Import Library

In [2]:
```
import TeraHertz_Dataset
import numpy as np
import pandas as pd
import keras.utils as utils
from sklearn import preprocessing
from sklearn.model_selection import train_test_split
```

Data Preprocessing

In [3]:
```
Input, Target = TeraHertz_Dataset.load_dataset()
```

In [4]:
```
print("Shape of Input: ", Input.shape)
print("Shape of Target: ", Target.shape)
```

```
Shape of Input:  (4200, 5074)
Shape of Target:  (4200,)
```

In [5]:
```
minmax_scale = preprocessing.MinMaxScaler(feature_range=(0, 1))
Input_Normalize = minmax_scale.fit_transform(Input)
```

In [6]:
```
Target_OneHot = utils.to_categorical(Target)
```

In [7]:
```
X_train, X_test, y_train, y_test = train_test_split(Input_Normalize, Target_OneHot,
                                                    test_size=0.2, random_state=36)
```

In [8]:
```
print("Training Data: \n", " Feature Array: ", X_train.shape, "\n",
                           " Target: ", y_train.shape)
print("Testing Data: \n", " Feature Array: ", X_test.shape, "\n",
                           " Target: ", y_test.shape)
```

```
Training Data:
  Feature Array:  (3360, 5074)
  Target:  (3360, 2)
Testing Data:
  Feature Array:  (840, 5074)
  Target:  (840, 2)
```

In [9]:
```
sum(y_test)
```

Out[9]:
```
array([ 396.,  444.])
```

Create Model

In [10]:
```
from keras.models import Sequential
from keras.layers import Dense,Dropout
```

In [11]:
```
model = Sequential()
```

In [12]:
```
model.add(Dense(units=2048, input_dim=5074,
                kernel_initializer='uniform',
                activation='relu'))
```

In [13]:
```
model.add(Dense(units=1024,
                kernel_initializer='uniform',
                activation='relu'))
```

In [14]:
```
model.add(Dense(units=512,
                kernel_initializer='uniform',
                activation='relu'))
```

In [15]:
```
model.add(Dense(units=256,
                kernel_initializer='uniform',
                activation='relu'))
```

In [16]:
```
model.add(Dense(units=128,
                kernel_initializer='uniform',
                activation='relu'))
```

In [17]:
```
model.add(Dense(2, activation='softmax'))
```

In [18]:
```
print(model.summary())
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_1 (Dense)              (None, 2048)              10393600
_________________________________________________________________
dense_2 (Dense)              (None, 1024)              2098176
_________________________________________________________________
dense_3 (Dense)              (None, 512)               524800
_________________________________________________________________
dense_4 (Dense)              (None, 256)               131328
_________________________________________________________________
dense_5 (Dense)              (None, 128)               32896
_________________________________________________________________
dense_6 (Dense)              (None, 2)                 258
=================================================================
Total params: 13,181,058
Trainable params: 13,181,058
Non-trainable params: 0
_________________________________________________________________
None
```

Train model

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

In [20]:
```
train_history =model.fit(X_train,
                         y_train,
                         validation_split=0.1,
                         epochs=100,
                         batch_size=30,verbose=1)
```

```
Train on 3024 samples, validate on 336 samples
Epoch 1/100
3024/3024 [==============================] - 1s 413us/step - loss: 0.0373 - acc: 0.985
4 - val_loss: 1.1138e-07 - val_acc: 1.0000
Epoch 2/100
3024/3024 [==============================] - 1s 241us/step - loss: 1.0961e-07 - acc:
1.0000 - val_loss: 1.1042e-07 - val_acc: 1.0000
Epoch 3/100
3024/3024 [==============================] - 1s 236us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 4/100
3024/3024 [==============================] - 1s 236us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 5/100
3024/3024 [==============================] - 1s 236us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 6/100
3024/3024 [==============================] - 1s 241us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 7/100
3024/3024 [==============================] - 1s 239us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 8/100
3024/3024 [==============================] - 1s 233us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 9/100
3024/3024 [==============================] - 1s 236us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 10/100
3024/3024 [==============================] - 1s 245us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 11/100
3024/3024 [==============================] - 1s 235us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 12/100
3024/3024 [==============================] - 1s 235us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 13/100
3024/3024 [==============================] - 1s 237us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 14/100
3024/3024 [==============================] - 1s 236us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 15/100
3024/3024 [==============================] - 1s 238us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 16/100
3024/3024 [==============================] - 1s 238us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 17/100
3024/3024 [==============================] - 1s 241us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 18/100
3024/3024 [==============================] - 1s 240us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 19/100
3024/3024 [==============================] - 1s 242us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 20/100
3024/3024 [==============================] - 1s 238us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 21/100
3024/3024 [==============================] - 1s 243us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 22/100
3024/3024 [==============================] - 1s 248us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 23/100
3024/3024 [==============================] - 1s 249us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
```

```
Epoch 24/100
3024/3024 [==============================] - 1s 252us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 25/100
3024/3024 [==============================] - 1s 251us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 26/100
3024/3024 [==============================] - 1s 245us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 27/100
3024/3024 [==============================] - 1s 236us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 28/100
3024/3024 [==============================] - 1s 237us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 29/100
3024/3024 [==============================] - 1s 239us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 30/100
3024/3024 [==============================] - 1s 236us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 31/100
3024/3024 [==============================] - 1s 239us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 32/100
3024/3024 [==============================] - 1s 250us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 33/100
3024/3024 [==============================] - 1s 245us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 34/100
3024/3024 [==============================] - 1s 236us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 35/100
3024/3024 [==============================] - 1s 237us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 36/100
3024/3024 [==============================] - 1s 237us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 37/100
3024/3024 [==============================] - 1s 241us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 38/100
3024/3024 [==============================] - 1s 236us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 39/100
3024/3024 [==============================] - 1s 238us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 40/100
3024/3024 [==============================] - 1s 243us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 41/100
3024/3024 [==============================] - 1s 254us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 42/100
3024/3024 [==============================] - 1s 246us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 43/100
3024/3024 [==============================] - 1s 243us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 44/100
3024/3024 [==============================] - 1s 232us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 45/100
3024/3024 [==============================] - 1s 244us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 46/100
3024/3024 [==============================] - 1s 252us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 47/100
```

```
3024/3024 [==============================] - 1s 241us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 48/100
3024/3024 [==============================] - 1s 255us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 49/100
3024/3024 [==============================] - 1s 241us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 50/100
3024/3024 [==============================] - 1s 237us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 51/100
3024/3024 [==============================] - 1s 241us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 52/100
3024/3024 [==============================] - 1s 242us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 53/100
3024/3024 [==============================] - 1s 241us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 54/100
3024/3024 [==============================] - 1s 244us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 55/100
3024/3024 [==============================] - 1s 243us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 56/100
3024/3024 [==============================] - 1s 241us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 57/100
3024/3024 [==============================] - 1s 241us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 58/100
3024/3024 [==============================] - 1s 240us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 59/100
3024/3024 [==============================] - 1s 241us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 60/100
3024/3024 [==============================] - 1s 237us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 61/100
3024/3024 [==============================] - 1s 243us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 62/100
3024/3024 [==============================] - 1s 240us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 63/100
3024/3024 [==============================] - 1s 233us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 64/100
3024/3024 [==============================] - 1s 238us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 65/100
3024/3024 [==============================] - 1s 235us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 66/100
3024/3024 [==============================] - 1s 242us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 67/100
3024/3024 [==============================] - 1s 240us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 68/100
3024/3024 [==============================] - 1s 234us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 69/100
3024/3024 [==============================] - 1s 250us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 70/100
3024/3024 [==============================] - 1s 246us/step - loss: 1.0960e-07 - acc:
```

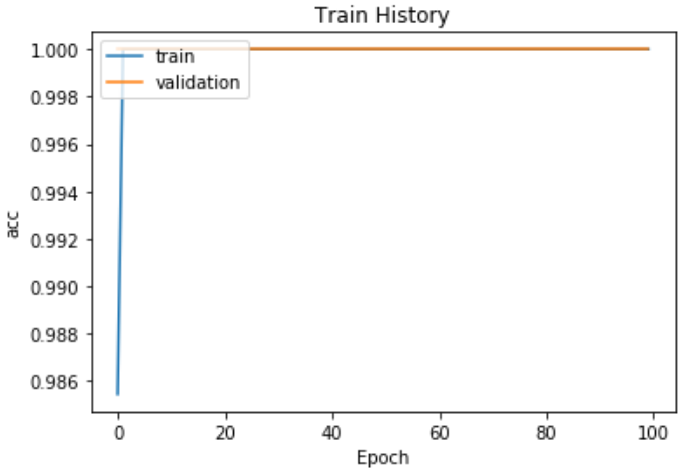
```
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 71/100
3024/3024 [==============================] - 1s 244us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 72/100
3024/3024 [==============================] - 1s 241us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 73/100
3024/3024 [==============================] - 1s 241us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 74/100
3024/3024 [==============================] - 1s 240us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 75/100
3024/3024 [==============================] - 1s 242us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 76/100
3024/3024 [==============================] - 1s 239us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 77/100
3024/3024 [==============================] - 1s 240us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 78/100
3024/3024 [==============================] - 1s 236us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 79/100
3024/3024 [==============================] - 1s 242us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 80/100
3024/3024 [==============================] - 1s 238us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 81/100
3024/3024 [==============================] - 1s 242us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 82/100
3024/3024 [==============================] - 1s 244us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 83/100
3024/3024 [==============================] - 1s 243us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 84/100
3024/3024 [==============================] - 1s 238us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 85/100
3024/3024 [==============================] - 1s 237us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 86/100
3024/3024 [==============================] - 1s 239us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 87/100
3024/3024 [==============================] - 1s 238us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 88/100
3024/3024 [==============================] - 1s 245us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 89/100
3024/3024 [==============================] - 1s 242us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 90/100
3024/3024 [==============================] - 1s 237us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 91/100
3024/3024 [==============================] - 1s 239us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 92/100
3024/3024 [==============================] - 1s 239us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 93/100
3024/3024 [==============================] - 1s 236us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
```

```
Epoch 94/100
3024/3024 [==============================] - 1s 238us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 95/100
3024/3024 [==============================] - 1s 240us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 96/100
3024/3024 [==============================] - 1s 236us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 97/100
3024/3024 [==============================] - 1s 242us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 98/100
3024/3024 [==============================] - 1s 236us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 99/100
3024/3024 [==============================] - 1s 247us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
Epoch 100/100
3024/3024 [==============================] - 1s 236us/step - loss: 1.0960e-07 - acc:
1.0000 - val_loss: 1.1029e-07 - val_acc: 1.0000
```

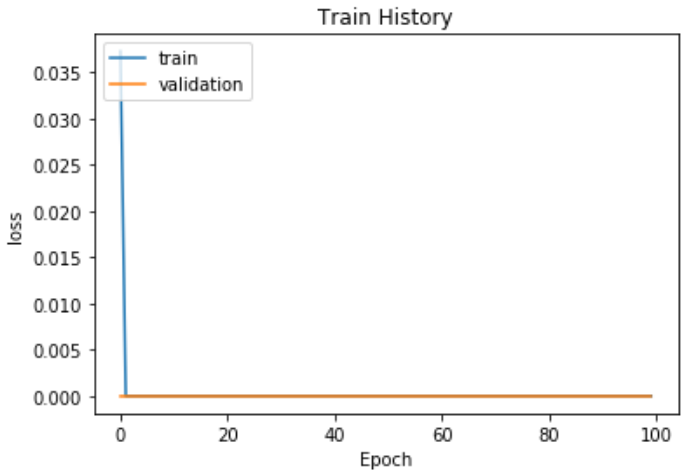
Print History

In [21]:
```
import matplotlib.pyplot as plt
def show_train_history(train_history,train,validation):
    plt.plot(train_history.history[train])
    plt.plot(train_history.history[validation])
    plt.title('Train History')
    plt.ylabel(train)
    plt.xlabel('Epoch')
    plt.legend(['train', 'validation'], loc='upper left')
    plt.show()
```

In [22]:
```
show_train_history(train_history,'acc','val_acc')
```



In [23]:
```
show_train_history(train_history,'loss','val_loss')
```



Evaluation Accuracy

In [24]:
```
scores = model.evaluate(X_test,
                        y_test)
```

```
840/840 [==============================] - 0s 38us/step
```

In [25]:
```
scores[1]
```

Out[25]:
```
1.0
```

In [26]:
```
model.save('Keras_Terahertz_1061211.h5')
```