

Prob. 1

(a) Recreation of textbook Figure 5.3 shown in Figure 1.

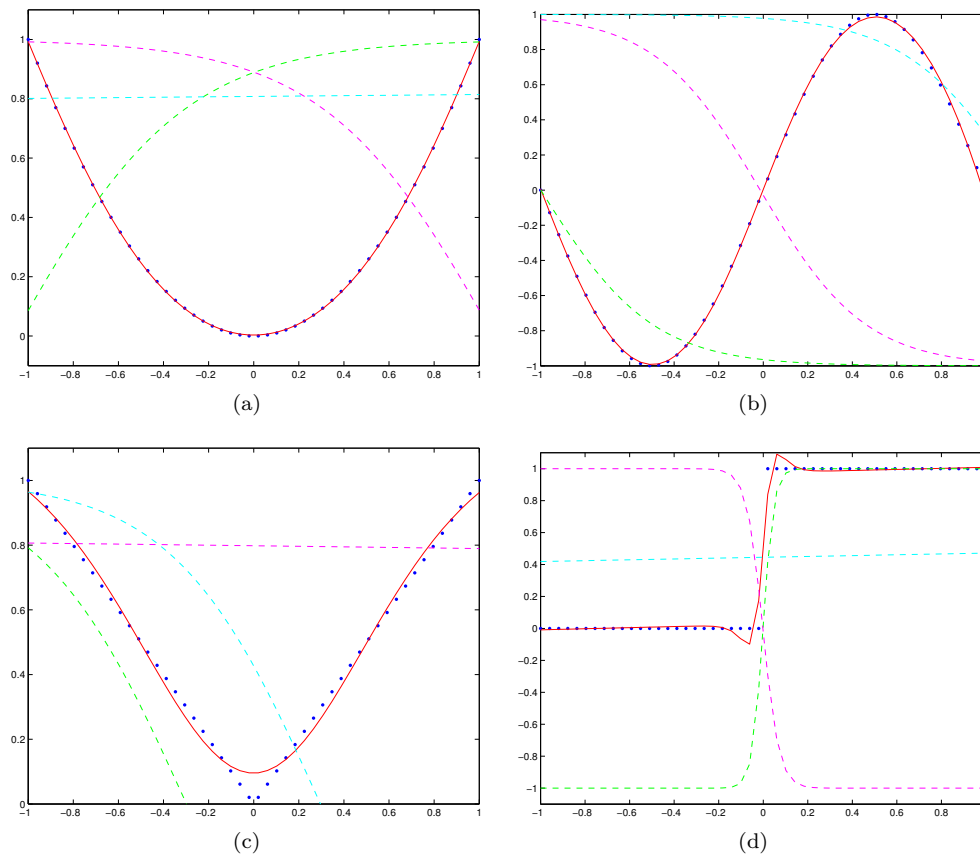


Figure 1: Recreation of Figure 5.3 for (a) $f(x) = x^2$, (b) $f(x) = \sin(x)$, (c) $f(x) = |x|$, and (d) $f(x) = H(x)$.

(b) Example of the first of each of the digits from MNIST training data.

0 1 2 3 4
5 6 7 8 9

Figure 2: MNIST handwritten digits from training data.

Prob. 2 (Netlab)

(a) Plot of MNIST error rate versus number of hidden units, M is shown in Figure 3(a).

(b) Plot of MNIST error rate versus number of iterations is shown in Figure 3(b).

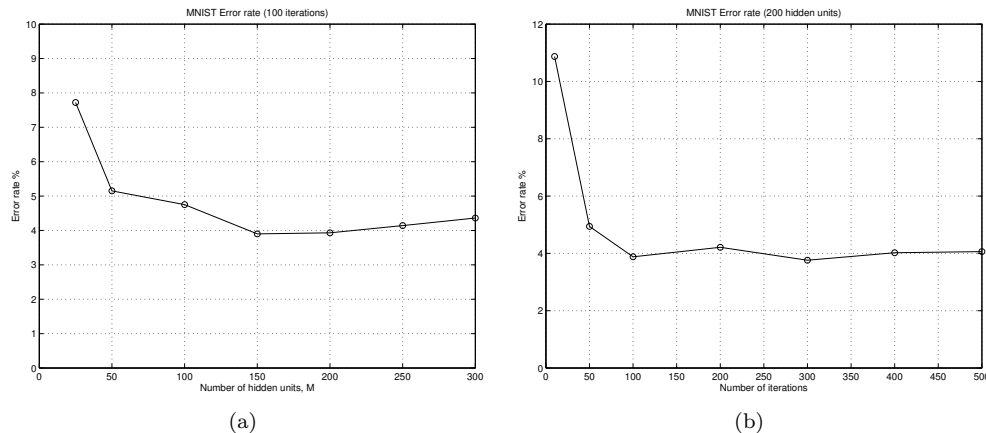


Figure 3: MNIST error rates as a function of (a) number of hidden units and (b) number of iterations.

(c) The confusion matrix for the complete evaluation is shown below. The overall classification error rate is 2.31% for the NN-based recognition system using 300 hidden units and 100 iterations. With 500 hidden units and 100 iterations, the overall classification error rate is 2.2%

Table 1: Confusion matrix for the NN-based recognition system using 300 hidden units and 100 iterations. Element i, j is the percentage of times digit i was classified as digit j .

0.9888	0	0.0019	0	0.0010	0.0011	0.0010	0.0010	0.0031	0.0020
0	0.9877	0.0039	0.0030	0	0	0.0021	0.0010	0.0031	0.0010
0.0041	0.0009	0.9767	0.0069	0.0020	0	0.0010	0.0039	0.0051	0
0	0.0018	0.0039	0.9743	0.0010	0.0034	0	0.0029	0.0051	0.0079
0.0010	0	0	0.0020	0.9766	0	0.0031	0.0039	0	0.0129
0.0020	0	0	0.0109	0.0010	0.9720	0.0073	0.0010	0.0021	0.0010
0.0031	0.0026	0.0010	0.0010	0.0031	0.0056	0.9781	0	0.0051	0
0.0010	0.0026	0.0097	0.0020	0.0031	0	0	0.9737	0.0031	0.0050
0.0041	0	0.0029	0.0059	0.0031	0.0045	0.0010	0.0029	0.9713	0.0040
0.0020	0.0026	0.0019	0.0059	0.0051	0.0022	0.0010	0.0049	0.0062	0.9683

Prob. 2 (Neural Network Toolbox)

(a) Plot of MNIST error rate versus number of hidden units, M is shown in Figure 4(a).

(b) Plot of MNIST error rate versus number of iterations is shown in Figure 4(b).

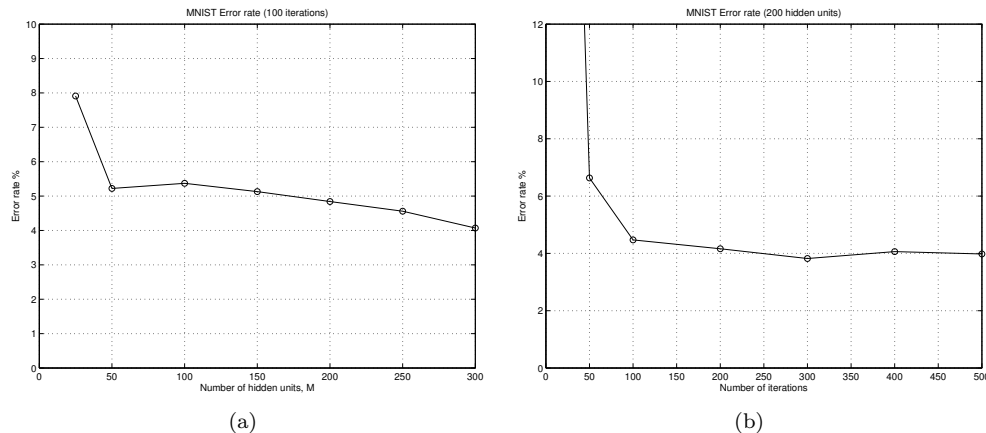


Figure 4: MNIST error rates as a function of (a) number of hidden units and (b) number of iterations.

(c) The confusion matrix for the complete evaluation is shown below. The overall classification error rate is 2.31% for the NN-based recognition system using 300 hidden units and 100 iterations.

Table 2: Confusion matrix for the NN-based recognition system using 300 hidden units and 100 iterations. Element i, j is the percentage of times digit i was classified as digit j .

0.9857	0	0.0019	0.0020	0	0.0034	0.0042	0.0010	0.0021	0
0	0.9859	0.0039	0.0020	0	0.0011	0.0031	0.0019	0.0041	0
0.0010	0.0009	0.9767	0.0040	0.0031	0	0.0021	0.0049	0.0062	0.0020
0.0010	0	0.0039	0.9762	0	0.0045	0	0.0049	0.0051	0.0050
0.0020	0	0.0068	0.0010	0.9684	0	0.0010	0.0019	0.0031	0.0149
0.0051	0.0009	0.0010	0.0079	0.0010	0.9630	0.0073	0.0010	0.0062	0.0030
0.0041	0.0026	0.0010	0	0.0051	0.0034	0.9802	0	0.0031	0
0	0.0044	0.0155	0.0020	0.0010	0	0	0.9650	0.0021	0.0099
0.0041	0	0.0048	0.0059	0.0031	0.0056	0.0031	0.0029	0.9682	0.0020
0.0051	0.0018	0.0010	0.0050	0.0081	0.0022	0.0031	0.0117	0.0062	0.9564