Handin 1

Søren Meldgaard 201303712, Malthe Bisbo 201303718

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1 PART I: SUPPORT VECTOR MACHINES

meantestscore	meantrainscore	stdtestscore	stdtrainscore	paramC
0.9109826589595376	1.0	0.003686151535589419	0.0	10
0.9109826589595376	1.0	0.003686151535589419	0.0	100
0.9133911368015414	0.9990366088631983	0.0025232756943561856	0.00018023397816832997	1
0.923121387283237	0.9803468208092486	0.0031748086807869263	0.0003121744074377559	0.1
0.924373795761079	0.9442678227360308	0.0027553660204383532	0.001441871825346432	0.01

meantestscore	meantrainscore	stdtestscore	stdtrainscore	paramC
0.9266859344894027	0.9415221579961465	0.002815344739152685	0.0014076723695763697	0.1
0.9274566473988439	0.9425337186897881	0.0032442116070294444	0.00120520192709024	0.1
0.9292870905587669	0.9489884393063583	0.0034386451440414022	0.0018988827884804228	0.1
0.9324662813102119	0.964402697495183	0.0026100611144786114	0.0017071334438024189	0.1
0.9360308285163776	0.9960982658959537	0.003006644804301981	0.00011799083539418567	1
0.936223506743738	1.0	0.002192640978177431	0.0	100
0.936223506743738	1.0	0.002192640978177431	0.0	10
0.9493256262042389	1.0	0.0009537085680743383	0.0	10
0.9493256262042389	1.0	0.0009537085680743383	0.0	100
0.9493256262042389	1.0	0.0009537085680743383	0.0	100
0.9493256262042389	1.0	0.0009537085680743383	0.0	1
0.9496146435452794	0.99990366088632	0.0010641002906731536	6.812204057671576e-05	0.1
0.9496146435452794	0.99990366088632	0.0010641002906731536	6.812204057671576e-05	10
0.9514450867052023	0.9894990366088633	0.0026593783702971822	0.0008855865274976228	1
0.9539499036608863	1.0	0.0014418718253463923	0.0	1
0.9539499036608863	1.0	0.0014418718253463923	0.0	1
0.9539499036608863	1.0	0.0014418718253463923	0.0	100
0.9539499036608863	0.9875722543352601	0.0029693709070178144	0.0009365232223132506	1
0.9539499036608863	1.0	0.0014418718253463923	0.0	10
0.9539499036608863	1.0	0.0014418718253463923	0.0	100
0.9539499036608863	1.0	0.0014418718253463923	0.0	10
0.9539499036608863	1.0	0.0014418718253463923	0.0	100
0.9539499036608863	1.0	0.0014418718253463923	0.0	0.1
0.954335260115607	1.0	0.0018730464446265354	0.0	100
0.954335260115607	1.0	0.0018730464446265354	0.0	10
0.954335260115607	1.0	0.0018730464446265354	0.0	10
0.954335260115607	1.0	0.0018730464446265354	0.0	100
0.954335260115607	1.0	0.0018730464446265354	0.0	100
0.954335260115607	1.0	0.0018730464446265354	0.0	10
0.954335260115607	1.0	0.0018730464446265354	0.0	1
0.954335260115607	1.0	0.0018730464446265354	0.0	1
0.954335260115607	1.0	0.0018730464446265354	0.0	0.1
0.954335260115607	1.0	0.0018730464446265354	0.0	1
0.954335260115607	1.0	0.0018730464446265354	0.0	0.1
0.954335260115607	1.0	0.0018730464446265354	0.0	100
0.9544315992292871	1.0	0.0019219592816242654	0.0	0.1
0.9544315992292871	1.0	0.0019219592816242654	0.0	100
0.9544315992292871	1.0	0.0019219592816242654	0.0	0.1
0.9544315992292871	1.0	0.0019219592816242654	0.0	0.1
0.9544315992292871	1.0	0.0019219592816242654	0.0	100
0.9544315992292871	1.0	0.0019219592816242654	0.0	100
0.9544315992292871	1.0	0.0019219592816242654	0.0	0.1
0.9544315992292871	1.0	0.0019219592816242654	0.0	100
0.9544315992292871	1.0	0.0019219592816242654	0.0	100
0.9544315992292871	1.0	0.0019219592816242654	0.0	100
0.9544315992292871	1.0	0.0019219592816242654	0.0	10
0.9544315992292871	1.0	0.0019219592816242654	0.0	0.1
0.9544315992292871	1.0	0.0019219592816242654	0.0	10
0.9544315992292871	1.0	0.0019219592816242654	0.0	1
0.9544315992292871	1.0	0.0019219592816242654	0.0	10
0.9544315992292871	1.0	0.0019219592816242654	0.0	1
0.9544315992292871	1.0	0.0019219592816242654	0.0	1
0.9544315992292871	1.0	0.0019219592816242654	0.0	10
0.9544315992292871	1.0	0.0019219592816242654	0.0	10
0.9544315992292871	1.0	0.0019219592816242654	0.0	1

meantestscore	meantrainscore	stdtestscore	stdtrainscore	paramC
0.940655105973025	1.0	0.00027248816230696765	0.0	10
0.940655105973025	1.0	0.00027248816230696765	0.0	1
0.940655105973025	1.0	0.00027248816230696765	0.0	100
0.9408477842003854	0.9994219653179192	0.00036046795633662036	0.00011799083539418567	0.1
0.9429672447013487	0.9693641618497111	0.0018927632663187377	0.0013296891851486028	0.1
0.9450867052023122	0.9716763005780346	0.0024637209735153156	0.0010619175185476257	0.1
0.9532755298651252	0.9835260115606936	0.0025452494823935893	0.0019423742922596995	0.1
0.9555876685934489	1.0	0.0010899526492278184	0.0	1
0.9555876685934489	1.0	0.0010899526492278184	0.0	100
0.9555876685934489	1.0	0.0010899526492278184	0.0	100
0.9555876685934489	1.0	0.0010899526492278184	0.0	0.1
0.9555876685934489	1.0	0.0010899526492278184	0.0	10
0.9555876685934489	1.0	0.0010899526492278184	0.0	10
0.9560693641618497	0.9995183044315992	0.0014737050617320017	0.00024561751028868875	1
0.9564547206165703	1.0	0.0028153447391526852	0.0	1
0.9564547206165703	1.0	0.0028153447391526852	0.0	10
0.9564547206165703	1.0	0.0028153447391526852	0.0	10
0.9564547206165703	1.0	0.0028153447391526852	0.0	1
0.9564547206165703	1.0	0.0028153447391526852	0.0	1
0.9564547206165703	1.0	0.0028153447391526852	0.0	100
0.9564547206165703	1.0	0.0028153447391526852	0.0	0.1
0.9564547206165703	1.0	0.0028153447391526852	0.0	0.1
0.9564547206165703	1.0	0.0028153447391526852	0.0	100
0.9564547206165703	1.0	0.0028153447391526852	0.0	100
0.9564547206165703	1.0	0.0028153447391526852	0.0	10
0.9564547206165703	1.0	0.0028153447391526852	0.0	0.1
0.9565510597302505	1.0	0.0029125657914895902	0.0	10
0.9565510597302505	1.0	0.0029125657914895902	0.0	100
0.9565510597302505	1.0	0.002755366020438353	0.0	10
0.9565510597302505	1.0	0.0029125657914895902	0.0	10
0.9565510597302505	1.0	0.0029125657914895902	0.0	100
0.9565510597302505	1.0	0.002755366020438353	0.0	100
0.9565510597302505	1.0	0.002755366020438353	0.0	10
0.9565510597302505	1.0	0.002755366020438353	0.0	100
0.9565510597302505	1.0	0.0029125657914895902	0.0	100
0.9565510597302505	1.0	0.002755366020438353	0.0	100
0.9565510597302505	1.0	0.002755366020438353	0.0	10
0.9565510597302505	1.0	0.002755366020438353	0.0	1
0.9565510597302505	1.0	0.0029125657914895902	0.0	10
0.9565510597302505	1.0	0.0029125657914895902	0.0	0.1
0.9565510597302505	1.0	0.002755366020438353	0.0	0.1
0.9565510597302505	1.0	0.0029125657914895902	0.0	0.1
0.9565510597302505	1.0	0.002755366020438353	0.0	0.1
0.9565510597302505	1.0	0.0029125657914895902	0.0	0.1
0.9565510597302505	1.0	0.002755366020438353	0.0	0.1
0.9565510597302505	1.0	0.002755366020438353	0.0	1
0.9565510597302505	1.0	0.0029125657914895902	0.0	1
0.9565510597302505	1.0	0.0029125657914895902	0.0	1
0.9565510597302505	1.0	0.002755366020438353	0.0	1
0.9565510597302505	1.0	0.0029125657914895902	0.0	1
0.9565510597302505	1.0	0.002755366020438353	0.0	100
0.9566473988439307	1.0	0.0024862211754458265	0.0	10
0.9570327552986513	0.9974470134874759	0.000758574939692837	0.000379287469846435	1
0.9578998073217726	1.0	0.0025011088604522777	0.0	1
0.9578998073217726	1.0	0.0025011088604522777	0.0	10

meantestscore	meantrainscore	stdtestscore	stdtrainscore	paramC
0.10568400770712909	1.0	0.0009537085680743411	0.0	0.1
0.13468208092485548	1.0	0.045575019785118166	0.0	1
0.1359344894026975	1.0	0.0453049982891233	0.0	10
0.1359344894026975	1.0	0.0453049982891233	0.0	100
0.1569364161849711	1.0	0.005442946779123517	0.0	1
0.16676300578034683	1.0	0.005218343955279707	0.0	10
0.16676300578034683	1.0	0.005218343955279707	0.0	100
0.3787090558766859	0.671242774566474	0.024416216597554507	0.02037145174498435	0.1
0.7266859344894027	1.0	0.11142841932517142	0.0	0.1
0.8135838150289018	1.0	0.0054887936544293645	0.0	1
0.8251445086705202	1.0	0.0057995826371068865	0.0	10
0.8251445086705202	1.0	0.0057995826371068865	0.0	100
0.9082851637764933	0.9198940269749518	0.004467060932319708	0.0019399836768403107	0.1
0.9577071290944124	0.9848265895953757	0.0030434622348615185	0.0010081141395209977	1
0.9657032755298651	0.9998073217726398	0.00238718915093717	6.812204057676808e-05	10
0.9659922928709056	1.0	0.0019790595938510625	0.0	100

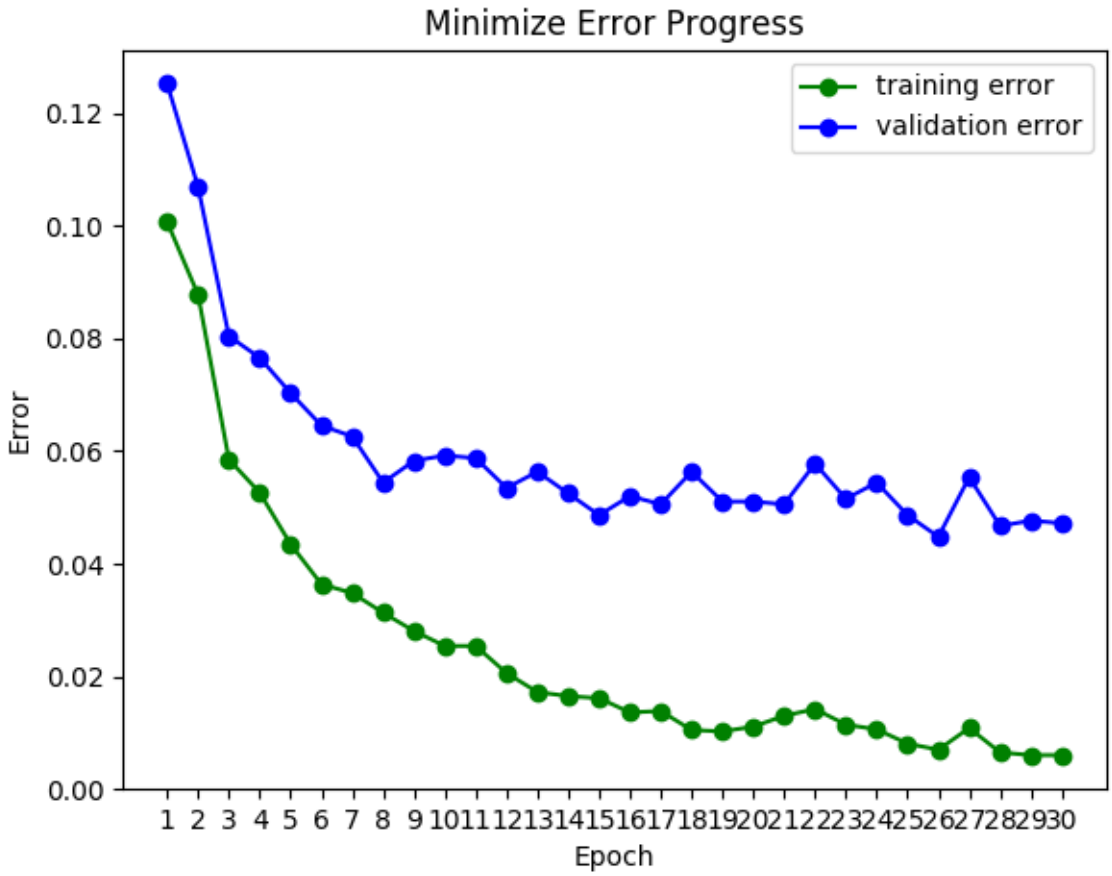
1.1 STATISTICS

2 PART II: NEURAL NETWORKS

Below is the confusion matrix for the neural network.

0	1	2	3	4	5	6	7	8	9
256	0	0	1	0	0	1	0	0	0
0	239	3	0	1	1	0	3	1	10
0	5	247	1	0	0	1	4	0	0
0	0	0	249	0	4	1	0	2	2
0	0	0	0	249	0	0	0	0	9
0	0	0	5	1	243	0	0	5	4
2	0	0	0	0	2	250	0	4	0
0	2	0	1	1	1	0	252	0	1
0	2	2	2	0	1	2	1	245	3
0	3	0	3	6	0	0	4	0	242

Below is the accuracy
train accuracy test accuracy
0.9854527938342967 0.958139534883721



2.1 Statistics

2.2 Theory

Parameters in a neural network:
U: 256(h) x 10(number of output nodes)
W: 786(input dimension) x 256(h)
b1: 256(h)
b2: 10 (number of output nodes)
Total parameters are the sum of the above.

Operations in a forwad pass:
Each parameter is used exactly once in a forward pass. Assuming we have N inputs (images) then we simply use N times the above number of operations.

3 PART III: CONVOLUTIONAL NEURAL NETWORKS

3.1 STATISTICS

Below is the confusion matrix for the neural network.

0	1	2	3	4	5	6	7	8	9
256	0	0	0	0	0	1	0	0	1
0	253	0	0	0	0	0	2	0	3
0	1	255	0	0	0	0	1	1	0
0	0	0	254	0	3	0	0	1	0
0	0	0	0	250	0	0	2	0	6
0	1	0	3	0	252	0	0	0	2
1	0	0	0	0	4	251	0	2	0
0	3	0	1	0	0	0	253	0	1
0	1	2	0	0	1	1	0	252	1
0	2	0	1	1	1	0	1	0	252

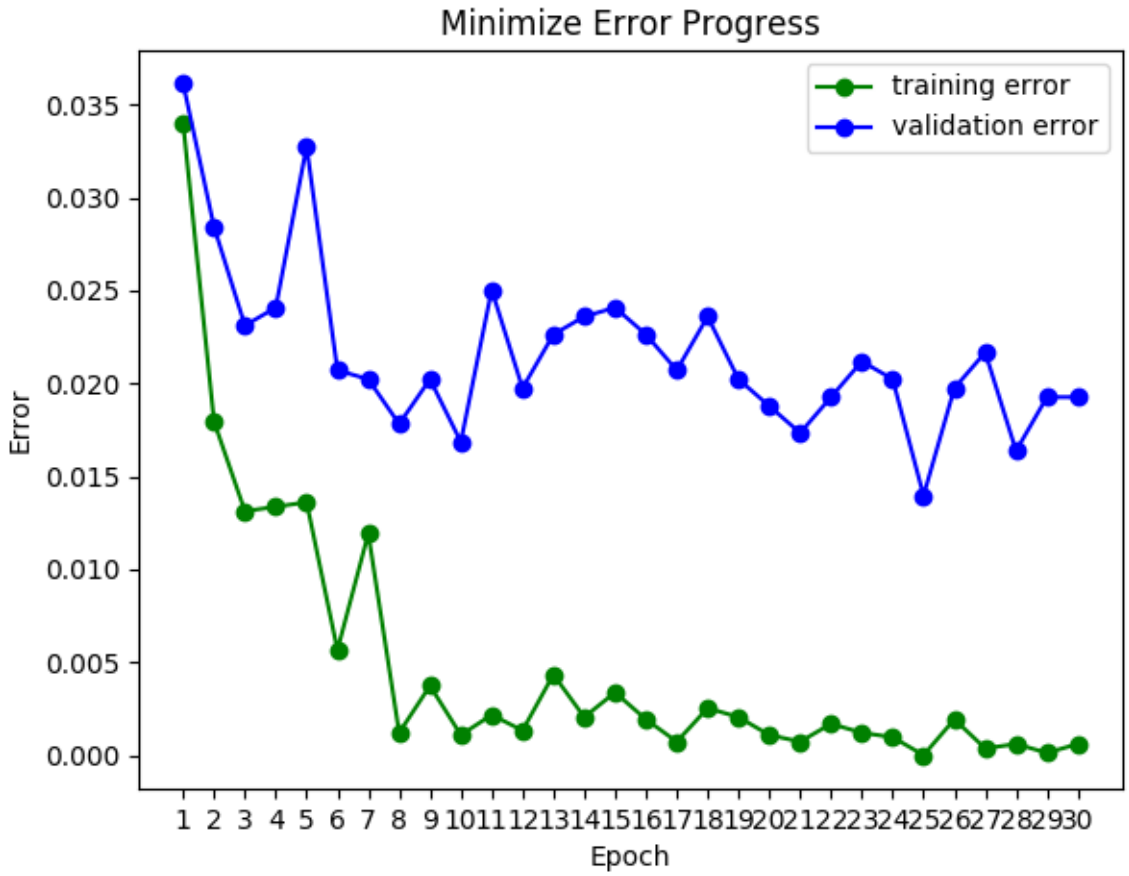
Below is the accuracy
train accuracy test accuracy
0.9972061657032756, 0.9798449612403101

3.2 STATISTICS

3.3 THEORY

Parameters in a convolutional neural network:
First convolution: 5 x 5 x 32 (assuming same weights all over the image)
Second convolution: 5 x 5 x 32 x 64
W-matrix: 7 x 7 x 64 x 1064(hidden layer size)??
U-matrix: 1064 x 10
b1: 32
b2: 64
b3: 1064
b4: 10

Operations in convolutional neural networks:
First convolution: 5 x 5 x 28 x 28 x 32
Adding b1: 32 x 28 x 28
First relu: 32 x 28 x 28
Pool 1: 4 x 14 x 14 x 32 (assuming 4 operations for each small pool)
Second convolution: 5 x 5 x 14 x 14 x 32 x 64
Adding b2: 64 x 14 x 14
Second relu: 64 x 14 x 14
Pool 2: 4 x 7 x 7 x 64



Matrix mul: 7 x 7 x 64 x 1064
Adding b3: 1064
Third relu: 1064
Matrix mul: 1064 x 10
Adding b4: 10
This was for one input.