CIFAR-100 Image Classification

Import libraries

In [2]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import tensorflow as tf
from keras import models
from keras import layers
```

In [3]:
```
data = tf.keras.datasets.cifar100
```

In [4]:
```
(train_images, train_labels), (test_images, test_labels) = data.load_data()
```

In [5]:
```
train_images.shape
```

Out[5]:
```
(50000, 32, 32, 3)
```

In [6]:
```
test_images.shape
```

Out[6]:
```
(10000, 32, 32, 3)
```

In [7]:
```
print(train_labels[0])
```

```
[19]
```

In [8]:
```
train_labels[0]
```

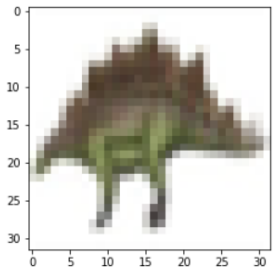
Out[8]:
```
array([19])
```

In [9]:
```
train_images[1]
```

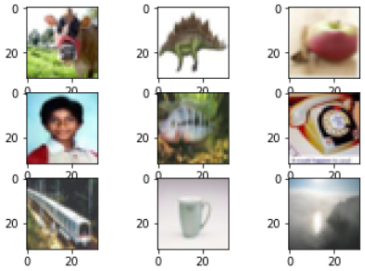
Out[9]:
```
array([[[255, 255, 255],
        [253, 253, 253],
        [253, 253, 253],
        ...,
        [253, 253, 253],
        [253, 253, 253],
        [255, 255, 255]],

       [[255, 255, 255],
        [255, 255, 255],
        [255, 255, 255],
        ...,
        [255, 255, 255],
        [255, 255, 255],
        [255, 255, 255]],
```

```
[[255, 255, 255],
 [255, 255, 255],
 [255, 255, 255],
 ...,
 [255, 255, 255],
 [255, 255, 255],
 [255, 255, 255]],

...,

[[255, 255, 255],
 [255, 255, 255],
 [255, 255, 255],
 ...,
 [255, 255, 255],
 [255, 255, 255],
 [255, 255, 255]],

[[255, 255, 255],
 [255, 255, 255],
 [255, 255, 255],
 ...,
 [255, 255, 255],
 [255, 255, 255],
 [255, 255, 255]],

[[255, 255, 255],
 [253, 253, 253],
 [253, 253, 253],
 ...,
 [253, 253, 253],
 [253, 253, 253],
 [255, 255, 255]]], dtype=uint8)
```

In [10]:
```
plt.figure()
plt.imshow(train_images[1])
plt.show()
```



In [11]:
```
for i in range(9):
    plt.subplot(330 + 1 + i)
    plt.imshow(train_images[i])
plt.show()
```



In [12]:
```
train_images, test_images = train_images / 255.0, test_images / 255.0
```

In [12]:
```
# 3 conv2d 2 maxpooling 256 adam
model = models.Sequential()
model.add(layers.Conv2D(32, (3, 3), activation='relu', input_shape=(32, 32, 3)))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(256, (3, 3), activation='relu'))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(256, (3, 3), activation='relu'))
model.add(layers.Flatten())
model.add(layers.Dense(256, activation='relu'))
model.add(layers.Dense(100, activation='softmax'))
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 30, 30, 32)        896
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 15, 15, 32)        0
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 13, 13, 256)       73984
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 6, 6, 256)         0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 4, 4, 256)         590080
_________________________________________________________________
flatten (Flatten)            (None, 4096)              0
_________________________________________________________________
dense (Dense)                (None, 256)               1048832
```

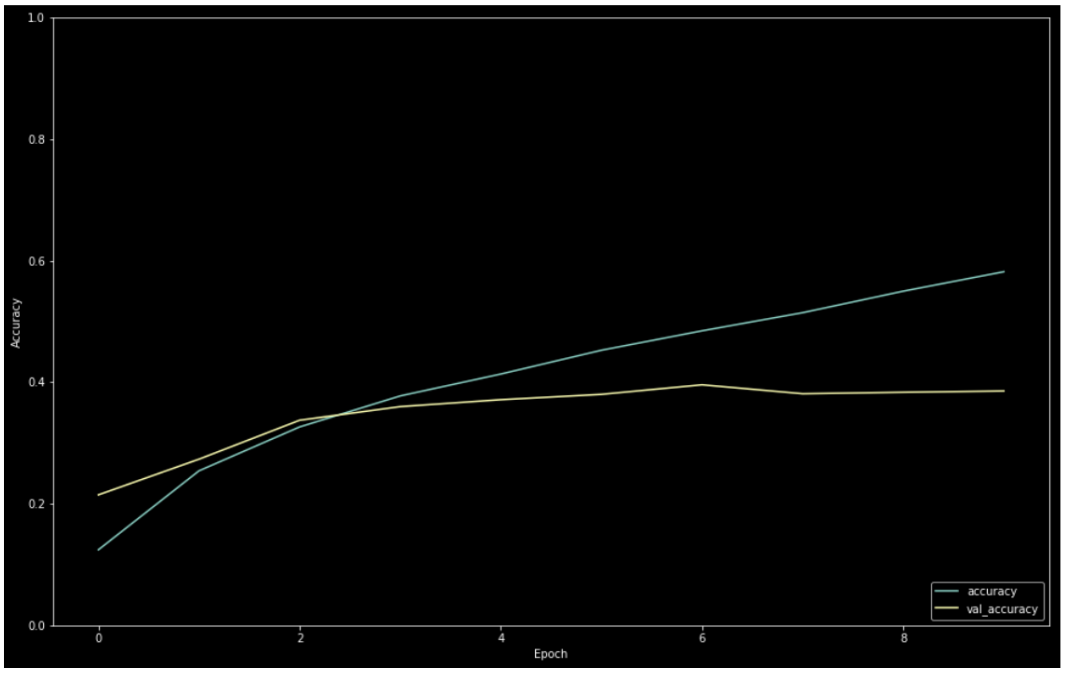
```
_________________________________________________________________
dense_1 (Dense)              (None, 100)               25700     
=================================================================
Total params: 1,739,492
Trainable params: 1,739,492
Non-trainable params: 0
_________________________________________________________________
```

In [13]:
```
model.compile(optimizer='adam', loss='sparse_categorical_crossentropy', metrics=['accuracy'])

history = model.fit(train_images, train_labels, epochs=10, validation_data=(test_images, test_labels))
```

```
Epoch 1/10
1563/1563 [==============================] - 107s 69ms/step - loss: 3.7768 - accuracy: 0.1243 - val_loss: 3.2441 - val_accurac
y: 0.2147
Epoch 2/10
1563/1563 [==============================] - 112s 72ms/step - loss: 3.0198 - accuracy: 0.2543 - val_loss: 2.9064 - val_accurac
y: 0.2734
Epoch 3/10
1563/1563 [==============================] - 108s 69ms/step - loss: 2.6630 - accuracy: 0.3265 - val_loss: 2.6191 - val_accurac
y: 0.3375
Epoch 4/10
1563/1563 [==============================] - 108s 69ms/step - loss: 2.4109 - accuracy: 0.3775 - val_loss: 2.5555 - val_accurac
y: 0.3599
Epoch 5/10
1563/1563 [==============================] - 109s 70ms/step - loss: 2.2283 - accuracy: 0.4135 - val_loss: 2.5135 - val_accurac
y: 0.3713
Epoch 6/10
1563/1563 [==============================] - 110s 70ms/step - loss: 2.0629 - accuracy: 0.4527 - val_loss: 2.4939 - val_accurac
y: 0.3801
Epoch 7/10
1563/1563 [==============================] - 109s 69ms/step - loss: 1.9209 - accuracy: 0.4847 - val_loss: 2.4453 - val_accurac
y: 0.3958
Epoch 8/10
1563/1563 [==============================] - 107s 69ms/step - loss: 1.7792 - accuracy: 0.5145 - val_loss: 2.5443 - val_accurac
y: 0.3811
Epoch 9/10
1563/1563 [==============================] - 106s 68ms/step - loss: 1.6327 - accuracy: 0.5499 - val_loss: 2.6389 - val_accurac
y: 0.3835
Epoch 10/10
1563/1563 [==============================] - 106s 68ms/step - loss: 1.4942 - accuracy: 0.5819 - val_loss: 2.7615 - val_accurac
y: 0.3856
```

In [14]:
```
plt.style.use('dark_background')
plt.figure(figsize=([16,10]))
plt.plot(history.history['accuracy'], label='accuracy')
plt.plot(history.history['val_accuracy'], label = 'val_accuracy')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.ylim([0, 1])
plt.legend(loc='lower right')
```

Out[14]: <matplotlib.legend.Legend at 0x1255df274e0>



In [15]:
```
# 2 conv2d 1 max pooling 256
model = models.Sequential()
model.add(layers.Conv2D(32, (3, 3), activation='relu', input_shape=(32, 32, 3)))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(256, (3, 3), activation='relu'))
model.add(layers.Flatten())
model.add(layers.Dense(256, activation='relu'))
model.add(layers.Dense(100, activation='softmax'))
model.summary()
```

```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
```

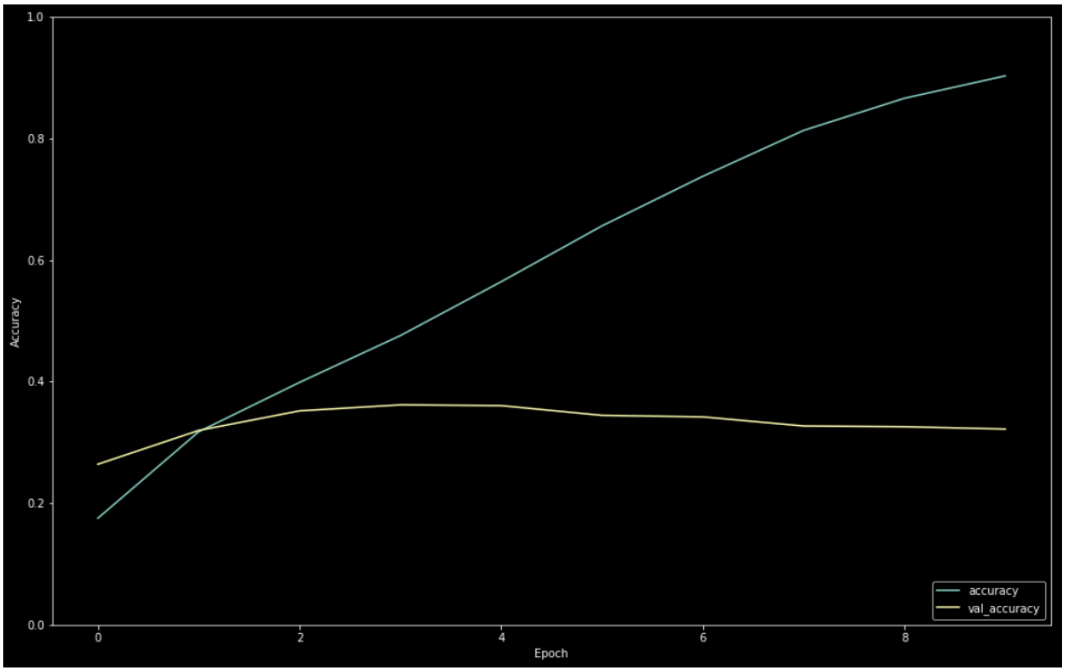
```
=================================================================
conv2d_3 (Conv2D)            (None, 30, 30, 32)        896
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 15, 15, 32)        0
_________________________________________________________________
conv2d_4 (Conv2D)            (None, 13, 13, 256)       73984
_________________________________________________________________
flatten_1 (Flatten)          (None, 43264)             0
_________________________________________________________________
dense_2 (Dense)              (None, 256)               11075840
_________________________________________________________________
dense_3 (Dense)              (None, 100)               25700
=================================================================
Total params: 11,176,420
Trainable params: 11,176,420
Non-trainable params: 0
_________________________________________________________________
```

In [16]:
```
model.compile(optimizer='adam', loss='sparse_categorical_crossentropy', metrics=['accuracy'])

history = model.fit(train_images, train_labels, epochs=10, validation_data=(test_images, test_labels))
```

```
Epoch 1/10
1563/1563 [==============================] - 107s 69ms/step - loss: 3.5243 - accuracy: 0.1752 - val_loss: 3.0372 - val_accurac
y: 0.2641
Epoch 2/10
1563/1563 [==============================] - 107s 69ms/step - loss: 2.7304 - accuracy: 0.3176 - val_loss: 2.7159 - val_accurac
y: 0.3197
Epoch 3/10
1563/1563 [==============================] - 106s 68ms/step - loss: 2.3411 - accuracy: 0.3987 - val_loss: 2.6267 - val_accurac
y: 0.3519
Epoch 4/10
1563/1563 [==============================] - 108s 69ms/step - loss: 1.9826 - accuracy: 0.4757 - val_loss: 2.5890 - val_accurac
y: 0.3618
Epoch 5/10
1563/1563 [==============================] - 109s 70ms/step - loss: 1.6125 - accuracy: 0.5644 - val_loss: 2.7185 - val_accurac
y: 0.3605
Epoch 6/10
1563/1563 [==============================] - 111s 71ms/step - loss: 1.2376 - accuracy: 0.6563 - val_loss: 3.0420 - val_accurac
y: 0.3445
Epoch 7/10
1563/1563 [==============================] - 110s 70ms/step - loss: 0.9189 - accuracy: 0.7378 - val_loss: 3.4343 - val_accurac
y: 0.3420
Epoch 8/10
1563/1563 [==============================] - 109s 70ms/step - loss: 0.6421 - accuracy: 0.8133 - val_loss: 4.0178 - val_accurac
y: 0.3270
Epoch 9/10
1563/1563 [==============================] - 109s 70ms/step - loss: 0.4454 - accuracy: 0.8662 - val_loss: 4.5698 - val_accurac
y: 0.3258
Epoch 10/10
1563/1563 [==============================] - 111s 71ms/step - loss: 0.3232 - accuracy: 0.9031 - val_loss: 5.2432 - val_accurac
y: 0.3220
```

In [17]:
```
plt.style.use('dark_background')
plt.figure(figsize=([16,10]))
plt.plot(history.history['accuracy'], label='accuracy')
plt.plot(history.history['val_accuracy'], label = 'val_accuracy')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.ylim([0, 1])
plt.legend(loc='lower right')
```

Out[17]:
```
<matplotlib.legend.Legend at 0x1252bf9e2b0>
```



In [18]:
```
# 2 conv2d and 1 maxpooling2d 128
model = models.Sequential()
model.add(layers.Conv2D(32, (3, 3), activation='relu', input_shape=(32, 32, 3)))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(128, (3, 3), activation='relu'))
model.add(layers.Flatten())
model.add(layers.Dense(128, activation='relu'))
model.add(layers.Dense(100, activation='softmax'))
model.summary()
```

```
Model: "sequential_2"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_5 (Conv2D)            (None, 30, 30, 32)        896
_________________________________________________________________
max_pooling2d_3 (MaxPooling2 (None, 15, 15, 32)        0
_________________________________________________________________
conv2d_6 (Conv2D)            (None, 13, 13, 128)       36992
_________________________________________________________________
flatten_2 (Flatten)          (None, 21632)             0
_________________________________________________________________
dense_4 (Dense)              (None, 128)               2769024
_________________________________________________________________
dense_5 (Dense)              (None, 100)               12900
=================================================================
Total params: 2,819,812
Trainable params: 2,819,812
Non-trainable params: 0
_________________________________________________________________
```

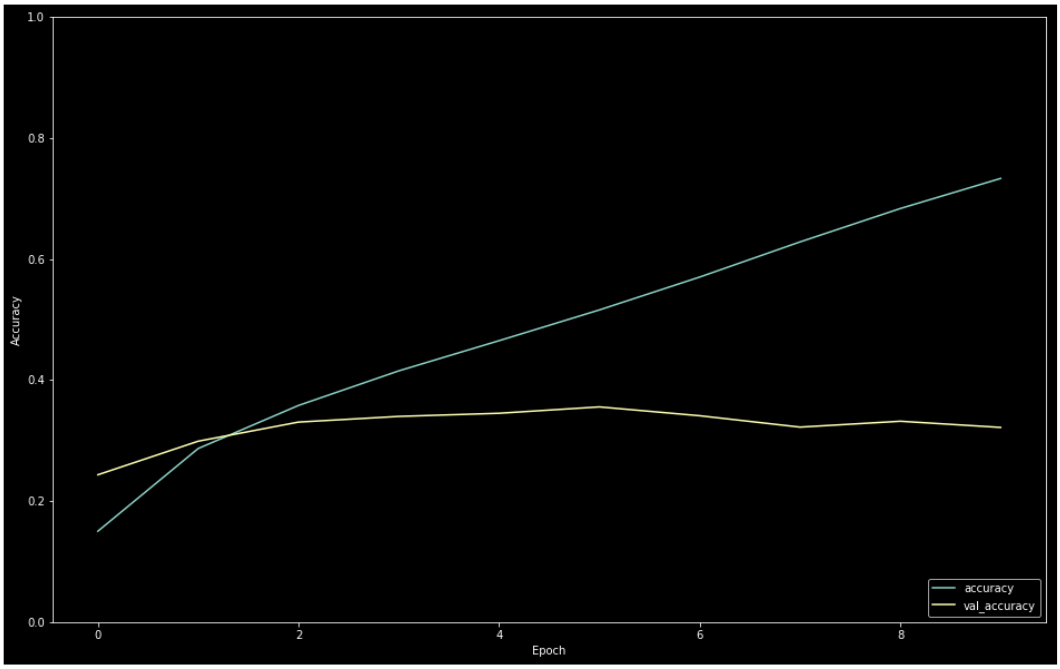
In [19]:
```
model.compile(optimizer='adam', loss='sparse_categorical_crossentropy', metrics=['accuracy'])

history = model.fit(train_images, train_labels, epochs=10, validation_data=(test_images, test_labels))
```

```
Epoch 1/10
1563/1563 [==============================] - 48s 30ms/step - loss: 3.6579 - accuracy: 0.1501 - val_loss: 3.1126 - val_accuracy:
0.2434
Epoch 2/10
1563/1563 [==============================] - 47s 30ms/step - loss: 2.8928 - accuracy: 0.2868 - val_loss: 2.8298 - val_accuracy:
0.2989
Epoch 3/10
1563/1563 [==============================] - 42s 27ms/step - loss: 2.5352 - accuracy: 0.3580 - val_loss: 2.6981 - val_accuracy:
0.3305
Epoch 4/10
1563/1563 [==============================] - 44s 28ms/step - loss: 2.2681 - accuracy: 0.4152 - val_loss: 2.6811 - val_accuracy:
0.3399
Epoch 5/10
1563/1563 [==============================] - 48s 31ms/step - loss: 2.0335 - accuracy: 0.4651 - val_loss: 2.6953 - val_accuracy:
0.3451
```

```
Epoch 6/10
1563/1563 [==============================] - 47s 30ms/step - loss: 1.8083 - accuracy: 0.5159 - val_loss: 2.7382 - val_accuracy:
0.3556
Epoch 7/10
1563/1563 [==============================] - 60s 39ms/step - loss: 1.5717 - accuracy: 0.5703 - val_loss: 2.9106 - val_accuracy:
0.3410
Epoch 8/10
1563/1563 [==============================] - 58s 37ms/step - loss: 1.3432 - accuracy: 0.6283 - val_loss: 3.2036 - val_accuracy:
0.3222
Epoch 9/10
1563/1563 [==============================] - 60s 38ms/step - loss: 1.1245 - accuracy: 0.6835 - val_loss: 3.4947 - val_accuracy:
0.3319
Epoch 10/10
1563/1563 [==============================] - 57s 36ms/step - loss: 0.9263 - accuracy: 0.7333 - val_loss: 3.8307 - val_accuracy:
0.3217
```

In [20]:
```
plt.style.use('dark_background')
plt.figure(figsize=([16,10]))
plt.plot(history.history['accuracy'], label='accuracy')
plt.plot(history.history['val_accuracy'], label = 'val_accuracy')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.ylim([0, 1])
plt.legend(loc='lower right')
```

Out[20]:
```
<matplotlib.legend.Legend at 0x1252c12cfd0>
```



In [19]:
```
# 3 conv2d 2 maxpooling 256 rmsprop
model = models.Sequential()
model.add(layers.Conv2D(32, (3, 3), activation='relu', input_shape=(32, 32, 3)))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(256, (3, 3), activation='relu'))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(256, (3, 3), activation='relu'))
model.add(layers.Flatten())
model.add(layers.Dense(256, activation='relu'))
model.add(layers.Dense(100, activation='softmax'))
model.summary()
```

```
Model: "sequential_2"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_6 (Conv2D)            (None, 30, 30, 32)        896
_________________________________________________________________
max_pooling2d_4 (MaxPooling2 (None, 15, 15, 32)        0
_________________________________________________________________
conv2d_7 (Conv2D)            (None, 13, 13, 256)       73984
_________________________________________________________________
max_pooling2d_5 (MaxPooling2 (None, 6, 6, 256)         0
_________________________________________________________________
conv2d_8 (Conv2D)            (None, 4, 4, 256)         590080
_________________________________________________________________
flatten_2 (Flatten)          (None, 4096)              0
_________________________________________________________________
dense_4 (Dense)              (None, 256)               1048832
_________________________________________________________________
dense_5 (Dense)              (None, 100)               25700
=================================================================
Total params: 1,739,492
Trainable params: 1,739,492
Non-trainable params: 0
_________________________________________________________________
```

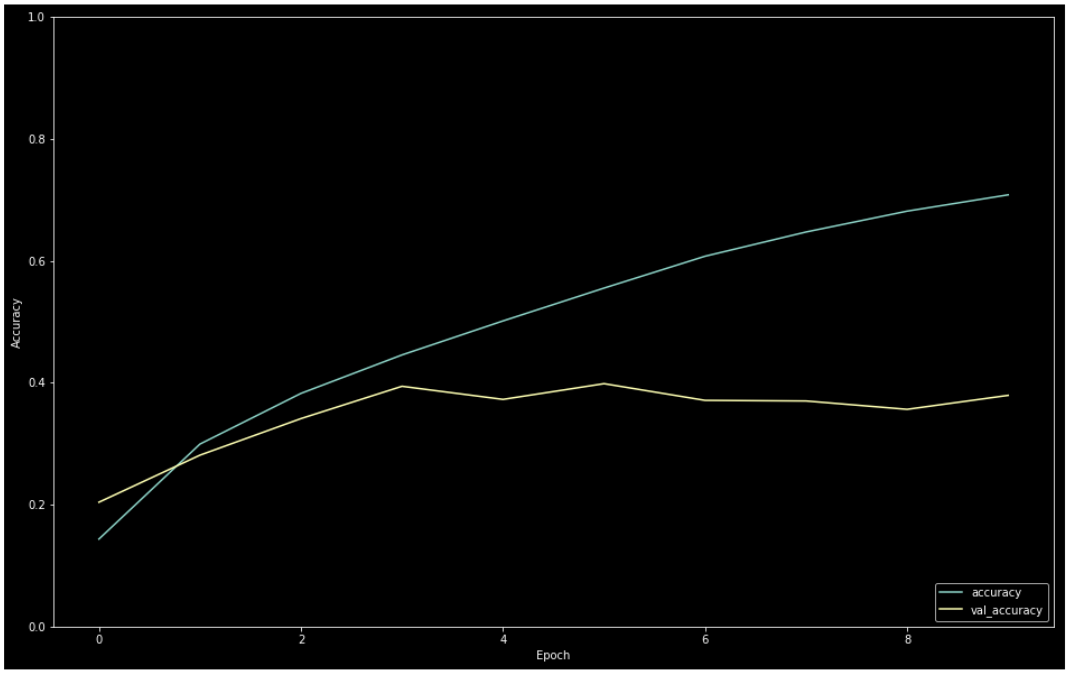
In [20]:
```
model.compile(optimizer='rmsprop', loss='sparse_categorical_crossentropy', metrics=['accuracy'])

history = model.fit(train_images, train_labels, epochs=10, validation_data=(test_images, test_labels))
```

```
Epoch 1/10
1563/1563 [==============================] - 118s 75ms/step - loss: 3.6785 - accuracy: 0.1435 - val_loss: 3.3553 - val_accurac
y: 0.2040
Epoch 2/10
1563/1563 [==============================] - 114s 73ms/step - loss: 2.8390 - accuracy: 0.2994 - val_loss: 2.9508 - val_accurac
y: 0.2812
Epoch 3/10
1563/1563 [==============================] - 116s 74ms/step - loss: 2.4253 - accuracy: 0.3826 - val_loss: 2.6713 - val_accurac
y: 0.3412
Epoch 4/10
1563/1563 [==============================] - 113s 73ms/step - loss: 2.1238 - accuracy: 0.4457 - val_loss: 2.5648 - val_accurac
y: 0.3942
Epoch 5/10
1563/1563 [==============================] - 111s 71ms/step - loss: 1.8752 - accuracy: 0.5014 - val_loss: 2.7001 - val_accurac
y: 0.3727
Epoch 6/10
1563/1563 [==============================] - 110s 70ms/step - loss: 1.6443 - accuracy: 0.5553 - val_loss: 2.4780 - val_accurac
y: 0.3985
```

```
Epoch 7/10
1563/1563 [==============================] - 110s 70ms/step - loss: 1.4403 - accuracy: 0.6076 - val_loss: 2.7444 - val_accurac
y: 0.3711
Epoch 8/10
1563/1563 [==============================] - 110s 71ms/step - loss: 1.2803 - accuracy: 0.6474 - val_loss: 2.9965 - val_accurac
y: 0.3701
Epoch 9/10
1563/1563 [==============================] - 110s 71ms/step - loss: 1.1573 - accuracy: 0.6815 - val_loss: 3.0933 - val_accurac
y: 0.3564
Epoch 10/10
1563/1563 [==============================] - 110s 71ms/step - loss: 1.0631 - accuracy: 0.7083 - val_loss: 3.7226 - val_accurac
y: 0.3793
```

In [21]:
```
plt.style.use('dark_background')
plt.figure(figsize=([16,10]))
plt.plot(history.history['accuracy'], label='accuracy')
plt.plot(history.history['val_accuracy'], label = 'val_accuracy')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.ylim([0, 1])
plt.legend(loc='lower right')
```

Out[21]:
```
<matplotlib.legend.Legend at 0x274885bc128>
```



In [13]:
```
# 3 conv2d 2 maxpooling 128 adam
model = models.Sequential()
model.add(layers.Conv2D(32, (3, 3), activation='relu', input_shape=(32, 32, 3)))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(128, (3, 3), activation='relu'))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(128, (3, 3), activation='relu'))
model.add(layers.Flatten())
model.add(layers.Dense(256, activation='relu'))
model.add(layers.Dense(100, activation='softmax'))
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 30, 30, 32)        896
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 15, 15, 32)        0
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 13, 13, 128)       36992
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 6, 6, 128)         0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 4, 4, 128)         147584
_________________________________________________________________
flatten (Flatten)            (None, 2048)              0
_________________________________________________________________
dense (Dense)                (None, 256)               524544
_________________________________________________________________
dense_1 (Dense)              (None, 100)               25700
=================================================================
Total params: 735,716
Trainable params: 735,716
Non-trainable params: 0
_________________________________________________________________
```

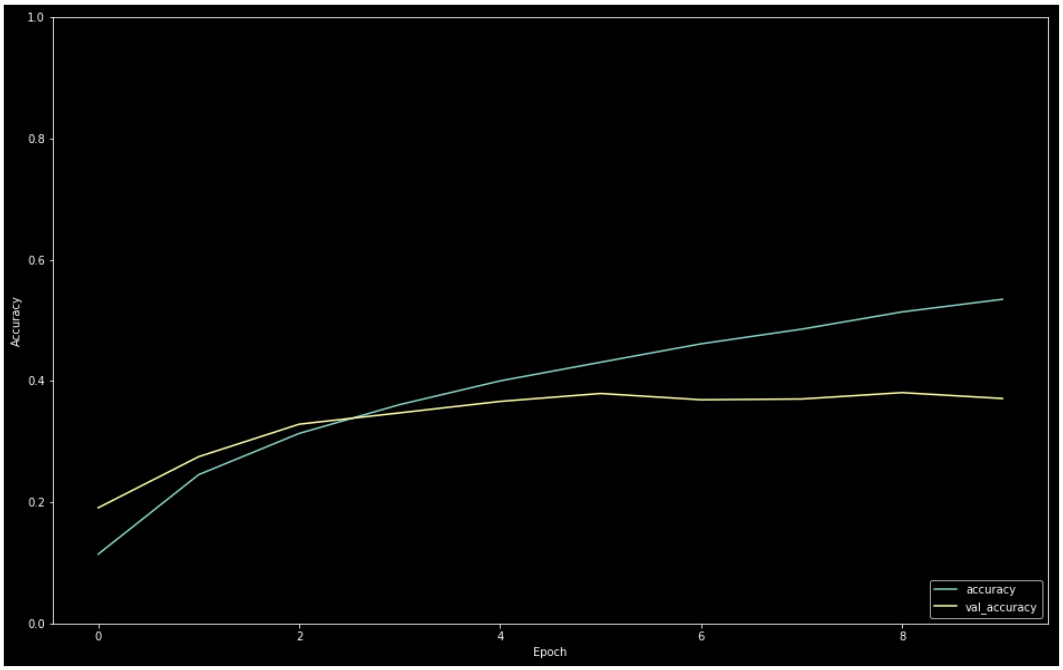
In [14]:
```
model.compile(optimizer='adam', loss='sparse_categorical_crossentropy', metrics=['accuracy'])

history = model.fit(train_images, train_labels, epochs=10, validation_data=(test_images, test_labels))
```

```
Epoch 1/10
1563/1563 [==============================] - 41s 26ms/step - loss: 3.8193 - accuracy: 0.1143 - val_loss: 3.3337 - val_accuracy:
0.1908
Epoch 2/10
1563/1563 [==============================] - 40s 26ms/step - loss: 3.0777 - accuracy: 0.2455 - val_loss: 2.9342 - val_accuracy:
0.2751
Epoch 3/10
1563/1563 [==============================] - 39s 25ms/step - loss: 2.7221 - accuracy: 0.3135 - val_loss: 2.7021 - val_accuracy:
0.3287
Epoch 4/10
1563/1563 [==============================] - 41s 26ms/step - loss: 2.4873 - accuracy: 0.3610 - val_loss: 2.5890 - val_accuracy:
0.3474
Epoch 5/10
1563/1563 [==============================] - 40s 26ms/step - loss: 2.3093 - accuracy: 0.4002 - val_loss: 2.5120 - val_accuracy:
0.3663
```

```
Epoch 6/10
1563/1563 [==============================] - 39s 25ms/step - loss: 2.1636 - accuracy: 0.4309 - val_loss: 2.4596 - val_accuracy:
0.3794
Epoch 7/10
1563/1563 [==============================] - 39s 25ms/step - loss: 2.0319 - accuracy: 0.4613 - val_loss: 2.5110 - val_accuracy:
0.3690
Epoch 8/10
1563/1563 [==============================] - 39s 25ms/step - loss: 1.9164 - accuracy: 0.4855 - val_loss: 2.5892 - val_accuracy:
0.3703
Epoch 9/10
1563/1563 [==============================] - 39s 25ms/step - loss: 1.7970 - accuracy: 0.5140 - val_loss: 2.5666 - val_accuracy:
0.3808
Epoch 10/10
1563/1563 [==============================] - 39s 25ms/step - loss: 1.6894 - accuracy: 0.5348 - val_loss: 2.6331 - val_accuracy:
0.3711
```

In [15]:
```
plt.style.use('dark_background')
plt.figure(figsize=([16,10]))
plt.plot(history.history['accuracy'], label='accuracy')
plt.plot(history.history['val_accuracy'], label = 'val_accuracy')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.ylim([0, 1])
plt.legend(loc='lower right')
```

Out[15]: <matplotlib.legend.Legend at 0x2748794bb00>



In [16]:
```
# 3 conv2d 2 maxpooling 256 adam
model = models.Sequential()
model.add(layers.Conv2D(32, (3, 3), activation='relu', input_shape=(32, 32, 3)))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(256, (3, 3), activation='relu'))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(256, (3, 3), activation='relu'))
model.add(layers.Flatten())
model.add(layers.Dense(256, activation='relu'))
model.add(layers.Dense(100, activation='softmax'))
model.summary()
```

```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_3 (Conv2D)            (None, 30, 30, 32)        896
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 15, 15, 32)        0
_________________________________________________________________
conv2d_4 (Conv2D)            (None, 13, 13, 256)       73984
_________________________________________________________________
max_pooling2d_3 (MaxPooling2 (None, 6, 6, 256)         0
_________________________________________________________________
conv2d_5 (Conv2D)            (None, 4, 4, 256)         590080
_________________________________________________________________
flatten_1 (Flatten)          (None, 4096)              0
_________________________________________________________________
dense_2 (Dense)              (None, 256)               1048832
_________________________________________________________________
dense_3 (Dense)              (None, 100)               25700
=================================================================
Total params: 1,739,492
Trainable params: 1,739,492
Non-trainable params: 0
_________________________________________________________________
```

In [17]:
```
model.compile(optimizer='adam', loss='sparse_categorical_crossentropy', metrics=['accuracy'])

history = model.fit(train_images, train_labels, epochs=10, validation_data=(test_images, test_labels))
```

```
Epoch 1/10
1563/1563 [==============================] - 108s 69ms/step - loss: 3.7649 - accuracy: 0.1260 - val_loss: 3.1670 - val_accurac
y: 0.2313
Epoch 2/10
1563/1563 [==============================] - 112s 72ms/step - loss: 2.9597 - accuracy: 0.2684 - val_loss: 2.8016 - val_accurac
y: 0.2990
Epoch 3/10
1563/1563 [==============================] - 116s 74ms/step - loss: 2.5667 - accuracy: 0.3454 - val_loss: 2.6180 - val_accurac
y: 0.3353
Epoch 4/10
1563/1563 [==============================] - 108s 69ms/step - loss: 2.3082 - accuracy: 0.3998 - val_loss: 2.4510 - val_accurac
y: 0.3744
Epoch 5/10
1563/1563 [==============================] - 112s 71ms/step - loss: 2.0957 - accuracy: 0.4479 - val_loss: 2.4775 - val_accurac
y: 0.3787
Epoch 6/10
1563/1563 [==============================] - 105s 67ms/step - loss: 1.8959 - accuracy: 0.4881 - val_loss: 2.4536 - val_accurac
y: 0.3849
Epoch 7/10
1563/1563 [==============================] - 105s 67ms/step - loss: 1.7161 - accuracy: 0.5328 - val_loss: 2.4765 - val_accurac
y: 0.3967
```

```
Epoch 8/10
1563/1563 [==============================] - 105s 67ms/step - loss: 1.5411 - accuracy: 0.5704 - val_loss: 2.6812 - val_accurac
y: 0.3767
Epoch 9/10
1563/1563 [==============================] - 109s 70ms/step - loss: 1.3826 - accuracy: 0.6100 - val_loss: 2.6829 - val_accurac
y: 0.3961
Epoch 10/10
1563/1563 [==============================] - 106s 68ms/step - loss: 1.2203 - accuracy: 0.6486 - val_loss: 2.8439 - val_accurac
y: 0.3859
```

In [18]:
```
plt.style.use('dark_background')
plt.figure(figsize=([16,10]))
plt.plot(history.history['accuracy'], label='accuracy')
plt.plot(history.history['val_accuracy'], label = 'val_accuracy')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.ylim([0, 1])
plt.legend(loc='lower right')
```

Out[18]:
```
<matplotlib.legend.Legend at 0x27487d15358>
```