In [6]:
```
!nvidia-smi
```

```
Mon Oct 12 20:42:56 2020
+-----------------------------------------------------------------------------+
| NVIDIA-SMI 419.71       Driver Version: 419.71       CUDA Version: 10.0     |
|-------------------------------+----------------------+----------------------+
| GPU  Name            TCC/WDDM | Bus-Id        Disp.A | Volatile Uncorr. ECC |
| Fan  Temp  Perf  Pwr:Usage/Cap|         Memory-Usage | GPU-Util  Compute M. |
|===============================+======================+======================|
|   0  GeForce GTX 1650   WDDM  | 00000000:01:00.0 Off |                  N/A |
| N/A   51C    P8     2W /  N/A |    132MiB /  4096MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+

+-----------------------------------------------------------------------------+
| Processes:                                                       GPU Memory |
|  GPU       PID   Type   Process name                             Usage      |
|=============================================================================|
|  No running processes found                                                 |
+-----------------------------------------------------------------------------+
WARNING: infoROM is corrupted at gpu 0000:01:00.0
```

In [7]:
```
!pip install gdown
!pip install tensorflow-gpu
```

```
Requirement already satisfied: gdown in c:\users\tt0342\appdata\local\continuum
\anaconda3\lib\site-packages (3.12.2)
Requirement already satisfied: filelock in c:\users\tt0342\appdata\local\contin
uum\anaconda3\lib\site-packages (from gdown) (3.0.12)
Requirement already satisfied: six in c:\users\tt0342\appdata\local\continuum\a
naconda3\lib\site-packages (from gdown) (1.12.0)
Requirement already satisfied: requests[socks] in c:\users\tt0342\appdata\local
\continuum\anaconda3\lib\site-packages (from gdown) (2.22.0)
Requirement already satisfied: tqdm in c:\users\tt0342\appdata\local\continuum
\anaconda3\lib\site-packages (from gdown) (4.48.2)
Requirement already satisfied: chardet<3.1.0,>=3.0.2 in c:\users\tt0342\appdata
\local\continuum\anaconda3\lib\site-packages (from requests[socks]->gdown) (3.
0.4)
Requirement already satisfied: certifi>=2017.4.17 in c:\users\tt0342\appdata\lo
cal\continuum\anaconda3\lib\site-packages (from requests[socks]->gdown) (2019.
9.11)
Requirement already satisfied: idna<2.9,>=2.5 in c:\users\tt0342\appdata\local
\continuum\anaconda3\lib\site-packages (from requests[socks]->gdown) (2.8)
Requirement already satisfied: urllib3!=1.25.0,!=1.25.1,<1.26,>=1.21.1 in c:\us
ers\tt0342\appdata\local\continuum\anaconda3\lib\site-packages (from requests[s
ocks]->gdown) (1.24.2)
Requirement already satisfied: PySocks!=1.5.7,>=1.5.6; extra == "socks" in c:\u
sers\tt0342\appdata\local\continuum\anaconda3\lib\site-packages (from requests
[socks]->gdown) (1.7.1)
Requirement already satisfied: tensorflow-gpu in c:\users\tt0342\appdata\local
\continuum\anaconda3\lib\site-packages (2.3.1)
Requirement already satisfied: six>=1.12.0 in c:\users\tt0342\appdata\local\con
tinuum\anaconda3\lib\site-packages (from tensorflow-gpu) (1.12.0)
Requirement already satisfied: grpcio>=1.8.6 in c:\users\tt0342\appdata\local\c
ontinuum\anaconda3\lib\site-packages (from tensorflow-gpu) (1.31.0)
Requirement already satisfied: astunparse==1.6.3 in c:\users\tt0342\appdata\loc
al\continuum\anaconda3\lib\site-packages (from tensorflow-gpu) (1.6.3)
Requirement already satisfied: tensorboard<3,>=2.3.0 in c:\users\tt0342\appdata
\local\continuum\anaconda3\lib\site-packages (from tensorflow-gpu) (2.3.0)
Requirement already satisfied: h5py<2.11.0,>=2.10.0 in c:\users\tt0342\appdata
\local\continuum\anaconda3\lib\site-packages (from tensorflow-gpu) (2.10.0)
Requirement already satisfied: absl-py>=0.7.0 in c:\users\tt0342\appdata\local
\continuum\anaconda3\lib\site-packages (from tensorflow-gpu) (0.9.0)
Requirement already satisfied: termcolor>=1.1.0 in c:\users\tt0342\appdata\loca
l\continuum\anaconda3\lib\site-packages (from tensorflow-gpu) (1.1.0)
Requirement already satisfied: wrapt>=1.11.1 in c:\users\tt0342\appdata\local\c
ontinuum\anaconda3\lib\site-packages (from tensorflow-gpu) (1.11.2)
Requirement already satisfied: tensorflow-gpu-estimator<2.4.0,>=2.3.0 in c:\use
rs\tt0342\appdata\local\continuum\anaconda3\lib\site-packages (from tensorflow-
gpu) (2.3.0)
Requirement already satisfied: gast==0.3.3 in c:\users\tt0342\appdata\local\con
tinuum\anaconda3\lib\site-packages (from tensorflow-gpu) (0.3.3)
Requirement already satisfied: opt-einsum>=2.3.2 in c:\users\tt0342\appdata\loc
al\continuum\anaconda3\lib\site-packages (from tensorflow-gpu) (3.1.0)
Requirement already satisfied: google-pasta>=0.1.8 in c:\users\tt0342\appdata\l
ocal\continuum\anaconda3\lib\site-packages (from tensorflow-gpu) (0.1.8)
Requirement already satisfied: keras-preprocessing<1.2,>=1.1.1 in c:\users\tt03
42\appdata\local\continuum\anaconda3\lib\site-packages (from tensorflow-gpu)
(1.1.2)
```

```
Requirement already satisfied: wheel>=0.26 in c:\users\tt0342\appdata\local\con
tinuum\anaconda3\lib\site-packages (from tensorflow-gpu) (0.33.6)
Requirement already satisfied: numpy<1.19.0,>=1.16.0 in c:\users\tt0342\appdata
\local\continuum\anaconda3\lib\site-packages (from tensorflow-gpu) (1.18.1)
Requirement already satisfied: protobuf>=3.9.2 in c:\users\tt0342\appdata\local
\continuum\anaconda3\lib\site-packages (from tensorflow-gpu) (3.13.0)
Requirement already satisfied: google-auth-oauthlib<0.5,>=0.4.1 in c:\users\tt0
342\appdata\local\continuum\anaconda3\lib\site-packages (from tensorboard<3,>=
2.3.0->tensorflow-gpu) (0.4.1)
Requirement already satisfied: google-auth<2,>=1.6.3 in c:\users\tt0342\appdata
\local\continuum\anaconda3\lib\site-packages (from tensorboard<3,>=2.3.0->tenso
rflow-gpu) (1.21.0)
Requirement already satisfied: tensorboard-plugin-wit>=1.6.0 in c:\users\tt0342
\appdata\local\continuum\anaconda3\lib\site-packages (from tensorboard<3,>=2.3.
0->tensorflow-gpu) (1.7.0)
Requirement already satisfied: werkzeug>=0.11.15 in c:\users\tt0342\appdata\loc
al\continuum\anaconda3\lib\site-packages (from tensorboard<3,>=2.3.0->tensorflo
w-gpu) (0.16.0)
Requirement already satisfied: setuptools>=41.0.0 in c:\users\tt0342\appdata\lo
cal\continuum\anaconda3\lib\site-packages (from tensorboard<3,>=2.3.0->tensorfl
ow-gpu) (41.4.0)
Requirement already satisfied: requests<3,>=2.21.0 in c:\users\tt0342\appdata\l
ocal\continuum\anaconda3\lib\site-packages (from tensorboard<3,>=2.3.0->tensorf
low-gpu) (2.22.0)
Requirement already satisfied: markdown>=2.6.8 in c:\users\tt0342\appdata\local
\continuum\anaconda3\lib\site-packages (from tensorboard<3,>=2.3.0->tensorflow-
gpu) (3.1.1)
Requirement already satisfied: requests-oauthlib>=0.7.0 in c:\users\tt0342\appd
ata\local\continuum\anaconda3\lib\site-packages (from google-auth-oauthlib<0.5,
>=0.4.1->tensorboard<3,>=2.3.0->tensorflow-gpu) (1.3.0)
Requirement already satisfied: cachetools<5.0,>=2.0.0 in c:\users\tt0342\appdat
a\local\continuum\anaconda3\lib\site-packages (from google-auth<2,>=1.6.3->tens
orboard<3,>=2.3.0->tensorflow-gpu) (4.0.0)
Requirement already satisfied: rsa<5,>=3.1.4; python_version >= "3.5" in c:\use
rs\tt0342\appdata\local\continuum\anaconda3\lib\site-packages (from google-auth
<2,>=1.6.3->tensorboard<3,>=2.3.0->tensorflow-gpu) (4.0)
Requirement already satisfied: pyasn1-modules>=0.2.1 in c:\users\tt0342\appdata
\local\continuum\anaconda3\lib\site-packages (from google-auth<2,>=1.6.3->tenso
rboard<3,>=2.3.0->tensorflow-gpu) (0.2.8)
Requirement already satisfied: idna<2.9,>=2.5 in c:\users\tt0342\appdata\local
\continuum\anaconda3\lib\site-packages (from requests<3,>=2.21.0->tensorboard<
3,>=2.3.0->tensorflow-gpu) (2.8)
Requirement already satisfied: certifi>=2017.4.17 in c:\users\tt0342\appdata\lo
cal\continuum\anaconda3\lib\site-packages (from requests<3,>=2.21.0->tensorboar
d<3,>=2.3.0->tensorflow-gpu) (2019.9.11)
Requirement already satisfied: urllib3!=1.25.0,!=1.25.1,<1.26,>=1.21.1 in c:\us
ers\tt0342\appdata\local\continuum\anaconda3\lib\site-packages (from requests<
3,>=2.21.0->tensorboard<3,>=2.3.0->tensorflow-gpu) (1.24.2)
Requirement already satisfied: chardet<3.1.0,>=3.0.2 in c:\users\tt0342\appdata
\local\continuum\anaconda3\lib\site-packages (from requests<3,>=2.21.0->tensorb
oard<3,>=2.3.0->tensorflow-gpu) (3.0.4)
Requirement already satisfied: oauthlib>=3.0.0 in c:\users\tt0342\appdata\local
\continuum\anaconda3\lib\site-packages (from requests-oauthlib>=0.7.0->google-a
uth-oauthlib<0.5,>=0.4.1->tensorboard<3,>=2.3.0->tensorflow-gpu) (3.1.0)
Requirement already satisfied: pyasn1>=0.1.3 in c:\users\tt0342\appdata\local\c
ontinuum\anaconda3\lib\site-packages (from rsa<5,>=3.1.4; python_version >= "3.
5"->google-auth<2,>=1.6.3->tensorboard<3,>=2.3.0->tensorflow-gpu) (0.4.8)
```

In [8]:
```
import numpy as np
import tensorflow as tf
from tensorflow import keras
import pandas as pd
import seaborn as sns
from pylab import rcParams
import matplotlib.pyplot as plt
import tensorflow as tf
from tensorboard.plugins.hparams import api as hp
from matplotlib import rc
from pandas.plotting import register_matplotlib_converters
from sklearn.preprocessing import RobustScaler
from sklearn.model_selection import train_test_split
from sklearn.model_selection import cross_val_score
from scipy import stats
from sklearn.preprocessing import OneHotEncoder
from tensorflow.keras.optimizers import Adam
from sklearn.model_selection import train_test_split
from sklearn.metrics import classification_report
from sklearn.model_selection import GroupKFold
%matplotlib inline
%config InlineBackend.figure_format='retina'

register_matplotlib_converters()
sns.set(style='whitegrid', palette='muted', font_scale=1.5)

rcParams['figure.figsize'] = 22, 10

RANDOM_SEED = 42

np.random.seed(RANDOM_SEED)
tf.random.set_seed(RANDOM_SEED)
```

In [9]:
```
#Labels each column for the pandas datafram
column_names = ['user_id', 'activity', 'timestamp', 'x_axis', 'y_axis', 'z_axis'

#Generate datafram (df) by reading the input .csv file
df = pd.read_csv('gesture_data.csv', header=None, names=column_names)
df.z_axis.replace(regex=True, inplace=True, to_replace=r';', value=r'') #Gets ri
df['z_axis'] = df.z_axis.astype(np.float64) #Convert z-axis values to float
df.dropna(axis=0, how='any', inplace=True) #Gets rid of blank lines

df['user_id'] = df.user_id.astype(int) #Convert the user id variable to int
```

```
C:\Users\tt0342\AppData\Local\Continuum\anaconda3\lib\site-packages\IPython\cor
e\interactiveshell.py:3058: DtypeWarning: Columns (0) have mixed types. Specify
dtype option on import or set low_memory=False.
  interactivity=interactivity, compiler=compiler, result=result)
```

In [10]:
```
#Check that the dataframe has been generated
print(df.head())
print("Shape", df.shape)
```

```
   user_id activity     timestamp    x_axis    y_axis    z_axis
0       30   waving  4.582675e+09 -0.353728  5.283476  7.901423
1       30   waving  4.588676e+09 -0.277715  5.296046  8.208766
2       30   waving  4.594678e+09 -0.277715  5.296046  8.208766
3       30   waving  4.607681e+09 -0.238512  5.258937  8.365580
4       30   waving  4.614681e+09 -0.201104  5.226916  8.395206
Shape (131205, 6)
```

In [11]:
```
class CustomCallback(tf.keras.callbacks.Callback):

    def on_epoch_end(self, epoch, logs=None):

        if logs.get('accuracy') >= 1.0:

            self.model.stop_training = True
```

In [12]:
```
def compile_model(X_train, X_val, y_train, y_val,units=128,dropout_rate=0.5):
    model = keras.Sequential()
    model.add(
        keras.layers.Bidirectional(
          keras.layers.LSTM(
              units=units,
              input_shape=[X_train.shape[1], X_train.shape[2]]
          )
        )
    )
    model.add(keras.layers.Dropout(rate=dropout_rate))
    model.add(keras.layers.Dense(units=units, activation='tanh'))
    model.add(keras.layers.Dense(y_train.shape[1], activation='softmax'))
    callback = CustomCallback()
    model.compile(optimizer=Adam(learning_rate = 0.001,decay = 1e-6), loss = 'ca
              metrics = ['accuracy'])
    history = model.fit(
        X_train, y_train,
        epochs=20,
        batch_size=64,
        validation_data=(X_val, y_val),
        callbacks=[callback]

    )
    return model, history
```

In [13]:
```
def create_dataset(X, y, time_steps=1, step=1):
    Xs, ys = [], []
    for i in range(0, len(X) - time_steps, step):
        v = X.iloc[i:(i + time_steps)].values
        labels = y.iloc[i: i + time_steps]
        Xs.append(v)
        ys.append(stats.mode(labels)[0][0])
    return np.array(Xs), np.array(ys).reshape(-1, 1)
```

In [14]:
```
def create_dataset_with_userid(X, y,subjects, time_steps=1, step=1):
    Xs, ys, us = [], [],[]
    for i in range(0, len(X) - time_steps, step):
        v = X.iloc[i:(i + time_steps)].values
        labels = y.iloc[i: i + time_steps]
        user_id = subjects.iloc[i: i + time_steps]
        Xs.append(v)
        us.append(stats.mode(user_id)[0][0])
        ys.append(stats.mode(labels)[0][0])
    return np.array(Xs), np.array(ys).reshape(-1, 1),np.array(us).reshape(-1, 1)
```

In [15]:
```
%load_ext tensorboard
```

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
```

In [110]:
```
!rm -rf ./logs/
```

```
'rm' is not recognized as an internal or external command,
operable program or batch file.
```

In [115]:
```
TIME_STEPS=200
Steps =40
X_train, y_train, groups_user = create_dataset_with_userid(
        df[['x_axis', 'y_axis', 'z_axis']],
        df.activity,
        df.user_id,
        TIME_STEPS,
        Steps

)
enc = OneHotEncoder(handle_unknown='ignore', sparse=False)

enc = enc.fit(y_train)

y_train = enc.transform(y_train)
```

In [116]:
```
X_train, X_val, y_train, y_val= train_test_split(X_train, y_train, test_size = 0
```

In [117]:
```
y_val.shape
```

Out[117]:
```
(656, 11)
```

In [123]:
```
HP_NUM_UNITS = hp.HParam('num_units', hp.Discrete([32,64,128]))
HP_DROPOUT = hp.HParam('dropout', hp.RealInterval(0.2,0.5))
HP_OPTIMIZER = hp.HParam('optimizer', hp.Discrete(['adam', 'sgd']))

METRIC_ACCURACY = 'accuracy'

with tf.summary.create_file_writer('logs2/hparam_tuning').as_default():
  hp.hparams_config(
    hparams=[HP_NUM_UNITS, HP_DROPOUT, HP_OPTIMIZER],
    metrics=[hp.Metric(METRIC_ACCURACY, display_name='Accuracy')],
  )
```

In [128]:
```
def train_test_model(hparams):
    model = keras.Sequential()
    model.add(
        keras.layers.Bidirectional(
          keras.layers.LSTM(
              units=hparams[HP_NUM_UNITS],
              input_shape=[X_train.shape[1], X_train.shape[2]]
          )
        )
    )
    model.add(keras.layers.Dropout(hparams[HP_DROPOUT]))
    model.add(keras.layers.Dense(units=hparams[HP_NUM_UNITS], activation='tanh'))
    model.add(keras.layers.Dense(y_train.shape[1], activation='softmax'))
    model.compile(optimizer=hparams[HP_OPTIMIZER], loss = 'categorical_crossentro
              metrics = ['accuracy'])

    model.fit(X_train, y_train, epochs=30) # Run with 1 epoch to speed things up
    _, accuracy = model.evaluate(X_val, y_val)
    return accuracy
```

In [134]:
```
def run(run_dir, hparams):
  with tf.summary.create_file_writer(run_dir).as_default():
    hp.hparams(hparams)  # record the values used in this trial
    accuracy = train_test_model(hparams)
    tf.summary.scalar(METRIC_ACCURACY, accuracy, step=1)
```

In [4]:
```
logdir = "logs2/hparam_tuning/"
```

In [136]:
```
session_num = 0

for num_units in HP_NUM_UNITS.domain.values:
  for dropout_rate in (HP_DROPOUT.domain.min_value, HP_DROPOUT.domain.max_value):
    for optimizer in HP_OPTIMIZER.domain.values:
      hparams = {
          HP_NUM_UNITS: num_units,
          HP_DROPOUT: dropout_rate,
          HP_OPTIMIZER: optimizer,
      }
#       print(train_test_model(hparams))
      run_name = "run-%d" % session_num
      print('--- Starting trial: %s' % run_name)
      print({h.name: hparams[h] for h in hparams})
      a = run('logs2/hparam_tuning/' + run_name, hparams)
      session_num += 1
```

```
--- Starting trial: run-0
{'num_units': 32, 'dropout': 0.2, 'optimizer': 'adam'}
Epoch 1/30
82/82 [==============================] - 3s 36ms/step - loss: 1.9097 - accura
cy: 0.3786
Epoch 2/30
82/82 [==============================] - 3s 36ms/step - loss: 1.0180 - accura
cy: 0.7168
Epoch 3/30
82/82 [==============================] - 3s 37ms/step - loss: 0.5461 - accura
cy: 0.8573
Epoch 4/30
82/82 [==============================] - 3s 37ms/step - loss: 0.3807 - accura
cy: 0.9122
Epoch 5/30
82/82 [==============================] - 3s 39ms/step - loss: 0.2637 - accura
cy: 0.9450
Epoch 6/30
82/82 [==============================] - 3s 37ms/step - loss: 0.1653 - accura
```

In [9]:
```
```

```
'kill' is not recognized as an internal or external command,
operable program or batch file.
```

In [3]:
```
%tensorboard --logdir logs2/hparam_tuning --port=8008
```

```
ERROR: Timed out waiting for TensorBoard to start. It may still be running as p
id 13904.
```

In [16]:
```
from sklearn.model_selection import LeaveOneGroupOut
TIME_STEPS=200
Steps =40
X_train, y_train, groups_user = create_dataset_with_userid(
        df[['x_axis', 'y_axis', 'z_axis']],
        df.activity,
        df.user_id,
        TIME_STEPS,
        Steps

)
```

In [17]:
```
enc = OneHotEncoder(handle_unknown='ignore', sparse=False)

enc = enc.fit(y_train)

y_train = enc.transform(y_train)
```

In [18]:
```
enc.categories_[0]
```

Out[18]:
```
array(['circle', 'dab', 'drinking', 'lineH', 'lineV', 'outwardsL',
       'outwardsR', 'semicircle', 'towards', 'waving', 'xmark'],
      dtype='<U10')
```

In [148]:
```
pip install -U scikit-learn
```

```
Collecting scikit-learn
  Downloading https://files.pythonhosted.org/packages/92/db/8c50996186faed765392cb5ba495e8764643b71adbd168535baf0fcae5f1/scikit_learn-0.23.2-cp37-cp37m-win_amd64.whl (https://files.pythonhosted.org/packages/92/db/8c50996186faed765392cb5ba495e8764643b71adbd168535baf0fcae5f1/scikit_learn-0.23.2-cp37-cp37m-win_amd64.whl) (6.8MB)
Requirement already satisfied, skipping upgrade: scipy>=0.19.1 in c:\users\tt0342\appdata\local\continuum\anaconda3\lib\site-packages (from scikit-learn) (1.4.1)
Requirement already satisfied, skipping upgrade: joblib>=0.11 in c:\users\tt0342\appdata\local\continuum\anaconda3\lib\site-packages (from scikit-learn) (0.13.2)
Collecting threadpoolctl>=2.0.0 (from scikit-learn)
  Downloading https://files.pythonhosted.org/packages/f7/12/ec3f2e203afa394a149911729357aa48affc59c20e2c1c8297a60f33f133/threadpoolctl-2.1.0-py3-none-any.whl (https://files.pythonhosted.org/packages/f7/12/ec3f2e203afa394a149911729357aa48affc59c20e2c1c8297a60f33f133/threadpoolctl-2.1.0-py3-none-any.whl)
Requirement already satisfied, skipping upgrade: numpy>=1.13.3 in c:\users\tt0342\appdata\local\continuum\anaconda3\lib\site-packages (from scikit-learn) (1.18.1)
Installing collected packages: threadpoolctl, scikit-learn
  Found existing installation: scikit-learn 0.21.3
    Uninstalling scikit-learn-0.21.3:
      Successfully uninstalled scikit-learn-0.21.3
Note: you may need to restart the kernel to use updated packages.

ERROR: Could not install packages due to an EnvironmentError: [WinError 5] Access is denied: 'c:\\users\\tt0342\\appdata\\local\\continuum\\anaconda3\\lib\\site-packages\\~klearn\\metrics\\cluster\\expected_mutual_info_fast.cp37-win_amd64.pyd'
Consider using the `--user` option or check the permissions.
```

In [19]:
```
from sklearn.metrics import confusion_matrix
def draw_confusion_matrix(y_true,y_pred,class_names,c):
    total = 0
    cm = confusion_matrix(y_true, y_pred, class_names )
    total += cm
    total = total/11
    fig, ax = plt.subplots(figsize=(10, 10))
    ax = sns.heatmap(
          cm,
          annot=True,
          fmt="d",
          ax=ax
      )

    plt.ylabel('Actual')
    plt.xlabel('Predicted')
    ax.set_title('Confusion Matrix')
    ax.set_xticklabels(class_names, rotation = 45)
    ax.set_yticklabels(class_names, rotation=0)
    b, t = plt.ylim() # discover the values for bottom and top
    b += 0.5 # Add 0.5 to the bottom
    t -= 0.5 # Subtract 0.5 from the top
    plt.ylim(b, t) # update the ylim(bottom, top) values
    plt.savefig("Confusion_matrix_cv_"+str(c)+".png")
    plt.show() # ta-da!
```

In [23]:
```
pred = list()
classifications = list()
e1 =list()
scores_list = list()
units = 128
dropout_rate = 0.2
gkf = GroupKFold(n_splits=6)
c = 1
for train, test in gkf.split(X_train, y_train,groups_user):
    X_train_c, X_val_c, y_train_c, y_val_c = train_test_split(X_train[train], y_
#     print(X_train_c, X_val_c, y_train_c, y_val_c)
#     print("%s %s" % (X_train[train], y_train[test]))
    model, history = compile_model(X_train_c, X_val_c, y_train_c, y_val_c,units,
    e= model.evaluate(X_train[test], y_train[test])
    e1.append(e)
    y_pred = model.predict(X_train[test])
    pred.append(y_pred)
    print(classification_report(enc.inverse_transform(y_train[test]), enc.inverse
    draw_confusion_matrix(enc.inverse_transform(y_train[test]),enc.inverse_trans
    c= c+1
```

```
Epoch 15/20
42/42 [==============================] - 21s 492ms/step - loss: 0.0051 - accu
racy: 0.9996 - val_loss: 0.0191 - val_accuracy: 0.9932
Epoch 16/20
42/42 [==============================] - 20s 479ms/step - loss: 0.0048 - accu
racy: 0.9996 - val_loss: 0.0197 - val_accuracy: 0.9932
Epoch 17/20
42/42 [==============================] - 21s 490ms/step - loss: 0.0048 - accu
racy: 0.9996 - val_loss: 0.0120 - val_accuracy: 0.9966
Epoch 18/20
42/42 [==============================] - 20s 483ms/step - loss: 0.0044 - accu
racy: 0.9996 - val_loss: 0.0091 - val_accuracy: 0.9966
Epoch 19/20
42/42 [==============================] - 20s 479ms/step - loss: 0.0037 - accu
racy: 0.9992 - val_loss: 0.0090 - val_accuracy: 0.9966
Epoch 20/20
42/42 [==============================] - 20s 482ms/step - loss: 0.0021 - accu
racy: 1.0000 - val_loss: 0.0079 - val_accuracy: 0.9966
11/11 [==============================] - 1s 55ms/step - loss: 0.0553 - accura
cy: 0.9850
```

In [24]:
```
e1
```

Out[24]:
```
[[0.25349730253219604, 0.9419035911560059],
 [0.011588847264647484, 0.9965397715568542],
 [0.47985923290252686, 0.9012131690979004],
 [0.018545199185609818, 0.9960707426071167],
 [0.08367559313774109, 0.9786780476570129],
 [0.05527763441205025, 0.985029935836792]]
```

In [30]:
```
import numpy as np
a=np.array(e1)
np.mean(a,axis=0)
```

Out[30]:
```
array([0.1504073 , 0.96657254])
```

In [33]:
```
np.std(a,axis=0)
```

Out[33]:
```
array([0.1679916 , 0.03448623])
```