



Int64[5, more

```

• begin
•     dataset_test = readlm(path_dataset * "test/X_test_new.txt", ' ')
•     X_test = dataset_test[:, 1:561]
•     y_test = Int.(dataset_test[:,563])
• end

```

2947×561 Array{Float64,2}:

```

0.257178 -0.0232852 -0.0146538 -0.938404 ... -0.720009 0.276801 -0.0579783
0.286027 -0.0131634 -0.119083 -0.975415 -0.698091 0.281343 -0.083898
0.275485 -0.0260504 -0.118152 -0.993819 -0.702771 0.280083 -0.0793462
0.270298 -0.0326139 -0.11752 -0.994743 -0.698954 0.284114 -0.077108
0.274833 -0.0278478 -0.129527 -0.993852 -0.692245 0.290722 -0.0738568
0.27922 -0.0186204 -0.113902 -0.994455 ... -0.689816 0.294896 -0.0684707
0.279746 -0.018271 -0.104 -0.995819 -0.690085 0.295282 -0.0670653
⋮
0.192275 -0.0336426 -0.105949 -0.354841 -0.646754 0.28215 0.181152
0.310155 -0.0533913 -0.0991087 -0.287866 -0.651732 0.274627 0.184784
0.363385 -0.039214 -0.105915 -0.305388 -0.655181 0.273578 0.182412
0.349966 0.0300774 -0.115788 -0.329638 -0.655357 0.274479 0.181184
0.237594 0.0184669 -0.0964989 -0.323114 ... -0.659719 0.264782 0.187563
0.153627 -0.0184365 -0.137018 -0.330046 -0.66008 0.263936 0.188103

```

• X\_test

Int64[5, more

• y\_test

## Utilisation de PCA pour réduire la dimension des données

Algorithme :

1. Centrer les données
2. Construire la matrice de covariance  $\Sigma$
3. Décomposer cette matrice en vecteur propres, valeur propres  $\{v_i, \lambda_i\}$
4. Ordonner les valeurs propres par ordre décroissant
5. Le sous-espace de dimension  $q$  qui représente 99% de la variance des données est utilisé pour le modèle ANN

```

• md"#### Utilisation de PCA pour réduire la dimension des données
•
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• 4. Ordonner les valeurs propres par ordre décroissant
• 5. Le sous-espace de dimension  $q$  qui représente 99% de la variance des données est
utilisé pour le modèle ANN
• "

```

$\mu$  = 1×561 Array{Float64,2}:

```

0.274488 -0.0176954 -0.109141 -0.605438 ... -0.489547 0.058593 -0.0565147

```

```

• # Calcul de la moyenne de chaque colonne
•  $\mu$  = mean(X_train, dims=1)

```

```

M = 7352×561 Array{Float64,2}:
 0.274488 -0.0176954 -0.109141 -0.605438 ... -0.489547 0.058593 -0.0565147
 0.274488 -0.0176954 -0.109141 -0.605438 ... -0.489547 0.058593 -0.0565147
 0.274488 -0.0176954 -0.109141 -0.605438 ... -0.489547 0.058593 -0.0565147
 0.274488 -0.0176954 -0.109141 -0.605438 ... -0.489547 0.058593 -0.0565147
 0.274488 -0.0176954 -0.109141 -0.605438 ... -0.489547 0.058593 -0.0565147
 0.274488 -0.0176954 -0.109141 -0.605438 ... -0.489547 0.058593 -0.0565147
 0.274488 -0.0176954 -0.109141 -0.605438 ... -0.489547 0.058593 -0.0565147
 ⋮
 0.274488 -0.0176954 -0.109141 -0.605438 ... -0.489547 0.058593 -0.0565147
 0.274488 -0.0176954 -0.109141 -0.605438 ... -0.489547 0.058593 -0.0565147
 0.274488 -0.0176954 -0.109141 -0.605438 ... -0.489547 0.058593 -0.0565147
 0.274488 -0.0176954 -0.109141 -0.605438 ... -0.489547 0.058593 -0.0565147
 0.274488 -0.0176954 -0.109141 -0.605438 ... -0.489547 0.058593 -0.0565147
 0.274488 -0.0176954 -0.109141 -0.605438 ... -0.489547 0.058593 -0.0565147

```

```
• M = repeat(μ, length(y_train), 1)
```

```

X̄ = 7352×561 Array{Float64,2}:
 0.0140964 -0.00259874 -0.0237641 ... -0.3517 0.121348 -0.00211222
 0.00393071 0.00128486 -0.0143792 ... -0.35524 0.121696 0.00219799
 0.00516494 -0.00177173 -0.00432067 ... -0.359386 0.122044 0.00739689
 0.00468582 -0.00850522 -0.0141415 ... -0.359102 0.123342 0.00885152
 0.00214065 0.00112577 -0.00622083 ... -0.358318 0.126558 0.0126224
 0.00271065 0.00759758 0.00400377 ... -0.360084 0.126229 0.0143883
 0.00496576 -0.00194535 -0.00088113 ... -0.362603 0.123577 0.0135047
 ⋮
 -0.0365216 0.0166076 -0.0391849 ... -0.307725 0.176403 0.105422
 0.0251772 -0.039498 -0.072092 ... -0.302336 0.180011 0.106334
 -0.000635415 0.0099461 -0.0383273 ... -0.282292 0.194083 0.106567
 -0.00110075 0.000684811 0.0641192 ... -0.289585 0.190552 0.0973259
 0.015166 -0.00114762 -0.0491396 ... -0.295634 0.187839 0.0818542
 0.0770153 0.00527231 -0.0947261 ... -0.29372 0.188215 0.0932095

```

```
• # Centrage des données
• X̄ = X_train - M
```

```

1×561 Array{Float64,2}:
-2.22286e-17 2.02353e-18 5.07392e-18 ... 4.25243e-17 -4.83231e-19 -3.86585e-18

```

```
• mean(X̄, dims=1) # La moyenne de chaque colonne est bien proche de 0
```

```

Σ = 561×561 Array{Float64,2}:
 0.00493665 0.000424552 -0.00102248 ... 0.00071841 0.000553863
 0.000424552 0.0016655 -0.000182059 ... 1.27823e-5 -0.000158369
 -0.00102248 -0.000182059 0.00320754 ... -0.000257575 -0.000357949
 1.95065e-5 -0.000827027 -0.000513799 ... 0.0628822 0.0494525
 -0.00077354 -0.000921444 -0.000473728 ... 0.0782923 0.0607733
 -0.00131251 -0.000850007 -0.000199433 ... 0.059287 0.0564256
 0.00018742 -0.000764614 -0.000450244 ... 0.0588409 0.0462727
 ⋮
 0.00038342 -0.000247742 -0.00101143 ... -0.0017324 -0.00219228
 0.00160038 0.000446035 -0.00219142 ... -0.0022809 -0.00337941
 0.000968681 0.00147623 -0.000921396 ... -0.000834531 -0.0007546
 -0.00126785 -0.000110889 0.000248914 ... -0.119343 -0.0919504
 0.00071841 1.27823e-5 -0.000257575 ... 0.0884944 0.0493952
 0.000553863 -0.000158369 -0.000357949 ... 0.0493952 0.0779092

```

```
• # Construction la matrice de covariance Σ
• Σ = cov(X̄) # Ou B'*B/(length(y_train) - 1)
```

```

Eigen{Float64,Float64,Array{Float64,2},Array{Float64,1}}
values:
561-element Array{Float64,1}:
-2.3818397070201475e-16
-1.803340291544898e-16
-3.718746783291804e-17
-1.4953023566224664e-17

```

```
-8.448811245005369e-18
-6.961354641112536e-18
-6.576259941595891e-18
⋮
0.7081523037131603
0.9435170027830603
1.0437752946684833
2.2943928417169275
2.7350462652009018
34.82363040636593
```

vectors:

561×561 Array{Float64,2}:

```
1.13183e-9 -1.05098e-9 -5.56484e-10 ... 0.00325696 7.15327e-5
-7.71805e-10 6.19934e-10 -1.79635e-9 -0.000422311 0.000299848
3.11581e-10 -7.50608e-10 -5.01163e-10 -0.000839509 0.000231385
1.43788e-8 -2.07142e-8 -1.88137e-8 0.0171947 -0.0728429
-1.30439e-8 -1.02185e-8 4.46897e-8 -0.0109697 -0.0830195
7.89386e-9 6.9804e-9 -1.16705e-8 ... -0.0240049 -0.0657876
1.10704e-10 5.47116e-11 3.31847e-9 0.0180022 0.0684675
```

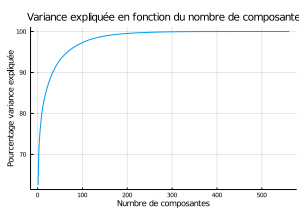
- *# Décomposer cette matrice en vecteur propres, valeur propres { $v_i$ ,  $\lambda_i$ }*
- $\lambda$ ,  $v$  = `eigen( $\Sigma$ )`

`order =`

```
Int64[561, 560, 559, 558, 557, 556, 555, 554, 553, 552, 551, 550, 549, 548, 547, 546, 545, 544, 543, 542, 541, 540, 539, 538, 537, 536, 535, 534, 533, 532, 531, 530, 529, 528, 527, 526, 525, 524, 523, 522, 521, 520, 519, 518, 517, 516, 515, 514, 513, 512, 511, 510, 509, 508, 507, 506, 505, 504, 503, 502, 501, 500, 499, 498, 497, 496, 495, 494, 493, 492, 491, 490, 489, 488, 487, 486, 485, 484, 483, 482, 481, 480, 479, 478, 477, 476, 475, 474, 473, 472, 471, 470, 469, 468, 467, 466, 465, 464, 463, 462, 461, 460, 459, 458, 457, 456, 455, 454, 453, 452, 451, 450, 449, 448, 447, 446, 445, 444, 443, 442, 441, 440, 439, 438, 437, 436, 435, 434, 433, 432, 431, 430, 429, 428, 427, 426, 425, 424, 423, 422, 421, 420, 419, 418, 417, 416, 415, 414, 413, 412, 411, 410, 409, 408, 407, 406, 405, 404, 403, 402, 401, 400, 399, 398, 397, 396, 395, 394, 393, 392, 391, 390, 389, 388, 387, 386, 385, 384, 383, 382, 381, 380, 379, 378, 377, 376, 375, 374, 373, 372, 371, 370, 369, 368, 367, 366, 365, 364, 363, 362, 361, 360, 359, 358, 357, 356, 355, 354, 353, 352, 351, 350, 349, 348, 347, 346, 345, 344, 343, 342, 341, 340, 339, 338, 337, 336, 335, 334, 333, 332, 331, 330, 329, 328, 327, 326, 325, 324, 323, 322, 321, 320, 319, 318, 317, 316, 315, 314, 313, 312, 311, 310, 309, 308, 307, 306, 305, 304, 303, 302, 301, 300, 299, 298, 297, 296, 295, 294, 293, 292, 291, 290, 289, 288, 287, 286, 285, 284, 283, 282, 281, 280, 279, 278, 277, 276, 275, 274, 273, 272, 271, 270, 269, 268, 267, 266, 265, 264, 263, 262, 261, 260, 259, 258, 257, 256, 255, 254, 253, 252, 251, 250, 249, 248, 247, 246, 245, 244, 243, 242, 241, 240, 239, 238, 237, 236, 235, 234, 233, 232, 231, 230, 229, 228, 227, 226, 225, 224, 223, 222, 221, 220, 219, 218, 217, 216, 215, 214, 213, 212, 211, 210, 209, 208, 207, 206, 205, 204, 203, 202, 201, 200, 199, 198, 197, 196, 195, 194, 193, 192, 191, 190, 189, 188, 187, 186, 185, 184, 183, 182, 181, 180, 179, 178, 177, 176, 175, 174, 173, 172, 171, 170, 169, 168, 167, 166, 165, 164, 163, 162, 161, 160, 159, 158, 157, 156, 155, 154, 153, 152, 151, 150, 149, 148, 147, 146, 145, 144, 143, 142, 141, 140, 139, 138, 137, 136, 135, 134, 133, 132, 131, 130, 129, 128, 127, 126, 125, 124, 123, 122, 121, 120, 119, 118, 117, 116, 115, 114, 113, 112, 111, 110, 109, 108, 107, 106, 105, 104, 103, 102, 101, 100, 99, 98, 97, 96, 95, 94, 93, 92, 91, 90, 89, 88, 87, 86, 85, 84, 83, 82, 81, 80, 79, 78, 77, 76, 75, 74, 73, 72, 71, 70, 69, 68, 67, 66, 65, 64, 63, 62, 61, 60, 59, 58, 57, 56, 55, 54, 53, 52, 51, 50, 49, 48, 47, 46, 45, 44, 43, 42, 41, 40, 39, 38, 37, 36, 35, 34, 33, 32, 31, 30, 29, 28, 27, 26, 25, 24, 23, 22, 21, 20, 19, 18, 17, 16, 15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1]
```

- *# Ordonner les valeurs propres par ordre décroissant*
- `order = sortperm( $\lambda$ , rev=true)`

- *# Recherche du nombre de composant permettant de conserver au moins 99% de la variance*
- `begin`
- `ebolli = float([0 for idx in 1:561])`
- `$\lambda\_drec = \lambda[order]$`
- `total = sum( $\lambda\_drec$ )`
- `for i in 1:561`
- `$som\_i = sum(\lambda\_drec[1:i])$`
- `$ebolli[i] = som\_i / total * 100$`
- `end`
- `end`



- `plot(1:561, eboli, legend=false, xlabel="Nombre de composantes", ylabel="Pourcentage variance expliquée", title="Variance expliquée en fonction du nombre de composante")`

- `begin`
- `print("Le pourcentage de la variance conservée avec 155 composantes est : ")`
- `print(eboli[155])`
- `end`
- *# Nous allons donc utiliser 155 composantes*

$\theta$  = 561×155 Array{Float64,2}:

```
7.15327e-5 0.00325696 0.00245574 ... -0.0222156 -0.0262348 0.00365807
0.000299848 -0.000422311 0.000624522 -0.00314018 -0.0166945 -0.0141309
0.000231385 -0.000839509 -0.00036828 0.0348822 0.0449157 0.0243496
-0.0728429 0.0171947 -0.0131377 0.0243761 0.0160184 -0.00331693
-0.0830195 -0.0109697 -0.00976856 -0.0093758 -0.0112564 -0.0237074
-0.0657876 -0.0240049 -0.0140109 ... -0.0108822 -0.00753059 0.00606941
```



## Utilisation d'un modèle RNN

```
initialLoss = 1.9887565f0
```

- *# Perte initiale*
- `initialLoss = loss(X_train_acp', Y_train)`

```
optimizer = ADAM(0.001, (0.9, 0.999), IdDict())
```

- *# Création de l'optimizer (Adam)*
- `optimizer = ADAM()`

```
train (generic function with 2 methods)
```

- *# Fonction d'entraînement*
- `function train(numEpochs=20)`
- `with_terminal() do`
- `@epochs numEpochs Flux.train!(loss, θ_rnn, [(X_train_acp', Y_train)],`
- `optimizer; cb = () -> println(loss(X_train_acp'[:,1:100], Y_train[:,1:100]))`
- `end`
- `end`

```
[ Info: Epoch 1
1.9754322
[ Info: Epoch 2
1.8977013
[ Info: Epoch 3
1.8449478
[ Info: Epoch 4
1.8006389
[ Info: Epoch 5
1.7588105
[ Info: Epoch 6
1.7192074
[ Info: Epoch 7
1.6829383
[ Info: Epoch 8
1.650897
[ Info: Epoch 9
1.6236354
[ Info: Epoch 10
1.6013852
[ Info: Epoch 11
1.5849478
[ Info: Epoch 12
1.5688105
[ Info: Epoch 13
1.5529383
[ Info: Epoch 14
1.5377013
[ Info: Epoch 15
1.5229478
[ Info: Epoch 16
1.5088105
[ Info: Epoch 17
1.4949478
[ Info: Epoch 18
1.4806389
[ Info: Epoch 19
1.466389
[ Info: Epoch 20
1.4529383
[ Info: Epoch 21
1.4392074
[ Info: Epoch 22
1.4254322
[ Info: Epoch 23
1.4116389
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1.3977013
[ Info: Epoch 25
1.3837565
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1.3697013
[ Info: Epoch 27
1.3556389
[ Info: Epoch 28
1.3415478
[ Info: Epoch 29
1.3274322
[ Info: Epoch 30
1.3132938
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1.2991478
[ Info: Epoch 32
1.2849478
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1.2706389
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1.2562938
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1.2419478
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1.2275478
[ Info: Epoch 37
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1.1987013
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1.1554938
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1.1410938
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1.1266938
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1.1122938
[ Info: Epoch 45
1.0978938
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1.0834938
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1.0690938
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[ Info: Epoch 49
1.0402938
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1.0258938
[ Info: Epoch 51
1.0114938
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1.0000000
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0.9887565
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0.9775000
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0.9662500
[ Info: Epoch 56
0.9550000
[ Info: Epoch 57
0.9437500
[ Info: Epoch 58
0.9325000
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0.9212500
[ Info: Epoch 60
0.9100000
[ Info: Epoch 61
0.8987500
[ Info: Epoch 62
0.8875000
[ Info: Epoch 63
0.8762500
[ Info: Epoch 64
0.8650000
[ Info: Epoch 65
0.8537500
[ Info: Epoch 66
0.8425000
[ Info: Epoch 67
0.8312500
[ Info: Epoch 68
0.8200000
[ Info: Epoch 69
0.8087500
[ Info: Epoch 70
0.7975000
[ Info: Epoch 71
0.7862500
[ Info: Epoch 72
0.7750000
[ Info: Epoch 73
0.7637500
[ Info: Epoch 74
0.7525000
[ Info: Epoch 75
0.7412500
[ Info: Epoch 76
0.7300000
[ Info: Epoch 77
0.7187500
[ Info: Epoch 78
0.7075000
[ Info: Epoch 79
0.6962500
[ Info: Epoch 80
0.6850000
[ Info: Epoch 81
0.6737500
[ Info: Epoch 82
0.6625000
[ Info: Epoch 83
0.6512500
[ Info: Epoch 84
0.6400000
[ Info: Epoch 85
0.6287500
[ Info: Epoch 86
0.6175000
[ Info: Epoch 87
0.6062500
[ Info: Epoch 88
0.5950000
[ Info: Epoch 89
0.5837500
[ Info: Epoch 90
0.5725000
[ Info: Epoch 91
0.5612500
[ Info: Epoch 92
0.5500000
[ Info: Epoch 93
0.5387500
[ Info: Epoch 94
0.5275000
[ Info: Epoch 95
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[ Info: Epoch 96
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0.4712500
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0.4600000
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0.4487500
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0.4375000
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0.4262500
[ Info: Epoch 104
0.4150000
[ Info: Epoch 105
0.4037500
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0.3925000
[ Info: Epoch 107
0.3812500
[ Info: Epoch 108
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[ Info: Epoch 109
0.3587500
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0.3475000
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0.3362500
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0.3250000
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[ Info: Epoch 115
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[ Info: Epoch 116
0.2800000
[ Info: Epoch 117
0.2687500
[ Info: Epoch 118
0.2575000
[ Info: Epoch 119
0.2462500
[ Info: Epoch 120
0.2350000
[ Info: Epoch 121
0.2237500
[ Info: Epoch 122
0.2125000
[ Info: Epoch 123
0.2012500
[ Info: Epoch 124
0.1900000
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0.1787500
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0.1675000
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0.1562500
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0.1450000
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0.1225000
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0.0887500
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0.0775000
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0.0662500
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0.0550000
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0.0325000
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0.0212500
[ Info: Epoch 140
0.0100000
[ Info: Epoch 141
0.0000000
[ Info: Epoch 142
-0.0112500
[ Info: Epoch 143
-0.0225000
[ Info: Epoch 144
-0.0337500
[ Info: Epoch 145
-0.0450000
[ Info: Epoch 146
-0.0562500
[ Info: Epoch 147
-0.0675000
[ Info: Epoch 148
-0.0787500
[ Info: Epoch 149
-0.0900000
[ Info: Epoch 150
-0.1012500
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-0.1125000
[ Info: Epoch 152
-0.1237500
[ Info: Epoch 153
-0.1350000
[ Info: Epoch 154
-0.1462500
[ Info: Epoch 155
-0.1575000
[ Info: Epoch 156
-0.1687500
[ Info: Epoch 157
-0.1800000
[ Info: Epoch 158
-0.1912500
[ Info: Epoch 159
-0.2025000
[ Info: Epoch 160
-0.2137500
[ Info: Epoch 161
-0.2250000
[ Info: Epoch 162
-0.2362500
[ Info: Epoch 163
-0.2475000
[ Info: Epoch 164
-0.2587500
[ Info: Epoch 165
-0.2700000
[ Info: Epoch 166
-0.2812500
[ Info: Epoch 167
-0.2925000
[ Info: Epoch 168
-0.3037500
[ Info: Epoch 169
-0.3150000
[ Info: Epoch 170
-0.3262500
[ Info: Epoch 171
-0.3375000
[ Info: Epoch 172
-0.3487500
[ Info: Epoch 173
-0.3600000
[ Info: Epoch 174
-0.3712500
[ Info: Epoch 175
-0.3825000
[ Info: Epoch 176
-0.3937500
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-0.5287500
[ Info: Epoch 189
-0.5400000
[ Info: Epoch 190
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```
• # Application de acp sur les données de test
• begin
•     M_test = repeat(μ, length(y_test), 1)
•     X̄_test = X_test - M_test
•     X_test_acp = X̄_test * θ
• end
```

```
test_accuracy = 0.9507974211062097
```

```
• test_accuracy = accuracy(X_test_acp', y_test)
```