

题目: MNIST 手写数字识别(用含一层隐含层的 DNN)

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题目:用含一层隐含层的DNN,做MNIST手写数字的识别

1.数据处理

MNIST数据集是由http://yann.lecun.com/exdb/mnist/网站提供的一个手写数字数据库,包括含60000个示例图片的训练集和含10000个示例图片的测试集.每一张图片都是0到9中的单个数字,这些数字经过大小规格化处理,集中在固定大小的图像中,即均由28×28个像素构成.

网页中给出了如下四个文件:

train-images-idx3-ubyte.gz: training set images (9912422 bytes)
train-labels-idx1-ubyte.gz: training set labels (28881 bytes)
t10k-images-idx3-ubyte.gz: test set images (1648877 bytes)
t10k-labels-idx1-ubyte.gz: test set labels (4542 bytes)

mnist数据集

其中第一个和第三个文件分别储存了60000张训练图片和10000张测试图片在28×28=784个像素点上的灰度值,第二个和第四个文件则分别储存了60000张训练图片和10000张测试图片所对应的标签.

在以二进制方式读入文件并去掉魔数后,得到四个文件的格式分别为"47040000x1 double","60000x1 double","7840000x1 double"和"10000x1 double"。此处为方便标签与识别结果对比,将标签形式分别更改成大小为 10×60000 和 10×10000 的矩阵,其中(以0开头)标签为i的图片代表的列向量的第i+1个分量为1,其余分量为0.而将图片形式分别更改成大小为 784×60000 和 784×10000 的矩阵,则每张图片由一个含784个分量的列向量表示。

在对一些图片的数据reshape还原成大小为28×28的方阵后观察发现: 1)所有灰度值的取值均为区间[-128,127]之间的整数. 2)绝对值较大的灰度值基本出现在数字的轮廓上. 3)数字笔迹未触及到的部分灰度值为0. 4)数字笔迹中间(即最深)部分灰度值为绝对值较小的负数.

结合以上信息,判断数据读取过程中将无符号数以反码表示方式读入,故通过将所有负值加上256以还原,并将所有灰度值除以256从而将数据归一化.

2.网络设计

该神经网络包含一层输入层,一层隐含层以及一层输出层.输入层节点数为像素点个数784,隐含层(全连接层)节点数选为28,输出层节点数设为10 (此处输出表示该网络将某张图片判断为各个数字的强度,最终以强度最大者作为识别的结果).

用正态随机函数得到隐含层和输出层中初始的权重w和偏置项b, 激活函数选取Sigmoid函数,即 $\sigma(x) = \frac{1}{1+e^{-x}}$. 误差反馈采用公式 $\Delta y = (y^*-y)(1-y)(y-0)$,并通过 $w = w + a(\Delta y * x)$ 以及 $b = b + a\Delta y$ 更新权重w 和偏置b, 其中a为学习率,此处设为0.05. 训练步数设为30.

3.结果呈现

利用隐含层和输出层中已训练好的权重u和偏置项b,对测试集中的10000张图片进行测

试,将神经网络判断第i张图片为 $0\sim9$ 十个数字的强度存放在一个大小为 10×10000 的矩阵的第i列(其中判断为"0"的放在第一行),然后将该矩阵每列中最大值所在行数j提取出来,并与标签最大值(即1)所在行数i进行比较.

比较完成之后,则在一个10×10的计数表格中的第i行第j列位置处加1,于是最后每一行的和表示该行所代表的的数字在样本中的实际数量,每一列的和表示神经网络识别为该行所代表的数字的数量,对角线上的数则表示相应数字识别正确的数量.最终将每个数字识别的准确率(对角线上数与其所在行的和的比)添加在表格右侧,并计算出总的准确率.

4.代码实现

```
TrainImage = fopen('train - images.idx3 - ubyte', 'rb'); %数据读入
A = fread(TrainImage, inf, 'int8');
A = A(end - 60000 * 784 + 1 : end);
A = reshape(A, 784, 60000);
TrainLabel = fopen('train - labels.idx1 - ubyte', 'rb');
B0 = fread(TrainLabel, inf, 'int8');
B0 = B0(end - 60000 + 1 : end);
TestImage = fopen('t10k - images.idx3 - ubyte', 'rb');
C = fread(TestImage, inf, 'int8');
C = C(end - 10000 * 784 + 1 : end);
C = reshape(C, 784, 10000);
TesstLabel = fopen('t10k - labels.idx1 - ubyte', 'rb');
D0 = fread(TesstLabel, inf, 'int8');
D0 = D0(end - 10000 + 1 : end);
for i = 1:60000
                 %处理图片集数据
    for j = 1:784
        if A(j,i) < 0
            A(j,i) = A(j,i) + 256;
        end
        if i <= 10000
            if C(j,i) < 0
                C(j,i) = C(j,i) + 256;
            end
        end
    end
end
A = A/256;
C = C/256;
B = zeros(10, 60000);
D = zeros(10, 10000);
for i = 1:60000 %处理标签集数据
    B(B0(i) + 1, i) = 1;
    if i <= 10000
        D(D0(i) + 1, i) = 1;
    end
end
step = 30;
            %设定参数
a = 0.05;
in = 784;
```

```
hid = 28;
out = 10;
out_{-}w = randn(out, hid);
                         %初始化权重及偏置
out_b = randn(out, 1);
hid_-w = randn(hid, in);
hid_b = randn(hid, 1);
for i = 1: step %训练神经网络
    r = randperm(60000); %打乱图片顺序
    A = A(:, r);
    B = B(:, r);
    for j = 1:60000
        x = A(:,j);
        y = B(:, j);
        put0 = F(hid_-w, hid_-b, x);
        put1 = F(out\_w, out\_b, put0);
        deltaout = (y - put1). * put1. * (1 - put1);
        deltahid = ((out\_w') * deltaout). * put0. * (1 - put0);
        out_w = out_w + a * (deltaout * (put0'));
        out_b = out_b + a * deltaout;
        hid_{-}w = hid_{-}w + a * (deltahid * (x'));
        hid_b = hid_b + a * deltahid;
    end
end
E = zeros(10, 10000);
for k = 1:10000
                  %测试神经网络
    x = C(:, k);
    put0 = F(hid_w, hid_h, x);
    E(:,k) = F(out_-w, out_b, put_0);
    [Res, Result] = max(E);
    [Ans, Answer] = max(D);
end
TABLE = zeros(12, 13);
for i = 1:10000 %存放识别结果
    TABLE(Answer(i)+1, Result(i)+1) = TABLE(Answer(i)+1, Result(i)+1)+1; \\
end
for i = 2:11 %表格展示以及测试结果分析
    TABLE(i, 1) = i - 2;
    TABLE(1, i) = i - 2;
    TABLE(12, i) = sum(TABLE(2:11, i), 1);
    TABLE(i, 12) = sum(TABLE(i, 2:11), 2);
    TABLE(i, 13) = TABLE(i, i)/TABLE(i, 12);
end
TABLE(12, 12) = sum(TABLE(2:11, 12));
TABLE(12, 13) = sum(diag(TABLE(2:11, 2:11)))/TABLE(12, 12);
fprintf('准确率: %.2f%%\n',TABLE(12,13)*100);
function[y] = F(w, b, x) %输出函数
```

```
\begin{split} y &= w*x + b;\\ n &= length(y);\\ for \ i &= 1:n\\ y(i) &= 1.0/(1 + exp(-y(i)));\\ end\\ end \end{split}
```

5.具体识别结果

由于隐含层和输出层中初始的权重w和偏置项b均是由正态随机函数得到的,故每次运行的结果以及准确率并不完全相同.以下是10次运行得到的表格和准确率.可发现整体识别准确率基本保持在94%以上,平均每次运行用时约2%35秒,属于较好地完成了手写数字的识别.

十个数字中识别准确率较高的数字为"1"和"0",相对而言识别度较低的数字为"5"和"9",其中"5"最易被识别成"3"或"6",而"9"易被识别成"4"或"7".这一结果符合一般事实.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	0	0	1	2	3	4	5	6	7	8	9	0	0	
ı	0	954	2	2	0	1	4	9	3	4	1	980	0.9735	
	1	0	1119	2	4	0	2	2	2	4	0	1135	0.9859	
	2	6	4	962	4	8	0	11	20	15	2	1032	0.9322	
	3	2	1	26	937	1	17	1	9	13	3	1010	0.9277	
	4	1	1	2	1	925	1	11	6	4	30	982	0.9420	
	5	8	2	1	23	4	816	18	3	10	7	892	0.9148	
	6	12	2	5	1	2	10	921	1	4	0	958	0.9614	
	7	0	10	24	7	3	3	1	960	1	19	1028	0.9339	
0	8	4	2	5	17	9	9	6	9	904	9	974	0.9281	
1	9	5	1	2	16	21	8	0	18	8	930	1009	0.9217	
2	0	992	1144	1031	1010	974	870	980	1031	967	1001	10000	0.9428	
3														
	TABLE ×													
H	12x13 double													
	1	2	3	4	5	6	7	8	9	10	11	12	13	1
	0	0	1	2	3	4	5	6	7	8	9	0	0	
	0	962	0	0	2	2	3	7	2	2	0	980	0.9816	
	1	0	1113	3	4	1	1	4	2	6	1	1135	0.9806	
1	2	9	1113	962	13	10	2	5	13	15	2	1032	0.9322	
	3	1	1	14	930	1	23	3	18	14	5	1010	0.9208	
ı	4	2	0	3	0	930	1	10	0	3	33	982	0.9470	
	5	10	1	3	11	3	829	16	3	9	7	892	0.9294	
3	6	10	3	6	1	9	13	913	0	3	0	958	0.9530	
,	7	1	5	22	5	5	1	2	968	2	17	1028	0.9416	
0	8	6	3	5	13	5	13	8	9	907	5	974	0.9312	
1	9	6	4	0	16	17	6	2	7	6	945	1009	0.9366	
2	0	1007	1131	1018	995	983	892	970	1022	967	1015	10000	0.9459	
3				1010							1010		0.0.100	
	TABLE ×													
9	TABLE ×				- 1				-					
9	12x13 double	2	3	4		6	7	9	0	10	11	12	12	
	12x13 double	2	3	4	5	6	7	8	9	10	11	12	13	1
	12x13 double 1 0	0	1	2	3	4	5	6	7	8	9	0	0	
	12x13 double 1 0	0 959	1	2 4	3	4 1	5	6 9	7	8	9	0 980	0 0.9786	1
	12x13 double 1 0 0	0 959 0	1 1 1117	2 4 2	3 0 2	4 1 1	5 3 1	6 9 4	7 2 3	8 1 4	9 0 1	980 1135	0 0.9786 0.9841	1
:	12x13 double 1 0 0 1 2	0 959 0 9	1 1 1117 1	2 4 2 960	3 0 2 10	4 1 1 1	5 3 1 2	6 9 4 6	7 2 3 13	8 1 4 16	9 0 1 4	980 1135 1032	0 0.9786 0.9841 0.9302	1
	12x13 double 1 0 0 1 2 3	0 959 0 9	1 1 1117 1 3	2 4 2 960 19	3 0 2 10 942	4 1 1 11 2	5 3 1 2 11	6 9 4 6	7 2 3 13	8 1 4 16 10	9 0 1 4 4	0 980 1135 1032 1010	0 0.9786 0.9841 0.9302 0.9327	1
	12x13 double 1 0 0 1 2 3 4	0 959 0 9 4	1 1 1117 1 3	2 4 2 960 19	3 0 2 10 942	4 1 1 11 2 915	5 3 1 2 11 2	6 9 4 6 3	7 2 3 13 12 4	8 1 4 16 10 3	9 0 1 4 4 36	980 1135 1032 1010 982	0 0.9786 0.9841 0.9302 0.9327 0.9318	1
	12x13 double 1 0 0 1 2 3 4 5	0 959 0 9 4 2	1 1 1117 1 3 1	2 4 2 960 19 9	3 0 2 10 942 0 27	4 1 1 11 2 915 5	5 3 1 2 11 2 808	6 9 4 6 3 10	7 2 3 13 12 4 3	8 1 4 16 10 3 14	9 0 1 4 4 36 5	980 1135 1032 1010 982 892	0 0.9786 0.9841 0.9302 0.9327 0.9318 0.9058	1
	12x13 double 1 0 0 1 2 3 4 5 6	0 959 0 9 4 2 10	1 1 1117 1 3 1 1 4	2 4 2 960 19 9 4 3	3 0 2 10 942 0 27 3	4 1 1 11 2 915 5	5 3 1 2 11 2 808 10	6 9 4 6 3 10 15 914	7 2 3 13 12 4 3	8 1 4 16 10 3 14 4	9 0 1 4 4 36 5	0 980 1135 1032 1010 982 892 958	0 0.9786 0.9841 0.9302 0.9327 0.9318 0.9058 0.9541	1
2	12x13 double 1 0 0 1 2 3 4 5 6 7	0 959 0 9 4 2 10 12	1 1 1117 1 3 1 1 4	2 4 2 960 19 9 4 3	3 0 2 10 942 0 27 3	4 1 1 11 2 915 5 7	5 3 1 2 11 2 808 10	6 9 4 6 3 10 15 914	7 2 3 13 12 4 3 1 971	8 1 4 16 10 3 14 4 5	9 0 1 4 4 36 5 0	0 980 1135 1032 1010 982 892 958 1028	0 0.9786 0.9841 0.9302 0.9327 0.9318 0.9058 0.9541	1
:	12x13 double 1 0 0 1 2 3 4 5 6 7	0 959 0 9 4 2 10 12	1 1 1117 1 3 1 1 4 7	2 4 2 960 19 9 4 3 12	3 0 2 10 942 0 27 3 12	4 1 1 11 2 915 5 7 5	5 3 1 2 11 2 808 10 1	6 9 4 6 3 10 15 914 0	7 2 3 13 12 4 3 1 971	8 1 4 16 10 3 14 4 5	9 0 1 4 4 36 5 0	980 1135 1032 1010 982 892 958 1028	0 0.9786 0.9841 0.9302 0.9327 0.9318 0.9058 0.9541 0.9446 0.9281	1
1 1 2 2 3 3 3 4 5 5 5 5 7 7 3 3 9 9 0 0 1 1	12x13 double 1 0 0 1 1 2 3 4 5 6 7 8 9	0 959 0 9 4 2 10 12 1 2	1 1 1117 1 3 3 1 1 4 7 2	2 4 2 960 19 9 4 3 12 7	3 0 2 10 942 0 27 3 12 19	4 1 1 11 2 915 5 7 5 10	5 3 1 2 11 2 808 10 1 11	6 9 4 6 3 10 15 914 0 9	7 2 3 13 12 4 3 1 971 9	8 1 4 16 10 3 14 4 5 904	9 0 1 4 4 36 5 0 14 1 1	980 1135 1032 1010 982 892 958 1028 974 1009	0 0.9786 0.9841 0.9302 0.9327 0.9318 0.9058 0.9541 0.9446 0.9281 0.9177	1
2: :: :: :: :: :: :: :: :: :: :: :: :: :	12x13 double 1 0 0 1 2 3 4 5 6 7	0 959 0 9 4 2 10 12	1 1 1117 1 3 1 1 4 7	2 4 2 960 19 9 4 3 12	3 0 2 10 942 0 27 3 12	4 1 1 11 2 915 5 7 5	5 3 1 2 11 2 808 10 1	6 9 4 6 3 10 15 914 0	7 2 3 13 12 4 3 1 971	8 1 4 16 10 3 14 4 5	9 0 1 4 4 36 5 0	980 1135 1032 1010 982 892 958 1028	0 0.9786 0.9841 0.9302 0.9327 0.9318 0.9058 0.9541 0.9446 0.9281	1
1 1 2 2	12x13 double 1 0 0 1 1 2 3 4 5 6 7 8 9	0 959 0 9 4 2 10 12 1 2	1 1 1117 1 3 3 1 1 4 7	2 4 2 960 19 9 4 3 12 7	3 0 2 10 942 0 27 3 12 19	4 1 1 11 2 915 5 7 5 10	5 3 1 2 11 2 808 10 1 11	6 9 4 6 3 10 15 914 0 9	7 2 3 13 12 4 3 1 971 9	8 1 4 16 10 3 14 4 5 904	9 0 1 4 4 36 5 0 14 1 1 926	980 1135 1032 1010 982 892 958 1028 974 1009	0 0.9786 0.9841 0.9302 0.9327 0.9318 0.9058 0.9541 0.9446 0.9281 0.9177	1
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神经网络识别结果分布表(1)~(4)

12x13 double	2	3	4	5	6	7	8	9	10	11	12	13	
0	0	1	2	3	4	5	6	7	8	9	0	0	
0	962	1	0	0	0	2	9	3	3	0	980	0.9816	
1 2	9	1111	5 953	13	0 11	2	6 9	2 10	7 20	0 5	1135 1032	0.9789 0.9234	
3	4	1	18	935	0	21	2	11	17	1	1010	0.9257	
4	2	1	5	0	921	4	11	4	6	28	982	0.9379	
5	8	0	4	21	3	821	11	4	15	5	892	0.9204	
6 7	11	3 9	13	0 10	9	20	903	968	7	0 17	958 1028	0.9426 0.9416	
8	4	3	4	10	4	10	9	7	921	2	974	0.9416	
9	6	7	2	6	30	8	0	12	20	918	1009	0.9098	
0	1009	1137	1006	997	982	890	960	1024	1019	976	10000	0.9413	
71515													
TABLE ×													
12x13 double	2	3	4	5	6	7	8	9	10	11	12	13	_
1 0	2 0	1	2	3	4	5	6	7	8	9	12	0	
0	959	0	2	2	2	6	5	1	2	1	980	0.9786	
1	0	1120	3	2	0	1	2	3	3	1	1135	0.9868	
2	10	5	955	8	10	2	11	13	18	0	1032	0.9254	
3 4	3	0	12	946	938	15 0	13	12	16 2	2 22	1010 982	0.9366 0.9552	
5	8	2	4	21	3	811	15	7	13	8	892	0.9092	
6	14	2	7	1	4	11	913	1	5	0	958	0.9530	
7	2	10	22	2	6	1	0	970	3	12	1028	0.9436	
8	5	5	10	11	6	9	11	9	906	2	974	0.9302	
9	12	7	1017	7	27	9	1	16	16	914	1009	0.9058	
0	1015	1152	1017	1000	998	865	972	1035	984	962	10000	0.9432	
TABLE ×													
12x13 double													Ī
1	2	3	4	5	6	7	8	9	10	11	12	13	
0	0	1	2	3	4	5	6	7	8	9	0	0	
0	951	0	2	0	2	6	9	2	5	3	980	0.9704	
1 2	0 5	1113	6 947	2 19	1 12	2 5	4 8	1 13	6 20	0	1135 1032	0.9806 0.9176	
3	2	0	15	940	3	20	2	13	16	3	1032	0.9176	
4	1	1	2	1	937	0	12	2	3	23	982	0.9542	
5	11	0	2	27	5	799	16	4	23	5	892	0.8957	
6	9	3	6	1	14	7	907	1	9	1	958	0.9468	
7	1	9	20	2	7	1	1	970	4	13	1028	0.9436	
8	5 9	6	7	14 10	10 42	14 9	12 4	5 10	902 12	905	974 1009	0.9261 0.8969	
0	994	1135	1009	1016	1033	863	975	1017	1000	958	10000	0.8969	
TABLE ×													
12x13 double													
1	2	3	4	5	6	7	8	9	10	11	12	13	
0	962	0	2	3	4	5	6 7	7	8	9	980	0.9816	
1	0	1110	5	3	1	2	5	4	5	0	1135	0.9780	
			965	14	7	4	8	10	6	1	1032	0.9351	
2	16	1	303				1	6	16	7	1010		
3	2	2	18	938	1	19						0.9287	
3 4	2 1	2 1	18 4	3	923	1	10	3	2	34	982	0.9399	
3 4 5	2 1 11	2 1 1	18 4 5	3 29	923 4	1 809	10 7	2	16	8	892	0.9399 0.9070	
3 4	2 1	2 1 1 3	18 4 5 4	3	923 4 9	1	10 7 911			8	892 958	0.9399 0.9070 0.9509	
3 4 5 6	2 1 11 11	2 1 1	18 4 5	3 29 1	923 4	1 809 10	10 7	2	16 8	8	892	0.9399 0.9070	
3 4 5 6 7 8 9	2 1 11 11 1 1 10 11	2 1 1 3 8 4 4	18 4 5 4 13 7	3 29 1 3 12 8	923 4 9 5 9	1 809 10 1 9	10 7 911 0 7	2 1 974 10 8	16 8 3 901 4	8 0 20 5 936	892 958 1028 974 1009	0.9399 0.9070 0.9509 0.9475 0.9251 0.9277	
3 4 5 6 7 8	2 1 11 11 1 1 10	2 1 1 3 8 4	18 4 5 4 13	3 29 1 3 12	923 4 9 5	1 809 10 1 9	10 7 911 0 7	2 1 974 10	16 8 3 901	8 0 20 5	958 1028 974	0.9399 0.9070 0.9509 0.9475 0.9251	
3 4 5 6 7 8 9	2 1 11 11 1 1 10 11	2 1 1 3 8 4 4	18 4 5 4 13 7	3 29 1 3 12 8	923 4 9 5 9	1 809 10 1 9	10 7 911 0 7	2 1 974 10 8	16 8 3 901 4	8 0 20 5 936	892 958 1028 974 1009	0.9399 0.9070 0.9509 0.9475 0.9251 0.9277	
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3 4 5 6 7 8 8 9 0 TABLE X 12x13 double 1 0 0	2 1 11 11 1 10 11 1025	2 1 1 3 8 4 4 1134	18 4 5 4 13 7 1 1023	3 29 1 3 12 8 1014	923 4 9 5 9 24 984	1 809 10 1 1 9 12 870	10 7 911 0 7 1 957	2 1 974 10 8 1020	16 8 3 901 4 962	8 0 20 5 936 1011	892 958 1028 974 1009 10000	0.9399 0.9070 0.9509 0.9475 0.9251 0.9277 0.9429	
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