CSC411

Assignment 3

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Part 1: Newsgroups

1. I used Logistic Regression, random Forest & multinomial Naive Bayes. I tried to use Svm and neural nets but it was taking too long.
2. The accuracies for each model including baseline.
   Baseline: BernoulliNB train accuracy = 0.598727240587
   Baseline: BernoulliNB test accuracy = 0.457912904939

   MultinomialNB train accuracy = 0.811384125862
   MultinomialNB test accuracy = 0.606213489113

   Random Forest train accuracy = 0.790701785399
   Random Forest test accuracy = 0.535050451407

   Logistic train accuracy = 0.895704436981
   Logistic test accuracy = 0.67750929368

3. The zero-one losses for each model including baseline.
   Baseline: BernoulliNB train zero-one loss = 0.401272759413
   Baseline: BernoulliNB test zero-one loss = 0.542087095061

   MultinomialNB train zero-one loss = 0.188615874138
   MultinomialNB test zero-one loss = 0.393786510887

   Random Forest train zero-one loss = 0.209298214601
   Random Forest test zero-one loss = 0.464949548593

   Logistic train zero-one loss = 0.104295563019
   Logistic test zero-one loss = 0.32249070632

4. For Logistic Regression & multinomial Naive Bayes I used the default parameters, which got accuracies above the baseline. However, for Random forest I had to use grid search to tune and find the best parameters in order to get an accuracy above the baseline.
5. I picked these methods because the where fast and would have an accuracy at least equal to the baseline.

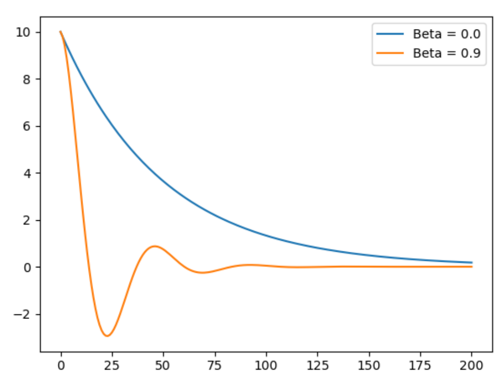
6. Confusion matrix for Logistic regression: The model with the best accuracy

```
[[141   1   1   0   2   4   2   4   9  18   1   2   6  10  17  63  13  10   5  10]
 [  5 272  19   8   7  16   8   3   5   8   0   5  14   3  11   3   0   1   1   0]
 [  3  25 240  33  17  11   5   1   3  24   1   4   2   4  11   1   3   2   3   1]
 [  1  13  38 243  28   4  12   5   1   8   0   2  34   0   2   0   0   0   1   0]
 [  0   7   8  27 256   4  12   9   7  15   3   2  25   0   8   1   1   0   0   0]
 [  0  46  29   7   4 271  11   1   1   6   0   2   6   2   4   4   0   0   1   0]
 [  0   3   2  17  12   0 313  10   6  11   0   1   8   1   4   1   0   1   0   0]
 [  2   2   1   1   0   2  13 278  14  29   1   1  26   3   9   0   5   3   5   1]
 [  3   1   0   1   0   0   8  24 310  19   0   0   9   6   6   2   5   0   4   0]
 [  7   3   0   0   1   1   7   0   6 330  26   0   3   2   3   5   0   0   3   0]
 [  5   1   0   1   0   1   0   1   4  26 346   1   2   4   2   1   1   3   0   0]
 [  3   7   5   2   5   6   4   6   9  27   0 261  10  10   6   2  20   4   8   1]
 [  2  15  10  20   8   3  21  10  11  16   1  16 238  10   8   2   1   1   0   0]
 [  6  11   1   1   1   0  11  10   6  15   3   0   9 301   6   3   1   4   7   0]
 [  4  11   2   0   1   1   6   9   3  21   2   0  17  10 290   2   4   2   9   0]
 [ 22   2   3   0   0   1   2   1   5  19   1   0   3  11   4 313   2   2   3   4]
 [  6   1   2   1   2   1   4   7   9  21   1   5   3   4   7   9 255   4  18   4]
 [ 22   2   1   0   0   1   3   2  11  14   1   3   4   4   2   9   8 276  13   0]
 [ 18   1   0   0   0   1   2   7  10  13   4   1   3   7  11   4  91   8 127   2]
 [ 45   4   2   0   0   0   6   5   7  10   2   1   1  15   5  67  21  11   7  42]]
```

7. The 2 classes where most confused from (classes 1…20)
   a. class 17 being mistaken for 19: 91 times
   b. class 16 being mistaken for 20: 67 times

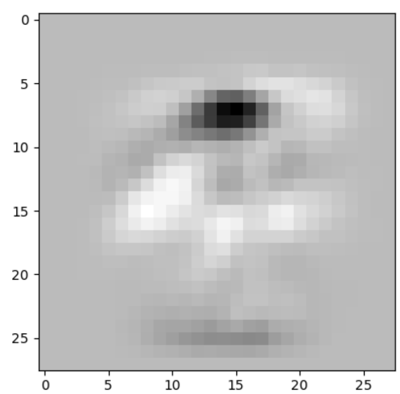
Part 2: Train SVM

1. Plot for weights history



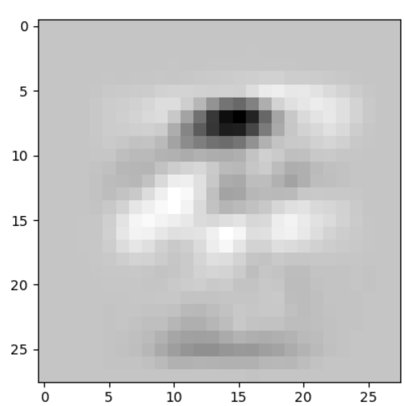
2. Code in the file
3. Digit classification
    a. Model 1 with beta 0.0:

        SVM Train with lr = 0.05 & beta = 0.0
        Train accuracy = 0.915011337868
        Test accuracy = 0.916938701487
        Train hinge loss = 0.39833051008
        Test hinge loss = 0.401406119389



    b. Model 2: with beta 0.1

        SVM Train with lr = 0.05 & beta = 0.1
        Train accuracy = 0.89306122449
        Test accuracy = 0.894087776569
        Train hinge loss = 0.363258049103
        Test hinge loss = 0.350357622194



Part 3: Kernals

Question 3.1:

$$x^T K x = \sum_{i,j} x_i k_{i,j} x_j$$
$$= \sum_{i,j} x_i \left\langle \Phi\left(x_i\right), \Phi\left(x_j\right)\right\rangle x_j$$
$$= \left\langle \sum_i x_i \Phi\left(x_i\right), \sum_j x_j \Phi\left(x_j\right)\right\rangle$$
$$= \left\| \sum_i x_i \Phi\left(x_i\right)\right\|^2 \geq 0$$

Question 3.2.1:

$$k(x, y) = \left\langle \Phi(x), \Phi(y)\right\rangle = x^T k x = \alpha > 0$$

Question 3.2.2:

$$k(x, y) = \left\langle \Phi(x), \Phi(y)\right\rangle$$

Where $\Phi\text{:x} \to \text{f(x)}$

Which means k is postive semidefinite

Question 3.2.3:

First showing $\text{a} \cdot \text{k}_1\text{(x,y)} \geq 0$

$\text{x}^T kx = a \cdot \text{x}^T k_1 x \geq 0$ same for k_2

Then since both $\text{a} \cdot \text{k}_1\text{(x,y)}$ & $\text{b} \cdot \text{k}_1\text{(x,y)}$ are ≥ 0 & a,b>0

$\text{x}^T kx = a \cdot \text{x}^T k_1 x + b \cdot \text{x}^T k_2 x \geq 0$

Question 3.2.4:

Let $\Phi^1 = \left(\Phi_1^1\text{(x)}, \Phi_2^1\text{(x)}, \ldots., \Phi_N^1\text{(x)}\right)$

Let $\Phi(x) = \dfrac{\Phi_i^1\text{(x)}}{\left\|\Phi_i^1\text{(x)}\right\|}$

Thus k find the inner product for Φ