- **Implementation of resNet with data augmentation**



Accuracy of dexpression



Loss of dexpression
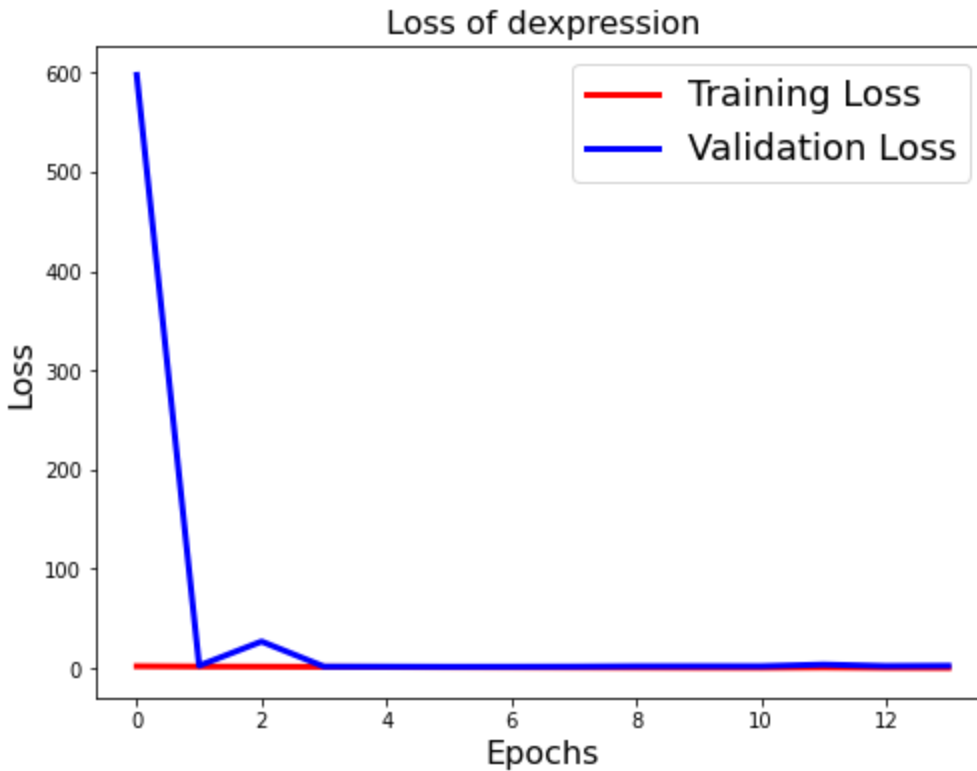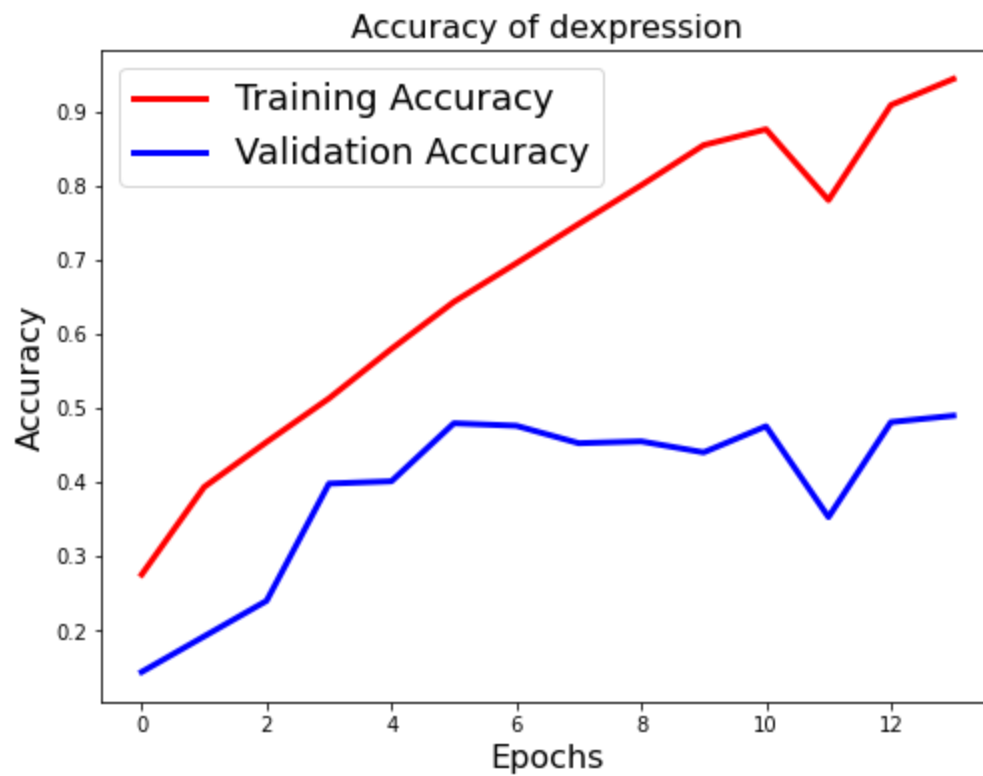
```
Testing Loss = 2.389908790588379
Testing Accuracy = 0.49623849987983704
```

- **Implementation of CNN_1 with data Augmentation**



Accuracy of dexpression

Loss of dexpression
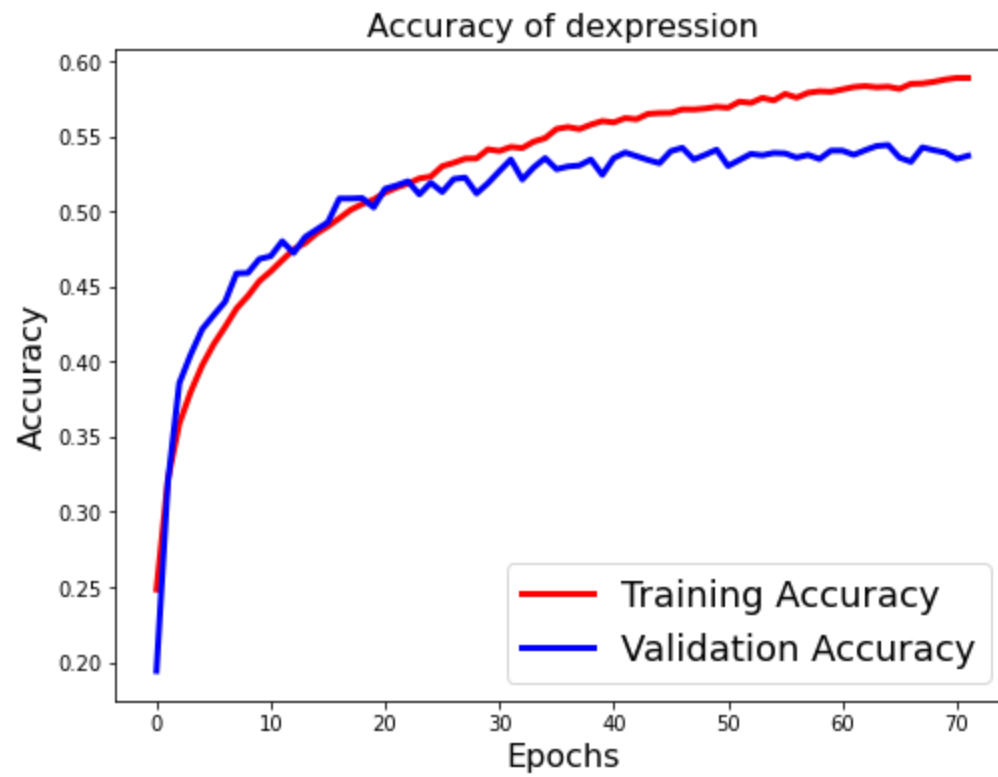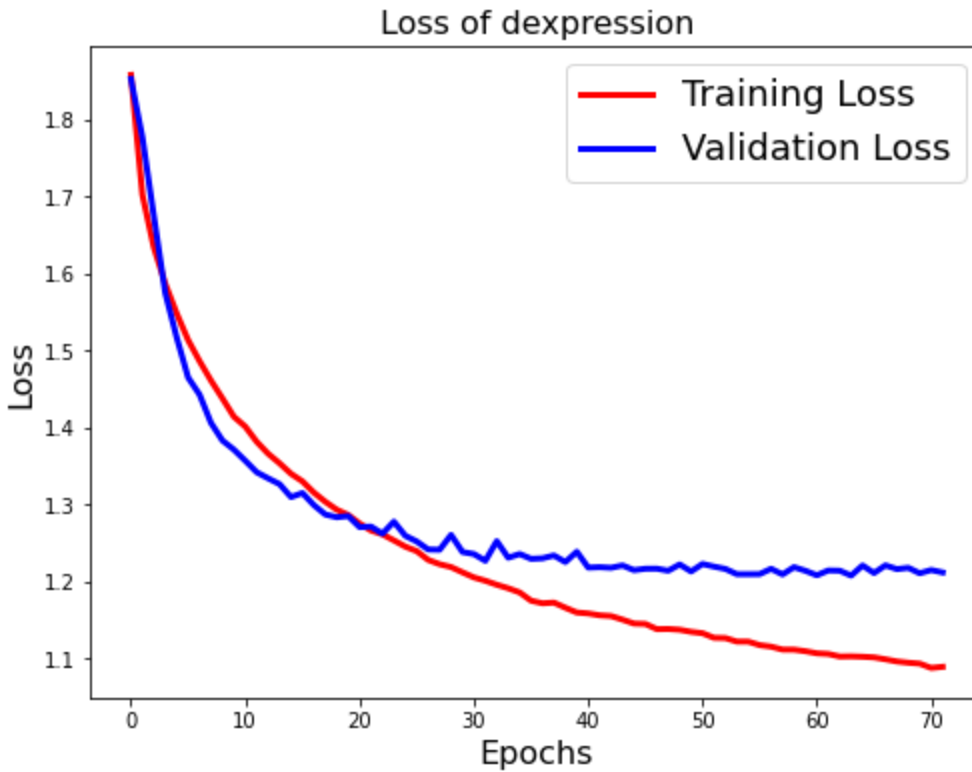
Testing Loss = 1.2271398305892944
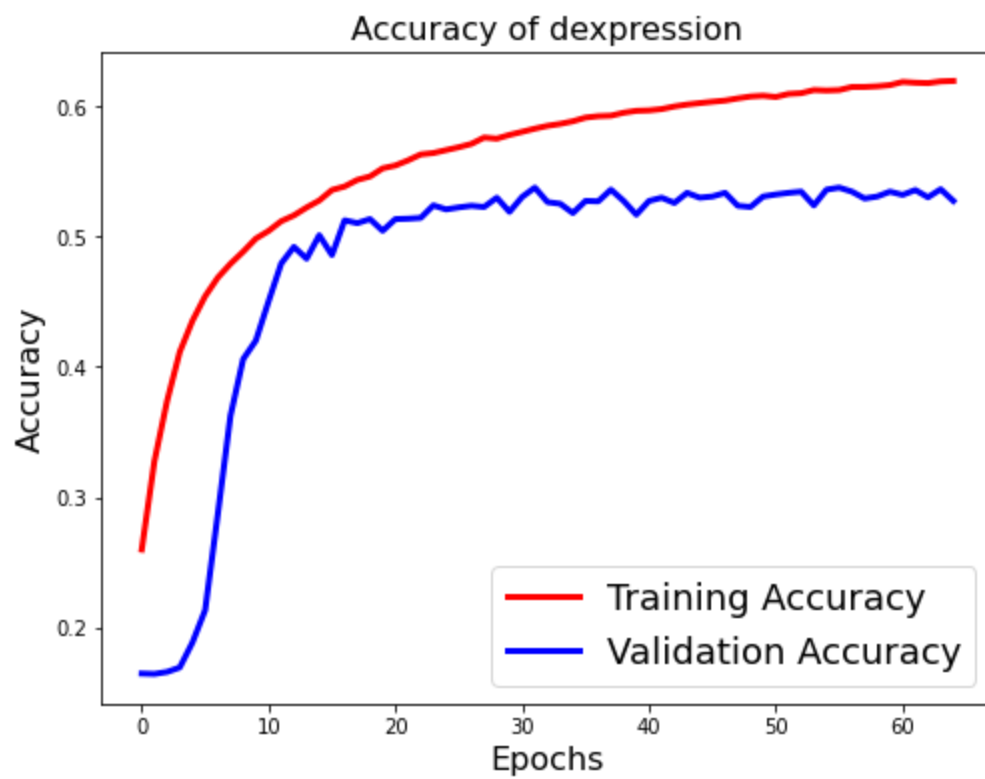Testing Accuracy = 0.5416550636291504

loss: 1.1023 - accuracy: 0.5827 - val_loss: 1.2072 - val_accuracy: 0.5437 - lr: 6.5610e-04

- **Tiny_Xception with data augmentation**

Testing Loss = 1.25651216506958
Testing Accuracy = 0.5285595059394836

## Loss of dexpression



## Accuracy of dexpression
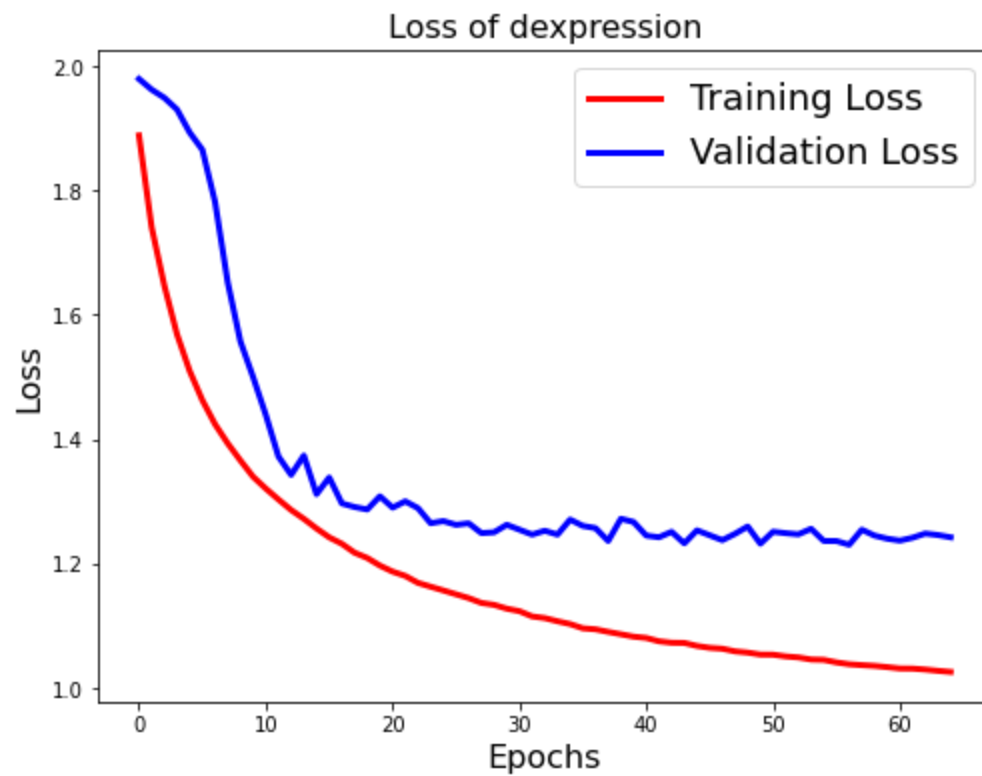


loss: 1.0381 - accuracy: 0.6147 - val_loss: 1.2303 - val_accuracy: 0.5344 - lr: 4.7830e-04

- ## **Start with HOG**
  - - 3 labels ⇒ accuracy 80%
  - - 7 labels ⇒ accuracy 65%
  - - 7 labels with data augmentation ⇒ 69%
  - - 7 labels with data balancing ⇒ 73%

1. **3 labels (sad, happy and neutral)**

Model :
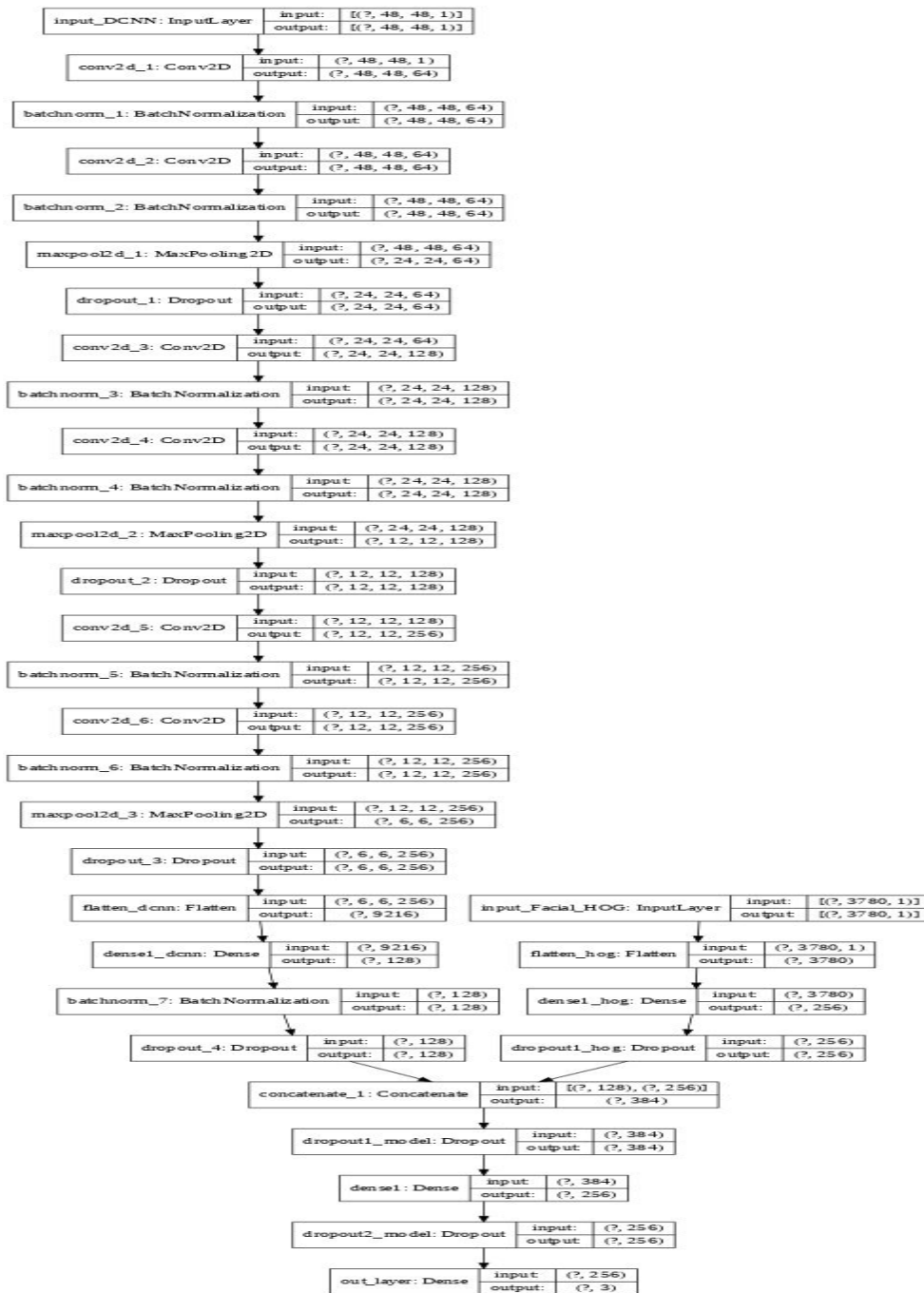
Train :

```
Epoch 31/100
599/598 [==============================] - 12s 20ms/step - loss: 0.4873 - accuracy: 0.7987 - val_loss: 0.4841 - val_accuracy: 0.8072 - lr:
Epoch 32/100
599/598 [==============================] - 12s 20ms/step - loss: 0.4845 - accuracy: 0.7991 - val_loss: 0.4840 - val_accuracy: 0.8025 - lr:
Epoch 33/100
599/598 [==============================] - 12s 20ms/step - loss: 0.4854 - accuracy: 0.8007 - val_loss: 0.4785 - val_accuracy: 0.8039 - lr:
Epoch 34/100
597/598 [=============================>.] - ETA: 0s - loss: 0.4786 - accuracy: 0.7996
Epoch 00034: ReduceLROnPlateau reducing learning rate to 6.25000029685907e-05.
599/598 [==============================] - 12s 20ms/step - loss: 0.4793 - accuracy: 0.7994 - val_loss: 0.4886 - val_accuracy: 0.7969 - lr:
Epoch 35/100
599/598 [==============================] - 12s 20ms/step - loss: 0.4663 - accuracy: 0.8060 - val_loss: 0.4754 - val_accuracy: 0.8035 - lr:
Epoch 36/100
598/598 [=============================>.] - ETA: 0s - loss: 0.4607 - accuracy: 0.8109Restoring model weights from the end of the best epoch
599/598 [==============================] - 12s 20ms/step - loss: 0.4607 - accuracy: 0.8108 - val_loss: 0.4770 - val_accuracy: 0.8054 - lr:
Epoch 00036: early stopping
```
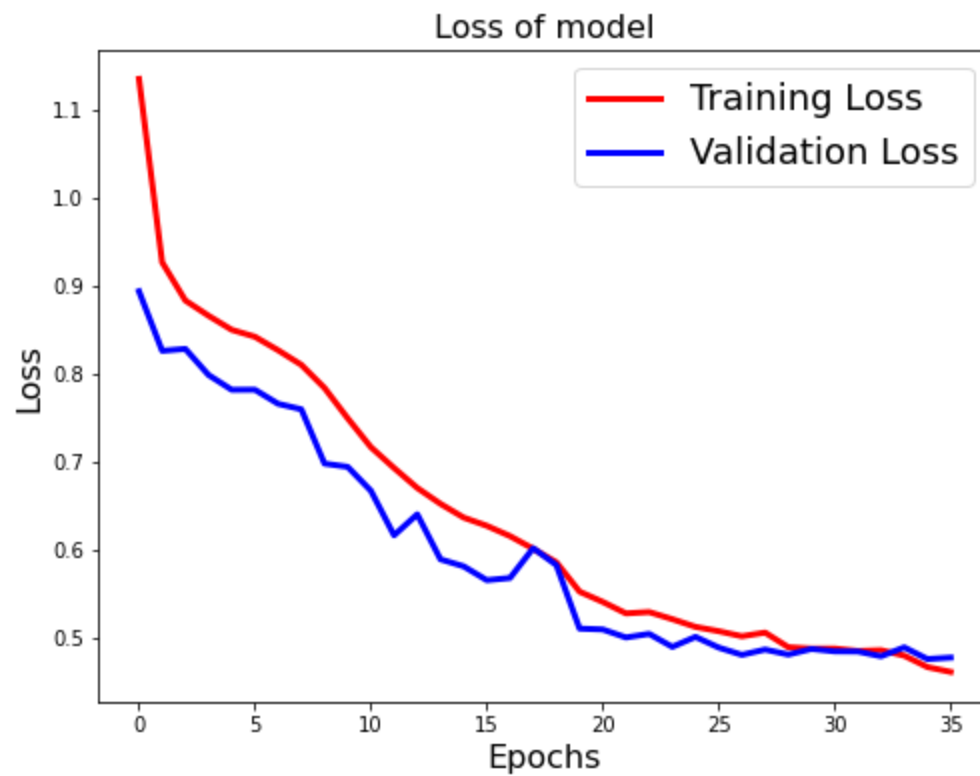

Accuracy of model

## Loss of model
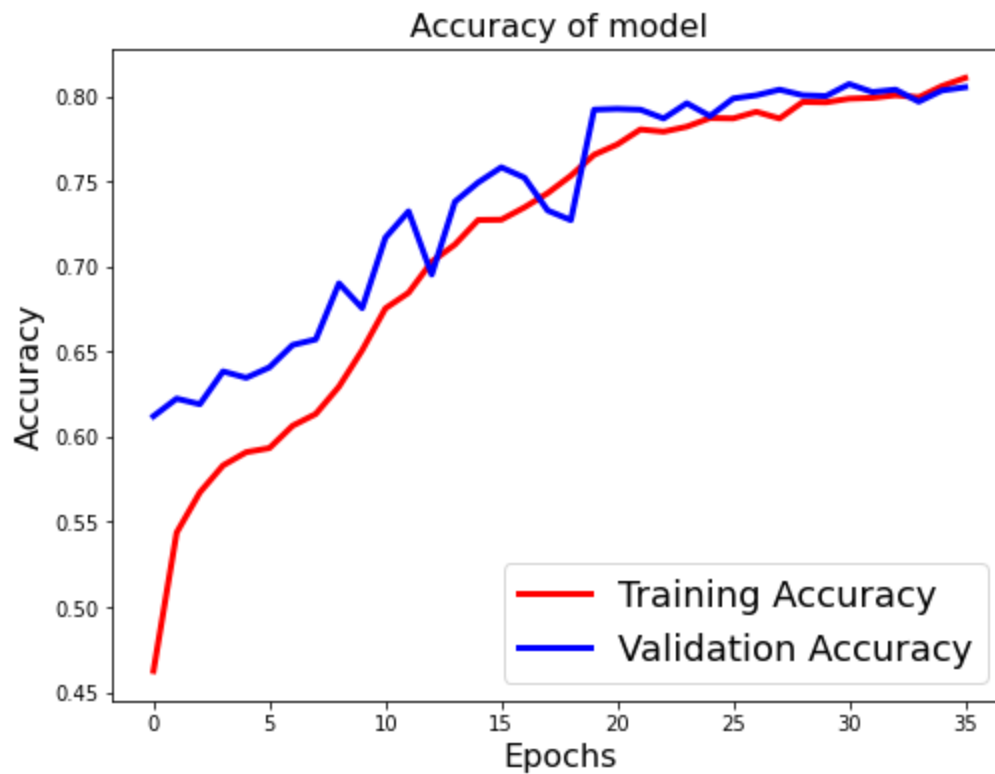


Accuracy :

```
total wrong validation predictions: 410
```

|  | precision | recall | f1-score | support |
|---|---|---|---|---|
| 0 | 0.92 | 0.92 | 0.92 | 899 |
| 1 | 0.76 | 0.72 | 0.74 | 608 |
| 2 | 0.70 | 0.74 | 0.72 | 620 |
| accuracy |  |  | 0.81 | 2127 |
| macro avg | 0.79 | 0.79 | 0.79 | 2127 |
| weighted avg | 0.81 | 0.81 | 0.81 | 2127 |

**2. 7 labels:**

Train:

```
Epoch 34/100
1010/1009 [==============================] - 15s 14ms/step - loss: 0.9711 - accuracy: 0.6402 - val_loss: 0.9282 - val_accuracy: 0.6556 - l
Epoch 35/100
1010/1009 [==============================] - 15s 15ms/step - loss: 0.9673 - accuracy: 0.6426 - val_loss: 0.9273 - val_accuracy: 0.6514 - l
Epoch 36/100
1010/1009 [==============================] - 15s 14ms/step - loss: 0.9599 - accuracy: 0.6439 - val_loss: 0.9287 - val_accuracy: 0.6478 - l
Epoch 37/100
1009/1009 [=============================>.] - ETA: 0s - loss: 0.9599 - accuracy: 0.6469
Epoch 00037: ReduceLROnPlateau reducing learning rate to 6.25000029685907e-05.
1010/1009 [==============================] - 15s 15ms/step - loss: 0.9600 - accuracy: 0.6469 - val_loss: 0.9222 - val_accuracy: 0.6548 - l
Epoch 38/100
1010/1009 [==============================] - 14s 14ms/step - loss: 0.9487 - accuracy: 0.6507 - val_loss: 0.9200 - val_accuracy: 0.6539 - l
Epoch 39/100
1009/1009 [=============================>.] - ETA: 0s - loss: 0.9458 - accuracy: 0.6509Restoring model weights from the end of the best epo
1010/1009 [==============================] - 15s 14ms/step - loss: 0.9457 - accuracy: 0.6510 - val_loss: 0.9203 - val_accuracy: 0.6556 - l
Epoch 00039: early stopping
```

## Loss of model
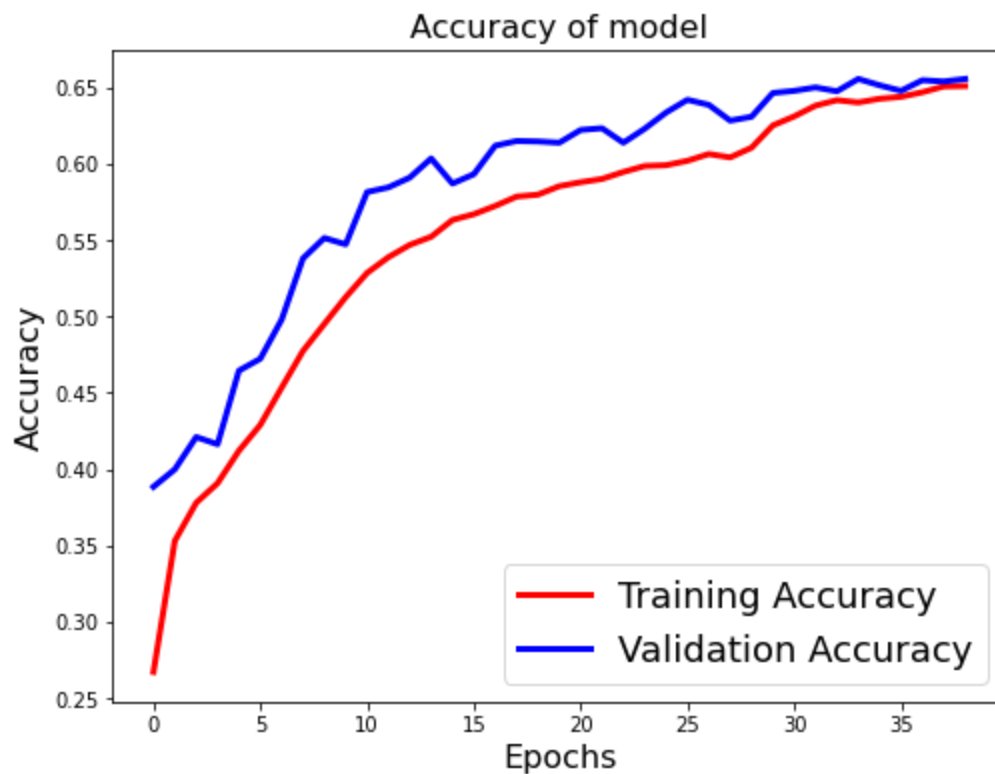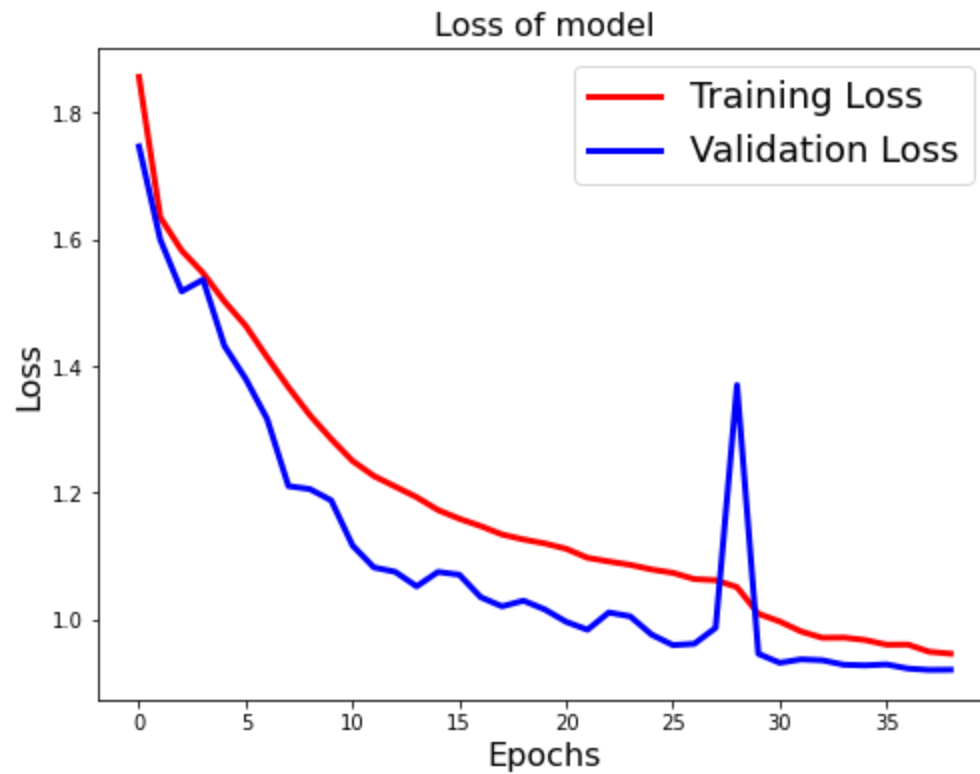


Accuracy :

```
total wrong validation predictions: 1236
```

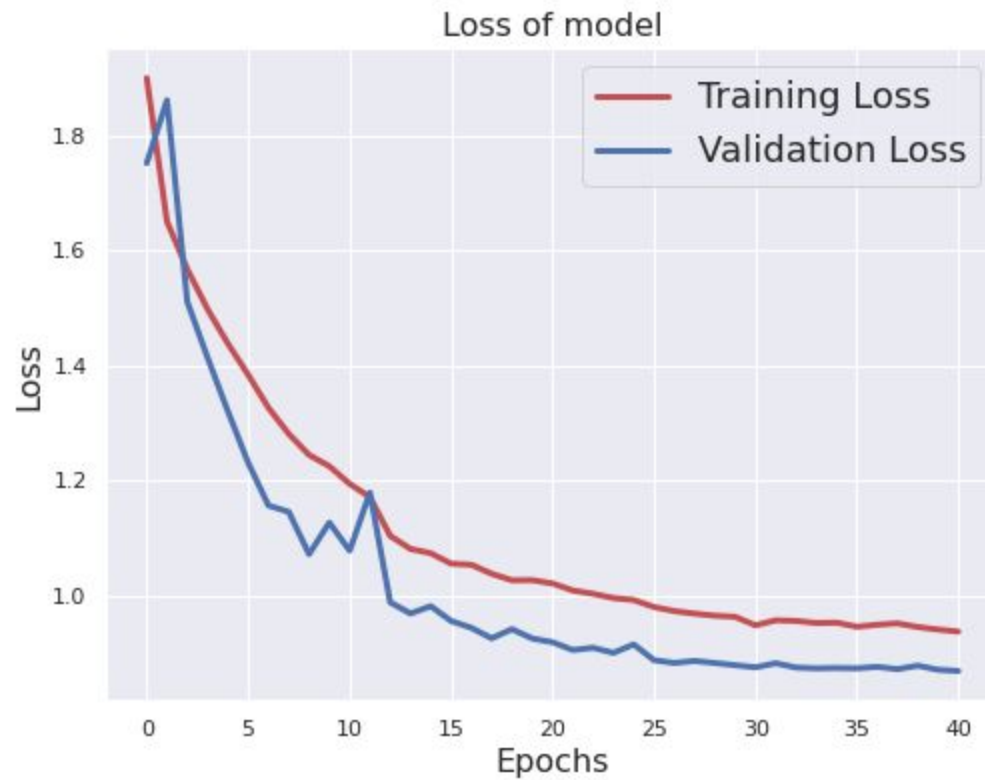|  | precision | recall | f1-score | support |
|---|---|---|---|---|
| 0 | 0.55 | 0.68 | 0.61 | 495 |
| 1 | 0.83 | 0.09 | 0.16 | 55 |
| 2 | 0.64 | 0.27 | 0.38 | 512 |
| 3 | 0.87 | 0.87 | 0.87 | 899 |
| 4 | 0.55 | 0.48 | 0.51 | 608 |
| 5 | 0.72 | 0.81 | 0.76 | 400 |
| 6 | 0.54 | 0.76 | 0.63 | 620 |
| accuracy |  |  | 0.66 | 3589 |
| macro avg | 0.67 | 0.57 | 0.56 | 3589 |
| weighted avg | 0.67 | 0.66 | 0.64 | 3589 |

### 3. 7 labels + data balancing :
Train:

1231/1230 [==============================] - 17s 14ms/step - loss: 0.9526 - accuracy: 0.6446 - val_loss: 0.8738 - val_accuracy: 0.6616 -
Epoch 36/100
1231/1230 [==============================] - 18s 14ms/step - loss: 0.9455 - accuracy: 0.6448 - val_loss: 0.8732 - val_accuracy: 0.6658 -
Epoch 37/100
1231/1230 [==============================] - 17s 14ms/step - loss: 0.9490 - accuracy: 0.6437 - val_loss: 0.8758 - val_accuracy: 0.6610 -
Epoch 38/100
1231/1230 [==============================] - 18s 14ms/step - loss: 0.9514 - accuracy: 0.6440 - val_loss: 0.8718 - val_accuracy: 0.6603 -
Epoch 39/100
1230/1230 [============================>.] - ETA: 0s - loss: 0.9449 - accuracy: 0.6461
Epoch 00039: ReduceLROnPlateau reducing learning rate to 1.5625000742147677e-05.
1231/1230 [==============================] - 17s 14ms/step - loss: 0.9450 - accuracy: 0.6461 - val_loss: 0.8778 - val_accuracy: 0.6566 -
Epoch 40/100
1231/1230 [==============================] - 17s 14ms/step - loss: 0.9407 - accuracy: 0.6458 - val_loss: 0.8706 - val_accuracy: 0.6623 -
Epoch 41/100
1230/1230 [============================>.] - ETA: 0s - loss: 0.9370 - accuracy: 0.6490Restoring model weights from the end of the best e
1231/1230 [==============================] - 17s 14ms/step - loss: 0.9371 - accuracy: 0.6490 - val_loss: 0.8687 - val_accuracy: 0.6628 -
Epoch 00041: early stopping

Loss of model
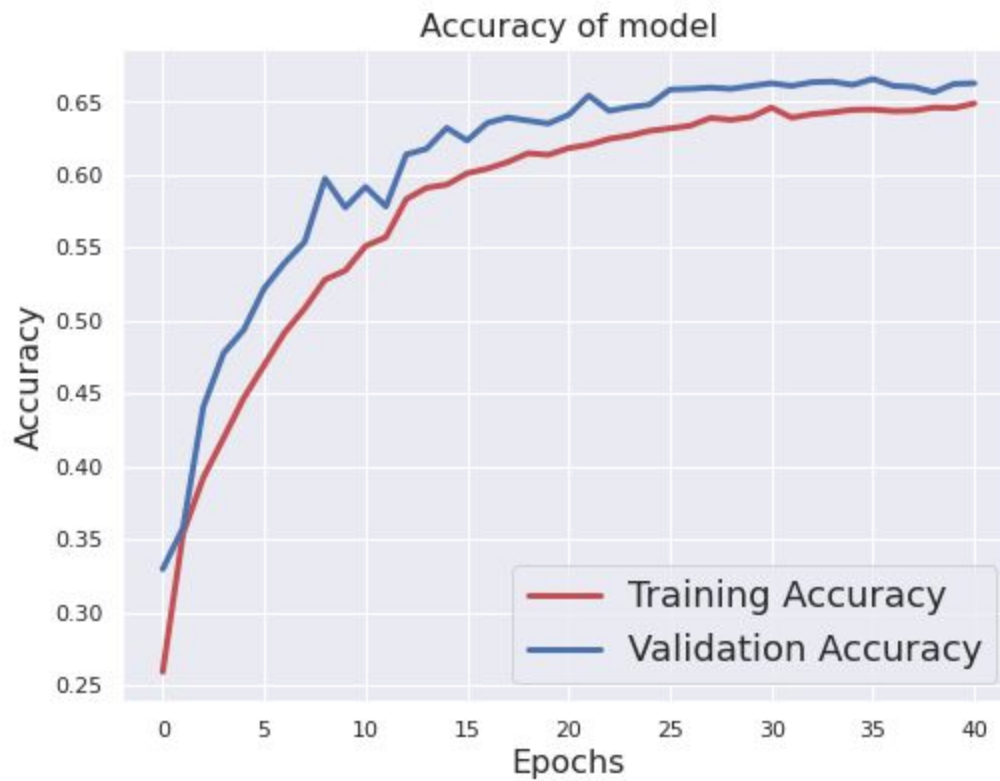
Accuracy:

```
total wrong validation predictions: 1463
```

```
              precision    recall  f1-score   support

           0       0.52      0.62      0.56       592
           1       0.85      0.86      0.86       438
           2       0.54      0.17      0.26       616
           3       0.89      0.89      0.89       899
           4       0.48      0.56      0.51       608
           5       0.76      0.79      0.77       604
           6       0.57      0.73      0.64       620

    accuracy                           0.67      4377
   macro avg       0.66      0.66      0.64      4377
weighted avg       0.67      0.67      0.65      4377
```

**4. Training more with 7 labels with data balancing :**

Train:

```
Epoch 31/100
1231/1230 [==============================] - 17s 14ms/step - loss: 0.8452 - accuracy: 0.6858 - val_loss: 0.8162 - val_accuracy: 0.6916 - l
Epoch 32/100
1230/1230 [==========================>.] - ETA: 0s - loss: 0.8443 - accuracy: 0.6875
Epoch 00032: ReduceLROnPlateau reducing learning rate to 1.5625000742147677e-05.
1231/1230 [==============================] - 17s 14ms/step - loss: 0.8443 - accuracy: 0.6875 - val_loss: 0.8084 - val_accuracy: 0.6929 - l
Epoch 33/100
1231/1230 [==============================] - 17s 14ms/step - loss: 0.8414 - accuracy: 0.6895 - val_loss: 0.8101 - val_accuracy: 0.6916 - l
Epoch 34/100
1231/1230 [==============================] - 17s 14ms/step - loss: 0.8386 - accuracy: 0.6909 - val_loss: 0.8112 - val_accuracy: 0.6925 - l
Epoch 35/100
1230/1230 [==========================>.] - ETA: 0s - loss: 0.8337 - accuracy: 0.6921Restoring model weights from the end of the best epc

Epoch 00035: ReduceLROnPlateau reducing learning rate to 3.906250185536919e-06.
1231/1230 [==============================] - 18s 14ms/step - loss: 0.8337 - accuracy: 0.6921 - val_loss: 0.8115 - val_accuracy: 0.6934 - l
Epoch 00035: early stopping
```

Loss of model
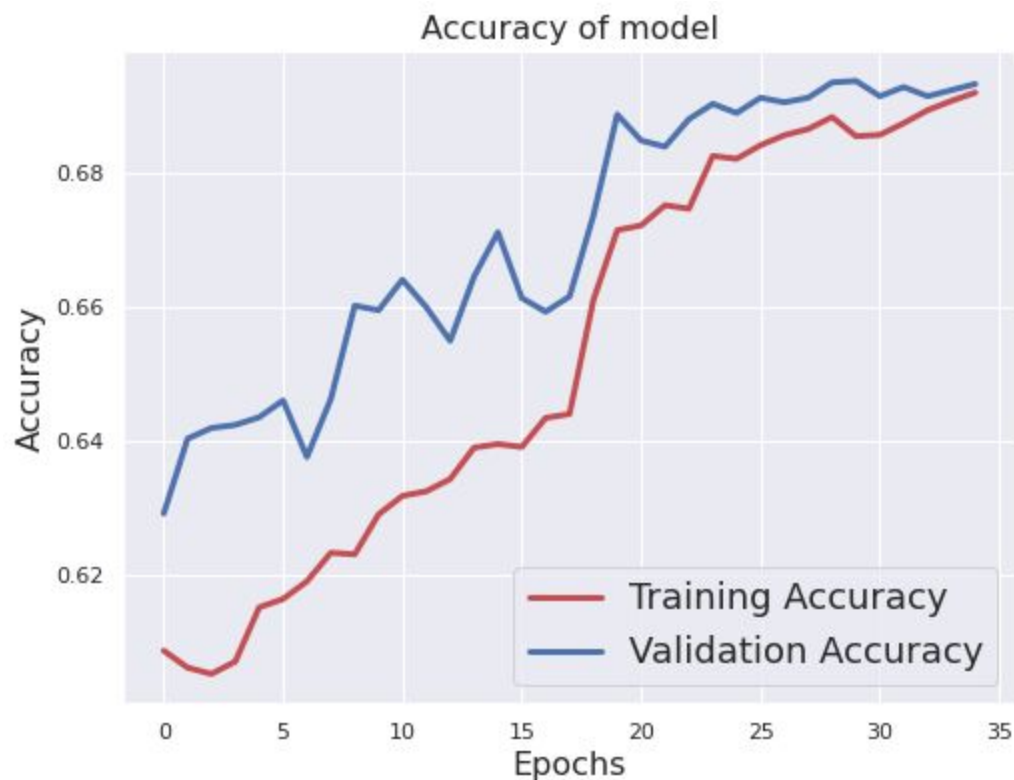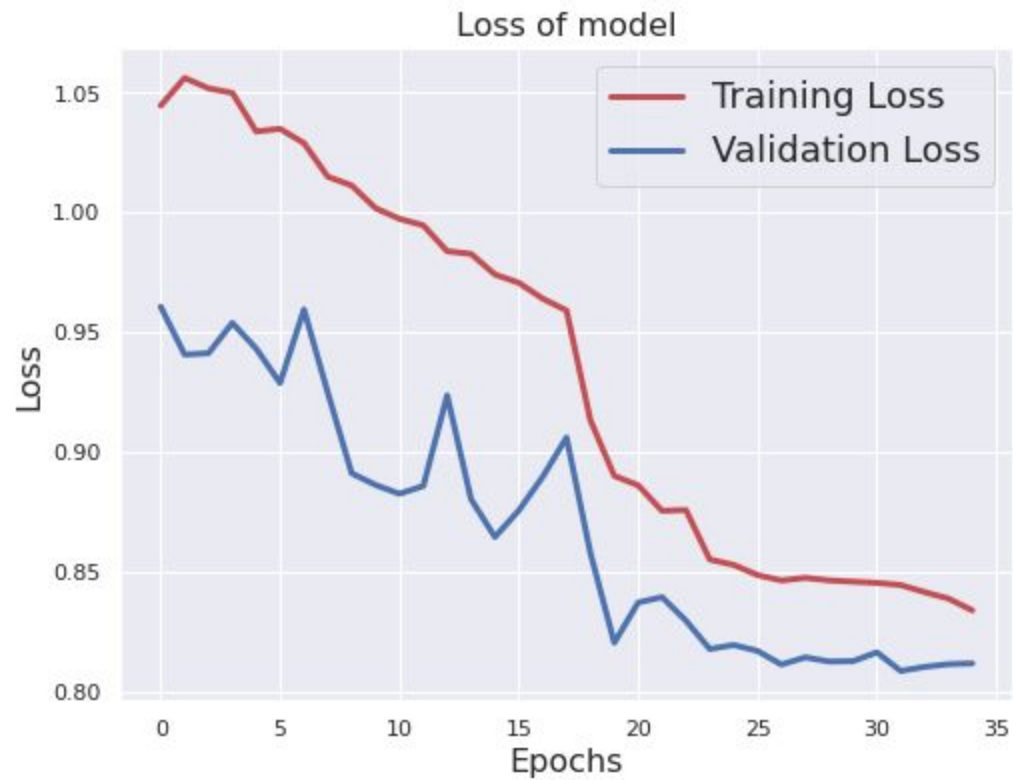
Accuracy:

```
total wrong validation predictions: 1340
```

|  | precision | recall | f1-score | support |
|---|---|---|---|---|
| 0 | 0.57 | 0.60 | 0.59 | 592 |
| 1 | 0.89 | 0.92 | 0.90 | 438 |
| 2 | 0.59 | 0.26 | 0.36 | 616 |
| 3 | 0.90 | 0.89 | 0.90 | 899 |
| 4 | 0.52 | 0.57 | 0.54 | 608 |
| 5 | 0.74 | 0.84 | 0.79 | 604 |
| 6 | 0.58 | 0.75 | 0.65 | 620 |
| accuracy |  |  | 0.69 | 4377 |
| macro avg | 0.69 | 0.69 | 0.68 | 4377 |
| weighted avg | 0.69 | 0.69 | 0.68 | 4377 |

**5. With more training :**

Train:

```
Epoch 15/100
1230/1230 [============================>.] - ETA: 0s - loss: 0.8107 - accuracy: 0.6997
Epoch 00015: ReduceLROnPlateau reducing learning rate to 1.5625000742147677e-05.
1231/1230 [=============================] - 17s 14ms/step - loss: 0.8108 - accuracy: 0.6996 - val_loss: 0.8037 - val_accuracy: 0.6941 - l
Epoch 16/100
1231/1230 [=============================] - 17s 14ms/step - loss: 0.8123 - accuracy: 0.6969 - val_loss: 0.8017 - val_accuracy: 0.6955 - l
Epoch 17/100
1229/1230 [============================>.] - ETA: 0s - loss: 0.8091 - accuracy: 0.7007Restoring model weights from the end of the best epo
1231/1230 [=============================] - 17s 14ms/step - loss: 0.8089 - accuracy: 0.7009 - val_loss: 0.7989 - val_accuracy: 0.6959 - l
Epoch 00017: early stopping
```
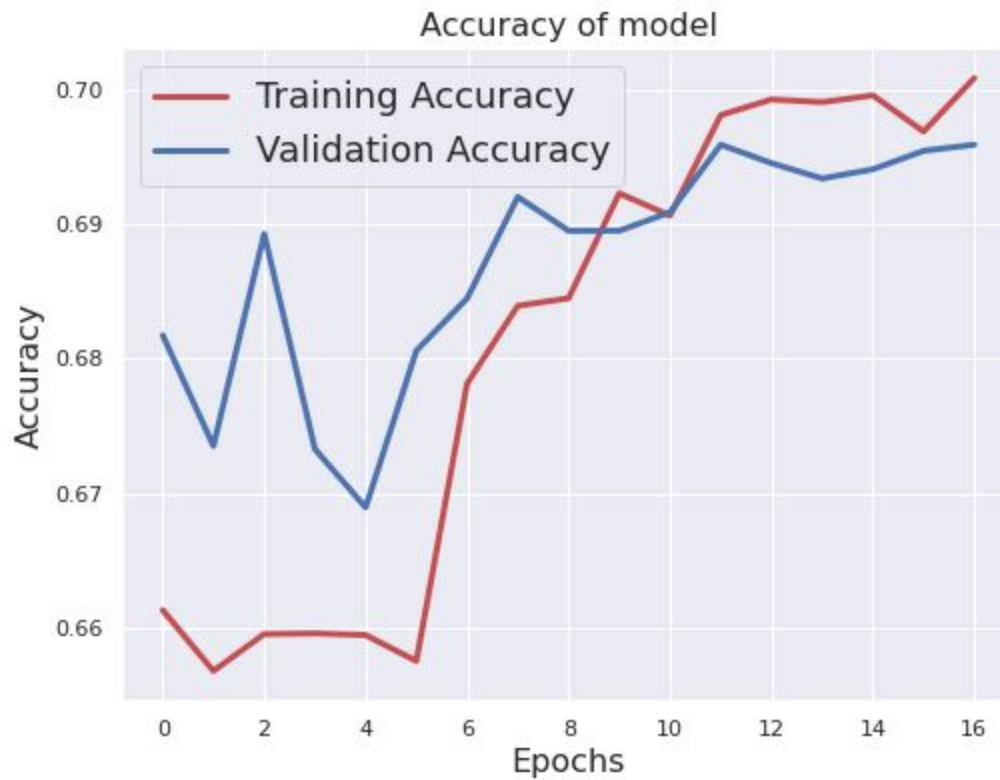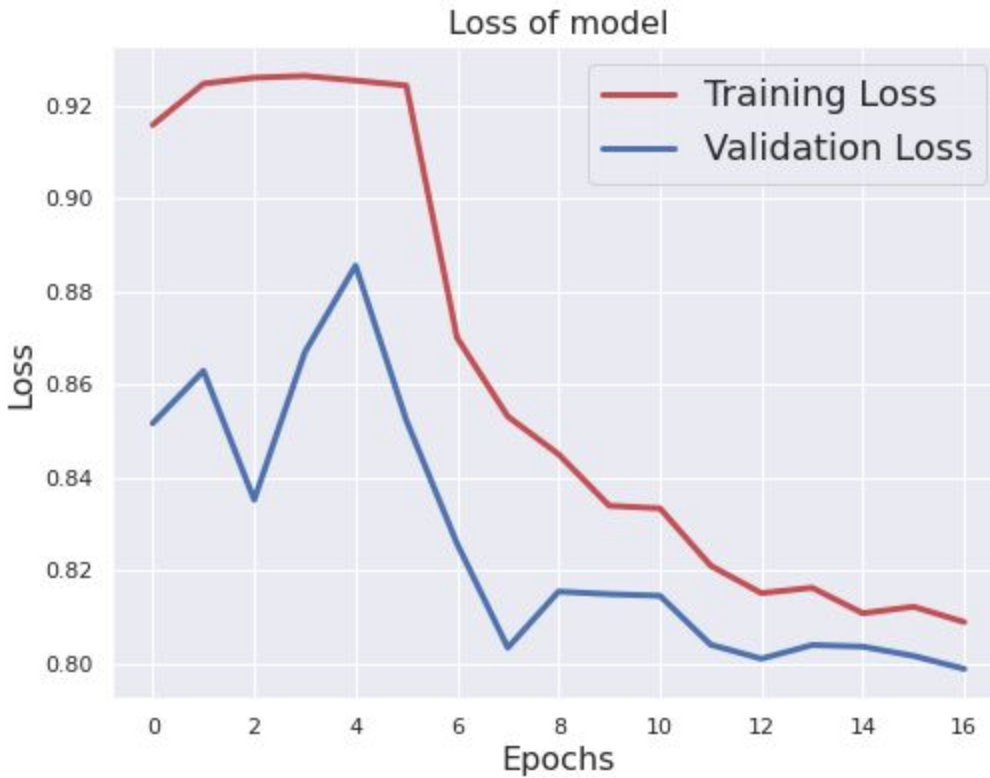


Accuracy of model

## Loss of model



Accuracy:

```
total wrong validation predictions: 1331
```

|   | precision | recall | f1-score | support |
|---|-----------|--------|----------|---------|
| 0 | 0.58 | 0.65 | 0.61 | 592 |
| 1 | 0.88 | 0.93 | 0.90 | 438 |
| 2 | 0.59 | 0.28 | 0.38 | 616 |
| 3 | 0.89 | 0.89 | 0.89 | 899 |
| 4 | 0.53 | 0.57 | 0.55 | 608 |
| 5 | 0.75 | 0.82 | 0.78 | 604 |
| 6 | 0.58 | 0.72 | 0.64 | 620 |
| accuracy |  |  | 0.70 | 4377 |
| macro avg | 0.69 | 0.69 | 0.68 | 4377 |
| weighted avg | 0.69 | 0.70 | 0.69 | 4377 |

**6. 7 labels with more data balancing with disgust to 5470 :**

Train:

Epoch 54/100
1291/1290 [==============================] - 18s 14ms/step - loss: 0.8243 - accuracy: 0.6934 - val_loss: 0.7692 - val_accuracy: 0.7167 - l
Epoch 55/100
1291/1290 [==============================] - 18s 14ms/step - loss: 0.8219 - accuracy: 0.6930 - val_loss: 0.7654 - val_accuracy: 0.7175 - l
Epoch 56/100
1290/1290 [==========================>.] - ETA: 0s - loss: 0.8212 - accuracy: 0.6945
Epoch 00056: ReduceLROnPlateau reducing learning rate to 3.906250185536919e-06.
1291/1290 [==============================] - 18s 14ms/step - loss: 0.8211 - accuracy: 0.6945 - val_loss: 0.7714 - val_accuracy: 0.7164 - l
Epoch 57/100
1291/1290 [==============================] - 18s 14ms/step - loss: 0.8271 - accuracy: 0.6912 - val_loss: 0.7705 - val_accuracy: 0.7162 - l
Epoch 58/100
1288/1290 [==========================>.] - ETA: 0s - loss: 0.8204 - accuracy: 0.6964Restoring model weights from the end of the best epo
1291/1290 [==============================] - 18s 14ms/step - loss: 0.8201 - accuracy: 0.6965 - val_loss: 0.7707 - val_accuracy: 0.7171 - l
Epoch 00058: early stopping

Loss of model
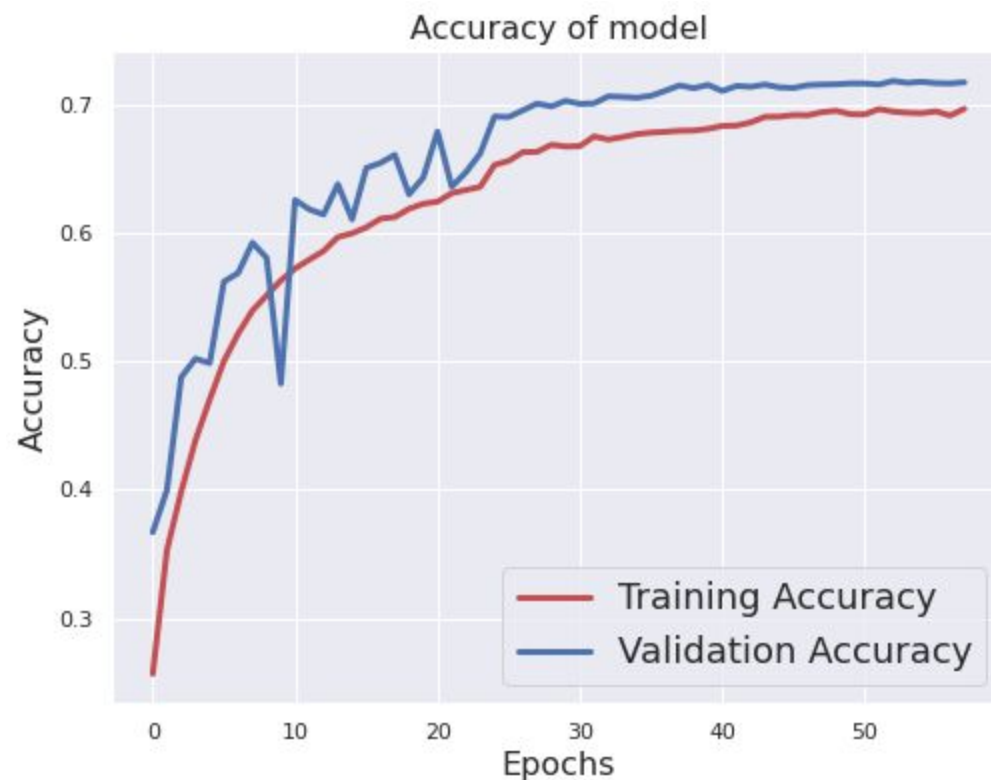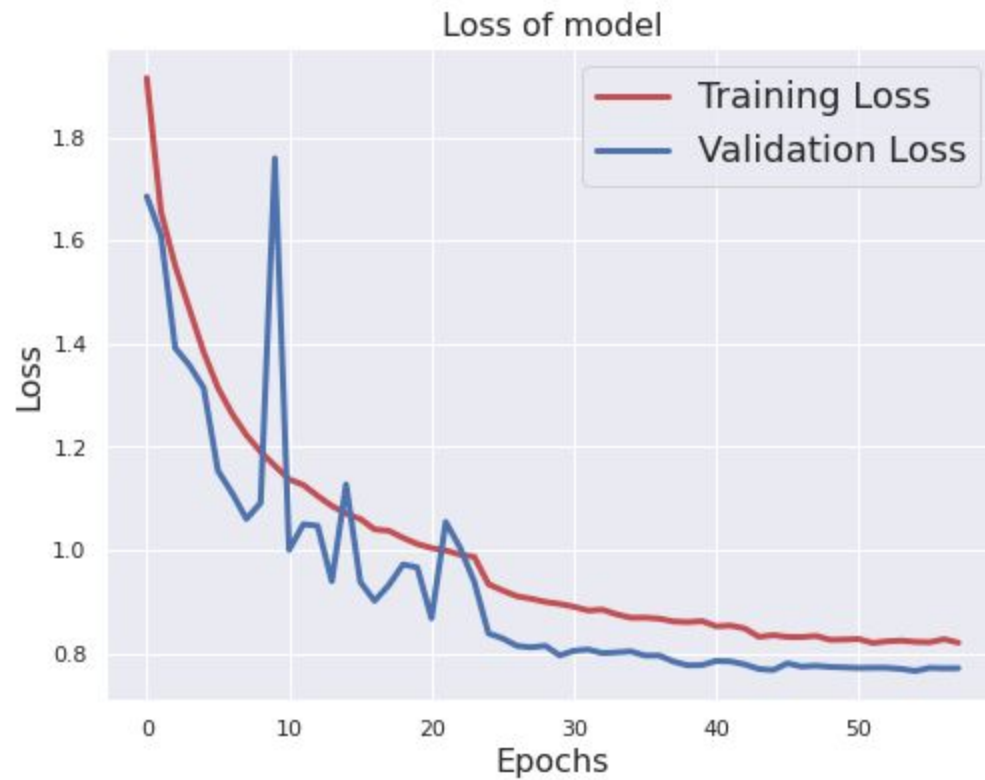
Accuracy:

```
total wrong validation predictions: 1293
```

```
              precision    recall  f1-score   support

           0       0.60      0.64      0.62       591
           1       0.89      0.98      0.93       657
           2       0.64      0.28      0.39       616
           3       0.88      0.92      0.90       899
           4       0.54      0.57      0.55       608
           5       0.80      0.79      0.80       597
           6       0.58      0.74      0.65       620

    accuracy                           0.72      4588
   macro avg       0.70      0.70      0.69      4588
weighted avg       0.72      0.72      0.71      4588
```

## 7.  More train:

Train:

```
Epoch 16/100
1291/1290 [==============================] - 18s 14ms/step - loss: 0.7742 - accuracy: 0.7142 - val_loss: 0.7491 - val_accuracy: 0.7299 - lr
Epoch 17/100
1291/1290 [==============================] - 18s 14ms/step - loss: 0.7717 - accuracy: 0.7134 - val_loss: 0.7457 - val_accuracy: 0.7269 - lr
Epoch 18/100
1291/1290 [==============================] - 18s 14ms/step - loss: 0.7687 - accuracy: 0.7145 - val_loss: 0.7498 - val_accuracy: 0.7293 - lr
Epoch 19/100
1290/1290 [===========================>.] - ETA: 0s - loss: 0.7668 - accuracy: 0.7151
Epoch 00019: ReduceLROnPlateau reducing learning rate to 1.5625000742147677e-05.
1291/1290 [==============================] - 18s 14ms/step - loss: 0.7670 - accuracy: 0.7151 - val_loss: 0.7438 - val_accuracy: 0.7284 - lr
Epoch 20/100
1291/1290 [==============================] - 18s 14ms/step - loss: 0.7635 - accuracy: 0.7184 - val_loss: 0.7505 - val_accuracy: 0.7265 - lr
Epoch 21/100
1288/1290 [===========================>.] - ETA: 0s - loss: 0.7596 - accuracy: 0.7202Restoring model weights from the end of the best epoc
1291/1290 [==============================] - 18s 14ms/step - loss: 0.7596 - accuracy: 0.7202 - val_loss: 0.7459 - val_accuracy: 0.7289 - lr
Epoch 00021: early stopping
```

## Loss of model



Accuracy:

```
total wrong validation predictions: 1239
```
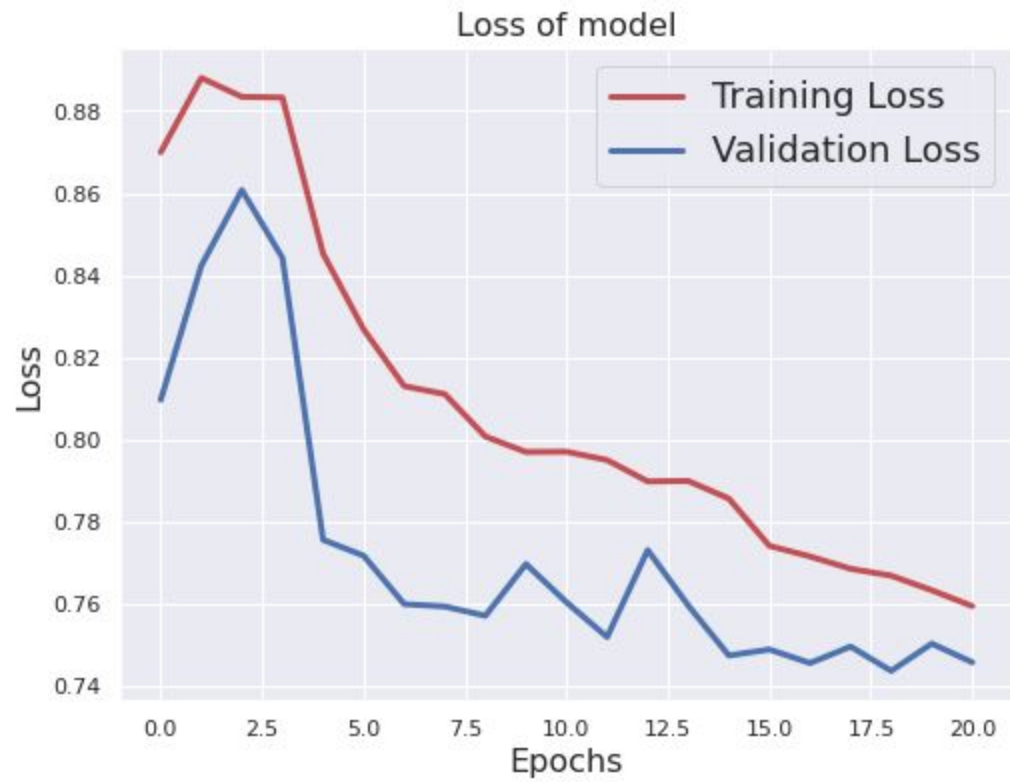
|   | precision | recall | f1-score |
|---|-----------|--------|----------|
| 0 | 0.63 | 0.66 | 0.64 |
| 1 | 0.89 | 0.99 | 0.94 |
| 2 | 0.65 | 0.33 | 0.44 |
| 3 | 0.88 | 0.91 | 0.89 |
| 4 | 0.57 | 0.54 | 0.56 |
| 5 | 0.78 | 0.82 | 0.80 |
| 6 | 0.60 | 0.76 | 0.67 |
| | | | |
| accuracy | | | 0.73 |

total wrong validation predictions: 1239

|  | precision | recall | f1-score | support |
|---|---|---|---|---|
| 0 | 0.63 | 0.66 | 0.64 | 591 |
| 1 | 0.89 | 0.99 | 0.94 | 657 |
| 2 | 0.65 | 0.33 | 0.44 | 616 |
| 3 | 0.88 | 0.91 | 0.89 | 899 |
| 4 | 0.57 | 0.54 | 0.56 | 608 |
| 5 | 0.78 | 0.82 | 0.80 | 597 |
| 6 | 0.60 | 0.76 | 0.67 | 620 |
| accuracy |  |  | 0.73 | 4588 |
| macro avg | 0.71 | 0.72 | 0.70 | 4588 |
| weighted avg | 0.73 | 0.73 | 0.72 | 4588 |

- **Simple CNN_2**

train:

```
Epoch 49/200
156/156 [============================>.] - ETA: 0s - loss: 0.5006 - accuracy: 0.8181
Epoch 00049: ReduceLROnPlateau reducing learning rate to 1.5625000742147677e-05.
157/156 [=============================] - 13s 85ms/step - loss: 0.5006 - accuracy: 0.8180 - val_loss: 0.9084 - val_accuracy: 0.7208 - lr
Epoch 50/200
157/156 [=============================] - 13s 85ms/step - loss: 0.4891 - accuracy: 0.8211 - val_loss: 0.9085 - val_accuracy: 0.7219 - lr
Epoch 51/200
157/156 [=============================] - 13s 85ms/step - loss: 0.4921 - accuracy: 0.8202 - val_loss: 0.9140 - val_accuracy: 0.7212 - lr
Epoch 52/200
156/156 [============================>.] - ETA: 0s - loss: 0.4917 - accuracy: 0.8200Restoring model weights from the end of the best epoc

Epoch 00052: ReduceLROnPlateau reducing learning rate to 3.906250185536919e-06.
157/156 [=============================] - 13s 85ms/step - loss: 0.4914 - accuracy: 0.8200 - val_loss: 0.9115 - val_accuracy: 0.7185 - lr
Epoch 00052: early stopping
                    Accuracy of depression
```
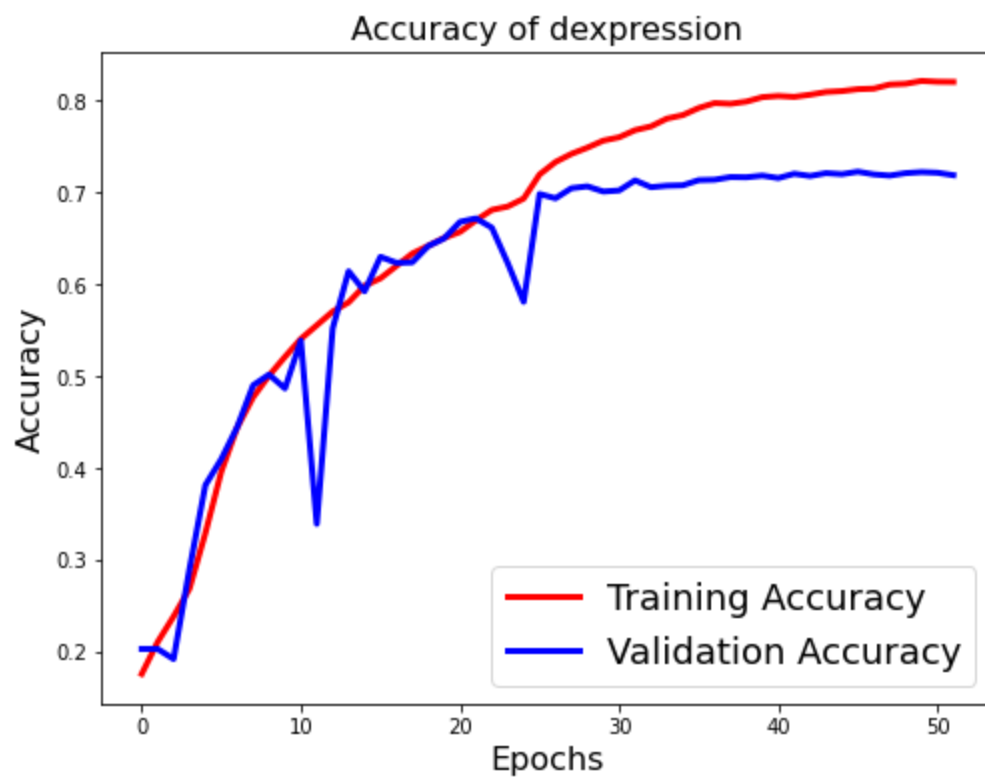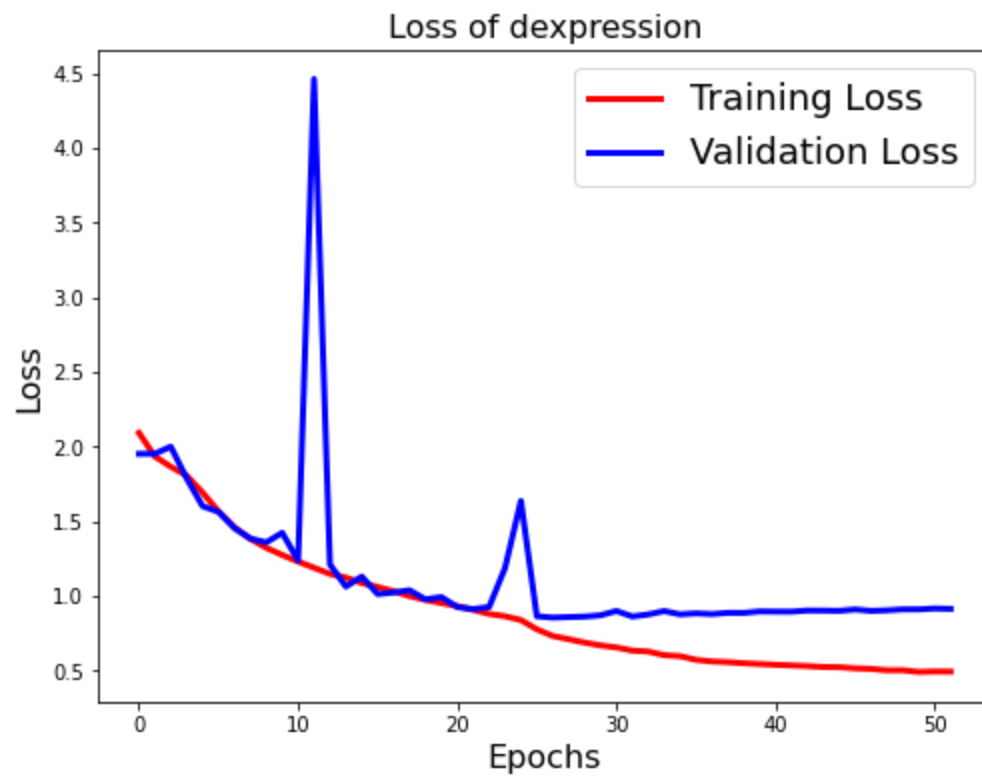
## Loss of dexpression



## Accuracy of dexpression



Accuracy:

```
total wrong validation predictions: 1235

              precision    recall  f1-score   support

           0       0.69      0.57      0.63       624
           1       0.95      0.97      0.96       559
           2       0.60      0.50      0.55       566
           3       0.82      0.87      0.84       903
           4       0.53      0.60      0.56       587
           5       0.83      0.79      0.81       554
           6       0.62      0.69      0.65       655

    accuracy                           0.72      4448
   macro avg       0.72      0.71      0.71      4448
weighted avg       0.72      0.72      0.72      4448
```

- **Ensemble :**

1) Training with 7 models (HoG, resNet and CNNs)

```
[86] from sklearn.metrics import accuracy_score
     test_accuracy_score = accuracy_score(rounded_labels, labels_w_average)
     print(test_accuracy_score)

     0.7052868391451068
```

```
[87] from sklearn.metrics import accuracy_score
     test_accuracy_score = accuracy_score(rounded_labels, labels_average)
     print(test_accuracy_score)

     0.6674915635545556
```

```
[88] from sklearn.metrics import accuracy_score
     test_accuracy_score = accuracy_score(rounded_labels, labels)
     print(test_accuracy_score)

     0.49426321709786275
```

2) Ensemble with two models CNN_2 and dcnn_hog :

```
[135] from sklearn.metrics import accuracy_score
      test_accuracy_score = accuracy_score(rounded_labels, labels_w_average)
      print(test_accuracy_score)
```

0.8499437570303712

```
[136] from sklearn.metrics import accuracy_score
      test_accuracy_score = accuracy_score(rounded_labels, labels_average)
      print(test_accuracy_score)
```

0.8434195725534308

```
[137] from sklearn.metrics import accuracy_score
      test_accuracy_score = accuracy_score(rounded_labels, labels)
      print(test_accuracy_score)
```

0.8137232845894263

DataSet FER2013:



Data Preprocessing

As shown in the charts the data is not balanced, so we augmented the dataset fer2013 to achieve data balancing(Additive Gaussian Noise, Mirror Flipping, Linear Contrast, Sharpen Images and Crop Images).

| before | After |
|---|---|
|  |  |
| {0: 'anger', 1: 'disgust', 2: 'fear', 3: 'happiness', 4: 'sadness', 5: 'surprise', 6: 'neutral'} ||
| Dataset size before data balancing = 35887 | Dataset size before data balancing = 60061 |

- **Results**


- **References**
    - **Fer-using-multiple-pipelines**
    - **Facial expression databases**
    - **Deep Facial Expression Recognition: A Survey**
    - **Suppressing Uncertainties for Large-Scale Facial Expression Recognition**