Face Emotional Recognition

Zijun Wang (Allen), Fei Xiong
Prof. Linda M. Sellis
CS-UY 4563
12/20/2022

Introduction

- Facial Emotion Recognition Dataset
  - Multi-class classification problem
  - 10 features: Distance between virtual and center markers
  - 6 classes: Happiness, Sadness, Anger, Fear, Disgust, Surprise
- Models Used
  - Logistic
  - Support Vector Machine (SVM)
  - Neural Networks

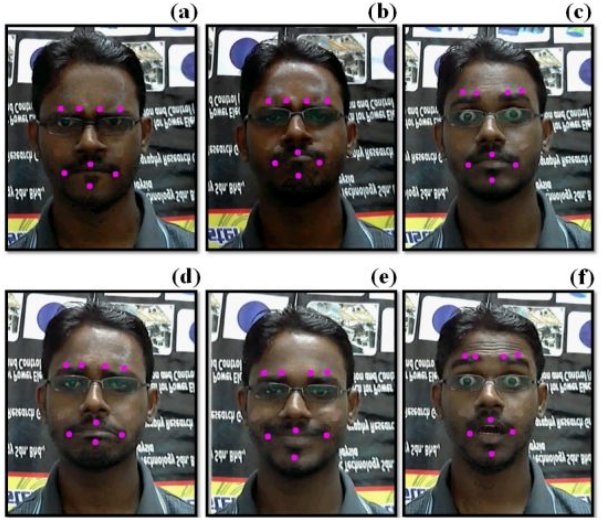

Figure 1: Virtual Markers

e1	e2	e3	e4	m1	m2	m3	m4	m6	m7	emtion
0.3492	0.28363	0.33276	0.21688	0.42806	0.30738	0.46403	0.477	0.37956	0.55543	0
0.31197	0.20382	0.32764	0.22509	0.30879	0.24826	0.3794	0.29301	0.40438	0.45144	0
0.31005	0.20022	0.328	0.22418	0.30933	0.2479	0.37777	0.29063	0.40143	0.44915	0
0.31146	0.20368	0.32894	0.22488	0.31177	0.24845	0.38068	0.2906	0.40237	0.45031	0
0.31057	0.19893	0.32097	0.2152	0.30845	0.24723	0.37734	0.28821	0.40143	0.4481	0
0.31182	0.20312	0.31903	0.21547	0.31079	0.24797	0.37862	0.28946	0.40427	0.44913	0
0.31155	0.19878	0.31643	0.21011	0.30609	0.24727	0.37558	0.28559	0.40259	0.44684	0
0.31965	0.21055	0.33818	0.23534	0.31251	0.2487	0.38137	0.29801	0.40454	0.45488	0
0.31872	0.21158	0.33596	0.23375	0.31354	0.24863	0.38186	0.29965	0.40626	0.456	0
0.31672	0.20723	0.33329	0.23147	0.31029	0.24766	0.38048	0.29862	0.40498	0.45521	0
0.31902	0.21017	0.33674	0.23403	0.30977	0.24796	0.38074	0.29656	0.40453	0.45449	0
0.31906	0.21042	0.33647	0.23421	0.30955	0.24774	0.38056	0.29724	0.40444	0.45434	0
0.31835	0.20986	0.33625	0.23364	0.31025	0.24809	0.38108	0.29779	0.40386	0.4554	0
0.31825	0.2093	0.33525	0.23306	0.31086	0.24841	0.3817	0.29917	0.40593	0.45502	0
0.31793	0.20866	0.3345	0.2323	0.31158	0.24855	0.38157	0.30019	0.40614	0.45581	0
0.31677	0.2053	0.33112	0.22711	0.30858	0.24899	0.38049	0.29852	0.405	0.45469	0
0.31703	0.20741	0.33412	0.23097	0.31171	0.24913	0.37946	0.30038	0.40717	0.45543	0
0.31658	0.2051	0.33115	0.22999	0.31055	0.24632	0.38068	0.29756	0.4068	0.45279	0
0.31561	0.20764	0.33422	0.23	0.31104	0.24838	0.38124	0.30035	0.41011	0.45577	0
0.31568	0.20632	0.33089	0.22747	0.3117	0.24907	0.38278	0.29928	0.40443	0.45292	0
0.31713	0.20742	0.33166	0.22787	0.31134	0.24926	0.38137	0.29937	0.4071	0.45549	0
0.31591	0.206	0.33374	0.2296	0.31157	0.24827	0.37882	0.29938	0.40633	0.45378	0
0.31793	0.20673	0.33258	0.23055	0.31071	0.24726	0.38173	0.29802	0.4071	0.45428	0
0.31522	0.20694	0.33414	0.22818	0.30977	0.24816	0.38067	0.29976	0.40857	0.45532	0

Figure 2: Dataset

Preprocessing

- Balanced Dataset
- No incomplete features
- 190967 instances, 11 columns
- 75% train, 25% test

number of instances	190967
number of features	11
number of classes	
number of missing values	0
number of instances with missing values	0
number of numeric features	11
number of symbolic features	0

Figure 3: Dataset Information on openML

Logistic Regression

- Feature adding:
    - Combinations ! (Brute-Force)
    - Divide and multiply current feature with next 1 to 5 features together -> 1264 features
- Feature deletion:
    - delete features that weights smaller than 0.5 in at least 3 classes -> 550 features
- Transformation: Square, Square root

Logistic Regression

- Sklearn Function
  - LogisticRegression(multi_class='multinomial', solver='lbfgs', penalty="l2")
- Scaling: StandardScalar()
- L2 Regularization
  - C=[0.1,0.5,10,100,1000,10000,10000]
- Best Accuracy: 83.46%

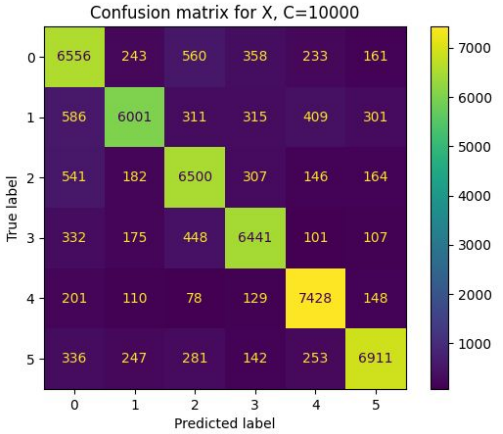

Figure 4: Confusion matrix

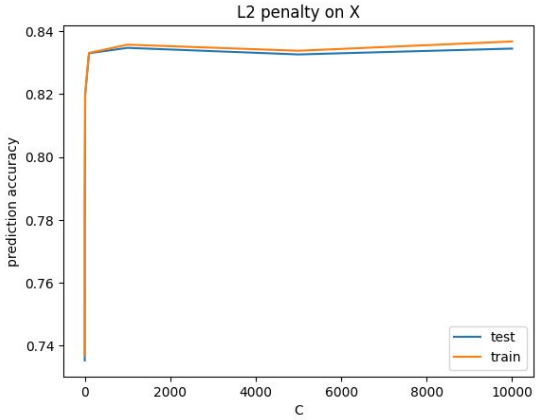

Figure 5: L2 penalty on the square root of the data set

Interesting Finding

Based on the most weighted features in different classes:

- Anger and disgust are related much more to eyes
- Fear, sad, happy, and surprise are related more to mouths, especially for sad.
- M2 stands out for surprise

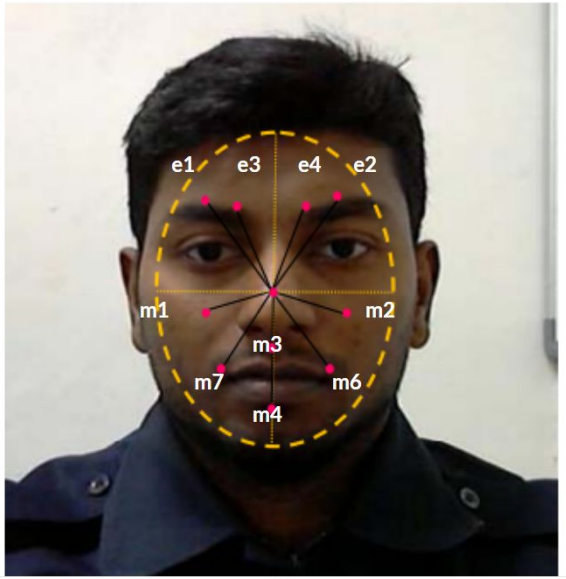

Figure 6: Virtual and center markers

Support Vector Machine(SVM)

- Sklearn Function: sklearn.svm.SVC()
- Scaling: StandardScalar()
- Transformation: Square, Square root
- Kernel: RBF
- L2 Regularization: C=[5,10,15,20,25]
- Best Accuracy: 86.76%

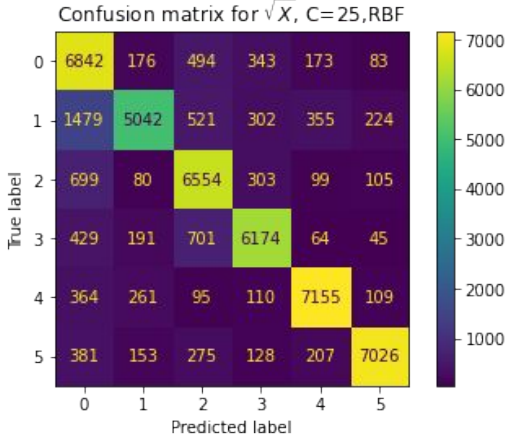

Figure 7: Confusion matrix

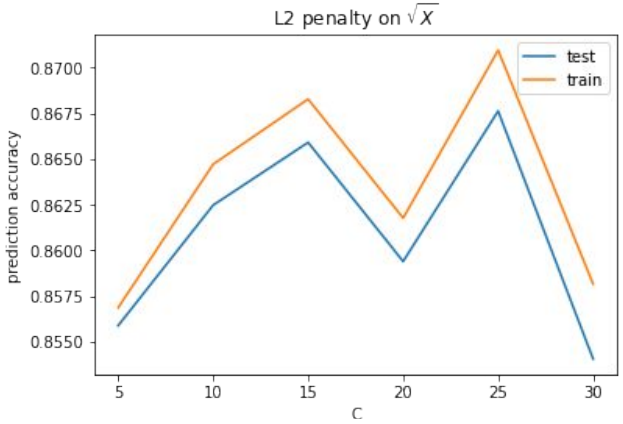

Figure 8: L2 penalty on the square root of the data set

Neural Network

- Sklearn.neural_network.MLPClassifier
- L2 regularization
- Choices of hyperparameters:
  - [0.0001, 0.001. 0.01, 0.1, 1, 10, 100, 1000]
  - [0.0001, 0.001, 0.01, 0.1, 1]
- Activation functions for hidden layers: Logistic, ReLU, Tanh

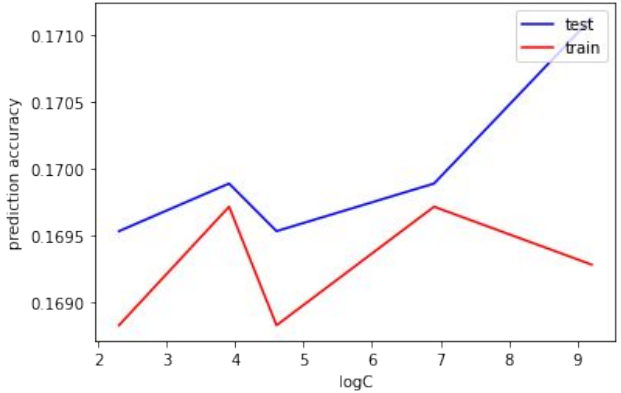

Figure 9: C = [10, 50, 100, 1000, 10000]

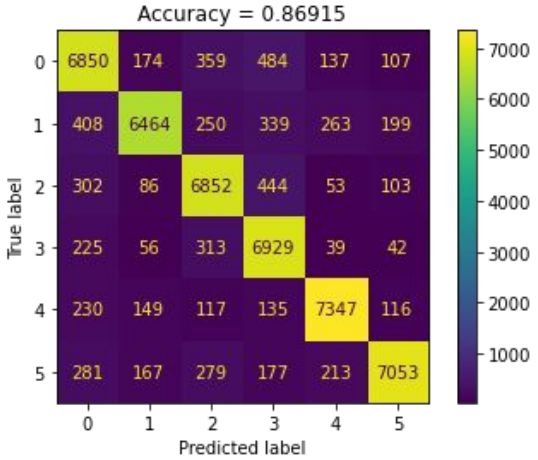

Figure 10: Confusion Matrix for X, C=0.0001

Neural Networks

- Layers Settings:
  - 3 Layer: 10 - 40 - 1
  - 4 Layer: 10 - 40 - 20 - 1
  - 5 Layer: 10 - 80 - 40 - 20 - 1
- Best Model: 5 layers, L2 regularization, ReLU, C=0.0001
- Best Accuracy: 87.57%
- Slight difference between different transformation

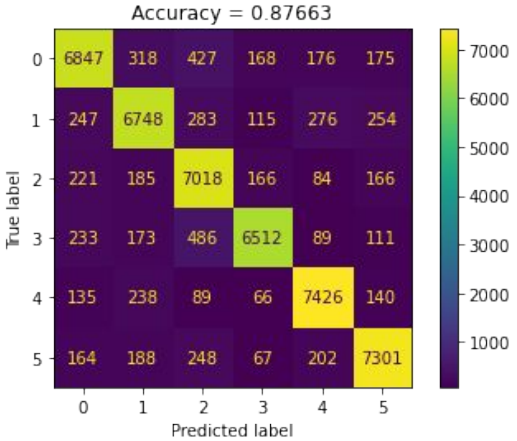

Figure 11: Confusion Matrix for X^2, C=0.0001

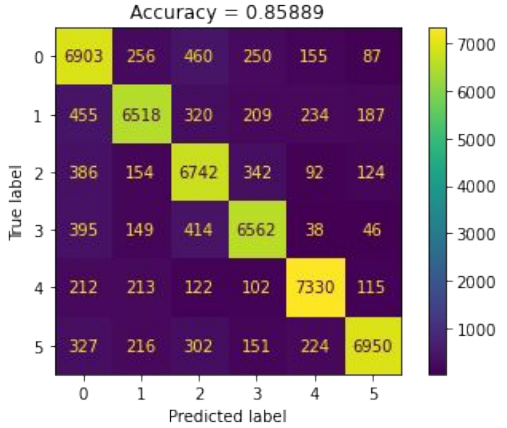

Figure 12: Confusion Matrix for X^(½), C=0.0001

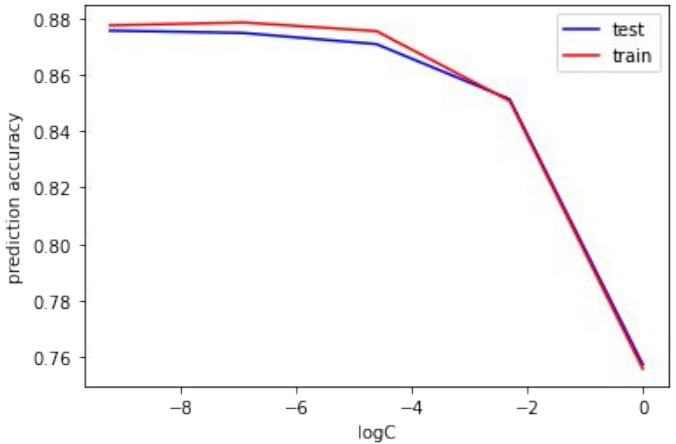

Figure 13: ReLU, hidden layers = (80, 40, 20)

Results

Logistic Regression (training prediction accuracy):

	C=0.1	C=0.5	C=1	C=10	C=100	c=1000	c=5000	c=10000
X^2	66.86%	70.36%	73.12%	78.29%	80.39%	80.83%	80.80%	80.79%
X	73.69%	76.56%	78.79%	81.97%	83.30%	83.57%	83.37%	83.69%
$\sqrt{X}$	72.91%	75.77%	77.00%	80.69%	81.59%	81.91%	81.72%	81.76%

Logistic Regression (testing prediction accuracy):

	C=0.1	C=0.5	C=1	C=10	C=100	c=1000	c=5000	c=10000
X^2	66.74%	70.29%	73.06%	78.28%	80.55%	81.03%	80.89%	80.90%
X	73.53%	76.51%	78.58%	81.99%	83.29%	83.47%	83.26%	83.44%
$\sqrt{X}$	72.72%	75.72%	76.88%	80.73%	81.61%	81.99%	81.73%	81.83%

Table 1: Test prediction accuracy result

Support Vector Machine (training prediction accuracy):

	C=5	C=10	C=15	C=20	C=25
X^2	80.69%	82.19%	83.91%	82.83%	81.24%
X	85.27%	85.98%	86.76%	86.61%	86.56%
$\sqrt{X}$	85.69%	86.47%	86.83%	86.18%	87.09%

Support Vector Machine (testing prediction accuracy):

	C=5	C=10	C=15	C=20	C=25
X^2	80.76%	82.20%	83.77%	82.56%	81.26%
X	85.27%	85.90%	86.54%	86.43%	86.27%
$\sqrt{X}$	85.59%	86.25%	86.59%	85.94%	86.76%

Neural Network (testing prediction accuracy for Logistic Activation Function):

	C=0.0001	C=0.001	C=0.01	C=0.1	C=1
(40)	83.53%	82.57%	74.52%	55.81%	28.10%
(40,20)	84.67%	84.02%	85.11%	85.25%	85.46%
(80,40,20)	86.82%	86.49%	84.60%	16.95%	16.95%

Neural Network (testing prediction accuracy for ReLU Activation Function):

	C=0.0001	C=0.001	C=0.01	C=0.1	C=1
(40)	81.49%	81.98%	79.76%	68.88%	53.28%
(40,20)	83.90%	84.09%	84.28%	82.14%	62.66%
(80,40,20)	87.57%	87.48%	87.09%	85.14%	75.73%

Neural Network (testing prediction accuracy for Tanh Activation Function):

	C=0.0001	C=0.001	C=0.01	C=0.1	C=1
(40)	81.49%	81.98%	79.76%	68.88%	53.28%
(40,20)	84.03%	84.41%	84.66%	82.99%	55.25%
(80,40,20)	86.76%	86.53%	86.40%	85.12%	63.19%

Table 2: Test prediction accuracy result

Conclusion

- Neural Network with 3 hidden layers , ReLU activation function, C=0.0001 has the best accuracy
- Three models have similar precision accuracy
- Potential Improvement:
  - Test more hyperparameter values
  - More Layers of Neural Network
  - Remove outliers

Logistic Regression	SVM	Neural Network
83.46%	86.76%	87.57%

Table 3: Best test prediction accuracy comparison

Works Cited

- **Face Emotion Recognition Dataset:**
  https://www.openml.org/search?type=datastatus=activeid=43602sort=runs

- **Virtual Markers based Facial Emotion Recognition using ELM and PNN Classifiers:**
  https://ieeexplore.ieee.org/document/9068708

- **Optimal Geometrical Set for Automated Marker Placement to Virtualized Real-Time Facial Emotions:**
  https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0149003

- **sklearn neural network documentation:**
  https://scikit-learn.org/stable/modules/classes.html#module-sklearn.neural network

- **sklearn support vector machine documentation:**
  https://scikit-learn.org/stable/modules/generated/sklearn.svm.SVC.html

- **sklearn logistic regression documentation:**
  https://scikit-learn.org/stable/modules/generated/sklearn.linear model.LogisticRegression.html