0.156653134  |  TrainAcc=95.382 %|  ValAcc=95.780 %
Epoch:  169  |  Loss=0.155294492  |  TrainAcc=95.447 %|  ValAcc=95.700 %
Epoch:  170  |  Loss=0.155948808  |  TrainAcc=95.478 %|  ValAcc=95.840 %
Epoch:  171  |  Loss=0.156179781  |  TrainAcc=95.464 %|  ValAcc=95.740 %
Epoch:  172  |  Loss=0.151935020  |  TrainAcc=95.496 %|  ValAcc=95.740 %
Epoch:  173  |  Loss=0.160131592  |  TrainAcc=95.515 %|  ValAcc=95.840 %
Epoch:  174  |  Loss=0.149119602  |  TrainAcc=95.487 %|  ValAcc=95.820 %
Epoch:  175  |  Loss=0.150963416  |  TrainAcc=95.564 %|  ValAcc=95.740 %
Epoch:  176  |  Loss=0.153489168  |  TrainAcc=95.556 %|  ValAcc=95.880 %
Epoch:  177  |  Loss=0.150545897  |  TrainAcc=95.591 %|  ValAcc=95.800 %
Epoch:  178  |  Loss=0.148704058  |  TrainAcc=95.624 %|  ValAcc=95.980 %
Epoch:  179  |  Loss=0.151458196  |  TrainAcc=95.582 %|  ValAcc=95.880 %
Epoch:  180  |  Loss=0.149281954  |  TrainAcc=95.651 %|  ValAcc=95.920 %
Epoch:  181  |  Loss=0.148003377  |  TrainAcc=95.676 %|  ValAcc=95.920 %
Epoch:  182  |  Loss=0.147801542  |  TrainAcc=95.691 %|  ValAcc=96.080 %
Epoch:  183  |  Loss=0.148273561  |  TrainAcc=95.756 %|  ValAcc=95.880 %
Epoch:  184  |  Loss=0.146991543  |  TrainAcc=95.744 %|  ValAcc=96.040 %
Epoch:  185  |  Loss=0.145601059  |  TrainAcc=95.764 %|  ValAcc=96.060 %
Epoch:  186  |  Loss=0.142590876  |  TrainAcc=95.785 %|  ValAcc=96.120 %
Epoch:  187  |  Loss=0.148276989  |  TrainAcc=95.762 %|  ValAcc=96.140 %
Epoch:  188  |  Loss=0.144793094  |  TrainAcc=95.809 %|  ValAcc=96.000 %
Epoch:  189  |  Loss=0.142560451  |  TrainAcc=95.825 %|  ValAcc=96.060 %
Epoch:  190  |  Loss=0.142002000  |  TrainAcc=95.864 %|  ValAcc=96.100 %
Epoch:  191  |  Loss=0.143785883  |  TrainAcc=95.798 %|  ValAcc=96.220 %
Epoch:  192  |  Loss=0.143809186  |  TrainAcc=95.882 %|  ValAcc=96.220 %
Epoch:  193  |  Loss=0.141037597  |  TrainAcc=95.920 %|  ValAcc=96.240 %
Epoch:  194  |  Loss=0.141473102  |  TrainAcc=95.907 %|  ValAcc=96.160 %
Epoch:  195  |  Loss=0.139092010  |  TrainAcc=95.902 %|  ValAcc=96.200 %
Epoch:  196  |  Loss=0.137800354  |  TrainAcc=95.960 %|  ValAcc=96.200 %
Epoch:  197  |  Loss=0.141285376  |  TrainAcc=95.962 %|  ValAcc=96.160 %
Epoch:  198  |  Loss=0.140247021  |  TrainAcc=95.978 %|  ValAcc=96.220 %
Epoch:  199  |  Loss=0.136024137  |  TrainAcc=95.989 %|  ValAcc=96.280 %
Epoch:  200  |  Loss=0.136971220  |  TrainAcc=96.018 %|  ValAcc=96.200 %
Epoch:  201  |  Loss=0.138395581  |  TrainAcc=96.053 %|  ValAcc=96.220 %
Epoch:  202  |  Loss=0.134938532  |  TrainAcc=96.038 %|  ValAcc=96.280 %
Epoch:  203  |  Loss=0.137524319  |  TrainAcc=96.053 %|  ValAcc=96.400 %
Epoch:  204  |  Loss=0.136034950  |  TrainAcc=96.087 %|  ValAcc=96.300 %
Epoch:  205  |  Loss=0.135439428  |  TrainAcc=96.082 %|  ValAcc=96.300 %
Epoch:  206  |  Loss=0.134429487  |  TrainAcc=96.087 %|  ValAcc=96.320 %
```

```
Epoch: 207 | Loss=0.133750065 | TrainAcc=96.105 %| ValAcc=96.360 %
Epoch: 208 | Loss=0.134040213 | TrainAcc=96.129 %| ValAcc=96.300 %
Epoch: 209 | Loss=0.134654282 | TrainAcc=96.124 %| ValAcc=96.460 %
Epoch: 210 | Loss=0.132733592 | TrainAcc=96.145 %| ValAcc=96.380 %
Epoch: 211 | Loss=0.131765544 | TrainAcc=96.162 %| ValAcc=96.360 %
Epoch: 212 | Loss=0.132059089 | TrainAcc=96.207 %| ValAcc=96.360 %
Epoch: 213 | Loss=0.132965419 | TrainAcc=96.191 %| ValAcc=96.440 %
Epoch: 214 | Loss=0.129213718 | TrainAcc=96.231 %| ValAcc=96.340 %
Epoch: 215 | Loss=0.129014924 | TrainAcc=96.225 %| ValAcc=96.500 %
Epoch: 216 | Loss=0.129576416 | TrainAcc=96.216 %| ValAcc=96.420 %
Epoch: 217 | Loss=0.130480536 | TrainAcc=96.224 %| ValAcc=96.640 %
Epoch: 218 | Loss=0.129588438 | TrainAcc=96.255 %| ValAcc=96.460 %
Epoch: 219 | Loss=0.127203240 | TrainAcc=96.296 %| ValAcc=96.520 %
Epoch: 220 | Loss=0.128085777 | TrainAcc=96.322 %| ValAcc=96.480 %
Epoch: 221 | Loss=0.128372911 | TrainAcc=96.291 %| ValAcc=96.460 %
Epoch: 222 | Loss=0.126331320 | TrainAcc=96.329 %| ValAcc=96.620 %
Epoch: 223 | Loss=0.127302805 | TrainAcc=96.342 %| ValAcc=96.600 %
Epoch: 224 | Loss=0.127195578 | TrainAcc=96.376 %| ValAcc=96.500 %
Epoch: 225 | Loss=0.126046078 | TrainAcc=96.345 %| ValAcc=96.580 %
Epoch: 226 | Loss=0.125183495 | TrainAcc=96.360 %| ValAcc=96.460 %
Epoch: 227 | Loss=0.124820395 | TrainAcc=96.407 %| ValAcc=96.560 %
Epoch: 228 | Loss=0.124684962 | TrainAcc=96.387 %| ValAcc=96.660 %
Epoch: 229 | Loss=0.123408470 | TrainAcc=96.380 %| ValAcc=96.560 %
Epoch: 230 | Loss=0.125455444 | TrainAcc=96.382 %| ValAcc=96.600 %
Epoch: 231 | Loss=0.123210281 | TrainAcc=96.418 %| ValAcc=96.620 %
Epoch: 232 | Loss=0.124717135 | TrainAcc=96.456 %| ValAcc=96.680 %
Epoch: 233 | Loss=0.119213459 | TrainAcc=96.458 %| ValAcc=96.680 %
Epoch: 234 | Loss=0.126141816 | TrainAcc=96.462 %| ValAcc=96.600 %
Epoch: 235 | Loss=0.119753075 | TrainAcc=96.480 %| ValAcc=96.680 %
Epoch: 236 | Loss=0.121573644 | TrainAcc=96.507 %| ValAcc=96.640 %
Epoch: 237 | Loss=0.121737504 | TrainAcc=96.485 %| ValAcc=96.680 %
Epoch: 238 | Loss=0.122521917 | TrainAcc=96.496 %| ValAcc=96.660 %
Epoch: 239 | Loss=0.119084093 | TrainAcc=96.518 %| ValAcc=96.640 %
Epoch: 240 | Loss=0.118705162 | TrainAcc=96.547 %| ValAcc=96.660 %
Epoch: 241 | Loss=0.120080533 | TrainAcc=96.542 %| ValAcc=96.620 %
Epoch: 242 | Loss=0.118810946 | TrainAcc=96.576 %| ValAcc=96.720 %
Epoch: 243 | Loss=0.118861000 | TrainAcc=96.545 %| ValAcc=96.720 %
Epoch: 244 | Loss=0.119461329 | TrainAcc=96.571 %| ValAcc=96.820 %
Epoch: 245 | Loss=0.117513268 | TrainAcc=96.573 %| ValAcc=96.660 %
Epoch: 246 | Loss=0.117326301 | TrainAcc=96.573 %| ValAcc=96.780 %
Epoch: 247 | Loss=0.119149440 | TrainAcc=96.589 %| ValAcc=96.680 %
Epoch: 248 | Loss=0.118075147 | TrainAcc=96.620 %| ValAcc=96.740 %
Epoch: 249 | Loss=0.113719353 | TrainAcc=96.649 %| ValAcc=96.800 %
Epoch: 250 | Loss=0.115177694 | TrainAcc=96.642 %| ValAcc=96.760 %
Training Finished in 8045.8 seconds.
Final accuracies:
~ TrainAcc: 96.642 %
~ ValAcc: 96.760 %
~ TestAcc: 96.650 %
Saving model in file: Models/lenet5-model_relu_lr00001_bs50
*Model [ lenet5-model_relu_lr00001_bs128 ] {l_r: 0.0001; n_iter: 100; ba
tch: 128}
Start Training!
Epoch: 01 | Loss=2.322786413 | TrainAcc=10.007 %| ValAcc=9.700 %
Epoch: 02 | Loss=2.307046299 | TrainAcc=10.085 %| ValAcc=9.920 %
Epoch: 03 | Loss=2.295670853 | TrainAcc=10.518 %| ValAcc=10.260 %
Epoch: 04 | Loss=2.285771324 | TrainAcc=11.305 %| ValAcc=10.880 %
Epoch: 05 | Loss=2.277320490 | TrainAcc=12.600 %| ValAcc=12.000 %
Epoch: 06 | Loss=2.268347038 | TrainAcc=14.502 %| ValAcc=13.520 %
Epoch: 07 | Loss=2.259515516 | TrainAcc=16.635 %| ValAcc=15.620 %
Epoch: 08 | Loss=2.252328448 | TrainAcc=18.853 %| ValAcc=17.820 %
```

```
Epoch:  09 |  Loss=2.244325393 |  TrainAcc=20.816 %|  ValAcc=19.740 %
Epoch:  10 |  Loss=2.235092477 |  TrainAcc=22.964 %|  ValAcc=21.960 %
Epoch:  11 |  Loss=2.228000410 |  TrainAcc=25.098 %|  ValAcc=23.860 %
Epoch:  12 |  Loss=2.218495022 |  TrainAcc=27.013 %|  ValAcc=25.800 %
Epoch:  13 |  Loss=2.209493330 |  TrainAcc=28.791 %|  ValAcc=28.220 %
Epoch:  14 |  Loss=2.199719649 |  TrainAcc=30.416 %|  ValAcc=30.160 %
Epoch:  15 |  Loss=2.189365889 |  TrainAcc=32.005 %|  ValAcc=31.880 %
Epoch:  16 |  Loss=2.178001434 |  TrainAcc=33.764 %|  ValAcc=34.060 %
Epoch:  17 |  Loss=2.166993818 |  TrainAcc=35.491 %|  ValAcc=35.980 %
Epoch:  18 |  Loss=2.153940103 |  TrainAcc=37.440 %|  ValAcc=38.440 %
Epoch:  19 |  Loss=2.139086447 |  TrainAcc=39.635 %|  ValAcc=40.640 %
Epoch:  20 |  Loss=2.124312734 |  TrainAcc=42.287 %|  ValAcc=43.420 %
Epoch:  21 |  Loss=2.106967799 |  TrainAcc=45.538 %|  ValAcc=46.900 %
Epoch:  22 |  Loss=2.088326276 |  TrainAcc=48.496 %|  ValAcc=49.720 %
Epoch:  23 |  Loss=2.069166414 |  TrainAcc=51.676 %|  ValAcc=53.020 %
Epoch:  24 |  Loss=2.047771516 |  TrainAcc=54.264 %|  ValAcc=55.740 %
Epoch:  25 |  Loss=2.022704663 |  TrainAcc=56.380 %|  ValAcc=58.020 %
Epoch:  26 |  Loss=1.996585790 |  TrainAcc=58.087 %|  ValAcc=59.840 %
Epoch:  27 |  Loss=1.966928986 |  TrainAcc=59.280 %|  ValAcc=60.900 %
Epoch:  28 |  Loss=1.937688264 |  TrainAcc=60.498 %|  ValAcc=62.240 %
Epoch:  29 |  Loss=1.901715566 |  TrainAcc=61.460 %|  ValAcc=63.220 %
Epoch:  30 |  Loss=1.862793120 |  TrainAcc=62.400 %|  ValAcc=64.200 %
Epoch:  31 |  Loss=1.822145738 |  TrainAcc=63.062 %|  ValAcc=65.120 %
Epoch:  32 |  Loss=1.779418231 |  TrainAcc=64.047 %|  ValAcc=65.940 %
Epoch:  33 |  Loss=1.728231279 |  TrainAcc=64.787 %|  ValAcc=66.840 %
Epoch:  34 |  Loss=1.676680680 |  TrainAcc=65.615 %|  ValAcc=67.540 %
Epoch:  35 |  Loss=1.623943850 |  TrainAcc=66.638 %|  ValAcc=68.800 %
Epoch:  36 |  Loss=1.566972327 |  TrainAcc=67.493 %|  ValAcc=69.200 %
Epoch:  37 |  Loss=1.502996355 |  TrainAcc=68.376 %|  ValAcc=70.120 %
Epoch:  38 |  Loss=1.445534814 |  TrainAcc=69.355 %|  ValAcc=70.980 %
Epoch:  39 |  Loss=1.383146668 |  TrainAcc=70.180 %|  ValAcc=71.600 %
Epoch:  40 |  Loss=1.323725369 |  TrainAcc=70.867 %|  ValAcc=72.220 %
Epoch:  41 |  Loss=1.259714164 |  TrainAcc=71.835 %|  ValAcc=73.040 %
Epoch:  42 |  Loss=1.203402391 |  TrainAcc=72.602 %|  ValAcc=73.860 %
Epoch:  43 |  Loss=1.149834964 |  TrainAcc=73.296 %|  ValAcc=74.620 %
Epoch:  44 |  Loss=1.094195289 |  TrainAcc=74.027 %|  ValAcc=75.280 %
Epoch:  45 |  Loss=1.047919147 |  TrainAcc=74.707 %|  ValAcc=75.860 %
Epoch:  46 |  Loss=1.001486297 |  TrainAcc=75.420 %|  ValAcc=76.360 %
Epoch:  47 |  Loss=0.958827297 |  TrainAcc=76.022 %|  ValAcc=76.860 %
Epoch:  48 |  Loss=0.918125708 |  TrainAcc=76.569 %|  ValAcc=77.460 %
Epoch:  49 |  Loss=0.880327590 |  TrainAcc=77.115 %|  ValAcc=77.880 %
Epoch:  50 |  Loss=0.850251869 |  TrainAcc=77.671 %|  ValAcc=78.660 %
Epoch:  51 |  Loss=0.821696190 |  TrainAcc=78.311 %|  ValAcc=79.140 %
Epoch:  52 |  Loss=0.792248034 |  TrainAcc=78.716 %|  ValAcc=79.600 %
Epoch:  53 |  Loss=0.765896645 |  TrainAcc=79.227 %|  ValAcc=80.140 %
Epoch:  54 |  Loss=0.743200235 |  TrainAcc=79.669 %|  ValAcc=80.500 %
Epoch:  55 |  Loss=0.721796864 |  TrainAcc=80.182 %|  ValAcc=80.940 %
Epoch:  56 |  Loss=0.700939522 |  TrainAcc=80.638 %|  ValAcc=81.280 %
Epoch:  57 |  Loss=0.684760879 |  TrainAcc=81.060 %|  ValAcc=81.700 %
Epoch:  58 |  Loss=0.666939806 |  TrainAcc=81.385 %|  ValAcc=81.940 %
Epoch:  59 |  Loss=0.647422488 |  TrainAcc=81.751 %|  ValAcc=82.460 %
Epoch:  60 |  Loss=0.637413307 |  TrainAcc=82.158 %|  ValAcc=82.700 %
Epoch:  61 |  Loss=0.622192703 |  TrainAcc=82.476 %|  ValAcc=83.240 %
Epoch:  62 |  Loss=0.606586226 |  TrainAcc=82.818 %|  ValAcc=83.260 %
Epoch:  63 |  Loss=0.596082183 |  TrainAcc=83.189 %|  ValAcc=83.680 %
Epoch:  64 |  Loss=0.586861113 |  TrainAcc=83.500 %|  ValAcc=83.880 %
Epoch:  65 |  Loss=0.572539531 |  TrainAcc=83.842 %|  ValAcc=84.140 %
Epoch:  66 |  Loss=0.565598261 |  TrainAcc=84.129 %|  ValAcc=84.460 %
Epoch:  67 |  Loss=0.550423336 |  TrainAcc=84.420 %|  ValAcc=84.660 %
Epoch:  68 |  Loss=0.547154660 |  TrainAcc=84.658 %|  ValAcc=84.840 %
Epoch:  69 |  Loss=0.530562904 |  TrainAcc=84.955 %|  ValAcc=85.140 %
```

```
Epoch: 70 | Loss=0.525955050 | TrainAcc=85.193 %| ValAcc=85.340 %
Epoch: 71 | Loss=0.521893564 | TrainAcc=85.405 %| ValAcc=85.480 %
Epoch: 72 | Loss=0.509557030 | TrainAcc=85.625 %| ValAcc=85.700 %
Epoch: 73 | Loss=0.502819771 | TrainAcc=85.793 %| ValAcc=85.960 %
Epoch: 74 | Loss=0.500924603 | TrainAcc=85.985 %| ValAcc=86.260 %
Epoch: 75 | Loss=0.489013893 | TrainAcc=86.180 %| ValAcc=86.260 %
Epoch: 76 | Loss=0.482810846 | TrainAcc=86.331 %| ValAcc=86.400 %
Epoch: 77 | Loss=0.478583624 | TrainAcc=86.495 %| ValAcc=86.620 %
Epoch: 78 | Loss=0.472155858 | TrainAcc=86.653 %| ValAcc=86.740 %
Epoch: 79 | Loss=0.468178588 | TrainAcc=86.795 %| ValAcc=86.860 %
Epoch: 80 | Loss=0.458374419 | TrainAcc=86.935 %| ValAcc=86.960 %
Epoch: 81 | Loss=0.459943284 | TrainAcc=87.142 %| ValAcc=87.060 %
Epoch: 82 | Loss=0.448902352 | TrainAcc=87.193 %| ValAcc=87.220 %
Epoch: 83 | Loss=0.443457911 | TrainAcc=87.360 %| ValAcc=87.360 %
Epoch: 84 | Loss=0.445978415 | TrainAcc=87.498 %| ValAcc=87.560 %
Epoch: 85 | Loss=0.435353727 | TrainAcc=87.613 %| ValAcc=87.560 %
Epoch: 86 | Loss=0.435593086 | TrainAcc=87.725 %| ValAcc=87.720 %
Epoch: 87 | Loss=0.427134861 | TrainAcc=87.838 %| ValAcc=87.800 %
Epoch: 88 | Loss=0.426932987 | TrainAcc=87.925 %| ValAcc=87.960 %
Epoch: 89 | Loss=0.420769198 | TrainAcc=88.029 %| ValAcc=88.080 %
Epoch: 90 | Loss=0.418061255 | TrainAcc=88.120 %| ValAcc=88.280 %
Epoch: 91 | Loss=0.413985109 | TrainAcc=88.213 %| ValAcc=88.260 %
Epoch: 92 | Loss=0.408096864 | TrainAcc=88.344 %| ValAcc=88.540 %
Epoch: 93 | Loss=0.407318063 | TrainAcc=88.416 %| ValAcc=88.620 %
Epoch: 94 | Loss=0.408314100 | TrainAcc=88.504 %| ValAcc=88.580 %
Epoch: 95 | Loss=0.397142939 | TrainAcc=88.589 %| ValAcc=88.760 %
Epoch: 96 | Loss=0.395994738 | TrainAcc=88.675 %| ValAcc=88.840 %
Epoch: 97 | Loss=0.397768723 | TrainAcc=88.800 %| ValAcc=89.060 %
Epoch: 98 | Loss=0.390778536 | TrainAcc=88.835 %| ValAcc=88.980 %
Epoch: 99 | Loss=0.388622540 | TrainAcc=88.945 %| ValAcc=89.180 %
Epoch: 100 | Loss=0.381312465 | TrainAcc=88.989 %| ValAcc=89.160 %
Training Finished in 2668.7 seconds.
Final accuracies:
~ TrainAcc: 88.989 %
~ ValAcc:  89.160 %
~ TestAcc: 89.590 %
Saving model in file: Models/lenet5-model_relu_lr00001_bs128
```

In [298]:
```python
# Trying parameters with Adam Optimizer
setOfParams = [ [0.001, 250, 50, 'lenet5-model_adam_relu_lr0001_bs50'],
                [0.001, 100, 128, 'lenet5-model_adam_relu_lr0001_bs128']
,
                [0.0001, 250, 50, 'lenet5-model_adam_relu_lr00001_bs50']
,
                [0.0001, 100, 128, 'lenet5-model_adam_relu_lr00001_bs128
'],

]
for p in setOfParams:
    CNNet (modelName=p[3],
           learning_rate = p[0],
           training_epochs = p[1],
           batch_size = p[2],
           activationFunc=tf.nn.relu,
           optimFunc=tf.train.AdamOptimizer
       )
```

```
*Model [ lenet5-model_adam_relu_lr0001_bs50 ] {l_r: 0.0010; n_iter: 250;
 batch: 50}
    Start Training!
    Epoch: 01 | Loss=0.244328993 | TrainAcc=97.695 %| ValAcc=97.900 %
```

```
Epoch: 02 | Loss=0.065261318 | TrainAcc=98.433 %| ValAcc=98.400 %
Epoch: 03 | Loss=0.045404583 | TrainAcc=98.811 %| ValAcc=98.600 %
Epoch: 04 | Loss=0.035783383 | TrainAcc=99.156 %| ValAcc=98.740 %
Epoch: 05 | Loss=0.029785236 | TrainAcc=99.391 %| ValAcc=98.880 %
Epoch: 06 | Loss=0.023469996 | TrainAcc=99.227 %| ValAcc=98.580 %
Epoch: 07 | Loss=0.022254807 | TrainAcc=99.578 %| ValAcc=98.780 %
Epoch: 08 | Loss=0.017690490 | TrainAcc=99.673 %| ValAcc=98.980 %
Epoch: 09 | Loss=0.013129403 | TrainAcc=99.747 %| ValAcc=99.180 %
Epoch: 10 | Loss=0.013963227 | TrainAcc=99.555 %| ValAcc=98.620 %
Epoch: 11 | Loss=0.012480628 | TrainAcc=99.584 %| ValAcc=98.860 %
Epoch: 12 | Loss=0.012241643 | TrainAcc=99.720 %| ValAcc=98.840 %
Epoch: 13 | Loss=0.009946326 | TrainAcc=99.849 %| ValAcc=99.180 %
Epoch: 14 | Loss=0.009944076 | TrainAcc=99.820 %| ValAcc=99.180 %
Epoch: 15 | Loss=0.009824660 | TrainAcc=99.811 %| ValAcc=99.120 %
Epoch: 16 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 17 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 18 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 19 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 20 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 21 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 22 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 23 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 24 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 25 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 26 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 27 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 28 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 29 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 30 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 31 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 32 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 33 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 34 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 35 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 36 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 37 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 38 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 39 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 40 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 41 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 42 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 43 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 44 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 45 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 46 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 47 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 48 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 49 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 50 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 51 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 52 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 53 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 54 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 55 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 56 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 57 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 58 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 59 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 60 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 61 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 62 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
```

```
Epoch: 63  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 64  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 65  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 66  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 67  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 68  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 69  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 70  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 71  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 72  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 73  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 74  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 75  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 76  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 77  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 78  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 79  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 80  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 81  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 82  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 83  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 84  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 85  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 86  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 87  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 88  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 89  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 90  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 91  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 92  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 93  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 94  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 95  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 96  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 97  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 98  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 99  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 100 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 101 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 102 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 103 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 104 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 105 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 106 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 107 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 108 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 109 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 110 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 111 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 112 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 113 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 114 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 115 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 116 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 117 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 118 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 119 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 120 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 121 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 122 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 123 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
```

```
Epoch: 124 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 125 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 126 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 127 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 128 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 129 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 130 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 131 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 132 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 133 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 134 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 135 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 136 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 137 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 138 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 139 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 140 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 141 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 142 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 143 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 144 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 145 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 146 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 147 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 148 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 149 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 150 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 151 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 152 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 153 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 154 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 155 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 156 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 157 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 158 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 159 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 160 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 161 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 162 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 163 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 164 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 165 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 166 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 167 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 168 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 169 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 170 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 171 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 172 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 173 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 174 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 175 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 176 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 177 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 178 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 179 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 180 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 181 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 182 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 183 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 184 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
```

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Epoch:  185 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  186 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  187 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  188 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  189 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  190 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  191 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  192 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  193 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  194 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  195 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  196 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  197 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  198 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  199 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  200 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  201 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  202 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  203 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  204 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  205 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  206 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  207 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  208 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  209 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  210 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  211 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  212 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  213 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  214 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  215 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  216 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  217 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  218 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  219 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  220 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  221 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  222 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  223 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  224 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  225 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  226 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  227 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  228 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  229 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  230 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  231 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  232 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  233 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  234 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  235 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  236 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  237 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  238 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  239 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  240 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  241 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  242 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  243 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  244 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  245 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
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        Epoch: 246 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
        Epoch: 247 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
        Epoch: 248 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
        Epoch: 249 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
        Epoch: 250 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
        Training Finished in 8012.0 seconds.
        Final accuracies:
        ~ TrainAcc: 9.898 %
        ~ ValAcc: 9.580 %
        ~ TestAcc: 9.800 %
        Saving model in file: Models/lenet5-model_adam_relu_lr0001_bs50
    *Model [ lenet5-model_adam_relu_lr0001_bs128 ] {l_r: 0.0010; n_iter: 100
    ; batch: 128}
        Start Training!
        Epoch: 01 | Loss=0.336491016 | TrainAcc=96.625 %| ValAcc=97.140 %
        Epoch: 02 | Loss=0.087823771 | TrainAcc=97.842 %| ValAcc=97.960 %
        Epoch: 03 | Loss=0.062794081 | TrainAcc=98.615 %| ValAcc=98.340 %
        Epoch: 04 | Loss=0.047299532 | TrainAcc=98.920 %| ValAcc=98.700 %
        Epoch: 05 | Loss=0.038719179 | TrainAcc=98.945 %| ValAcc=98.700 %
        Epoch: 06 | Loss=0.033209020 | TrainAcc=99.238 %| ValAcc=98.880 %
        Epoch: 07 | Loss=0.029150596 | TrainAcc=99.196 %| ValAcc=98.840 %
        Epoch: 08 | Loss=0.022505452 | TrainAcc=99.035 %| ValAcc=98.500 %
        Epoch: 09 | Loss=0.022066285 | TrainAcc=99.582 %| ValAcc=98.880 %
        Epoch: 10 | Loss=0.020705636 | TrainAcc=99.256 %| ValAcc=98.800 %
        Epoch: 11 | Loss=0.014939778 | TrainAcc=99.600 %| ValAcc=98.620 %
        Epoch: 12 | Loss=0.015436752 | TrainAcc=99.695 %| ValAcc=99.000 %
        Epoch: 13 | Loss=0.013359710 | TrainAcc=99.740 %| ValAcc=99.000 %
        Epoch: 14 | Loss=0.011378326 | TrainAcc=99.467 %| ValAcc=98.780 %
        Epoch: 15 | Loss=0.012907592 | TrainAcc=99.745 %| ValAcc=98.900 %
        Epoch: 16 | Loss=0.009455264 | TrainAcc=99.878 %| ValAcc=99.220 %
        Epoch: 17 | Loss=0.009712120 | TrainAcc=99.707 %| ValAcc=98.740 %
        Epoch: 18 | Loss=0.008370863 | TrainAcc=99.784 %| ValAcc=99.080 %
        Epoch: 19 | Loss=0.008306214 | TrainAcc=99.835 %| ValAcc=99.060 %
        Epoch: 20 | Loss=0.005540892 | TrainAcc=99.902 %| ValAcc=99.140 %
        Epoch: 21 | Loss=0.009586892 | TrainAcc=99.784 %| ValAcc=98.980 %
        Epoch: 22 | Loss=0.006334985 | TrainAcc=99.858 %| ValAcc=99.200 %
        Epoch: 23 | Loss=0.005407022 | TrainAcc=99.816 %| ValAcc=98.960 %
        Epoch: 24 | Loss=0.007346477 | TrainAcc=99.905 %| ValAcc=99.100 %
        Epoch: 25 | Loss=0.005765667 | TrainAcc=99.935 %| ValAcc=99.200 %
        Epoch: 26 | Loss=0.006273060 | TrainAcc=99.767 %| ValAcc=99.000 %
        Epoch: 27 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
        Epoch: 28 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
        Epoch: 29 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
        Epoch: 30 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
        Epoch: 31 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
        Epoch: 32 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
        Epoch: 33 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
        Epoch: 34 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
        Epoch: 35 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
        Epoch: 36 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
        Epoch: 37 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
        Epoch: 38 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
        Epoch: 39 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
        Epoch: 40 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
        Epoch: 41 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
        Epoch: 42 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
        Epoch: 43 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
        Epoch: 44 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
        Epoch: 45 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
        Epoch: 46 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
        Epoch: 47 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
```

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Epoch: 48  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 49  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 50  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 51  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 52  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 53  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 54  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 55  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 56  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 57  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 58  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 59  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 60  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 61  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 62  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 63  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 64  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 65  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 66  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 67  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 68  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 69  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 70  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 71  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 72  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 73  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 74  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 75  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 76  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 77  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 78  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 79  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 80  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 81  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 82  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 83  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 84  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 85  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 86  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 87  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 88  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 89  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 90  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 91  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 92  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 93  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 94  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 95  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 96  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 97  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 98  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 99  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 100 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Training Finished in 2676.3 seconds.
Final accuracies:
~ TrainAcc: 9.898 %
~ ValAcc: 9.580 %
~ TestAcc: 9.800 %
Saving model in file: Models/lenet5-model_adam_relu_lr0001_bs128
*Model [ lenet5-model_adam_relu_lr00001_bs50 ] {l_r: 0.0001; n_iter: 250
; batch: 50}
```

```
Start Training!
Epoch: 01 | Loss=0.800074414 | TrainAcc=91.435 %| ValAcc=92.040 %
Epoch: 02 | Loss=0.232612559 | TrainAcc=94.473 %| ValAcc=95.240 %
Epoch: 03 | Loss=0.165665199 | TrainAcc=95.824 %| ValAcc=96.360 %
Epoch: 04 | Loss=0.129587101 | TrainAcc=96.598 %| ValAcc=96.860 %
Epoch: 05 | Loss=0.108686594 | TrainAcc=97.136 %| ValAcc=97.340 %
Epoch: 06 | Loss=0.092979553 | TrainAcc=97.418 %| ValAcc=97.560 %
Epoch: 07 | Loss=0.083623754 | TrainAcc=97.549 %| ValAcc=97.740 %
Epoch: 08 | Loss=0.076368846 | TrainAcc=97.896 %| ValAcc=98.060 %
Epoch: 09 | Loss=0.068475015 | TrainAcc=98.104 %| ValAcc=98.140 %
Epoch: 10 | Loss=0.064992078 | TrainAcc=98.182 %| ValAcc=98.260 %
Epoch: 11 | Loss=0.058705781 | TrainAcc=98.475 %| ValAcc=98.280 %
Epoch: 12 | Loss=0.054053025 | TrainAcc=98.398 %| ValAcc=98.380 %
Epoch: 13 | Loss=0.052144248 | TrainAcc=98.429 %| ValAcc=98.300 %
Epoch: 14 | Loss=0.046998210 | TrainAcc=98.689 %| ValAcc=98.460 %
Epoch: 15 | Loss=0.046525351 | TrainAcc=98.704 %| ValAcc=98.320 %
Epoch: 16 | Loss=0.041771256 | TrainAcc=98.713 %| ValAcc=98.400 %
Epoch: 17 | Loss=0.041033997 | TrainAcc=98.878 %| ValAcc=98.540 %
Epoch: 18 | Loss=0.038263413 | TrainAcc=99.018 %| ValAcc=98.660 %
Epoch: 19 | Loss=0.035132884 | TrainAcc=98.962 %| ValAcc=98.680 %
Epoch: 20 | Loss=0.034132983 | TrainAcc=99.018 %| ValAcc=98.620 %
Epoch: 21 | Loss=0.032466385 | TrainAcc=99.151 %| ValAcc=98.640 %
Epoch: 22 | Loss=0.029523266 | TrainAcc=99.053 %| ValAcc=98.740 %
Epoch: 23 | Loss=0.029812324 | TrainAcc=99.291 %| ValAcc=98.680 %
Epoch: 24 | Loss=0.027621515 | TrainAcc=99.324 %| ValAcc=98.560 %
Epoch: 25 | Loss=0.026531568 | TrainAcc=99.255 %| ValAcc=98.700 %
Epoch: 26 | Loss=0.025878912 | TrainAcc=99.238 %| ValAcc=98.700 %
Epoch: 27 | Loss=0.023946666 | TrainAcc=99.236 %| ValAcc=98.800 %
Epoch: 28 | Loss=0.021727157 | TrainAcc=99.473 %| ValAcc=98.880 %
Epoch: 29 | Loss=0.022842133 | TrainAcc=99.340 %| ValAcc=98.680 %
Epoch: 30 | Loss=0.021067322 | TrainAcc=99.493 %| ValAcc=98.960 %
Epoch: 31 | Loss=0.018080928 | TrainAcc=99.360 %| ValAcc=98.900 %
Epoch: 32 | Loss=0.019563682 | TrainAcc=99.427 %| ValAcc=98.780 %
Epoch: 33 | Loss=0.016981285 | TrainAcc=99.398 %| ValAcc=98.800 %
Epoch: 34 | Loss=0.017121460 | TrainAcc=99.515 %| ValAcc=98.880 %
Epoch: 35 | Loss=0.015632870 | TrainAcc=99.551 %| ValAcc=98.880 %
Epoch: 36 | Loss=0.015889073 | TrainAcc=99.684 %| ValAcc=98.820 %
Epoch: 37 | Loss=0.014673981 | TrainAcc=99.705 %| ValAcc=98.820 %
Epoch: 38 | Loss=0.013237425 | TrainAcc=99.704 %| ValAcc=98.860 %
Epoch: 39 | Loss=0.012777660 | TrainAcc=99.631 %| ValAcc=98.760 %
Epoch: 40 | Loss=0.013384059 | TrainAcc=99.595 %| ValAcc=98.820 %
Epoch: 41 | Loss=0.010264258 | TrainAcc=99.738 %| ValAcc=98.880 %
Epoch: 42 | Loss=0.011598217 | TrainAcc=99.749 %| ValAcc=98.740 %
Epoch: 43 | Loss=0.010276781 | TrainAcc=99.793 %| ValAcc=98.960 %
Epoch: 44 | Loss=0.009798509 | TrainAcc=99.782 %| ValAcc=98.920 %
Epoch: 45 | Loss=0.008598425 | TrainAcc=99.825 %| ValAcc=98.920 %
Epoch: 46 | Loss=0.009067529 | TrainAcc=99.851 %| ValAcc=98.960 %
Epoch: 47 | Loss=0.008154073 | TrainAcc=99.862 %| ValAcc=99.020 %
Epoch: 48 | Loss=0.007881212 | TrainAcc=99.838 %| ValAcc=98.820 %
Epoch: 49 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 50 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 51 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 52 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 53 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 54 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 55 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 56 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 57 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 58 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 59 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 60 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
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Epoch: 61  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 62  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 63  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 64  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 65  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 66  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 67  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 68  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 69  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 70  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 71  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 72  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 73  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 74  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 75  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 76  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 77  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 78  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 79  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 80  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 81  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 82  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
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Epoch: 88  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
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Epoch: 90  | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
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Epoch: 119 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 120 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 121 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
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Epoch: 122 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 123 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 124 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 125 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
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Epoch: 179 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 180 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 181 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 182 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
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Epoch: 183 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 184 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
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Epoch: 200 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 201 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
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Epoch: 206 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
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Epoch: 213 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 214 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 215 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 216 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 217 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
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Epoch: 220 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
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Epoch: 222 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 223 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 224 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 225 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 226 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 227 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 228 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 229 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 230 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 231 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 232 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 233 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 234 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 235 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 236 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 237 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 238 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 239 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 240 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 241 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 242 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 243 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
```

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Epoch: 244 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 245 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 246 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 247 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 248 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 249 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 250 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Training Finished in 8012.1 seconds.
Final accuracies:
~ TrainAcc: 9.898 %
~ ValAcc: 9.580 %
~ TestAcc: 9.800 %
Saving model in file: Models/lenet5-model_adam_relu_lr00001_bs50
*Model [ lenet5-model_adam_relu_lr00001_bs128 ] {l_r: 0.0001; n_iter: 10
0; batch: 128}
Start Training!
Epoch: 01 | Loss=1.243151578 | TrainAcc=87.002 %| ValAcc=87.460 %
Epoch: 02 | Loss=0.359933009 | TrainAcc=91.498 %| ValAcc=91.940 %
Epoch: 03 | Loss=0.259833849 | TrainAcc=93.315 %| ValAcc=93.820 %
Epoch: 04 | Loss=0.204902797 | TrainAcc=94.387 %| ValAcc=94.980 %
Epoch: 05 | Loss=0.174768799 | TrainAcc=95.224 %| ValAcc=95.640 %
Epoch: 06 | Loss=0.146592573 | TrainAcc=96.018 %| ValAcc=96.600 %
Epoch: 07 | Loss=0.130953929 | TrainAcc=96.384 %| ValAcc=96.860 %
Epoch: 08 | Loss=0.118611152 | TrainAcc=96.635 %| ValAcc=97.180 %
Epoch: 09 | Loss=0.106283579 | TrainAcc=97.056 %| ValAcc=97.460 %
Epoch: 10 | Loss=0.095082833 | TrainAcc=97.253 %| ValAcc=97.620 %
Epoch: 11 | Loss=0.090205770 | TrainAcc=97.435 %| ValAcc=97.860 %
Epoch: 12 | Loss=0.082553578 | TrainAcc=97.507 %| ValAcc=97.720 %
Epoch: 13 | Loss=0.077852895 | TrainAcc=97.616 %| ValAcc=97.960 %
Epoch: 14 | Loss=0.071480656 | TrainAcc=97.775 %| ValAcc=98.020 %
Epoch: 15 | Loss=0.070990781 | TrainAcc=98.031 %| ValAcc=98.360 %
Epoch: 16 | Loss=0.064028748 | TrainAcc=97.905 %| ValAcc=98.060 %
Epoch: 17 | Loss=0.063709609 | TrainAcc=98.296 %| ValAcc=98.240 %
Epoch: 18 | Loss=0.058705929 | TrainAcc=98.385 %| ValAcc=98.320 %
Epoch: 19 | Loss=0.056092837 | TrainAcc=98.400 %| ValAcc=98.440 %
Epoch: 20 | Loss=0.054884658 | TrainAcc=98.358 %| ValAcc=98.340 %
Epoch: 21 | Loss=0.051762977 | TrainAcc=98.569 %| ValAcc=98.460 %
Epoch: 22 | Loss=0.050787053 | TrainAcc=98.518 %| ValAcc=98.220 %
Epoch: 23 | Loss=0.045924386 | TrainAcc=98.607 %| ValAcc=98.560 %
Epoch: 24 | Loss=0.047333643 | TrainAcc=98.760 %| ValAcc=98.560 %
Epoch: 25 | Loss=0.043663675 | TrainAcc=98.807 %| ValAcc=98.580 %
Epoch: 26 | Loss=0.041773758 | TrainAcc=98.651 %| ValAcc=98.620 %
Epoch: 27 | Loss=0.042589592 | TrainAcc=98.667 %| ValAcc=98.520 %
Epoch: 28 | Loss=0.039210400 | TrainAcc=98.771 %| ValAcc=98.680 %
Epoch: 29 | Loss=0.037513105 | TrainAcc=98.947 %| ValAcc=98.520 %
Epoch: 30 | Loss=0.037314608 | TrainAcc=98.947 %| ValAcc=98.720 %
Epoch: 31 | Loss=0.035301512 | TrainAcc=99.024 %| ValAcc=98.580 %
Epoch: 32 | Loss=0.035654814 | TrainAcc=98.989 %| ValAcc=98.680 %
Epoch: 33 | Loss=0.032341450 | TrainAcc=98.987 %| ValAcc=98.620 %
Epoch: 34 | Loss=0.033059189 | TrainAcc=99.111 %| ValAcc=98.580 %
Epoch: 35 | Loss=0.030910072 | TrainAcc=99.040 %| ValAcc=98.620 %
Epoch: 36 | Loss=0.030249225 | TrainAcc=99.205 %| ValAcc=98.620 %
Epoch: 37 | Loss=0.028323251 | TrainAcc=99.165 %| ValAcc=98.620 %
Epoch: 38 | Loss=0.027994644 | TrainAcc=99.131 %| ValAcc=98.580 %
Epoch: 39 | Loss=0.028260773 | TrainAcc=99.304 %| ValAcc=98.740 %
Epoch: 40 | Loss=0.024990981 | TrainAcc=99.211 %| ValAcc=98.640 %
Epoch: 41 | Loss=0.025866443 | TrainAcc=99.284 %| ValAcc=98.720 %
Epoch: 42 | Loss=0.024167910 | TrainAcc=99.316 %| ValAcc=98.700 %
Epoch: 43 | Loss=0.025538293 | TrainAcc=99.315 %| ValAcc=98.660 %
Epoch: 44 | Loss=0.023930598 | TrainAcc=99.315 %| ValAcc=98.880 %
Epoch: 45 | Loss=0.021857773 | TrainAcc=99.387 %| ValAcc=98.740 %
```

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Epoch:  46 | Loss=0.022430068 | TrainAcc=99.447 %| ValAcc=98.640 %
Epoch:  47 | Loss=0.018786778 | TrainAcc=99.444 %| ValAcc=98.760 %
Epoch:  48 | Loss=0.021054137 | TrainAcc=99.500 %| ValAcc=98.920 %
Epoch:  49 | Loss=0.019998885 | TrainAcc=99.462 %| ValAcc=98.680 %
Epoch:  50 | Loss=0.019766372 | TrainAcc=99.576 %| ValAcc=98.880 %
Epoch:  51 | Loss=0.018265747 | TrainAcc=99.464 %| ValAcc=98.880 %
Epoch:  52 | Loss=0.017254081 | TrainAcc=99.498 %| ValAcc=98.780 %
Epoch:  53 | Loss=0.018538862 | TrainAcc=99.529 %| ValAcc=98.600 %
Epoch:  54 | Loss=0.016953231 | TrainAcc=99.531 %| ValAcc=98.880 %
Epoch:  55 | Loss=0.015863687 | TrainAcc=99.609 %| ValAcc=98.680 %
Epoch:  56 | Loss=0.014810196 | TrainAcc=99.642 %| ValAcc=98.880 %
Epoch:  57 | Loss=0.015748078 | TrainAcc=99.524 %| ValAcc=98.760 %
Epoch:  58 | Loss=0.015422316 | TrainAcc=99.571 %| ValAcc=98.760 %
Epoch:  59 | Loss=0.013619001 | TrainAcc=99.716 %| ValAcc=98.880 %
Epoch:  60 | Loss=0.013755894 | TrainAcc=99.673 %| ValAcc=98.920 %
Epoch:  61 | Loss=0.013852081 | TrainAcc=99.736 %| ValAcc=98.820 %
Epoch:  62 | Loss=0.011031355 | TrainAcc=99.669 %| ValAcc=98.760 %
Epoch:  63 | Loss=0.011998245 | TrainAcc=99.784 %| ValAcc=98.860 %
Epoch:  64 | Loss=0.012225419 | TrainAcc=99.711 %| ValAcc=98.920 %
Epoch:  65 | Loss=0.011627046 | TrainAcc=99.780 %| ValAcc=98.900 %
Epoch:  66 | Loss=0.010133227 | TrainAcc=99.705 %| ValAcc=98.780 %
Epoch:  67 | Loss=0.011849558 | TrainAcc=99.796 %| ValAcc=98.980 %
Epoch:  68 | Loss=0.009863431 | TrainAcc=99.642 %| ValAcc=98.540 %
Epoch:  69 | Loss=0.009812404 | TrainAcc=99.669 %| ValAcc=98.740 %
Epoch:  70 | Loss=0.009197602 | TrainAcc=99.816 %| ValAcc=98.840 %
Epoch:  71 | Loss=0.009015236 | TrainAcc=99.682 %| ValAcc=98.660 %
Epoch:  72 | Loss=0.009391751 | TrainAcc=99.780 %| ValAcc=98.780 %
Epoch:  73 | Loss=0.009050498 | TrainAcc=99.835 %| ValAcc=98.760 %
Epoch:  74 | Loss=0.007686785 | TrainAcc=99.875 %| ValAcc=98.800 %
Epoch:  75 | Loss=0.008135438 | TrainAcc=99.871 %| ValAcc=98.820 %
Epoch:  76 | Loss=0.007799114 | TrainAcc=99.844 %| ValAcc=98.860 %
Epoch:  77 | Loss=0.006827752 | TrainAcc=99.909 %| ValAcc=98.920 %
Epoch:  78 | Loss=0.006551904 | TrainAcc=99.889 %| ValAcc=98.900 %
Epoch:  79 | Loss=0.007174227 | TrainAcc=99.813 %| ValAcc=98.740 %
Epoch:  80 | Loss=0.006238979 | TrainAcc=99.913 %| ValAcc=98.880 %
Epoch:  81 | Loss=0.006978288 | TrainAcc=99.896 %| ValAcc=98.880 %
Epoch:  82 | Loss=0.005869644 | TrainAcc=99.876 %| ValAcc=98.800 %
Epoch:  83 | Loss=0.005809541 | TrainAcc=99.911 %| ValAcc=98.960 %
Epoch:  84 | Loss=0.005085145 | TrainAcc=99.871 %| ValAcc=98.880 %
Epoch:  85 | Loss=0.006105772 | TrainAcc=99.925 %| ValAcc=98.940 %
Epoch:  86 | Loss=0.006132292 | TrainAcc=99.942 %| ValAcc=98.920 %
Epoch:  87 | Loss=0.004119795 | TrainAcc=99.951 %| ValAcc=98.940 %
Epoch:  88 | Loss=0.004874629 | TrainAcc=99.935 %| ValAcc=98.900 %
Epoch:  89 | Loss=0.005838063 | TrainAcc=99.758 %| ValAcc=98.800 %
Epoch:  90 | Loss=0.004928051 | TrainAcc=99.949 %| ValAcc=98.800 %
Epoch:  91 | Loss=0.004511933 | TrainAcc=99.865 %| ValAcc=98.880 %
Epoch:  92 | Loss=0.003457094 | TrainAcc=99.944 %| ValAcc=98.840 %
Epoch:  93 | Loss=0.003789006 | TrainAcc=99.909 %| ValAcc=98.920 %
Epoch:  94 | Loss=0.003867277 | TrainAcc=99.882 %| ValAcc=98.840 %
Epoch:  95 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  96 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  97 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  98 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch:  99 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Epoch: 100 | Loss=nan | TrainAcc=9.898 %| ValAcc=9.580 %
Training Finished in 2691.6 seconds.
Final accuracies:
~ TrainAcc: 9.898 %
~ ValAcc: 9.580 %
~ TestAcc: 9.800 %
Saving model in file: Models/lenet5-model_adam_relu_lr00001_bs128
```

> **COMMENT:**
> As seen in the training, the AdamOptimizer gets NaN at a certain point. In order to make it numerically stable, we have included a small value in the logarighm of the loss node in the grapl (1e-9), and we have reduced the standard deviation in the weight initialization

In [320]:
```python
# Trying parameters with Adam Optimizer - AFTER CHANGING THE OPTIMIZER!
# (Weight init & safe softmax)
setOfParams = [ [0.001, 100, 50, 'lenet5-model_adam_relu_lr0001_bs50'],
                [0.001, 100, 128, 'lenet5-model_adam_relu_lr0001_bs128']
,
                [0.0001, 100, 50, 'lenet5-model_adam_relu_lr00001_bs50']
,
                [0.0001, 100, 128, 'lenet5-model_adam_relu_lr00001_bs128
'],

]
for p in setOfParams:
    CNNet (modelName=p[3],
           learning_rate = p[0],
           training_epochs = p[1],
           batch_size = p[2],
           activationFunc=tf.nn.relu,
           optimFunc=tf.train.AdamOptimizer
       )
```

```
*Model [ lenet5-model_adam_relu_lr0001_bs50 ] {l_r: 0.0010; n_iter: 100;
 batch: 50}
   Start Training!
   Epoch: 01 | Loss=0.502500334 | TrainAcc=95.858 % | ValAcc=96.600 %
   Epoch: 02 | Loss=0.106422822 | TrainAcc=97.651 % | ValAcc=97.320 %
   Epoch: 03 | Loss=0.073697202 | TrainAcc=98.216 % | ValAcc=98.040 %
   Epoch: 04 | Loss=0.058289272 | TrainAcc=98.545 % | ValAcc=98.040 %
   Epoch: 05 | Loss=0.045475034 | TrainAcc=98.578 % | ValAcc=98.200 %
   Epoch: 06 | Loss=0.040004382 | TrainAcc=99.122 % | ValAcc=98.800 %
   Epoch: 07 | Loss=0.032673832 | TrainAcc=99.055 % | ValAcc=98.660 %
   Epoch: 08 | Loss=0.030387537 | TrainAcc=99.180 % | ValAcc=98.800 %
   Epoch: 09 | Loss=0.024355082 | TrainAcc=99.173 % | ValAcc=98.700 %
   Epoch: 10 | Loss=0.023165833 | TrainAcc=99.229 % | ValAcc=98.820 %
   Epoch: 11 | Loss=0.018626527 | TrainAcc=99.598 % | ValAcc=99.080 %
   Epoch: 12 | Loss=0.018691430 | TrainAcc=99.309 % | ValAcc=98.560 %
   Epoch: 13 | Loss=0.016446427 | TrainAcc=99.685 % | ValAcc=99.020 %
   Epoch: 14 | Loss=0.014194758 | TrainAcc=99.722 % | ValAcc=98.980 %
   Epoch: 15 | Loss=0.013725779 | TrainAcc=99.385 % | ValAcc=98.700 %
   Epoch: 16 | Loss=0.012012833 | TrainAcc=99.685 % | ValAcc=98.920 %
   Epoch: 17 | Loss=0.009427501 | TrainAcc=99.267 % | ValAcc=98.480 %
   Epoch: 18 | Loss=0.010868581 | TrainAcc=99.798 % | ValAcc=99.100 %
   Epoch: 19 | Loss=0.010313067 | TrainAcc=99.782 % | ValAcc=99.060 %
   Epoch: 20 | Loss=0.009137813 | TrainAcc=99.756 % | ValAcc=98.960 %
   Epoch: 21 | Loss=0.006883903 | TrainAcc=99.855 % | ValAcc=99.100 %
   Epoch: 22 | Loss=0.008016893 | TrainAcc=99.884 % | ValAcc=99.100 %
   Epoch: 23 | Loss=0.006898535 | TrainAcc=99.762 % | ValAcc=99.080 %
   Epoch: 24 | Loss=0.007394552 | TrainAcc=99.856 % | ValAcc=99.080 %
   Epoch: 25 | Loss=0.007185219 | TrainAcc=99.749 % | ValAcc=98.960 %
   Epoch: 26 | Loss=0.006179710 | TrainAcc=99.873 % | ValAcc=99.120 %
   Epoch: 27 | Loss=0.005712089 | TrainAcc=99.873 % | ValAcc=99.180 %
   Epoch: 28 | Loss=0.006438843 | TrainAcc=99.920 % | ValAcc=99.240 %
```

```
Epoch:  29  |  Loss=0.006216850  |  TrainAcc=99.784 %  |  ValAcc=99.020 %
Epoch:  30  |  Loss=0.005091197  |  TrainAcc=99.609 %  |  ValAcc=98.840 %
Epoch:  31  |  Loss=0.006682526  |  TrainAcc=99.824 %  |  ValAcc=99.060 %
Epoch:  32  |  Loss=0.004923757  |  TrainAcc=99.345 %  |  ValAcc=98.600 %
Epoch:  33  |  Loss=0.005443350  |  TrainAcc=99.645 %  |  ValAcc=98.800 %
Epoch:  34  |  Loss=0.005969307  |  TrainAcc=99.933 %  |  ValAcc=99.100 %
Epoch:  35  |  Loss=0.003896548  |  TrainAcc=99.862 %  |  ValAcc=99.080 %
Epoch:  36  |  Loss=0.004548977  |  TrainAcc=99.887 %  |  ValAcc=99.080 %
Epoch:  37  |  Loss=0.005475617  |  TrainAcc=99.927 %  |  ValAcc=99.120 %
Epoch:  38  |  Loss=0.004850613  |  TrainAcc=99.796 %  |  ValAcc=99.020 %
Epoch:  39  |  Loss=0.005263624  |  TrainAcc=99.645 %  |  ValAcc=98.920 %
Epoch:  40  |  Loss=0.005503693  |  TrainAcc=99.911 %  |  ValAcc=99.100 %
Epoch:  41  |  Loss=0.004473619  |  TrainAcc=99.960 %  |  ValAcc=99.280 %
Epoch:  42  |  Loss=0.003109437  |  TrainAcc=99.829 %  |  ValAcc=98.880 %
Epoch:  43  |  Loss=0.004165636  |  TrainAcc=99.936 %  |  ValAcc=98.940 %
Epoch:  44  |  Loss=0.005126901  |  TrainAcc=99.927 %  |  ValAcc=99.100 %
Epoch:  45  |  Loss=0.003757262  |  TrainAcc=99.942 %  |  ValAcc=99.100 %
Epoch:  46  |  Loss=0.005871023  |  TrainAcc=99.916 %  |  ValAcc=99.280 %
Epoch:  47  |  Loss=0.004543459  |  TrainAcc=99.931 %  |  ValAcc=99.140 %
Epoch:  48  |  Loss=0.002589572  |  TrainAcc=99.811 %  |  ValAcc=99.180 %
Epoch:  49  |  Loss=0.004607118  |  TrainAcc=99.898 %  |  ValAcc=99.140 %
Epoch:  50  |  Loss=0.003624668  |  TrainAcc=99.756 %  |  ValAcc=98.960 %
Epoch:  51  |  Loss=0.002096287  |  TrainAcc=99.949 %  |  ValAcc=99.240 %
Epoch:  52  |  Loss=0.006060471  |  TrainAcc=99.913 %  |  ValAcc=99.080 %
Epoch:  53  |  Loss=0.002603652  |  TrainAcc=99.967 %  |  ValAcc=99.320 %
Epoch:  54  |  Loss=0.004032092  |  TrainAcc=99.718 %  |  ValAcc=98.940 %
Epoch:  55  |  Loss=0.005231744  |  TrainAcc=99.949 %  |  ValAcc=99.220 %
Epoch:  56  |  Loss=0.003214992  |  TrainAcc=99.971 %  |  ValAcc=99.320 %
Epoch:  57  |  Loss=0.002487833  |  TrainAcc=99.944 %  |  ValAcc=99.280 %
Epoch:  58  |  Loss=0.003247790  |  TrainAcc=99.916 %  |  ValAcc=99.180 %
Epoch:  59  |  Loss=0.003783373  |  TrainAcc=99.949 %  |  ValAcc=99.260 %
Epoch:  60  |  Loss=0.004298883  |  TrainAcc=99.982 %  |  ValAcc=99.180 %
Epoch:  61  |  Loss=0.001291642  |  TrainAcc=99.795 %  |  ValAcc=99.060 %
Epoch:  62  |  Loss=0.005252897  |  TrainAcc=99.953 %  |  ValAcc=99.100 %
Epoch:  63  |  Loss=0.003517381  |  TrainAcc=99.947 %  |  ValAcc=99.080 %
Epoch:  64  |  Loss=0.001931658  |  TrainAcc=99.896 %  |  ValAcc=99.020 %
Epoch:  65  |  Loss=0.005800207  |  TrainAcc=99.867 %  |  ValAcc=98.740 %
Epoch:  66  |  Loss=0.002431609  |  TrainAcc=99.933 %  |  ValAcc=99.020 %
Epoch:  67  |  Loss=0.003836611  |  TrainAcc=99.931 %  |  ValAcc=99.240 %
Epoch:  68  |  Loss=0.003983492  |  TrainAcc=99.924 %  |  ValAcc=99.260 %
Epoch:  69  |  Loss=0.001929705  |  TrainAcc=99.944 %  |  ValAcc=99.160 %
Epoch:  70  |  Loss=0.003326075  |  TrainAcc=99.989 %  |  ValAcc=99.160 %
Epoch:  71  |  Loss=0.001090932  |  TrainAcc=99.895 %  |  ValAcc=98.980 %
Epoch:  72  |  Loss=0.004659232  |  TrainAcc=99.913 %  |  ValAcc=99.040 %
Epoch:  73  |  Loss=0.002539748  |  TrainAcc=99.942 %  |  ValAcc=99.180 %
Epoch:  74  |  Loss=0.003375766  |  TrainAcc=99.936 %  |  ValAcc=99.020 %
Epoch:  75  |  Loss=0.004620667  |  TrainAcc=99.956 %  |  ValAcc=99.200 %
Epoch:  76  |  Loss=0.002987844  |  TrainAcc=99.985 %  |  ValAcc=99.220 %
Epoch:  77  |  Loss=0.003254300  |  TrainAcc=99.915 %  |  ValAcc=99.140 %
Epoch:  78  |  Loss=0.002797339  |  TrainAcc=99.980 %  |  ValAcc=99.160 %
Epoch:  79  |  Loss=0.002236209  |  TrainAcc=99.929 %  |  ValAcc=99.020 %
Epoch:  80  |  Loss=0.004490857  |  TrainAcc=99.833 %  |  ValAcc=98.940 %
Epoch:  81  |  Loss=0.001345857  |  TrainAcc=99.991 %  |  ValAcc=99.240 %
Epoch:  82  |  Loss=0.000267231  |  TrainAcc=99.998 %  |  ValAcc=99.260 %
Epoch:  83  |  Loss=0.006268715  |  TrainAcc=99.893 %  |  ValAcc=99.060 %
Epoch:  84  |  Loss=0.003011923  |  TrainAcc=99.967 %  |  ValAcc=99.060 %
Epoch:  85  |  Loss=0.001397270  |  TrainAcc=99.971 %  |  ValAcc=99.280 %
Epoch:  86  |  Loss=0.002735677  |  TrainAcc=99.933 %  |  ValAcc=99.080 %
Epoch:  87  |  Loss=0.004854355  |  TrainAcc=99.965 %  |  ValAcc=99.080 %
Epoch:  88  |  Loss=0.002383849  |  TrainAcc=99.985 %  |  ValAcc=99.160 %
Epoch:  89  |  Loss=0.000544503  |  TrainAcc=99.985 %  |  ValAcc=99.180 %
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Epoch: 90 | Loss=0.005933389 | TrainAcc=99.918 % | ValAcc=98.980 %
Epoch: 91 | Loss=0.001724779 | TrainAcc=99.945 % | ValAcc=98.980 %
Epoch: 92 | Loss=0.003749183 | TrainAcc=99.918 % | ValAcc=98.920 %
Epoch: 93 | Loss=0.002835511 | TrainAcc=99.893 % | ValAcc=99.080 %
Epoch: 94 | Loss=0.004027278 | TrainAcc=99.971 % | ValAcc=99.080 %
Epoch: 95 | Loss=0.002428934 | TrainAcc=99.962 % | ValAcc=99.120 %
Epoch: 96 | Loss=0.002612717 | TrainAcc=99.980 % | ValAcc=99.160 %
Epoch: 97 | Loss=0.003043559 | TrainAcc=99.973 % | ValAcc=99.180 %
Epoch: 98 | Loss=0.003138739 | TrainAcc=99.940 % | ValAcc=99.080 %
Epoch: 99 | Loss=0.001992881 | TrainAcc=99.949 % | ValAcc=99.160 %
Epoch: 100 | Loss=0.004590027 | TrainAcc=99.873 % | ValAcc=98.980 %
Training Finished in 3280.2 seconds.
Final accuracies:
~ TrainAcc: 99.873 %
~ ValAcc: 98.980 %
~ TestAcc: 98.820 %
Saving model in file: Models/lenet5-model_adam_relu_lr0001_bs50
*Model [ lenet5-model_adam_relu_lr0001_bs128 ] {l_r: 0.0010; n_iter: 100
; batch: 128}
Start Training!
Epoch: 01 | Loss=1.002236798 | TrainAcc=91.249 % | ValAcc=92.020 %
Epoch: 02 | Loss=0.175105191 | TrainAcc=96.762 % | ValAcc=96.880 %
Epoch: 03 | Loss=0.097114358 | TrainAcc=97.424 % | ValAcc=97.580 %
Epoch: 04 | Loss=0.073504702 | TrainAcc=98.193 % | ValAcc=98.060 %
Epoch: 05 | Loss=0.064052049 | TrainAcc=98.487 % | ValAcc=98.260 %
Epoch: 06 | Loss=0.052486020 | TrainAcc=98.707 % | ValAcc=98.360 %
Epoch: 07 | Loss=0.045462362 | TrainAcc=98.645 % | ValAcc=98.320 %
Epoch: 08 | Loss=0.042176366 | TrainAcc=98.784 % | ValAcc=98.360 %
Epoch: 09 | Loss=0.035755820 | TrainAcc=99.085 % | ValAcc=98.740 %
Epoch: 10 | Loss=0.031740524 | TrainAcc=99.091 % | ValAcc=98.640 %
Epoch: 11 | Loss=0.028404766 | TrainAcc=98.945 % | ValAcc=98.520 %
Epoch: 12 | Loss=0.026590637 | TrainAcc=99.355 % | ValAcc=98.720 %
Epoch: 13 | Loss=0.022017988 | TrainAcc=99.476 % | ValAcc=98.820 %
Epoch: 14 | Loss=0.022185760 | TrainAcc=99.495 % | ValAcc=99.040 %
Epoch: 15 | Loss=0.019726115 | TrainAcc=99.505 % | ValAcc=98.780 %
Epoch: 16 | Loss=0.015350560 | TrainAcc=99.669 % | ValAcc=98.920 %
Epoch: 17 | Loss=0.016147256 | TrainAcc=99.475 % | ValAcc=98.800 %
Epoch: 18 | Loss=0.013094706 | TrainAcc=99.795 % | ValAcc=98.960 %
Epoch: 19 | Loss=0.012707344 | TrainAcc=99.453 % | ValAcc=98.820 %
Epoch: 20 | Loss=0.012458899 | TrainAcc=99.773 % | ValAcc=98.860 %
Epoch: 21 | Loss=0.010439487 | TrainAcc=99.602 % | ValAcc=98.860 %
Epoch: 22 | Loss=0.010920267 | TrainAcc=99.842 % | ValAcc=99.000 %
Epoch: 23 | Loss=0.009402394 | TrainAcc=99.776 % | ValAcc=98.860 %
Epoch: 24 | Loss=0.008562180 | TrainAcc=99.867 % | ValAcc=98.980 %
Epoch: 25 | Loss=0.007158565 | TrainAcc=99.738 % | ValAcc=98.840 %
Epoch: 26 | Loss=0.006940532 | TrainAcc=99.853 % | ValAcc=99.000 %
Epoch: 27 | Loss=0.005100343 | TrainAcc=99.825 % | ValAcc=98.840 %
Epoch: 28 | Loss=0.007680293 | TrainAcc=99.869 % | ValAcc=99.140 %
Epoch: 29 | Loss=0.006324617 | TrainAcc=99.787 % | ValAcc=98.900 %
Epoch: 30 | Loss=0.006417040 | TrainAcc=99.773 % | ValAcc=98.860 %
Epoch: 31 | Loss=0.009357255 | TrainAcc=99.853 % | ValAcc=98.900 %
Epoch: 32 | Loss=0.005197679 | TrainAcc=99.895 % | ValAcc=98.980 %
Epoch: 33 | Loss=0.004114275 | TrainAcc=99.949 % | ValAcc=99.040 %
Epoch: 34 | Loss=0.005493058 | TrainAcc=99.815 % | ValAcc=98.880 %
Epoch: 35 | Loss=0.003721849 | TrainAcc=99.613 % | ValAcc=98.500 %
Epoch: 36 | Loss=0.004956170 | TrainAcc=99.700 % | ValAcc=98.620 %
Epoch: 37 | Loss=0.007215095 | TrainAcc=99.891 % | ValAcc=98.860 %
Epoch: 38 | Loss=0.003994456 | TrainAcc=99.436 % | ValAcc=98.640 %
Epoch: 39 | Loss=0.005395620 | TrainAcc=99.940 % | ValAcc=99.000 %
Epoch: 40 | Loss=0.004410369 | TrainAcc=99.907 % | ValAcc=98.960 %
Epoch: 41 | Loss=0.003368580 | TrainAcc=99.855 % | ValAcc=98.840 %
```

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Epoch: 42 | Loss=0.006076222 | TrainAcc=99.907 % | ValAcc=99.040 %
Epoch: 43 | Loss=0.002378694 | TrainAcc=99.960 % | ValAcc=99.160 %
Epoch: 44 | Loss=0.002030471 | TrainAcc=99.936 % | ValAcc=98.880 %
Epoch: 45 | Loss=0.008238401 | TrainAcc=99.776 % | ValAcc=98.820 %
Epoch: 46 | Loss=0.002818661 | TrainAcc=99.965 % | ValAcc=99.000 %
Epoch: 47 | Loss=0.002121241 | TrainAcc=99.975 % | ValAcc=99.140 %
Epoch: 48 | Loss=0.003487663 | TrainAcc=99.900 % | ValAcc=98.920 %
Epoch: 49 | Loss=0.005742704 | TrainAcc=99.875 % | ValAcc=98.760 %
Epoch: 50 | Loss=0.003228344 | TrainAcc=99.833 % | ValAcc=98.960 %
Epoch: 51 | Loss=0.004218740 | TrainAcc=99.980 % | ValAcc=99.040 %
Epoch: 52 | Loss=0.002472707 | TrainAcc=99.980 % | ValAcc=99.080 %
Epoch: 53 | Loss=0.000636644 | TrainAcc=99.996 % | ValAcc=99.140 %
Epoch: 54 | Loss=0.001012747 | TrainAcc=99.855 % | ValAcc=98.800 %
Epoch: 55 | Loss=0.007610590 | TrainAcc=99.676 % | ValAcc=98.380 %
Epoch: 56 | Loss=0.003878254 | TrainAcc=99.858 % | ValAcc=99.020 %
Epoch: 57 | Loss=0.005084838 | TrainAcc=99.969 % | ValAcc=99.060 %
Epoch: 58 | Loss=0.000523700 | TrainAcc=99.980 % | ValAcc=99.080 %
Epoch: 59 | Loss=0.000786924 | TrainAcc=99.984 % | ValAcc=99.160 %
Epoch: 60 | Loss=0.003253044 | TrainAcc=99.640 % | ValAcc=98.780 %
Epoch: 61 | Loss=0.006802880 | TrainAcc=99.931 % | ValAcc=98.980 %
Epoch: 62 | Loss=0.001660514 | TrainAcc=99.995 % | ValAcc=99.080 %
Epoch: 63 | Loss=0.000323113 | TrainAcc=99.984 % | ValAcc=99.020 %
Epoch: 64 | Loss=0.003235942 | TrainAcc=99.893 % | ValAcc=99.040 %
Epoch: 65 | Loss=0.003523793 | TrainAcc=99.945 % | ValAcc=98.980 %
Epoch: 66 | Loss=0.005059128 | TrainAcc=99.931 % | ValAcc=98.900 %
Epoch: 67 | Loss=0.003044531 | TrainAcc=99.907 % | ValAcc=99.020 %
Epoch: 68 | Loss=0.003061482 | TrainAcc=99.769 % | ValAcc=98.660 %
Epoch: 69 | Loss=0.002238971 | TrainAcc=99.996 % | ValAcc=98.960 %
Epoch: 70 | Loss=0.000122698 | TrainAcc=100.000 % | ValAcc=98.980 %
100% Training accuracy -> Stopping
Training Finished in 1868.4 seconds.
Final accuracies:
~ TrainAcc: 100.000 %
~ ValAcc: 98.980 %
~ TestAcc: 98.970 %
Saving model in file: Models/lenet5-model_adam_relu_lr0001_bs128
*Model [ lenet5-model_adam_relu_lr00001_bs50 ] {l_r: 0.0001; n_iter: 100
; batch: 50}
Start Training!
Epoch: 01 | Loss=1.653044257 | TrainAcc=61.880 % | ValAcc=63.180 %
Epoch: 02 | Loss=0.694801312 | TrainAcc=84.556 % | ValAcc=85.660 %
Epoch: 03 | Loss=0.376531262 | TrainAcc=90.951 % | ValAcc=91.900 %
Epoch: 04 | Loss=0.250102368 | TrainAcc=93.451 % | ValAcc=94.320 %
Epoch: 05 | Loss=0.192515003 | TrainAcc=94.458 % | ValAcc=95.020 %
Epoch: 06 | Loss=0.160383661 | TrainAcc=95.418 % | ValAcc=96.040 %
Epoch: 07 | Loss=0.142976664 | TrainAcc=95.976 % | ValAcc=96.280 %
Epoch: 08 | Loss=0.124162167 | TrainAcc=96.556 % | ValAcc=96.820 %
Epoch: 09 | Loss=0.115263588 | TrainAcc=96.636 % | ValAcc=96.760 %
Epoch: 10 | Loss=0.104776766 | TrainAcc=96.785 % | ValAcc=97.120 %
Epoch: 11 | Loss=0.099918639 | TrainAcc=97.131 % | ValAcc=97.240 %
Epoch: 12 | Loss=0.089135405 | TrainAcc=97.404 % | ValAcc=97.400 %
Epoch: 13 | Loss=0.088641560 | TrainAcc=97.513 % | ValAcc=97.520 %
Epoch: 14 | Loss=0.082265236 | TrainAcc=97.465 % | ValAcc=97.480 %
Epoch: 15 | Loss=0.080980202 | TrainAcc=97.760 % | ValAcc=97.720 %
Epoch: 16 | Loss=0.073589752 | TrainAcc=97.695 % | ValAcc=97.700 %
Epoch: 17 | Loss=0.070708526 | TrainAcc=97.749 % | ValAcc=97.640 %
Epoch: 18 | Loss=0.070103623 | TrainAcc=97.884 % | ValAcc=97.620 %
Epoch: 19 | Loss=0.065713172 | TrainAcc=97.844 % | ValAcc=97.600 %
Epoch: 20 | Loss=0.062628484 | TrainAcc=98.113 % | ValAcc=98.040 %
Epoch: 21 | Loss=0.060265606 | TrainAcc=98.320 % | ValAcc=98.000 %
Epoch: 22 | Loss=0.057173781 | TrainAcc=98.433 % | ValAcc=98.160 %
```

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Epoch:  23 |  Loss=0.054629861 |  TrainAcc=98.413 % |  ValAcc=98.360 %
Epoch:  24 |  Loss=0.054466080 |  TrainAcc=98.345 % |  ValAcc=98.200 %
Epoch:  25 |  Loss=0.052718307 |  TrainAcc=98.575 % |  ValAcc=98.140 %
Epoch:  26 |  Loss=0.048289416 |  TrainAcc=98.516 % |  ValAcc=98.220 %
Epoch:  27 |  Loss=0.048102016 |  TrainAcc=98.520 % |  ValAcc=98.240 %
Epoch:  28 |  Loss=0.045260448 |  TrainAcc=98.520 % |  ValAcc=98.140 %
Epoch:  29 |  Loss=0.045914190 |  TrainAcc=98.813 % |  ValAcc=98.340 %
Epoch:  30 |  Loss=0.043232146 |  TrainAcc=98.693 % |  ValAcc=98.440 %
Epoch:  31 |  Loss=0.040299431 |  TrainAcc=98.902 % |  ValAcc=98.560 %
Epoch:  32 |  Loss=0.040621529 |  TrainAcc=98.704 % |  ValAcc=98.140 %
Epoch:  33 |  Loss=0.038627299 |  TrainAcc=98.927 % |  ValAcc=98.400 %
Epoch:  34 |  Loss=0.037620246 |  TrainAcc=98.671 % |  ValAcc=98.440 %
Epoch:  35 |  Loss=0.036426143 |  TrainAcc=98.896 % |  ValAcc=98.440 %
Epoch:  36 |  Loss=0.034827471 |  TrainAcc=98.971 % |  ValAcc=98.560 %
Epoch:  37 |  Loss=0.036088676 |  TrainAcc=99.053 % |  ValAcc=98.640 %
Epoch:  38 |  Loss=0.032539033 |  TrainAcc=99.082 % |  ValAcc=98.700 %
Epoch:  39 |  Loss=0.032122850 |  TrainAcc=99.024 % |  ValAcc=98.620 %
Epoch:  40 |  Loss=0.030219525 |  TrainAcc=99.084 % |  ValAcc=98.660 %
Epoch:  41 |  Loss=0.028135105 |  TrainAcc=99.275 % |  ValAcc=98.720 %
Epoch:  42 |  Loss=0.031449848 |  TrainAcc=99.224 % |  ValAcc=98.800 %
Epoch:  43 |  Loss=0.026506793 |  TrainAcc=98.955 % |  ValAcc=98.540 %
Epoch:  44 |  Loss=0.027793184 |  TrainAcc=99.233 % |  ValAcc=98.680 %
Epoch:  45 |  Loss=0.027660849 |  TrainAcc=99.207 % |  ValAcc=98.540 %
Epoch:  46 |  Loss=0.025486373 |  TrainAcc=99.447 % |  ValAcc=98.700 %
Epoch:  47 |  Loss=0.025951856 |  TrainAcc=99.296 % |  ValAcc=98.660 %
Epoch:  48 |  Loss=0.024498205 |  TrainAcc=99.138 % |  ValAcc=98.700 %
Epoch:  49 |  Loss=0.023631162 |  TrainAcc=99.062 % |  ValAcc=98.460 %
Epoch:  50 |  Loss=0.021649753 |  TrainAcc=99.022 % |  ValAcc=98.220 %
Epoch:  51 |  Loss=0.022120994 |  TrainAcc=99.462 % |  ValAcc=98.740 %
Epoch:  52 |  Loss=0.021921927 |  TrainAcc=99.345 % |  ValAcc=98.760 %
Epoch:  53 |  Loss=0.021021124 |  TrainAcc=99.425 % |  ValAcc=98.720 %
Epoch:  54 |  Loss=0.019883006 |  TrainAcc=99.564 % |  ValAcc=98.920 %
Epoch:  55 |  Loss=0.018838957 |  TrainAcc=99.520 % |  ValAcc=98.880 %
Epoch:  56 |  Loss=0.017875378 |  TrainAcc=99.509 % |  ValAcc=98.780 %
Epoch:  57 |  Loss=0.018208221 |  TrainAcc=99.591 % |  ValAcc=98.780 %
Epoch:  58 |  Loss=0.018245151 |  TrainAcc=99.593 % |  ValAcc=98.760 %
Epoch:  59 |  Loss=0.017215948 |  TrainAcc=99.571 % |  ValAcc=98.760 %
Epoch:  60 |  Loss=0.015720472 |  TrainAcc=99.631 % |  ValAcc=98.820 %
Epoch:  61 |  Loss=0.017319894 |  TrainAcc=99.602 % |  ValAcc=98.740 %
Epoch:  62 |  Loss=0.014363396 |  TrainAcc=99.640 % |  ValAcc=98.700 %
Epoch:  63 |  Loss=0.015350660 |  TrainAcc=99.527 % |  ValAcc=98.600 %
Epoch:  64 |  Loss=0.014143817 |  TrainAcc=99.620 % |  ValAcc=98.780 %
Epoch:  65 |  Loss=0.014015471 |  TrainAcc=99.529 % |  ValAcc=98.760 %
Epoch:  66 |  Loss=0.012598137 |  TrainAcc=99.571 % |  ValAcc=98.780 %
Epoch:  67 |  Loss=0.013760652 |  TrainAcc=99.644 % |  ValAcc=98.860 %
Epoch:  68 |  Loss=0.012145134 |  TrainAcc=99.649 % |  ValAcc=98.780 %
Epoch:  69 |  Loss=0.012439666 |  TrainAcc=99.609 % |  ValAcc=98.760 %
Epoch:  70 |  Loss=0.011371418 |  TrainAcc=99.700 % |  ValAcc=98.920 %
Epoch:  71 |  Loss=0.011684269 |  TrainAcc=99.762 % |  ValAcc=98.960 %
Epoch:  72 |  Loss=0.011503224 |  TrainAcc=99.738 % |  ValAcc=98.640 %
Epoch:  73 |  Loss=0.010204002 |  TrainAcc=99.782 % |  ValAcc=98.760 %
Epoch:  74 |  Loss=0.010355979 |  TrainAcc=99.849 % |  ValAcc=98.840 %
Epoch:  75 |  Loss=0.009948653 |  TrainAcc=99.715 % |  ValAcc=98.860 %
Epoch:  76 |  Loss=0.009427563 |  TrainAcc=99.838 % |  ValAcc=98.900 %
Epoch:  77 |  Loss=0.008447451 |  TrainAcc=99.793 % |  ValAcc=98.920 %
Epoch:  78 |  Loss=0.010013980 |  TrainAcc=99.818 % |  ValAcc=98.780 %
Epoch:  79 |  Loss=0.008427799 |  TrainAcc=99.796 % |  ValAcc=98.820 %
Epoch:  80 |  Loss=0.009098957 |  TrainAcc=99.725 % |  ValAcc=98.800 %
Epoch:  81 |  Loss=0.007252152 |  TrainAcc=99.771 % |  ValAcc=98.880 %
Epoch:  82 |  Loss=0.008566782 |  TrainAcc=99.787 % |  ValAcc=98.820 %
Epoch:  83 |  Loss=0.006861291 |  TrainAcc=99.789 % |  ValAcc=98.680 %
```

```
Epoch:  84 | Loss=0.007148428 | TrainAcc=99.769 % | ValAcc=98.660 %
Epoch:  85 | Loss=0.007568949 | TrainAcc=99.882 % | ValAcc=98.860 %
Epoch:  86 | Loss=0.006765739 | TrainAcc=99.902 % | ValAcc=98.980 %
Epoch:  87 | Loss=0.006327723 | TrainAcc=99.571 % | ValAcc=98.800 %
Epoch:  88 | Loss=0.006656284 | TrainAcc=99.807 % | ValAcc=98.880 %
Epoch:  89 | Loss=0.005832313 | TrainAcc=99.802 % | ValAcc=98.760 %
Epoch:  90 | Loss=0.006304638 | TrainAcc=99.776 % | ValAcc=98.800 %
Epoch:  91 | Loss=0.005213225 | TrainAcc=99.833 % | ValAcc=98.900 %
Epoch:  92 | Loss=0.006485936 | TrainAcc=99.800 % | ValAcc=98.740 %
Epoch:  93 | Loss=0.005248056 | TrainAcc=99.796 % | ValAcc=98.900 %
Epoch:  94 | Loss=0.005520959 | TrainAcc=99.905 % | ValAcc=98.980 %
Epoch:  95 | Loss=0.005380047 | TrainAcc=99.904 % | ValAcc=98.880 %
Epoch:  96 | Loss=0.004708211 | TrainAcc=99.865 % | ValAcc=98.900 %
Epoch:  97 | Loss=0.005393801 | TrainAcc=99.931 % | ValAcc=98.960 %
Epoch:  98 | Loss=0.004514299 | TrainAcc=99.907 % | ValAcc=98.820 %
Epoch:  99 | Loss=0.004401247 | TrainAcc=99.924 % | ValAcc=98.920 %
Epoch: 100 | Loss=0.005224040 | TrainAcc=99.933 % | ValAcc=99.020 %
Training Finished in 3250.5 seconds.
Final accuracies:
~ TrainAcc: 99.933 %
~ ValAcc: 99.020 %
~ TestAcc: 98.750 %
Saving model in file: Models/lenet5-model_adam_relu_lr00001_bs50
*Model [ lenet5-model_adam_relu_lr00001_bs128 ] {l_r: 0.0001; n_iter: 10
0; batch: 128}
Start Training!
Epoch: 01 | Loss=2.119865159 | TrainAcc=42.864 % | ValAcc=43.780 %
Epoch: 02 | Loss=1.177369959 | TrainAcc=69.644 % | ValAcc=70.920 %
Epoch: 03 | Loss=0.740548670 | TrainAcc=79.242 % | ValAcc=80.340 %
Epoch: 04 | Loss=0.555677451 | TrainAcc=84.238 % | ValAcc=85.680 %
Epoch: 05 | Loss=0.445546990 | TrainAcc=87.493 % | ValAcc=88.600 %
Epoch: 06 | Loss=0.366048601 | TrainAcc=89.771 % | ValAcc=90.880 %
Epoch: 07 | Loss=0.301066094 | TrainAcc=91.516 % | ValAcc=92.520 %
Epoch: 08 | Loss=0.258525223 | TrainAcc=92.642 % | ValAcc=93.280 %
Epoch: 09 | Loss=0.228178994 | TrainAcc=93.324 % | ValAcc=94.140 %
Epoch: 10 | Loss=0.202880211 | TrainAcc=93.811 % | ValAcc=94.600 %
Epoch: 11 | Loss=0.188782848 | TrainAcc=94.611 % | ValAcc=95.280 %
Epoch: 12 | Loss=0.172132074 | TrainAcc=94.987 % | ValAcc=95.560 %
Epoch: 13 | Loss=0.161448823 | TrainAcc=95.344 % | ValAcc=95.860 %
Epoch: 14 | Loss=0.148115502 | TrainAcc=95.609 % | ValAcc=96.180 %
Epoch: 15 | Loss=0.143532305 | TrainAcc=95.893 % | ValAcc=96.300 %
Epoch: 16 | Loss=0.136909417 | TrainAcc=96.035 % | ValAcc=96.580 %
Epoch: 17 | Loss=0.126735421 | TrainAcc=96.167 % | ValAcc=96.640 %
Epoch: 18 | Loss=0.121645490 | TrainAcc=96.547 % | ValAcc=96.880 %
Epoch: 19 | Loss=0.118714501 | TrainAcc=96.524 % | ValAcc=96.880 %
Epoch: 20 | Loss=0.112385490 | TrainAcc=96.598 % | ValAcc=96.900 %
Epoch: 21 | Loss=0.107862289 | TrainAcc=96.800 % | ValAcc=96.920 %
Epoch: 22 | Loss=0.104625574 | TrainAcc=96.980 % | ValAcc=97.000 %
Epoch: 23 | Loss=0.095747969 | TrainAcc=97.098 % | ValAcc=97.100 %
Epoch: 24 | Loss=0.098790052 | TrainAcc=96.965 % | ValAcc=97.180 %
Epoch: 25 | Loss=0.094677257 | TrainAcc=97.284 % | ValAcc=97.280 %
Epoch: 26 | Loss=0.092580360 | TrainAcc=97.404 % | ValAcc=97.360 %
Epoch: 27 | Loss=0.086211580 | TrainAcc=97.431 % | ValAcc=97.260 %
Epoch: 28 | Loss=0.085795628 | TrainAcc=97.475 % | ValAcc=97.480 %
Epoch: 29 | Loss=0.082100380 | TrainAcc=97.495 % | ValAcc=97.460 %
Epoch: 30 | Loss=0.079325410 | TrainAcc=97.551 % | ValAcc=97.680 %
Epoch: 31 | Loss=0.079744811 | TrainAcc=97.722 % | ValAcc=97.520 %
Epoch: 32 | Loss=0.074975699 | TrainAcc=97.749 % | ValAcc=97.500 %
Epoch: 33 | Loss=0.076304431 | TrainAcc=97.905 % | ValAcc=97.720 %
Epoch: 34 | Loss=0.071786366 | TrainAcc=97.778 % | ValAcc=97.640 %
Epoch: 35 | Loss=0.071164667 | TrainAcc=97.915 % | ValAcc=97.820 %
```

```
Epoch:  36  |  Loss=0.068906329  |  TrainAcc=98.000 %  |  ValAcc=97.920 %
Epoch:  37  |  Loss=0.066967504  |  TrainAcc=98.107 %  |  ValAcc=97.880 %
Epoch:  38  |  Loss=0.066970239  |  TrainAcc=98.049 %  |  ValAcc=98.020 %
Epoch:  39  |  Loss=0.065297960  |  TrainAcc=98.073 %  |  ValAcc=97.760 %
Epoch:  40  |  Loss=0.061918050  |  TrainAcc=98.047 %  |  ValAcc=97.860 %
Epoch:  41  |  Loss=0.060881495  |  TrainAcc=98.176 %  |  ValAcc=97.880 %
Epoch:  42  |  Loss=0.058141665  |  TrainAcc=98.196 %  |  ValAcc=97.980 %
Epoch:  43  |  Loss=0.061175777  |  TrainAcc=98.313 %  |  ValAcc=98.100 %
Epoch:  44  |  Loss=0.056304927  |  TrainAcc=98.369 %  |  ValAcc=98.020 %
Epoch:  45  |  Loss=0.058273177  |  TrainAcc=98.118 %  |  ValAcc=97.820 %
Epoch:  46  |  Loss=0.054806114  |  TrainAcc=98.264 %  |  ValAcc=98.120 %
Epoch:  47  |  Loss=0.053744064  |  TrainAcc=98.395 %  |  ValAcc=98.200 %
Epoch:  48  |  Loss=0.054394091  |  TrainAcc=98.431 %  |  ValAcc=98.220 %
Epoch:  49  |  Loss=0.051815206  |  TrainAcc=98.420 %  |  ValAcc=98.260 %
Epoch:  50  |  Loss=0.050138636  |  TrainAcc=98.507 %  |  ValAcc=98.300 %
Epoch:  51  |  Loss=0.050775044  |  TrainAcc=98.544 %  |  ValAcc=98.260 %
Epoch:  52  |  Loss=0.048942290  |  TrainAcc=98.549 %  |  ValAcc=98.340 %
Epoch:  53  |  Loss=0.048570286  |  TrainAcc=98.578 %  |  ValAcc=98.200 %
Epoch:  54  |  Loss=0.046933646  |  TrainAcc=98.660 %  |  ValAcc=98.340 %
Epoch:  55  |  Loss=0.048275059  |  TrainAcc=98.449 %  |  ValAcc=98.320 %
Epoch:  56  |  Loss=0.046286487  |  TrainAcc=98.584 %  |  ValAcc=98.460 %
Epoch:  57  |  Loss=0.044650686  |  TrainAcc=98.584 %  |  ValAcc=98.240 %
Epoch:  58  |  Loss=0.043889275  |  TrainAcc=98.622 %  |  ValAcc=98.400 %
Epoch:  59  |  Loss=0.044345253  |  TrainAcc=98.618 %  |  ValAcc=98.220 %
Epoch:  60  |  Loss=0.041081192  |  TrainAcc=98.767 %  |  ValAcc=98.460 %
Epoch:  61  |  Loss=0.043266359  |  TrainAcc=98.818 %  |  ValAcc=98.440 %
Epoch:  62  |  Loss=0.041104993  |  TrainAcc=98.565 %  |  ValAcc=98.100 %
Epoch:  63  |  Loss=0.038774961  |  TrainAcc=98.735 %  |  ValAcc=98.280 %
Epoch:  64  |  Loss=0.039534543  |  TrainAcc=98.776 %  |  ValAcc=98.480 %
Epoch:  65  |  Loss=0.039370675  |  TrainAcc=98.796 %  |  ValAcc=98.360 %
Epoch:  66  |  Loss=0.037999256  |  TrainAcc=98.865 %  |  ValAcc=98.520 %
Epoch:  67  |  Loss=0.037137022  |  TrainAcc=98.924 %  |  ValAcc=98.580 %
Epoch:  68  |  Loss=0.037509132  |  TrainAcc=98.882 %  |  ValAcc=98.540 %
Epoch:  69  |  Loss=0.037059930  |  TrainAcc=98.880 %  |  ValAcc=98.620 %
Epoch:  70  |  Loss=0.036499026  |  TrainAcc=98.960 %  |  ValAcc=98.640 %
Epoch:  71  |  Loss=0.033778524  |  TrainAcc=99.024 %  |  ValAcc=98.560 %
Epoch:  72  |  Loss=0.036193774  |  TrainAcc=98.987 %  |  ValAcc=98.640 %
Epoch:  73  |  Loss=0.033613385  |  TrainAcc=98.835 %  |  ValAcc=98.360 %
Epoch:  74  |  Loss=0.034406991  |  TrainAcc=99.033 %  |  ValAcc=98.640 %
Epoch:  75  |  Loss=0.032862643  |  TrainAcc=98.856 %  |  ValAcc=98.360 %
Epoch:  76  |  Loss=0.033273037  |  TrainAcc=98.976 %  |  ValAcc=98.500 %
Epoch:  77  |  Loss=0.031886878  |  TrainAcc=99.009 %  |  ValAcc=98.600 %
Epoch:  78  |  Loss=0.032120317  |  TrainAcc=99.058 %  |  ValAcc=98.420 %
Epoch:  79  |  Loss=0.030135295  |  TrainAcc=98.965 %  |  ValAcc=98.480 %
Epoch:  80  |  Loss=0.030467471  |  TrainAcc=99.104 %  |  ValAcc=98.580 %
Epoch:  81  |  Loss=0.029909991  |  TrainAcc=99.129 %  |  ValAcc=98.600 %
Epoch:  82  |  Loss=0.030432300  |  TrainAcc=99.078 %  |  ValAcc=98.520 %
Epoch:  83  |  Loss=0.028039969  |  TrainAcc=99.069 %  |  ValAcc=98.560 %
Epoch:  84  |  Loss=0.028668668  |  TrainAcc=99.136 %  |  ValAcc=98.820 %
Epoch:  85  |  Loss=0.029780842  |  TrainAcc=99.224 %  |  ValAcc=98.640 %
Epoch:  86  |  Loss=0.026394663  |  TrainAcc=99.158 %  |  ValAcc=98.540 %
Epoch:  87  |  Loss=0.026846643  |  TrainAcc=99.233 %  |  ValAcc=98.700 %
Epoch:  88  |  Loss=0.027267599  |  TrainAcc=99.193 %  |  ValAcc=98.740 %
Epoch:  89  |  Loss=0.025434776  |  TrainAcc=99.244 %  |  ValAcc=98.620 %
Epoch:  90  |  Loss=0.026467450  |  TrainAcc=99.289 %  |  ValAcc=98.760 %
Epoch:  91  |  Loss=0.025113746  |  TrainAcc=99.120 %  |  ValAcc=98.480 %
Epoch:  92  |  Loss=0.024460365  |  TrainAcc=99.300 %  |  ValAcc=98.780 %
Epoch:  93  |  Loss=0.026168538  |  TrainAcc=99.222 %  |  ValAcc=98.720 %
Epoch:  94  |  Loss=0.023431352  |  TrainAcc=99.315 %  |  ValAcc=98.700 %
Epoch:  95  |  Loss=0.024043131  |  TrainAcc=99.231 %  |  ValAcc=98.640 %
Epoch:  96  |  Loss=0.022724619  |  TrainAcc=99.269 %  |  ValAcc=98.760 %
```

```
Epoch: 97 | Loss=0.024427595 | TrainAcc=99.376 % | ValAcc=98.660 %
Epoch: 98 | Loss=0.022164499 | TrainAcc=99.347 % | ValAcc=98.660 %
Epoch: 99 | Loss=0.021782059 | TrainAcc=99.378 % | ValAcc=98.800 %
Epoch: 100 | Loss=0.022131189 | TrainAcc=99.142 % | ValAcc=98.640 %
Training Finished in 2686.6 seconds.
Final accuracies:
~ TrainAcc: 99.142 %
~ ValAcc: 98.640 %
~ TestAcc: 98.450 %
Saving model in file: Models/lenet5-model_adam_relu_lr00001_bs128
```

> **COMMENT:**
>
> Other measure that we took was to stop the training when reaching 100% accuracy.
> Nevertheless, even with 100% accuracy the loss keeps going down, which is why we
> implemented the model loading and retrained the best model for other 30 epochs:

In [344]:
```python
# Ending the training of the best optimizer
CNNet (modelName='lenet5-model_best',
        learning_rate = 0.001,
        training_epochs = 30,
        batch_size = 128,
        activationFunc=tf.nn.relu,
        optimFunc=tf.train.AdamOptimizer,
        loadModel='lenet5-model_adam_relu_lr0001_bs128'
    )
```

```
*Model [ lenet5-model_best ] {l_r: 0.0010; n_iter: 30; batch: 128}
Start Training!
Epoch: 01 | Loss=0.000036285 | TrainAcc=100.000 % | ValAcc=99.040 %
Epoch: 02 | Loss=0.000020620 | TrainAcc=100.000 % | ValAcc=99.060 %
Epoch: 03 | Loss=0.000013097 | TrainAcc=100.000 % | ValAcc=99.060 %
Epoch: 04 | Loss=0.000011698 | TrainAcc=100.000 % | ValAcc=99.060 %
Epoch: 05 | Loss=0.000008156 | TrainAcc=100.000 % | ValAcc=99.040 %
Epoch: 06 | Loss=0.000006704 | TrainAcc=100.000 % | ValAcc=99.020 %
Epoch: 07 | Loss=0.000005328 | TrainAcc=100.000 % | ValAcc=99.040 %
Epoch: 08 | Loss=0.000004981 | TrainAcc=100.000 % | ValAcc=99.040 %
Epoch: 09 | Loss=0.000003284 | TrainAcc=100.000 % | ValAcc=99.020 %
Epoch: 10 | Loss=0.000003292 | TrainAcc=100.000 % | ValAcc=99.040 %
Epoch: 11 | Loss=0.000002527 | TrainAcc=100.000 % | ValAcc=99.040 %
Epoch: 12 | Loss=0.000001922 | TrainAcc=100.000 % | ValAcc=99.020 %
Epoch: 13 | Loss=0.000001719 | TrainAcc=100.000 % | ValAcc=99.020 %
Epoch: 14 | Loss=0.000001187 | TrainAcc=100.000 % | ValAcc=99.020 %
Epoch: 15 | Loss=0.000001085 | TrainAcc=100.000 % | ValAcc=99.020 %
Epoch: 16 | Loss=0.000000890 | TrainAcc=100.000 % | ValAcc=99.040 %
Epoch: 17 | Loss=0.000000700 | TrainAcc=100.000 % | ValAcc=99.040 %
Epoch: 18 | Loss=0.000000528 | TrainAcc=100.000 % | ValAcc=99.080 %
Epoch: 19 | Loss=0.000000464 | TrainAcc=100.000 % | ValAcc=99.040 %
Epoch: 20 | Loss=0.000000353 | TrainAcc=100.000 % | ValAcc=99.060 %
Epoch: 21 | Loss=0.000000281 | TrainAcc=100.000 % | ValAcc=99.080 %
Epoch: 22 | Loss=0.000000242 | TrainAcc=100.000 % | ValAcc=99.060 %
Epoch: 23 | Loss=0.000000182 | TrainAcc=100.000 % | ValAcc=99.080 %
Epoch: 24 | Loss=0.000000135 | TrainAcc=100.000 % | ValAcc=99.080 %
Epoch: 25 | Loss=0.000000126 | TrainAcc=100.000 % | ValAcc=99.080 %
Epoch: 26 | Loss=0.000000096 | TrainAcc=100.000 % | ValAcc=99.080 %
Epoch: 27 | Loss=0.000000078 | TrainAcc=100.000 % | ValAcc=99.060 %
Epoch: 28 | Loss=0.000000057 | TrainAcc=100.000 % | ValAcc=99.080 %
Epoch: 29 | Loss=0.000000048 | TrainAcc=100.000 % | ValAcc=99.100 %
```

```
Epoch: 30 | Loss=0.000000037 | TrainAcc=100.000 % | ValAcc=99.080 %
Training Finished in 805.4 seconds.
Final accuracies:
~ TrainAcc: 100.000 %
~ ValAcc: 99.080 %
~ TestAcc: 99.110 %
Saving model in file: Models/lenet5-model_best
```

2.2.2 Dropout layer [Question 2.2.2]

What about applying a dropout layer on the Fully conntected layer and then retraining the model with the best Optimizer and parameters(Learning rate and Batsh size) obtained in the previous section? (probability to keep units=0.75). For this stage we ensure that the keep prob is set to 1.0 to evaluate the performance of the network including all nodes.

In [312]:
```python
CNNet ('lenet5-model',
        learning_rate = 0.001,
        training_epochs = 100,
        batch_size = 128,
        activationFunc = tf.nn.relu,
        optimFunc=tf.train.AdamOptimizer,
        keep_p = 0.75
    )
```

```
*Model [ lenet5-model ] {l_r: 0.0010; n_iter: 100; batch: 128}
  Start Training!
  Epoch: 01 | Loss=1.462579143 | TrainAcc=86.182 % | ValAcc=86.920 %
  Epoch: 02 | Loss=0.320648048 | TrainAcc=95.773 % | ValAcc=95.900 %
  Epoch: 03 | Loss=0.156452648 | TrainAcc=97.318 % | ValAcc=97.500 %
  Epoch: 04 | Loss=0.107257504 | TrainAcc=97.940 % | ValAcc=97.900 %
  Epoch: 05 | Loss=0.079941446 | TrainAcc=98.598 % | ValAcc=98.300 %
  Epoch: 06 | Loss=0.067996642 | TrainAcc=98.916 % | ValAcc=98.600 %
  Epoch: 07 | Loss=0.056781804 | TrainAcc=98.987 % | ValAcc=98.820 %
  Epoch: 08 | Loss=0.049156536 | TrainAcc=99.084 % | ValAcc=98.780 %
  Epoch: 09 | Loss=0.046372587 | TrainAcc=99.335 % | ValAcc=98.820 %
  Epoch: 10 | Loss=0.039569505 | TrainAcc=99.242 % | ValAcc=98.860 %
  Epoch: 11 | Loss=0.035637989 | TrainAcc=99.491 % | ValAcc=99.100 %
  Epoch: 12 | Loss=0.033921816 | TrainAcc=99.558 % | ValAcc=99.000 %
  Epoch: 13 | Loss=0.029400493 | TrainAcc=99.427 % | ValAcc=98.780 %
  Epoch: 14 | Loss=0.029948988 | TrainAcc=99.547 % | ValAcc=98.920 %
  Epoch: 15 | Loss=0.025876489 | TrainAcc=99.580 % | ValAcc=98.900 %
  Epoch: 16 | Loss=0.024096347 | TrainAcc=99.653 % | ValAcc=99.000 %
  Epoch: 17 | Loss=0.021928211 | TrainAcc=99.691 % | ValAcc=99.020 %
  Epoch: 18 | Loss=0.020788123 | TrainAcc=99.789 % | ValAcc=98.960 %
  Epoch: 19 | Loss=0.017248768 | TrainAcc=99.685 % | ValAcc=99.000 %
  Epoch: 20 | Loss=0.019471339 | TrainAcc=99.747 % | ValAcc=98.920 %
  Epoch: 21 | Loss=0.018876892 | TrainAcc=99.787 % | ValAcc=99.040 %
  Epoch: 22 | Loss=0.016631310 | TrainAcc=99.796 % | ValAcc=98.960 %
  Epoch: 23 | Loss=0.015412680 | TrainAcc=99.833 % | ValAcc=98.940 %
  Epoch: 24 | Loss=0.014776390 | TrainAcc=99.838 % | ValAcc=99.220 %
  Epoch: 25 | Loss=0.016413795 | TrainAcc=99.882 % | ValAcc=99.140 %
  Epoch: 26 | Loss=0.013022174 | TrainAcc=99.878 % | ValAcc=99.080 %
  Epoch: 27 | Loss=0.013108108 | TrainAcc=99.751 % | ValAcc=98.920 %
  Epoch: 28 | Loss=0.012482495 | TrainAcc=99.845 % | ValAcc=99.020 %
  Epoch: 29 | Loss=0.011373647 | TrainAcc=99.911 % | ValAcc=99.140 %
  Epoch: 30 | Loss=0.013156030 | TrainAcc=99.884 % | ValAcc=99.220 %
  Epoch: 31 | Loss=0.012250657 | TrainAcc=99.933 % | ValAcc=99.220 %
  Epoch: 32 | Loss=0.011849047 | TrainAcc=99.945 % | ValAcc=99.180 %
  Epoch: 33 | Loss=0.009569408 | TrainAcc=99.876 % | ValAcc=98.980 %
```

```
Epoch: 34 | Loss=0.010187886 | TrainAcc=99.876 % | ValAcc=99.020 %
Epoch: 35 | Loss=0.008628585 | TrainAcc=99.920 % | ValAcc=98.960 %
Epoch: 36 | Loss=0.011090174 | TrainAcc=99.880 % | ValAcc=99.140 %
Epoch: 37 | Loss=0.010603959 | TrainAcc=99.791 % | ValAcc=98.900 %
Epoch: 38 | Loss=0.010294543 | TrainAcc=99.949 % | ValAcc=99.140 %
Epoch: 39 | Loss=0.009244751 | TrainAcc=99.976 % | ValAcc=99.200 %
Epoch: 40 | Loss=0.007726011 | TrainAcc=99.904 % | ValAcc=99.000 %
Epoch: 41 | Loss=0.007734558 | TrainAcc=99.935 % | ValAcc=99.020 %
Epoch: 42 | Loss=0.009800617 | TrainAcc=99.918 % | ValAcc=99.060 %
Epoch: 43 | Loss=0.008972260 | TrainAcc=99.925 % | ValAcc=99.120 %
Epoch: 44 | Loss=0.007027677 | TrainAcc=99.931 % | ValAcc=99.140 %
Epoch: 45 | Loss=0.008789836 | TrainAcc=99.956 % | ValAcc=99.080 %
Epoch: 46 | Loss=0.008016213 | TrainAcc=99.962 % | ValAcc=99.220 %
Epoch: 47 | Loss=0.008566651 | TrainAcc=99.927 % | ValAcc=99.160 %
Epoch: 48 | Loss=0.006483152 | TrainAcc=99.849 % | ValAcc=99.000 %
Epoch: 49 | Loss=0.007160175 | TrainAcc=99.978 % | ValAcc=99.200 %
Epoch: 50 | Loss=0.006316839 | TrainAcc=99.949 % | ValAcc=99.120 %
Epoch: 51 | Loss=0.007614891 | TrainAcc=99.984 % | ValAcc=99.000 %
Epoch: 52 | Loss=0.007235258 | TrainAcc=99.880 % | ValAcc=98.980 %
Epoch: 53 | Loss=0.008472990 | TrainAcc=99.935 % | ValAcc=99.040 %
Epoch: 54 | Loss=0.005591699 | TrainAcc=99.947 % | ValAcc=99.100 %
Epoch: 55 | Loss=0.006767461 | TrainAcc=99.956 % | ValAcc=99.120 %
Epoch: 56 | Loss=0.008023979 | TrainAcc=99.949 % | ValAcc=99.100 %
Epoch: 57 | Loss=0.006355836 | TrainAcc=99.978 % | ValAcc=99.040 %
Epoch: 58 | Loss=0.007154427 | TrainAcc=99.982 % | ValAcc=99.220 %
Epoch: 59 | Loss=0.005448605 | TrainAcc=99.969 % | ValAcc=99.020 %
Epoch: 60 | Loss=0.005992711 | TrainAcc=99.951 % | ValAcc=99.000 %
Epoch: 61 | Loss=0.007338103 | TrainAcc=99.989 % | ValAcc=99.180 %
Epoch: 62 | Loss=0.006021912 | TrainAcc=99.982 % | ValAcc=99.240 %
Epoch: 63 | Loss=0.007646662 | TrainAcc=99.975 % | ValAcc=99.280 %
Epoch: 64 | Loss=0.005512220 | TrainAcc=99.984 % | ValAcc=99.180 %
Epoch: 65 | Loss=0.005569470 | TrainAcc=99.976 % | ValAcc=99.200 %
Epoch: 66 | Loss=0.005267732 | TrainAcc=99.982 % | ValAcc=99.160 %
Epoch: 67 | Loss=0.004858207 | TrainAcc=99.904 % | ValAcc=98.920 %
Epoch: 68 | Loss=0.008335329 | TrainAcc=99.913 % | ValAcc=99.040 %
Epoch: 69 | Loss=0.006250409 | TrainAcc=99.987 % | ValAcc=99.180 %
Epoch: 70 | Loss=0.007171843 | TrainAcc=99.929 % | ValAcc=99.060 %
Epoch: 71 | Loss=0.005226717 | TrainAcc=99.987 % | ValAcc=99.200 %
Epoch: 72 | Loss=0.005610764 | TrainAcc=99.995 % | ValAcc=99.260 %
Epoch: 73 | Loss=0.003621007 | TrainAcc=99.944 % | ValAcc=98.960 %
Epoch: 74 | Loss=0.005122103 | TrainAcc=99.991 % | ValAcc=99.140 %
Epoch: 75 | Loss=0.007763147 | TrainAcc=99.958 % | ValAcc=99.100 %
Epoch: 76 | Loss=0.004949913 | TrainAcc=99.975 % | ValAcc=99.120 %
Epoch: 77 | Loss=0.005895723 | TrainAcc=99.982 % | ValAcc=99.000 %
Epoch: 78 | Loss=0.005900653 | TrainAcc=99.982 % | ValAcc=99.140 %
Epoch: 79 | Loss=0.006594847 | TrainAcc=99.980 % | ValAcc=99.120 %
Epoch: 80 | Loss=0.004076439 | TrainAcc=99.993 % | ValAcc=99.220 %
Epoch: 81 | Loss=0.006026144 | TrainAcc=99.995 % | ValAcc=99.220 %
Epoch: 82 | Loss=0.004031588 | TrainAcc=99.993 % | ValAcc=99.140 %
Epoch: 83 | Loss=0.004725516 | TrainAcc=99.942 % | ValAcc=99.060 %
Epoch: 84 | Loss=0.004953352 | TrainAcc=99.980 % | ValAcc=99.060 %
Epoch: 85 | Loss=0.007481557 | TrainAcc=99.927 % | ValAcc=99.100 %
Epoch: 86 | Loss=0.004820829 | TrainAcc=99.982 % | ValAcc=99.120 %
Epoch: 87 | Loss=0.004262584 | TrainAcc=99.980 % | ValAcc=99.080 %
Epoch: 88 | Loss=0.004377514 | TrainAcc=99.989 % | ValAcc=99.120 %
Epoch: 89 | Loss=0.006101638 | TrainAcc=99.995 % | ValAcc=99.180 %
Epoch: 90 | Loss=0.004651474 | TrainAcc=99.982 % | ValAcc=99.080 %
Epoch: 91 | Loss=0.003524272 | TrainAcc=99.976 % | ValAcc=99.060 %
Epoch: 92 | Loss=0.003793414 | TrainAcc=99.978 % | ValAcc=98.960 %
Epoch: 93 | Loss=0.004249668 | TrainAcc=99.982 % | ValAcc=99.140 %
Epoch: 94 | Loss=0.005965028 | TrainAcc=99.920 % | ValAcc=99.120 %
```

```
Epoch: 95  | Loss=0.005710053 | TrainAcc=99.967 % | ValAcc=99.140 %
Epoch: 96  | Loss=0.003603934 | TrainAcc=99.958 % | ValAcc=99.080 %
Epoch: 97  | Loss=0.003396762 | TrainAcc=99.958 % | ValAcc=99.060 %
Epoch: 98  | Loss=0.004033627 | TrainAcc=99.989 % | ValAcc=99.100 %
Epoch: 99  | Loss=0.006118423 | TrainAcc=99.984 % | ValAcc=99.000 %
Epoch: 100 | Loss=0.003984706 | TrainAcc=99.991 % | ValAcc=99.200 %
Training Finished in 2681.9 seconds.
Final accuracies:
~ TrainAcc: 99.991 %
~ ValAcc: 99.200 %
~ TestAcc: 99.040 %
Saving model in file: Models/lenet5-model
```

COMMENT:

We had everything implemented in the functions above, we only needed to call it.

We once again surpass the 99% frontier! In fact, since the validation acuracy is 99.2%, this suggests that further playing with the keep probability could lead to an even better model. However, this is our of the scope of this notebook