IA

- práctica 5 -

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1.1 Perceptron

Para el perceptron se han hecho multiples pruebas y se ha sacado la media para tener un resultado lo más correcto posible, la primera linea es la combinación de opciones, la segunda linea especifica la columna de los datos y las siguientes son las distintas pruebas, en donde la última linea es la media de los resultados:

EarlyStopping	sigmoid	SGD	categorical_crossentropy
Time	Accuracy Tr	Accuracy Test	
16,157	90	90,7	
16,042	90,01	90,52	
16,278	89,96	90,71	
16,324	89,97	90,56	
16,19950344356 66	89,9849952 769906	90,622422543 929	

EarlyStopping	softmax	SGD	categorical_crossentropy
Time	Accuracy Tr	Accuracy Test	
15,13	90,12	90,86	
14,944	90,1	90,67	
14,938	90,14	90,82	
14,923	90,12	90,82	
14,98327330480 36	90,1199977 807367	90,792441924 1184	

EarlyStopping	sigmoid	RMSprop	categorical_crossentropy
Time	Accuracy Tr	Accuracy Test	
18,119	93,16	92,78	
18,846	93,28	92,63	
17,879	93,17	92,6	
18,27219564482 09	93,2033016 352407	92,669933131 7728	

EarlyStopping	softmax	RMSprop	categorical_crossentropy
Time	Accuracy Tr	Accuracy Test	
16,653	93,21	92,63	
17,012	93,12	92,76	
16,888	93,3	92,77	
16,84968046231 69	93,2099420 662839	92,719956119 4029	

EarlyStopping Time	sigmoid Accuracy Tr	Adam Accuracy Test	categorical_crossentropy
18,038	93,25	92,75	
17,943	93,33	92,83	
17,699	93,31	92,67	
17,89218957911 51	93,2966542 784648	92,749953998 1917	

EarlyStopping Time	softmax Accuracy Tr	Adam Accuracy Test	Categorical crossentropy
16,867	93,26	92,8	
16,519	93,19	92,62	
16,904	93,28	92,64	
16,76152631071 17	93,2433173 618048	92,686596698 8122	

sigmoid RMSprop mean_squared_error

Training time: 15.144135000000002

Accuracy train: 92.41999983787537

Accuracy test: 92.39000082015991

sigmoid Adam mean_squared_error

Training time: 14.786914

Accuracy train: 92.330002784729

Accuracy test: 92.35000014305115

softmax RMSprop mean_squared_error

Training time: 15.850992000000005

Accuracy train: 93.78666877746582

Accuracy test: 93.07000041007996

softmax Adam mean_squared_error

Training time: 15.671536000000003

Accuracy train: 93.99166703224182

Accuracy test: 93.19000244140625

1.2. Resultados

Gracias a las pruebas del perceptron podemos hacer varias hipotesis. SGD es un peor optimizador que Adam y RMSprop. Con una sola neurona, parece que la función de activación importa, pero no mucho. Por otro lado, la función de coste de la media del error al cuadrado mejora significativamente los resultados de las combinaciones.

2.1 Multicapa con una capa oculta.

Dos capas	earlyStopping	Capa oculta relu
softmax SGD mean_squared_error 128		**softmax SGD mean_squared_error 64**
Training time: 33.317894		Training time: 23.30974
Accuracy train: 77.65499949455261		Accuracy train: 72.680002450943
Accuracy test: 78.51999998092651		Accuracy test: 73.11000227928162
softmax RMSprop mean_squared_error 128		**softmax RMSprop mean_squared_error 64**
Training time: 44.454765		Training time: 29.749688
Accuracy train: 99.48333501815796		Accuracy train: 99.0066647529602
Accuracy test: 97.7400004863739		Accuracy test: 97.53999710083008

softmax Adam mean_squared_error 128

Training time:
38.35821100000001

Accuracy train:
99.54000115394592

Accuracy test:
97.9099988937378

softmax SGD categorical_crossentropy 128

Training time:
35.07533699999999

Accuracy train:
93.6383306980133

Accuracy test: 93.75

softmax RMSprop categorical_crossentropy 128

Training time:
37.668443999999994

Accuracy train:
99.51333403587341

Accuracy test:
97.78000116348267

softmax Adam categorical_crossentropy 128

Training time: 32.613226

Accuracy train:
99.71166849136353

softmax Adam mean_squared_error 64

Training time:
28.287138999999996

Accuracy train:
99.14166927337646

Accuracy test:
97.50999808311462

softmax SGD categorical_crossentropy 64

Training time: 25.780653

Accuracy train:
92.81166791915894

Accuracy test:
92.79000163078308

softmax RMSprop categorical_crossentropy 64

Training time:
30.353694999999988

Accuracy train:
99.3149995803833

Accuracy test:
97.39000201225281

softmax Adam categorical_crossentropy 64

Training time:
28.355664999999988

Accuracy train:
99.40833449363708

Accuracy test:
97.83999919891357

**sigmoid SGD
mean_squared_error 128**

Training time:
34.89066700000001

Accuracy train:
77.07499861717224

Accuracy test:
77.97999978065491

**sigmoid RMSprop
mean_squared_error 128**

Training time:
44.090851999999984

Accuracy train:
99.18666481971741

Accuracy test:
98.00999760627747

**sigmoid Adam
mean_squared_error 128**

Training time:
38.04436300000003

Accuracy train:
99.194997549057

Accuracy test:
97.9200005531311

**sigmoid SGD
categorical_crossentropy
128**

Training time:
36.79341900000003

Accuracy train:
93.25666427612305

Accuracy test:
97.32000231742859

**sigmoid SGD
mean_squared_error 64**

Training time:
25.483953999999983

Accuracy train:
73.27166795730591

Accuracy test:
74.14000034332275

**sigmoid RMSprop
mean_squared_error 64**

Training time:
29.904609000000022

Accuracy train:
98.6383318901062

Accuracy test:
97.42000102996826

**sigmoid Adam
mean_squared_error 64**

Training time:
29.740471999999983

Accuracy train:
98.54833483695984

Accuracy test:
97.17000126838684

**sigmoid SGD
categorical_crossentropy
64**

Training time:
29.09911199999999

Accuracy train:
93.19833517074585

Accuracy test:
93.4000015258789

**sigmoid RMSprop
categorical_crossentropy
128**

Training time:
39.14729299999999

Accuracy train:
99.39833283424377

Accuracy test:
97.93999791145325

**sigmoid Adam
categorical_crossentropy
128**

Training time:
31.85119500000002

Accuracy train:
99.44833517074585

Accuracy test:
97.75999784469604

Dos capas   dropout

**softmax SGD
mean_squared_error 128**

Training time:
39.90108999999996

Accuracy train:
78.96999716758728

Accuracy test:
79.96000051498413

**softmax RMSprop
mean_squared_error 128**

Training time:
50.866808999999996

Accuracy test:
93.09999942779541

**sigmoid RMSprop
categorical_crossentropy
64**

Training time:
34.29400599999997

Accuracy train:
98.99166822433472

Accuracy test:
97.36999869346619

**sigmoid Adam
categorical_crossentropy
64**

Training time:
31.838074000000006

Accuracy train:
98.9216685295105

Accuracy test:
97.03999757766724

**softmax SGD
mean_squared_error 64**

Training time:
27.391080999999996

Accuracy train:
70.65500020980835

Accuracy test:
71.1899995803833

**softmax RMSprop
mean_squared_error 64**

Training time: 32.908857

Accuracy train:
99.18166399002075

Accuracy test:
97.94999957084656

**softmax Adam
mean_squared_error 128**

Training time: 43.632373

Accuracy train:
99.2983341217041

Accuracy test:
97.82000184059143

**softmax SGD
categorical_crossentropy
128**

Training time:
40.36688900000015

Accuracy train:
93.41999888420105

Accuracy test:
93.51999759674072

**softmax RMSprop
categorical_crossentropy
128**

Training time:
50.124807000000004

Accuracy train:
99.42833185195923

Accuracy test:
98.01999926567078

**softmax Adam
categorical_crossentropy
128**

Training time:

Accuracy train:
98.416668176651

Accuracy test:
97.45000004768372

**softmax Adam
mean_squared_error 64**

Training time:
30.158513000000013

Accuracy train:
98.65666627883911

Accuracy test:
97.17000126838684

**softmax SGD
categorical_crossentropy
64**

Training time:
27.647940000000006

Accuracy train:
93.50666403770447

Accuracy test:
93.55000257492065

**softmax RMSprop
categorical_crossentropy
64**

Training time: 32.191216

Accuracy train:
98.68166446685791

Accuracy test:
97.47999906539917

**softmax Adam
categorical_crossentropy
64**

Training time:

43.37372099999999

Accuracy train:
99.54833388328552

Accuracy test:
98.00000190734863

**sigmoid SGD
mean_squared_error 128**

Training time: 39.928855

Accuracy train:
75.59333443641663

Accuracy test:
75.94000101089478

**sigmoid RMSprop
mean_squared_error 128**

Training time:
49.44473900000003

Accuracy train:
98.81166815757751

Accuracy test:
97.9099988937378

**sigmoid Adam
mean_squared_error 128**

Training time:
43.55064399999998

Accuracy train:
98.7833321094513

Accuracy test:
97.78000116348267

**sigmoid SGD
categorical_crossentropy
128**

Training time:

30.239071999999993

Accuracy train:
99.00500178337097

Accuracy test:
97.51999974250793

**sigmoid SGD
mean_squared_error 64**

Training time:
27.292131000000012

Accuracy train:
70.41166424751282

Accuracy test:
71.17999792098999

**sigmoid RMSprop
mean_squared_error 64**

Training time: 32.289356

Accuracy train:
97.79000282287598

Accuracy test:
97.11999893188477

**sigmoid Adam
mean_squared_error 64**

Training time:
29.91670099999999

Accuracy train:
97.9283332824707

Accuracy test:
97.02000021934509

**sigmoid SGD
categorical_crossentropy
64**

Training time:

41.975355000000036

Accuracy train:
93.51500272750854

Accuracy test:
93.80000233650208

**sigmoid RMSprop
categorical_crossentropy
128**

Training time:
51.42113899999998

Accuracy train:
99.3233323097229

Accuracy test:
97.89000153541565

**sigmoid Adam
categorical_crossentropy
128**

Training time:
45.05565300000001

Accuracy train:
99.54000115394592

Accuracy test:
98.089998960495

Dos capas   dropout

**softmax SGD
mean_squared_error 128**

Training time:
44.087824999999995

Accuracy train:
41.10333323478699

Accuracy test:
41.08000099658966

**softmax RMSprop

30.080921999999987

Accuracy train:
93.11166405677795

Accuracy test:
93.36000084877014

**sigmoid RMSprop
categorical_crossentropy
64**

Training time:
34.647130000000004

Accuracy train:
98.62499833106995

Accuracy test:
97.26999998092651

**sigmoid Adam
categorical_crossentropy
64**

Training time:
31.595039999999983

Accuracy train:
98.84166717529297

Accuracy test:
97.61000275611877

**softmax SGD
mean_squared_error 64**

Training time: 25.544432

Accuracy train:
41.153332591056824

Accuracy test:
41.839998960494995

**softmax RMSprop

mean_squared_error 128**

Training time: 54.218033

Accuracy train:
98.43500256538391

Accuracy test:
97.49000072479248

**softmax Adam
mean_squared_error 128**

Training time: 51.456023

Accuracy train:
98.53000044822693

Accuracy test:
97.3800003528595

**softmax SGD
categorical_crossentropy
128**

Training time:
38.88702699999999

Accuracy train:
88.86666893959045

Accuracy test:
89.38999772071838

**softmax RMSprop
categorical_crossentropy
128**

Training time:
47.77428100000003

Accuracy train:
98.50000143051147

Accuracy test:
97.60000109672546

**softmax Adam

mean_squared_error 64**

Training time: 32.221284

Accuracy train:
97.34833240509033

Accuracy test:
96.4900016784668

**softmax Adam
mean_squared_error 64**

Training time:
30.178510000000003

Accuracy train:
97.65499830245972

Accuracy test:
96.56999707221985

**softmax SGD
categorical_crossentropy
64**

Training time:
28.348211000000006

Accuracy train:
88.62166404724121

Accuracy test:
89.30000066757202

**softmax RMSprop
categorical_crossentropy
64**

Training time:
32.811518999999976

Accuracy train:
97.60333299636841

Accuracy test:
96.86999917030334

**softmax Adam

categorical_crossentropy
128**

Training time:
41.88265100000001

Accuracy train:
98.74666929244995

Accuracy test:
97.61000275611877

**sigmoid SGD
mean_squared_error 128**

Training time:
38.30607500000002

Accuracy train:
36.45166754722595

Accuracy test:
36.6100013256073

**sigmoid RMSprop
mean_squared_error 128**

Training time: 47.795276

Accuracy train:
97.52166867256165

Accuracy test:
96.74999713897705

**sigmoid Adam
mean_squared_error 128**

Training time:
41.76147400000002

Accuracy train:
97.44666814804077

Accuracy test:
96.71000242233276

**sigmoid SGD

categorical_crossentropy
64**

Training time:
30.096490999999986

Accuracy train:
97.86666631698608

Accuracy test:
96.82999849319458

**sigmoid SGD
mean_squared_error 64**

Training time:
27.292911000000004

Accuracy train:
42.26166605949402

Accuracy test:
44.359999895095825

**sigmoid RMSprop
mean_squared_error 64**

Training time:
32.98433899999998

Accuracy train:
96.3533341884613

Accuracy test:
95.78999876976013

**sigmoid Adam
mean_squared_error 64**

Training time: 30.063964

Accuracy train:
96.069997549057

Accuracy test:
95.46999931335449

**sigmoid SGD

categorical_crossentropy
128**

Training time:
40.01716499999998

Accuracy train:
88.54166865348816

Accuracy test:
89.28999900817871

**sigmoid RMSprop
categorical_crossentropy
128**

Training time:
49.82473599999997

Accuracy train:
98.25833439826965

Accuracy test:
97.2100019454956

**sigmoid Adam
categorical_crossentropy
128**

Training time:
43.63503000000003

Accuracy train:
98.40166568756104

Accuracy test:
97.26999998092651

categorical_crossentropy
64**

Training time:
30.022293999999988

Accuracy train:
88.0649983882904

Accuracy test:
88.73000144958496

**sigmoid RMSprop
categorical_crossentropy
64**

Training time:
34.83771899999999

Accuracy train:
97.14166522026062

Accuracy test:
96.29999995231628

**sigmoid Adam
categorical_crossentropy
64**

Training time:
31.589635000000044

Accuracy train:
97.22999930381775

Accuracy test:
96.42999768257141

Función de coste de regularización:

Dos capas dropout Capa oculta relu

L2
**softmax relu empty
RMSprop
categorical_crossentropy
128**

L1
**softmax relu empty
RMSprop
categorical_crossentropy
128**

Training time: 46.107481

Accuracy train:
90.7450020313263

Accuracy test:
90.9600019454956

**softmax relu empty
Adam
categorical_crossentropy
128**

Training time: 42.107277

Accuracy train:
91.03999733924866

Accuracy test:
91.28999710083008

**sigmoid relu empty
RMSprop
categorical_crossentropy
128**

Training time:
50.55031300000002

Accuracy train:
90.23333191871643

Accuracy test:
90.46000242233276

**sigmoid relu empty
Adam
categorical_crossentropy
128**

Training time:
44.46426099999999

Accuracy train:
90.77333211898804

Accuracy test:

Training time:
58.290407

Accuracy train:
84.43999886512756

Accuracy test:
84.83999967575073

**softmax relu empty
Adam
categorical_crossentropy
128**

Training time:
102.35332100000001

Accuracy train:
84.39499735832214

Accuracy test:
84.93000268936157

**sigmoid relu empty
RMSprop
categorical_crossentropy
128**

Training time:
49.13546299999999

Accuracy train:
11.236666887998581

Accuracy test:
11.349999904632568

**sigmoid relu empty
Adam
categorical_crossentropy
128**

Training time:
44.02817200000001

Accuracy train:
11.236666887998581

Accuracy test:

90.89999794960022

**softmax sigmoid
empty RMSprop
categorical_crossentropy
128**

Training time:
49.20316200000002

Accuracy train:
86.18000149726868

Accuracy test:
86.87999844551086

**softmax sigmoid
empty Adam
categorical_crossentropy
128**

Training time:
43.200874999999996

Accuracy train:
85.23666858673096

Accuracy test:
86.23999953269958

**sigmoid sigmoid
empty RMSprop
categorical_crossentropy
128**

Training time:
50.57176000000004

Accuracy train:
85.4099988937378

Accuracy test:
86.11999750137329

**sigmoid sigmoid
empty Adam
categorical_crossentropy
128**

11.349999904632568

**softmax sigmoid
empty RMSprop
categorical_crossentropy
128**

Training time:
49.310562000000004

Accuracy train:
11.236666887998581

Accuracy test:
11.349999904632568

**softmax sigmoid
empty Adam
categorical_crossentropy
128**

Training time:
43.34185299999996

Accuracy train:
11.236666887998581

Accuracy test:
11.349999904632568

**sigmoid sigmoid
empty RMSprop
categorical_crossentropy
128**

Training time:
50.78270500000002

Accuracy train:
11.236666887998581

Accuracy test:
11.349999904632568

**sigmoid sigmoid
empty Adam
categorical_crossentropy
128**

Training time: Training time:
44.45918599999999   44.59750700000001

Accuracy train: Accuracy train:
85.83666682243347   11.236666887998581

Accuracy test: Accuracy test:
86.40000224113464   11.349999904632568

softmax relu empty RMSprop categorical_crossentropy 16

Training time: 17.65788

Accuracy train: 94.50666904449463

Accuracy test: 93.77999901771545

softmax relu empty RMSprop categorical_crossentropy 256

Training time: 48.292018

Accuracy train: 99.62499737739563

Accuracy test: 98.00000190734863

softmax relu empty RMSprop categorical_crossentropy 512

Training time: 92.866116

Accuracy train: 99.75833296775818

Accuracy test: 98.18000197410583

softmax relu empty Adam categorical_crossentropy 16

Training time: 18.67625099999998

Accuracy train: 95.05333304405212

Accuracy test: 94.24999952316284

softmax relu empty Adam categorical_crossentropy 256

Training time: 58.05377300000001

Accuracy train: 99.72000122070312

Accuracy test: 98.19999933242798

softmax relu empty Adam categorical_crossentropy 512

Training time: 88.84051099999999

Accuracy train: 99.79166388511658

Accuracy test: 98.4000027179718

2.2. Resultados

Esta segunda prueba, con una multicapa, se ha intentado afirmar las hipótesis del peceptron.

Sin lugar a duda, SGD es mucho peor que RMSprop o Adam, Categorical_cossentropy ha conseguido mejores resultados con varias capas que mean_squared_error. Dropout y EarlyStop están muy por encima que cualquier combinación de regularización. Aunque la diferencia es pequeña, parece que la función de activación softmax consigue siempre mejores resultados.

Este último punto se puede argumentar porque softmax es mejor para clasificación multi-clase, la clasificación necesaria para este problema, mientras que sigmoid es mejor para clasificación con 2 clases.

La diferencia de neuronas en las capas es muy importante, cuando tenemos muchas neuronas, conseguimos mejores resultados en la precisión, pero a veces no merece la pena invertir el tiempo necesario con 512 neuronas para conseguir un resultado ligeramente mejor que con 128.

3.1. Multicapa con 2 capas ocultas

3 capas	dropout	3 capas	earlystop

softmax sigmoid sigmoid SGD mean_squared_error 128

Training time: 45.241248

Accuracy train: 11.441666632890701

Accuracy test: 11.580000072717667

softmax sigmoid sigmoid RMSprop mean_squared_error 128

Training time: 55.302801

Accuracy train: 98.95166754722595

Accuracy test: 97.75000214576721

softmax sigmoid sigmoid Adam mean_squared_error 128

Training time: 48.973489

Accuracy train: 99.07733254814148

Accuracy test: 97.58999943733215

softmax sigmoid sigmoid SGD categorical_crossentropy 128

Training time: 47.41760200000002

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softmax sigmoid sigmoid SGD mean_squared_error 128

Training time: 35.095081

Accuracy train: 14.193333685398102

Accuracy test: 13.79999965429306

softmax sigmoid sigmoid RMSprop mean_squared_error 128

Training time: 45.657131

Accuracy train: 99.1266667842865

Accuracy test: 97.63000011444092

softmax sigmoid sigmoid Adam mean_squared_error 128

Training time: 42.245982

Accuracy train: 99.31166768074036

Accuracy test: 97.53000140190125

softmax sigmoid sigmoid SGD categorical_crossentropy 128

Training time: 38.881789999999995

Accuracy train:
83.40333104133606

Accuracy test:
83.63999724388123

**softmax sigmoid sigmoid
RMSprop
categorical_crossentropy 128**

Training time: 54.548383

Accuracy train:
99.34166669845581

Accuracy test:
97.76999950408936

**softmax sigmoid sigmoid
Adam categorical_crossentropy
128**

Training time:
48.00539600000002

Accuracy train:
99.48833584785461

Accuracy test:
97.83999919891357

**sigmoid sigmoid sigmoid
SGD mean_squared_error
128**

Training time:
44.22924599999999

Accuracy train:
11.283333599567413

Accuracy test:
11.469999700784683

**sigmoid sigmoid sigmoid
RMSprop mean_squared_error
128**

Accuracy train:
84.88166928291321

Accuracy test:
85.36999821662903

**softmax sigmoid sigmoid
RMSprop
categorical_crossentropy 128**

Training time:
49.851440999999994

Accuracy train:
99.37333464622498

Accuracy test: 97.680002450943

**softmax sigmoid sigmoid
Adam categorical_crossentropy
128**

Training time: 44.65960599999997

Accuracy train:
99.59666728973389

Accuracy test:
97.79999852180481

**sigmoid sigmoid sigmoid SGD
mean_squared_error 128**

Training time: 40.96781500000003

Accuracy train:
12.858332693576813

Accuracy test:
13.519999384880066

**sigmoid sigmoid sigmoid
RMSprop mean_squared_error
128**

Training time:
55.399918000000014

Accuracy train:
98.72166514396667

Accuracy test:
97.60000109672546

**sigmoid sigmoid sigmoid
Adam mean_squared_error
128**

Training time:
48.62758299999996

Accuracy train:
98.82166385650635

Accuracy test:
97.4399983882904

**sigmoid sigmoid sigmoid
SGD categorical_crossentropy
128**

Training time:
45.73524900000001

Accuracy train:
78.4916639328003

Accuracy test:
78.8100004196167

**sigmoid sigmoid sigmoid
RMSprop
categorical_crossentropy 128**

Training time:
57.63645900000006

Accuracy train:
99.24333095550537

Accuracy test:
97.78000116348267

Training time: 52.18064599999997

Accuracy train:
98.95166754722595

Accuracy test:
97.64000177383423

**sigmoid sigmoid sigmoid
Adam mean_squared_error 128**

Training time:
46.208797000000004

Accuracy train:
99.11333322525024

Accuracy test:
97.60000109672546

**sigmoid sigmoid sigmoid SGD
categorical_crossentropy 128**

Training time:
43.111522000000036

Accuracy train:
83.15500020980835

Accuracy test:
83.53999853134155

**sigmoid sigmoid sigmoid
RMSprop
categorical_crossentropy 128**

Training time: 54.98299700000001

Accuracy train:
99.39333200454712

Accuracy test:
97.68999814987183

sigmoid sigmoid sigmoid Adam categorical_crossentropy 128

Training time:
49.94719699999996

Accuracy train:
99.47999715805054

Accuracy test:
97.71000146865845

softmax sigmoid relu SGD mean_squared_error 128

Training time:
44.67385200000001

Accuracy train:
33.08333456516266

Accuracy test:
34.07999873161316

softmax sigmoid relu RMSprop mean_squared_error 128

Training time:
55.53436799999997

Accuracy train:
99.38666820526123

Accuracy test:
97.8600025177002

softmax sigmoid relu Adam mean_squared_error 128

Training time:
48.74879199999998

Accuracy train:
99.40166473388672

Accuracy test:
97.7400004863739

sigmoid sigmoid sigmoid Adam categorical_crossentropy 128

Training time: 47.65179999999998

Accuracy train:
99.65333342552185

Accuracy test:
97.86999821662903

softmax sigmoid relu SGD mean_squared_error 128

Training time: 41.81917999999996

Accuracy train:
36.23333275318146

Accuracy test:
36.75000071525574

softmax sigmoid relu RMSprop mean_squared_error 128

Training time: 52.34720200000004

Accuracy train:
99.55666661262512

Accuracy test:
98.15000295639038

softmax sigmoid relu Adam mean_squared_error 128

Training time: 39.25638600000002

Accuracy train:
99.51000213623047

Accuracy test:
97.82999753952026

softmax sigmoid relu SGD categorical_crossentropy 128

Training time:
44.40917200000001

Accuracy train:
91.00833535194397

Accuracy test:
91.38000011444092

softmax sigmoid relu RMSprop categorical_crossentropy 128

Training time:
55.592201000000045

Accuracy train:
99.57333207130432

Accuracy test:
97.8600025177002

softmax sigmoid relu Adam categorical_crossentropy 128

Training time: 48.933448

Accuracy train:
99.6999979019165

Accuracy test:
97.83999919891357

sigmoid sigmoid relu SGD mean_squared_error 128

Training time:
44.344850000000065

Accuracy train:
36.996665596961975

Accuracy test:
36.970001459121704

softmax sigmoid relu SGD categorical_crossentropy 128

Training time: 41.74820599999998

Accuracy train:
91.16166830062866

Accuracy test: 91.4900004863739

softmax sigmoid relu RMSprop categorical_crossentropy 128

Training time: 42.54780500000004

Accuracy train:
99.68166947364807

Accuracy test:
97.93999791145325

softmax sigmoid relu Adam categorical_crossentropy 128

Training time: 44.83085700000004

Accuracy train:
99.70666766166687

Accuracy test:
97.87999987602234

sigmoid sigmoid relu SGD mean_squared_error 128

Training time: 41.89986099999999

Accuracy train:
32.90333449840546

Accuracy test:
32.21000134944916

sigmoid sigmoid relu RMSprop mean_squared_error 128

Training time: 55.453410000000076

Accuracy train: 99.38666820526123

Accuracy test: 98.00999760627747

sigmoid sigmoid relu Adam mean_squared_error 128

Training time: 48.57122800000002

Accuracy train: 99.4533360004425

Accuracy test: 98.01999926567078

sigmoid sigmoid relu SGD categorical_crossentropy 128

Training time: 45.90963099999999

Accuracy train: 90.59500098228455

Accuracy test: 90.85999727249146

sigmoid sigmoid relu RMSprop categorical_crossentropy 128

Training time: 56.94945400000006

Accuracy train: 99.64500069618225

Accuracy test: 97.85000085830688

sigmoid sigmoid relu RMSprop mean_squared_error 128

Training time: 52.83551299999999

Accuracy train: 99.51000213623047

Accuracy test: 97.97999858856201

sigmoid sigmoid relu Adam mean_squared_error 128

Training time: 45.806276000000025

Accuracy train: 99.51833486557007

Accuracy test: 97.87999987602234

sigmoid sigmoid relu SGD categorical_crossentropy 128

Training time: 43.041058999999905

Accuracy train: 90.7966673374176

Accuracy test: 91.29999876022339

sigmoid sigmoid relu RMSprop categorical_crossentropy 128

Training time: 38.043998999999985

Accuracy train: 99.58500266075134

Accuracy test: 97.96000123023987

sigmoid sigmoid relu Adam categorical_crossentropy 128

Training time:
50.146101000000044

Accuracy train:
99.6649980545044

Accuracy test:
97.85000085830688

softmax relu sigmoid SGD mean_squared_error 128

Training time:
45.02852700000017

Accuracy train:
34.3916654586792

Accuracy test:
34.97999906539917

softmax relu sigmoid RMSprop mean_squared_error 128

Training time:
56.12204799999995

Accuracy train:
99.11166429519653

Accuracy test:
97.78000116348267

softmax relu sigmoid Adam mean_squared_error 128

Training time:
49.05182100000002

Accuracy train:
99.2816686630249

Accuracy test:
97.75999784469604

sigmoid sigmoid relu Adam categorical_crossentropy 128

Training time: 40.45360400000004

Accuracy train:
99.75333213806152

Accuracy test:
97.97999858856201

softmax relu sigmoid SGD mean_squared_error 128

Training time: 41.85748100000001

Accuracy train:
39.92833197116852

Accuracy test:
41.40999913215637

softmax relu sigmoid RMSprop mean_squared_error 128

Training time:
53.647257999999965

Accuracy train:
99.34666752815247

Accuracy test:
97.83999919891357

softmax relu sigmoid Adam mean_squared_error 128

Training time:
46.120959000000084

Accuracy train:
99.33833479881287

Accuracy test:
97.68999814987183

softmax relu sigmoid SGD categorical_crossentropy 128

Training time:
44.63972100000001

Accuracy train:
90.57666659355164

Accuracy test:
90.829998254776

softmax relu sigmoid RMSprop categorical_crossentropy 128

Training time: 55.695694

Accuracy train:
99.4350016117096

Accuracy test:
97.79000282287598

softmax relu sigmoid Adam categorical_crossentropy 128

Training time:
48.92113999999992

Accuracy train:
99.62166547775269

Accuracy test:
97.89999723434448

sigmoid relu sigmoid SGD mean_squared_error 128

Training time:
44.73445699999979

Accuracy train:
30.851668119430542

Accuracy test:
31.549999117851257

softmax relu sigmoid SGD categorical_crossentropy 128

Training time:
41.819904999999835

Accuracy train: 90.8133327960968

Accuracy test: 90.829998254776

softmax relu sigmoid RMSprop categorical_crossentropy 128

Training time: 45.06838799999991

Accuracy train:
99.21000003814697

Accuracy test:
97.61999845504761

softmax relu sigmoid Adam categorical_crossentropy 128

Training time:
41.300267000000076

Accuracy train:
99.39500093460083

Accuracy test:
97.65999913215637

sigmoid relu sigmoid SGD mean_squared_error 128

Training time:
41.683881000000156

Accuracy train:
32.659998536109924

Accuracy test:
32.12999999523163

sigmoid relu sigmoid RMSprop mean_squared_error 128

Training time:
55.92253700000015

Accuracy train:
99.1349995136261

Accuracy test:
97.93999791145325

sigmoid relu sigmoid Adam mean_squared_error 128

Training time:
48.955961000000116

Accuracy train:
99.17333126068115

Accuracy test:
97.9200005531311

sigmoid relu sigmoid SGD categorical_crossentropy 128

Training time:
46.13236400000005

Accuracy train:
90.18833041191101

Accuracy test:
90.53999781608582

sigmoid relu sigmoid RMSprop categorical_crossentropy 128

Training time:
57.409879000000046

Accuracy train:
99.36666488647461

Accuracy test:
97.78000116348267

sigmoid relu sigmoid RMSprop mean_squared_error 128

Training time: 53.06707900000015

Accuracy train:
99.26499724388123

Accuracy test: 97.9200005531311

sigmoid relu sigmoid Adam mean_squared_error 128

Training time: 46.97918400000003

Accuracy train:
99.18333292007446

Accuracy test:
97.81000018119812

sigmoid relu sigmoid SGD categorical_crossentropy 128

Training time:
44.231692000000066

Accuracy train:
90.64499735832214

Accuracy test:
91.07000231742859

sigmoid relu sigmoid RMSprop categorical_crossentropy 128

Training time: 54.57190800000012

Accuracy train:
99.54666495323181

Accuracy test:
97.81000018119812

sigmoid relu sigmoid Adam categorical_crossentropy 128

Training time: 50.115319

Accuracy train:
99.39333200454712

Accuracy test:
97.67000079154968

softmax relu relu SGD mean_squared_error 128

Training time:
44.74610299999995

Accuracy train:
72.00166583061218

Accuracy test:
72.28000164031982

softmax relu relu RMSprop mean_squared_error 128

Training time:
55.59255300000018

Accuracy train:
99.4599997997284

Accuracy test:
97.89000153541565

softmax relu relu Adam mean_squared_error 128

Training time:
49.496423999999934

Accuracy train:
99.46666955947876

Accuracy test:
98.07000160217285

sigmoid relu sigmoid Adam categorical_crossentropy 128

Training time:
47.128048000000035

Accuracy train:
99.56499934196472

Accuracy test:
97.53000140190125

softmax relu relu SGD mean_squared_error 128

Training time: 41.87453000000005

Accuracy train: 72.3716676235199

Accuracy test:
73.11000227928162

softmax relu relu RMSprop mean_squared_error 128

Training time: 45.2137909999999

Accuracy train:
99.46666955947876

Accuracy test:
97.85000085830688

softmax relu relu Adam mean_squared_error 128

Training time:
45.743024000000105

Accuracy train: 99.4949996471405

Accuracy test:
97.71999716758728

softmax relu relu SGD categorical_crossentropy 128

Training time: 44.81457

Accuracy train:
94.9500024318695

Accuracy test:
94.91000175476074

softmax relu relu RMSprop categorical_crossentropy 128

Training time:
56.06342600000016

Accuracy train:
99.55333471298218

Accuracy test:
97.65999913215637

softmax relu relu Adam categorical_crossentropy 128

Training time:
48.94770900000003

Accuracy train:
99.69499707221985

Accuracy test:
98.11000227928162

sigmoid relu relu SGD mean_squared_error 128

Training time:
44.461964999999964

Accuracy train:
69.6399986743927

Accuracy test:
70.24999856948853

sigmoid relu relu RMSprop mean_squared_error 128

softmax relu relu SGD categorical_crossentropy 128

Training time: 41.72139799999991

Accuracy train:
95.01166939735413

Accuracy test: 94.760000705719

softmax relu relu RMSprop categorical_crossentropy 128

Training time: 30.72881200000006

Accuracy train:
99.58500266075134

Accuracy test:
97.97000288963318

softmax relu relu Adam categorical_crossentropy 128

Training time: 24.80253199999993

Accuracy train:
99.50000047683716

Accuracy test:
97.76999950408936

sigmoid relu relu SGD mean_squared_error 128

Training time:
41.197799999999916

Accuracy train:
73.94166588783264

Accuracy test:
75.04000067710876

sigmoid relu relu RMSprop mean_squared_error 128

Training time:
55.481671000000006

Accuracy train:
99.54000115394592

Accuracy test:
98.089998960495

**sigmoid relu relu Adam
mean_squared_error 128**

Training time:
48.97279400000025

Accuracy train:
99.46500062942505

Accuracy test:
98.1000006198883

**sigmoid relu relu SGD
categorical_crossentropy 128**

Training time:
46.22533599999997

Accuracy train:
94.43333148956299

Accuracy test:
94.42999958992004

**sigmoid relu relu RMSprop
categorical_crossentropy 128**

Training time:
56.84057800000028

Accuracy train:
99.6999979019165

Accuracy test:
97.9200005531311

**sigmoid relu relu Adam
categorical_crossentropy 128**

Training time: 36.35967500000015

Accuracy train:
99.41166639328003

Accuracy test:
98.07000160217285

**sigmoid relu relu Adam
mean_squared_error 128**

Training time: 44.57956000000013

Accuracy train:
99.52666759490967

Accuracy test:
98.04999828338623

**sigmoid relu relu SGD
categorical_crossentropy 128**

Training time: 41.9047599999999

Accuracy train:
94.43666934967041

Accuracy test:
94.34999823570251

**sigmoid relu relu RMSprop
categorical_crossentropy 128**

Training time:
28.957222999999885

Accuracy train:
99.34333562850952

Accuracy test:
97.72999882698059

**sigmoid relu relu Adam
categorical_crossentropy 128**

Training time:
49.647547999999915

Accuracy train:
99.53833222389221

Accuracy test:
97.63000011444092

Training time:
27.344465000000127

Accuracy train:
99.24499988555908

Accuracy test:
97.46000170707703

Capas con diferentes neuronas

**softmax relu relu Adam
categorical_crossentropy
1616**

Training time: 19.633005

Accuracy train:
93.80666613578796

Accuracy test:
93.26000213623047

**softmax relu relu Adam
categorical_crossentropy 6416**

Training time:
30.728782000000024

Accuracy train:
98.36999773979187

Accuracy test:
97.04999923706055

**softmax relu relu Adam
categorical_crossentropy
1632**

Training time:
21.700129000000004

Accuracy train:
94.94166374206543

Accuracy test:
94.31999921798706

**softmax relu relu Adam
categorical_crossentropy 6432**

Training time: 32.12904400000002

Accuracy train:
98.76166582107544

Accuracy test:
97.33999967575073

**softmax relu relu Adam
categorical_crossentropy
1664**

Training time:
24.227622999999994

Accuracy train:
95.39666771888733

Accuracy test:

**softmax relu relu Adam
categorical_crossentropy 6464**

Training time: 33.50150299999996

Accuracy train:
99.03333187103271

Accuracy test:

94.45000290870667

softmax relu relu Adam categorical_crossentropy 16128

Training time: 27.545659

Accuracy train:
95.77000141143799

Accuracy test:
94.80000138282776

softmax relu relu Adam categorical_crossentropy 3216

Training time:
25.251364999999993

Accuracy train:
97.03999757766724

Accuracy test:
95.87000012397766

softmax relu relu Adam categorical_crossentropy 3232

Training time: 26.418835

Accuracy train:
97.46666550636292

Accuracy test:
96.24999761581421

softmax relu relu Adam categorical_crossentropy 3264

Training time:
27.956117000000006

Accuracy train:
97.7400004863739

97.72999882698059

softmax relu relu Adam categorical_crossentropy 64128

Training time: 38.083597

Accuracy train:
99.06833171844482

Accuracy test:
97.51999974250793

softmax relu relu Adam categorical_crossentropy 12816

Training time:
42.075226999999984

Accuracy train:
99.19666647911072

Accuracy test:
97.72999882698059

softmax relu relu Adam categorical_crossentropy 12832

Training time: 43.770398

Accuracy train:
99.36500191688538

Accuracy test:
97.93000221252441

softmax relu relu Adam categorical_crossentropy 12864

Training time: 47.08993200000003

Accuracy train: 99.4783341884613

Accuracy test:
96.46999835968018

Accuracy test:
98.00000190734863

**softmax relu relu Adam
categorical_crossentropy
32128**

**softmax relu relu Adam
categorical_crossentropy
128128**

Training time:
30.612785000000002

Training time: 52.01180499999998

Accuracy train:
97.97166585922241

Accuracy train:
99.55833554267883

Accuracy test:
96.78999781608582

Accuracy test:
97.97999858856201

3.1. Resultados

En las pruebas donde cambiamos el número de neuronas hemos reducido el número de casos y combinaciones, eligiendo las combinaciones que, anteriormente, nos han dado los mejores resultados. En concreto, la combinación softmax en la capa final, relus en las capas ocultas, optimizador Adam y coste categorical_crossentropy.

El uso de relus está justificado, dado que cuando el valor resultante de la neurona puede ser ignorado, se ignora, cosa que sigmoid no hace y siempre devuelve un valor distinto de cero, y cuando un valor es importante, cada vez es más importante, ya que la función es una pendiente, frente a la sigmoid que cuando un valor es importante, llega a un tope donde no es más importante que otro.

Volviendo a las pruebas, de nuevo, la idea es la misma, el mejor resultado es sin duda 128 neuronas en las dos capas ocultas, pero se pueden conseguir resultados muy similares con menos neuronas y en menos tiempo, como por ejemplo teniendo 64 en la primera capa y 128 en la segunda capa.

4.1. Red neuronal convolucional

acy: 0.6929
Test loss:
0.8454878926277161
Test accuracy:
0.8388000130653381