UNIVERSIDADE FEDERAL DE UBERLÂNDIA
FACULDADE DE CIÊNCIA DA COMPUTAÇÃO
Construção de Compiladores
Av. João Naves de Ávila 2121, Campus Santa Mônica

Reconhecimento de padrões em matrizes utilizando Redes Neurais Perceptron

Aluno: Eduardo Costa de Paiva **Matrícula:** 11221BCC012
Email: eduardocspv@gmail.com
Profº.: Gina Maira Barbosa de Oliveira

Sumário

UFU, Universidade Federal de Uberlândia, Minas Gerais, Brasil

1 Introdução

Esse relatório tem como objetivo explicar o uso das redes neurais perceptron para reconhecimento de padrões em matrizes (números 0,1,2,3,4,5). Para o primeiro exercício foi utilizado apenas 1 neurônio, para o segundo 2 neurônios e para o terceiro exercício foram utilizado 6 neurônios.

O sistema operacional que utilizado foi o Ubuntu 16.04 e a para o desenvolvimento foi utilizado a linguagem **Java**.

2 Especificação

Os padrões foram representados por matrizes de 6 linhas e 5 colunas salvos em arquivos **.txt**. Onde os índices marcados pelo número 1 representam o padrão desejado.

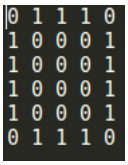

Figura 1: Número 0

Para o caso em que os pesos inicias são gerados aleatoriamente, estes foram gerados no intervalo de -1 a 1.

3 Testes realizados

3.1 Exercício 1

Pesos inicias zerados

3.1.1 Pesos após término do treinamento

```
Weights after traning process: [0.0, 0.0, -1.0, 0.0, -1.0, 0.0, -1.0, 1.0, 1.0,
0.0, -1.0, -1.0, 0.0, 1.0, 0.0, -1.0, -1.0, 0.0, 1.0, 0.0, -1.0, -1.0, 0.0, 1.0,
 0.0, -1.0, 1.0, 0.0, 0.0, 0.0, 1.0]
```

Figura 2: Pesos

3.1.2 Número de épocas e entradas distorcidas

```
Number of epochs to learn the patterns: 2
Result entry number 0: 0
Distorted 0 entrys
Result distorted entry number 0_1: 0
Result distorted entry number 0_2: 0
Result distorted entry number 0_3: 0
Result distorted entry number 0_4: 0
Result distorted entry number 0_5: 0
Result distorted entry number 0_6: 0
Result distorted entry number 0_7: 0
Result distorted entry number 0_8: 0
Result distorted entry number 0_9: 0
Result distorted entry number 0_10: 1

Result entry number 1: 1
Distorted 1 entrys
Result distorted entry number 1_1: 1
Result distorted entry number 1_2: 1
Result distorted entry number 1_3: 1
Result distorted entry number 1_4: 1
Result distorted entry number 1_5: 1
Result distorted entry number 1_6: 1
Result distorted entry number 1_7: 1
Result distorted entry number 1_8: 1
Result distorted entry number 1_9: 1
Result distorted entry number 1_10: 1
```

Figura 3: Número de épocas e resultados para entradas distorcidas

3.1.3 Saída para as entradas 2,3,4,5

```
Other entrys
Result distorted entry number 2: 1
Result distorted entry number 3: 0
Result distorted entry number 4: 0
Result distorted entry number 5: 0
```

Figura 4: Resultado para os padrões 2,3,4,5

Pesos inicias aleatórios

3.1.4 Pesos após término do treinamento iniciando-os aleatoriamente

```
Weights after traning process: [-0.11560314921218584, -0.2092334694070579, -1.405276269313143,
0.6058684245551169, -0.11817178421817509, -0.02940527220474931, -0.7468369511770554, 0.99602243
93136745, 1.2996521095214526, 0.4750178570683734, -0.2681817708380074, -0.32527860278726384, -0
.9178170468912861, 1.930656305772487, -0.5766356922110787, -0.7352591231000893, -0.524400074634
7006, 0.007974140540844887, 1.8573114638809738, -0.18340639801822123, -0.3739880103068267, -0.3
606047343435099, 0.35378872963217356, 0.5162398121349105, 0.0024758013354486685, -1.26262477318
54907, 0.060416013830176585, -0.6748428720197606, -0.44139775291050265, 0.25038113895402914, 0.
5134404204245924]
```

Figura 5: Pesos

3.1.5 Número de épocas e entradas distorcidas com pesos inicias aleatórios

```
Number of epochs to learn the patterns: 2
Result entry number 0: 0
Distorted 0 entrys
Result distorted entry number 0_1: 0
Result distorted entry number 0_2: 0
Result distorted entry number 0_3: 0
Result distorted entry number 0_4: 0
Result distorted entry number 0_5: 0
Result distorted entry number 0_6: 0
Result distorted entry number 0_7: 0
Result distorted entry number 0_8: 0
Result distorted entry number 0_9: 0
Result distorted entry number 0_10: 1

Result entry number 1: 1
Distorted 1 entrys
Result distorted entry number 1_1: 1
Result distorted entry number 1_2: 1
Result distorted entry number 1_3: 1
Result distorted entry number 1_4: 1
Result distorted entry number 1_5: 1
Result distorted entry number 1_6: 1
Result distorted entry number 1_7: 1
Result distorted entry number 1_8: 1
Result distorted entry number 1_9: 1
Result distorted entry number 1_10: 1
```

Figura 6: Número de épocas e resultados para entradas distorcidas

Em média são gastas de 2 a 3 épocas para o treinamento.

3.1.6 Saída para as entradas 2,3,4,5

```
Other entrys
Result distorted entry number 2: 1
Result distorted entry number 3: 0
Result distorted entry number 4: 0
Result distorted entry number 5: 0
```

Figura 7: Resultado para os padrões 2,3,4,5

3.2 Exercício 2

Pesos inicias zerados

3.2.1 Pesos e épocas após término do treinamento

```
Neuron 1 - Weights of after traning process: [0.0, 0.0, 1.0, 0.0, 1.0, 0.0, 1.0,
 -1.0, -1.0, 0.0, 1.0, 1.0, 0.0, -1.0, 0.0, 1.0, 1.0, 0.0, -1.0, 0.0, 1.0, 1.0,
0.0, -1.0, 0.0, 1.0, -1.0, 0.0, 0.0, 0.0, -1.0]


Neuron 1 - Number of epochs to learn the patterns : 2


Neuron 2 - Weights of Neuron1 after traning process: [0.0, 0.0, -1.0, 0.0, -1.0,
 0.0, -1.0, 1.0, 1.0, 0.0, -1.0, -1.0, 0.0, 1.0, 0.0, -1.0, -1.0, 0.0, 1.0, 0.0,
 -1.0, -1.0, 0.0, 1.0, 0.0, -1.0, 1.0, 0.0, 0.0, 0.0, 1.0]


Neuron 2 - Number of epochs to learn the patterns: 3
```

Figura 8: Pesos e épocas

3.2.2 Resultados para entradas distorcidas

```
Result entry number 0: 0
Distorted 0 entrys
Result distorted entry number 0_1: 0
Result distorted entry number 0_2: 0
Result distorted entry number 0_3: 0
Result distorted entry number 0_4: 0
Result distorted entry number 0_5: 0
Result distorted entry number 0_6: 0
Result distorted entry number 0_7: 0
Result distorted entry number 0_8: 0
Result distorted entry number 0_9: 0
Result distorted entry number 0_10: 0

Result entry number 1: 1
Distorted 1 entrys
Result distorted entry number 1_1: 1
Result distorted entry number 1_2: 1
Result distorted entry number 1_3: 1
Result distorted entry number 1_4: 1
Result distorted entry number 1_5: 0
Result distorted entry number 1_6: 1
Result distorted entry number 1_7: 1
Result distorted entry number 1_8: 1
Result distorted entry number 1_9: 1
Result distorted entry number 1_10: 1
```

Figura 9: Entradas distorcidas

3.2.3 Saída para as entradas 2,3,4,5

```
Result entry number 0: 0
Result entry number 1: 1
Result entry number 2: 1
Result entry number 3: 0
Result entry number 4: 0
Result entry number 5: 0
```

Figura 10: Resultado para os padrões 2,3,4,5

Pesos inicias aleatórios

3.2.4 Pesos e épocas após término do treinamento com pesos inicias aleatórios

```
Neuron 1 - Weights of after traning process: [-0.15383037983529602, 0.1993944127
8600478, 1.70422636628967, -0.20777424836453284, 0.9551502641061846, -0.80188983
51466333, 0.7992047411559282, -1.8253598386978014, -0.4756061416138544, 0.577664
1208972604, 0.9211205725016391, 0.7962401079772079, -0.6018784396272314, -0.9718
973012781134, -0.4953087330031962, 1.2522098901803864, 0.6074571972751084, -0.98
10496853446733, -1.929527949150899, 0.5164603960873144, 0.7049057080503243, 0.05
861076384267139, 0.4051717792424496, -0.6417836045121319, -0.15582849384426267,
0.28579449139416924, -1.4099994791743984, 0.7638773764930626, 0.9147045877102264
, 0.9098779981237191, -0.5664929243661663]


Neuron 1 - Number of epochs to learn the patterns : 3


Neuron 2 - Weights of Neuron1 after traning process: [0.39451935756978296, 0.488
8548088141653, -0.41702001590913174, 1.7480541964263456, -0.11935233007603019, 0
.47410851481173766, -0.5017830948789133, 0.738754432534722, 1.082799427952204, -
0.7271283116952347, -0.9737619350044264, -0.5997075374149168, -0.811645186061845
9, 1.2084043645173757, -0.38717874557576115, -0.5040830270456138, 0.320398243031
6936, 0.3455717362320201, 1.5151211920347651, 0.6358015255582554, 0.027755792096
588294, -0.6848515095026775, 0.44790052940910585, 0.3576478623497863, 0.96811099
80090692, -0.30635563277394073, 1.693256164602164, 0.4221426378324411, 0.1751308
042575399, 0.7675689954390916, 1.7415286117215811]


Neuron 2 - Number of epochs to learn the patterns: 2
```

Figura 11: Pesos e épocas

Em média são gastas de 2 a 3 épocas para o treinamento.

3.2.5 Resultados para entradas distorcidas

```
Result entry number 0: 0
Distorted 0 entrys
Result distorted entry number 0_1: 0
Result distorted entry number 0_2: -1
Result distorted entry number 0_3: 0
Result distorted entry number 0_4: 0
Result distorted entry number 0_5: -1
Result distorted entry number 0_6: -1
Result distorted entry number 0_7: 0
Result distorted entry number 0_8: 0
Result distorted entry number 0_9: 0
Result distorted entry number 0_10: 1

Result entry number 1: 1
Distorted 1 entrys
Result distorted entry number 1_1: 1
Result distorted entry number 1_2: 1
Result distorted entry number 1_3: 1
Result distorted entry number 1_4: -1
Result distorted entry number 1_5: -1
Result distorted entry number 1_6: -1
Result distorted entry number 1_7: 1
Result distorted entry number 1_8: 1
Result distorted entry number 1_9: -1
Result distorted entry number 1_10: -1
```

Figura 12: Entradas distorcidas

3.2.6 Saída para as entradas 2,3,4,5

```
Result entry number 0: 0
Result entry number 1: 1
Result entry number 2: 1
Result entry number 3: -1
Result entry number 4: -1
Result entry number 5: -1
```

Figura 13: Resultado para os padrões 2,3,4,5

3.3 Exercício 3

Pesos inicias zerados

3.3.1 Pesos e épocas após término do treinamento

```
Neuron1 - Weights of after traning process: [-1.0, -1.0, 1.0, 0.0, 0.0, -1.0, 1.
0, -1.0, -1.0, -1.0, 1.0, 1.0, -1.0, -2.0, -2.0, 1.0, 1.0, -1.0, -2.0, -1.0, 1.0
, 2.0, 0.0, -1.0, -1.0, 1.0, -1.0, 0.0, 0.0, -1.0, -2.0]

Neuron1 - Number of epochs to learn the patterns : 3

Neuron2 - Weights of after traning process: [0.0, 0.0, -1.0, 0.0, -1.0, 0.0, 0.0
, 0.0, 1.0, -1.0, 0.0, 0.0, 0.0, 1.0, -1.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, -
1.0, 1.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0]

Neuron2 - Number of epochs to learn the patterns : 2

Neuron3 - Weights of after traning process: [-1.0, -1.0, 0.0, 0.0, -1.0, -2.0, -
1.0, 1.0, 0.0, 1.0, -1.0, -1.0, -2.0, -2.0, -1.0, -2.0, -1.0, -1.0, 1.0, -1.0, -
2.0, 0.0, 2.0, 0.0, -1.0, -2.0, 2.0, 0.0, 0.0, -1.0, 0.0]

Neuron3 - Number of epochs to learn the patterns : 3

Neuron4 - Weights of after traning process: [-1.0, -1.0, 0.0, 0.0, -1.0, 0.0, -1
.0, -5.0, 0.0, -1.0, 5.0, -1.0, 0.0, 0.0, -1.0, 0.0, -1.0, -1.0, -1.0, -1.0, 0.0
, 0.0, 0.0, 0.0, -1.0, 0.0, 0.0, 0.0, 0.0, -1.0, 0.0]

Neuron4 - Number of epochs to learn the patterns : 6

Neuron5 - Weights of after traning process: [0.0, 1.0, -1.0, -1.0, 0.0, -1.0, 1.
0, -1.0, 0.0, 1.0, 0.0, 1.0, -1.0, -1.0, 0.0, -1.0, 1.0, 1.0, 1.0, 1.0, -1.0, 0.
0, 0.0, 0.0, 1.0, -1.0, 0.0, -1.0, -1.0, 0.0, -1.0]

Neuron5 - Number of epochs to learn the patterns : 2

Neuron6 - Weights of after traning process: [-1.0, 0.0, 0.0, -1.0, 0.0, 2.0, -1.
0, 3.0, -1.0, -1.0, -4.0, -1.0, 2.0, 1.0, 1.0, 1.0, -1.0, 0.0, -2.0, 0.0, 1.0, -
1.0, -1.0, -1.0, 0.0, 1.0, -2.0, -1.0, -1.0, -1.0, 0.0]

Neuron6 - Number of epochs to learn the patterns : 6
```

Figura 14: Pesos e épocas

3.3.2 Resultados para entradas distorcidas

```
Result entry number 0_1: 0
Result entry number 0_2: 0
Result entry number 0_3: 0
Result entry number 0_4: 0
Result entry number 0_5: 0
Result entry number 0_6: 0
Result entry number 0_7: 0
Result entry number 0_8: 0
Result entry number 0_9: 0
Result entry number 0_10: 1
Result entry number 1_1: 1
Result entry number 1_2: 1
Result entry number 1_3: 1
Result entry number 1_4: 1
Result entry number 1_5: 1
Result entry number 1_6: 1
Result entry number 1_7: 1
Result entry number 1_8: 1
Result entry number 1_9: 1
Result entry number 1_10: -1
Result entry number 2_1: 2
Result entry number 2_2: 2
Result entry number 2_3: -1
Result entry number 2_4: 2
Result entry number 2_5: 2
Result entry number 2_6: 2
Result entry number 2_7: 2
Result entry number 2_8: 2
Result entry number 2_9: -1
Result entry number 2_10: -1
```

Figura 15: Resultados para entradas distorcidas 0,1,2

```
Result entry number 3_1: 5
Result entry number 3_2: -1
Result entry number 3_3: 5
Result entry number 3_4: 3
Result entry number 3_5: 5
Result entry number 3_6: -1
Result entry number 3_7: -1
Result entry number 3_8: -1
Result entry number 3_9: -1
Result entry number 3_10: -1
Result entry number 4_1: 4
Result entry number 4_2: 4
Result entry number 4_3: 4
Result entry number 4_4: 4
Result entry number 4_5: 4
Result entry number 4_6: 4
Result entry number 4_7: 4
Result entry number 4_8: 4
Result entry number 4_9: 4
Result entry number 4_10: -1
Result entry number 5_1: 5
Result entry number 5_2: 5
Result entry number 5_3: 5
Result entry number 5_4: 5
Result entry number 5_5: 5
Result entry number 5_6: -1
Result entry number 5_7: 5
Result entry number 5_8: 5
Result entry number 5_9: 5
Result entry number 5_10: 5
```

Figura 16: Resultados para entradas distorcidas 3,4,5

3.3.3 Saída para as entradas A,E,T,H,C,N

```
Result letter A: 0
Result letter E: -1
Result letter T: -1
Result letter C: -1
Result letter H: -1
Result letter N: 1
```

Figura 17: Resultado para os padrões A,E,T,H,C,N

Pesos inicias aleatórios

3.3.4 Pesos e épocas para os neurônios 1 2 e 3, após término do treinamento com pesos inicias aleatórios

```
Neuron1 - Weights of after traning process: [-0.4849266000717305, -1.30153763530
11716, -0.8996908018116585, 0.3125137194352223, -1.2357918072596692, -1.03485050
26711405, 1.5611247063981357, -0.6540978319694197, -0.28681375791629327, -1.0462
064668720374, -0.5134478296140945, 0.7446279553642046, -2.886093459927742, -2.31
95413117100045, -2.8030406178799434, 0.18765239418067847, 1.7100534137406338, -0
.7501675656459728, -1.8570862351936168, -0.9961654824674613, 0.3597086241647436,
 2.991363064391178, -0.9132600078394397, -0.601758409304133, -1.4726649809021097
, -0.02978395850425941, -0.8238151887105167, 0.14364058759597476, -0.51594052940
92583, -0.8832374407224215, -2.593656478336363]

Neuron1 - Number of epochs to learn the patterns : 4

Neuron2 - Weights of after traning process: [0.988852861528303, -0.0029403904636
1938, -2.137965690919925, 0.07579783302804954, -1.3437603170815688, -0.563934116
7552672, -1.0937726053024057, 0.2979798684926749, 1.8492859597393538, -0.0608388
0085736082, -0.5562726979031913, -1.6643253477521662, -0.20692370318326048, 2.66
9524553685311, -1.8648908432994387, -0.15331627073284126, -0.9114673909407103, -
0.6850982799293985, 0.9981129078587738, 0.9381967515146192, -1.4697098919261147,
 -0.8980632628260445, -0.02417493419215333, 2.746957962846038, 0.625151902901208
, -0.14728916240590562, 0.9884293261029571, -0.27133694834809496, 0.209620884586
9154, 0.08208556040082948, 0.7273747383625491]

Neuron2 - Number of epochs to learn the patterns : 3

Neuron3 - Weights of after traning process: [-1.3202728298426543, -0.47083783852
755356, 1.8951518655868482, -0.3298099047246119, 0.14718674102843465, -0.9954719
506149541, -1.1445460625566408, 0.760630967994214, -1.7932352434998442, 1.309151
7923193807, -0.5891859698829502, -1.2754226038442809, -0.18460250410144452, -2.8
359712404254527, -0.5482445601060941, -1.2800627106217404, -0.8523300917867243,
-1.4771148033208714, 0.014650762748631196, -0.020147681181807098, -0.51835598321
53388, -0.31972357658107575, 1.7381310157919312, -1.482218077586874, -1.37752965
28623595, -1.4295021513386248, 0.8363115837424742, -0.849860412304666, -0.396411
36510668806, -1.1566921641611123, 0.27493200330449175]

Neuron3 - Number of epochs to learn the patterns : 4
```

Figura 18: Pesos e épocas dos neurônios 1,2,3

3.3.5 Pesos e épocas para os neurônios 4 5 e 6, após término do treinamento com pesos inicias aleatórios

```
Neuron4 - Weights of after traning process: [-0.7936247494230926, -0.14367334320
868586, -0.10105920806762292, -0.4974585440000485, -0.4094046160654059, 0.567861
9765308712, -0.23962787718329737, -2.815590999889972, -0.9568957729963374, -0.84
74809533165781, 3.6162162873580055, -0.8273288923330913, -0.18794865657846627, -
0.9315968597130366, 0.15497038173935773, -0.03479468943345232, -0.48567975190084
733, -0.8042255681374495, -0.5525397925878226, 0.6496229564251421, -0.8151161841
429309, 0.24399709871436825, -0.6581651113776523, -0.5612364732080803, -0.756289
4195175511, -0.5679877349622777, -0.20176225411686066, 0.44348737735090293, -0.1
3558594290773684, -0.18626738134583487, -0.05870941919581618]

Neuron4 - Number of epochs to learn the patterns : 4

Neuron5 - Weights of after traning process: [-0.45792137972664015, 1.22071599635
57686, -0.04732120448127919, -0.8174541773183039, 1.371940764264942, -0.36011796
136881524, 0.7510639021068954, -0.752865556311304, -0.7823956190661601, 0.327153
2691439303, -0.19557641100723466, 0.9208440397339976, -0.08086528429831907, -1.2
973395959408254, 0.31659715297641244, 0.954856767364912, 0.6026088167058228, 1.6
230089852740053, 0.25554359442488184, 1.131722920277715, 0.48590869781486457, -0
.3050915899840463, 0.049550962984458824, -0.4619830813839867, 0.3826594794857758
3, -0.855006719966098, -0.4638137283286401, -0.6086143412599065, -1.339523353166
9364, -0.5756349310179667, -0.05934102965103549]

Neuron5 - Number of epochs to learn the patterns : 2

Neuron6 - Weights of after traning process: [-2.205157177940274, -1.531356989624
4072, -0.6306269864994969, -1.3539685530677974, -1.2617302631613478, 2.894775148
117402, -1.349731589650335, 4.961857394942065, -1.9953124913405182, -1.569023560
9202026, -5.118263245346553, -1.4161484508530828, 2.3568156132569413, 0.03316178
4637138814, 0.6537783023528658, 0.1381217962612824, -1.037252417937327, -1.11866
099647112, -3.4895103835625183, -1.7430272965747868, 0.18850034870854482, -0.601
1565316097669, -0.9150514631876481, -0.0772167232492309, -0.09314556143001829, 0
.18619406710515163, -1.2999945600566662, -1.5482440570744078, -1.935999298220902
7, -2.9899880407691226, 0.7126297324274278]

Neuron6 - Number of epochs to learn the patterns : 8
```

Figura 19: Pesos e épocas dos neurônios 4,5,6

No treinamento, o neurônio com maior número de épocas é 8.

3.3.6 Resultados para entradas distorcidas

```
Result entry number 0_1: 0
Result entry number 0_2: 0
Result entry number 0_3: 0
Result entry number 0_4: 0
Result entry number 0_5: -1
Result entry number 0_6: -1
Result entry number 0_7: 0
Result entry number 0_8: 0
Result entry number 0_9: 0
Result entry number 0_10: -1
Result entry number 1_1: 1
Result entry number 1_2: -1
Result entry number 1_3: -1
Result entry number 1_4: -1
Result entry number 1_5: -1
Result entry number 1_6: -1
Result entry number 1_7: 3
Result entry number 1_8: -1
Result entry number 1_9: -1
Result entry number 1_10: -1
Result entry number 2_1: 2
Result entry number 2_2: -1
Result entry number 2_3: -1
Result entry number 2_4: 2
Result entry number 2_5: 2
Result entry number 2_6: -1
Result entry number 2_7: -1
Result entry number 2_8: 2
Result entry number 2_9: -1
Result entry number 2_10: -1
Result entry number 3_1: 3
Result entry number 3_2: 3
Result entry number 3_3: 3
Result entry number 3_4: 3
Result entry number 3_5: 3
Result entry number 3_6: -1
Result entry number 3_7: 3
Result entry number 3_8: 3
Result entry number 3_9: -1
Result entry number 3_10: 3
```

Figura 20: Resultados para entradas distorcidas 0,1,2,3

```
Result entry number 4_1: 4
Result entry number 4_2: 4
Result entry number 4_3: 4
Result entry number 4_4: 4
Result entry number 4_5: 4
Result entry number 4_6: 4
Result entry number 4_7: 4
Result entry number 4_8: -1
Result entry number 4_9: 4
Result entry number 4_10: -1
Result entry number 5_1: 5
Result entry number 5_2: 5
Result entry number 5_3: -1
Result entry number 5_4: 5
Result entry number 5_5: 5
Result entry number 5_6: 3
Result entry number 5_7: 5
Result entry number 5_8: -1
Result entry number 5_9: 5
Result entry number 5_10: -1
```

Figura 21: Resultados para entradas distorcidas 4 e 5

3.3.7 Saída para as entradas A,E,T,H,C,N

```
Result letter A: 0
Result letter E: -1
Result letter T: 1
Result letter C: -1
Result letter H: 0
Result letter N: 0
```

Figura 22: Resultado para os padrões A,E,T,H,C,N