Homework 5

David A. Halloran

March 8, 2022

1 Theory

$$\begin{split} g(z) &= \frac{e^z - e^{-z}}{e^z + e^{-z}} \\ \frac{\partial g(z)}{\partial z} &= \frac{(e^z + e^{-z})(e^z + e^{-z})}{(e^z + e^{-z})^2} - \frac{(e^z - e^{-z})(e^z - e^{-z})}{(e^z + e^{-z})^2} \\ \frac{\partial g(z)}{\partial z} &= \frac{(e^z + e^{-z})^2 - (e^z - e^{-z})^2}{(e^z + e^{-z})^2} \\ \frac{\partial g(z)}{\partial z} &= 1 - \left(\frac{e^z - e^{-z}}{e^z + e^{-z}}\right)^2 \\ \frac{\partial g(z)}{\partial z} &= 1 - g(z)^2 \end{split}$$

2 Logistical Regression

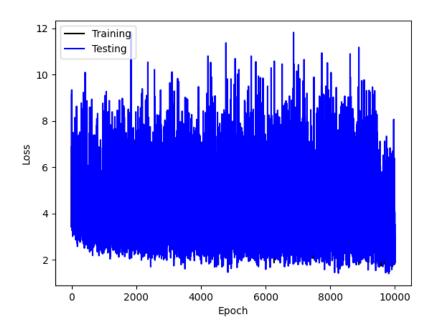


Figure 1: Logistical Regression

```
PROBLEMS 14
                       DEBUG CONSOLE
                                      TERMINAL
epoch: 8950. train loss: 3.2986 train acc %: 66.00 test loss: 4.4160 test acc %: 40.00
             train loss: 3.3929 train acc %: 59.00 test loss: 2.0304 test acc %: 60.00
epoch: 9000,
epoch: 9050,
             train loss: 2.8719 train acc %: 57.00 test loss: 3.3250 test acc %: 60.00
             train loss: 3.5919 train acc %: 54.00 test loss: 7.9638 test acc %: 50.00
epoch: 9100,
epoch: 9150,
             train loss: 3.1331 train acc %: 52.00 test loss: 2.5619 test acc %: 70.00
epoch: 9200,
             train loss: 3.1244 train acc %: 59.00 test loss: 4.0325 test acc %: 30.00
epoch: 9250,
             train loss: 2.7715 train acc %: 70.00 test loss: 2.4401 test acc %: 40.00
epoch: 9300,
             train loss:
                         3.6332 train acc %: 70.00 test loss: 4.8085 test acc %: 50.00
epoch: 9350,
             train loss: 3.0654 train acc %: 67.00 test loss: 5.8352 test acc %: 60.00
                         2.9275 train acc %: 53.00 test loss: 2.1740 test acc
             train loss:
epoch: 9450,
                         3.2909 train acc %: 58.00 test loss: 3.2697 test acc %: 50.00
             train loss:
epoch: 9500,
             train loss: 2.0733 train acc %: 71.00 test loss: 2.5005 test acc %: 60.00
epoch: 9550,
             train loss: 2.0404 train acc %: 64.00 test loss: 3.7020 test acc %: 50.00
epoch: 9600.
             train loss: 1.9400 train acc %: 66.00 test loss: 4.2730 test acc %: 30.00
             train loss: 1.8442 train acc %: 63.00 test loss: 2.8251 test acc %: 20.00
epoch: 9650,
             train loss: 2.2319 train acc %: 54.00 test loss: 4.6214 test acc %: 30.00
epoch: 9700,
             train loss: 1.9176 train acc %: 64.00 test loss: 3.5391 test acc %: 60.00
epoch: 9750,
epoch: 9800,
             train loss: 1.7449 train acc %: 71.00 test loss: 3.1685 test acc %: 50.00
epoch: 9850,
             train loss: 1.7834 train acc %: 71.00 test loss: 4.1405 test acc %: 60.00
epoch: 9900,
             train loss: 2.1385 train acc %: 52.00 test loss: 2.4597 test acc %: 40.00
epoch: 9950, train loss: 1.9474 train acc %: 66.00 test loss: 2.3117 test acc %: 60.00
Training Accuracy: 61.0
Testing Accuracy: 40.0
```

Figure 2: Results

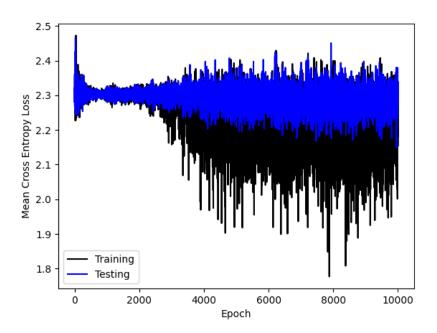


Figure 3: Results

3 ANN

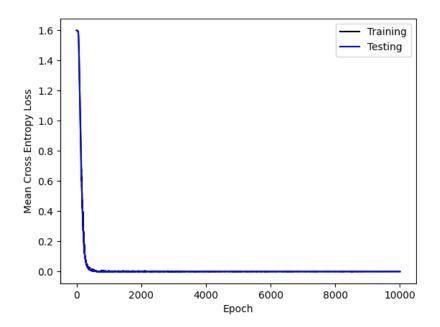


Figure 4: Results

4 MLP

- 1. Architecture 1: [IL, FC1, RL, FC2, SIG, SQ]
- 2. Architecture 2: [IL, FC1, LIN, FC2, TAN, SQ]
- 3. Architecture 3: [IL, FC1, FC2, FC3, FC4, SM, CE]

```
TERMINAL
epoch: 8200, train loss: 0.0000 train acc %: 10.00 test loss: 0.0004 test acc %: 0.00
epoch: 8300, train loss: 0.0001 train acc %: 0.00 test loss: 0.0000 test acc %: 20.00
epoch: 8400,
            train loss: 0.0000 train acc %: 10.00 test loss: 0.0000 test acc %: 20.00
epoch: 8500,
            train loss: 0.0000 train acc %: 0.00 test loss: 0.0000 test acc %: 10.00
                  loss: 0.0000 train acc %: 0.00 test loss: 0.0000 test acc %: 10.00
            train
epoch: 8700, train loss: 0.0000 train acc %: 0.00 test loss: 0.0002 test acc %: 0.00
epoch: 8800, train loss: 0.0000 train acc %: 10.00 test loss: 0.0000 test acc %: 0.00
epoch: 8900,
            train loss: 0.0000 train acc %: 20.00 test loss: 0.0000 test acc %: 10.00
epoch: 9000,
             train loss: 0.0000 train acc %: 10.00 test loss: 0.0000 test acc %: 20.00
epoch: 9100,
             train loss: 0.0000 train acc %: 20.00 test loss: 0.0000 test acc %: 10.00
epoch: 9200,
             train loss: 0.0000 train acc %: 0.00 test loss: 0.0000 test acc %: 20.00
             train loss: 0.0000 train acc %: 0.00 test loss: 0.0000 test acc %: 10.00
epoch:
epoch: 9400, train loss: 0.0000 train acc %: 10.00 test loss: 0.0000 test acc %: 0.00
epoch: 9500, train loss: 0.0000 train acc %: 20.00 test loss: 0.0000 test acc %: 0.00
epoch: 9600, train loss: 0.0000 train acc %: 0.00 test loss: 0.0000 test acc %: 10.00
epoch: 9700, train loss: 0.0000 train acc %: 0.00 test loss: 0.0000 test acc %: 20.00
epoch: 9800,
            train loss: 0.0000 train acc %: 10.00 test loss: 0.0000 test acc %: 20.00
epoch: 9900, train loss: 0.0000 train acc %: 10.00 test loss: 0.0000 test acc %: 10.00
Training Accuracy: 10.0
Testing Accuracy: 10.0
```

Figure 5: Results

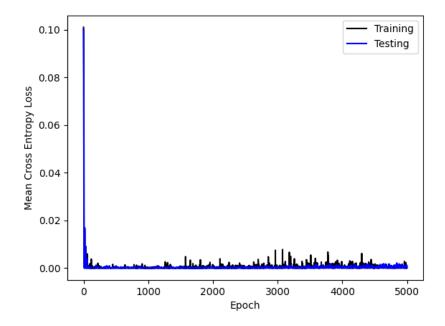


Figure 6: Results

```
TERMINAL
epoch: 3200, train loss: 0.0006 train acc %: 60.00 test loss: 0.0006 test acc %: 30.00
epoch: 3300, train loss: 0.0005 train acc %: 40.00 test loss: 0.0001 test acc %: 20.00
             train loss: 0.0001 train acc %: 10.00 test loss: 0.0001 test acc %: 50.00
epoch: 3400,
             train loss: 0.0003 train acc %: 20.00 test loss: 0.0006 test acc %: 60.00
epoch: 3500,
             train loss: 0.0005 train acc %: 30.00 test loss: 0.0004 test acc %: 30.00
epoch:
      3600.
epoch: 3700,
             train loss: 0.0005 train acc %: 20.00 test loss: 0.0004 test acc %: 30.00
epoch:
       3800,
                         0.0001 train acc %: 20.00 test loss: 0.0003 test acc %: 20.00
epoch: 3900,
             train loss: 0.0008 train acc %: 20.00 test loss: 0.0011 test acc %: 40.00
epoch:
                                train acc %: 20.00 test loss: 0.0004
epoch: 4100,
             train loss: 0.0018 train acc %: 60.00 test loss: 0.0001 test acc %: 20.00
             train loss: 0.0008 train acc %: 30.00 test loss: 0.0006 test acc %: 10.00
epoch: 4200,
             train loss: 0.0002 train acc %: 50.00 test loss: 0.0002 test acc %: 60.00
epoch: 4300,
epoch: 4400,
             train loss: 0.0005 train acc %: 30.00 test loss: 0.0002 test acc %: 30.00
epoch: 4500,
             train loss: 0.0001 train acc %: 60.00 test loss: 0.0003 test acc %: 30.00
             train loss: 0.0006 train acc %: 50.00 test loss: 0.0007 test acc %: 30.00
epoch: 4600,
             train loss: 0.0002 train acc %: 60.00 test loss: 0.0000 test acc %: 10.00
epoch: 4700,
epoch: 4800,
             train loss: 0.0002 train acc %: 40.00 test loss: 0.0002 test acc %: 30.00
epoch: 4900, train loss: 0.0001 train acc %: 10.00 test loss: 0.0001 test acc %: 40.00
Training Accuracy: 50.0
Testing Accuracy: 10.0
```

Figure 7: Results

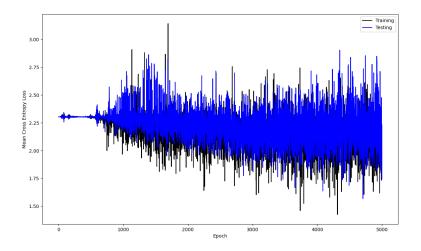


Figure 8: Results

```
PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL
epoch: 3200, train loss: 2.0461 train acc %: 30.00 test loss: 2.4324 test acc %: 10.00
epoch: 3300, train loss: 2.2461 train acc %: 0.00 test loss: 2.0221 test acc %: 30.00
epoch: 3400, train loss: 2.1247 train acc %: 20.00 test loss: 1.9519 test acc %: 30.00
epoch: 3500, train loss: 1.9889 train acc %: 20.00 test loss: 2.1370 test acc %: 10.00
epoch: 3600, train loss: 2.1616 train acc %: 10.00 test loss: 2.3830 test acc %: 0.00
epoch: 3700, train loss: 1.9369 train acc %: 50.00 test loss: 1.9610 test acc %: 30.00
epoch: 3800, train loss: 2.1202 train acc %: 10.00 test loss: 2.2655 test acc %: 10.00
epoch: 3900, train loss: 2.1484 train acc %: 20.00 test loss: 1.9355 test acc %: 10.00
epoch: 4000, train loss: 2.5558 train acc %: 10.00 test loss: 2.6044 test acc %: 0.00
epoch: 4100, train loss: 1.9340 train acc %: 20.00 test loss: 2.0901 test acc %: 30.00
epoch: 4200, train loss: 2.4112 train acc %: 0.00 test loss: 2.2629 test acc %: 10.00
epoch: 4300, train loss: 2.2649 train acc %: 0.00 test loss: 2.4107 test acc %: 20.00
epoch: 4400, train loss: 2.0734 train acc %: 20.00 test loss: 2.2567 test acc %: 20.00
epoch: 4500, train loss: 1.9924 train acc %: 20.00 test loss: 2.1032 test acc %: 20.00
epoch: 4600, train loss: 1.8657 train acc %: 30.00 test loss: 1.9937 test acc %: 30.00
epoch: 4700, train loss: 2.1422 train acc %: 0.00 test loss: 2.1435 test acc %: 10.00
epoch: 4800, train loss: 2.2656 train acc %: 10.00 test loss: 2.2732 test acc %: 10.00
epoch: 4900, train loss: 2.1027 train acc %: 20.00 test loss: 2.2359 test acc %: 10.00
Training Accuracy: 30.0
```

Figure 9: Results