Width: 1024

Stride: 256

Only use channels LEFT\_TA, LEFT\_TS,RIGHT\_TA, RIGHT\_TS.

No scale on raw signal. Not shuffle and pick the last 20% data of each labels out for validation. Shuffle and split the rest to 80% for training and 20% for test.

Use empirical mode decomposition on raw data. Then get data with dimension [N,C,L,I].

N: number of the data

I: number of the components from decomposition

L: length of the window width

C: number of channels

Feed the data to 1D CNN model.

No detrend

rate=0.2

kernel\_size=7

kernel\_size2=5

stride=1

acti='relu'

with averagepooling

Train (acc 1.000)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 277 | 0 | 0 |
| Actual 2 | 0 | 605 | 0 |
| Actual 6 | 0 | 0 | 392 |

Test (acc 0.974)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 66 | 2 | 0 |
| Actual 2 | 4 | 139 | 1 |
| Actual 6 | 1 | 0 | 106 |

Last 20% (acc 0.801)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 45 | 15 | 28 |
| Actual 2 | 8 | 177 | 10 |
| Actual 6 | 6 | 14 | 106 |

input\_ = layers.Input(shape=imfs[:,[0,1,3,5],:,:].shape[1:])

cnn1 = layers.Conv1D(256,kernel\_size,strides=stride,

padding='same')(input\_)

cnn1 = layers.Activation(acti)(cnn1)

cnn1 = layers.AveragePooling2D((1,2))(cnn1)

cnn1 = layers.Dropout(rate)(cnn1)

cnn2 = layers.Conv1D(128,kernel\_size,strides=stride,

padding='same')(cnn1)

cnn2 = layers.Activation(acti)(cnn2)

cnn2 = layers.BatchNormalization(momentum=0.8)(cnn2)

cnn2 = layers.AveragePooling2D((1,2))(cnn2)

cnn2 = layers.Dropout(rate)(cnn2)

cnn3 = layers.Conv1D(64,kernel\_size,strides=stride,

padding='same')(cnn2)

cnn3 = layers.Activation(acti)(cnn3)

cnn3 = layers.BatchNormalization(momentum=0.8)(cnn3)

cnn3 = layers.AveragePooling2D((1,2))(cnn3)

cnn3 = layers.Dropout(rate)(cnn3)

cnn4 = layers.Conv1D(32,kernel\_size2,strides=stride,

padding='same')(cnn3)

cnn4 = layers.Activation(acti)(cnn4)

cnn4 = layers.BatchNormalization(momentum=0.8)(cnn4)

cnn4 = layers.AveragePooling2D((1,2))(cnn4)

cnn4 = layers.Dropout(rate)(cnn4)

cnn5 = layers.Conv1D(16,kernel\_size,strides=stride,

padding='same')(cnn4)

cnn5 = layers.Activation(acti)(cnn5)

cnn5 = layers.BatchNormalization(momentum=0.8)(cnn5)

cnn5 = layers.AveragePooling2D((1,2))(cnn5)

cnn5 = layers.Dropout(rate)(cnn5)

cnn6 = layers.Conv1D(8,kernel\_size2,strides=stride,

padding='same')(cnn5)

cnn6 = layers.Activation(acti)(cnn6)

cnn6 = layers.BatchNormalization(momentum=0.8)(cnn6)

cnn6 = layers.AveragePooling2D((1,2))(cnn6)

cnn6 = layers.Dropout(rate)(cnn6)

cnn7 = layers.Conv1D(4,kernel\_size2,strides=stride,

padding='same')(cnn6)

cnn7 = layers.Activation(acti)(cnn7)

cnn7 = layers.BatchNormalization(momentum=0.8)(cnn7)

cnn7 = layers.AveragePooling2D((1,2))(cnn7)

cnn7 = layers.Dropout(rate)(cnn7)

flatten = layers.Flatten()(cnn7)

dropout = layers.Dropout(rate)(flatten)

output = layers.Dense(3,activation = 'softmax')(dropout)

model = Model(inputs=[input\_],outputs=[output])

without pooling:

Train (acc 1.000)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 277 | 0 | 0 |
| Actual 2 | 0 | 605 | 0 |
| Actual 6 | 0 | 0 | 392 |

Test (acc 0.990)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 67 | 1 | 0 |
| Actual 2 | 2 | 142 | 0 |
| Actual 6 | 0 | 0 | 107 |

Last 20% (acc 0.748)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 55 | 22 | 11 |
| Actual 2 | 25 | 162 | 8 |
| Actual 6 | 29 | 8 | 89 |

With maxpooling:

Train (acc 1.000)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 277 | 0 | 0 |
| Actual 2 | 0 | 605 | 0 |
| Actual 6 | 0 | 0 | 392 |

Test (acc 0.990)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 67 | 1 | 0 |
| Actual 2 | 2 | 142 | 0 |
| Actual 6 | 0 | 0 | 107 |

Last 20% (acc 0. 831)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 59 | 16 | 13 |
| Actual 2 | 16 | 167 | 12 |
| Actual 6 | 2 | 10 | 114 |

Detrend(lambda=300):

Maxpooling:

Train (acc 1.000)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 277 | 0 | 0 |
| Actual 2 | 0 | 605 | 0 |
| Actual 6 | 0 | 0 | 392 |

Test (acc 0.981)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 65 | 2 | 1 |
| Actual 2 | 1 | 142 | 1 |
| Actual 6 | 1 | 0 | 106 |

Last 20% (acc 0.777)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 50 | 24 | 14 |
| Actual 2 | 25 | 166 | 4 |
| Actual 6 | 8 | 16 | 102 |

Averagepooling:

Train (acc 0.992)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 275 | 0 | 2 |
| Actual 2 | 3 | 600 | 2 |
| Actual 6 | 2 | 0 | 390 |

Test (acc 0.962)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 63 | 3 | 2 |
| Actual 2 | 3 | 140 | 1 |
| Actual 6 | 3 | 0 | 104 |

Last 20% (acc 0.816)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 55 | 14 | 19 |
| Actual 2 | 21 | 167 | 7 |
| Actual 6 | 4 | 10 | 112 |

No detrend:

rate=0.2

kernel\_size=7

kernel\_size2=7

stride=1

acti='relu'

averagepooling

Train (acc 0.995)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 275 | 0 | 1 |
| Actual 2 | 2 | 602 | 1 |
| Actual 6 | 2 | 0 | 390 |

Test (acc 0.937)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 62 | 2 | 4 |
| Actual 2 | 4 | 137 | 3 |
| Actual 6 | 6 | 1 | 100 |

Last 20% (acc 0.814)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 65 | 9 | 14 |
| Actual 2 | 11 | 166 | 18 |
| Actual 6 | 19 | 5 | 102 |

rate=0.2

kernel\_size=14

kernel\_size2=7

stride=1

acti='relu'

averagepooling

Train (acc 0.997)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 276 | 0 | 0 |
| Actual 2 | 1 | 604 | 0 |
| Actual 6 | 0 | 1 | 391 |

Test (acc 0.937)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 62 | 3 | 3 |
| Actual 2 | 4 | 133 | 4 |
| Actual 6 | 3 | 3 1 | 101 |

Last 20% (acc 0.804)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 50 | 18 | 20 |
| Actual 2 | 11 | 175 | 9 |
| Actual 6 | 17 | 5 | 104 |

rate=0.2

kernel\_size=7

kernel\_size2=7

stride=1

acti='relu'

averagepooling:

[N,I,L,C]

Train (acc 0 967)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 263 | 13 | 1 |
| Actual 2 | 9 | 595 | 1 |
| Actual 6 | 11 | 7 | 374 |

Test (acc 0.896)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 57 | 9 | 2 |
| Actual 2 | 6 | 137 | 1 |
| Actual 6 | 11 | 4 | 92 |

Last 20% (acc 0.821)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 52 | 20 | 16 |
| Actual 2 | 13 | 180 | 2 |
| Actual 6 | 8 | 14 | 104 |

Using LayerNormalization:

rate=0.2

kernel\_size=7

kernel\_size2=7

stride=1

acti='relu'

averagepooling:

layer normalization axis: 1

Train (acc 0 996)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 274 | 2 | 1 |
| Actual 2 | 0 | 605 | 0 |
| Actual 6 | 1 | 0 | 391 |

Test (acc 0.962)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 63 | 1 | 4 |
| Actual 2 | 3 | 138 | 3 |
| Actual 6 | 1 | 0 | 106 |

Last 20% (acc 0.711)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 24 | 21 | 43 |
| Actual 2 | 16 | 167 | 12 |
| Actual 6 | 10 | 16 | 100 |

Raw data(channel[0,1,4,5]):

Using WaveNet:

model = keras.models.Sequential()

model.add(layers.InputLayer(input\_shape=feature[:,[0,1,3,5],:].shape[1:]))

for rate in (1, 2, 4, 8,16,32,64):

model.add(layers.Conv1D(filters=20, kernel\_size=2, padding="causal",

activation="relu", dilation\_rate=rate))

model.add(layers.Conv1D(filters=10, kernel\_size=1))

model.add(layers.Conv1D(filters=16, kernel\_size=5,padding='same'))

model.add(layers.BatchNormalization(momentum=0.8))

model.add(layers.Activation('relu'))

model.add(layers.AveragePooling2D((1,2)))

model.add(layers.Dropout(0.2))

model.add(layers.Conv1D(filters=8, kernel\_size=5,padding='same'))

model.add(layers.BatchNormalization(momentum=0.8))

model.add(layers.Activation('relu'))

model.add(layers.AveragePooling2D((1,2)))

model.add(layers.Dropout(0.2))

model.add(layers.Conv1D(filters=4, kernel\_size=5,padding='same'))

model.add(layers.BatchNormalization(momentum=0.8))

model.add(layers.Activation('relu'))

model.add(layers.AveragePooling2D((1,2)))

model.add(layers.Dropout(0.2))

model.add(layers.Flatten())

model.add(layers.Dense(3,activation='softmax'))

Train (acc 1 000)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 277 | 0 | 0 |
| Actual 2 | 0 | 605 | 0 |
| Actual 6 | 0 | 0 | 392 |

Test (acc 0.868)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 48 | 8 | 12 |
| Actual 2 | 7 | 131 | 6 |
| Actual 6 | 6 | 3 | 98 |

Last 20% (acc 0.782)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 44 | 22 | 22 |
| Actual 2 | 9 | 170 | 16 |
| Actual 6 | 5 | 15 | 106 |

input\_ = layers.Input(shape=feature[:,:,:,[0,1,3,5]].shape[1:])

cnn1 = layers.Conv1D(16,kernel\_size,strides=stride,

padding='same')(input\_)

cnn1 = layers.BatchNormalization()(cnn1)

cnn1 = layers.Activation(acti)(cnn1)

cnn1 = layers.AveragePooling2D((1,2))(cnn1)

cnn1 = layers.Dropout(rate)(cnn1)

cnn2 = layers.Conv1D(32,kernel\_size,strides=stride,

padding='same')(cnn1)

cnn2 = layers.BatchNormalization(momentum=0.8)(cnn2)

cnn2 = layers.Activation(acti)(cnn2)

cnn2 = layers.AveragePooling2D((1,2))(cnn2)

cnn2 = layers.Dropout(rate)(cnn2)

cnn3 = layers.Conv1D(64,kernel\_size,strides=stride,

padding='same')(cnn2)

cnn3 = layers.BatchNormalization(momentum=0.8)(cnn3)

cnn3 = layers.Activation(acti)(cnn3)

cnn3 = layers.AveragePooling2D((1,2))(cnn3)

cnn3 = layers.Dropout(rate)(cnn3)

cnn4 = layers.Conv1D(128,kernel\_size2,strides=stride,

padding='same')(cnn3)

cnn4 = layers.BatchNormalization(momentum=0.8)(cnn4)

cnn4 = layers.Activation(acti)(cnn4)

cnn4 = layers.AveragePooling2D((1,2))(cnn4)

cnn4 = layers.Dropout(rate)(cnn4)

cnn5 = layers.Conv1D(64,kernel\_size,strides=stride,

padding='same')(cnn4)

cnn5 = layers.BatchNormalization(momentum=0.8)(cnn5)

cnn5 = layers.Activation(acti)(cnn5)

cnn5 = layers.AveragePooling2D((1,2))(cnn5)

cnn5 = layers.Dropout(rate)(cnn5)

cnn6 = layers.Conv1D(32,kernel\_size2,strides=stride,

padding='same')(cnn5)

cnn6 = layers.BatchNormalization(momentum=0.8)(cnn6)

cnn6 = layers.Activation(acti)(cnn6)

cnn6 = layers.AveragePooling2D((1,2))(cnn6)

cnn6 = layers.Dropout(rate)(cnn6)

cnn7 = layers.Conv1D(16,kernel\_size2,strides=stride,

padding='same')(cnn6)

cnn7 = layers.BatchNormalization(momentum=0.8)(cnn7)

cnn7 = layers.Activation(acti)(cnn7)

cnn7 = layers.AveragePooling2D((1,2))(cnn7)

cnn7 = layers.Dropout(rate)(cnn7)

flatten = layers.Flatten()(cnn7)

dropout = layers.Dropout(rate)(flatten)

output = layers.Dense(3,activation = 'softmax')(dropout)

model = Model(inputs=[input\_],outputs=[output])

Train (acc 999)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 277 | 0 | 0 |
| Actual 2 | 0 | 605 | 0 |
| Actual 6 | 1 | 0 | 391 |

Test (acc 0.937)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 59 | 6 | 3 |
| Actual 2 | 2 | 139 | 3 |
| Actual 6 | 6 | 0 | 101 |

Last 20% (acc 0.787)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 47 | 17 | 24 |
| Actual 2 | 15 | 171 | 9 |
| Actual 6 | 14 | 8 | 104 |

input\_ = layers.Input(shape=feature[:,:,:,[0,1,3,5]].shape[1:])

cnn1 = layers.Conv1D(16,kernel\_size,strides=stride,

padding='same')(input\_)

cnn1 = layers.BatchNormalization()(cnn1)

cnn1 = layers.Activation(acti)(cnn1)

cnn1 = layers.AveragePooling2D((1,2))(cnn1)

cnn1 = layers.Dropout(rate)(cnn1)

cnn2 = layers.Conv1D(32,kernel\_size,strides=stride,

padding='same')(cnn1)

cnn2 = layers.BatchNormalization(momentum=0.8)(cnn2)

cnn2 = layers.Activation(acti)(cnn2)

cnn2 = layers.AveragePooling2D((1,2))(cnn2)

cnn2 = layers.Dropout(rate)(cnn2)

cnn3 = layers.Conv1D(64,kernel\_size,strides=stride,

padding='same')(cnn2)

cnn3 = layers.BatchNormalization(momentum=0.8)(cnn3)

cnn3 = layers.Activation(acti)(cnn3)

cnn3 = layers.AveragePooling2D((1,2))(cnn3)

cnn3 = layers.Dropout(rate)(cnn3)

cnn4 = layers.Conv1D(128,kernel\_size2,strides=stride,

padding='same')(cnn3)

cnn4 = layers.BatchNormalization(momentum=0.8)(cnn4)

cnn4 = layers.Activation(acti)(cnn4)

cnn4 = layers.AveragePooling2D((1,2))(cnn4)

cnn4 = layers.Dropout(rate)(cnn4)

cnn5 = layers.Conv1D(64,kernel\_size,strides=stride,

padding='same')(cnn4)

cnn5 = layers.BatchNormalization(momentum=0.8)(cnn5)

cnn5 = layers.Activation(acti)(cnn5)

cnn5 = layers.AveragePooling2D((1,2))(cnn5)

cnn5 = layers.Dropout(rate)(cnn5)

cnn6 = layers.Conv1D(32,kernel\_size2,strides=stride,

padding='same')(cnn5)

cnn6 = layers.BatchNormalization(momentum=0.8)(cnn6)

cnn6 = layers.Activation(acti)(cnn6)

cnn6 = layers.AveragePooling2D((1,2))(cnn6)

cnn6 = layers.Dropout(rate)(cnn6)

cnn7 = layers.Conv1D(16,kernel\_size2,strides=stride,

padding='same')(cnn6)

cnn7 = layers.BatchNormalization(momentum=0.8)(cnn7)

cnn7 = layers.Activation(acti)(cnn7)

cnn7 = layers.AveragePooling2D((1,2))(cnn7)

cnn7 = layers.Dropout(rate)(cnn7)

output = layers.Dense(3,activation = 'softmax')(cnn7)

model = Model(inputs=[input\_],outputs=[output])

rate=0.2

kernel\_size=7

kernel\_size2=7

stride=1

acti='relu'

Train (acc 998)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 275 | 2 | 0 |
| Actual 2 | 0 | 605 | 0 |
| Actual 6 | 0 | 0 | 392 |

Test (acc 0.931)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 54 | 12 | 2 |
| Actual 2 | 3 | 140 | 1 |
| Actual 6 | 4 | 0 | 103 |

Last 20% (acc 0.806)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Predicted 1 | Predicted 2 | Predicted 6 |
| Actual 1 | 51 | 19 | 18 |
| Actual 2 | 11 | 182 | 2 |
| Actual 6 | 14 | 15 | 97 |