# Building_single-sample_regulatory_networks_using_LIONESS_and_netZooPy

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# 1 Building single-sample regulatory networks using LIONESS and netZooPy

### 1.0.1 Author:

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## 1.1 1. Introduction

In this tutorial, we will briefly walk through the steps to perform analysis with Lioness algorithm using netZooPy package. Lioness is an algorithm for estimating sample-specific gene regualtory networks in a population. LIONESS infers individual sample networks by applying linear interpolation to the predictions made by existing aggregate network inference approaches [1]. In this tutorial, we will use Panda as our basic network inference apporach to build sample-specific networks.

## 1.2 2. Installation of netZooPy.

netZooPy comes with full support for Lioness algorithm. netZooPy can be installed through `pip` command. For more details, please refer to the installation guide at netZooPy documentation site here.

## 1.3 3. Load required modules

We will need `Panda` and `Lioness` python classes from netZooPy package. We will also need `read_csv()` function from pandas package for demonstrating the input data sets.

```
[2]: from netZooPy.panda import Panda
     from netZooPy.lioness import Lioness
     from netZooPy.lioness.analyze_lioness import AnalyzeLioness
     import pandas as pd
```

## 1.4  4. Load input data

Now let's look at the three data sets to get a sense about what the inputs look like.

```
[3]: exp_data = pd.read_csv('~/netZooPy/tests/puma/ToyData/ToyExpressionData.
      ↪txt',header=None, index_col = 0, sep = "\t")
     motif_data = pd.read_csv('~/netZooPy/tests/puma/ToyData/ToyMotifData.
      ↪txt',header=None, sep = "\t")
     ppi_data = pd.read_csv('~/netZooPy/tests/puma/ToyData/ToyPPIData.
      ↪txt',header=None, sep = "\t")
```

Expression data is a matrix where rows are genes and columns are samples.There are 1000 genes and 50 samples in this expression dataset

```
[4]: exp_data
```

```
[4]:                   1         2         3         4         5         6  \
     0
     AACSL      0.141431 -4.153056  2.854971  0.413670  1.082093  1.882361
     AAK1       3.528478 -0.949701  1.039986 -1.618816 -1.228012 -0.171763
     ABCA17P   -2.597842  3.970710 -2.809212  0.474679 -2.714377 -0.474146
     ABCB8      0.352052 -1.866545 -0.007765  3.289632  2.675149  3.819294
     ABCC1     -4.638927  2.440799 -1.655580  0.506424  3.289914  2.460479
     ABCF3      3.822458  0.241117 -0.629730 -6.448074 -2.221022  0.559189
     ABCG1      0.562681  0.348409 -1.800319 -3.869393  6.949607 -0.700023
     ACOT2      2.411224 -4.461962  2.932685 -3.482673  1.622149  1.970574
     ACSF2      0.452929  2.932288  2.580745  0.576073  1.568796 -3.090774
     ADAM2      0.355641 -0.011333  3.167627 -2.292000  0.309439  1.242176
     ADAMTS10  -6.435335 -3.484197 -1.334098 -6.257098  1.414799  1.847578
     ADAMTS8   -1.500518 -1.781252  0.390679 -4.498557 -2.950740  2.187399
     ADCY6      0.239552  3.663878 -2.478119 -1.249731 -4.508629 -1.559120
     ADCYAP1R1  0.458076  5.646495  1.054934  2.420345  1.272796  2.603719
     ADH1B     -2.498004  4.363269  3.047640 -2.887588 -0.382138 -2.791821
     ADH6      -0.224751 -4.080510  3.996458  2.259859 -0.291146  0.586628
     AFF1       1.267301 -1.743443 -0.558082  0.711610 -1.599487 -4.036190
     AGR3       2.689198  0.551704  4.595840  5.758756  2.143647  6.210038
     AGRN      -3.803666  3.013388  0.094045 -3.100119  3.327980 -3.495524
     AHR       -0.206353  5.031601 -6.772378  0.658805 -4.815799  2.131688
     AIM1      -3.253885 -1.344785  0.778770 -3.178421 -2.241247  0.076789
     AJAP1     -0.671359 -1.453216  1.583014  2.223739  6.980131 -3.211525
     AKAP10     2.111122  1.642002  1.268021  0.915710 -2.686503  0.648780
     AKAP8L    -2.076503  5.121783  0.120849  4.835900  4.528920 -4.010499
     AKIRIN2    0.182562 -2.814136 -1.704658 -2.635369 -2.622177 -2.169776
     AKT1      -0.600257 -1.156250  4.269575 -2.652594  1.637202  6.342937
     ALG14      1.457071 -1.123955  1.168836 -4.140685 -0.767143  2.490318
     ALPPL2     0.278612 -3.347032 -1.047794 -3.167413 -0.413878 -1.187347
     AMDHD1     1.442675  2.435977 -2.655512 -0.262620 -0.133281  0.071852
     AMIGO1    -0.632069 -4.026140 -0.023985  1.703159  2.216783 -2.408620
     ...             ...       ...       ...       ...       ...       ...
     YY1        1.955807  0.441289 -4.025722  3.241794 -1.471559  2.546710
```

```
ZBTB25     -0.465745   2.731525   0.583832   0.952136    3.981221 -6.242749
ZCCHC6      2.616518   3.725200  -3.604447   0.953095   -1.414919 -1.686620
ZDHHC15     0.287416   4.228220  -1.932585   1.280172   -0.361667 -3.245687
ZDHHC16     3.983208  -4.736054   1.431894  -0.534885    1.189214  2.050506
ZDHHC2     -5.452097  -2.864681   6.239840   4.199863   -1.725535 -3.715479
ZDHHC7     -1.438812   0.525433   1.646436   1.928655    3.225473 -2.751004
ZDHHC9     -5.000444  -0.419128  -1.826055  -7.374587    0.431975  0.447008
ZFAT       -2.931567  -1.559858  -1.483557  -1.574698   -0.874071 -2.881306
ZFP62      -1.271041  -2.920962  -3.853412   0.748130    4.703092  3.214546
ZFR        -4.744726   4.316600  -4.468643   5.237806    1.316022 -0.874962
ZMYM3       1.471251   0.652375  -1.932988   2.670401   -2.737013  0.057174
ZMYND17     4.619858  -3.475264   0.038139   4.313893   -1.061013 -1.304709
ZNF124      3.330737   5.589767  -4.290391  -0.717922    0.811929  4.553090
ZNF132     -2.168550  -2.412464  -3.149500  -2.440988   10.078211  1.902683
ZNF138      5.501906  -0.524335  -4.959888   1.751520   -1.605983 -1.376737
ZNF283     -3.034221   2.111506  -0.719169   0.225898   -2.721097  1.546914
ZNF322B    -5.860660   6.129064   1.159615  -2.537294   -3.155169 -1.897060
ZNF426      6.177740  -2.424839  -0.226201   2.234599   -1.458643 -3.694419
ZNF451      3.249119   1.893897   1.717736  -0.659733    1.719676  3.294666
ZNF480     -0.140409  -1.341108   0.018698  -1.008055    0.655969 -0.532847
ZNF660     -5.134059  -2.887868  -5.682801  -4.584404    0.923337 -3.747658
ZNF696      1.536629  -1.218671  -1.244199  -4.751498   -2.160287  1.626458
ZNF772      1.805567   4.059267  -7.479062  -0.471547   -0.378794 -5.751023
ZNF776     -0.739313   4.252302  -1.231494   1.584117    5.788495  0.016007
ZNF826     -4.294209  -4.498573   2.786462  -1.588052    1.542248  3.222761
ZNF845     -1.661144  -6.986089   2.273928  -2.426933   -4.627002 -4.044476
ZNF878      3.395504  -6.274497   0.455548   0.592239   -0.852212  1.373684
ZSWIM3     -0.494841   2.840674  -3.816640   3.052187    4.979421 -5.889279
ZWILCH      0.694298  -2.725693  -1.752258  -1.789789    2.228141 -4.494592

                       7          8          9         10  ...        41        42  \
0                                                          ...
AACSL       1.450223   2.130209   0.548923   0.583043  ... -4.551870 -6.645621
AAK1       -2.822020   0.047464  -0.456019   1.134087  ...  2.808942 -0.035529
ABCA17P    -6.738092  -2.811364  -1.017466  -1.646993  ... -2.324379 -0.999586
ABCB8       0.668285   2.608310   3.342104  -2.792534  ... -3.666569 -0.074404
ABCC1      -1.003678   1.537393  -1.342323  -1.003316  ... -0.375289 -3.214583
ABCF3      -0.817507   0.404023  -2.105254   6.397036  ...  0.416917 -1.061398
ABCG1       0.613762  -0.194774   0.477825   1.010311  ... -6.687904 -2.232982
ACOT2       3.783328   2.018564  -4.157278  -0.454352  ...  3.496161 -4.542483
ACSF2      -2.057883  -5.726421  -5.013427   1.913956  ... -3.264008  0.828671
ADAM2      -0.447120   0.028113  -3.598405   1.442208  ...  0.352784  2.091205
ADAMTS10   -0.854010  -1.351184  -5.122214   2.551296  ...  4.033988  3.940538
ADAMTS8    -4.911543  -2.987357   1.188654  -4.559955  ... -1.554750 -1.501601
ADCY6      -1.018709   0.820547  -0.839912  -2.340473  ...  4.726817 -2.105939
ADCYAP1R1   1.006353   5.376351  -0.302532   6.419028  ...  4.236462 -1.691084
ADH1B      -3.554774  -4.072156   0.171069  -4.810303  ... -3.070164 -2.778129
```

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```
ADH6        3.458583  3.730949  5.144894 -0.546617  ...  3.345719  1.916228
AFF1        1.768361  3.132970  0.851968 -0.930023  ...  0.079065 -7.419378
AGR3        3.802123  4.112670  3.055105 -2.853347  ...  0.480619 -1.733525
AGRN        3.172164  0.686780  1.848163 -4.764568  ... -0.059656  1.874475
AHR        -0.616780  2.924277 -0.459491  1.096779  ... -2.079071  7.787621
AIM1        0.705845 -3.178349 -3.290212 -4.055884  ...  2.506882  0.238419
AJAP1      -2.033678 -3.638395  1.529547  0.024004  ... -1.760967  0.402947
AKAP10      3.363863 -1.063846 -1.164144  2.371818  ... -1.532954  0.104894
AKAP8L     -0.570129 -1.910726 -5.247164 -3.205733  ... -0.448418 -0.832548
AKIRIN2     3.083701 -4.855234 -1.960743 -1.231475  ... -1.941039 -4.338502
AKT1        2.674969 -0.104879 -0.478754 -0.124468  ... -0.399697 -2.622513
ALG14       3.910973  1.030674  3.085856 -1.179364  ... -1.414906 -1.151661
ALPPL2     -2.064943  1.779923 -4.103784 -3.772628  ... -0.636912 -0.258916
AMDHD1     -0.937521  3.380939  1.799345  2.822316  ...  2.361554 -3.860945
AMIGO1      2.931212 -3.947217  0.862303 -2.412431  ...  1.330087 -0.709538
...             ...       ...       ...       ...    ...       ...       ...
YY1        -3.392705 -0.801326  8.747804 -0.891846  ...  3.968216 -4.094314
ZBTB25      0.274338 -1.281054  3.280473  5.293598  ...  0.832881 -0.647692
ZCCHC6      1.115142 -1.938877 -0.005253 -5.008178  ...  2.148678 -3.049896
ZDHHC15    -4.729219 -3.941767  3.047753  0.983202  ...  0.924528  0.802575
ZDHHC16     1.918995 -1.047002  4.168625 -1.529144  ... -1.787969 -0.655874
ZDHHC2     -3.816561 -2.090490  2.274487 -3.430965  ...  0.157227 -2.579084
ZDHHC7     -2.989698 -5.601409  2.200852  1.691665  ...  3.800466  5.007216
ZDHHC9      0.498743 -1.178437  0.252175 -0.106776  ... -0.178797 -0.721575
ZFAT        4.222129 -1.200172 -0.990453  5.082496  ... -1.772075  3.798225
ZFP62       0.476954  0.005453  0.526652  1.999028  ... -0.526324 -0.229234
ZFR         5.295222 -3.100937 -0.505455 -4.697889  ... -1.011458 -2.350506
ZMYM3       2.756968  1.152510 -2.647043  7.612432  ... -6.551895  1.795703
ZMYND17     0.256868  0.419320  3.540630  3.040002  ...  0.813865  5.155772
ZNF124     -2.496052  1.730051  0.636785  0.818016  ... -1.356317 -1.932498
ZNF132      3.813724 -3.439067  1.787848  2.228660  ...  0.986353 -1.858777
ZNF138      4.639871  2.583844  1.688727 -0.609936  ...  2.701609 -1.919130
ZNF283     -3.126284  0.706536  2.476561 -1.737517  ... -0.950084  0.811290
ZNF322B     1.876461 -6.812772 -0.795365  7.940787  ... -1.441415  3.249069
ZNF426      5.435978  2.113951 -0.548585 -0.587499  ...  1.810145 -0.509916
ZNF451     -0.481807  0.529062 -6.321060 -1.217092  ... -1.084075  2.081276
ZNF480      1.634830  1.264774  1.879042  1.682834  ...  2.166815 -0.138187
ZNF660      2.117484 -5.564895 -2.821189 -1.254334  ... -1.868436 -0.401334
ZNF696     -0.817378  0.777225 -0.594485  0.026376  ... -1.468312 -0.279803
ZNF772      6.168965  2.467858 -0.962984 -2.699509  ...  0.734462 -4.688808
ZNF776      2.675882  3.143431 -1.671526 -1.230410  ...  1.841290  3.199943
ZNF826     -0.005525 -4.711981 -0.580551  2.152243  ... -1.023105 -1.675647
ZNF845     -3.991184 -0.903110  1.558416  0.672473  ... -0.990304 -1.806129
ZNF878     -2.638325  4.028651 -1.117790 -2.844150  ... -4.858309  1.752461
ZSWIM3     -6.640408  3.711903 -3.156978  0.475878  ... -2.065756  1.069487
ZWILCH      1.233303 -1.748305  2.534993  0.819987  ... -4.033845  2.497995
```

|         | 43 | 44 | 45 | 46 | 47 | 48 \ |
|---------|----|----|----|----|----|----|
| 0 | | | | | | |
| AACSL | -3.970460 | -2.041915 | 0.811989 | 0.979641 | 0.063161 | 3.652624 |
| AAK1 | 0.473384 | -1.971053 | 1.759803 | 3.151289 | -5.189503 | -0.233187 |
| ABCA17P | 0.987566 | 2.591347 | -1.445705 | -2.788339 | 2.295727 | 0.953828 |
| ABCB8 | 4.630231 | 0.883074 | -1.573444 | 4.909868 | 0.866853 | 2.374492 |
| ABCC1 | 5.531917 | -1.693335 | 1.506472 | 1.020980 | 4.933972 | 2.268159 |
| ABCF3 | 4.559200 | -1.014232 | 0.372768 | 1.563113 | 2.331843 | 7.556858 |
| ABCG1 | -3.412368 | -2.943314 | -2.985734 | 1.551215 | 1.133610 | 0.454167 |
| ACOT2 | 1.584941 | -0.167026 | -1.091618 | 0.266757 | 0.242896 | -1.986338 |
| ACSF2 | 0.139710 | -0.038387 | 1.705630 | 5.832881 | -0.075640 | -3.998545 |
| ADAM2 | -1.578376 | 5.417486 | 1.012646 | -2.214839 | -2.154928 | 2.582198 |
| ADAMTS10 | 3.105636 | -0.830551 | 0.912196 | -0.126224 | -2.345661 | 7.605495 |
| ADAMTS8 | -4.605737 | -2.175497 | 3.599596 | 2.921266 | 3.366518 | -3.623441 |
| ADCY6 | 2.066263 | 1.598242 | -4.352578 | 2.937616 | 0.838953 | 0.873717 |
| ADCYAP1R1 | -0.661785 | 0.803437 | -0.274287 | -0.872806 | 1.080127 | -1.647711 |
| ADH1B | -0.110080 | -3.957719 | -1.410711 | 0.695792 | 2.330447 | -3.053955 |
| ADH6 | 4.300311 | -4.651193 | 0.775120 | -3.972906 | -0.698086 | -0.430629 |
| AFF1 | 3.747206 | -2.912467 | -3.456261 | 2.962799 | -3.951777 | -4.874321 |
| AGR3 | -0.008265 | 4.462258 | -8.505583 | -0.109861 | -1.752762 | -0.309343 |
| AGRN | 2.730239 | 2.368229 | 0.895757 | 1.090120 | 3.247198 | 3.194017 |
| AHR | 4.173739 | -4.853682 | 1.384796 | -2.567371 | -4.304014 | -2.440764 |
| AIM1 | 0.795984 | 0.555804 | 3.693480 | 3.648031 | -2.599992 | -1.235266 |
| AJAP1 | 2.047986 | 9.711038 | -5.583309 | -1.635951 | -2.851895 | -4.855163 |
| AKAP10 | 2.236829 | 1.582274 | 1.728103 | 2.456019 | -2.895845 | -3.776638 |
| AKAP8L | 2.501409 | 4.901713 | 1.762507 | -3.798529 | -2.656816 | 1.570357 |
| AKIRIN2 | -6.590048 | -6.723866 | 2.562907 | -4.462658 | -3.158130 | -1.700410 |
| AKT1 | 1.185376 | 4.711334 | -1.332219 | -2.756439 | 3.066091 | 3.494977 |
| ALG14 | 3.431068 | 2.462015 | -0.172023 | 4.241700 | 2.498942 | 1.538316 |
| ALPPL2 | -4.925722 | 0.192451 | 3.438164 | 0.687503 | 0.757951 | -1.844243 |
| AMDHD1 | 2.688930 | -1.500954 | -2.484701 | -4.613864 | 2.601704 | 1.524390 |
| AMIGO1 | 4.998298 | 5.434680 | 0.447682 | 0.431151 | 0.342613 | 0.362589 |
| ... | ... | ... | ... | ... | ... | ... |
| YY1 | -0.874615 | 1.884760 | 0.013866 | 0.810367 | -1.970884 | -2.359943 |
| ZBTB25 | 0.002772 | -1.540829 | -0.289737 | -4.011846 | -1.242774 | 1.763224 |
| ZCCHC6 | -7.382941 | -0.647739 | -1.921551 | -1.810419 | -4.233128 | 3.262738 |
| ZDHHC15 | 0.580516 | -2.626980 | 1.650896 | -0.486386 | -1.465460 | 2.756558 |
| ZDHHC16 | 3.368040 | 0.137512 | -2.539163 | 3.851830 | -0.946804 | 1.647447 |
| ZDHHC2 | 0.958787 | 3.746606 | -0.782082 | 0.901215 | -4.032160 | 3.597801 |
| ZDHHC7 | -6.883397 | 0.784845 | 0.651235 | -0.521085 | -4.866340 | -0.103401 |
| ZDHHC9 | 10.173612 | -0.566138 | 1.952077 | 0.953530 | -4.176484 | -2.543994 |
| ZFAT | 0.403502 | -3.078181 | 4.188723 | 5.179436 | 2.422908 | 2.133740 |
| ZFP62 | 0.321802 | 1.108952 | 3.446266 | -5.234739 | 1.145793 | 1.785877 |
| ZFR | -6.253545 | 0.666908 | 1.212308 | -0.688220 | 0.660413 | -2.524871 |
| ZMYM3 | 1.051413 | -1.358606 | 1.383776 | -2.503557 | 3.385820 | -0.745977 |
| ZMYND17 | -5.260261 | 1.344561 | -2.431417 | 4.107977 | 0.237943 | -1.939147 |
| ZNF124 | -3.455120 | -0.084919 | -1.237713 | 3.506137 | -1.885701 | 0.273054 |

```
ZNF132      8.075192  7.790025 -2.206606  6.022623 -0.591418  -5.578319
ZNF138     -1.581302 -2.705314 -1.775207  7.263195 -5.359276  -1.377007
ZNF283      7.654198 -0.602563 -0.485668  0.706387  0.637638   1.044513
ZNF322B    -4.036189  0.334181 -2.639774  7.711171  5.733905   0.518429
ZNF426     -1.958090 -2.925023 -1.296322  3.874413  5.068583  -7.030104
ZNF451     -2.132384  0.780504 -2.191865 -3.959255 -5.588040  -1.734270
ZNF480      0.269705  2.945537 -6.374132 -4.319404 -1.417171  -3.086070
ZNF660      1.951397  4.396688  4.859973  4.140445  2.204386   1.565369
ZNF696      5.001230  2.464151 -0.827188 -2.598237 -1.420780   2.221469
ZNF772     -1.912480 -3.396070  1.147704 -3.591208 -3.216311   2.329710
ZNF776      5.509921 -0.675689 -0.410618  2.722958 -2.857927   0.232340
ZNF826      3.320340  2.108714 -5.961589  1.679723 -1.473783   1.871397
ZNF845      1.643056  1.932765  1.084221 -1.214410 -2.985126 -10.986240
ZNF878      1.630060 -0.079563 -0.545380 -2.694063 -0.535988  -0.038242
ZSWIM3     -1.682956  4.824188 -0.930484 -3.155203 -4.252213  -6.578125
ZWILCH     -3.744730 -2.536536 -3.004383  3.336575 -1.095170  -3.466885


                    49        50
0
AACSL      -2.387639  0.929521
AAK1        0.349614  0.704183
ABCA17P    -1.094031 -2.104951
ABCB8       1.410069 -3.828003
ABCC1      -0.734398 -2.618825
ABCF3       1.705383 -1.658708
ABCG1      -2.928591  2.399636
ACOT2       1.453353 -3.237589
ACSF2      -0.008504 -0.974825
ADAM2      -0.176870  1.551844
ADAMTS10    1.028245 -3.296487
ADAMTS8     6.498009  0.601931
ADCY6       2.164306 -7.228367
ADCYAP1R1  -7.314351 -0.454197
ADH1B      -4.306005  1.839237
ADH6       -0.816764  0.763499
AFF1       -0.339520  3.577241
AGR3       -0.280030 -3.342774
AGRN        1.101338  2.587900
AHR         2.933068  3.258371
AIM1       -1.932245  1.393250
AJAP1      -1.584887  1.328536
AKAP10     -2.602940  1.132555
AKAP8L      1.879632  4.546102
AKIRIN2    -3.032855 -1.274919
AKT1       -2.954487 -1.335418
ALG14       4.271883  9.790623
ALPPL2     -4.572469  0.661904
```

```
AMDHD1     -0.309889  6.049197
AMIGO1      0.124003 -4.286540
...              ...       ...
YY1         4.105038 -1.566941
ZBTB25     -4.739805  4.830278
ZCCHC6     -0.812537  3.522548
ZDHHC15     1.240380  1.369940
ZDHHC16     1.379092 -5.007336
ZDHHC2     -0.142247 -2.502663
ZDHHC7      0.323577  0.927459
ZDHHC9     -4.591273  1.720633
ZFAT       -0.258086 -5.022865
ZFP62       6.950120  1.517959
ZFR         0.319327  2.381417
ZMYM3      -0.627234 -1.546457
ZMYND17    -0.133882  3.983232
ZNF124     -2.894267 -0.983415
ZNF132     -6.060207  1.476551
ZNF138     -2.831965  2.458768
ZNF283      1.126691  1.881236
ZNF322B    -2.275928 -1.721815
ZNF426     -1.901056 -1.727810
ZNF451      6.236782 -4.415510
ZNF480     -4.755754  2.109595
ZNF660      1.391193  0.320414
ZNF696      0.488647 -7.675989
ZNF772      2.226982 -0.744886
ZNF776      0.472510 -0.760252
ZNF826      1.968646 -1.017821
ZNF845      0.159237  0.906706
ZNF878     -1.353040 -1.713555
ZSWIM3     -6.558922 -0.104826
ZWILCH      1.519252 -0.729152

[1000 rows x 50 columns]
```

Motif data should be formatted into a three-column list, where first column contains TF IDs and second column the target gene IDs and third column the interaction scores.

```
[5]: motif_data

[5]:           0        1    2
     0       AHR    41157  1.0
     1       AHR     AAK1  1.0
     2       AHR  ABCA17P  1.0
     3       AHR    ABCB8  1.0
     4       AHR    ABCC1  1.0
     5       AHR    ABCF3  1.0
     6       AHR    ABCG1  1.0
```

```
7      AHR        ADAM2  1.0
8      AHR      ADAMTS10  1.0
9      AHR       ADAMTS8  1.0
10     AHR         ADCY6  1.0
11     AHR     ADCYAP1R1  1.0
12     AHR          AFF1  1.0
13     AHR          AGRN  1.0
14     AHR         AJAP1  1.0
15     AHR        AKAP10  1.0
16     AHR       AKIRIN2  1.0
17     AHR          AKT1  1.0
18     AHR         ALG14  1.0
19     AHR         AMDHD1  1.0
20     AHR        AMIGO1  1.0
21     AHR          AMPH  1.0
22     AHR       ANKRD16  1.0
23     AHR       ANKRD36  1.0
24     AHR       ANKRD39  1.0
25     AHR        ANP32E  1.0
26     AHR       ARHGEF2  1.0
27     AHR         ASAP3  1.0
28     AHR       ASPSCR1  1.0
29     AHR          ATL1  1.0
...    ...           ...  ...
14567  YY1       WBSCR26  1.0
14568  YY1          WDR4  1.0
14569  YY1         WDR54  1.0
14570  YY1         WDR61  1.0
14571  YY1       WFDC10B  1.0
14572  YY1         WIPF3  1.0
14573  YY1          YBX2  1.0
14574  YY1        ZBTB25  1.0
14575  YY1       ZDHHC15  1.0
14576  YY1       ZDHHC16  1.0
14577  YY1        ZDHHC7  1.0
14578  YY1        ZDHHC9  1.0
14579  YY1          ZFAT  1.0
14580  YY1         ZFP62  1.0
14581  YY1           ZFR  1.0
14582  YY1         ZMYM3  1.0
14583  YY1       ZMYND17  1.0
14584  YY1        ZNF124  1.0
14585  YY1        ZNF132  1.0
14586  YY1        ZNF138  1.0
14587  YY1        ZNF283  1.0
14588  YY1       ZNF322B  1.0
14589  YY1        ZNF426  1.0
```

```
14590  YY1      ZNF660  1.0
14591  YY1      ZNF772  1.0
14592  YY1      ZNF776  1.0
14593  YY1      ZNF826  1.0
14594  YY1      ZNF878  1.0
14595  YY1      ZSWIM3  1.0
14596  YY1      ZWILCH  1.0

[14597 rows x 3 columns]
```

There are 87 unique TFs and 913 unique motifs in this motif dataset.

[6]: `motif_data[0].unique().shape[0]`

[6]: 87

[7]: `motif_data[1].unique().shape[0]`

[7]: 913

PPI (protein protein interaction) data should be formatted into a three-column list, where first two columns contain protein IDs and third column contains a score for each interaction

[9]: `pd.concat([ppi_data[0],ppi_data[1]]).unique().size`

[9]: 87

This PPI dataset has 238 interactions among 87 TFs.

## 1.5  5. Run Panda

Before running Lioness, we will first need to generate a `Panda` object. This will be used later to run `Lioness`. Note that the argument `keep_expression_matrix` should be specified as `True`. As Lioness iterations need to call Panda function to build networks, which needs expression matrix as input.

[16]:
```
panda_obj = Panda('~/netZooPy/tests/puma/ToyData/ToyExpressionData.txt',
                  '~/netZooPy/tests/puma/ToyData/ToyMotifData.txt',
                  '~/netZooPy/tests/puma/ToyData/ToyPPIData.txt',
                  remove_missing=False,
                  keep_expression_matrix=True, save_memory=False)
```

```
Loading motif data ...
  Elapsed time: 0.02 sec.
Loading expression data ...
  Elapsed time: 0.02 sec.
Loading PPI data ...
Number of PPIs: 238
  Elapsed time: 0.00 sec.
Calculating coexpression network ...
  Elapsed time: 0.01 sec.
Creating motif network ...
  Elapsed time: 0.01 sec.
```

```
Creating PPI network ...
  Elapsed time: 0.00 sec.
Normalizing networks ...
  Elapsed time: 0.04 sec.
Saving expression matrix and normalized networks ...
  Elapsed time: 0.00 sec.
Running PANDA algorithm ...
step: 0, hamming: 0.7189662815459754
step: 1, hamming: 0.3899291546314954
step: 2, hamming: 0.4023668388969203
step: 3, hamming: 0.40052096181128466
step: 4, hamming: 0.38904060163854676
step: 5, hamming: 0.37050927774796627
step: 6, hamming: 0.346813714233211
step: 7, hamming: 0.3197200219092709
step: 8, hamming: 0.2908059296381211
step: 9, hamming: 0.2614076747991081
step: 10, hamming: 0.23256674933108332
step: 11, hamming: 0.2050473463652485
step: 12, hamming: 0.17936756642941443
step: 13, hamming: 0.1558282020394879
step: 14, hamming: 0.1345640692729987
step: 15, hamming: 0.1155876981777767
step: 16, hamming: 0.09882404071423918
step: 17, hamming: 0.08414234823461533
step: 18, hamming: 0.07137863350560043
step: 19, hamming: 0.06035259742114878
step: 20, hamming: 0.050879894600761214
step: 21, hamming: 0.04278075541305479
step: 22, hamming: 0.03588517917018383
step: 23, hamming: 0.030036230563844166
step: 24, hamming: 0.025091497107547298
step: 25, hamming: 0.020923570455323982
step: 26, hamming: 0.01741975365490937
step: 27, hamming: 0.014481280791973363
step: 28, hamming: 0.012022271977958703
step: 29, hamming: 0.009968530625360779
step: 30, hamming: 0.008256316822080972
step: 31, hamming: 0.0068311523959430605
step: 32, hamming: 0.005646666396278007
step: 33, hamming: 0.0046635404280628776
step: 34, hamming: 0.0038485478068236794
step: 35, hamming: 0.0031736932436243594
step: 36, hamming: 0.0026154528841061666
step: 37, hamming: 0.0021541086160812906
step: 38, hamming: 0.0017731679664810445
step: 39, hamming: 0.0014588635383778888
step: 40, hamming: 0.0011997237010732422
```

```
step: 41, hamming: 0.0009862051158053523
Running panda took: 1.02 seconds!
```

## 1.6 6. Run Lioness to estimate sample-specific networks

We will first use the `Panda` object as input for `Lioness` object. Then `Lioness` will run Panda algorithm in its iterations to estimate sample-specific network for each sample.

```
[17]: lioness_obj = Lioness(panda_obj)
```

```
Loading input data ...
  Elapsed time: 0.00 sec.
Running LIONESS for sample 1:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.03 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6451915130131666
step: 1, hamming: 0.6067461274659866
step: 2, hamming: 0.6105604110178084
step: 3, hamming: 0.5875350566544837
step: 4, hamming: 0.553598317095621
step: 5, hamming: 0.5130977642028344
step: 6, hamming: 0.46888897174383576
step: 7, hamming: 0.42325335262309544
step: 8, hamming: 0.3780071410446651
step: 9, hamming: 0.3345126063650471
step: 10, hamming: 0.29371889150860553
step: 11, hamming: 0.256215635375215
step: 12, hamming: 0.22230296688024526
step: 13, hamming: 0.19205902295385965
step: 14, hamming: 0.1654029965339068
step: 15, hamming: 0.14214587924488872
step: 16, hamming: 0.12203018089850885
step: 17, hamming: 0.10475927721891458
step: 18, hamming: 0.09001790128025045
step: 19, hamming: 0.07748617353400274
step: 20, hamming: 0.06684920778474639
step: 21, hamming: 0.05780549039322097
step: 22, hamming: 0.05007527318165609
step: 23, hamming: 0.04341014640011884
step: 24, hamming: 0.037602349632078355
step: 25, hamming: 0.03249107812351406
step: 26, hamming: 0.027962472467870057
step: 27, hamming: 0.023942393402995726
step: 28, hamming: 0.02038421216362342
step: 29, hamming: 0.017255759085262886
```

```
step: 30, hamming: 0.014529132197793934
step: 31, hamming: 0.012174934686279325
step: 32, hamming: 0.01016047354805776
step: 33, hamming: 0.00845045102340879
step: 34, hamming: 0.007008679501096658
step: 35, hamming: 0.005799847383305955
step: 36, hamming: 0.004790869857934986
step: 37, hamming: 0.003951715021127735
step: 38, hamming: 0.0032557729560454486
step: 39, hamming: 0.0026798912102927977
step: 40, hamming: 0.0022041994917917375
step: 41, hamming: 0.0018118190733138495
step: 42, hamming: 0.0014885231793603086
step: 43, hamming: 0.0012223905275455381
step: 44, hamming: 0.0010034762989084784
step: 45, hamming: 0.0008235128661467346
Running panda took: 1.24 seconds!
  Elapsed time: 1.24 sec.
Saving LIONESS network 1 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 2:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6445476038755726
step: 1, hamming: 0.6066183636796103
step: 2, hamming: 0.6105445645592842
step: 3, hamming: 0.5875332090279165
step: 4, hamming: 0.5536082244075643
step: 5, hamming: 0.5131126090450783
step: 6, hamming: 0.4689036142976635
step: 7, hamming: 0.4232673243729872
step: 8, hamming: 0.37801889244651404
step: 9, hamming: 0.33452219983661163
step: 10, hamming: 0.2937266882099521
step: 11, hamming: 0.2562219876264076
step: 12, hamming: 0.2223082180455078
step: 13, hamming: 0.192063458293167
step: 14, hamming: 0.16540684598000693
step: 15, hamming: 0.14214929350383068
step: 16, hamming: 0.1220332658570197
step: 17, hamming: 0.10476213861746783
step: 18, hamming: 0.09002061402300265
step: 19, hamming: 0.07748873372939052
step: 20, hamming: 0.06685160145106346
step: 21, hamming: 0.05780769330088384
```

```
step: 22, hamming: 0.050077286995798435
step: 23, hamming: 0.04341196756403582
step: 24, hamming: 0.03760397086506173
step: 25, hamming: 0.032492502477724144
step: 26, hamming: 0.02796370867990172
step: 27, hamming: 0.023943455630073412
step: 28, hamming: 0.02038511733123427
step: 29, hamming: 0.017256526537376277
step: 30, hamming: 0.014529780088585702
step: 31, hamming: 0.012175478875860603
step: 32, hamming: 0.010160929649048585
step: 33, hamming: 0.00845083256181436
step: 34, hamming: 0.007008998275263659
step: 35, hamming: 0.005800112931660261
step: 36, hamming: 0.004791090473343346
step: 37, hamming: 0.003951898060626235
step: 38, hamming: 0.00325592456445805
step: 39, hamming: 0.0026800165805499643
step: 40, hamming: 0.0022043030339044378
step: 41, hamming: 0.0018119045001386961
step: 42, hamming: 0.0014885935906914832
step: 43, hamming: 0.0012224485182821014
step: 44, hamming: 0.001003524027229861
step: 45, hamming: 0.000823552124868469
Running panda took: 1.27 seconds!
  Elapsed time: 1.27 sec.
Saving LIONESS network 2 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 3:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6452294464816624
step: 1, hamming: 0.6066718767537945
step: 2, hamming: 0.6105013812906783
step: 3, hamming: 0.5874769465007301
step: 4, hamming: 0.5535467800773779
step: 5, hamming: 0.5130509623219738
step: 6, hamming: 0.46884619807330863
step: 7, hamming: 0.42321422343773074
step: 8, hamming: 0.37797019212390504
step: 9, hamming: 0.3344779785095642
step: 10, hamming: 0.29368704884702534
step: 11, hamming: 0.25618720406795764
step: 12, hamming: 0.22227787688473347
step: 13, hamming: 0.19203719585754386
```

```
step: 14, hamming: 0.16538418880501976
step: 15, hamming: 0.14212975837567024
step: 16, hamming: 0.12201639360763507
step: 17, hamming: 0.10474755327204792
step: 18, hamming: 0.09000797360987652
step: 19, hamming: 0.07747770691527575
step: 20, hamming: 0.06684195286417426
step: 21, hamming: 0.05779924885457799
step: 22, hamming: 0.0500699126573237
step: 23, hamming: 0.04340556363927609
step: 24, hamming: 0.03759846201370095
step: 25, hamming: 0.032487809256736604
step: 26, hamming: 0.02795974130382637
step: 27, hamming: 0.023940126981286655
step: 28, hamming: 0.020382340568109492
step: 29, hamming: 0.017254219929107445
step: 30, hamming: 0.01452786846588523
step: 31, hamming: 0.01217389759028471
step: 32, hamming: 0.010159622712944908
step: 33, hamming: 0.008449753233040156
step: 34, hamming: 0.00700810750381105
step: 35, hamming: 0.00579937824697735
step: 36, hamming: 0.004790484906858998
step: 37, hamming: 0.003951399167495923
step: 38, hamming: 0.003255513771648308
step: 39, hamming: 0.002679678513780071
step: 40, hamming: 0.002204024959443254
step: 41, hamming: 0.0018116758740187903
step: 42, hamming: 0.0014884057006634569
step: 43, hamming: 0.0012222941612371455
step: 44, hamming: 0.0010033972608179476
step: 45, hamming: 0.0008234480506902824
Running panda took: 1.36 seconds!
  Elapsed time: 1.36 sec.
Saving LIONESS network 3 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 4:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6451852429809524
step: 1, hamming: 0.6065219652377926
step: 2, hamming: 0.6104344926479941
step: 3, hamming: 0.5874558460006226
step: 4, hamming: 0.553544963247136
step: 5, hamming: 0.5130643774408143
```

```
step: 6, hamming: 0.46887054373788917
step: 7, hamming: 0.4232496104307795
step: 8, hamming: 0.37801701958351697
step: 9, hamming: 0.3345340739226694
step: 10, hamming: 0.2937480738815744
step: 11, hamming: 0.2562488692873377
step: 12, hamming: 0.2223372706725651
step: 13, hamming: 0.1920924868386737
step: 14, hamming: 0.16543446318988872
step: 15, hamming: 0.1421747497816679
step: 16, hamming: 0.12205609283083736
step: 17, hamming: 0.10478214956850972
step: 18, hamming: 0.09003785868900757
step: 19, hamming: 0.07750337290976046
step: 20, hamming: 0.06686386614000323
step: 21, hamming: 0.05781785478415813
step: 22, hamming: 0.05008562777061508
step: 23, hamming: 0.04341877501262821
step: 24, hamming: 0.03760951592560503
step: 25, hamming: 0.032497011652074345
step: 26, hamming: 0.027967369113727127
step: 27, hamming: 0.02394642097778111
step: 28, hamming: 0.02038752008866367
step: 29, hamming: 0.017258473103985816
step: 30, hamming: 0.014531357492569013
step: 31, hamming: 0.012176759183597894
step: 32, hamming: 0.010161970824797957
step: 33, hamming: 0.008451681020184565
step: 34, hamming: 0.007009691223106566
step: 35, hamming: 0.005800680312786877
step: 36, hamming: 0.00479155596191386
step: 37, hamming: 0.003952280550194625
step: 38, hamming: 0.0032562392620936955
step: 39, hamming: 0.0026802756996071823
step: 40, hamming: 0.0022045164857199514
step: 41, hamming: 0.0018120803581844036
step: 42, hamming: 0.0014887385206301762
step: 43, hamming: 0.0012225679351576793
step: 44, hamming: 0.001003622395160614
step: 45, hamming: 0.0008236331272743103
Running panda took: 1.37 seconds!
  Elapsed time: 1.37 sec.
Saving LIONESS network 4 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 5:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
```

```
   Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6446007808140573
step: 1, hamming: 0.60665616126626608
step: 2, hamming: 0.6105143267305173
step: 3, hamming: 0.5875153809819786
step: 4, hamming: 0.5536025207133696
step: 5, hamming: 0.5131152115952172
step: 6, hamming: 0.468908514507496
step: 7, hamming: 0.42326886776988787
step: 8, hamming: 0.3780158211356529
step: 9, hamming: 0.3345152633298887
step: 10, hamming: 0.29371784199314155
step: 11, hamming: 0.2562128416941286
step: 12, hamming: 0.22229937209191522
step: 13, hamming: 0.1920554156626861
step: 14, hamming: 0.1653996761052681
step: 15, hamming: 0.14214304912137624
step: 16, hamming: 0.12202778290912643
step: 17, hamming: 0.10475728352365837
step: 18, hamming: 0.090016151593947
step: 19, hamming: 0.07748448858975361
step: 20, hamming: 0.06684754079961648
step: 21, hamming: 0.05780382637771552
step: 22, hamming: 0.050073651393493325
step: 23, hamming: 0.043408598021709384
step: 24, hamming: 0.0376009243886287
step: 25, hamming: 0.03248980843262918
step: 26, hamming: 0.027961372564714905
step: 27, hamming: 0.023941467122490446
step: 28, hamming: 0.020383446949155254
step: 29, hamming: 0.017255136000071034
step: 30, hamming: 0.014528627076186464
step: 31, hamming: 0.012174525611025125
step: 32, hamming: 0.010160143004486259
step: 33, hamming: 0.008450183672932479
step: 34, hamming: 0.007008462914496333
step: 35, hamming: 0.005799671567508499
step: 36, hamming: 0.004790726755136287
step: 37, hamming: 0.003951598399939781
step: 38, hamming: 0.0032556778303245064
step: 39, hamming: 0.002679813604130496
step: 40, hamming: 0.002204136137859893
step: 41, hamming: 0.0018117673263748342
step: 42, hamming: 0.0014884808938152945
step: 43, hamming: 0.001222355966581887
step: 44, hamming: 0.0010034480459104299
step: 45, hamming: 0.0008234897655709252
```

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Running panda took: 1.52 seconds!
  Elapsed time: 1.53 sec.
Saving LIONESS network 5 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 6:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.644914727175676
step: 1, hamming: 0.6066459340545902
step: 2, hamming: 0.6105137892381168
step: 3, hamming: 0.5875076422353582
step: 4, hamming: 0.553580794787596
step: 5, hamming: 0.5130868604034443
step: 6, hamming: 0.4688806568825481
step: 7, hamming: 0.42324491174509904
step: 8, hamming: 0.37799750607572563
step: 9, hamming: 0.33450195921162135
step: 10, hamming: 0.29370783535904643
step: 11, hamming: 0.25620490280375174
step: 12, hamming: 0.22229274056922746
step: 13, hamming: 0.19204960851436947
step: 14, hamming: 0.1653945212440373
step: 15, hamming: 0.142138365221463
step: 16, hamming: 0.12202359171841876
step: 17, hamming: 0.1047535348014802
step: 18, hamming: 0.09001300549732213
step: 19, hamming: 0.07748198595168344
step: 20, hamming: 0.06684561523161113
step: 21, hamming: 0.05780239331926075
step: 22, hamming: 0.05007261907425589
step: 23, hamming: 0.043407887819397944
step: 24, hamming: 0.03760046113425872
step: 25, hamming: 0.032489527040096326
step: 26, hamming: 0.027961217331469623
step: 27, hamming: 0.023941395280352773
step: 28, hamming: 0.020383428084858147
step: 29, hamming: 0.017255148056676124
step: 30, hamming: 0.01452865748618028
step: 31, hamming: 0.012174566104760918
step: 32, hamming: 0.010160186691797838
step: 33, hamming: 0.008450226110780602
step: 34, hamming: 0.007008501791631317
step: 35, hamming: 0.005799706008307911
step: 36, hamming: 0.004790756420696586
step: 37, hamming: 0.003951623456964684
```

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step: 38, hamming: 0.003255698700340377
step: 39, hamming: 0.0026798307735675883
step: 40, hamming: 0.0022041501770806667
step: 41, hamming: 0.0018117787582195672
step: 42, hamming: 0.0014884901773124198
step: 43, hamming: 0.0012223635096057423
step: 44, hamming: 0.0010034541834039337
step: 45, hamming: 0.0008234947565908471
Running panda took: 1.70 seconds!
  Elapsed time: 1.71 sec.
Saving LIONESS network 6 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 7:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.03 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6446977027334075
step: 1, hamming: 0.6064843916807413
step: 2, hamming: 0.6103824327902414
step: 3, hamming: 0.5873860105971278
step: 4, hamming: 0.553462428350063
step: 5, hamming: 0.5129759831080029
step: 6, hamming: 0.46877915323218355
step: 7, hamming: 0.42315760514309175
step: 8, hamming: 0.37792629014527557
step: 9, hamming: 0.3344456468150189
step: 10, hamming: 0.29366421996136893
step: 11, hamming: 0.2561711405522022
step: 12, hamming: 0.22226630385566215
step: 13, hamming: 0.1920287469868379
step: 14, hamming: 0.16537787361436804
step: 15, hamming: 0.1421248493580307
step: 16, hamming: 0.12201243940238896
step: 17, hamming: 0.10474418411446189
step: 18, hamming: 0.09000497478051855
step: 19, hamming: 0.07747497601974163
step: 20, hamming: 0.06683946462194992
step: 21, hamming: 0.05779698175620104
step: 22, hamming: 0.05006786610992063
step: 23, hamming: 0.043403719979106144
step: 24, hamming: 0.03759681143075523
step: 25, hamming: 0.03248634755930703
step: 26, hamming: 0.02795846902706733
step: 27, hamming: 0.023939039176463242
step: 28, hamming: 0.020381427355326855
step: 29, hamming: 0.017253462963678152
```

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step: 30, hamming: 0.014527247466191108
step: 31, hamming: 0.012173391298399963
step: 32, hamming: 0.01015921171833301
step: 33, hamming: 0.008449420102928762
step: 34, hamming: 0.007007837027271363
step: 35, hamming: 0.0057991584489345185
step: 36, hamming: 0.004790305989739413
step: 37, hamming: 0.00395125337010865
step: 38, hamming: 0.0032553948541319596
step: 39, hamming: 0.0026795814132303626
step: 40, hamming: 0.0022039455997269405
step: 41, hamming: 0.0018116109753956102
step: 42, hamming: 0.0014883526051433333
step: 43, hamming: 0.001222250710520977
step: 44, hamming: 0.0010033616948213141
step: 45, hamming: 0.0008234189320553601
Running panda took: 1.71 seconds!
  Elapsed time: 1.71 sec.
Saving LIONESS network 7 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 8:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.03 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6459338403224688
step: 1, hamming: 0.6066595645190107
step: 2, hamming: 0.6104610627797933
step: 3, hamming: 0.5874377958138726
step: 4, hamming: 0.5535034427944524
step: 5, hamming: 0.5130076219885702
step: 6, hamming: 0.4688044641107459
step: 7, hamming: 0.423176090435273
step: 8, hamming: 0.37793707228730244
step: 9, hamming: 0.3344497542143437
step: 10, hamming: 0.29366290145773005
step: 11, hamming: 0.2561661870411493
step: 12, hamming: 0.2222596495321926
step: 13, hamming: 0.19202134254653255
step: 14, hamming: 0.16537035801892333
step: 15, hamming: 0.14211767839413375
step: 16, hamming: 0.1220058624837419
step: 17, hamming: 0.10473836447075485
step: 18, hamming: 0.0899999344875568
step: 19, hamming: 0.07747066783111718
step: 20, hamming: 0.06683582626078942
step: 21, hamming: 0.05779392295165679
```

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step: 22, hamming: 0.050065285528220704
step: 23, hamming: 0.04340155522633314
step: 24, hamming: 0.03759500641756283
step: 25, hamming: 0.03248484646178138
step: 26, hamming: 0.02795721995514243
step: 27, hamming: 0.023938001058869156
step: 28, hamming: 0.020380561586156625
step: 29, hamming: 0.017252738442971306
step: 30, hamming: 0.014526640538941682
step: 31, hamming: 0.012172882604496534
step: 32, hamming: 0.010158785500792763
step: 33, hamming: 0.008449063051904349
step: 34, hamming: 0.0070075388029142436
step: 35, hamming: 0.005798910108587988
step: 36, hamming: 0.004790099693035461
step: 37, hamming: 0.003951082234771274
step: 38, hamming: 0.0032552531011320086
step: 39, hamming: 0.002679464173946342
step: 40, hamming: 0.0022038487570621634
step: 41, hamming: 0.0018115310562277804
step: 42, hamming: 0.0014882867079583839
step: 43, hamming: 0.0012221964189122294
step: 44, hamming: 0.0010033169964392796
step: 45, hamming: 0.0008233821537042094
Running panda took: 1.56 seconds!
  Elapsed time: 1.56 sec.
Saving LIONESS network 8 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 9:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.644835199383118
step: 1, hamming: 0.6064879489440818
step: 2, hamming: 0.6103640777269351
step: 3, hamming: 0.5873512050264047
step: 4, hamming: 0.5534219407870922
step: 5, hamming: 0.5129356817661759
step: 6, hamming: 0.46874212604373694
step: 7, hamming: 0.4231236796419835
step: 8, hamming: 0.3778956914256716
step: 9, hamming: 0.3344187635926774
step: 10, hamming: 0.2936404320381599
step: 11, hamming: 0.25615039464431727
step: 12, hamming: 0.22224837772568842
step: 13, hamming: 0.1920133441212464
```

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step: 14, hamming: 0.16536460861948546
step: 15, hamming: 0.14211341395771593
step: 16, hamming: 0.12200253916357386
step: 17, hamming: 0.10473558500674479
step: 18, hamming: 0.0899975091761514
step: 19, hamming: 0.07746846011445685
step: 20, hamming: 0.0668337240386083
step: 21, hamming: 0.05779188696902117
step: 22, hamming: 0.05006331165089909
step: 23, hamming: 0.04339965073511143
step: 24, hamming: 0.03759319857032192
step: 25, hamming: 0.03248315937467175
step: 26, hamming: 0.02795567387570829
step: 27, hamming: 0.023936604678199185
step: 28, hamming: 0.020379322269235813
step: 29, hamming: 0.017251656706988562
step: 30, hamming: 0.01452570782373028
step: 31, hamming: 0.012172086330504326
step: 32, hamming: 0.010158111149147997
step: 33, hamming: 0.008448495729481614
step: 34, hamming: 0.00700706386061792
step: 35, hamming: 0.005798513835817575
step: 36, hamming: 0.004789769960958667
step: 37, hamming: 0.003950808640232261
step: 38, hamming: 0.0032550265635088484
step: 39, hamming: 0.0026792769994106813
step: 40, hamming: 0.002203694319478647
step: 41, hamming: 0.0018114037631512844
step: 42, hamming: 0.001488181878943554
step: 43, hamming: 0.0012221101496973901
step: 44, hamming: 0.0010032460442440806
step: 45, hamming: 0.0008233238300691849
Running panda took: 1.53 seconds!
  Elapsed time: 1.53 sec.
Saving LIONESS network 9 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 10:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6446385831077223
step: 1, hamming: 0.6067294163043445
step: 2, hamming: 0.6105288665126055
step: 3, hamming: 0.5875025168461765
step: 4, hamming: 0.5535668756916816
step: 5, hamming: 0.5130674611873673
```

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step: 6, hamming: 0.46885934016141356
step: 7, hamming: 0.4232239036245543
step: 8, hamming: 0.37797846107383204
step: 9, hamming: 0.3344846104039678
step: 10, hamming: 0.29369144682583337
step: 11, hamming: 0.25618942581891635
step: 12, hamming: 0.22227830891129285
step: 13, hamming: 0.19203629520565335
step: 14, hamming: 0.16538234596848075
step: 15, hamming: 0.14212736448871938
step: 16, hamming: 0.12201379782743488
step: 17, hamming: 0.10474497350107496
step: 18, hamming: 0.09000555414562793
step: 19, hamming: 0.07747554704258396
step: 20, hamming: 0.06684008398127479
step: 21, hamming: 0.05779766899483369
step: 22, hamming: 0.05006859159088394
step: 23, hamming: 0.04340445929636735
step: 24, hamming: 0.03759753082194868
step: 25, hamming: 0.032487015363301903
step: 26, hamming: 0.027959057287518883
step: 27, hamming: 0.023939533290787757
step: 28, hamming: 0.020381824851220524
step: 29, hamming: 0.017253772055378196
step: 30, hamming: 0.014527481551427154
step: 31, hamming: 0.012173565486877314
step: 32, hamming: 0.01015933951894841
step: 33, hamming: 0.008449513032409811
step: 34, hamming: 0.0070079049394139465
step: 35, hamming: 0.005799208359310958
step: 36, hamming: 0.004790342845117795
step: 37, hamming: 0.0039512806754933355
step: 38, hamming: 0.003255415200843872
step: 39, hamming: 0.0026795966888821237
step: 40, hamming: 0.0022039571502874525
step: 41, hamming: 0.0018116197541239644
step: 42, hamming: 0.0014883593143952011
step: 43, hamming: 0.0012222558625903583
step: 44, hamming: 0.0010033656704848061
step: 45, hamming: 0.0008234220134066721
Running panda took: 1.16 seconds!
  Elapsed time: 1.16 sec.
Saving LIONESS network 10 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 11:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
```

```
   Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6445970723339551
step: 1, hamming: 0.6063968880265757
step: 2, hamming: 0.6103628950894618
step: 3, hamming: 0.5873891776463085
step: 4, hamming: 0.5534802081887704
step: 5, hamming: 0.513002081253175
step: 6, hamming: 0.4688120305062983
step: 7, hamming: 0.42319558082755526
step: 8, hamming: 0.37796866634930115
step: 9, hamming: 0.33449062529413504
step: 10, hamming: 0.2937094300379334
step: 11, hamming: 0.25621479946024567
step: 12, hamming: 0.22230732905919462
step: 13, hamming: 0.1920663351741951
step: 14, hamming: 0.16541153798715835
step: 15, hamming: 0.14215454775653846
step: 16, hamming: 0.12203842025372977
step: 17, hamming: 0.10476672314281758
step: 18, hamming: 0.09002441117486851
step: 19, hamming: 0.0774916478941815
step: 20, hamming: 0.06685368125563591
step: 21, hamming: 0.057809051101809394
step: 22, hamming: 0.05007803092604654
step: 23, hamming: 0.043412213334691245
step: 24, hamming: 0.03760386116781324
step: 25, hamming: 0.03249215842908324
step: 26, hamming: 0.027963237690867417
step: 27, hamming: 0.023942944227938814
step: 28, hamming: 0.020384620173815014
step: 29, hamming: 0.01725607696542481
step: 30, hamming: 0.014529391608107673
step: 31, hamming: 0.012175154165384169
step: 32, hamming: 0.010160664950073586
step: 33, hamming: 0.008450619213181503
step: 34, hamming: 0.0070088270324212805
step: 35, hamming: 0.005799976086644725
step: 36, hamming: 0.004790981350177024
step: 37, hamming: 0.00395181094359943
step: 38, hamming: 0.003255854969433178
step: 39, hamming: 0.0026799609209546085
step: 40, hamming: 0.002204258454443337
step: 41, hamming: 0.001811868738304759
step: 42, hamming: 0.0014885648646981047
step: 43, hamming: 0.0012224254093928502
step: 44, hamming: 0.0010035054146104428
step: 45, hamming: 0.000823537115427815
```

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Running panda took: 1.15 seconds!
  Elapsed time: 1.15 sec.
Saving LIONESS network 11 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 12:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6449227035246179
step: 1, hamming: 0.6067351153769638
step: 2, hamming: 0.6106375012468723
step: 3, hamming: 0.5876437952563218
step: 4, hamming: 0.5537178078810691
step: 5, hamming: 0.5132213547717155
step: 6, hamming: 0.4690101547789507
step: 7, hamming: 0.4233685648402591
step: 8, hamming: 0.37811364961234867
step: 9, hamming: 0.33460905552916437
step: 10, hamming: 0.2938046259139321
step: 11, hamming: 0.2562907749359493
step: 12, hamming: 0.22236807687185267
step: 13, hamming: 0.19211508180706444
step: 14, hamming: 0.16545097662140518
step: 15, hamming: 0.14218673742040688
step: 16, hamming: 0.12206484516686276
step: 17, hamming: 0.10478861898320703
step: 18, hamming: 0.09004269287907357
step: 19, hamming: 0.07750702507205871
step: 20, hamming: 0.06686675609772615
step: 21, hamming: 0.05782028426552099
step: 22, hamming: 0.050087769533937905
step: 23, hamming: 0.043420696376732626
step: 24, hamming: 0.037611262734358726
step: 25, hamming: 0.032498609240512365
step: 26, hamming: 0.027968830176749452
step: 27, hamming: 0.023947752343236345
step: 28, hamming: 0.020388722079863027
step: 29, hamming: 0.01725954609362629
step: 30, hamming: 0.014532302553875656
step: 31, hamming: 0.012177581011002225
step: 32, hamming: 0.010162676990644746
step: 33, hamming: 0.008452281514633632
step: 34, hamming: 0.007010197176704603
step: 35, hamming: 0.0058011034340297776
step: 36, hamming: 0.0047919078009273945
step: 37, hamming: 0.003952571735671334
```

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step: 38, hamming: 0.0032564793806740488
step: 39, hamming: 0.002680473211329055
step: 40, hamming: 0.0022046786306772798
step: 41, hamming: 0.0018122132860573493
step: 42, hamming: 0.001488847347481173
step: 43, hamming: 0.001222656971478183
step: 44, hamming: 0.0010036952106255847
step: 45, hamming: 0.0008236926599718458
Running panda took: 1.16 seconds!
  Elapsed time: 1.16 sec.
Saving LIONESS network 12 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 13:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6454815045482025
step: 1, hamming: 0.6064888334615246
step: 2, hamming: 0.6103537850467549
step: 3, hamming: 0.5873467987983988
step: 4, hamming: 0.5534173891580667
step: 5, hamming: 0.5129251262883209
step: 6, hamming: 0.4687264900712108
step: 7, hamming: 0.4231036921678549
step: 8, hamming: 0.3778721072843273
step: 9, hamming: 0.33439250879973836
step: 10, hamming: 0.29361248905541215
step: 11, hamming: 0.25612178099974314
step: 12, hamming: 0.22222032595119312
step: 13, hamming: 0.19198634671852602
step: 14, hamming: 0.16533917584848357
step: 15, hamming: 0.14208990495011609
step: 16, hamming: 0.1219811952488296
step: 17, hamming: 0.10471648707194937
step: 18, hamming: 0.08998053903852753
step: 19, hamming: 0.07745350260977646
step: 20, hamming: 0.06682062957867617
step: 21, hamming: 0.05778050118366357
step: 22, hamming: 0.05005347176858947
step: 23, hamming: 0.04339119603182728
step: 24, hamming: 0.03758595561496705
step: 25, hamming: 0.03247697829457956
step: 26, hamming: 0.0279504168476757
step: 27, hamming: 0.023932149875743866
step: 28, hamming: 0.020375560744930257
step: 29, hamming: 0.017248488850848613
```

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step: 30, hamming: 0.014523048953008228
step: 31, hamming: 0.012169862212797651
step: 32, hamming: 0.010156256059334045
step: 33, hamming: 0.00844695177768301
step: 34, hamming: 0.007005781213394503
step: 35, hamming: 0.005797450270253753
step: 36, hamming: 0.004788889434590357
step: 37, hamming: 0.003950080544120968
step: 38, hamming: 0.0032544251655959506
step: 39, hamming: 0.002678780646612269
step: 40, hamming: 0.0022032850078452723
step: 41, hamming: 0.0018110664850589538
step: 42, hamming: 0.001487904142285912
step: 43, hamming: 0.0012218815774630246
step: 44, hamming: 0.001003058031224306
step: 45, hamming: 0.0008231692507589993
Running panda took: 1.25 seconds!
  Elapsed time: 1.25 sec.
Saving LIONESS network 13 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 14:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.03 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6443394902350985
step: 1, hamming: 0.6066808238313084
step: 2, hamming: 0.6105000628534961
step: 3, hamming: 0.5874753808094995
step: 4, hamming: 0.5535342710047162
step: 5, hamming: 0.5130322757657333
step: 6, hamming: 0.46882485488303
step: 7, hamming: 0.42319334974995565
step: 8, hamming: 0.37795210281175695
step: 9, hamming: 0.3344633679474345
step: 10, hamming: 0.2936753764324572
step: 11, hamming: 0.2561774279980078
step: 12, hamming: 0.2222694459009427
step: 13, hamming: 0.19203006056522645
step: 14, hamming: 0.16537809623297536
step: 15, hamming: 0.14212455805772894
step: 16, hamming: 0.12201199051973263
step: 17, hamming: 0.10474380875818415
step: 18, hamming: 0.09000482045293938
step: 19, hamming: 0.07747506491160118
step: 20, hamming: 0.06683975370409435
step: 21, hamming: 0.05779742984599141
```

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step: 22, hamming: 0.050068421477429015
step: 23, hamming: 0.04340433264758675
step: 24, hamming: 0.03759742735740402
step: 25, hamming: 0.032486926776789646
step: 26, hamming: 0.0279589832412535
step: 27, hamming: 0.023939475652045558
step: 28, hamming: 0.020381784048555823
step: 29, hamming: 0.017253746643295972
step: 30, hamming: 0.014527468810299439
step: 31, hamming: 0.012173562253857687
step: 32, hamming: 0.010159342835363386
step: 33, hamming: 0.008449520673285476
step: 34, hamming: 0.00700791419914384
step: 35, hamming: 0.005799217819609791
step: 36, hamming: 0.004790352300931195
step: 37, hamming: 0.00395128963016098
step: 38, hamming: 0.003255423348636021
step: 39, hamming: 0.0026796039355505563
step: 40, hamming: 0.002203963484083055
step: 41, hamming: 0.0018116252199462354
step: 42, hamming: 0.0014883639807463868
step: 43, hamming: 0.0012222598171972396
step: 44, hamming: 0.0010033690024990117
step: 45, hamming: 0.000823424809994582
Running panda took: 1.47 seconds!
  Elapsed time: 1.47 sec.
Saving LIONESS network 14 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 15:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6442838140322694
step: 1, hamming: 0.6065432591877655
step: 2, hamming: 0.6104256202756484
step: 3, hamming: 0.587423936441978
step: 4, hamming: 0.553504385366511
step: 5, hamming: 0.5130177294826509
step: 6, hamming: 0.4688195259817124
step: 7, hamming: 0.42319353876507343
step: 8, hamming: 0.37795644651552873
step: 9, hamming: 0.3344697612732674
step: 10, hamming: 0.29368304260522193
step: 11, hamming: 0.25618591729315593
step: 12, hamming: 0.22227818582319145
step: 13, hamming: 0.19203847272328892
```

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step: 14, hamming: 0.16538591145842108
step: 15, hamming: 0.14213154151205495
step: 16, hamming: 0.12201804684367133
step: 17, hamming: 0.10474891800358453
step: 18, hamming: 0.09000896576805426
step: 19, hamming: 0.07747832725281116
step: 20, hamming: 0.06684227158737589
step: 21, hamming: 0.05779932753307891
step: 22, hamming: 0.05006981276657545
step: 23, hamming: 0.04340535193546641
step: 24, hamming: 0.037598189054180546
step: 25, hamming: 0.0324875206504374
step: 26, hamming: 0.027959467696440896
step: 27, hamming: 0.023939886206924728
step: 28, hamming: 0.020382138917549576
step: 29, hamming: 0.017254056868073377
step: 30, hamming: 0.014527740108929025
step: 31, hamming: 0.01217379823366811
step: 32, hamming: 0.010159546268615196
step: 33, hamming: 0.008449694062619572
step: 34, hamming: 0.007008060926552581
step: 35, hamming: 0.005799341301245976
step: 36, hamming: 0.004790455394888103
step: 37, hamming: 0.003951375363936759
step: 38, hamming: 0.003255494471286037
step: 39, hamming: 0.0026796628068911565
step: 40, hamming: 0.0022040121296349868
step: 41, hamming: 0.001811665368656811
step: 42, hamming: 0.0014883970876660596
step: 43, hamming: 0.0012222870952029116
step: 44, hamming: 0.0010033914641085328
step: 45, hamming: 0.0008234432936021228
Running panda took: 1.23 seconds!
  Elapsed time: 1.23 sec.
Saving LIONESS network 15 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 16:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6451357933509942
step: 1, hamming: 0.6066460429428087
step: 2, hamming: 0.6104672809769209
step: 3, hamming: 0.5874429022191956
step: 4, hamming: 0.5535053796996752
step: 5, hamming: 0.5130102568327171
```

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step: 6, hamming: 0.46880788051023403
step: 7, hamming: 0.4231820754210904
step: 8, hamming: 0.37794630825110404
step: 9, hamming: 0.33446172175110056
step: 10, hamming: 0.2936769576201944
step: 11, hamming: 0.2561810037908882
step: 12, hamming: 0.22227406388621238
step: 13, hamming: 0.19203490092286687
step: 14, hamming: 0.1653828131013553
step: 15, hamming: 0.14212890528332242
step: 16, hamming: 0.12201583114277063
step: 17, hamming: 0.10474707223510565
step: 18, hamming: 0.09000753562825538
step: 19, hamming: 0.07747728987948439
step: 20, hamming: 0.06684154362198168
step: 21, hamming: 0.05779884394184241
step: 22, hamming: 0.05006952159265663
step: 23, hamming: 0.04340519640748409
step: 24, hamming: 0.037598110122971234
step: 25, hamming: 0.03248747270773837
step: 26, hamming: 0.027959425880675674
step: 27, hamming: 0.023939839110948595
step: 28, hamming: 0.020382085146816525
step: 29, hamming: 0.01725399643445798
step: 30, hamming: 0.014527676899527596
step: 31, hamming: 0.012173735023499315
step: 32, hamming: 0.010159486018898033
step: 33, hamming: 0.008449638740920182
step: 34, hamming: 0.00700801161545041
step: 35, hamming: 0.005799298264348275
step: 36, hamming: 0.004790418528106761
step: 37, hamming: 0.003951344147935315
step: 38, hamming: 0.0032554682222274765
step: 39, hamming: 0.0026796408398129705
step: 40, hamming: 0.002203993820812896
step: 41, hamming: 0.0018116502262686576
step: 42, hamming: 0.0014883845846321853
step: 43, hamming: 0.0012222767839663946
step: 44, hamming: 0.0010033829666874486
step: 45, hamming: 0.0008234362966904189
Running panda took: 1.25 seconds!
  Elapsed time: 1.25 sec.
Saving LIONESS network 16 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 17:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
```

```
   Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6453372188039735
step: 1, hamming: 0.6066676287287169
step: 2, hamming: 0.6104644764183814
step: 3, hamming: 0.5874393760760523
step: 4, hamming: 0.553506577030067
step: 5, hamming: 0.5130098317112232
step: 6, hamming: 0.46880493446531935
step: 7, hamming: 0.42317541168503864
step: 8, hamming: 0.3779353604570779
step: 9, hamming: 0.33444725718243223
step: 10, hamming: 0.2936601064819789
step: 11, hamming: 0.2561633601925414
step: 12, hamming: 0.2222568377191461
step: 13, hamming: 0.19201879569173996
step: 14, hamming: 0.16536830973066036
step: 15, hamming: 0.1421162248277369
step: 16, hamming: 0.12200488017569686
step: 17, hamming: 0.10473769975276602
step: 18, hamming: 0.08999949865507745
step: 19, hamming: 0.077470424217288
step: 20, hamming: 0.06683571528299424
step: 21, hamming: 0.057793931389394995
step: 22, hamming: 0.0500654130944078
step: 23, hamming: 0.04340179230182477
step: 24, hamming: 0.03759532580717451
step: 25, hamming: 0.0324852250857994
step: 26, hamming: 0.027957631020622514
step: 27, hamming: 0.023938413555977024
step: 28, hamming: 0.020380954334854536
step: 29, hamming: 0.017253098946343814
step: 30, hamming: 0.014526961138535554
step: 31, hamming: 0.0121731618457686
step: 32, hamming: 0.010159024956166728
step: 33, hamming: 0.008449266035746403
step: 34, hamming: 0.00700770946888819
step: 35, hamming: 0.005799052725515068
step: 36, hamming: 0.004790218419084313
step: 37, hamming: 0.003951180792084351
step: 38, hamming: 0.0032553347191006453
step: 39, hamming: 0.0026795316594392417
step: 40, hamming: 0.00220390448313955
step: 41, hamming: 0.0018115770171323311
step: 42, hamming: 0.0014883245770206178
step: 43, hamming: 0.0012222275926846073
step: 44, hamming: 0.0010033426427683515
step: 45, hamming: 0.0008234032422371829
```

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Running panda took: 1.24 seconds!
  Elapsed time: 1.24 sec.
Saving LIONESS network 17 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 18:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6449357768289141
step: 1, hamming: 0.6067478759109104
step: 2, hamming: 0.6105187387290016
step: 3, hamming: 0.5874835466275927
step: 4, hamming: 0.5535417550864121
step: 5, hamming: 0.5130402196441705
step: 6, hamming: 0.46883185330556426
step: 7, hamming: 0.4231991954317866
step: 8, hamming: 0.3779561923867192
step: 9, hamming: 0.3344661242851883
step: 10, hamming: 0.29367727342311356
step: 11, hamming: 0.2561788722687788
step: 12, hamming: 0.22227085717962164
step: 13, hamming: 0.19203122760644709
step: 14, hamming: 0.16537907569669916
step: 15, hamming: 0.1421253806373162
step: 16, hamming: 0.12201265787241684
step: 17, hamming: 0.10474431714590453
step: 18, hamming: 0.09000515595301477
step: 19, hamming: 0.07747531799818602
step: 20, hamming: 0.06683996904018247
step: 21, hamming: 0.057797597602988214
step: 22, hamming: 0.05006852906896945
step: 23, hamming: 0.043404392081109584
step: 24, hamming: 0.03759745306277048
step: 25, hamming: 0.032486925619651025
step: 26, hamming: 0.02795896080983829
step: 27, hamming: 0.023939439452491513
step: 28, hamming: 0.020381738530574928
step: 29, hamming: 0.017253695360279313
step: 30, hamming: 0.014527415793591236
step: 31, hamming: 0.012173510704249173
step: 32, hamming: 0.010159294487304498
step: 33, hamming: 0.008449476113258232
step: 34, hamming: 0.0070078742878287355
step: 35, hamming: 0.005799182820196557
step: 36, hamming: 0.004790321840049444
step: 37, hamming: 0.003951263491362447
```

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step: 38, hamming: 0.0032554011485745643
step: 39, hamming: 0.002679585187798109
step: 40, hamming: 0.0022039477307740168
step: 41, hamming: 0.0018116120424978204
step: 42, hamming: 0.001488352999338743
step: 43, hamming: 0.0012222506897605569
step: 44, hamming: 0.0010033614331443708
step: 45, hamming: 0.0008234185581224581
Running panda took: 1.24 seconds!
  Elapsed time: 1.25 sec.
Saving LIONESS network 18 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 19:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6455081786434625
step: 1, hamming: 0.6064194187335534
step: 2, hamming: 0.6103607543150152
step: 3, hamming: 0.5873862777167244
step: 4, hamming: 0.553480413292402
step: 5, hamming: 0.5130026093014715
step: 6, hamming: 0.4688113588544863
step: 7, hamming: 0.42318953580922025
step: 8, hamming: 0.37795441759448034
step: 9, hamming: 0.33446855180911206
step: 10, hamming: 0.29368214409431076
step: 11, hamming: 0.2561851448411255
step: 12, hamming: 0.22227745758160627
step: 13, hamming: 0.192037632845968
step: 14, hamming: 0.1653849673949693
step: 15, hamming: 0.14213058508151208
step: 16, hamming: 0.12201710874059979
step: 17, hamming: 0.10474810732061202
step: 18, hamming: 0.0900083402499391
step: 19, hamming: 0.07747789189112711
step: 20, hamming: 0.06684199669576117
step: 21, hamming: 0.05779919229936601
step: 22, hamming: 0.05006980214737102
step: 23, hamming: 0.04340543355149784
step: 24, hamming: 0.03759834459496707
step: 25, hamming: 0.03248771827770938
step: 26, hamming: 0.02795969480756446
step: 27, hamming: 0.023940128620517382
step: 28, hamming: 0.020382385800924933
step: 29, hamming: 0.01725429871240458
```

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step: 30, hamming: 0.014527969806710518
step: 31, hamming: 0.012174010998701938
step: 32, hamming: 0.010159739559041083
step: 33, hamming: 0.008449866915345711
step: 34, hamming: 0.007008213042126161
step: 35, hamming: 0.005799473355581619
step: 36, hamming: 0.00479056874436645
step: 37, hamming: 0.003951471883857408
step: 38, hamming: 0.0032555761831291954
step: 39, hamming: 0.0026797315837817047
step: 40, hamming: 0.0022040697609956345
step: 41, hamming: 0.0018117134754357912
step: 42, hamming: 0.0014884371182850343
step: 43, hamming: 0.0012223203233192148
step: 44, hamming: 0.0010034189869899289
step: 45, hamming: 0.0008234660519401823
Running panda took: 1.24 seconds!
  Elapsed time: 1.24 sec.
Saving LIONESS network 19 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 20:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6439395298412643
step: 1, hamming: 0.606444636415115
step: 2, hamming: 0.6103874530759168
step: 3, hamming: 0.587378224328637
step: 4, hamming: 0.5534408069230906
step: 5, hamming: 0.5129461968109986
step: 6, hamming: 0.4687480609928045
step: 7, hamming: 0.42312972606616733
step: 8, hamming: 0.37790354425769523
step: 9, hamming: 0.3344283359725711
step: 10, hamming: 0.29365126515501877
step: 11, hamming: 0.25616176939524715
step: 12, hamming: 0.2222599888792308
step: 13, hamming: 0.19202452498598024
step: 14, hamming: 0.165375017595712
step: 15, hamming: 0.14212288137746548
step: 16, hamming: 0.12201101905345443
step: 17, hamming: 0.10474308059192008
step: 18, hamming: 0.09000401407761764
step: 19, hamming: 0.07747412442844388
step: 20, hamming: 0.06683863595804257
step: 21, hamming: 0.057796138871261137
```

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step: 22, hamming: 0.05006700914121159
step: 23, hamming: 0.043402875353600476
step: 24, hamming: 0.03759601882243465
step: 25, hamming: 0.032485634181046795
step: 26, hamming: 0.027957849133881683
step: 27, hamming: 0.023938508535798864
step: 28, hamming: 0.020380978291102244
step: 29, hamming: 0.01725308408299542
step: 30, hamming: 0.014526928573715072
step: 31, hamming: 0.012173124106190272
step: 32, hamming: 0.01015898896686592
step: 33, hamming: 0.008449235814467616
step: 34, hamming: 0.007007685785454704
step: 35, hamming: 0.005799035223298282
step: 36, hamming: 0.0047902061802674555
step: 37, hamming: 0.0039511729044897055
step: 38, hamming: 0.0032553302873377593
step: 39, hamming: 0.0026795297588183766
step: 40, hamming: 0.0022039043608018728
step: 41, hamming: 0.0018115780790296146
step: 42, hamming: 0.0014883263714357737
step: 43, hamming: 0.0012222297878657674
step: 44, hamming: 0.0010033450031440958
step: 45, hamming: 0.0008234056073751187
Running panda took: 1.24 seconds!
  Elapsed time: 1.24 sec.
Saving LIONESS network 20 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 21:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6450848367279334
step: 1, hamming: 0.6066233811194319
step: 2, hamming: 0.6104738378033744
step: 3, hamming: 0.5874590505004481
step: 4, hamming: 0.553529311711965
step: 5, hamming: 0.5130347272475934
step: 6, hamming: 0.4688311364101988
step: 7, hamming: 0.423201202950783
step: 8, hamming: 0.3779600554810355
step: 9, hamming: 0.33447046880848674
step: 10, hamming: 0.29368153860449103
step: 11, hamming: 0.256182992647495
step: 12, hamming: 0.22227459868710234
step: 13, hamming: 0.19203454863632288
```

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step: 14, hamming: 0.16538197139376914
step: 15, hamming: 0.14212785490634228
step: 16, hamming: 0.12201474746203654
step: 17, hamming: 0.10474604616613903
step: 18, hamming: 0.09000658579037367
step: 19, hamming: 0.07747648716459518
step: 20, hamming: 0.06684087416347566
step: 21, hamming: 0.057798285097580865
step: 22, hamming: 0.05006904051012411
step: 23, hamming: 0.04340476637970672
step: 24, hamming: 0.03759772603328491
step: 25, hamming: 0.03248712996303483
step: 26, hamming: 0.02795911898727303
step: 27, hamming: 0.023939563169657063
step: 28, hamming: 0.02038183836027533
step: 29, hamming: 0.01725377713847119
step: 30, hamming: 0.014527483895349053
step: 31, hamming: 0.01217356730581402
step: 32, hamming: 0.010159341931297585
step: 33, hamming: 0.008449516089574675
step: 34, hamming: 0.007007908113106246
step: 35, hamming: 0.005799211545052688
step: 36, hamming: 0.004790346079477174
step: 37, hamming: 0.003951283832559894
step: 38, hamming: 0.003255418189643129
step: 39, hamming: 0.0026795994570336643
step: 40, hamming: 0.0022039596712132357
step: 41, hamming: 0.0018116220164900937
step: 42, hamming: 0.0014883613416886991
step: 43, hamming: 0.0012222576717636905
step: 44, hamming: 0.0010033672638236329
step: 45, hamming: 0.0008234234034135342
Running panda took: 1.25 seconds!
  Elapsed time: 1.25 sec.
Saving LIONESS network 21 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 22:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6453859638093248
step: 1, hamming: 0.606696579098816
step: 2, hamming: 0.6104918352908492
step: 3, hamming: 0.5874671302827963
step: 4, hamming: 0.5535319083441806
step: 5, hamming: 0.5130343438245887
```

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step: 6, hamming: 0.46883010704011957
step: 7, hamming: 0.42319927931184576
step: 8, hamming: 0.377958105463949
step: 9, hamming: 0.3344683776483375
step: 10, hamming: 0.29367955113712857
step: 11, hamming: 0.2561812888003239
step: 12, hamming: 0.22227300354666066
step: 13, hamming: 0.1920330583902126
step: 14, hamming: 0.16538058859573115
step: 15, hamming: 0.14212657310449725
step: 16, hamming: 0.12201356805469019
step: 17, hamming: 0.10474498314173354
step: 18, hamming: 0.09000563040511554
step: 19, hamming: 0.07747556450073831
step: 20, hamming: 0.06684002119191149
step: 21, hamming: 0.05779753362320707
step: 22, hamming: 0.05006839068356395
step: 23, hamming: 0.0434042189139166
step: 24, hamming: 0.03759727805610255
step: 25, hamming: 0.03248676757264254
step: 26, hamming: 0.027958831924822302
step: 27, hamming: 0.02393934131099991
step: 28, hamming: 0.0203816693839802
step: 29, hamming: 0.017253650955294644
step: 30, hamming: 0.014527390237321747
step: 31, hamming: 0.01217349800996446
step: 32, hamming: 0.010159290165315724
step: 33, hamming: 0.008449476812725698
step: 34, hamming: 0.00700787781935247
step: 35, hamming: 0.005799187804456238
step: 36, hamming: 0.004790327214202528
step: 37, hamming: 0.003951268652192236
step: 38, hamming: 0.003255405875696191
step: 39, hamming: 0.002679589392770106
step: 40, hamming: 0.0022039513978170484
step: 41, hamming: 0.001811615192450883
step: 42, hamming: 0.0014883556795001673
step: 43, hamming: 0.0012222529540384143
step: 44, hamming: 0.0010033633357891564
step: 45, hamming: 0.0008234201342693849
Running panda took: 1.29 seconds!
  Elapsed time: 1.29 sec.
Saving LIONESS network 22 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 23:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
```

```
   Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6435616555805806
step: 1, hamming: 0.6065774661127371
step: 2, hamming: 0.610468595413635
step: 3, hamming: 0.5874707578579494
step: 4, hamming: 0.5535538083324445
step: 5, hamming: 0.5130651148399518
step: 6, hamming: 0.4688591784891974
step: 7, hamming: 0.4232231791435238
step: 8, hamming: 0.37797491630976726
step: 9, hamming: 0.33447914071665064
step: 10, hamming: 0.29368549481398054
step: 11, hamming: 0.25618363859574517
step: 12, hamming: 0.22227301663758203
step: 13, hamming: 0.19203158876314616
step: 14, hamming: 0.1653781653066901
step: 15, hamming: 0.14212379235777953
step: 16, hamming: 0.12201066274790016
step: 17, hamming: 0.10474203578042608
step: 18, hamming: 0.09000269743578625
step: 19, hamming: 0.07747275376080467
step: 20, hamming: 0.06683734743392256
step: 21, hamming: 0.0577950210516337
step: 22, hamming: 0.05006608553256088
step: 23, hamming: 0.04340213107403853
step: 24, hamming: 0.03759541702968891
step: 25, hamming: 0.03248513867836512
step: 26, hamming: 0.02795742639550285
step: 27, hamming: 0.02393814160249087
step: 28, hamming: 0.020380652363289783
step: 29, hamming: 0.017252792040855006
step: 30, hamming: 0.014526666851716613
step: 31, hamming: 0.012172890239012218
step: 32, hamming: 0.010158780660191595
step: 33, hamming: 0.008449050574685639
step: 34, hamming: 0.007007521946824569
step: 35, hamming: 0.0057988910697919045
step: 36, hamming: 0.004790080090026641
step: 37, hamming: 0.003951063180798141
step: 38, hamming: 0.0032552352818237323
step: 39, hamming: 0.0026794480123289452
step: 40, hamming: 0.0022038343696844176
step: 41, hamming: 0.0018115184280167015
step: 42, hamming: 0.0014882757448709764
step: 43, hamming: 0.001222186981081775
step: 44, hamming: 0.0010033089289654196
step: 45, hamming: 0.0008233752989717556
```

```
Running panda took: 1.29 seconds!
  Elapsed time: 1.29 sec.
Saving LIONESS network 23 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 24:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6451374874258015
step: 1, hamming: 0.6065597248100143
step: 2, hamming: 0.6104785268315843
step: 3, hamming: 0.5874892432769233
step: 4, hamming: 0.553567791572826
step: 5, hamming: 0.5130739316093189
step: 6, hamming: 0.46886944915852674
step: 7, hamming: 0.4232372785450944
step: 8, hamming: 0.3779939472775404
step: 9, hamming: 0.33450152147245443
step: 10, hamming: 0.2937094193739473
step: 11, hamming: 0.2562077730351675
step: 12, hamming: 0.22229629530279874
step: 13, hamming: 0.19205343679473316
step: 14, hamming: 0.16539838482864916
step: 15, hamming: 0.14214207545812796
step: 16, hamming: 0.12202716731448059
step: 17, hamming: 0.10475689437070312
step: 18, hamming: 0.09001608575237814
step: 19, hamming: 0.0774847471094978
step: 20, hamming: 0.06684806346197887
step: 21, hamming: 0.05780455531349574
step: 22, hamming: 0.05007450535329472
step: 23, hamming: 0.04340951742134202
step: 24, hamming: 0.037601852012909276
step: 25, hamming: 0.03249070133634119
step: 26, hamming: 0.02796219819782178
step: 27, hamming: 0.023942208045912385
step: 28, hamming: 0.020384097306212396
step: 29, hamming: 0.01725569964822445
step: 30, hamming: 0.014529113182227082
step: 31, hamming: 0.012174941631275542
step: 32, hamming: 0.010160495993560505
step: 33, hamming: 0.008450481219030376
step: 34, hamming: 0.007008712784988989
step: 35, hamming: 0.005799880479159794
step: 36, hamming: 0.004790900762682554
step: 37, hamming: 0.003951742881773002
```

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step: 38, hamming: 0.0032557974943049667
step: 39, hamming: 0.0026799124669886366
step: 40, hamming: 0.0022042177025821622
step: 41, hamming: 0.0018118345457225498
step: 42, hamming: 0.0014885362410434037
step: 43, hamming: 0.0012224015057432387
step: 44, hamming: 0.0010034854919391918
step: 45, hamming: 0.0008235205432486282
Running panda took: 1.24 seconds!
  Elapsed time: 1.24 sec.
Saving LIONESS network 24 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 25:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6457395627686134
step: 1, hamming: 0.6064608877070142
step: 2, hamming: 0.6103727825941945
step: 3, hamming: 0.5873823343108445
step: 4, hamming: 0.5534684140947953
step: 5, hamming: 0.5129868713457605
step: 6, hamming: 0.46879289203841173
step: 7, hamming: 0.4231710646886092
step: 8, hamming: 0.37793701543032326
step: 9, hamming: 0.33445323750400024
step: 10, hamming: 0.29366868496976617
step: 11, hamming: 0.25617307269249323
step: 12, hamming: 0.22226674885043102
step: 13, hamming: 0.19202822641393982
step: 14, hamming: 0.16537671830260126
step: 15, hamming: 0.14212334810171476
step: 16, hamming: 0.1220107685282419
step: 17, hamming: 0.10474248793357537
step: 18, hamming: 0.09000330140588078
step: 19, hamming: 0.07747333480760728
step: 20, hamming: 0.06683787049330008
step: 21, hamming: 0.057795449353665554
step: 22, hamming: 0.05006637373531308
step: 23, hamming: 0.043402273765913546
step: 24, hamming: 0.037595421359931186
step: 25, hamming: 0.03248502656477798
step: 26, hamming: 0.027957229203086794
step: 27, hamming: 0.023937892823722058
step: 28, hamming: 0.02038038336070406
step: 29, hamming: 0.017252529167439
```

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step: 30, hamming: 0.014526424760499897
step: 31, hamming: 0.012172676375081907
step: 32, hamming: 0.010158597046433317
step: 33, hamming: 0.008448896060811562
step: 34, hamming: 0.007007393568975932
step: 35, hamming: 0.005798785453088683
step: 36, hamming: 0.004789993873907058
step: 37, hamming: 0.003950993159323438
step: 38, hamming: 0.003255178560133814
step: 39, hamming: 0.0026794020858112956
step: 40, hamming: 0.0022037972259520604
step: 41, hamming: 0.001811488397401407
step: 42, hamming: 0.001488251462841637
step: 43, hamming: 0.0012221673419373616
step: 44, hamming: 0.00100329303825463
step: 45, hamming: 0.0008233624337668047
Running panda took: 1.25 seconds!
  Elapsed time: 1.25 sec.
Saving LIONESS network 25 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 26:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.645496705325531
step: 1, hamming: 0.6066220697004651
step: 2, hamming: 0.6104569962998728
step: 3, hamming: 0.5874394872323974
step: 4, hamming: 0.553510740033988
step: 5, hamming: 0.5130174988541942
step: 6, hamming: 0.46881371156127255
step: 7, hamming: 0.423183189727278
step: 8, hamming: 0.3779417340382216
step: 9, hamming: 0.33445240537930465
step: 10, hamming: 0.29366433099533695
step: 11, hamming: 0.25616701474636144
step: 12, hamming: 0.22226007042599125
step: 13, hamming: 0.19202153205178443
step: 14, hamming: 0.1653704289664206
step: 15, hamming: 0.1421176990914315
step: 16, hamming: 0.12200588715609274
step: 17, hamming: 0.10473835923993631
step: 18, hamming: 0.08999989292935066
step: 19, hamming: 0.07747064160809623
step: 20, hamming: 0.0668358086697313
step: 21, hamming: 0.05779392045356974
```

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step: 22, hamming: 0.050065303344148486
step: 23, hamming: 0.04340157748923955
step: 24, hamming: 0.03759501485574574
step: 25, hamming: 0.03248483073655701
step: 26, hamming: 0.027957178391357862
step: 27, hamming: 0.023937933402786545
step: 28, hamming: 0.020380473632123763
step: 29, hamming: 0.01725263894437879
step: 30, hamming: 0.01452653691101459
step: 31, hamming: 0.012172781802429688
step: 32, hamming: 0.010158691621547705
step: 33, hamming: 0.008448978359003054
step: 34, hamming: 0.007007463803651778
step: 35, hamming: 0.005798844650285862
step: 36, hamming: 0.004790043434414073
step: 37, hamming: 0.003951034364586717
step: 38, hamming: 0.003255212664761859
step: 39, hamming: 0.0026794302159438544
step: 40, hamming: 0.0022038203680394266
step: 41, hamming: 0.0018115074140994405
step: 42, hamming: 0.0014882670710365026
step: 43, hamming: 0.0012221801429058432
step: 44, hamming: 0.0010033035277769993
step: 45, hamming: 0.0008233710253226138
Running panda took: 1.25 seconds!
  Elapsed time: 1.25 sec.
Saving LIONESS network 26 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 27:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6453631316746891
step: 1, hamming: 0.6065851763245884
step: 2, hamming: 0.6104687108084998
step: 3, hamming: 0.5874708414567841
step: 4, hamming: 0.553550407750318
step: 5, hamming: 0.5130590911886108
step: 6, hamming: 0.46885507018779043
step: 7, hamming: 0.42322248970490667
step: 8, hamming: 0.37797766912185493
step: 9, hamming: 0.3344846767623718
step: 10, hamming: 0.2936929239245133
step: 11, hamming: 0.2561922957060964
step: 12, hamming: 0.22228219573712402
step: 13, hamming: 0.1920407638069488
```

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step: 14, hamming: 0.1653870519561906
step: 15, hamming: 0.14213208646367623
step: 16, hamming: 0.1220182928027473
step: 17, hamming: 0.10474902300437654
step: 18, hamming: 0.09000903326934917
step: 19, hamming: 0.07747844392157899
step: 20, hamming: 0.06684245770007372
step: 21, hamming: 0.05779957445832755
step: 22, hamming: 0.05007009118596108
step: 23, hamming: 0.04340563042618257
step: 24, hamming: 0.03759844243481214
step: 25, hamming: 0.03248772255656214
step: 26, hamming: 0.02795960379491282
step: 27, hamming: 0.023939953980151828
step: 28, hamming: 0.020382151479531884
step: 29, hamming: 0.01725402442350402
step: 30, hamming: 0.014527676045144938
step: 31, hamming: 0.012173715629341523
step: 32, hamming: 0.01015945637253753
step: 33, hamming: 0.008449604489718607
step: 34, hamming: 0.007007976542379953
step: 35, hamming: 0.005799264728544191
step: 36, hamming: 0.004790387758916936
step: 37, hamming: 0.003951316728991022
step: 38, hamming: 0.0032554443063554026
step: 39, hamming: 0.0026796202983168298
step: 40, hamming: 0.002203976375195704
step: 41, hamming: 0.0018116354595428003
step: 42, hamming: 0.0014883721681424797
step: 43, hamming: 0.0012222663986386558
step: 44, hamming: 0.0010033743151023368
step: 45, hamming: 0.0008234291107443008
Running panda took: 1.25 seconds!
  Elapsed time: 1.25 sec.
Saving LIONESS network 27 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 28:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6451358310824151
step: 1, hamming: 0.6067202812268652
step: 2, hamming: 0.6105084509106121
step: 3, hamming: 0.5874770766110783
step: 4, hamming: 0.5535401297746914
step: 5, hamming: 0.5130406798275531
```

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step: 6, hamming: 0.46883450589918707
step: 7, hamming: 0.42320295085821286
step: 8, hamming: 0.37796147500536276
step: 9, hamming: 0.33447178250965853
step: 10, hamming: 0.2936826915890226
step: 11, hamming: 0.25618414233804776
step: 12, hamming: 0.22227561563567474
step: 13, hamming: 0.19203539669004427
step: 14, hamming: 0.16538265059792898
step: 15, hamming: 0.14212839414046055
step: 16, hamming: 0.12201518520640053
step: 17, hamming: 0.10474641185408665
step: 18, hamming: 0.09000687786719422
step: 19, hamming: 0.07747669705672466
step: 20, hamming: 0.0668410413623714
step: 21, hamming: 0.057798435063911136
step: 22, hamming: 0.050069179429029616
step: 23, hamming: 0.04340488739282702
step: 24, hamming: 0.0375978199151767
step: 25, hamming: 0.03248719460754284
step: 26, hamming: 0.027959154377771425
step: 27, hamming: 0.023939574661234145
step: 28, hamming: 0.020381831962738853
step: 29, hamming: 0.0172537603782067
step: 30, hamming: 0.014527461133636087
step: 31, hamming: 0.012173542661750417
step: 32, hamming: 0.010159317402521096
step: 33, hamming: 0.008449492965825199
step: 34, hamming: 0.007007887028456989
step: 35, hamming: 0.0057991926884953865
step: 36, hamming: 0.004790329522725734
step: 37, hamming: 0.0039512694941902776
step: 38, hamming: 0.0032554058740101076
step: 39, hamming: 0.0026795889452937774
step: 40, hamming: 0.002203950746453345
step: 41, hamming: 0.0018116144780692218
step: 42, hamming: 0.001488354974026338
step: 43, hamming: 0.0012222522977348139
step: 44, hamming: 0.00100336274382203
step: 45, hamming: 0.0008234196121337712
Running panda took: 1.25 seconds!
  Elapsed time: 1.25 sec.
Saving LIONESS network 28 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 29:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
```

```
   Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6455351008769453
step: 1, hamming: 0.6066727499218522
step: 2, hamming: 0.610483504192098
step: 3, hamming: 0.5874613800094756
step: 4, hamming: 0.5535261027676674
step: 5, hamming: 0.5130277394158711
step: 6, hamming: 0.4688217647975806
step: 7, hamming: 0.42319024909743624
step: 8, hamming: 0.3779481583579115
step: 9, hamming: 0.33445799331873677
step: 10, hamming: 0.29366902135579254
step: 11, hamming: 0.25617054999127764
step: 12, hamming: 0.22226262032373942
step: 13, hamming: 0.19202326345396328
step: 14, hamming: 0.16537148632869753
step: 15, hamming: 0.142118264201008
step: 16, hamming: 0.12200609786553841
step: 17, hamming: 0.10473832871874272
step: 18, hamming: 0.08999971271249907
step: 19, hamming: 0.07747039064766185
step: 20, hamming: 0.06683555388538216
step: 21, hamming: 0.057793686110969834
step: 22, hamming: 0.050065094270375594
step: 23, hamming: 0.04340140844053629
step: 24, hamming: 0.03759489383654498
step: 25, hamming: 0.032484760257860644
step: 26, hamming: 0.027957153083011842
step: 27, hamming: 0.02393794536063863
step: 28, hamming: 0.020380515556205
step: 29, hamming: 0.01725270067904533
step: 30, hamming: 0.014526608601153238
step: 31, hamming: 0.012172855437592785
step: 32, hamming: 0.010158762007530757
step: 33, hamming: 0.008449042800011774
step: 34, hamming: 0.0070075209839526925
step: 35, hamming: 0.0057988942286212805
step: 36, hamming: 0.00479008565892259
step: 37, hamming: 0.003951069946375388
step: 38, hamming: 0.0032552424077837267
step: 39, hamming: 0.002679454936658191
step: 40, hamming: 0.0022038408329425113
step: 41, hamming: 0.0018115242912096806
step: 42, hamming: 0.0014882809567832752
step: 43, hamming: 0.0012221915474429246
step: 44, hamming: 0.0010033128856263525
step: 45, hamming: 0.0008233786956426908
```

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Running panda took: 1.25 seconds!
  Elapsed time: 1.25 sec.
Saving LIONESS network 29 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 30:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6441925069818978
step: 1, hamming: 0.6063136112432319
step: 2, hamming: 0.6103932208346182
step: 3, hamming: 0.5874474722143483
step: 4, hamming: 0.5535649464335758
step: 5, hamming: 0.5130928337695616
step: 6, hamming: 0.4688939095266525
step: 7, hamming: 0.4232588527650599
step: 8, hamming: 0.3780087198271526
step: 9, hamming: 0.3345100558700422
step: 10, hamming: 0.2937142747732435
step: 11, hamming: 0.2562107598757153
step: 12, hamming: 0.22229857181764945
step: 13, hamming: 0.19205531145425267
step: 14, hamming: 0.16539978011088835
step: 15, hamming: 0.14214287312471557
step: 16, hamming: 0.12202708424929
step: 17, hamming: 0.10475587118837185
step: 18, hamming: 0.09001400820385419
step: 19, hamming: 0.07748166638509847
step: 20, hamming: 0.06684413555730546
step: 21, hamming: 0.05779998950120316
step: 22, hamming: 0.050069556133776956
step: 23, hamming: 0.04340444199041317
step: 24, hamming: 0.03759688450174653
step: 25, hamming: 0.03248603443830073
step: 26, hamming: 0.02795796675997988
step: 27, hamming: 0.023938483652704987
step: 28, hamming: 0.0203808962291558
step: 29, hamming: 0.017252993901731097
step: 30, hamming: 0.01452685247958995
step: 31, hamming: 0.012173067882296
step: 32, hamming: 0.010158950869745383
step: 33, hamming: 0.008449210882153616
step: 34, hamming: 0.007007669688350226
step: 35, hamming: 0.005799024608140825
step: 36, hamming: 0.0047901987375082965
step: 37, hamming: 0.003951167141327139
```

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step: 38, hamming: 0.003255325350745027
step: 39, hamming: 0.0026795253550045647
step: 40, hamming: 0.0022039003201826408
step: 41, hamming: 0.0018115743353996415
step: 42, hamming: 0.0014883229143649365
step: 43, hamming: 0.001222226622914164
step: 44, hamming: 0.0010033421337824078
step: 45, hamming: 0.0008234030345286966
Running panda took: 1.31 seconds!
  Elapsed time: 1.31 sec.
Saving LIONESS network 30 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 31:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6453374894828802
step: 1, hamming: 0.6066967069145408
step: 2, hamming: 0.6104840389078137
step: 3, hamming: 0.5874565733434927
step: 4, hamming: 0.5535188219795216
step: 5, hamming: 0.5130204873787859
step: 6, hamming: 0.46881505964233362
step: 7, hamming: 0.4231847518707811
step: 8, hamming: 0.37794456875278243
step: 9, hamming: 0.33445666843682814
step: 10, hamming: 0.29366950408238246
step: 11, hamming: 0.25617272617649023
step: 12, hamming: 0.22226581478746255
step: 13, hamming: 0.1920270800407892
step: 14, hamming: 0.1653756413311506
step: 15, hamming: 0.14212251274972568
step: 16, hamming: 0.12201028566869025
step: 17, hamming: 0.10474235378727433
step: 18, hamming: 0.09000359838145931
step: 19, hamming: 0.07747406299496648
step: 20, hamming: 0.0668389202442914
step: 21, hamming: 0.05779672357526197
step: 22, hamming: 0.05006780392032585
step: 23, hamming: 0.043403791059584765
step: 24, hamming: 0.03759695373852516
step: 25, hamming: 0.032486517555771505
step: 26, hamming: 0.027958627760509558
step: 27, hamming: 0.023939165045318303
step: 28, hamming: 0.02038151237433263
step: 29, hamming: 0.017253509321226976
```

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step: 30, hamming: 0.01452726248992398
step: 31, hamming: 0.01217338409078206
step: 32, hamming: 0.01015918998360408
step: 33, hamming: 0.008449389939631926
step: 34, hamming: 0.007007803396138961
step: 35, hamming: 0.0057991246636717375
step: 36, hamming: 0.004790274070575602
step: 37, hamming: 0.003951224259266886
step: 38, hamming: 0.0032553690960775237
step: 39, hamming: 0.002679559015472811
step: 40, hamming: 0.002203926367689019
step: 41, hamming: 0.0018115946043863224
step: 42, hamming: 0.0014883387657010924
step: 43, hamming: 0.0012222390734737913
step: 44, hamming: 0.0010033519517067173
step: 45, hamming: 0.000823410802845808
Running panda took: 1.40 seconds!
  Elapsed time: 1.41 sec.
Saving LIONESS network 31 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 32:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6449746310280962
step: 1, hamming: 0.6067058332082043
step: 2, hamming: 0.6105227585080633
step: 3, hamming: 0.5874998685226731
step: 4, hamming: 0.5535644118765826
step: 5, hamming: 0.5130637409325514
step: 6, hamming: 0.468855207197495
step: 7, hamming: 0.4232205988814208
step: 8, hamming: 0.37797509767336696
step: 9, hamming: 0.33448191453778925
step: 10, hamming: 0.2936901232265988
step: 11, hamming: 0.2561893953353568
step: 12, hamming: 0.2222794648610085
step: 13, hamming: 0.19203833582770796
step: 14, hamming: 0.16538499865483383
step: 15, hamming: 0.14213033937025307
step: 16, hamming: 0.1220168447185877
step: 17, hamming: 0.10474787876788032
step: 18, hamming: 0.09000825020978295
step: 19, hamming: 0.0774780088393839
step: 20, hamming: 0.06684228198432349
step: 21, hamming: 0.057799594299135344
```

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step: 22, hamming: 0.05007025371136523
step: 23, hamming: 0.04340587382574411
step: 24, hamming: 0.03759871933174081
step: 25, hamming: 0.03248800162100365
step: 26, hamming: 0.027959871764145786
step: 27, hamming: 0.023940202435957
step: 28, hamming: 0.020382372773605797
step: 29, hamming: 0.017254220926788584
step: 30, hamming: 0.014527849564486101
step: 31, hamming: 0.01217386793079806
step: 32, hamming: 0.010159588465741654
step: 33, hamming: 0.008449718062226337
step: 34, hamming: 0.007008073488535545
step: 35, hamming: 0.005799346994199014
step: 36, hamming: 0.004790456976200905
step: 37, hamming: 0.003951374637817457
step: 38, hamming: 0.0032554925944706567
step: 39, hamming: 0.0026796605246515583
step: 40, hamming: 0.002204009784151203
step: 41, hamming: 0.0018116631348835946
step: 42, hamming: 0.001488395046021938
step: 43, hamming: 0.0012222852787877193
step: 44, hamming: 0.0010033898748033525
step: 45, hamming: 0.0008234419197268575
Running panda took: 1.40 seconds!
  Elapsed time: 1.40 sec.
Saving LIONESS network 32 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 33:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6456567808462211
step: 1, hamming: 0.6066002678232714
step: 2, hamming: 0.6105813100451256
step: 3, hamming: 0.5876366440945432
step: 4, hamming: 0.5537384939042065
step: 5, hamming: 0.5132510551234207
step: 6, hamming: 0.4690351665376202
step: 7, hamming: 0.42338117383780194
step: 8, hamming: 0.3781135868865882
step: 9, hamming: 0.33459944752452325
step: 10, hamming: 0.2937892636785368
step: 11, hamming: 0.25627321887464255
step: 12, hamming: 0.22235047832920657
step: 13, hamming: 0.1920987613785881
```

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step: 14, hamming: 0.16543669817665527
step: 15, hamming: 0.14217460617494096
step: 16, hamming: 0.12205478208053701
step: 17, hamming: 0.10478042130530228
step: 18, hamming: 0.09003612775603832
step: 19, hamming: 0.07750184049531986
step: 20, hamming: 0.06686269734372635
step: 21, hamming: 0.05781712126932585
step: 22, hamming: 0.050085333681801514
step: 23, hamming: 0.0434188542719053
step: 24, hamming: 0.0376098970862519
step: 25, hamming: 0.0324976193016997
step: 26, hamming: 0.027968121638909667
step: 27, hamming: 0.023947253186378716
step: 28, hamming: 0.02038837093130006
step: 29, hamming: 0.01725930031609945
step: 30, hamming: 0.01453213057480876
step: 31, hamming: 0.012177459602951914
step: 32, hamming: 0.010162590210066961
step: 33, hamming: 0.008452218615141236
step: 34, hamming: 0.007010150880511295
step: 35, hamming: 0.005801068940490524
step: 36, hamming: 0.004791881667170449
step: 37, hamming: 0.003952551627023815
step: 38, hamming: 0.003256463710290392
step: 39, hamming: 0.0026804608719384142
step: 40, hamming: 0.0022046688418683176
step: 41, hamming: 0.0018122054772229583
step: 42, hamming: 0.0014888410848218332
step: 43, hamming: 0.0012226519307712378
step: 44, hamming: 0.0010036911397340632
step: 45, hamming: 0.0008236893647987591
Running panda took: 1.71 seconds!
  Elapsed time: 1.71 sec.
Saving LIONESS network 33 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 34:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6449981971449824
step: 1, hamming: 0.6065931831332112
step: 2, hamming: 0.6105293103087643
step: 3, hamming: 0.5875457591281374
step: 4, hamming: 0.5536260899397788
step: 5, hamming: 0.5131280856850265
```

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step: 6, hamming: 0.46891540277206692
step: 7, hamming: 0.4232740123691572
step: 8, hamming: 0.37802087584233957
step: 9, hamming: 0.33452104855520154
step: 10, hamming: 0.29372314994988774
step: 11, hamming: 0.25621717754897094
step: 12, hamming: 0.2223028366559903
step: 13, hamming: 0.19205800982166413
step: 14, hamming: 0.16540159888503903
step: 15, hamming: 0.14214436276067294
step: 16, hamming: 0.12202874055933112
step: 17, hamming: 0.10475804762546262
step: 18, hamming: 0.0900169464745131
step: 19, hamming: 0.07748544549209825
step: 20, hamming: 0.06684869516951135
step: 21, hamming: 0.05780513650530213
step: 22, hamming: 0.05007505612580251
step: 23, hamming: 0.04341002702171404
step: 24, hamming: 0.03760230583906534
step: 25, hamming: 0.03249108895337307
step: 26, hamming: 0.027962521329952538
step: 27, hamming: 0.023942471148388367
step: 28, hamming: 0.020384308356420206
step: 29, hamming: 0.01725586604933187
step: 30, hamming: 0.0145292430032475
step: 31, hamming: 0.012175043490551075
step: 32, hamming: 0.010160576904046072
step: 33, hamming: 0.008450545793374795
step: 34, hamming: 0.007008764233183781
step: 35, hamming: 0.005799922014886088
step: 36, hamming: 0.0047909345756681
step: 37, hamming: 0.0039517704601507225
step: 38, hamming: 0.0032558200052223347
step: 39, hamming: 0.002679930861517707
step: 40, hamming: 0.0022042327414596506
step: 41, hamming: 0.001811846845087572
step: 42, hamming: 0.0014885463019372123
step: 43, hamming: 0.0012224097309378736
step: 44, hamming: 0.0010034922163639033
step: 45, hamming: 0.000823526038024523
Running panda took: 1.43 seconds!
  Elapsed time: 1.43 sec.
Saving LIONESS network 34 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 35:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
```

```
   Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6426000250494666
step: 1, hamming: 0.6063071921865067
step: 2, hamming: 0.6104809784525866
step: 3, hamming: 0.5875787789957999
step: 4, hamming: 0.5536924206915095
step: 5, hamming: 0.5132239248844174
step: 6, hamming: 0.4690279451515534
step: 7, hamming: 0.4234005441297799
step: 8, hamming: 0.37815866164971773
step: 9, hamming: 0.33466411068445123
step: 10, hamming: 0.2938652232754584
step: 11, hamming: 0.25635291398589555
step: 12, hamming: 0.2224278035307866
step: 13, hamming: 0.1921699165297888
step: 14, hamming: 0.16549975125668104
step: 15, hamming: 0.14222892834479822
step: 16, hamming: 0.12210051057291255
step: 17, hamming: 0.1048181600149727
step: 18, hamming: 0.09006670326722839
step: 19, hamming: 0.07752617005100722
step: 20, hamming: 0.06688172438724069
step: 21, hamming: 0.05783176894755019
step: 22, hamming: 0.05009647661533095
step: 23, hamming: 0.04342729230869477
step: 24, hamming: 0.037616314867588554
step: 25, hamming: 0.032502556849793765
step: 26, hamming: 0.027971999052752584
step: 27, hamming: 0.02395035939389856
step: 28, hamming: 0.02039090053720676
step: 29, hamming: 0.017261384985951662
step: 30, hamming: 0.01453386083972818
step: 31, hamming: 0.01217890040608688
step: 32, hamming: 0.010163791137853357
step: 33, hamming: 0.008453219201499561
step: 34, hamming: 0.007010983652762794
step: 35, hamming: 0.0058017611584794
step: 36, hamming: 0.0047924564415076777
step: 37, hamming: 0.003953028346447056
step: 38, hamming: 0.0032568587382547803
step: 39, hamming: 0.002680787897775716
step: 40, hamming: 0.0022049393777273303
step: 41, hamming: 0.0018124290872041876
step: 42, hamming: 0.0014890257649965667
step: 43, hamming: 0.0012228043489239595
step: 44, hamming: 0.0010038168464440735
step: 45, hamming: 0.000823792977083675
```

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Running panda took: 1.31 seconds!
  Elapsed time: 1.31 sec.
Saving LIONESS network 35 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 36:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6453822083232199
step: 1, hamming: 0.6066969273795092
step: 2, hamming: 0.6105383132265271
step: 3, hamming: 0.5875246652799395
step: 4, hamming: 0.5535923400428431
step: 5, hamming: 0.5130969212335402
step: 6, hamming: 0.4688916302793686
step: 7, hamming: 0.4232591493736284
step: 8, hamming: 0.3780152221141369
step: 9, hamming: 0.33452209514331444
step: 10, hamming: 0.2937286374246192
step: 11, hamming: 0.25622520736811455
step: 12, hamming: 0.22231178357995593
step: 13, hamming: 0.19206706531225234
step: 14, hamming: 0.16541028792801
step: 15, hamming: 0.14215237669006922
step: 16, hamming: 0.1220358856668059
step: 17, hamming: 0.10476421069641416
step: 18, hamming: 0.09002215316977837
step: 19, hamming: 0.07748976024988688
step: 20, hamming: 0.06685218168838662
step: 21, hamming: 0.05780791039379919
step: 22, hamming: 0.05007722152860851
step: 23, hamming: 0.0434117205050181
step: 24, hamming: 0.037603623119995024
step: 25, hamming: 0.0324921143107474
step: 26, hamming: 0.027963316385545108
step: 27, hamming: 0.02394308925055814
step: 28, hamming: 0.020384791637139875
step: 29, hamming: 0.017256245588859704
step: 30, hamming: 0.014529542455540407
step: 31, hamming: 0.012175281230148287
step: 32, hamming: 0.010160766715614725
step: 33, hamming: 0.008450698522426142
step: 34, hamming: 0.00700888797478153
step: 35, hamming: 0.005800022398900317
step: 36, hamming: 0.004791016237650569
step: 37, hamming: 0.003951837291752229
```

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step: 38, hamming: 0.0032558748913572885
step: 39, hamming: 0.0026799760260441618
step: 40, hamming: 0.0022042699447564146
step: 41, hamming: 0.0018118775067475117
step: 42, hamming: 0.0014885715795620953
step: 43, hamming: 0.0012224305718871052
step: 44, hamming: 0.001003509395952679
step: 45, hamming: 0.0008235401960124114
Running panda took: 1.28 seconds!
  Elapsed time: 1.28 sec.
Saving LIONESS network 36 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 37:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6450937603753659
step: 1, hamming: 0.6064436660837452
step: 2, hamming: 0.6105412861118334
step: 3, hamming: 0.5876066009972607
step: 4, hamming: 0.5537181506446464
step: 5, hamming: 0.5132401622393848
step: 6, hamming: 0.46903005243019497
step: 7, hamming: 0.4233816338164551
step: 8, hamming: 0.37811730216131945
step: 9, hamming: 0.3346042764085535
step: 10, hamming: 0.29379370959045664
step: 11, hamming: 0.2562765055577094
step: 12, hamming: 0.22235228297194926
step: 13, hamming: 0.1920990888414815
step: 14, hamming: 0.16543565555984818
step: 15, hamming: 0.14217249050227085
step: 16, hamming: 0.12205187338509321
step: 17, hamming: 0.10477697957160514
step: 18, hamming: 0.09003236276240752
step: 19, hamming: 0.07749793593084385
step: 20, hamming: 0.06685876647177448
step: 21, hamming: 0.057813243887915165
step: 22, hamming: 0.0500815676624227
step: 23, hamming: 0.04341524699674484
step: 24, hamming: 0.03760647449990497
step: 25, hamming: 0.032494402723185246
step: 26, hamming: 0.027965137026658638
step: 27, hamming: 0.023944516079917964
step: 28, hamming: 0.020385898620171303
step: 29, hamming: 0.01725709609099151
```

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step: 30, hamming: 0.014530191634674654
step: 31, hamming: 0.012175775564193872
step: 32, hamming: 0.010161143736087763
step: 33, hamming: 0.008450987745447076
step: 34, hamming: 0.007009111445933516
step: 35, hamming: 0.005800196669853901
step: 36, hamming: 0.004791153274172694
step: 37, hamming: 0.003951945757724805
step: 38, hamming: 0.0032559612971043766
step: 39, hamming: 0.0026800452215014316
step: 40, hamming: 0.002204325608741197
step: 41, hamming: 0.001811922446478191
step: 42, hamming: 0.0014886079619687142
step: 43, hamming: 0.0012224600919155358
step: 44, hamming: 0.0010035333901201532
step: 45, hamming: 0.0008235597257708719
Running panda took: 1.30 seconds!
  Elapsed time: 1.30 sec.
Saving LIONESS network 37 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 38:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6440630972479126
step: 1, hamming: 0.6065362164769552
step: 2, hamming: 0.6104532026394006
step: 3, hamming: 0.5874604045897801
step: 4, hamming: 0.5535439576972261
step: 5, hamming: 0.5130532048778697
step: 6, hamming: 0.46884617663248207
step: 7, hamming: 0.4232106291765286
step: 8, hamming: 0.37796351385560745
step: 9, hamming: 0.3344694203478318
step: 10, hamming: 0.29367784651746603
step: 11, hamming: 0.2561779100594673
step: 12, hamming: 0.2222690261377353
step: 13, hamming: 0.19202898759027912
step: 14, hamming: 0.16537677619988345
step: 15, hamming: 0.1421232526413549
step: 16, hamming: 0.12201074582554952
step: 17, hamming: 0.10474263477818666
step: 18, hamming: 0.09000370065023104
step: 19, hamming: 0.0774740215271501
step: 20, hamming: 0.06683879577708175
step: 21, hamming: 0.0577965551811048
```

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step: 22, hamming: 0.050067607385594834
step: 23, hamming: 0.043403573496942294
step: 24, hamming: 0.03759672349751944
step: 25, hamming: 0.03248628020522619
step: 26, hamming: 0.02795839210769396
step: 27, hamming: 0.023938938938551046
step: 28, hamming: 0.020381302269394757
step: 29, hamming: 0.0172533193330902395
step: 30, hamming: 0.014527095084336911
step: 31, hamming: 0.012173239529471585
step: 32, hamming: 0.010159067354651509
step: 33, hamming: 0.008449287001086301
step: 34, hamming: 0.007007717820632076
step: 35, hamming: 0.0057990536240283075
step: 36, hamming: 0.004790215055454623
step: 37, hamming: 0.003951175336782722
step: 38, hamming: 0.0032553284588682893
step: 39, hamming: 0.002679525308582265
step: 40, hamming: 0.002203898423392684
step: 41, hamming: 0.0018115714471615195
step: 42, hamming: 0.0014883195860679456
step: 43, hamming: 0.0012222231985379258
step: 44, hamming: 0.0010033388191364977
step: 45, hamming: 0.000823399944870464
Running panda took: 1.33 seconds!
  Elapsed time: 1.33 sec.
Saving LIONESS network 38 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 39:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.645008672822219
step: 1, hamming: 0.6066279590964606
step: 2, hamming: 0.6105189710157038
step: 3, hamming: 0.5875129702246186
step: 4, hamming: 0.5535881728916275
step: 5, hamming: 0.5130942680692989
step: 6, hamming: 0.4688837087451931
step: 7, hamming: 0.42324469194157627
step: 8, hamming: 0.3779945678456299
step: 9, hamming: 0.3344972254062105
step: 10, hamming: 0.2937027228697728
step: 11, hamming: 0.2561999698599468
step: 12, hamming: 0.22228841230441757
step: 13, hamming: 0.19204594680519657
```

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step: 14, hamming: 0.16539145284192142
step: 15, hamming: 0.14213579042349994
step: 16, hamming: 0.12202150658243803
step: 17, hamming: 0.10475182786542586
step: 18, hamming: 0.09001151446194962
step: 19, hamming: 0.077480629396115
step: 20, hamming: 0.06684439090269251
step: 21, hamming: 0.0578012977397978
step: 22, hamming: 0.050071632819650706
step: 23, hamming: 0.043407005970971885
step: 24, hamming: 0.037599660950331404
step: 25, hamming: 0.032488803075486614
step: 26, hamming: 0.027960560323392912
step: 27, hamming: 0.02394080074258424
step: 28, hamming: 0.020382896359423752
step: 29, hamming: 0.01725467844967507
step: 30, hamming: 0.01452824788682867
step: 31, hamming: 0.012174211893688454
step: 32, hamming: 0.010159883384549461
step: 33, hamming: 0.008449969131479787
step: 34, hamming: 0.007008285718950417
step: 35, hamming: 0.005799525161101374
step: 36, hamming: 0.004790605850968231
step: 37, hamming: 0.003951498594437267
step: 38, hamming: 0.0032555954389956172
step: 39, hamming: 0.002679745529938827
step: 40, hamming: 0.0022040799086265896
step: 41, hamming: 0.0018117209077095193
step: 42, hamming: 0.0014884425909900132
step: 43, hamming: 0.0012223243766523943
step: 44, hamming: 0.0010034220089883334
step: 45, hamming: 0.0008234683171750288
Running panda took: 1.34 seconds!
  Elapsed time: 1.34 sec.
Saving LIONESS network 39 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 40:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6446899829950574
step: 1, hamming: 0.6065720657385845
step: 2, hamming: 0.6104769060458073
step: 3, hamming: 0.587468913447344
step: 4, hamming: 0.553541697529604
step: 5, hamming: 0.5130476369210646
```

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step: 6, hamming: 0.4688442859318447
step: 7, hamming: 0.4232147915742599
step: 8, hamming: 0.3779745725802862
step: 9, hamming: 0.33448614616016825
step: 10, hamming: 0.29369793769767927
step: 11, hamming: 0.25619940627415155
step: 12, hamming: 0.22229019835157474
step: 13, hamming: 0.19204895567253835
step: 14, hamming: 0.16539501582991115
step: 15, hamming: 0.1421394748862269
step: 16, hamming: 0.12202499625028414
step: 17, hamming: 0.10475511557113841
step: 18, hamming: 0.09001460630282851
step: 19, hamming: 0.07748348660857822
step: 20, hamming: 0.06684699483703208
step: 21, hamming: 0.05780364640854137
step: 22, hamming: 0.05007375265804036
step: 23, hamming: 0.043408911909504244
step: 24, hamming: 0.03760138090088409
step: 25, hamming: 0.03249034534683271
step: 26, hamming: 0.027961940282617167
step: 27, hamming: 0.02394202780317782
step: 28, hamming: 0.020383977524069202
step: 29, hamming: 0.017255623043299226
step: 30, hamming: 0.014529064889671078
step: 31, hamming: 0.012174912034662342
step: 32, hamming: 0.01016047845157582
step: 33, hamming: 0.008450471314942094
step: 34, hamming: 0.00700870709647639
step: 35, hamming: 0.005799877499710262
step: 36, hamming: 0.004790899569917692
step: 37, hamming: 0.003951742693309238
step: 38, hamming: 0.0032557978512664306
step: 39, hamming: 0.002679913100611094
step: 40, hamming: 0.0022042184426658384
step: 41, hamming: 0.0018118352905121438
step: 42, hamming: 0.001488536939266653
step: 43, hamming: 0.0012224021313626224
step: 44, hamming: 0.001003486038915215
step: 45, hamming: 0.0008235210127976309
Running panda took: 1.34 seconds!
  Elapsed time: 1.34 sec.
Saving LIONESS network 40 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 41:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
```

```
   Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.643958877072217
step: 1, hamming: 0.6066729641072985
step: 2, hamming: 0.6105706441429531
step: 3, hamming: 0.5875671840941765
step: 4, hamming: 0.5536412525576695
step: 5, hamming: 0.5131442161431156
step: 6, hamming: 0.46893158026561005
step: 7, hamming: 0.42328943886764275
step: 8, hamming: 0.3780348238806755
step: 9, hamming: 0.3345325891631173
step: 10, hamming: 0.2937325823349309
step: 11, hamming: 0.2562249355349886
step: 12, hamming: 0.22230910059206208
step: 13, hamming: 0.1920630661505349
step: 14, hamming: 0.16540567166944584
step: 15, hamming: 0.142147668817602
step: 16, hamming: 0.12203143924750816
step: 17, hamming: 0.10476020433355153
step: 18, hamming: 0.09001866866683568
step: 19, hamming: 0.07748681890195008
step: 20, hamming: 0.06684977392071134
step: 21, hamming: 0.0578060040584336
step: 22, hamming: 0.050075759807870907
step: 23, hamming: 0.043410587150283765
step: 24, hamming: 0.037602741756048684
step: 25, hamming: 0.03249142680963005
step: 26, hamming: 0.02796277245679931
step: 27, hamming: 0.023942649977909784
step: 28, hamming: 0.0203844295732805
step: 29, hamming: 0.017255942798246854
step: 30, hamming: 0.0145292867393714
step: 31, hamming: 0.012175064147083636
step: 32, hamming: 0.010160581814379423
step: 33, hamming: 0.008450540939725247
step: 34, hamming: 0.007008754041534418
step: 35, hamming: 0.0057999088696900685
step: 36, hamming: 0.004790920217625292
step: 37, hamming: 0.003951756159188347
step: 38, hamming: 0.003255806511443424
step: 39, hamming: 0.0026799185423229273
step: 40, hamming: 0.0022042217409228124
step: 41, hamming: 0.0018118371780350337
step: 42, hamming: 0.0014885379101339323
step: 43, hamming: 0.0012224025182755486
step: 44, hamming: 0.0010034860661721828
step: 45, hamming: 0.0008235208251140591
```

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Running panda took: 1.33 seconds!
  Elapsed time: 1.33 sec.
Saving LIONESS network 41 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 42:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.645090088879035
step: 1, hamming: 0.6066516738621497
step: 2, hamming: 0.6104985666021202
step: 3, hamming: 0.5874788063748753
step: 4, hamming: 0.553540130637487
step: 5, hamming: 0.5130397114128462
step: 6, hamming: 0.46883365127766485
step: 7, hamming: 0.42320294317071977
step: 8, hamming: 0.3779626905033645
step: 9, hamming: 0.33447473860572524
step: 10, hamming: 0.29368685975225084
step: 11, hamming: 0.2561887985822545
step: 12, hamming: 0.22228041328144352
step: 13, hamming: 0.1920401220158585
step: 14, hamming: 0.16538712296890062
step: 15, hamming: 0.14213253273283044
step: 16, hamming: 0.12201908520533228
step: 17, hamming: 0.10475002765824207
step: 18, hamming: 0.09001017467263965
step: 19, hamming: 0.07747969955501102
step: 20, hamming: 0.0668437502548238
step: 21, hamming: 0.05780086764535796
step: 22, hamming: 0.05007135445772276
step: 23, hamming: 0.04340683431558541
step: 24, hamming: 0.0375995690096326
step: 25, hamming: 0.032488762864861374
step: 26, hamming: 0.027960559636943563
step: 27, hamming: 0.02394082711040951
step: 28, hamming: 0.02038293768653359
step: 29, hamming: 0.01725472869077617
step: 30, hamming: 0.014528302543333647
step: 31, hamming: 0.012174266467077246
step: 32, hamming: 0.010159934842999263
step: 33, hamming: 0.008450015826353949
step: 34, hamming: 0.007008327003644894
step: 35, hamming: 0.005799561059886952
step: 36, hamming: 0.004790636812690917
step: 37, hamming: 0.00395152498915356
```

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step: 38, hamming: 0.0032556177779712583
step: 39, hamming: 0.0026797643542427977
step: 40, hamming: 0.00220409572282963
step: 41, hamming: 0.0018117341418863407
step: 42, hamming: 0.0014884536410248793
step: 43, hamming: 0.0012223335797172307
step: 44, hamming: 0.0010034296580480623
step: 45, hamming: 0.0008234746634137464
Running panda took: 1.33 seconds!
  Elapsed time: 1.33 sec.
Saving LIONESS network 42 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 43:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.644052761896358
step: 1, hamming: 0.606846793585411
step: 2, hamming: 0.610728857719017
step: 3, hamming: 0.5877376684115262
step: 4, hamming: 0.5538142766265395
step: 5, hamming: 0.5133115341098062
step: 6, hamming: 0.4690898708650283
step: 7, hamming: 0.4234332320104306
step: 8, hamming: 0.3781623554018539
step: 9, hamming: 0.3346437191689542
step: 10, hamming: 0.29382891080082413
step: 11, hamming: 0.25630804132509455
step: 12, hamming: 0.22238058991015805
step: 13, hamming: 0.1921244069073419
step: 14, hamming: 0.16545817957481052
step: 15, hamming: 0.14219255890384128
step: 16, hamming: 0.12206981536725259
step: 17, hamming: 0.10479308912740204
step: 18, hamming: 0.09004682418382234
step: 19, hamming: 0.07751094005916007
step: 20, hamming: 0.0668704475528378
step: 21, hamming: 0.05782371001722576
step: 22, hamming: 0.05009090857316944
step: 23, hamming: 0.04342352724644389
step: 24, hamming: 0.037613742843345156
step: 25, hamming: 0.032500717866233104
step: 26, hamming: 0.027970567103492498
step: 27, hamming: 0.023949145946046774
step: 28, hamming: 0.020389814594208796
step: 29, hamming: 0.017260389673325376
```

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step: 30, hamming: 0.014532948325301723
step: 31, hamming: 0.012178073966408829
step: 32, hamming: 0.010163053860804867
step: 33, hamming: 0.00845257088969216
step: 34, hamming: 0.007010420899916855
step: 35, hamming: 0.00580127765077189
step: 36, hamming: 0.0047920442777004526
step: 37, hamming: 0.003952679304999424
step: 38, hamming: 0.003256564629252693
step: 39, hamming: 0.002680541077531178
step: 40, hamming: 0.0022047328812271954
step: 41, hamming: 0.0018122567957040041
step: 42, hamming: 0.0014888823408190466
step: 43, hamming: 0.0012226851824785946
step: 44, hamming: 0.0010037179959729236
step: 45, hamming: 0.0008237110939490808
Running panda took: 1.32 seconds!
  Elapsed time: 1.32 sec.
Saving LIONESS network 43 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 44:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6455018706675434
step: 1, hamming: 0.6066771889037847
step: 2, hamming: 0.6104927458207806
step: 3, hamming: 0.5874724098807874
step: 4, hamming: 0.5535381852036291
step: 5, hamming: 0.5130412181815369
step: 6, hamming: 0.4688357436456272
step: 7, hamming: 0.4232060516712834
step: 8, hamming: 0.3779651681944428
step: 9, hamming: 0.33447578182458715
step: 10, hamming: 0.29368699908851514
step: 11, hamming: 0.25618810836906636
step: 12, hamming: 0.22227915239937623
step: 13, hamming: 0.19203863188744116
step: 14, hamming: 0.16538554120286297
step: 15, hamming: 0.1421309400195572
step: 16, hamming: 0.12201736565539253
step: 17, hamming: 0.10474825814801286
step: 18, hamming: 0.09000844987911948
step: 19, hamming: 0.07747797083444702
step: 20, hamming: 0.0668420504052051
step: 21, hamming: 0.05779924629784824
```

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step: 22, hamming: 0.05006983470329827
step: 23, hamming: 0.0434054377789933
step: 24, hamming: 0.03759830798077482
step: 25, hamming: 0.032487644623876356
step: 26, hamming: 0.027959585227725067
step: 27, hamming: 0.023939993281594022
step: 28, hamming: 0.020382235303793
step: 29, hamming: 0.017254142326846075
step: 30, hamming: 0.0145278165923739
step: 31, hamming: 0.012173865559254832
step: 32, hamming: 0.010159605065697939
step: 33, hamming: 0.008449745022944615
step: 34, hamming: 0.00700810475512328
step: 35, hamming: 0.005799378660948917
step: 36, hamming: 0.0047904869216820745
step: 37, hamming: 0.003951402165785128
step: 38, hamming: 0.0032555171432301403
step: 39, hamming: 0.002679681888018421
step: 40, hamming: 0.0022040281149082117
step: 41, hamming: 0.0018116787055630656
step: 42, hamming: 0.001488408176557867
step: 43, hamming: 0.0012222962914605249
step: 44, hamming: 0.00100339907294035
step: 45, hamming: 0.0008234495793931117
Running panda took: 1.33 seconds!
  Elapsed time: 1.33 sec.
Saving LIONESS network 44 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 45:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6451609513913849
step: 1, hamming: 0.60682301694336
step: 2, hamming: 0.6106083346123937
step: 3, hamming: 0.5875838988028538
step: 4, hamming: 0.5536474918555495
step: 5, hamming: 0.5131464111654228
step: 6, hamming: 0.46893531465023547
step: 7, hamming: 0.4232953952543082
step: 8, hamming: 0.3780435892681105
step: 9, hamming: 0.33454365128594743
step: 10, hamming: 0.29374508748769934
step: 11, hamming: 0.2562377909089144
step: 12, hamming: 0.22232178821340307
step: 13, hamming: 0.19207512806462554
```

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step: 14, hamming: 0.16541683124420956
step: 15, hamming: 0.1421577806735096
step: 16, hamming: 0.12204047685598642
step: 17, hamming: 0.10476822857697907
step: 18, hamming: 0.09002567471379647
step: 19, hamming: 0.0774928879378122
step: 20, hamming: 0.06685499297134434
step: 21, hamming: 0.05781044528986368
step: 22, hamming: 0.050079503532131836
step: 23, hamming: 0.043413743732357984
step: 24, hamming: 0.03760540071279273
step: 25, hamming: 0.03249365564796301
step: 26, hamming: 0.027964640608281126
step: 27, hamming: 0.02394421340556936
step: 28, hamming: 0.02038573503818736
step: 29, hamming: 0.017257031000157456
step: 30, hamming: 0.014530192108341458
step: 31, hamming: 0.012175817632282373
step: 32, hamming: 0.01016120800943048
step: 33, hamming: 0.008451061098622106
step: 34, hamming: 0.0070091856123166265
step: 35, hamming: 0.005800266586091691
step: 36, hamming: 0.0047912165562239845
step: 37, hamming: 0.003952001550810153
step: 38, hamming: 0.003256009551690285
step: 39, hamming: 0.0026800863984453036
step: 40, hamming: 0.002204360400847909
step: 41, hamming: 0.0018119516331865828
step: 42, hamming: 0.001488632316391934
step: 43, hamming: 0.0012224803346953504
step: 44, hamming: 0.001003550166649098
step: 45, hamming: 0.0008235735965779465
Running panda took: 1.32 seconds!
  Elapsed time: 1.32 sec.
Saving LIONESS network 45 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 46:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6444561373205833
step: 1, hamming: 0.6065980545917278
step: 2, hamming: 0.6105128971327527
step: 3, hamming: 0.5875110985863032
step: 4, hamming: 0.5535881909404929
step: 5, hamming: 0.513091592106618
```

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step: 6, hamming: 0.46888363850009035
step: 7, hamming: 0.42324816999840126
step: 8, hamming: 0.3780016536091072
step: 9, hamming: 0.3345068620657478
step: 10, hamming: 0.29371300156314933
step: 11, hamming: 0.2562101677520666
step: 12, hamming: 0.22229782461584252
step: 13, hamming: 0.19205431495200018
step: 14, hamming: 0.16539873221832643
step: 15, hamming: 0.14214201379337854
step: 16, hamming: 0.1220266912618745
step: 17, hamming: 0.10475621059832577
step: 18, hamming: 0.09001529971582535
step: 19, hamming: 0.07748388708610993
step: 20, hamming: 0.06684718843182244
step: 21, hamming: 0.05780369052361184
step: 22, hamming: 0.05007369620781047
step: 23, hamming: 0.04340879060521526
step: 24, hamming: 0.0376012098195711
step: 25, hamming: 0.03249013651071767
step: 26, hamming: 0.02796170164783043
step: 27, hamming: 0.023941767943218586
step: 28, hamming: 0.02038370710945001
step: 29, hamming: 0.01725535251678685
step: 30, hamming: 0.01452880343841106
step: 31, hamming: 0.012174667193433731
step: 32, hamming: 0.01016025513605103
step: 33, hamming: 0.008450271975505555
step: 34, hamming: 0.00700853253028554
step: 35, hamming: 0.005799726752184736
step: 36, hamming: 0.004790770756328513
step: 37, hamming: 0.003951633741495329
step: 38, hamming: 0.003255706284492106
step: 39, hamming: 0.002679836512915264
step: 40, hamming: 0.0022041546289165016
step: 41, hamming: 0.0018117822850880238
step: 42, hamming: 0.001488493020323518
step: 43, hamming: 0.0012223658117307828
step: 44, hamming: 0.0010034560492991984
step: 45, hamming: 0.0008234962794548378
Running panda took: 1.32 seconds!
  Elapsed time: 1.32 sec.
Saving LIONESS network 46 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 47:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
```

```
   Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6451094435014055
step: 1, hamming: 0.6067224879320416
step: 2, hamming: 0.6104855876766591
step: 3, hamming: 0.5874302260560214
step: 4, hamming: 0.5534812095958547
step: 5, hamming: 0.5129821856517683
step: 6, hamming: 0.46878098398796686
step: 7, hamming: 0.42315657041730387
step: 8, hamming: 0.3779239978979505
step: 9, hamming: 0.3344427227132656
step: 10, hamming: 0.29366102731476706
step: 11, hamming: 0.25616821630801284
step: 12, hamming: 0.22226395137122448
step: 13, hamming: 0.19202681658475126
step: 14, hamming: 0.16537625986764548
step: 15, hamming: 0.1421235728034832
step: 16, hamming: 0.12201150665910697
step: 17, hamming: 0.10474353103231468
step: 18, hamming: 0.09000454950906786
step: 19, hamming: 0.07747470953904387
step: 20, hamming: 0.0668393074229943
step: 21, hamming: 0.057796887158797904
step: 22, hamming: 0.050067790022936765
step: 23, hamming: 0.0434036556616216
step: 24, hamming: 0.03759676223186337
step: 25, hamming: 0.03248631716762014
step: 26, hamming: 0.027958452078804107
step: 27, hamming: 0.023939028616903377
step: 28, hamming: 0.02038141944916723
step: 29, hamming: 0.017253456558720872
step: 30, hamming: 0.014527240970954449
step: 31, hamming: 0.012173384845798182
step: 32, hamming: 0.01015920549888837
step: 33, hamming: 0.008449414288126908
step: 34, hamming: 0.00700783251428514
step: 35, hamming: 0.00579915532069411
step: 36, hamming: 0.004790304232521376
step: 37, hamming: 0.003951252628490434
step: 38, hamming: 0.0032553948817023253
step: 39, hamming: 0.002679582018442492
step: 40, hamming: 0.0022039466024797337
step: 41, hamming: 0.0018116122118621118
step: 42, hamming: 0.0014883539520461812
step: 43, hamming: 0.0012222520794900557
step: 44, hamming: 0.0010033630290072085
step: 45, hamming: 0.0008234201909991959
```

```
Running panda took: 1.33 seconds!
  Elapsed time: 1.33 sec.
Saving LIONESS network 47 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 48:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6450729208857101
step: 1, hamming: 0.6063501512150871
step: 2, hamming: 0.6103715026046173
step: 3, hamming: 0.5874284484527396
step: 4, hamming: 0.5535259596516843
step: 5, hamming: 0.5130547047753817
step: 6, hamming: 0.4688708582148043
step: 7, hamming: 0.42325992634308324
step: 8, hamming: 0.37803721253202954
step: 9, hamming: 0.3345609217695329
step: 10, hamming: 0.2937790878929319
step: 11, hamming: 0.2562812448018168
step: 12, hamming: 0.22236874382375207
step: 13, hamming: 0.19212159497551798
step: 14, hamming: 0.16546046772472403
step: 15, hamming: 0.14219729408942722
step: 16, hamming: 0.12207523597375466
step: 17, hamming: 0.10479810759599201
step: 18, hamming: 0.09005092233539187
step: 19, hamming: 0.0775138622498422
step: 20, hamming: 0.06687216133585415
step: 21, hamming: 0.05782432168099327
step: 22, hamming: 0.050090599604048575
step: 23, hamming: 0.04342254449049325
step: 24, hamming: 0.037612354730298586
step: 25, hamming: 0.03249915130287423
step: 26, hamming: 0.027968991909988243
step: 27, hamming: 0.023947673742928516
step: 28, hamming: 0.020388507929298593
step: 29, hamming: 0.01725926821592624
step: 30, hamming: 0.014532009040509329
step: 31, hamming: 0.012177299988630045
step: 32, hamming: 0.010162422517800812
step: 33, hamming: 0.008452059415929544
step: 34, hamming: 0.0070100082569057925
step: 35, hamming: 0.005800945322716096
step: 36, hamming: 0.004791776880461754
step: 37, hamming: 0.003952464204685849
```

```
step: 38, hamming: 0.0032563915570548445
step: 39, hamming: 0.0026804017615245797
step: 40, hamming: 0.002204620661194443
step: 41, hamming: 0.0018121663562190129
step: 42, hamming: 0.0014888093898348781
step: 43, hamming: 0.001222626284457484
step: 44, hamming: 0.0010036704002436717
step: 45, hamming: 0.0008236725986009675
Running panda took: 1.33 seconds!
  Elapsed time: 1.33 sec.
Saving LIONESS network 48 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 49:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6450184972229367
step: 1, hamming: 0.6068240235253973
step: 2, hamming: 0.6105965948530253
step: 3, hamming: 0.5875567675582667
step: 4, hamming: 0.5536089018867548
step: 5, hamming: 0.5130991941025524
step: 6, hamming: 0.46888336965000044
step: 7, hamming: 0.42324358671229345
step: 8, hamming: 0.37799368552636897
step: 9, hamming: 0.33449716705491805
step: 10, hamming: 0.2937026837940896
step: 11, hamming: 0.25619963891549247
step: 12, hamming: 0.22228779180603883
step: 13, hamming: 0.1920451228053333
step: 14, hamming: 0.165390605047534
step: 15, hamming: 0.14213514394319682
step: 16, hamming: 0.12202099792941383
step: 17, hamming: 0.1047515095155968
step: 18, hamming: 0.09001138629352733
step: 19, hamming: 0.0774807387620337
step: 20, hamming: 0.06684470509459199
step: 21, hamming: 0.05780176344875446
step: 22, hamming: 0.05007220261612099
step: 23, hamming: 0.0434076228109129
step: 24, hamming: 0.037600282707592456
step: 25, hamming: 0.03248939173711592
step: 26, hamming: 0.027961098540398802
step: 27, hamming: 0.023941274385556592
step: 28, hamming: 0.0203833012069568
step: 29, hamming: 0.017255017889970633
```

```
step: 30, hamming: 0.014528528671629803
step: 31, hamming: 0.01217444290051738
step: 32, hamming: 0.010160072735999441
step: 33, hamming: 0.008450124179654739
step: 34, hamming: 0.007008412715800018
step: 35, hamming: 0.005799629423267301
step: 36, hamming: 0.00479069148047581
step: 37, hamming: 0.003951568960336358
step: 38, hamming: 0.0032556533190094515
step: 39, hamming: 0.0026797931825938656
step: 40, hamming: 0.0022041191628977
step: 41, hamming: 0.0018117532364711282
step: 42, hamming: 0.0014884692131398442
step: 43, hamming: 0.0012223462917056505
step: 44, hamming: 0.001003440041109761
step: 45, hamming: 0.0008234831485799504
Running panda took: 1.33 seconds!
  Elapsed time: 1.33 sec.
Saving LIONESS network 49 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
Running LIONESS for sample 50:
Computing coexpression network:
  Elapsed time: 0.01 sec.
Normalizing networks:
  Elapsed time: 0.02 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6452671619076494
step: 1, hamming: 0.6066848794849176
step: 2, hamming: 0.6105275873120232
step: 3, hamming: 0.5875201390790638
step: 4, hamming: 0.5535905216591732
step: 5, hamming: 0.5130937685955772
step: 6, hamming: 0.4688858948251511
step: 7, hamming: 0.42325035103333314
step: 8, hamming: 0.3780020754008558
step: 9, hamming: 0.33450587862635855
step: 10, hamming: 0.29371071766895035
step: 11, hamming: 0.25620695600438853
step: 12, hamming: 0.22229411692149165
step: 13, hamming: 0.1920505169749237
step: 14, hamming: 0.16539508199998468
step: 15, hamming: 0.14213872037052774
step: 16, hamming: 0.12202392388371454
step: 17, hamming: 0.10475390584465226
step: 18, hamming: 0.09001338394595733
step: 19, hamming: 0.07748237123447736
step: 20, hamming: 0.06684601761691708
step: 21, hamming: 0.05780280883485421
```

```
step: 22, hamming: 0.05007303285774467
step: 23, hamming: 0.043408286930817476
step: 24, hamming: 0.03760082097488881
step: 25, hamming: 0.0324898273735242
step: 26, hamming: 0.02796144715861602
step: 27, hamming: 0.023941554838090757
step: 28, hamming: 0.020383526490059086
step: 29, hamming: 0.017255198122503472
step: 30, hamming: 0.014528673059252926
step: 31, hamming: 0.012174559156125178
step: 32, hamming: 0.010160166553288554
step: 33, hamming: 0.008450200171028089
step: 34, hamming: 0.007008474696064771
step: 35, hamming: 0.005799679944846654
step: 36, hamming: 0.0047907327210686135
step: 37, hamming: 0.003951602686458482
step: 38, hamming: 0.003255680919601847
step: 39, hamming: 0.002679815808328275
step: 40, hamming: 0.0022041377721913641
step: 41, hamming: 0.001811768467971286
step: 42, hamming: 0.0014884817149678226
step: 43, hamming: 0.0012223565551249145
step: 44, hamming: 0.0010034484651433202
step: 45, hamming: 0.0008234900629489583
Running panda took: 1.32 seconds!
  Elapsed time: 1.33 sec.
Saving LIONESS network 50 to lioness_output using npy format:
  Elapsed time: 0.00 sec.
```

### 1.7  7. Run Lioness with co-expression matrix

Lioness can work with co-expression matrix. To compute Lioness with coexpression matrix, we can set motif data to `None`:

```
[15]: motif = None

      # Make sure to keep epxression matrix for next step
      panda_obj = Panda('netZooPy/tests/ToyData/ToyExpressionData.txt',
                        None,
                        'netZooPy/tests/ToyData/ToyPPIData.txt',
                        save_tmp=True,
                        remove_missing=False,
                        keep_expression_matrix=True)
      lioness_obj = Lioness(panda_obj)
```

```
Loading expression data ...
Expression matrix: (1000, 50)
  Elapsed time: 0.02 sec.
Loading PPI data ...
```

```
Number of PPIs: 238
  Elapsed time: 0.01 sec.
Calculating coexpression network ...
  Elapsed time: 0.03 sec.
Returning the correlation matrix of expression data in
<Panda_obj>.correlation_matrix
Loading input data ...
  Elapsed time: 0.00 sec.
Running LIONESS for sample 1:
Computing coexpression network:
  Elapsed time: 0.02 sec.
Normalizing networks:
  Elapsed time: 0.04 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 1 to lioness_output using npy format:
  Elapsed time: 0.04 sec.
Running LIONESS for sample 2:
Computing coexpression network:
  Elapsed time: 0.03 sec.
Normalizing networks:
  Elapsed time: 0.18 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 2 to lioness_output using npy format:
  Elapsed time: 0.05 sec.
Running LIONESS for sample 3:
Computing coexpression network:
  Elapsed time: 0.02 sec.
Normalizing networks:
  Elapsed time: 0.04 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 3 to lioness_output using npy format:
  Elapsed time: 0.04 sec.
Running LIONESS for sample 4:
Computing coexpression network:
  Elapsed time: 0.02 sec.
Normalizing networks:
  Elapsed time: 0.07 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 4 to lioness_output using npy format:
  Elapsed time: 0.05 sec.
Running LIONESS for sample 5:
Computing coexpression network:
  Elapsed time: 0.03 sec.
Normalizing networks:
```

```
  Elapsed time: 0.05 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 5 to lioness_output using npy format:
  Elapsed time: 0.04 sec.
Running LIONESS for sample 6:
Computing coexpression network:
  Elapsed time: 0.02 sec.
Normalizing networks:
  Elapsed time: 0.03 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 6 to lioness_output using npy format:
  Elapsed time: 0.04 sec.
Running LIONESS for sample 7:
Computing coexpression network:
  Elapsed time: 0.03 sec.
Normalizing networks:
  Elapsed time: 0.09 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 7 to lioness_output using npy format:
  Elapsed time: 0.06 sec.
Running LIONESS for sample 8:
Computing coexpression network:
  Elapsed time: 0.03 sec.
Normalizing networks:
  Elapsed time: 0.03 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 8 to lioness_output using npy format:
  Elapsed time: 0.04 sec.
Running LIONESS for sample 9:
Computing coexpression network:
  Elapsed time: 0.04 sec.
Normalizing networks:
  Elapsed time: 0.04 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 9 to lioness_output using npy format:
  Elapsed time: 0.04 sec.
Running LIONESS for sample 10:
Computing coexpression network:
  Elapsed time: 0.04 sec.
Normalizing networks:
  Elapsed time: 0.06 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
```

```
Saving LIONESS network 10 to lioness_output using npy format:
  Elapsed time: 0.04 sec.
Running LIONESS for sample 11:
Computing coexpression network:
  Elapsed time: 0.03 sec.
Normalizing networks:
  Elapsed time: 0.06 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 11 to lioness_output using npy format:
  Elapsed time: 0.04 sec.
Running LIONESS for sample 12:
Computing coexpression network:
  Elapsed time: 0.02 sec.
Normalizing networks:
  Elapsed time: 0.03 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 12 to lioness_output using npy format:
  Elapsed time: 0.05 sec.
Running LIONESS for sample 13:
Computing coexpression network:
  Elapsed time: 0.02 sec.
Normalizing networks:
  Elapsed time: 0.03 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 13 to lioness_output using npy format:
  Elapsed time: 0.05 sec.
Running LIONESS for sample 14:
Computing coexpression network:
  Elapsed time: 0.03 sec.
Normalizing networks:
  Elapsed time: 0.06 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 14 to lioness_output using npy format:
  Elapsed time: 0.05 sec.
Running LIONESS for sample 15:
Computing coexpression network:
  Elapsed time: 0.03 sec.
Normalizing networks:
  Elapsed time: 0.06 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 15 to lioness_output using npy format:
  Elapsed time: 0.04 sec.
Running LIONESS for sample 16:
```

```
Computing coexpression network:
  Elapsed time: 0.03 sec.
Normalizing networks:
  Elapsed time: 0.06 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 16 to lioness_output using npy format:
  Elapsed time: 0.04 sec.
Running LIONESS for sample 17:
Computing coexpression network:
  Elapsed time: 0.02 sec.
Normalizing networks:
  Elapsed time: 0.04 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 17 to lioness_output using npy format:
  Elapsed time: 0.05 sec.
Running LIONESS for sample 18:
Computing coexpression network:
  Elapsed time: 0.04 sec.
Normalizing networks:
  Elapsed time: 0.04 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 18 to lioness_output using npy format:
  Elapsed time: 0.03 sec.
Running LIONESS for sample 19:
Computing coexpression network:
  Elapsed time: 0.03 sec.
Normalizing networks:
  Elapsed time: 0.03 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 19 to lioness_output using npy format:
  Elapsed time: 0.05 sec.
Running LIONESS for sample 20:
Computing coexpression network:
  Elapsed time: 0.02 sec.
Normalizing networks:
  Elapsed time: 0.03 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 20 to lioness_output using npy format:
  Elapsed time: 0.03 sec.
Running LIONESS for sample 21:
Computing coexpression network:
  Elapsed time: 0.02 sec.
Normalizing networks:
```

```
  Elapsed time: 0.03 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 21 to lioness_output using npy format:
  Elapsed time: 0.03 sec.
Running LIONESS for sample 22:
Computing coexpression network:
  Elapsed time: 0.02 sec.
Normalizing networks:
  Elapsed time: 0.05 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 22 to lioness_output using npy format:
  Elapsed time: 0.03 sec.
Running LIONESS for sample 23:
Computing coexpression network:
  Elapsed time: 0.02 sec.
Normalizing networks:
  Elapsed time: 0.04 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 23 to lioness_output using npy format:
  Elapsed time: 0.05 sec.
Running LIONESS for sample 24:
Computing coexpression network:
  Elapsed time: 0.02 sec.
Normalizing networks:
  Elapsed time: 0.03 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 24 to lioness_output using npy format:
  Elapsed time: 0.06 sec.
Running LIONESS for sample 25:
Computing coexpression network:
  Elapsed time: 0.03 sec.
Normalizing networks:
  Elapsed time: 0.03 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 25 to lioness_output using npy format:
  Elapsed time: 0.05 sec.
Running LIONESS for sample 26:
Computing coexpression network:
  Elapsed time: 0.04 sec.
Normalizing networks:
  Elapsed time: 0.04 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
```

```
Saving LIONESS network 26 to lioness_output using npy format:
  Elapsed time: 0.05 sec.
Running LIONESS for sample 27:
Computing coexpression network:
  Elapsed time: 0.02 sec.
Normalizing networks:
  Elapsed time: 0.04 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 27 to lioness_output using npy format:
  Elapsed time: 0.07 sec.
Running LIONESS for sample 28:
Computing coexpression network:
  Elapsed time: 0.03 sec.
Normalizing networks:
  Elapsed time: 0.06 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 28 to lioness_output using npy format:
  Elapsed time: 0.05 sec.
Running LIONESS for sample 29:
Computing coexpression network:
  Elapsed time: 0.03 sec.
Normalizing networks:
  Elapsed time: 0.06 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 29 to lioness_output using npy format:
  Elapsed time: 0.08 sec.
Running LIONESS for sample 30:
Computing coexpression network:
  Elapsed time: 0.02 sec.
Normalizing networks:
  Elapsed time: 0.03 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 30 to lioness_output using npy format:
  Elapsed time: 0.04 sec.
Running LIONESS for sample 31:
Computing coexpression network:
  Elapsed time: 0.03 sec.
Normalizing networks:
  Elapsed time: 0.04 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 31 to lioness_output using npy format:
  Elapsed time: 0.03 sec.
Running LIONESS for sample 32:
```

```
Computing coexpression network:
  Elapsed time: 0.02 sec.
Normalizing networks:
  Elapsed time: 0.04 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 32 to lioness_output using npy format:
  Elapsed time: 0.04 sec.
Running LIONESS for sample 33:
Computing coexpression network:
  Elapsed time: 0.02 sec.
Normalizing networks:
  Elapsed time: 0.04 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 33 to lioness_output using npy format:
  Elapsed time: 0.05 sec.
Running LIONESS for sample 34:
Computing coexpression network:
  Elapsed time: 0.02 sec.
Normalizing networks:
  Elapsed time: 0.04 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 34 to lioness_output using npy format:
  Elapsed time: 0.04 sec.
Running LIONESS for sample 35:
Computing coexpression network:
  Elapsed time: 0.02 sec.
Normalizing networks:
  Elapsed time: 0.03 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 35 to lioness_output using npy format:
  Elapsed time: 0.05 sec.
Running LIONESS for sample 36:
Computing coexpression network:
  Elapsed time: 0.03 sec.
Normalizing networks:
  Elapsed time: 0.04 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 36 to lioness_output using npy format:
  Elapsed time: 0.06 sec.
Running LIONESS for sample 37:
Computing coexpression network:
  Elapsed time: 0.03 sec.
Normalizing networks:
```

```
  Elapsed time: 0.04 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 37 to lioness_output using npy format:
  Elapsed time: 0.05 sec.
Running LIONESS for sample 38:
Computing coexpression network:
  Elapsed time: 0.06 sec.
Normalizing networks:
  Elapsed time: 0.03 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 38 to lioness_output using npy format:
  Elapsed time: 0.06 sec.
Running LIONESS for sample 39:
Computing coexpression network:
  Elapsed time: 0.02 sec.
Normalizing networks:
  Elapsed time: 0.03 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 39 to lioness_output using npy format:
  Elapsed time: 0.05 sec.
Running LIONESS for sample 40:
Computing coexpression network:
  Elapsed time: 0.04 sec.
Normalizing networks:
  Elapsed time: 0.08 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 40 to lioness_output using npy format:
  Elapsed time: 0.08 sec.
Running LIONESS for sample 41:
Computing coexpression network:
  Elapsed time: 0.04 sec.
Normalizing networks:
  Elapsed time: 0.06 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 41 to lioness_output using npy format:
  Elapsed time: 0.04 sec.
Running LIONESS for sample 42:
Computing coexpression network:
  Elapsed time: 0.04 sec.
Normalizing networks:
  Elapsed time: 0.07 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
```

```
Saving LIONESS network 42 to lioness_output using npy format:
  Elapsed time: 0.09 sec.
Running LIONESS for sample 43:
Computing coexpression network:
  Elapsed time: 0.05 sec.
Normalizing networks:
  Elapsed time: 0.07 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 43 to lioness_output using npy format:
  Elapsed time: 0.06 sec.
Running LIONESS for sample 44:
Computing coexpression network:
  Elapsed time: 0.05 sec.
Normalizing networks:
  Elapsed time: 0.06 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 44 to lioness_output using npy format:
  Elapsed time: 0.05 sec.
Running LIONESS for sample 45:
Computing coexpression network:
  Elapsed time: 0.04 sec.
Normalizing networks:
  Elapsed time: 0.08 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 45 to lioness_output using npy format:
  Elapsed time: 0.06 sec.
Running LIONESS for sample 46:
Computing coexpression network:
  Elapsed time: 0.03 sec.
Normalizing networks:
  Elapsed time: 0.06 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 46 to lioness_output using npy format:
  Elapsed time: 0.05 sec.
Running LIONESS for sample 47:
Computing coexpression network:
  Elapsed time: 0.05 sec.
Normalizing networks:
  Elapsed time: 0.08 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 47 to lioness_output using npy format:
  Elapsed time: 0.06 sec.
Running LIONESS for sample 48:
```

```
Computing coexpression network:
  Elapsed time: 0.08 sec.
Normalizing networks:
  Elapsed time: 0.08 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 48 to lioness_output using npy format:
  Elapsed time: 0.08 sec.
Running LIONESS for sample 49:
Computing coexpression network:
  Elapsed time: 0.02 sec.
Normalizing networks:
  Elapsed time: 0.04 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 49 to lioness_output using npy format:
  Elapsed time: 0.08 sec.
Running LIONESS for sample 50:
Computing coexpression network:
  Elapsed time: 0.03 sec.
Normalizing networks:
  Elapsed time: 0.06 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 50 to lioness_output using npy format:
  Elapsed time: 0.08 sec.
```

## 1.8   8. Visualize Lioness results

AnalyzeLioness() can be used to visualize lioness network. You may select only the top genes to be visualized in the graph. In current version of Lioness. Only the network of the first sample will be visualized using .top_network_plot() function.

```
[19]: analyze_lioness_obj = AnalyzeLioness(lioness_obj)
      analyze_lioness_obj.top_network_plot(top = 10, file = "lioness_top_10.png")
```
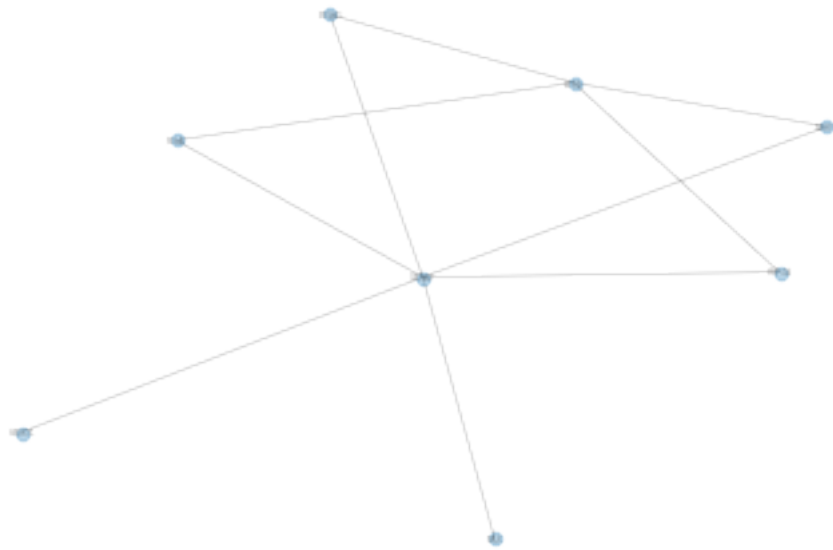
## 1.9   9. Save Lioness results

We can save Lioness results by using `save_lioness_results()` method of the `Lioness` object. The edge weights of Lioness predictions will be saved into output file. We can get TF and target IDs from the `.export_panda_results` property of `Panda` object. Each row correspond to a row in the Lioness output file.

```
[20]: panda_obj.export_panda_results
```

```
[20]:            tf    gene   motif        force
      0         AHR   AACSL     0.0   -53.984356
      1          AR   AACSL     0.0    27.276521
      2       ARID3A  AACSL     1.0   -64.531519
      3        ARNT   AACSL     1.0   -70.183704
      4       BRCA1   AACSL     0.0   -57.854191
      ...       ...    ...      ...          ...
      86995    TLX1   ZWILCH    0.0    15.673701
      86996    TP53   ZWILCH    0.0    23.789647
      86997    USF1   ZWILCH    0.0    -6.855873
      86998     VDR   ZWILCH    0.0    20.885728
      86999     YY1   ZWILCH    1.0   -80.408914

      [87000 rows x 4 columns]
```

```
[21]: lioness_obj.save_lioness_results(file = 'lioness.txt')
```

## 1.10 References

Kuijjer ML, Tung MG, Yuan GC, Quackenbush J, Glass K: Estimating Sample-Specific Regulatory Networks. iScience 2019.