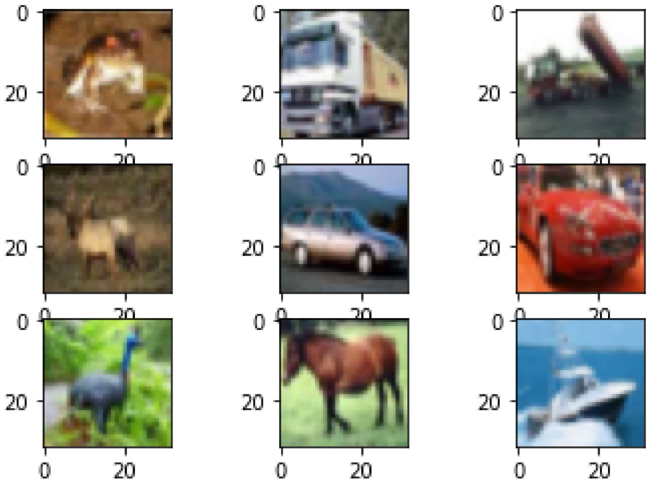
In [1]:

```python
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
import seaborn as sns
import keras as k
import tensorflow as tf
from keras.datasets import cifar10
from sklearn.metrics import accuracy_score,confusion_matrix,classification_report
from sklearn.model_selection import train_test_split
```

In [2]:

```python
(trainX, trainy), (testX, testy) = cifar10.load_data()
print('Train: X=%s, y=%s' % (trainX.shape, trainy.shape))
print('Test: X=%s, y=%s' % (testX.shape, testy.shape))
for i in range(9):
    plt.subplot(330 + 1 + i)
    plt.imshow(trainX[i])
plt.show()
```

```
Downloading data from https://www.cs.toronto.edu/~kriz/cifar-10-python.tar.gz (https://www.cs.toronto.edu/~kriz/cifar-10-py
thon.tar.gz)
170500096/170498071 [==============================] - 2s 0us/step
Train: X=(50000, 32, 32, 3), y=(50000, 1)
Test: X=(10000, 32, 32, 3), y=(10000, 1)
```



In [3]:

```
from keras.utils import to_categorical
trainy = to_categorical(trainy)
testy = to_categorical(testy)
```

In [4]:

```
from keras.layers import Conv2D,MaxPooling2D,Flatten,Dense,BatchNormalization
from keras.models import Sequential
from keras.optimizers import SGD
from keras.preprocessing.image import ImageDataGenerator
```

In [5]:

```
datagen = ImageDataGenerator(width_shift_range=0.1, height_shift_range=0.1, horizontal_flip=True)
```

In [6]:

```
model = Sequential()
model.add(Conv2D(32, (3, 3), activation='relu', kernel_initializer='he_uniform', padding='same', input_shape=(32, 32, 3)))
model.add(Conv2D(32, (3, 3), activation='relu', kernel_initializer='he_uniform', padding='same'))
model.add(MaxPooling2D((2, 2)))
model.add(BatchNormalization()) # Adding Batch Normalization
model.add(Conv2D(64, (3, 3), activation='relu', kernel_initializer='he_uniform', padding='same'))
model.add(Conv2D(64, (3, 3), activation='relu', kernel_initializer='he_uniform', padding='same'))
model.add(MaxPooling2D((2, 2)))
model.add(Conv2D(128, (3, 3), activation='relu', kernel_initializer='he_uniform', padding='same'))
model.add(Conv2D(128, (3, 3), activation='relu', kernel_initializer='he_uniform', padding='same'))
model.add(MaxPooling2D((2, 2)))
model.add(Flatten())
model.add(Dense(128, activation='relu', kernel_initializer='he_uniform'))
model.add(Dense(10, activation='softmax'))
# compile model
opt = SGD(lr=0.001, momentum=0.9)
model.compile(optimizer=opt, loss='categorical_crossentropy', metrics=['accuracy'])
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 32, 32, 32)        896
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 32, 32, 32)        9248
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 16, 16, 32)        0
_________________________________________________________________
batch_normalization (BatchNo (None, 16, 16, 32)        128
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 16, 16, 64)        18496
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 16, 16, 64)        36928
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 8, 8, 64)          0
_________________________________________________________________
conv2d_4 (Conv2D)            (None, 8, 8, 128)         73856
_________________________________________________________________
conv2d_5 (Conv2D)            (None, 8, 8, 128)         147584
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 4, 4, 128)         0
_________________________________________________________________
```

```
flatten (Flatten)            (None, 2048)              0
_________________________________________________________________
dense (Dense)                (None, 128)               262272
_________________________________________________________________
dense_1 (Dense)              (None, 10)                1290
=================================================================
Total params: 550,698
Trainable params: 550,634
Non-trainable params: 64
_________________________________________________________________
```

In [7]:

```python
it_train = datagen.flow(trainX, trainy, batch_size=64)
```

In [8]:

```python
steps = int(trainX.shape[0] / 64)
history = model.fit_generator(it_train, steps_per_epoch=steps, epochs=20, validation_data=(testX, testy), verbose=0)
```

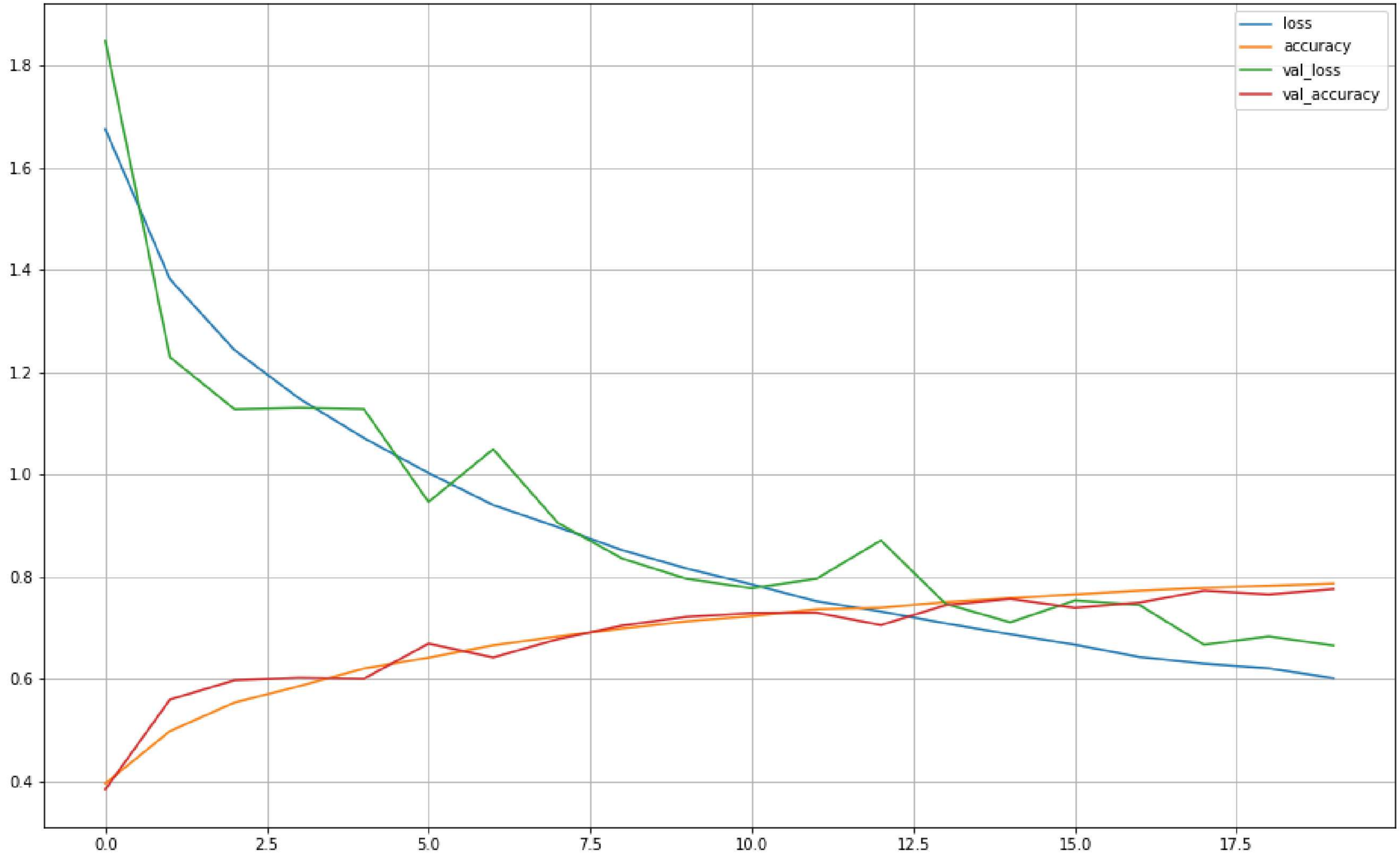
```
/usr/local/lib/python3.7/dist-packages/tensorflow/python/keras/engine/training.py:1844: UserWarning: `Model.fit_generator` is deprecated and will be removed in a future version. Please use `Model.fit`, which supports generators.
  warnings.warn('`Model.fit_generator` is deprecated and '
```

In [9]:

```python
history = pd.DataFrame(history.history)
```

In [16]:

```
history.plot.line(figsize=(16,10)).grid("whitegrid")
```



In [11]:
```
ypred = np.argmax(model.predict(testX),axis=1)
```

In [12]:
```
ypred
```

Out[12]:
```
array([3, 8, 8, ..., 5, 1, 7])
```

In [13]:
```
testty = np.argmax(testy,axis=1)
```

In [14]:
```
testty
```

Out[14]:
```
array([3, 8, 8, ..., 5, 1, 7])
```

In [15]:
```
accuracy_score(ypred,testty)
```

Out[15]:
```
0.7764
```