

In [7]:

```
import math
import numpy as np
import h5py
import matplotlib.pyplot as plt
import scipy
from PIL import Image
from scipy import ndimage
import tensorflow as tf
from tensorflow.python.framework import ops
from cnn_utils import *

%matplotlib inline
np.random.seed(1)
```

In [8]:

```
tf.version
```

Out[8]:

```
<module 'tensorflow._api.v2.version' from 'D:\\environment\\anaconda\\lib\\site-packages\\tensorflow\\_api\\v2\\version\\__init__.py'>
```

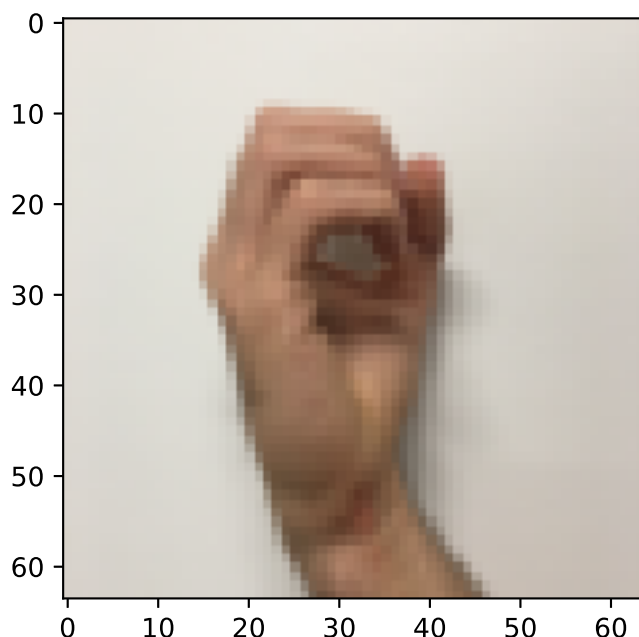
In [9]:

```
X_train_orig, Y_train_orig, X_test_orig, Y_test_orig, classes = load_dataset()
```

In [10]:

```
# Example of a picture
index = 20
plt.imshow(X_train_orig[index])
print ("y = " + str(np.squeeze(Y_train_orig[:, index])))
#从数组的形状中删除单维度条目，即把shape中为1的维度去掉
```

y = 0



In [23]:

```

X_train = X_train_orig/255.
X_test = X_test_orig/255.
Y_train = np.eye(6)[Y_train_orig.reshape(-1)]
Y_test = np.eye(6)[Y_test_orig.reshape(-1)]
#np.eye()的函数，除了生成对角阵外，还可以将一个label数组，大小为(1,m)或者(m,1)的数组，转化成one-hot数组。
print ("number of training examples = " + str(X_train.shape[0]))
print ("number of test examples = " + str(X_test.shape[0]))
print ("X_train shape: " + str(X_train.shape))
print ("Y_train shape: " + str(Y_train.shape))
print ("X_test shape: " + str(X_test.shape))
print ("Y_test shape: " + str(Y_test.shape))
conv_layers = {}

```

```

number of training examples = 1080
number of test examples = 120
X_train shape: (1080, 64, 64, 3)
Y_train shape: (1080, 6)
X_test shape: (120, 64, 64, 3)
Y_test shape: (120, 6)

```

In [39]:

```

model = tf.keras.models.Sequential()
model.add(tf.keras.layers.Conv2D(64, (4, 4), padding='same', activation='relu', input_shape=(64, 64, 3)))
model.add(tf.keras.layers.MaxPool2D((8, 8), strides=8, padding='same'))
model.add(tf.keras.layers.Conv2D(64, (2, 2), activation='relu', padding='same'))
model.add(tf.keras.layers.MaxPool2D((4, 4), strides=4, padding='same'))
model.add(tf.keras.layers.Flatten())
model.add(tf.keras.layers.Dense(64, activation='relu'))
model.add(tf.keras.layers.Dense(6))

```

In [40]:

```
model.summary()
```

Model: "sequential_2"

Layer (type)	Output Shape	Param #
=====		
conv2d_3 (Conv2D)	(None, 64, 64, 64)	3136
max_pooling2d_2 (MaxPooling2D)	(None, 8, 8, 64)	0
conv2d_4 (Conv2D)	(None, 8, 8, 64)	16448
max_pooling2d_3 (MaxPooling2D)	(None, 2, 2, 64)	0
flatten_1 (Flatten)	(None, 256)	0
dense (Dense)	(None, 64)	16448
dense_1 (Dense)	(None, 6)	390
=====		
Total params: 36,422		
Trainable params: 36,422		
Non-trainable params: 0		

In [45]:

```
model.compile(optimizer='adam',  
loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=True),  
metrics=['accuracy'])  
history=model.fit(X_train,Y_train_orig.reshape((-1,1)),epochs=100,validation_data=(X_test,Y_test  
_orig.reshape((-1,1))))
```

Epoch 1/100
34/34 [=====] - 2s 59ms/step - loss: 1.8010 - accuracy:
0.1685 - val_loss: 1.7864 - val_accuracy: 0.1750
Epoch 2/100
34/34 [=====] - 2s 55ms/step - loss: 1.7744 - accuracy:
0.2250 - val_loss: 1.7536 - val_accuracy: 0.2500
Epoch 3/100
34/34 [=====] - 2s 55ms/step - loss: 1.7265 - accuracy:
0.3009 - val_loss: 1.6813 - val_accuracy: 0.3667
Epoch 4/100
34/34 [=====] - 2s 55ms/step - loss: 1.5736 - accuracy:
0.4269 - val_loss: 1.4650 - val_accuracy: 0.5083
Epoch 5/100
34/34 [=====] - 2s 54ms/step - loss: 1.2784 - accuracy:
0.5315 - val_loss: 1.1842 - val_accuracy: 0.5167
Epoch 6/100
34/34 [=====] - 2s 56ms/step - loss: 1.0504 - accuracy:
0.6269 - val_loss: 1.0540 - val_accuracy: 0.5667
Epoch 7/100
34/34 [=====] - 2s 55ms/step - loss: 0.9501 - accuracy:
0.6398 - val_loss: 0.8458 - val_accuracy: 0.7250
Epoch 8/100
34/34 [=====] - 2s 55ms/step - loss: 0.8137 - accuracy:
0.7213 - val_loss: 0.8528 - val_accuracy: 0.6250
Epoch 9/100
34/34 [=====] - 2s 56ms/step - loss: 0.7278 - accuracy:
0.7546 - val_loss: 0.7234 - val_accuracy: 0.7250
Epoch 10/100
34/34 [=====] - 2s 56ms/step - loss: 0.6728 - accuracy:
0.7796 - val_loss: 0.6661 - val_accuracy: 0.7833
Epoch 11/100
34/34 [=====] - 2s 56ms/step - loss: 0.6060 - accuracy:
0.7880 - val_loss: 0.5942 - val_accuracy: 0.8000
Epoch 12/100
34/34 [=====] - 2s 55ms/step - loss: 0.5342 - accuracy:
0.8306 - val_loss: 0.5754 - val_accuracy: 0.7917
Epoch 13/100
34/34 [=====] - 2s 56ms/step - loss: 0.4973 - accuracy:
0.8435 - val_loss: 0.5477 - val_accuracy: 0.7917
Epoch 14/100
34/34 [=====] - 2s 56ms/step - loss: 0.4650 - accuracy:
0.8500 - val_loss: 0.4710 - val_accuracy: 0.8500
Epoch 15/100
34/34 [=====] - 2s 55ms/step - loss: 0.3968 - accuracy:
0.8843 - val_loss: 0.4317 - val_accuracy: 0.8500
Epoch 16/100
34/34 [=====] - 2s 56ms/step - loss: 0.3677 - accuracy:
0.8972 - val_loss: 0.3863 - val_accuracy: 0.8500
Epoch 17/100
34/34 [=====] - 2s 63ms/step - loss: 0.3271 - accuracy:
0.9093 - val_loss: 0.4399 - val_accuracy: 0.8167
Epoch 18/100
34/34 [=====] - 2s 59ms/step - loss: 0.3169 - accuracy:
0.9074 - val_loss: 0.3612 - val_accuracy: 0.8833
Epoch 19/100
34/34 [=====] - 2s 57ms/step - loss: 0.2874 - accuracy:
0.9093 - val_loss: 0.3288 - val_accuracy: 0.8917
Epoch 20/100
34/34 [=====] - 2s 56ms/step - loss: 0.2675 - accuracy:
0.9185 - val_loss: 0.3627 - val_accuracy: 0.8417
Epoch 21/100

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34/34 [=====] - 2s 56ms/step - loss: 0.2444 - accuracy:
0.9361 - val_loss: 0.3042 - val_accuracy: 0.9000
Epoch 22/100
34/34 [=====] - 2s 58ms/step - loss: 0.2061 - accuracy:
0.9519 - val_loss: 0.2908 - val_accuracy: 0.8917
Epoch 23/100
34/34 [=====] - 2s 63ms/step - loss: 0.2181 - accuracy:
0.9324 - val_loss: 0.2829 - val_accuracy: 0.9000
Epoch 24/100
34/34 [=====] - 2s 62ms/step - loss: 0.1906 - accuracy:
0.9454 - val_loss: 0.2738 - val_accuracy: 0.9000
Epoch 25/100
34/34 [=====] - 2s 61ms/step - loss: 0.1628 - accuracy:
0.9546 - val_loss: 0.2372 - val_accuracy: 0.9000
Epoch 26/100
34/34 [=====] - 2s 57ms/step - loss: 0.1608 - accuracy:
0.9519 - val_loss: 0.3530 - val_accuracy: 0.8583
Epoch 27/100
34/34 [=====] - 2s 55ms/step - loss: 0.1777 - accuracy:
0.9463 - val_loss: 0.2353 - val_accuracy: 0.9250
Epoch 28/100
34/34 [=====] - 2s 55ms/step - loss: 0.1508 - accuracy:
0.9602 - val_loss: 0.3123 - val_accuracy: 0.8667
Epoch 29/100
34/34 [=====] - 2s 56ms/step - loss: 0.1258 - accuracy:
0.9731 - val_loss: 0.2153 - val_accuracy: 0.9250
Epoch 30/100
34/34 [=====] - 2s 61ms/step - loss: 0.1056 - accuracy:
0.9731 - val_loss: 0.2090 - val_accuracy: 0.9167
Epoch 31/100
34/34 [=====] - 2s 59ms/step - loss: 0.0944 - accuracy:
0.9806 - val_loss: 0.2314 - val_accuracy: 0.8750
Epoch 32/100
34/34 [=====] - 2s 57ms/step - loss: 0.0945 - accuracy:
0.9787 - val_loss: 0.2020 - val_accuracy: 0.9000
Epoch 33/100
34/34 [=====] - 2s 56ms/step - loss: 0.1004 - accuracy:
0.9787 - val_loss: 0.2063 - val_accuracy: 0.9083
Epoch 34/100
34/34 [=====] - 2s 57ms/step - loss: 0.0877 - accuracy:
0.9778 - val_loss: 0.2492 - val_accuracy: 0.9000
Epoch 35/100
34/34 [=====] - 2s 55ms/step - loss: 0.0834 - accuracy:
0.9769 - val_loss: 0.1980 - val_accuracy: 0.9250
Epoch 36/100
34/34 [=====] - 2s 56ms/step - loss: 0.1020 - accuracy:
0.9648 - val_loss: 0.2232 - val_accuracy: 0.9000
Epoch 37/100
34/34 [=====] - 2s 55ms/step - loss: 0.0837 - accuracy:
0.9769 - val_loss: 0.2554 - val_accuracy: 0.9083
Epoch 38/100
34/34 [=====] - 2s 55ms/step - loss: 0.0733 - accuracy:
0.9806 - val_loss: 0.2200 - val_accuracy: 0.9167
Epoch 39/100
34/34 [=====] - 2s 55ms/step - loss: 0.0709 - accuracy:
0.9880 - val_loss: 0.2156 - val_accuracy: 0.8750
Epoch 40/100
34/34 [=====] - 2s 55ms/step - loss: 0.0583 - accuracy:
0.9870 - val_loss: 0.1664 - val_accuracy: 0.9250
Epoch 41/100
34/34 [=====] - 2s 58ms/step - loss: 0.0502 - accuracy:
```

```
0.9944 - val_loss: 0.1703 - val_accuracy: 0.9500
Epoch 42/100
34/34 [=====] - 2s 60ms/step - loss: 0.0531 - accuracy:
0.9907 - val_loss: 0.2106 - val_accuracy: 0.9167
Epoch 43/100
34/34 [=====] - 2s 57ms/step - loss: 0.0702 - accuracy:
0.9778 - val_loss: 0.1538 - val_accuracy: 0.9333
Epoch 44/100
34/34 [=====] - 2s 56ms/step - loss: 0.0416 - accuracy:
0.9944 - val_loss: 0.1562 - val_accuracy: 0.9333
Epoch 45/100
34/34 [=====] - 2s 56ms/step - loss: 0.0357 - accuracy:
0.9944 - val_loss: 0.1513 - val_accuracy: 0.9250
Epoch 46/100
34/34 [=====] - 2s 56ms/step - loss: 0.0374 - accuracy:
0.9944 - val_loss: 0.1488 - val_accuracy: 0.9500
Epoch 47/100
34/34 [=====] - 2s 56ms/step - loss: 0.0313 - accuracy:
0.9963 - val_loss: 0.1439 - val_accuracy: 0.9250
Epoch 48/100
34/34 [=====] - 2s 56ms/step - loss: 0.0336 - accuracy:
0.9963 - val_loss: 0.2050 - val_accuracy: 0.9000
Epoch 49/100
34/34 [=====] - 2s 56ms/step - loss: 0.0387 - accuracy:
0.9926 - val_loss: 0.3341 - val_accuracy: 0.8750
Epoch 50/100
34/34 [=====] - 2s 55ms/step - loss: 0.0443 - accuracy:
0.9907 - val_loss: 0.1822 - val_accuracy: 0.9000
Epoch 51/100
34/34 [=====] - 2s 58ms/step - loss: 0.0307 - accuracy:
0.9954 - val_loss: 0.1197 - val_accuracy: 0.9500
Epoch 52/100
34/34 [=====] - 2s 55ms/step - loss: 0.0303 - accuracy:
0.9935 - val_loss: 0.2722 - val_accuracy: 0.8917
Epoch 53/100
34/34 [=====] - 2s 55ms/step - loss: 0.0342 - accuracy:
0.9944 - val_loss: 0.1681 - val_accuracy: 0.9500
Epoch 54/100
34/34 [=====] - 2s 56ms/step - loss: 0.0322 - accuracy:
0.9944 - val_loss: 0.2043 - val_accuracy: 0.9000
Epoch 55/100
34/34 [=====] - 2s 56ms/step - loss: 0.0236 - accuracy:
0.9991 - val_loss: 0.1671 - val_accuracy: 0.9333
Epoch 56/100
34/34 [=====] - 2s 55ms/step - loss: 0.0261 - accuracy:
0.9944 - val_loss: 0.1517 - val_accuracy: 0.9167
Epoch 57/100
34/34 [=====] - 2s 55ms/step - loss: 0.0162 - accuracy:
0.9981 - val_loss: 0.2004 - val_accuracy: 0.8917
Epoch 58/100
34/34 [=====] - 2s 56ms/step - loss: 0.0179 - accuracy:
0.9991 - val_loss: 0.1551 - val_accuracy: 0.9417
Epoch 59/100
34/34 [=====] - 2s 56ms/step - loss: 0.0163 - accuracy:
0.9981 - val_loss: 0.2014 - val_accuracy: 0.9000
Epoch 60/100
34/34 [=====] - 2s 57ms/step - loss: 0.0156 - accuracy:
0.9981 - val_loss: 0.1443 - val_accuracy: 0.9417
Epoch 61/100
34/34 [=====] - 2s 56ms/step - loss: 0.0143 - accuracy:
0.9991 - val_loss: 0.3016 - val_accuracy: 0.9083
```

Epoch 62/100
34/34 [=====] - 2s 57ms/step - loss: 0.0167 - accuracy: 0.9972 - val_loss: 0.1454 - val_accuracy: 0.9417

Epoch 63/100
34/34 [=====] - 2s 60ms/step - loss: 0.0118 - accuracy: 0.9991 - val_loss: 0.1206 - val_accuracy: 0.9667

Epoch 64/100
34/34 [=====] - 2s 61ms/step - loss: 0.0085 - accuracy: 1.0000 - val_loss: 0.1400 - val_accuracy: 0.9583

Epoch 65/100
34/34 [=====] - 2s 57ms/step - loss: 0.0086 - accuracy: 1.0000 - val_loss: 0.2022 - val_accuracy: 0.9167

Epoch 66/100
34/34 [=====] - 2s 57ms/step - loss: 0.0098 - accuracy: 1.0000 - val_loss: 0.1230 - val_accuracy: 0.9583

Epoch 67/100
34/34 [=====] - 2s 55ms/step - loss: 0.0074 - accuracy: 1.0000 - val_loss: 0.1289 - val_accuracy: 0.9500

Epoch 68/100
34/34 [=====] - 2s 55ms/step - loss: 0.0075 - accuracy: 1.0000 - val_loss: 0.1661 - val_accuracy: 0.9500

Epoch 69/100
34/34 [=====] - 2s 55ms/step - loss: 0.0076 - accuracy: 1.0000 - val_loss: 0.1273 - val_accuracy: 0.9667

Epoch 70/100
34/34 [=====] - 2s 58ms/step - loss: 0.0062 - accuracy: 1.0000 - val_loss: 0.1331 - val_accuracy: 0.9417

Epoch 71/100
34/34 [=====] - 2s 56ms/step - loss: 0.0059 - accuracy: 1.0000 - val_loss: 0.1302 - val_accuracy: 0.9583

Epoch 72/100
34/34 [=====] - 2s 56ms/step - loss: 0.0056 - accuracy: 1.0000 - val_loss: 0.1407 - val_accuracy: 0.9417

Epoch 73/100
34/34 [=====] - 2s 54ms/step - loss: 0.0054 - accuracy: 1.0000 - val_loss: 0.1579 - val_accuracy: 0.9167

Epoch 74/100
34/34 [=====] - 2s 56ms/step - loss: 0.0059 - accuracy: 1.0000 - val_loss: 0.1911 - val_accuracy: 0.9083

Epoch 75/100
34/34 [=====] - 2s 56ms/step - loss: 0.0061 - accuracy: 1.0000 - val_loss: 0.1833 - val_accuracy: 0.9083

Epoch 76/100
34/34 [=====] - 2s 56ms/step - loss: 0.0048 - accuracy: 1.0000 - val_loss: 0.1742 - val_accuracy: 0.9167

Epoch 77/100
34/34 [=====] - 2s 56ms/step - loss: 0.0047 - accuracy: 1.0000 - val_loss: 0.1431 - val_accuracy: 0.9333

Epoch 78/100
34/34 [=====] - 2s 56ms/step - loss: 0.0045 - accuracy: 1.0000 - val_loss: 0.1725 - val_accuracy: 0.9167

Epoch 79/100
34/34 [=====] - 2s 58ms/step - loss: 0.0039 - accuracy: 1.0000 - val_loss: 0.1698 - val_accuracy: 0.9333

Epoch 80/100
34/34 [=====] - 2s 57ms/step - loss: 0.0036 - accuracy: 1.0000 - val_loss: 0.1438 - val_accuracy: 0.9500

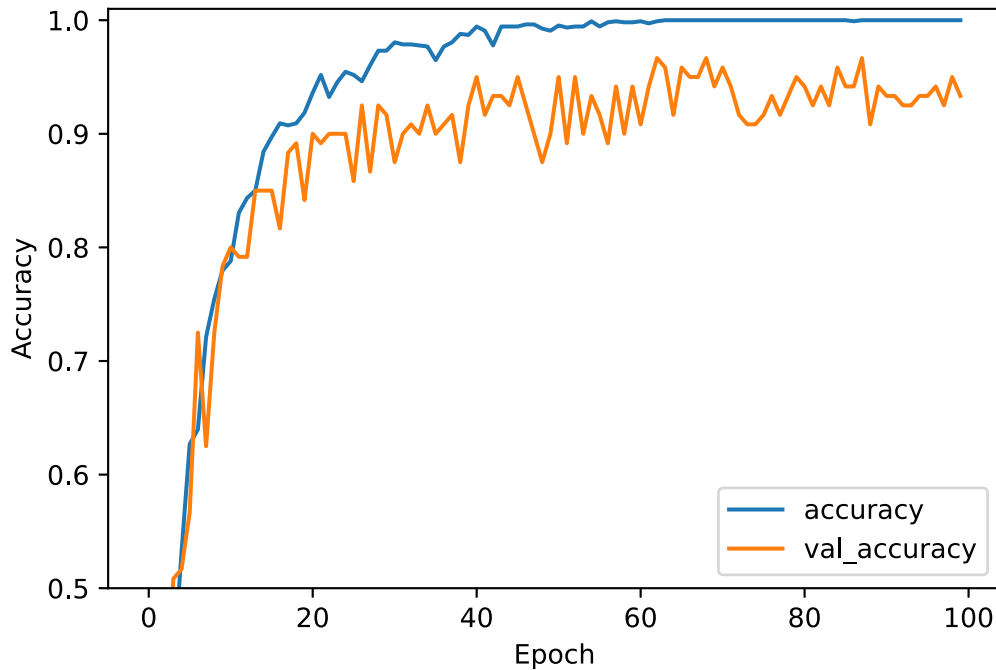
Epoch 81/100
34/34 [=====] - 2s 58ms/step - loss: 0.0034 - accuracy: 1.0000 - val_loss: 0.1482 - val_accuracy: 0.9417

Epoch 82/100


```
34/34 [=====] - 2s 56ms/step - loss: 0.0040 - accuracy:
1.0000 - val_loss: 0.1640 - val_accuracy: 0.9250
Epoch 83/100
34/34 [=====] - 2s 57ms/step - loss: 0.0037 - accuracy:
1.0000 - val_loss: 0.1559 - val_accuracy: 0.9417
Epoch 84/100
34/34 [=====] - 2s 55ms/step - loss: 0.0032 - accuracy:
1.0000 - val_loss: 0.1634 - val_accuracy: 0.9250
Epoch 85/100
34/34 [=====] - 2s 56ms/step - loss: 0.0030 - accuracy:
1.0000 - val_loss: 0.1460 - val_accuracy: 0.9583
Epoch 86/100
34/34 [=====] - 2s 55ms/step - loss: 0.0036 - accuracy:
1.0000 - val_loss: 0.1584 - val_accuracy: 0.9417
Epoch 87/100
34/34 [=====] - 2s 56ms/step - loss: 0.0100 - accuracy:
0.9991 - val_loss: 0.1365 - val_accuracy: 0.9417
Epoch 88/100
34/34 [=====] - 2s 56ms/step - loss: 0.0055 - accuracy:
1.0000 - val_loss: 0.1567 - val_accuracy: 0.9667
Epoch 89/100
34/34 [=====] - 2s 55ms/step - loss: 0.0055 - accuracy:
1.0000 - val_loss: 0.2439 - val_accuracy: 0.9083
Epoch 90/100
34/34 [=====] - 2s 56ms/step - loss: 0.0038 - accuracy:
1.0000 - val_loss: 0.1523 - val_accuracy: 0.9417
Epoch 91/100
34/34 [=====] - 2s 56ms/step - loss: 0.0026 - accuracy:
1.0000 - val_loss: 0.1678 - val_accuracy: 0.9333
Epoch 92/100
34/34 [=====] - 2s 59ms/step - loss: 0.0024 - accuracy:
1.0000 - val_loss: 0.1552 - val_accuracy: 0.9333
Epoch 93/100
34/34 [=====] - 2s 56ms/step - loss: 0.0023 - accuracy:
1.0000 - val_loss: 0.1570 - val_accuracy: 0.9250
Epoch 94/100
34/34 [=====] - 2s 59ms/step - loss: 0.0021 - accuracy:
1.0000 - val_loss: 0.1744 - val_accuracy: 0.9250
Epoch 95/100
34/34 [=====] - 2s 58ms/step - loss: 0.0020 - accuracy:
1.0000 - val_loss: 0.1778 - val_accuracy: 0.9333
Epoch 96/100
34/34 [=====] - 2s 57ms/step - loss: 0.0021 - accuracy:
1.0000 - val_loss: 0.1670 - val_accuracy: 0.9333
Epoch 97/100
34/34 [=====] - 2s 56ms/step - loss: 0.0019 - accuracy:
1.0000 - val_loss: 0.1468 - val_accuracy: 0.9417
Epoch 98/100
34/34 [=====] - 2s 55ms/step - loss: 0.0018 - accuracy:
1.0000 - val_loss: 0.1731 - val_accuracy: 0.9250
Epoch 99/100
34/34 [=====] - 2s 56ms/step - loss: 0.0019 - accuracy:
1.0000 - val_loss: 0.1344 - val_accuracy: 0.9500
Epoch 100/100
34/34 [=====] - 2s 57ms/step - loss: 0.0017 - accuracy:
1.0000 - val_loss: 0.1796 - val_accuracy: 0.9333
```

In [48]:

```
plt.plot(history.history['accuracy'], label='accuracy')
plt.plot(history.history['val_accuracy'], label='val_accuracy')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.ylim([0.5, 1.01])
plt.legend(loc='lower right')
plt.show()
```



In [56]:

```
test_loss, test_acc = model.evaluate(X_test, Y_test_orig.reshape((-1, 1)), verbose=2)
```

4/4 - 0s - loss: 0.1796 - accuracy: 0.9333

In []: