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    "from keras.models import Sequential\n",
    "from keras.layers import Dense\n",
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    "import matplotlib.pyplot as plt\n",
    "%matplotlib inline"
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    "X_test = X_test.astype('float32')"
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0.          0.\n",
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0.          0.\n",
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    "print(X_train[0])"
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    "print(y_test.shape)"
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      "(10000, 10)\n"
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```

```
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  "y_test = to_categorical(y_test,10)\n",
  "print(y_train.shape)\n",
  "print(y_test.shape)"
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 ]
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\n",
    "model.add(Dense(512, activation='relu'))\n",
    "model.add(Dense(10,activation='softmax'))"
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metrics=['accuracy'])"
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",
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#   \n",

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\n",

"_________________________________________________________________\n
",
      "dense_2 (Dense)              (None, 512)               262656
\n",

"_________________________________________________________________\n
",
      "dense_3 (Dense)              (None, 10)                5130
\n",

"=================================================================\n
",
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      "Non-trainable params: 0\n",

"_________________________________________________________________\n
"
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0.1833 - acc: 0.9437 - val_loss: 0.1020 - val_acc: 0.9679\n",
```

```
      "Epoch 2/20\n",
      "60000/60000 [==============================] - 36s - loss:
0.0793 - acc: 0.9759 - val_loss: 0.1037 - val_acc: 0.9687\n",
      "Epoch 3/20\n",
      "60000/60000 [==============================] - 36s - loss:
0.0570 - acc: 0.9821 - val_loss: 0.1066 - val_acc: 0.9719\n",
      "Epoch 4/20\n",
      "60000/60000 [==============================] - 36s - loss:
0.0438 - acc: 0.9859 - val_loss: 0.0738 - val_acc: 0.9802\n",
      "Epoch 5/20\n",
      "60000/60000 [==============================] - 34s - loss:
0.0352 - acc: 0.9881 - val_loss: 0.1097 - val_acc: 0.9695\n",
      "Epoch 6/20\n",
      "60000/60000 [==============================] - 31s - loss:
0.0281 - acc: 0.9911 - val_loss: 0.0735 - val_acc: 0.9803\n",
      "Epoch 7/20\n",
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0.0254 - acc: 0.9921 - val_loss: 0.0874 - val_acc: 0.9800\n",
      "Epoch 8/20\n",
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0.0233 - acc: 0.9931 - val_loss: 0.0949 - val_acc: 0.9798\n",
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0.0201 - acc: 0.9935 - val_loss: 0.0927 - val_acc: 0.9809\n",
      "Epoch 10/20\n",
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0.0163 - acc: 0.9943 - val_loss: 0.1108 - val_acc: 0.9793\n",
      "Epoch 11/20\n",
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      "Epoch 12/20\n",
      "60000/60000 [==============================] - 31s - loss:
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      "60000/60000 [==============================] - 31s - loss:
0.0166 - acc: 0.9952 - val_loss: 0.1206 - val_acc: 0.9807\n",
      "Epoch 14/20\n",
      "60000/60000 [==============================] - 32s - loss:
0.0149 - acc: 0.9959 - val_loss: 0.0959 - val_acc: 0.9837\n",
      "Epoch 15/20\n",
      "60000/60000 [==============================] - 34s - loss:
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      "Epoch 16/20\n",
      "60000/60000 [==============================] - 31s - loss:
0.0126 - acc: 0.9962 - val_loss: 0.1104 - val_acc: 0.9819\n",
      "Epoch 17/20\n",
      "60000/60000 [==============================] - 32s - loss:
0.0181 - acc: 0.9955 - val_loss: 0.1102 - val_acc: 0.9809\n",
      "Epoch 18/20\n",
      "60000/60000 [==============================] - 31s - loss:
0.0122 - acc: 0.9968 - val_loss: 0.1060 - val_acc: 0.9826\n",
      "Epoch 19/20\n",
      "60000/60000 [==============================] - 33s - loss:
0.0141 - acc: 0.9961 - val_loss: 0.1392 - val_acc: 0.9814\n",
```

```
      "Epoch 20/20\n",
      "60000/60000 [==============================] - 33s - loss:
0.0119 - acc: 0.9969 - val_loss: 0.1471 - val_acc: 0.9783\n"
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validation_data=(X_test, y_test))"
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  "print(y_test.shape)"
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  "X_test = X_test.reshape(10000,28,28,1)\n",
  "X_train = X_train.astype('float32')\n",
  "X_test = X_test.astype('float32')\n",
  "X_train /= 255.0\n",
  "X_test /= 255.0\n",
```

```
    "y_train = to_categorical(y_train,num_classes)\n",
    "y_test = to_categorical(y_test, num_classes)\n",
    "\n",
    "batch_size = 128\n",
    "num_classes = 10\n",
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      "(10000, 28, 28, 1)\n",
      "(10000, 10)\n"
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    "print(y_test.shape)"
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#   \n",
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padding='same', activation='relu'))\n",
    "cnn.add(MaxPooling2D())\n",
    "cnn.add(Conv2D(32, kernel_size=(3,3),padding='same',
```

```
activation='relu'))\n",
    "cnn.add(MaxPooling2D())\n",
    "cnn.add(Flatten())\n",
    "cnn.add(Dense(64,activation='relu'))\n",
    "cnn.add(Dense(10,activation='softmax'))\n",

"cnn.compile(optimizer='adam',loss='categorical_crossentropy',metric
s=['accuracy'])\n",
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0.1546 - acc: 0.9524 - val_loss: 0.0521 - val_acc: 0.9845\n",
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0.0488 - acc: 0.9845 - val_loss: 0.0301 - val_acc: 0.9913\n",
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0.0350 - acc: 0.9890 - val_loss: 0.0204 - val_acc: 0.9939\n",
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0.0272 - acc: 0.9912 - val_loss: 0.0185 - val_acc: 0.9938\n",
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0.0205 - acc: 0.9934 - val_loss: 0.0121 - val_acc: 0.9964\n",
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0.0158 - acc: 0.9949 - val_loss: 0.0086 - val_acc: 0.9974\n",
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0.0136 - acc: 0.9956 - val_loss: 0.0090 - val_acc: 0.9970\n",
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0.0105 - acc: 0.9967 - val_loss: 0.0065 - val_acc: 0.9979\n",
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0.0095 - acc: 0.9966 - val_loss: 0.0092 - val_acc: 0.9967\n",
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0.0077 - acc: 0.9972 - val_loss: 0.0058 - val_acc: 0.9981\n",
      "Epoch 11/20\n",
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0.0080 - acc: 0.9973 - val_loss: 0.0056 - val_acc: 0.9980\n",
```

```
      "Epoch 12/20\n",
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0.0055 - acc: 0.9983 - val_loss: 0.0037 - val_acc: 0.9987\n",
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0.0070 - acc: 0.9978 - val_loss: 0.0027 - val_acc: 0.9991\n",
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loss: 0.0068 - acc: 0.9976"
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cnn.fit(X_train,y_train,epochs=20,verbose=1,validation_data=(X_train
,y_train))"
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  "plt.plot(history_cnn.history['val_acc'])"
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HUN    Men   \n",
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