

Building single-sample regulatory networks using LIONESS and netZooPy

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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 regulatory 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 approach to build sample-specific networks.

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](https://netzooPy.readthedocs.io/en/latest/install/index.html) (<https://netzooPy.readthedocs.io/en/latest/install/index.html>).

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.

```
In [1]: from netZooPy.panda import Panda
        from netZooPy.lioness import Lioness
        from netZooPy.lioness.analyze_lioness import AnalyzeLioness
        import pandas as pd
```

4. Load input data

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

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

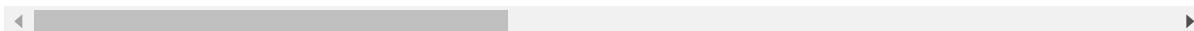
Expression data is a matrix where rows are genes and columns are samples. There are 1000 genes and 50 samples in this expression dataset

In [4]: exp_data

Out[4]:

	1	2	3	4	5	6	7	8
0								
AACSL	0.141431	-4.153056	2.854971	0.413670	1.082093	1.882361	1.450223	2.130209
AAK1	3.528478	-0.949701	1.039986	-1.618816	-1.228012	-0.171763	-2.822020	0.047464
ABCA17P	-2.597842	3.970710	-2.809212	0.474679	-2.714377	-0.474146	-6.738092	-2.811364
ABCB8	0.352052	-1.866545	-0.007765	3.289632	2.675149	3.819294	0.668285	2.608310
ABCC1	-4.638927	2.440799	-1.655580	0.506424	3.289914	2.460479	-1.003678	1.537390
...
ZNF826	-4.294209	-4.498573	2.786462	-1.588052	1.542248	3.222761	-0.005525	-4.711980
ZNF845	-1.661144	-6.986089	2.273928	-2.426933	-4.627002	-4.044476	-3.991184	-0.903110
ZNF878	3.395504	-6.274497	0.455548	0.592239	-0.852212	1.373684	-2.638325	4.028650
ZSWIM3	-0.494841	2.840674	-3.816640	3.052187	4.979421	-5.889279	-6.640408	3.711900
ZWILCH	0.694298	-2.725693	-1.752258	-1.789789	2.228141	-4.494592	1.233303	-1.748300

1000 rows × 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.

In [5]: motif_data

Out[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
...
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 × 3 columns

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

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

Out[6]: 87

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

Out[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

In [8]: `ppi_data`

Out[8]:

	0	1	2
0	AHR	ESR1	1
1	AHR	RELA	1
2	AHR	NR2F1	1
3	AR	SP1	1
4	RUNX1	JUN	1
...
233	NFKB1	RELA	1
234	DDIT3	HOXA5	1
235	NR3C1	NR2E3	1
236	HLF	MYB	1
237	PPARG	NR2E3	1

238 rows × 3 columns

This PPI dataset has 238 interactions among 87 TFs.

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

Out[9]: 87

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.

```
In [17]: panda_obj = Panda('netZooPy/tests/ToyData/ToyExpressionData.txt',  
                           'netZooPy/tests/ToyData/ToyMotifData.txt',  
                           'netZooPy/tests/ToyData/ToyPPIData.txt',  
                           remove_missing=False,  
                           keep_expression_matrix=True)
```

```
Loading motif data ...
Unique TFs: 87
  Elapsed time: 0.01 sec.
Loading expression data ...
Expression matrix: (1000, 50)
  Elapsed time: 0.01 sec.
Loading PPI data ...
Number of PPIs: 238
  Elapsed time: 0.00 sec.
Calculating coexpression network ...
  Elapsed time: 0.03 sec.
Creating motif network ...
  Elapsed time: 0.02 sec.
Creating PPI network ...
  Elapsed time: 0.00 sec.
Normalizing networks ...
  Elapsed time: 0.07 sec.
Saving expression matrix and normalized networks ...
  Elapsed time: 0.02 sec.
Running PANDA algorithm ...
step: 0, hamming: 0.7189662815459754
step: 1, hamming: 0.3899291546314954
step: 2, hamming: 0.40236683889692043
step: 3, hamming: 0.4005209618112847
step: 4, hamming: 0.38904060163854676
step: 5, hamming: 0.37050927774796627
step: 6, hamming: 0.346813714233211
step: 7, hamming: 0.3197200219092709
step: 8, hamming: 0.290805929638121
step: 9, hamming: 0.2614076747991081
step: 10, hamming: 0.2325667493310834
step: 11, hamming: 0.2050473463652485
step: 12, hamming: 0.17936756642941445
step: 13, hamming: 0.15582820203948794
step: 14, hamming: 0.13456406927299874
step: 15, hamming: 0.11558769817777673
step: 16, hamming: 0.09882404071423921
step: 17, hamming: 0.08414234823461533
step: 18, hamming: 0.07137863350560043
step: 19, hamming: 0.060352597421148776
step: 20, hamming: 0.05087989460076123
step: 21, hamming: 0.04278075541305479
step: 22, hamming: 0.03588517917018383
step: 23, hamming: 0.030036230563844166
step: 24, hamming: 0.025091497107547298
step: 25, hamming: 0.020923570455323975
step: 26, hamming: 0.01741975365490937
step: 27, hamming: 0.014481280791973365
step: 28, hamming: 0.012022271977958703
step: 29, hamming: 0.009968530625360775
step: 30, hamming: 0.008256316822080976
step: 31, hamming: 0.006831152395943062
step: 32, hamming: 0.005646666396278005
step: 33, hamming: 0.004663540428062875
step: 34, hamming: 0.0038485478068236807
step: 35, hamming: 0.0031736932436243577
step: 36, hamming: 0.002615452884106168
```

```
step: 37, hamming: 0.002154108616081292
step: 38, hamming: 0.0017731679664810425
step: 39, hamming: 0.0014588635383778908
step: 40, hamming: 0.001199723701073244
step: 41, hamming: 0.0009862051158053544
Running panda took: 1.31 seconds!
```

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.

```
In [18]: lioness_obj = Lioness(panda_obj)
```



```
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: 0.05 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6451915130131665
step: 1, hamming: 0.6067461274659866
step: 2, hamming: 0.6105604110178086
step: 3, hamming: 0.5875350566544837
step: 4, hamming: 0.553598317095621
step: 5, hamming: 0.5130977642028344
step: 6, hamming: 0.46888897174383587
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: 0.2223029668802453
step: 13, hamming: 0.19205902295385965
step: 14, hamming: 0.16540299653390683
step: 15, hamming: 0.14214587924488872
step: 16, hamming: 0.12203018089850888
step: 17, hamming: 0.10475927721891459
step: 18, hamming: 0.09001790128025045
step: 19, hamming: 0.07748617353400274
step: 20, hamming: 0.06684920778474639
step: 21, hamming: 0.05780549039322097
step: 22, hamming: 0.050075273181656076
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: 0.020384212163623416
step: 29, hamming: 0.017255759085262883
step: 30, hamming: 0.014529132197793934
step: 31, hamming: 0.012174934686279325
step: 32, hamming: 0.010160473548057764
step: 33, hamming: 0.008450451023408795
step: 34, hamming: 0.007008679501096658
step: 35, hamming: 0.005799847383305951
step: 36, hamming: 0.0047908698579349875
step: 37, hamming: 0.003951715021127739
step: 38, hamming: 0.0032557729560454525
step: 39, hamming: 0.0026798912102928003
step: 40, hamming: 0.0022041994917917375
step: 41, hamming: 0.0018118190733138475
step: 42, hamming: 0.001488523179360306
step: 43, hamming: 0.0012223905275455405
step: 44, hamming: 0.0010034762989084775
step: 45, hamming: 0.0008235128661467359
Running panda took: 1.57 seconds!
  Elapsed time: 1.57 sec.
Saving LIONESS network 1 to lioness_output using npy format:
```

```
Elapsed time: 0.02 sec.
Running LIONESS for sample 2:
Computing coexpression network:
Elapsed time: 0.01 sec.
Normalizing networks:
Elapsed time: 0.03 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6445476038755726
step: 1, hamming: 0.6066183636796103
step: 2, hamming: 0.6105445645592841
step: 3, hamming: 0.5875332090279166
step: 4, hamming: 0.5536082244075643
step: 5, hamming: 0.5131126090450783
step: 6, hamming: 0.4689036142976634
step: 7, hamming: 0.42326732437298714
step: 8, hamming: 0.37801889244651393
step: 9, hamming: 0.3345221998366117
step: 10, hamming: 0.2937266882099521
step: 11, hamming: 0.25622198762640763
step: 12, hamming: 0.2223082180455078
step: 13, hamming: 0.19206345829316707
step: 14, hamming: 0.16540684598000693
step: 15, hamming: 0.14214929350383065
step: 16, hamming: 0.12203326585701965
step: 17, hamming: 0.10476213861746786
step: 18, hamming: 0.09002061402300268
step: 19, hamming: 0.07748873372939052
step: 20, hamming: 0.06685160145106347
step: 21, hamming: 0.05780769330088383
step: 22, hamming: 0.05007728699579842
step: 23, hamming: 0.043411967564035835
step: 24, hamming: 0.03760397086506173
step: 25, hamming: 0.03249250247772415
step: 26, hamming: 0.02796370867990171
step: 27, hamming: 0.023943455630073416
step: 28, hamming: 0.020385117331234274
step: 29, hamming: 0.017256526537376273
step: 30, hamming: 0.014529780088585704
step: 31, hamming: 0.01217547887586061
step: 32, hamming: 0.01016092964904858
step: 33, hamming: 0.00845083256181436
step: 34, hamming: 0.007008998275263656
step: 35, hamming: 0.00580011293166026
step: 36, hamming: 0.004791090473343346
step: 37, hamming: 0.003951898060626234
step: 38, hamming: 0.0032559245644580514
step: 39, hamming: 0.002680016580549968
step: 40, hamming: 0.002204303033904436
step: 41, hamming: 0.0018119045001386948
step: 42, hamming: 0.0014885935906914863
step: 43, hamming: 0.0012224485182821007
step: 44, hamming: 0.001003524027229864
step: 45, hamming: 0.0008235521248684664
Running panda took: 1.44 seconds!
Elapsed time: 1.44 sec.
Saving LIONESS network 2 to lioness_output using npy format:
Elapsed time: 0.02 sec.
```

```
Running LIONESS for sample 3:
Computing coexpression network:
  Elapsed time: 0.02 sec.
Normalizing networks:
  Elapsed time: 0.05 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6452294464816625
step: 1, hamming: 0.6066718767537945
step: 2, hamming: 0.6105013812906783
step: 3, hamming: 0.5874769465007303
step: 4, hamming: 0.5535467800773778
step: 5, hamming: 0.5130509623219737
step: 6, hamming: 0.46884619807330846
step: 7, hamming: 0.42321422343773074
step: 8, hamming: 0.37797019212390504
step: 9, hamming: 0.3344779785095642
step: 10, hamming: 0.29368704884702534
step: 11, hamming: 0.2561872040679576
step: 12, hamming: 0.22227787688473338
step: 13, hamming: 0.19203719585754386
step: 14, hamming: 0.1653841888050198
step: 15, hamming: 0.14212975837567024
step: 16, hamming: 0.12201639360763507
step: 17, hamming: 0.10474755327204792
step: 18, hamming: 0.09000797360987653
step: 19, hamming: 0.07747770691527577
step: 20, hamming: 0.06684195286417426
step: 21, hamming: 0.05779924885457799
step: 22, hamming: 0.0500699126573237
step: 23, hamming: 0.04340556363927608
step: 24, hamming: 0.03759846201370095
step: 25, hamming: 0.032487809256736604
step: 26, hamming: 0.027959741303826367
step: 27, hamming: 0.023940126981286655
step: 28, hamming: 0.020382340568109492
step: 29, hamming: 0.017254219929107445
step: 30, hamming: 0.014527868465885224
step: 31, hamming: 0.01217389759028471
step: 32, hamming: 0.010159622712944908
step: 33, hamming: 0.008449753233040156
step: 34, hamming: 0.00700810750381105
step: 35, hamming: 0.005799378246977346
step: 36, hamming: 0.004790484906859
step: 37, hamming: 0.003951399167495922
step: 38, hamming: 0.0032555137716483097
step: 39, hamming: 0.0026796785137800714
step: 40, hamming: 0.0022040249594432525
step: 41, hamming: 0.0018116758740187896
step: 42, hamming: 0.00148840570066346
step: 43, hamming: 0.0012222941612371428
step: 44, hamming: 0.001003397260817946
step: 45, hamming: 0.0008234480506902851
Running panda took: 1.45 seconds!
  Elapsed time: 1.45 sec.
Saving LIONESS network 3 to lioness_output using npy format:
  Elapsed time: 0.02 sec.
Running LIONESS for sample 4:
```

```
Computing coexpression network:
  Elapsed time: 0.02 sec.
Normalizing networks:
  Elapsed time: 0.03 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6451852429809524
step: 1, hamming: 0.6065219652377924
step: 2, hamming: 0.6104344926479942
step: 3, hamming: 0.5874558460006224
step: 4, hamming: 0.5535449632471361
step: 5, hamming: 0.5130643774408143
step: 6, hamming: 0.4688705437378891
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: 0.22233727067256506
step: 13, hamming: 0.19209248683867375
step: 14, hamming: 0.16543446318988872
step: 15, hamming: 0.1421747497816679
step: 16, hamming: 0.12205609283083738
step: 17, hamming: 0.10478214956850972
step: 18, hamming: 0.09003785868900757
step: 19, hamming: 0.07750337290976046
step: 20, hamming: 0.06686386614000324
step: 21, hamming: 0.05781785478415813
step: 22, hamming: 0.05008562777061508
step: 23, hamming: 0.04341877501262821
step: 24, hamming: 0.03760951592560502
step: 25, hamming: 0.032497011652074345
step: 26, hamming: 0.02796736911372712
step: 27, hamming: 0.02394642097778111
step: 28, hamming: 0.020387520088663666
step: 29, hamming: 0.017258473103985816
step: 30, hamming: 0.01453135749256901
step: 31, hamming: 0.012176759183597896
step: 32, hamming: 0.010161970824797953
step: 33, hamming: 0.008451681020184565
step: 34, hamming: 0.007009691223106571
step: 35, hamming: 0.005800680312786872
step: 36, hamming: 0.004791555961913859
step: 37, hamming: 0.003952280550194627
step: 38, hamming: 0.003256239262093696
step: 39, hamming: 0.002680275699607181
step: 40, hamming: 0.0022045164857199522
step: 41, hamming: 0.0018120803581844042
step: 42, hamming: 0.001488738520630177
step: 43, hamming: 0.0012225679351576834
step: 44, hamming: 0.0010036223951606135
step: 45, hamming: 0.0008236331272743101
Running panda took: 1.37 seconds!
  Elapsed time: 1.37 sec.
Saving LIONESS network 4 to lioness_output using npy format:
  Elapsed time: 0.02 sec.
Running LIONESS for sample 5:
Computing coexpression network:
```

```
Elapsed time: 0.02 sec.
Normalizing networks:
  Elapsed time: 0.03 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6446007808140573
step: 1, hamming: 0.6066561612626608
step: 2, hamming: 0.6105143267305174
step: 3, hamming: 0.5875153809819785
step: 4, hamming: 0.5536025207133696
step: 5, hamming: 0.5131152115952171
step: 6, hamming: 0.46890851450749593
step: 7, hamming: 0.42326886776988776
step: 8, hamming: 0.3780158211356529
step: 9, hamming: 0.3345152633298887
step: 10, hamming: 0.2937178419931415
step: 11, hamming: 0.2562128416941286
step: 12, hamming: 0.22229937209191528
step: 13, hamming: 0.19205541566268614
step: 14, hamming: 0.16539967610526804
step: 15, hamming: 0.14214304912137624
step: 16, hamming: 0.12202778290912641
step: 17, hamming: 0.10475728352365837
step: 18, hamming: 0.090016151593947
step: 19, hamming: 0.07748448858975361
step: 20, hamming: 0.06684754079961647
step: 21, hamming: 0.05780382637771552
step: 22, hamming: 0.050073651393493325
step: 23, hamming: 0.04340859802170938
step: 24, hamming: 0.0376009243886287
step: 25, hamming: 0.032489808432629164
step: 26, hamming: 0.027961372564714912
step: 27, hamming: 0.023941467122490446
step: 28, hamming: 0.020383446949155247
step: 29, hamming: 0.01725513600007104
step: 30, hamming: 0.014528627076186464
step: 31, hamming: 0.012174525611025123
step: 32, hamming: 0.010160143004486255
step: 33, hamming: 0.008450183672932479
step: 34, hamming: 0.0070084629144963285
step: 35, hamming: 0.005799671567508494
step: 36, hamming: 0.00479072675513629
step: 37, hamming: 0.00395159839993978
step: 38, hamming: 0.0032556778303245086
step: 39, hamming: 0.002679813604130495
step: 40, hamming: 0.0022041361378598878
step: 41, hamming: 0.0018117673263748355
step: 42, hamming: 0.0014884808938152954
step: 43, hamming: 0.001222355966581887
step: 44, hamming: 0.001003448045910429
step: 45, hamming: 0.0008234897655709236
Running panda took: 1.46 seconds!
  Elapsed time: 1.46 sec.
Saving LIONESS network 5 to lioness_output using npy format:
  Elapsed time: 0.05 sec.
Running LIONESS for sample 6:
Computing coexpression network:
  Elapsed time: 0.02 sec.
```

Normalizing networks:

Elapsed time: 0.03 sec.

Inferring LIONESS network:

step: 0, hamming: 0.6449147271756762
step: 1, hamming: 0.6066459340545902
step: 2, hamming: 0.6105137892381169
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: 0.3345019592116213
step: 10, hamming: 0.29370783535904643
step: 11, hamming: 0.25620490280375174
step: 12, hamming: 0.2222927405692275
step: 13, hamming: 0.19204960851436953
step: 14, hamming: 0.16539452124403728
step: 15, hamming: 0.14213836522146303
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: 0.057802393319260764
step: 22, hamming: 0.05007261907425589
step: 23, hamming: 0.043407887819397944
step: 24, hamming: 0.03760046113425871
step: 25, hamming: 0.032489527040096326
step: 26, hamming: 0.027961217331469623
step: 27, hamming: 0.023941395280352783
step: 28, hamming: 0.020383428084858147
step: 29, hamming: 0.01725514805667612
step: 30, hamming: 0.01452865748618028
step: 31, hamming: 0.012174566104760925
step: 32, hamming: 0.010160186691797834
step: 33, hamming: 0.008450226110780602
step: 34, hamming: 0.007008501791631318
step: 35, hamming: 0.005799706008307911
step: 36, hamming: 0.004790756420696588
step: 37, hamming: 0.003951623456964681
step: 38, hamming: 0.0032556987003403777
step: 39, hamming: 0.00267983077356759
step: 40, hamming: 0.002204150177080668
step: 41, hamming: 0.0018117787582195696
step: 42, hamming: 0.0014884901773124216
step: 43, hamming: 0.0012223635096057386
step: 44, hamming: 0.0010034541834039374
step: 45, hamming: 0.0008234947565908472

Running panda took: 1.28 seconds!

Elapsed time: 1.28 sec.

Saving LIONESS network 6 to lioness_output using npy format:

Elapsed time: 0.05 sec.

Running LIONESS for sample 7:

Computing coexpression network:

Elapsed time: 0.02 sec.

Normalizing networks:

```
Elapsed time: 0.03 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6446977027334075
step: 1, hamming: 0.6064843916807414
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: 0.42315760514309164
step: 8, hamming: 0.37792629014527557
step: 9, hamming: 0.3344456468150189
step: 10, hamming: 0.29366421996136893
step: 11, hamming: 0.25617114055220225
step: 12, hamming: 0.22226630385566215
step: 13, hamming: 0.19202874698683792
step: 14, hamming: 0.1653778736143681
step: 15, hamming: 0.14212484935803069
step: 16, hamming: 0.12201243940238896
step: 17, hamming: 0.10474418411446189
step: 18, hamming: 0.09000497478051857
step: 19, hamming: 0.07747497601974164
step: 20, hamming: 0.06683946462194991
step: 21, hamming: 0.05779698175620105
step: 22, hamming: 0.05006786610992063
step: 23, hamming: 0.04340371997910614
step: 24, hamming: 0.03759681143075524
step: 25, hamming: 0.03248634755930704
step: 26, hamming: 0.02795846902706734
step: 27, hamming: 0.02393903917646325
step: 28, hamming: 0.02038142735532686
step: 29, hamming: 0.017253462963678155
step: 30, hamming: 0.014527247466191108
step: 31, hamming: 0.012173391298399968
step: 32, hamming: 0.01015921171833301
step: 33, hamming: 0.008449420102928758
step: 34, hamming: 0.007007837027271363
step: 35, hamming: 0.005799158448934519
step: 36, hamming: 0.0047903059897394145
step: 37, hamming: 0.00395125337010865
step: 38, hamming: 0.0032553948541319587
step: 39, hamming: 0.0026795814132303665
step: 40, hamming: 0.0022039455997269423
step: 41, hamming: 0.0018116109753956073
step: 42, hamming: 0.001488352605143334
step: 43, hamming: 0.001222507105209746
step: 44, hamming: 0.0010033616948213154
step: 45, hamming: 0.0008234189320553584
Running panda took: 1.28 seconds!
Elapsed time: 1.28 sec.
Saving LIONESS network 7 to lioness_output using npy format:
Elapsed time: 0.05 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: 0.6104610627797932
step: 3, hamming: 0.5874377958138726
step: 4, hamming: 0.5535034427944524
step: 5, hamming: 0.5130076219885701
step: 6, hamming: 0.4688044641107459
step: 7, hamming: 0.423176090435273
step: 8, hamming: 0.37793707228730244
step: 9, hamming: 0.3344497542143437
step: 10, hamming: 0.29366290145773
step: 11, hamming: 0.2561661870411493
step: 12, hamming: 0.22225964953219257
step: 13, hamming: 0.19202134254653253
step: 14, hamming: 0.16537035801892333
step: 15, hamming: 0.14211767839413378
step: 16, hamming: 0.12200586248374187
step: 17, hamming: 0.10473836447075487
step: 18, hamming: 0.08999993448755682
step: 19, hamming: 0.07747066783111718
step: 20, hamming: 0.06683582626078943
step: 21, hamming: 0.05779392295165678
step: 22, hamming: 0.05006528552822069
step: 23, hamming: 0.04340155522633314
step: 24, hamming: 0.037595006417562825
step: 25, hamming: 0.03248484646178138
step: 26, hamming: 0.02795721995514243
step: 27, hamming: 0.023938001058869156
step: 28, hamming: 0.020380561586156625
step: 29, hamming: 0.017252738442971302
step: 30, hamming: 0.014526640538941682
step: 31, hamming: 0.01217288260449653
step: 32, hamming: 0.010158785500792763
step: 33, hamming: 0.008449063051904343
step: 34, hamming: 0.007007538802914241
step: 35, hamming: 0.005798910108587993
step: 36, hamming: 0.004790099693035461
step: 37, hamming: 0.003951082234771278
step: 38, hamming: 0.003255253101132006
step: 39, hamming: 0.0026794641739463394
step: 40, hamming: 0.0022038487570621673
step: 41, hamming: 0.0018115310562277815
step: 42, hamming: 0.0014882867079583828
step: 43, hamming: 0.0012221964189122285
step: 44, hamming: 0.0010033169964392779
step: 45, hamming: 0.0008233821537042111

Running panda took: 1.37 seconds!

Elapsed time: 1.37 sec.

Saving LIONESS network 8 to lioness_output using npy format:

Elapsed time: 0.06 sec.

Running LIONESS for sample 9:

Computing coexpression network:

Elapsed time: 0.02 sec.

Normalizing networks:

Elapsed time: 0.05 sec.

Inferring LIONESS network:


```
step: 0, hamming: 0.6448351993831178
step: 1, hamming: 0.6064879489440816
step: 2, hamming: 0.6103640777269351
step: 3, hamming: 0.5873512050264047
step: 4, hamming: 0.5534219407870923
step: 5, hamming: 0.5129356817661761
step: 6, hamming: 0.46874212604373694
step: 7, hamming: 0.42312367964198355
step: 8, hamming: 0.37789569142567153
step: 9, hamming: 0.33441876359267736
step: 10, hamming: 0.2936404320381599
step: 11, hamming: 0.25615039464431727
step: 12, hamming: 0.2222483777256884
step: 13, hamming: 0.1920133441212464
step: 14, hamming: 0.16536460861948546
step: 15, hamming: 0.14211341395771593
step: 16, hamming: 0.12200253916357386
step: 17, hamming: 0.10473558500674482
step: 18, hamming: 0.08999750917615142
step: 19, hamming: 0.07746846011445688
step: 20, hamming: 0.0668337240386083
step: 21, hamming: 0.05779188696902117
step: 22, hamming: 0.05006331165089908
step: 23, hamming: 0.043399650735111435
step: 24, hamming: 0.03759319857032193
step: 25, hamming: 0.03248315937467175
step: 26, hamming: 0.02795567387570829
step: 27, hamming: 0.023936604678199185
step: 28, hamming: 0.02037932226923581
step: 29, hamming: 0.01725165670698856
step: 30, hamming: 0.014525707823730277
step: 31, hamming: 0.012172086330504326
step: 32, hamming: 0.010158111149147997
step: 33, hamming: 0.008448495729481618
step: 34, hamming: 0.007007063860617916
step: 35, hamming: 0.00579851383581758
step: 36, hamming: 0.004789769960958664
step: 37, hamming: 0.003950808640232261
step: 38, hamming: 0.0032550265635088458
step: 39, hamming: 0.002679276999410677
step: 40, hamming: 0.0022036943194786497
step: 41, hamming: 0.001811403763151287
step: 42, hamming: 0.0014881818789435535
step: 43, hamming: 0.0012221101496973927
step: 44, hamming: 0.0010032460442440812
step: 45, hamming: 0.0008233238300691795
Running panda took: 1.40 seconds!
Elapsed time: 1.40 sec.
Saving LIONESS network 9 to lioness_output using npy format:
Elapsed time: 0.02 sec.
Running LIONESS for sample 10:
Computing coexpression network:
Elapsed time: 0.02 sec.
Normalizing networks:
Elapsed time: 0.03 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6446385831077224
```

```
step: 1, hamming: 0.6067294163043444
step: 2, hamming: 0.6105288665126055
step: 3, hamming: 0.5875025168461764
step: 4, hamming: 0.5535668756916815
step: 5, hamming: 0.5130674611873675
step: 6, hamming: 0.46885934016141356
step: 7, hamming: 0.42322390362455425
step: 8, hamming: 0.3779784610738321
step: 9, hamming: 0.3344846104039679
step: 10, hamming: 0.2936914468258334
step: 11, hamming: 0.25618942581891635
step: 12, hamming: 0.2222783089112929
step: 13, hamming: 0.19203629520565335
step: 14, hamming: 0.1653823459684807
step: 15, hamming: 0.14212736448871935
step: 16, hamming: 0.12201379782743489
step: 17, hamming: 0.10474497350107494
step: 18, hamming: 0.09000555414562793
step: 19, hamming: 0.07747554704258397
step: 20, hamming: 0.06684008398127479
step: 21, hamming: 0.05779766899483368
step: 22, hamming: 0.05006859159088394
step: 23, hamming: 0.04340445929636734
step: 24, hamming: 0.03759753082194868
step: 25, hamming: 0.03248701536330191
step: 26, hamming: 0.027959057287518876
step: 27, hamming: 0.02393953329078775
step: 28, hamming: 0.02038182485122052
step: 29, hamming: 0.01725377205537819
step: 30, hamming: 0.01452748155142716
step: 31, hamming: 0.012173565486877314
step: 32, hamming: 0.010159339518948408
step: 33, hamming: 0.008449513032409811
step: 34, hamming: 0.0070079049394139465
step: 35, hamming: 0.005799208359310959
step: 36, hamming: 0.004790342845117792
step: 37, hamming: 0.003951280675493335
step: 38, hamming: 0.0032554152008438713
step: 39, hamming: 0.0026795966888212373
step: 40, hamming: 0.002203957150287452
step: 41, hamming: 0.0018116197541239662
step: 42, hamming: 0.0014883593143951975
step: 43, hamming: 0.0012222558625903603
step: 44, hamming: 0.0010033656704848055
step: 45, hamming: 0.0008234220134066718
```

Running panda took: 1.48 seconds!

Elapsed time: 1.48 sec.

Saving LIONESS network 10 to lioness_output using npy format:

Elapsed time: 0.02 sec.

Running LIONESS for sample 11:

Computing coexpression network:

Elapsed time: 0.02 sec.

Normalizing networks:

Elapsed time: 0.03 sec.

Inferring LIONESS network:

step: 0, hamming: 0.6445970723339552

step: 1, hamming: 0.6063968880265759

```
step: 2, hamming: 0.610362895089462
step: 3, hamming: 0.5873891776463085
step: 4, hamming: 0.5534802081887703
step: 5, hamming: 0.5130020812531749
step: 6, hamming: 0.4688120305062983
step: 7, hamming: 0.42319558082755515
step: 8, hamming: 0.377968666349301
step: 9, hamming: 0.33449062529413504
step: 10, hamming: 0.29370943003793337
step: 11, hamming: 0.25621479946024567
step: 12, hamming: 0.22230732905919456
step: 13, hamming: 0.1920663351741951
step: 14, hamming: 0.16541153798715838
step: 15, hamming: 0.1421545477565385
step: 16, hamming: 0.12203842025372977
step: 17, hamming: 0.10476672314281757
step: 18, hamming: 0.0900244111748685
step: 19, hamming: 0.07749164789418152
step: 20, hamming: 0.06685368125563591
step: 21, hamming: 0.05780905110180941
step: 22, hamming: 0.05007803092604655
step: 23, hamming: 0.04341221333469125
step: 24, hamming: 0.03760386116781324
step: 25, hamming: 0.03249215842908325
step: 26, hamming: 0.027963237690867417
step: 27, hamming: 0.023942944227938814
step: 28, hamming: 0.02038462017381501
step: 29, hamming: 0.017256076965424815
step: 30, hamming: 0.014529391608107678
step: 31, hamming: 0.01217515416538417
step: 32, hamming: 0.01016066495007358
step: 33, hamming: 0.008450619213181505
step: 34, hamming: 0.007008827032421282
step: 35, hamming: 0.0057999760866447245
step: 36, hamming: 0.004790981350177024
step: 37, hamming: 0.003951810943599431
step: 38, hamming: 0.003255854969433177
step: 39, hamming: 0.0026799609209546132
step: 40, hamming: 0.0022042584544433395
step: 41, hamming: 0.0018118687383047569
step: 42, hamming: 0.001488564864698104
step: 43, hamming: 0.0012224254093928496
step: 44, hamming: 0.001003505414610442
step: 45, hamming: 0.0008235371154278103
```

Running panda took: 1.46 seconds!

Elapsed time: 1.46 sec.

Saving LIONESS network 11 to lioness_output using npy format:

Elapsed time: 0.03 sec.

Running LIONESS for sample 12:

Computing coexpression network:

Elapsed time: 0.02 sec.

Normalizing networks:

Elapsed time: 0.03 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: 0.5132213547717154
step: 6, hamming: 0.4690101547789507
step: 7, hamming: 0.42336856484025914
step: 8, hamming: 0.37811364961234867
step: 9, hamming: 0.3346090555291644
step: 10, hamming: 0.29380462591393197
step: 11, hamming: 0.25629077493594926
step: 12, hamming: 0.2223680768718527
step: 13, hamming: 0.1921150818070645
step: 14, hamming: 0.1654509766214052
step: 15, hamming: 0.14218673742040683
step: 16, hamming: 0.12206484516686276
step: 17, hamming: 0.10478861898320703
step: 18, hamming: 0.09004269287907357
step: 19, hamming: 0.0775070250720587
step: 20, hamming: 0.06686675609772613
step: 21, hamming: 0.05782028426552099
step: 22, hamming: 0.05008776953393789
step: 23, hamming: 0.043420696376732626
step: 24, hamming: 0.037611262734358726
step: 25, hamming: 0.03249860924051235
step: 26, hamming: 0.027968830176749445
step: 27, hamming: 0.023947752343236338
step: 28, hamming: 0.020388722079863027
step: 29, hamming: 0.017259546093626295
step: 30, hamming: 0.014532302553875647
step: 31, hamming: 0.01217758101100222
step: 32, hamming: 0.010162676990644747
step: 33, hamming: 0.00845228151463363
step: 34, hamming: 0.0070101971767046085
step: 35, hamming: 0.005801103434029777
step: 36, hamming: 0.0047919078009273945
step: 37, hamming: 0.003952571735671334
step: 38, hamming: 0.0032564793806740514
step: 39, hamming: 0.0026804732113290546
step: 40, hamming: 0.00220467863067728
step: 41, hamming: 0.0018122132860573486
step: 42, hamming: 0.0014888473474811738
step: 43, hamming: 0.0012226569714781802
step: 44, hamming: 0.0010036952106255875
step: 45, hamming: 0.0008236926599718468
```

Running panda took: 1.44 seconds!

Elapsed time: 1.44 sec.

Saving LIONESS network 12 to lioness_output using npy format:

Elapsed time: 0.02 sec.

Running LIONESS for sample 13:

Computing coexpression network:

Elapsed time: 0.02 sec.

Normalizing networks:

Elapsed time: 0.05 sec.

Inferring LIONESS network:

```
step: 0, hamming: 0.6454815045482025
step: 1, hamming: 0.6064888334615245
step: 2, hamming: 0.610353785046755
step: 3, hamming: 0.5873467987983988
```

```
step: 4, hamming: 0.5534173891580667
step: 5, hamming: 0.5129251262883208
step: 6, hamming: 0.4687264900712108
step: 7, hamming: 0.4231036921678549
step: 8, hamming: 0.37787210728432713
step: 9, hamming: 0.3343925087997385
step: 10, hamming: 0.2936124890554121
step: 11, hamming: 0.2561217809997432
step: 12, hamming: 0.22222032595119312
step: 13, hamming: 0.19198634671852602
step: 14, hamming: 0.16533917584848354
step: 15, hamming: 0.14208990495011609
step: 16, hamming: 0.12198119524882962
step: 17, hamming: 0.10471648707194936
step: 18, hamming: 0.08998053903852753
step: 19, hamming: 0.07745350260977645
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: 0.023932149875743877
step: 28, hamming: 0.020375560744930254
step: 29, hamming: 0.01724848885084861
step: 30, hamming: 0.014523048953008225
step: 31, hamming: 0.012169862212797655
step: 32, hamming: 0.010156256059334054
step: 33, hamming: 0.008446951777683006
step: 34, hamming: 0.007005781213394501
step: 35, hamming: 0.0057974502702537525
step: 36, hamming: 0.004788889434590357
step: 37, hamming: 0.00395008054412097
step: 38, hamming: 0.003254425165595956
step: 39, hamming: 0.0026787806466122715
step: 40, hamming: 0.0022032850078452723
step: 41, hamming: 0.0018110664850589518
step: 42, hamming: 0.0014879041422859187
step: 43, hamming: 0.0012218815774630238
step: 44, hamming: 0.0010030580312243072
step: 45, hamming: 0.0008231692507589999
```

Running panda took: 1.63 seconds!

Elapsed time: 1.63 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: 0.02 sec.

Normalizing networks:

Elapsed time: 0.04 sec.

Inferring LIONESS network:

```
step: 0, hamming: 0.6443394902350985
step: 1, hamming: 0.6066808238313083
step: 2, hamming: 0.610500062853496
step: 3, hamming: 0.5874753808094995
step: 4, hamming: 0.5535342710047162
```

```
step: 5, hamming: 0.5130322757657333
step: 6, hamming: 0.46882485488303
step: 7, hamming: 0.42319334974995554
step: 8, hamming: 0.37795210281175695
step: 9, hamming: 0.3344633679474344
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: 0.1220119905197326
step: 17, hamming: 0.10474380875818415
step: 18, hamming: 0.0900048204529394
step: 19, hamming: 0.07747506491160117
step: 20, hamming: 0.06683975370409437
step: 21, hamming: 0.05779742984599143
step: 22, hamming: 0.050068421477429015
step: 23, hamming: 0.04340433264758675
step: 24, hamming: 0.03759742735740401
step: 25, hamming: 0.03248692677678964
step: 26, hamming: 0.0279589832412535
step: 27, hamming: 0.023939475652045558
step: 28, hamming: 0.020381784048555823
step: 29, hamming: 0.017253746643295972
step: 30, hamming: 0.01452746881029944
step: 31, hamming: 0.012173562253857687
step: 32, hamming: 0.010159342835363386
step: 33, hamming: 0.008449520673285471
step: 34, hamming: 0.0070079141991438425
step: 35, hamming: 0.00579921781960979
step: 36, hamming: 0.004790352300931194
step: 37, hamming: 0.003951289630160982
step: 38, hamming: 0.003255423348636021
step: 39, hamming: 0.0026796039355505563
step: 40, hamming: 0.002203963484083054
step: 41, hamming: 0.0018116252199462351
step: 42, hamming: 0.0014883639807463862
step: 43, hamming: 0.001222598171972375
step: 44, hamming: 0.0010033690024990156
step: 45, hamming: 0.0008234248099945843
Running panda took: 1.51 seconds!
Elapsed time: 1.51 sec.
Saving LIONESS network 14 to lioness_output using npy format:
Elapsed time: 0.02 sec.
Running LIONESS for sample 15:
Computing coexpression network:
Elapsed time: 0.02 sec.
Normalizing networks:
Elapsed time: 0.06 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6442838140322693
step: 1, hamming: 0.6065432591877655
step: 2, hamming: 0.6104256202756483
step: 3, hamming: 0.587423936441978
step: 4, hamming: 0.553504385366511
step: 5, hamming: 0.513017729482651
```

```
step: 6, hamming: 0.46881952598171256
step: 7, hamming: 0.42319353876507343
step: 8, hamming: 0.3779564465155286
step: 9, hamming: 0.3344697612732674
step: 10, hamming: 0.29368304260522193
step: 11, hamming: 0.256185917293156
step: 12, hamming: 0.2222781858231914
step: 13, hamming: 0.19203847272328894
step: 14, hamming: 0.16538591145842108
step: 15, hamming: 0.14213154151205495
step: 16, hamming: 0.12201804684367129
step: 17, hamming: 0.1047489180035845
step: 18, hamming: 0.09000896576805427
step: 19, hamming: 0.07747832725281115
step: 20, hamming: 0.06684227158737589
step: 21, hamming: 0.05779932753307891
step: 22, hamming: 0.05006981276657544
step: 23, hamming: 0.0434053519354664
step: 24, hamming: 0.037598189054180546
step: 25, hamming: 0.032487520650437404
step: 26, hamming: 0.027959467696440886
step: 27, hamming: 0.02393988620692473
step: 28, hamming: 0.020382138917549576
step: 29, hamming: 0.017254056868073374
step: 30, hamming: 0.014527740108929025
step: 31, hamming: 0.012173798233668112
step: 32, hamming: 0.010159546268615193
step: 33, hamming: 0.008449694062619568
step: 34, hamming: 0.007008060926552585
step: 35, hamming: 0.005799341301245978
step: 36, hamming: 0.004790455394888105
step: 37, hamming: 0.00395137536393676
step: 38, hamming: 0.0032554944712860395
step: 39, hamming: 0.0026796628068911574
step: 40, hamming: 0.002204012129634986
step: 41, hamming: 0.0018116653686568124
step: 42, hamming: 0.0014883970876660615
step: 43, hamming: 0.001222870952029131
step: 44, hamming: 0.0010033914641085341
step: 45, hamming: 0.0008234432936021232
```

Running panda took: 1.87 seconds!

Elapsed time: 1.87 sec.

Saving LIONESS network 15 to lioness_output using npy format:

Elapsed time: 0.03 sec.

Running LIONESS for sample 16:

Computing coexpression network:

Elapsed time: 0.02 sec.

Normalizing networks:

Elapsed time: 0.04 sec.

Inferring LIONESS network:

```
step: 0, hamming: 0.6451357933509941
step: 1, hamming: 0.6066460429428087
step: 2, hamming: 0.6104672809769208
step: 3, hamming: 0.5874429022191956
step: 4, hamming: 0.5535053796996751
step: 5, hamming: 0.5130102568327171
step: 6, hamming: 0.4688078805102339
```

```
step: 7, hamming: 0.4231820754210904
step: 8, hamming: 0.37794630825110404
step: 9, hamming: 0.3344617217511006
step: 10, hamming: 0.29367695762019436
step: 11, hamming: 0.2561810037908881
step: 12, hamming: 0.22227406388621243
step: 13, hamming: 0.19203490092286687
step: 14, hamming: 0.16538281310135527
step: 15, hamming: 0.14212890528332245
step: 16, hamming: 0.12201583114277065
step: 17, hamming: 0.10474707223510565
step: 18, hamming: 0.09000753562825538
step: 19, hamming: 0.07747728987948438
step: 20, hamming: 0.0668415436219817
step: 21, hamming: 0.05779884394184241
step: 22, hamming: 0.05006952159265663
step: 23, hamming: 0.04340519640748409
step: 24, hamming: 0.03759811012297122
step: 25, hamming: 0.03248747270773837
step: 26, hamming: 0.027959425880675678
step: 27, hamming: 0.023939839110948585
step: 28, hamming: 0.020382085146816525
step: 29, hamming: 0.01725399643445798
step: 30, hamming: 0.014527676899527598
step: 31, hamming: 0.01217373502349932
step: 32, hamming: 0.010159486018898028
step: 33, hamming: 0.00844963874092018
step: 34, hamming: 0.007008011615450409
step: 35, hamming: 0.0057992982643482755
step: 36, hamming: 0.004790418528106762
step: 37, hamming: 0.003951344147935315
step: 38, hamming: 0.003255468222274782
step: 39, hamming: 0.0026796408398129684
step: 40, hamming: 0.002203993820812893
step: 41, hamming: 0.0018116502262686585
step: 42, hamming: 0.001488384584632186
step: 43, hamming: 0.0012222767839663953
step: 44, hamming: 0.0010033829666874518
step: 45, hamming: 0.000823436296690418
Running panda took: 1.47 seconds!
Elapsed time: 1.47 sec.
Saving LIONESS network 16 to lioness_output using npy format:
Elapsed time: 0.02 sec.
Running LIONESS for sample 17:
Computing coexpression network:
Elapsed time: 0.02 sec.
Normalizing networks:
Elapsed time: 0.03 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6453372188039735
step: 1, hamming: 0.6066676287287168
step: 2, hamming: 0.6104644764183814
step: 3, hamming: 0.5874393760760523
step: 4, hamming: 0.553506577030067
step: 5, hamming: 0.513009831711223
step: 6, hamming: 0.46880493446531923
step: 7, hamming: 0.42317541168503875
```



```
step: 8, hamming: 0.3779353604570779
step: 9, hamming: 0.3344472571824323
step: 10, hamming: 0.2936601064819789
step: 11, hamming: 0.2561633601925414
step: 12, hamming: 0.2222568377191461
step: 13, hamming: 0.19201879569174002
step: 14, hamming: 0.16536830973066033
step: 15, hamming: 0.14211622482773686
step: 16, hamming: 0.1220048801756969
step: 17, hamming: 0.10473769975276605
step: 18, hamming: 0.08999949865507745
step: 19, hamming: 0.07747042421728799
step: 20, hamming: 0.06683571528299426
step: 21, hamming: 0.057793931389394995
step: 22, hamming: 0.0500654130944078
step: 23, hamming: 0.043401792301824775
step: 24, hamming: 0.037595325807174514
step: 25, hamming: 0.032485225085799395
step: 26, hamming: 0.027957631020622514
step: 27, hamming: 0.023938413555977034
step: 28, hamming: 0.020380954334854536
step: 29, hamming: 0.017253098946343814
step: 30, hamming: 0.01452696113853556
step: 31, hamming: 0.0121731618457686
step: 32, hamming: 0.010159024956166727
step: 33, hamming: 0.008449266035746398
step: 34, hamming: 0.00700770946888819
step: 35, hamming: 0.005799052725515067
step: 36, hamming: 0.004790218419084312
step: 37, hamming: 0.0039511807920843516
step: 38, hamming: 0.0032553347191006422
step: 39, hamming: 0.0026795316594392425
step: 40, hamming: 0.002203904483139546
step: 41, hamming: 0.0018115770171323303
step: 42, hamming: 0.0014883245770206238
step: 43, hamming: 0.001222275926846026
step: 44, hamming: 0.0010033426427683537
step: 45, hamming: 0.0008234032422371877
Running panda took: 1.44 seconds!
Elapsed time: 1.44 sec.
Saving LIONESS network 17 to lioness_output using npy format:
Elapsed time: 0.02 sec.
Running LIONESS for sample 18:
Computing coexpression network:
Elapsed time: 0.03 sec.
Normalizing networks:
Elapsed time: 0.03 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6449357768289141
step: 1, hamming: 0.6067478759109104
step: 2, hamming: 0.6105187387290015
step: 3, hamming: 0.5874835466275927
step: 4, hamming: 0.5535417550864121
step: 5, hamming: 0.5130402196441705
step: 6, hamming: 0.4688318533055642
step: 7, hamming: 0.4231991954317866
step: 8, hamming: 0.3779561923867192
```

```
step: 9, hamming: 0.3344661242851883
step: 10, hamming: 0.2936772734231136
step: 11, hamming: 0.2561788722687788
step: 12, hamming: 0.22227085717962167
step: 13, hamming: 0.19203122760644709
step: 14, hamming: 0.1653790756966992
step: 15, hamming: 0.1421253806373162
step: 16, hamming: 0.12201265787241682
step: 17, hamming: 0.10474431714590451
step: 18, hamming: 0.09000515595301478
step: 19, hamming: 0.07747531799818602
step: 20, hamming: 0.06683996904018245
step: 21, hamming: 0.05779759760298822
step: 22, hamming: 0.05006852906896944
step: 23, hamming: 0.04340439208110958
step: 24, hamming: 0.03759745306277047
step: 25, hamming: 0.032486925619651025
step: 26, hamming: 0.02795896080983829
step: 27, hamming: 0.023939439452491516
step: 28, hamming: 0.020381738530574928
step: 29, hamming: 0.017253695360279313
step: 30, hamming: 0.014527415793591236
step: 31, hamming: 0.012173510704249178
step: 32, hamming: 0.010159294487304502
step: 33, hamming: 0.008449476113258234
step: 34, hamming: 0.007007874287828733
step: 35, hamming: 0.005799182820196558
step: 36, hamming: 0.004790321840049439
step: 37, hamming: 0.003951263491362449
step: 38, hamming: 0.0032554011485745617
step: 39, hamming: 0.0026795851877981086
step: 40, hamming: 0.0022039477307740163
step: 41, hamming: 0.0018116120424978204
step: 42, hamming: 0.0014883529993387446
step: 43, hamming: 0.001222250689760564
step: 44, hamming: 0.00100336143314437
step: 45, hamming: 0.0008234185581224598
Running panda took: 1.39 seconds!
  Elapsed time: 1.39 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: 0.02 sec.
Normalizing networks:
  Elapsed time: 0.03 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6455081786434624
step: 1, hamming: 0.6064194187335534
step: 2, hamming: 0.6103607543150151
step: 3, hamming: 0.5873862777167242
step: 4, hamming: 0.553480413292402
step: 5, hamming: 0.5130026093014715
step: 6, hamming: 0.4688113588544863
step: 7, hamming: 0.4231895358092202
step: 8, hamming: 0.3779544175944803
step: 9, hamming: 0.334468551809112
```

```
step: 10, hamming: 0.29368214409431076
step: 11, hamming: 0.2561851448411255
step: 12, hamming: 0.22227745758160627
step: 13, hamming: 0.19203763284596798
step: 14, hamming: 0.16538496739496927
step: 15, hamming: 0.14213058508151208
step: 16, hamming: 0.12201710874059979
step: 17, hamming: 0.10474810732061204
step: 18, hamming: 0.0900083402499391
step: 19, hamming: 0.0774778918911271
step: 20, hamming: 0.06684199669576119
step: 21, hamming: 0.05779919229936601
step: 22, hamming: 0.05006980214737102
step: 23, hamming: 0.043405433551497834
step: 24, hamming: 0.03759834459496707
step: 25, hamming: 0.03248771827770938
step: 26, hamming: 0.027959694807564463
step: 27, hamming: 0.02394012862051738
step: 28, hamming: 0.02038238580092493
step: 29, hamming: 0.017254298712404578
step: 30, hamming: 0.014527969806710518
step: 31, hamming: 0.012174010998701936
step: 32, hamming: 0.010159739559041087
step: 33, hamming: 0.008449866915345706
step: 34, hamming: 0.007008213042126161
step: 35, hamming: 0.005799473355581618
step: 36, hamming: 0.004790568744366452
step: 37, hamming: 0.003951471883857407
step: 38, hamming: 0.0032555761831291967
step: 39, hamming: 0.0026797315837817073
step: 40, hamming: 0.0022040697609956353
step: 41, hamming: 0.0018117134754357936
step: 42, hamming: 0.001488437118285034
step: 43, hamming: 0.001222320323319217
step: 44, hamming: 0.001003418986989929
step: 45, hamming: 0.0008234660519401803
```

Running panda took: 1.68 seconds!

Elapsed time: 1.68 sec.

Saving LIONESS network 19 to lioness_output using npy format:

Elapsed time: 0.02 sec.

Running LIONESS for sample 20:

Computing coexpression network:

Elapsed time: 0.02 sec.

Normalizing networks:

Elapsed time: 0.03 sec.

Inferring LIONESS network:

```
step: 0, hamming: 0.6439395298412646
step: 1, hamming: 0.6064446364151149
step: 2, hamming: 0.6103874530759167
step: 3, hamming: 0.587378224328637
step: 4, hamming: 0.5534408069230905
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: 0.2561617693952472
step: 12, hamming: 0.2222599888792307
step: 13, hamming: 0.19202452498598022
step: 14, hamming: 0.16537501759571194
step: 15, hamming: 0.14212288137746554
step: 16, hamming: 0.1220110190534544
step: 17, hamming: 0.10474308059192004
step: 18, hamming: 0.09000401407761763
step: 19, hamming: 0.0774741244284439
step: 20, hamming: 0.06683863595804257
step: 21, hamming: 0.057796138871261137
step: 22, hamming: 0.05006700914121158
step: 23, hamming: 0.04340287535360048
step: 24, hamming: 0.03759601882243467
step: 25, hamming: 0.032485634181046795
step: 26, hamming: 0.027957849133881683
step: 27, hamming: 0.023938508535798857
step: 28, hamming: 0.020380978291102247
step: 29, hamming: 0.01725308408299542
step: 30, hamming: 0.014526928573715066
step: 31, hamming: 0.01217312410619027
step: 32, hamming: 0.01015898896686592
step: 33, hamming: 0.008449235814467613
step: 34, hamming: 0.007007685785454703
step: 35, hamming: 0.00579903522329828
step: 36, hamming: 0.004790206180267455
step: 37, hamming: 0.003951172904489711
step: 38, hamming: 0.0032553302873377606
step: 39, hamming: 0.0026795297588183783
step: 40, hamming: 0.002203904360801872
step: 41, hamming: 0.0018115780790296146
step: 42, hamming: 0.0014883263714357698
step: 43, hamming: 0.0012222297878657692
step: 44, hamming: 0.0010033450031440966
step: 45, hamming: 0.0008234056073751168
```

Running panda took: 1.44 seconds!

Elapsed time: 1.44 sec.

Saving LIONESS network 20 to lioness_output using npy format:

Elapsed time: 0.02 sec.

Running LIONESS for sample 21:

Computing coexpression network:

Elapsed time: 0.01 sec.

Normalizing networks:

Elapsed time: 0.05 sec.

Inferring LIONESS network:

```
step: 0, hamming: 0.6450848367279335
step: 1, hamming: 0.6066233811194319
step: 2, hamming: 0.6104738378033745
step: 3, hamming: 0.5874590505004481
step: 4, hamming: 0.5535293117119651
step: 5, hamming: 0.5130347272475934
step: 6, hamming: 0.4688311364101987
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: 0.2222745986871024
step: 13, hamming: 0.19203454863632288
step: 14, hamming: 0.16538197139376912
step: 15, hamming: 0.14212785490634228
step: 16, hamming: 0.12201474746203655
step: 17, hamming: 0.10474604616613903
step: 18, hamming: 0.09000658579037368
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: 0.027959118987273036
step: 27, hamming: 0.02393956316965707
step: 28, hamming: 0.020381838360275333
step: 29, hamming: 0.01725377713847119
step: 30, hamming: 0.014527483895349053
step: 31, hamming: 0.012173567305814021
step: 32, hamming: 0.010159341931297581
step: 33, hamming: 0.008449516089574678
step: 34, hamming: 0.007007908113106247
step: 35, hamming: 0.005799211545052685
step: 36, hamming: 0.004790346079477176
step: 37, hamming: 0.0039512838325598924
step: 38, hamming: 0.0032554181896431323
step: 39, hamming: 0.0026795994570336656
step: 40, hamming: 0.002203959671213237
step: 41, hamming: 0.0018116220164900933
step: 42, hamming: 0.0014883613416886985
step: 43, hamming: 0.0012222576717636868
step: 44, hamming: 0.0010033672638236294
step: 45, hamming: 0.0008234234034135413
```

Running panda took: 1.49 seconds!

Elapsed time: 1.50 sec.

Saving LIONESS network 21 to lioness_output using npy format:

Elapsed time: 0.02 sec.

Running LIONESS for sample 22:

Computing coexpression network:

Elapsed time: 0.04 sec.

Normalizing networks:

Elapsed time: 0.03 sec.

Inferring LIONESS network:

```
step: 0, hamming: 0.6453859638093248
step: 1, hamming: 0.6066965790988161
step: 2, hamming: 0.610491835290849
step: 3, hamming: 0.5874671302827961
step: 4, hamming: 0.5535319083441806
step: 5, hamming: 0.5130343438245889
step: 6, hamming: 0.46883010704011946
step: 7, hamming: 0.42319927931184576
step: 8, hamming: 0.377958105463949
step: 9, hamming: 0.3344683776483375
step: 10, hamming: 0.2936795511371286
step: 11, hamming: 0.2561812888003239
step: 12, hamming: 0.22227300354666066
```

```
step: 13, hamming: 0.19203305839021254
step: 14, hamming: 0.1653805885957311
step: 15, hamming: 0.14212657310449728
step: 16, hamming: 0.12201356805469017
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: 0.05006839068356394
step: 23, hamming: 0.0434042189139166
step: 24, hamming: 0.037597278056102544
step: 25, hamming: 0.032486767572642544
step: 26, hamming: 0.02795883192482231
step: 27, hamming: 0.023939341310999906
step: 28, hamming: 0.0203816693839802
step: 29, hamming: 0.017253650955294648
step: 30, hamming: 0.014527390237321747
step: 31, hamming: 0.01217349800996446
step: 32, hamming: 0.01015929016531572
step: 33, hamming: 0.008449476812725697
step: 34, hamming: 0.007007877819352467
step: 35, hamming: 0.005799187804456239
step: 36, hamming: 0.004790327214202527
step: 37, hamming: 0.0039512686521922325
step: 38, hamming: 0.003255405875696191
step: 39, hamming: 0.002679589392770105
step: 40, hamming: 0.002203951397817051
step: 41, hamming: 0.0018116151924508805
step: 42, hamming: 0.001488355679500168
step: 43, hamming: 0.00122252954038418
step: 44, hamming: 0.0010033633357891538
step: 45, hamming: 0.0008234201342693884
Running panda took: 1.60 seconds!
Elapsed time: 1.60 sec.
Saving LIONESS network 22 to lioness_output using npy format:
Elapsed time: 0.02 sec.
Running LIONESS for sample 23:
Computing coexpression network:
Elapsed time: 0.02 sec.
Normalizing networks:
Elapsed time: 0.05 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6435616555805806
step: 1, hamming: 0.6065774661127371
step: 2, hamming: 0.610468595413635
step: 3, hamming: 0.5874707578579492
step: 4, hamming: 0.5535538083324445
step: 5, hamming: 0.5130651148399519
step: 6, hamming: 0.4688591784891974
step: 7, hamming: 0.4232231791435239
step: 8, hamming: 0.37797491630976726
step: 9, hamming: 0.33447914071665064
step: 10, hamming: 0.29368549481398054
step: 11, hamming: 0.2561836385957451
step: 12, hamming: 0.22227301663758198
step: 13, hamming: 0.19203158876314616
```

```
step: 14, hamming: 0.16537816530669008
step: 15, hamming: 0.14212379235777955
step: 16, hamming: 0.12201066274790016
step: 17, hamming: 0.10474203578042608
step: 18, hamming: 0.09000269743578625
step: 19, hamming: 0.07747275376080467
step: 20, hamming: 0.06683734743392257
step: 21, hamming: 0.0577950210516337
step: 22, hamming: 0.05006608553256088
step: 23, hamming: 0.04340213107403853
step: 24, hamming: 0.03759541702968891
step: 25, hamming: 0.03248513867836511
step: 26, hamming: 0.02795742639550285
step: 27, hamming: 0.023938141602490862
step: 28, hamming: 0.020380652363289783
step: 29, hamming: 0.017252792040855003
step: 30, hamming: 0.014526666851716616
step: 31, hamming: 0.01217289023901222
step: 32, hamming: 0.010158780660191595
step: 33, hamming: 0.00844905057468564
step: 34, hamming: 0.007007521946824564
step: 35, hamming: 0.0057988910697919045
step: 36, hamming: 0.0047900800900266445
step: 37, hamming: 0.00395106318079814
step: 38, hamming: 0.003255235281823731
step: 39, hamming: 0.002679448012328946
step: 40, hamming: 0.0022038343696844176
step: 41, hamming: 0.0018115184280166996
step: 42, hamming: 0.001488275744870974
step: 43, hamming: 0.0012221869810817728
step: 44, hamming: 0.0010033089289654207
step: 45, hamming: 0.0008233752989717561
```

Running panda took: 1.69 seconds!

Elapsed time: 1.69 sec.

Saving LIONESS network 23 to lioness_output using npy format:

Elapsed time: 0.04 sec.

Running LIONESS for sample 24:

Computing coexpression network:

Elapsed time: 0.02 sec.

Normalizing networks:

Elapsed time: 0.05 sec.

Inferring LIONESS network:

```
step: 0, hamming: 0.6451374874258013
step: 1, hamming: 0.6065597248100142
step: 2, hamming: 0.6104785268315843
step: 3, hamming: 0.5874892432769232
step: 4, hamming: 0.553567791572826
step: 5, hamming: 0.5130739316093188
step: 6, hamming: 0.46886944915852663
step: 7, hamming: 0.42323727854509435
step: 8, hamming: 0.3779939472775404
step: 9, hamming: 0.3345015214724543
step: 10, hamming: 0.2937094193739473
step: 11, hamming: 0.2562077730351674
step: 12, hamming: 0.22229629530279874
step: 13, hamming: 0.1920534367947331
step: 14, hamming: 0.1653983848286492
```

```
step: 15, hamming: 0.14214207545812796
step: 16, hamming: 0.1220271673144806
step: 17, hamming: 0.10475689437070312
step: 18, hamming: 0.09001608575237811
step: 19, hamming: 0.0774847471094978
step: 20, hamming: 0.06684806346197888
step: 21, hamming: 0.05780455531349575
step: 22, hamming: 0.05007450535329472
step: 23, hamming: 0.043409517421342025
step: 24, hamming: 0.03760185201290928
step: 25, hamming: 0.032490701336341195
step: 26, hamming: 0.027962198197821787
step: 27, hamming: 0.023942208045912385
step: 28, hamming: 0.020384097306212396
step: 29, hamming: 0.017255699648224446
step: 30, hamming: 0.014529113182227082
step: 31, hamming: 0.01217494163127554
step: 32, hamming: 0.010160495993560507
step: 33, hamming: 0.00845048121903037
step: 34, hamming: 0.007008712784988987
step: 35, hamming: 0.005799880479159791
step: 36, hamming: 0.0047909007626825515
step: 37, hamming: 0.003951742881773004
step: 38, hamming: 0.003255797494304968
step: 39, hamming: 0.002679912466988639
step: 40, hamming: 0.0022042177025821627
step: 41, hamming: 0.0018118345457225505
step: 42, hamming: 0.001488536241043407
step: 43, hamming: 0.0012224015057432389
step: 44, hamming: 0.0010034854919391913
step: 45, hamming: 0.0008235205432486311
```

Running panda took: 1.63 seconds!

Elapsed time: 1.63 sec.

Saving LIONESS network 24 to lioness_output using npy format:

Elapsed time: 0.03 sec.

Running LIONESS for sample 25:

Computing coexpression network:

Elapsed time: 0.02 sec.

Normalizing networks:

Elapsed time: 0.05 sec.

Inferring LIONESS network:

```
step: 0, hamming: 0.6457395627686134
step: 1, hamming: 0.6064608877070141
step: 2, hamming: 0.6103727825941946
step: 3, hamming: 0.5873823343108445
step: 4, hamming: 0.5534684140947953
step: 5, hamming: 0.5129868713457605
step: 6, hamming: 0.4687928920384118
step: 7, hamming: 0.42317106468860927
step: 8, hamming: 0.37793701543032326
step: 9, hamming: 0.33445323750400024
step: 10, hamming: 0.2936686849697661
step: 11, hamming: 0.2561730726924933
step: 12, hamming: 0.22226674885043102
step: 13, hamming: 0.19202822641393982
step: 14, hamming: 0.16537671830260126
step: 15, hamming: 0.14212334810171473
```



```
step: 16, hamming: 0.1220107685282419
step: 17, hamming: 0.10474248793357539
step: 18, hamming: 0.0900033014058808
step: 19, hamming: 0.07747333480760729
step: 20, hamming: 0.06683787049330008
step: 21, hamming: 0.057795449353665554
step: 22, hamming: 0.05006637373531308
step: 23, hamming: 0.04340227376591354
step: 24, hamming: 0.037595421359931186
step: 25, hamming: 0.03248502656477799
step: 26, hamming: 0.027957229203086794
step: 27, hamming: 0.023937892823722058
step: 28, hamming: 0.02038038336070406
step: 29, hamming: 0.017252529167439003
step: 30, hamming: 0.014526424760499897
step: 31, hamming: 0.012172676375081907
step: 32, hamming: 0.010158597046433316
step: 33, hamming: 0.00844889606081156
step: 34, hamming: 0.007007393568975931
step: 35, hamming: 0.005798785453088683
step: 36, hamming: 0.00478999387390706
step: 37, hamming: 0.003950993159323441
step: 38, hamming: 0.0032551785601338114
step: 39, hamming: 0.0026794020858112943
step: 40, hamming: 0.0022037972259520604
step: 41, hamming: 0.001811488397401411
step: 42, hamming: 0.0014882514628416364
step: 43, hamming: 0.0012221673419373596
step: 44, hamming: 0.0010032930382546355
step: 45, hamming: 0.0008233624337668082
Running panda took: 1.46 seconds!
Elapsed time: 1.46 sec.
Saving LIONESS network 25 to lioness_output using npy format:
Elapsed time: 0.02 sec.
Running LIONESS for sample 26:
Computing coexpression network:
Elapsed time: 0.02 sec.
Normalizing networks:
Elapsed time: 0.03 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6454967053255309
step: 1, hamming: 0.6066220697004651
step: 2, hamming: 0.6104569962998728
step: 3, hamming: 0.5874394872323973
step: 4, hamming: 0.5535107400339879
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: 0.22226007042599116
step: 13, hamming: 0.19202153205178443
step: 14, hamming: 0.16537042896642054
step: 15, hamming: 0.14211769909143143
step: 16, hamming: 0.12200588715609277
```

```
step: 17, hamming: 0.10473835923993632
step: 18, hamming: 0.08999989292935066
step: 19, hamming: 0.07747064160809622
step: 20, hamming: 0.0668358086697313
step: 21, hamming: 0.05779392045356974
step: 22, hamming: 0.0500653033441485
step: 23, hamming: 0.04340157748923955
step: 24, hamming: 0.03759501485574575
step: 25, hamming: 0.032484830736557
step: 26, hamming: 0.02795717839135787
step: 27, hamming: 0.023937933402786545
step: 28, hamming: 0.020380473632123763
step: 29, hamming: 0.017252638944378788
step: 30, hamming: 0.014526536911014595
step: 31, hamming: 0.012172781802429688
step: 32, hamming: 0.010158691621547707
step: 33, hamming: 0.008448978359003058
step: 34, hamming: 0.007007463803651777
step: 35, hamming: 0.005798844650285859
step: 36, hamming: 0.004790043434414072
step: 37, hamming: 0.003951034364586719
step: 38, hamming: 0.0032552126647618614
step: 39, hamming: 0.0026794302159438544
step: 40, hamming: 0.002203820368039428
step: 41, hamming: 0.0018115074140994402
step: 42, hamming: 0.0014882670710365021
step: 43, hamming: 0.001222180142905843
step: 44, hamming: 0.0010033035277769954
step: 45, hamming: 0.0008233710253226156
```

Running panda took: 1.31 seconds!

Elapsed time: 1.31 sec.

Saving LIONESS network 26 to lioness_output using npy format:

Elapsed time: 0.02 sec.

Running LIONESS for sample 27:

Computing coexpression network:

Elapsed time: 0.02 sec.

Normalizing networks:

Elapsed time: 0.04 sec.

Inferring LIONESS network:

```
step: 0, hamming: 0.6453631316746891
step: 1, hamming: 0.6065851763245883
step: 2, hamming: 0.6104687108084997
step: 3, hamming: 0.5874708414567839
step: 4, hamming: 0.553550407750318
step: 5, hamming: 0.5130590911886108
step: 6, hamming: 0.46885507018779043
step: 7, hamming: 0.42322248970490667
step: 8, hamming: 0.3779776691218549
step: 9, hamming: 0.3344846767623718
step: 10, hamming: 0.2936929239245133
step: 11, hamming: 0.25619229570609636
step: 12, hamming: 0.22228219573712402
step: 13, hamming: 0.19204076380694882
step: 14, hamming: 0.16538705195619063
step: 15, hamming: 0.1421320864636762
step: 16, hamming: 0.12201829280274731
step: 17, hamming: 0.10474902300437654
```

```
step: 18, hamming: 0.09000903326934918
step: 19, hamming: 0.07747844392157899
step: 20, hamming: 0.06684245770007373
step: 21, hamming: 0.05779957445832755
step: 22, hamming: 0.05007009118596108
step: 23, hamming: 0.04340563042618257
step: 24, hamming: 0.03759844243481214
step: 25, hamming: 0.032487722556562154
step: 26, hamming: 0.027959603794912816
step: 27, hamming: 0.023939953980151817
step: 28, hamming: 0.020382151479531888
step: 29, hamming: 0.017254024423504023
step: 30, hamming: 0.01452767604514493
step: 31, hamming: 0.012173715629341518
step: 32, hamming: 0.010159456372537531
step: 33, hamming: 0.008449604489718605
step: 34, hamming: 0.007007976542379953
step: 35, hamming: 0.005799264728544192
step: 36, hamming: 0.004790387758916941
step: 37, hamming: 0.003951316728991019
step: 38, hamming: 0.003255444306355403
step: 39, hamming: 0.0026796202983168293
step: 40, hamming: 0.002203976375195701
step: 41, hamming: 0.0018116354595427964
step: 42, hamming: 0.0014883721681424754
step: 43, hamming: 0.001222663986386547
step: 44, hamming: 0.0010033743151023403
step: 45, hamming: 0.0008234291107443008
```

Running panda took: 1.40 seconds!

Elapsed time: 1.40 sec.

Saving LIONESS network 27 to lioness_output using npy format:

Elapsed time: 0.06 sec.

Running LIONESS for sample 28:

Computing coexpression network:

Elapsed time: 0.02 sec.

Normalizing networks:

Elapsed time: 0.05 sec.

Inferring LIONESS network:

```
step: 0, hamming: 0.6451358310824151
step: 1, hamming: 0.6067202812268652
step: 2, hamming: 0.6105084509106121
step: 3, hamming: 0.5874770766110782
step: 4, hamming: 0.5535401297746914
step: 5, hamming: 0.5130406798275531
step: 6, hamming: 0.468834505899187
step: 7, hamming: 0.42320295085821286
step: 8, hamming: 0.37796147500536265
step: 9, hamming: 0.33447178250965853
step: 10, hamming: 0.29368269158902255
step: 11, hamming: 0.2561841423380478
step: 12, hamming: 0.22227561563567477
step: 13, hamming: 0.19203539669004427
step: 14, hamming: 0.16538265059792898
step: 15, hamming: 0.14212839414046055
step: 16, hamming: 0.12201518520640055
step: 17, hamming: 0.10474641185408667
step: 18, hamming: 0.0900068778671942
```

```
step: 19, hamming: 0.07747669705672466
step: 20, hamming: 0.06684104136237137
step: 21, hamming: 0.05779843506391113
step: 22, hamming: 0.0500691794290296
step: 23, hamming: 0.04340488739282701
step: 24, hamming: 0.03759781991517671
step: 25, hamming: 0.032487194607542826
step: 26, hamming: 0.027959154377771425
step: 27, hamming: 0.02393957466123415
step: 28, hamming: 0.02038183196273885
step: 29, hamming: 0.0172537603782067
step: 30, hamming: 0.014527461133636087
step: 31, hamming: 0.012173542661750416
step: 32, hamming: 0.010159317402521097
step: 33, hamming: 0.008449492965825199
step: 34, hamming: 0.0070078870284569885
step: 35, hamming: 0.005799192688495383
step: 36, hamming: 0.004790329522725734
step: 37, hamming: 0.003951269494190278
step: 38, hamming: 0.0032554058740101068
step: 39, hamming: 0.002679588945293777
step: 40, hamming: 0.002203950746453343
step: 41, hamming: 0.0018116144780692205
step: 42, hamming: 0.0014883549740263417
step: 43, hamming: 0.001222522977348154
step: 44, hamming: 0.0010033627438220327
step: 45, hamming: 0.0008234196121337722
```

Running panda took: 1.47 seconds!

Elapsed time: 1.47 sec.

Saving LIONESS network 28 to lioness_output using npy format:

Elapsed time: 0.02 sec.

Running LIONESS for sample 29:

Computing coexpression network:

Elapsed time: 0.02 sec.

Normalizing networks:

Elapsed time: 0.03 sec.

Inferring LIONESS network:

```
step: 0, hamming: 0.6455351008769453
step: 1, hamming: 0.606672749921852
step: 2, hamming: 0.6104835041920981
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: 0.3344579933187368
step: 10, hamming: 0.29366902135579265
step: 11, hamming: 0.25617054999127764
step: 12, hamming: 0.22226262032373947
step: 13, hamming: 0.19202326345396323
step: 14, hamming: 0.16537148632869755
step: 15, hamming: 0.142118264201008
step: 16, hamming: 0.12200609786553838
step: 17, hamming: 0.10473832871874272
step: 18, hamming: 0.08999971271249907
step: 19, hamming: 0.07747039064766185
```

```
step: 20, hamming: 0.06683555388538215
step: 21, hamming: 0.057793686110969834
step: 22, hamming: 0.05006509427037561
step: 23, hamming: 0.0434014084405363
step: 24, hamming: 0.03759489383654498
step: 25, hamming: 0.03248476025786066
step: 26, hamming: 0.027957153083011842
step: 27, hamming: 0.02393794536063863
step: 28, hamming: 0.020380515556205
step: 29, hamming: 0.017252700679045323
step: 30, hamming: 0.014526608601153243
step: 31, hamming: 0.012172855437592786
step: 32, hamming: 0.010158762007530757
step: 33, hamming: 0.008449042800011774
step: 34, hamming: 0.007007520983952693
step: 35, hamming: 0.0057988942286212805
step: 36, hamming: 0.004790085658922592
step: 37, hamming: 0.003951069946375388
step: 38, hamming: 0.003255242407783724
step: 39, hamming: 0.0026794549366581924
step: 40, hamming: 0.0022038408329425082
step: 41, hamming: 0.0018115242912096789
step: 42, hamming: 0.0014882809567832705
step: 43, hamming: 0.0012221915474429238
step: 44, hamming: 0.0010033128856263504
step: 45, hamming: 0.0008233786956426912
Running panda took: 1.48 seconds!
```

Elapsed time: 1.48 sec.

Saving LIONESS network 29 to lioness_output using npy format:

Elapsed time: 0.02 sec.

Running LIONESS for sample 30:

Computing coexpression network:

Elapsed time: 0.02 sec.

Normalizing networks:

Elapsed time: 0.03 sec.

Inferring LIONESS network:

```
step: 0, hamming: 0.6441925069818978
step: 1, hamming: 0.6063136112432318
step: 2, hamming: 0.6103932208346182
step: 3, hamming: 0.5874474722143483
step: 4, hamming: 0.5535649464335758
step: 5, hamming: 0.5130928337695615
step: 6, hamming: 0.4688939095266525
step: 7, hamming: 0.42325885276505987
step: 8, hamming: 0.3780087198271526
step: 9, hamming: 0.3345100558700422
step: 10, hamming: 0.29371427477324347
step: 11, hamming: 0.2562107598757153
step: 12, hamming: 0.22229857181764945
step: 13, hamming: 0.19205531145425267
step: 14, hamming: 0.16539978011088832
step: 15, hamming: 0.14214287312471557
step: 16, hamming: 0.12202708424928997
step: 17, hamming: 0.10475587118837182
step: 18, hamming: 0.09001400820385419
step: 19, hamming: 0.07748166638509849
step: 20, hamming: 0.06684413555730546
```

```
step: 21, hamming: 0.05779998950120317
step: 22, hamming: 0.050069556133776956
step: 23, hamming: 0.04340444199041316
step: 24, hamming: 0.03759688450174655
step: 25, hamming: 0.03248603443830073
step: 26, hamming: 0.027957966759979882
step: 27, hamming: 0.023938483652704984
step: 28, hamming: 0.020380896229155798
step: 29, hamming: 0.017252993901731097
step: 30, hamming: 0.014526852479589947
step: 31, hamming: 0.012173067882295998
step: 32, hamming: 0.010158950869745383
step: 33, hamming: 0.008449210882153614
step: 34, hamming: 0.007007669688350223
step: 35, hamming: 0.0057990246081408205
step: 36, hamming: 0.0047901987375082965
step: 37, hamming: 0.003951167141327133
step: 38, hamming: 0.003255325350745026
step: 39, hamming: 0.0026795253550045642
step: 40, hamming: 0.00220390032018264
step: 41, hamming: 0.00181157433539964
step: 42, hamming: 0.0014883229143649352
step: 43, hamming: 0.001222266229141624
step: 44, hamming: 0.0010033421337824068
step: 45, hamming: 0.0008234030345286952
Running panda took: 1.34 seconds!
```

Elapsed time: 1.34 sec.

Saving LIONESS network 30 to lioness_output using npy format:

Elapsed time: 0.02 sec.

Running LIONESS for sample 31:

Computing coexpression network:

Elapsed time: 0.02 sec.

Normalizing networks:

Elapsed time: 0.03 sec.

Inferring LIONESS network:

```
step: 0, hamming: 0.6453374894828801
step: 1, hamming: 0.6066967069145408
step: 2, hamming: 0.6104840389078136
step: 3, hamming: 0.5874565733434927
step: 4, hamming: 0.5535188219795216
step: 5, hamming: 0.513020487378786
step: 6, hamming: 0.46881505964233633
step: 7, hamming: 0.4231847518707811
step: 8, hamming: 0.37794456875278254
step: 9, hamming: 0.33445666843682814
step: 10, hamming: 0.29366950408238246
step: 11, hamming: 0.25617272617649023
step: 12, hamming: 0.2222658147874626
step: 13, hamming: 0.1920270800407892
step: 14, hamming: 0.1653756413311506
step: 15, hamming: 0.14212251274972568
step: 16, hamming: 0.12201028566869024
step: 17, hamming: 0.10474235378727428
step: 18, hamming: 0.09000359838145934
step: 19, hamming: 0.07747406299496645
step: 20, hamming: 0.06683892024429142
step: 21, hamming: 0.05779672357526197
```

```
step: 22, hamming: 0.05006780392032587
step: 23, hamming: 0.043403791059584765
step: 24, hamming: 0.03759695373852516
step: 25, hamming: 0.032486517555771505
step: 26, hamming: 0.027958627760509547
step: 27, hamming: 0.023939165045318303
step: 28, hamming: 0.020381512374332632
step: 29, hamming: 0.017253509321226976
step: 30, hamming: 0.01452726248992399
step: 31, hamming: 0.01217338409078206
step: 32, hamming: 0.01015918998360408
step: 33, hamming: 0.008449389939631924
step: 34, hamming: 0.007007803396138958
step: 35, hamming: 0.00579912466367174
step: 36, hamming: 0.004790274070575606
step: 37, hamming: 0.0039512242592668854
step: 38, hamming: 0.0032553690960775276
step: 39, hamming: 0.0026795590154728125
step: 40, hamming: 0.002203926367689019
step: 41, hamming: 0.0018115946043863235
step: 42, hamming: 0.0014883387657010927
step: 43, hamming: 0.001222390734737921
step: 44, hamming: 0.0010033519517067167
step: 45, hamming: 0.000823410802845809
Running panda took: 1.45 seconds!
Elapsed time: 1.45 sec.
Saving LIONESS network 31 to lioness_output using npy format:
Elapsed time: 0.02 sec.
Running LIONESS for sample 32:
Computing coexpression network:
Elapsed time: 0.02 sec.
Normalizing networks:
Elapsed time: 0.03 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6449746310280959
step: 1, hamming: 0.6067058332082043
step: 2, hamming: 0.6105227585080634
step: 3, hamming: 0.5874998685226731
step: 4, hamming: 0.5535644118765825
step: 5, hamming: 0.5130637409325514
step: 6, hamming: 0.46885520719749507
step: 7, hamming: 0.4232205988814208
step: 8, hamming: 0.37797509767336696
step: 9, hamming: 0.33448191453778936
step: 10, hamming: 0.2936901232265988
step: 11, hamming: 0.25618939533535684
step: 12, hamming: 0.22227946486100847
step: 13, hamming: 0.19203833582770793
step: 14, hamming: 0.16538499865483383
step: 15, hamming: 0.14213033937025302
step: 16, hamming: 0.12201684471858767
step: 17, hamming: 0.10474787876788032
step: 18, hamming: 0.09000825020978294
step: 19, hamming: 0.07747800883938391
step: 20, hamming: 0.06684228198432347
step: 21, hamming: 0.057799594299135344
step: 22, hamming: 0.050070253711365226
```

```
step: 23, hamming: 0.043405873825744117
step: 24, hamming: 0.03759871933174081
step: 25, hamming: 0.03248800162100365
step: 26, hamming: 0.027959871764145786
step: 27, hamming: 0.023940202435957004
step: 28, hamming: 0.0203823727736058
step: 29, hamming: 0.01725422092678858
step: 30, hamming: 0.014527849564486101
step: 31, hamming: 0.01217386793079806
step: 32, hamming: 0.010159588465741652
step: 33, hamming: 0.008449718062226332
step: 34, hamming: 0.007008073488535551
step: 35, hamming: 0.005799346994199016
step: 36, hamming: 0.004790456976200907
step: 37, hamming: 0.003951374637817454
step: 38, hamming: 0.003255492594470654
step: 39, hamming: 0.0026796605246515556
step: 40, hamming: 0.002204009784151208
step: 41, hamming: 0.0018116631348835933
step: 42, hamming: 0.0014883950460219354
step: 43, hamming: 0.001222285278787714
step: 44, hamming: 0.0010033898748033553
step: 45, hamming: 0.0008234419197268525
Running panda took: 1.49 seconds!
Elapsed time: 1.49 sec.
Saving LIONESS network 32 to lioness_output using npy format:
Elapsed time: 0.02 sec.
Running LIONESS for sample 33:
Computing coexpression network:
Elapsed time: 0.02 sec.
Normalizing networks:
Elapsed time: 0.03 sec.
Inferring LIONESS network:
step: 0, hamming: 0.645656780846221
step: 1, hamming: 0.6066002678232713
step: 2, hamming: 0.6105813100451256
step: 3, hamming: 0.5876366440945432
step: 4, hamming: 0.5537384939042065
step: 5, hamming: 0.5132510551234207
step: 6, hamming: 0.46903516653762006
step: 7, hamming: 0.42338117383780194
step: 8, hamming: 0.3781135868865883
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
step: 14, hamming: 0.16543669817665527
step: 15, hamming: 0.14217460617494093
step: 16, hamming: 0.12205478208053704
step: 17, hamming: 0.1047804213053023
step: 18, hamming: 0.09003612775603831
step: 19, hamming: 0.07750184049531987
step: 20, hamming: 0.06686269734372635
step: 21, hamming: 0.057817121269325866
step: 22, hamming: 0.050085333681801514
step: 23, hamming: 0.043418854271905304
```



```
step: 24, hamming: 0.037609897086251905
step: 25, hamming: 0.03249761930169969
step: 26, hamming: 0.02796812163890966
step: 27, hamming: 0.02394725318637872
step: 28, hamming: 0.020388370931300064
step: 29, hamming: 0.01725930031609945
step: 30, hamming: 0.014532130574808764
step: 31, hamming: 0.012177459602951909
step: 32, hamming: 0.010162590210066961
step: 33, hamming: 0.008452218615141232
step: 34, hamming: 0.007010150880511294
step: 35, hamming: 0.005801068940490524
step: 36, hamming: 0.004791881667170446
step: 37, hamming: 0.003952551627023813
step: 38, hamming: 0.0032564637102903927
step: 39, hamming: 0.0026804608719384142
step: 40, hamming: 0.002204668841868316
step: 41, hamming: 0.0018122054772229607
step: 42, hamming: 0.0014888410848218324
step: 43, hamming: 0.0012226519307712387
step: 44, hamming: 0.0010036911397340626
step: 45, hamming: 0.0008236893647987569
```

Running panda took: 1.57 seconds!

Elapsed time: 1.57 sec.

Saving LIONESS network 33 to lioness_output using npy format:

Elapsed time: 0.03 sec.

Running LIONESS for sample 34:

Computing coexpression network:

Elapsed time: 0.02 sec.

Normalizing networks:

Elapsed time: 0.03 sec.

Inferring LIONESS network:

```
step: 0, hamming: 0.6449981971449824
step: 1, hamming: 0.6065931831332113
step: 2, hamming: 0.6105293103087643
step: 3, hamming: 0.5875457591281373
step: 4, hamming: 0.5536260899397788
step: 5, hamming: 0.5131280856850265
step: 6, hamming: 0.4689154027720692
step: 7, hamming: 0.42327401236915707
step: 8, hamming: 0.37802087584233957
step: 9, hamming: 0.3345210485552016
step: 10, hamming: 0.2937231499498878
step: 11, hamming: 0.25621717754897094
step: 12, hamming: 0.2223028366559903
step: 13, hamming: 0.19205800982166413
step: 14, hamming: 0.16540159888503908
step: 15, hamming: 0.14214436276067294
step: 16, hamming: 0.12202874055933112
step: 17, hamming: 0.10475804762546265
step: 18, hamming: 0.09001694647451311
step: 19, hamming: 0.07748544549209825
step: 20, hamming: 0.06684869516951136
step: 21, hamming: 0.05780513650530213
step: 22, hamming: 0.0500750561258025
step: 23, hamming: 0.04341002702171404
step: 24, hamming: 0.03760230583906534
```

```
step: 25, hamming: 0.032491088953373076
step: 26, hamming: 0.027962521329952538
step: 27, hamming: 0.02394247114838837
step: 28, hamming: 0.020384308356420206
step: 29, hamming: 0.017255866049331867
step: 30, hamming: 0.0145292430032475
step: 31, hamming: 0.012175043490551072
step: 32, hamming: 0.010160576904046068
step: 33, hamming: 0.008450545793374795
step: 34, hamming: 0.00700876423318378
step: 35, hamming: 0.005799922014886081
step: 36, hamming: 0.0047909345756680976
step: 37, hamming: 0.003951770460150725
step: 38, hamming: 0.003255820005222335
step: 39, hamming: 0.0026799308615177105
step: 40, hamming: 0.0022042327414596497
step: 41, hamming: 0.0018118468450875748
step: 42, hamming: 0.0014885463019372101
step: 43, hamming: 0.0012224097309378745
step: 44, hamming: 0.0010034922163639059
step: 45, hamming: 0.0008235260380245241
```

Running panda took: 1.42 seconds!

Elapsed time: 1.42 sec.

Saving LIONESS network 34 to lioness_output using npy format:

Elapsed time: 0.02 sec.

Running LIONESS for sample 35:

Computing coexpression network:

Elapsed time: 0.02 sec.

Normalizing networks:

Elapsed time: 0.03 sec.

Inferring LIONESS network:

```
step: 0, hamming: 0.6426000250494666
step: 1, hamming: 0.6063071921865066
step: 2, hamming: 0.6104809784525866
step: 3, hamming: 0.5875787789957998
step: 4, hamming: 0.5536924206915095
step: 5, hamming: 0.5132239248844174
step: 6, hamming: 0.4690279451515534
step: 7, hamming: 0.4234005441297798
step: 8, hamming: 0.37815866164971773
step: 9, hamming: 0.3346641106844513
step: 10, hamming: 0.29386522327545833
step: 11, hamming: 0.25635291398589544
step: 12, hamming: 0.22242780353078664
step: 13, hamming: 0.1921699165297888
step: 14, hamming: 0.16549975125668107
step: 15, hamming: 0.14222892834479822
step: 16, hamming: 0.12210051057291259
step: 17, hamming: 0.10481816001497271
step: 18, hamming: 0.0900667032672284
step: 19, hamming: 0.07752617005100722
step: 20, hamming: 0.0668817243872407
step: 21, hamming: 0.0578317689475502
step: 22, hamming: 0.05009647661533095
step: 23, hamming: 0.04342729230869476
step: 24, hamming: 0.037616314867588554
step: 25, hamming: 0.03250255684979377
```

```
step: 26, hamming: 0.027971999052752584
step: 27, hamming: 0.023950359393898557
step: 28, hamming: 0.020390900537206765
step: 29, hamming: 0.017261384985951662
step: 30, hamming: 0.014533860839728177
step: 31, hamming: 0.01217890040608688
step: 32, hamming: 0.010163791137853356
step: 33, hamming: 0.008453219201499561
step: 34, hamming: 0.007010983652762791
step: 35, hamming: 0.0058017611584794
step: 36, hamming: 0.004792456415076777
step: 37, hamming: 0.003953028346447055
step: 38, hamming: 0.0032568587382547807
step: 39, hamming: 0.00268078789777572
step: 40, hamming: 0.002204939377727329
step: 41, hamming: 0.0018124290872041863
step: 42, hamming: 0.0014890257649965678
step: 43, hamming: 0.0012228043489239575
step: 44, hamming: 0.001003816846444069
step: 45, hamming: 0.000823792977083675
Running panda took: 1.43 seconds!
Elapsed time: 1.43 sec.
Saving LIONESS network 35 to lioness_output using npy format:
Elapsed time: 0.02 sec.
Running LIONESS for sample 36:
Computing coexpression network:
Elapsed time: 0.02 sec.
Normalizing networks:
Elapsed time: 0.03 sec.
Inferring LIONESS network:
step: 0, hamming: 0.64538220832322
step: 1, hamming: 0.6066969273795093
step: 2, hamming: 0.6105383132265271
step: 3, hamming: 0.5875246652799395
step: 4, hamming: 0.5535923400428431
step: 5, hamming: 0.5130969212335403
step: 6, hamming: 0.4688916302793686
step: 7, hamming: 0.42325914937362835
step: 8, hamming: 0.378015222114137
step: 9, hamming: 0.33452209514331444
step: 10, hamming: 0.2937286374246192
step: 11, hamming: 0.25622520736811455
step: 12, hamming: 0.22231178357995593
step: 13, hamming: 0.1920670653122524
step: 14, hamming: 0.16541028792801002
step: 15, hamming: 0.14215237669006922
step: 16, hamming: 0.12203588566680589
step: 17, hamming: 0.10476421069641416
step: 18, hamming: 0.09002215316977837
step: 19, hamming: 0.07748976024988688
step: 20, hamming: 0.06685218168838661
step: 21, hamming: 0.05780791039379919
step: 22, hamming: 0.050077221528608516
step: 23, hamming: 0.0434117205050181
step: 24, hamming: 0.037603623119995024
step: 25, hamming: 0.03249211431074741
step: 26, hamming: 0.027963316385545108
```

step: 27, hamming: 0.023943089250558148
step: 28, hamming: 0.020384791637139868
step: 29, hamming: 0.017256245588859704
step: 30, hamming: 0.014529542455540409
step: 31, hamming: 0.012175281230148284
step: 32, hamming: 0.010160766715614722
step: 33, hamming: 0.008450698522426137
step: 34, hamming: 0.007008887974781527
step: 35, hamming: 0.005800022398900317
step: 36, hamming: 0.004791016237650568
step: 37, hamming: 0.003951837291752234
step: 38, hamming: 0.00325587489135729
step: 39, hamming: 0.0026799760260441635
step: 40, hamming: 0.0022042699447564137
step: 41, hamming: 0.0018118775067475124
step: 42, hamming: 0.0014885715795620964
step: 43, hamming: 0.0012224305718871041
step: 44, hamming: 0.0010035093959526774
step: 45, hamming: 0.0008235401960124153
Running panda took: 1.34 seconds!

Elapsed time: 1.34 sec.

Saving LIONESS network 36 to lioness_output using npy format:

Elapsed time: 0.03 sec.

Running LIONESS for sample 37:

Computing coexpression network:

Elapsed time: 0.02 sec.

Normalizing networks:

Elapsed time: 0.03 sec.

Inferring LIONESS network:

step: 0, hamming: 0.6450937603753659
step: 1, hamming: 0.6064436660837454
step: 2, hamming: 0.6105412861118334
step: 3, hamming: 0.5876066009972608
step: 4, hamming: 0.5537181506446464
step: 5, hamming: 0.513240162239385
step: 6, hamming: 0.46903005243019497
step: 7, hamming: 0.4233816338164551
step: 8, hamming: 0.37811730216131945
step: 9, hamming: 0.33460427640855356
step: 10, hamming: 0.2937937095904566
step: 11, hamming: 0.2562765055577094
step: 12, hamming: 0.2223522829719493
step: 13, hamming: 0.19209908884148155
step: 14, hamming: 0.16543565555984818
step: 15, hamming: 0.14217249050227085
step: 16, hamming: 0.12205187338509321
step: 17, hamming: 0.10477697957160514
step: 18, hamming: 0.09003236276240753
step: 19, hamming: 0.07749793593084385
step: 20, hamming: 0.06685876647177448
step: 21, hamming: 0.057813243887915165
step: 22, hamming: 0.0500815676624227
step: 23, hamming: 0.04341524699674483
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: 0.0172570960909915
step: 30, hamming: 0.014530191634674654
step: 31, hamming: 0.012175775564193877
step: 32, hamming: 0.010161143736087765
step: 33, hamming: 0.008450987745447076
step: 34, hamming: 0.007009111445933513
step: 35, hamming: 0.0058001966698539
step: 36, hamming: 0.004791153274172695
step: 37, hamming: 0.003951945757724806
step: 38, hamming: 0.003255961297104378
step: 39, hamming: 0.0026800452215014355
step: 40, hamming: 0.0022043256087412007
step: 41, hamming: 0.001811922446478194
step: 42, hamming: 0.0014886079619687155
step: 43, hamming: 0.0012224600919155365
step: 44, hamming: 0.0010035333901201558
step: 45, hamming: 0.0008235597257708738
```

Running panda took: 1.47 seconds!

Elapsed time: 1.47 sec.

Saving LIONESS network 37 to lioness_output using npy format:

Elapsed time: 0.02 sec.

Running LIONESS for sample 38:

Computing coexpression network:

Elapsed time: 0.03 sec.

Normalizing networks:

Elapsed time: 0.06 sec.

Inferring LIONESS network:

```
step: 0, hamming: 0.6440630972479127
step: 1, hamming: 0.6065362164769551
step: 2, hamming: 0.6104532026394006
step: 3, hamming: 0.5874604045897802
step: 4, hamming: 0.5535439576972261
step: 5, hamming: 0.5130532048778697
step: 6, hamming: 0.46884617663248196
step: 7, hamming: 0.4232106291765286
step: 8, hamming: 0.37796351385560756
step: 9, hamming: 0.3344694203478319
step: 10, hamming: 0.29367784651746603
step: 11, hamming: 0.25617791005946733
step: 12, hamming: 0.2222690261377353
step: 13, hamming: 0.19202898759027917
step: 14, hamming: 0.16537677619988342
step: 15, hamming: 0.1421232526413549
step: 16, hamming: 0.12201074582554954
step: 17, hamming: 0.10474263477818664
step: 18, hamming: 0.09000370065023104
step: 19, hamming: 0.07747402152715009
step: 20, hamming: 0.06683879577708175
step: 21, hamming: 0.0577965551811048
step: 22, hamming: 0.05006760738559485
step: 23, hamming: 0.04340357349694229
step: 24, hamming: 0.03759672349751944
step: 25, hamming: 0.032486280205226196
step: 26, hamming: 0.027958392107693967
step: 27, hamming: 0.023938938938551046
step: 28, hamming: 0.02038130226939476
```

```
step: 29, hamming: 0.017253319330902392
step: 30, hamming: 0.014527095084336914
step: 31, hamming: 0.012173239529471589
step: 32, hamming: 0.010159067354651505
step: 33, hamming: 0.008449287001086303
step: 34, hamming: 0.007007717820632078
step: 35, hamming: 0.005799053624028304
step: 36, hamming: 0.004790215055454622
step: 37, hamming: 0.003951175336782719
step: 38, hamming: 0.0032553284588682867
step: 39, hamming: 0.002679525308582267
step: 40, hamming: 0.0022038984233926826
step: 41, hamming: 0.0018115714471615197
step: 42, hamming: 0.0014883195860679434
step: 43, hamming: 0.001222231985379237
step: 44, hamming: 0.0010033388191364957
step: 45, hamming: 0.0008233999448704641
Running panda took: 1.71 seconds!
```

Elapsed time: 1.71 sec.

Saving LIONESS network 38 to lioness_output using npy format:

Elapsed time: 0.05 sec.

Running LIONESS for sample 39:

Computing coexpression network:

Elapsed time: 0.03 sec.

Normalizing networks:

Elapsed time: 0.05 sec.

Inferring LIONESS network:

```
step: 0, hamming: 0.6450086728222191
step: 1, hamming: 0.6066279590964608
step: 2, hamming: 0.6105189710157038
step: 3, hamming: 0.5875129702246185
step: 4, hamming: 0.5535881728916275
step: 5, hamming: 0.5130942680692989
step: 6, hamming: 0.46888370874519314
step: 7, hamming: 0.4232446919415762
step: 8, hamming: 0.3779945678456299
step: 9, hamming: 0.3344972254062106
step: 10, hamming: 0.2937027228697728
step: 11, hamming: 0.2561999698599468
step: 12, hamming: 0.22228841230441748
step: 13, hamming: 0.19204594680519657
step: 14, hamming: 0.1653914528419214
step: 15, hamming: 0.1421357904234999
step: 16, hamming: 0.12202150658243802
step: 17, hamming: 0.10475182786542589
step: 18, hamming: 0.0900115144619496
step: 19, hamming: 0.077480629396115
step: 20, hamming: 0.06684439090269251
step: 21, hamming: 0.057801297739797815
step: 22, hamming: 0.050071632819650706
step: 23, hamming: 0.043407005970971885
step: 24, hamming: 0.03759966095033141
step: 25, hamming: 0.032488803075486614
step: 26, hamming: 0.027960560323392912
step: 27, hamming: 0.02394080074258424
step: 28, hamming: 0.020382896359423756
step: 29, hamming: 0.017254678449675067
```

```
step: 30, hamming: 0.014528247886828674
step: 31, hamming: 0.012174211893688459
step: 32, hamming: 0.010159883384549461
step: 33, hamming: 0.008449969131479785
step: 34, hamming: 0.007008285718950414
step: 35, hamming: 0.005799525161101376
step: 36, hamming: 0.004790605850968227
step: 37, hamming: 0.003951498594437272
step: 38, hamming: 0.00325559543899562
step: 39, hamming: 0.002679745529938822
step: 40, hamming: 0.002204079908626591
step: 41, hamming: 0.0018117209077095206
step: 42, hamming: 0.0014884425909900134
step: 43, hamming: 0.0012223243766523934
step: 44, hamming: 0.001003422008988331
step: 45, hamming: 0.0008234683171750291
```

Running panda took: 1.63 seconds!

Elapsed time: 1.63 sec.

Saving LIONESS network 39 to lioness_output using npy format:

Elapsed time: 0.03 sec.

Running LIONESS for sample 40:

Computing coexpression network:

Elapsed time: 0.03 sec.

Normalizing networks:

Elapsed time: 0.03 sec.

Inferring LIONESS network:

```
step: 0, hamming: 0.6446899829950575
step: 1, hamming: 0.6065720657385845
step: 2, hamming: 0.6104769060458073
step: 3, hamming: 0.587468913447344
step: 4, hamming: 0.553541697529604
step: 5, hamming: 0.5130476369210645
step: 6, hamming: 0.4688442859318447
step: 7, hamming: 0.42321479157426
step: 8, hamming: 0.3779745725802862
step: 9, hamming: 0.33448614616016825
step: 10, hamming: 0.2936979376976792
step: 11, hamming: 0.2561994062741515
step: 12, hamming: 0.22229019835157474
step: 13, hamming: 0.19204895567253832
step: 14, hamming: 0.16539501582991112
step: 15, hamming: 0.14213947488622694
step: 16, hamming: 0.12202499625028415
step: 17, hamming: 0.10475511557113841
step: 18, hamming: 0.09001460630282851
step: 19, hamming: 0.07748348660857823
step: 20, hamming: 0.06684699483703208
step: 21, hamming: 0.05780364640854137
step: 22, hamming: 0.050073752658040344
step: 23, hamming: 0.04340891190950424
step: 24, hamming: 0.03760138090088408
step: 25, hamming: 0.03249034534683271
step: 26, hamming: 0.027961940282617167
step: 27, hamming: 0.02394202780317782
step: 28, hamming: 0.020383977524069206
step: 29, hamming: 0.017255623043299223
step: 30, hamming: 0.014529064889671081
```

```
step: 31, hamming: 0.012174912034662342
step: 32, hamming: 0.010160478451575828
step: 33, hamming: 0.008450471314942093
step: 34, hamming: 0.007008707096476387
step: 35, hamming: 0.005799877499710264
step: 36, hamming: 0.0047908995699176915
step: 37, hamming: 0.00395174269330924
step: 38, hamming: 0.0032557978512664297
step: 39, hamming: 0.002679913100611091
step: 40, hamming: 0.0022042184426658354
step: 41, hamming: 0.0018118352905121414
step: 42, hamming: 0.0014885369392666512
step: 43, hamming: 0.0012224021313626207
step: 44, hamming: 0.0010034860389152175
step: 45, hamming: 0.0008235210127976292
Running panda took: 1.75 seconds!
  Elapsed time: 1.75 sec.
Saving LIONESS network 40 to lioness_output using npy format:
  Elapsed time: 0.03 sec.
Running LIONESS for sample 41:
Computing coexpression network:
  Elapsed time: 0.02 sec.
Normalizing networks:
  Elapsed time: 0.03 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6439588770722169
step: 1, hamming: 0.6066729641072987
step: 2, hamming: 0.610570644142953
step: 3, hamming: 0.5875671840941767
step: 4, hamming: 0.5536412525576695
step: 5, hamming: 0.5131442161431155
step: 6, hamming: 0.46893158026561005
step: 7, hamming: 0.42328943886764275
step: 8, hamming: 0.3780348238806754
step: 9, hamming: 0.33453258916311723
step: 10, hamming: 0.2937325823349309
step: 11, hamming: 0.2562249355349886
step: 12, hamming: 0.2223091005920621
step: 13, hamming: 0.1920630661505349
step: 14, hamming: 0.16540567166944584
step: 15, hamming: 0.142147668817602
step: 16, hamming: 0.12203143924750813
step: 17, hamming: 0.10476020433355153
step: 18, hamming: 0.09001866866683568
step: 19, hamming: 0.07748681890195007
step: 20, hamming: 0.06684977392071134
step: 21, hamming: 0.0578060040584336
step: 22, hamming: 0.050075759807870907
step: 23, hamming: 0.04341058715028377
step: 24, hamming: 0.03760274175604868
step: 25, hamming: 0.03249142680963005
step: 26, hamming: 0.02796277245679931
step: 27, hamming: 0.023942649977909784
step: 28, hamming: 0.020384429573280502
step: 29, hamming: 0.017255942798246847
step: 30, hamming: 0.0145292867393714
step: 31, hamming: 0.012175064147083636
```



```
step: 32, hamming: 0.010160581814379425
step: 33, hamming: 0.00845054093972525
step: 34, hamming: 0.007008754041534421
step: 35, hamming: 0.005799908869690069
step: 36, hamming: 0.004790920217625292
step: 37, hamming: 0.003951756159188346
step: 38, hamming: 0.0032558065114434266
step: 39, hamming: 0.0026799185423229273
step: 40, hamming: 0.0022042217409228154
step: 41, hamming: 0.0018118371780350322
step: 42, hamming: 0.0014885379101339346
step: 43, hamming: 0.0012224025182755501
step: 44, hamming: 0.0010034860661721843
step: 45, hamming: 0.0008235208251140585
Running panda took: 1.82 seconds!
  Elapsed time: 1.82 sec.
Saving LIONESS network 41 to lioness_output using npy format:
  Elapsed time: 0.02 sec.
Running LIONESS for sample 42:
Computing coexpression network:
  Elapsed time: 0.03 sec.
Normalizing networks:
  Elapsed time: 0.06 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6450900888790349
step: 1, hamming: 0.6066516738621498
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: 0.3779626905033644
step: 9, hamming: 0.3344747386057253
step: 10, hamming: 0.2936868597522509
step: 11, hamming: 0.2561887985822545
step: 12, hamming: 0.2222804132814435
step: 13, hamming: 0.1920401220158585
step: 14, hamming: 0.16538712296890065
step: 15, hamming: 0.14213253273283047
step: 16, hamming: 0.12201908520533228
step: 17, hamming: 0.10475002765824205
step: 18, hamming: 0.09001017467263965
step: 19, hamming: 0.077479699555011
step: 20, hamming: 0.0668437502548238
step: 21, hamming: 0.057800867645357974
step: 22, hamming: 0.05007135445772276
step: 23, hamming: 0.04340683431558541
step: 24, hamming: 0.03759956900963259
step: 25, hamming: 0.03248876286486136
step: 26, hamming: 0.02796055963694356
step: 27, hamming: 0.02394082711040951
step: 28, hamming: 0.020382937686533594
step: 29, hamming: 0.01725472869077617
step: 30, hamming: 0.014528302543333647
step: 31, hamming: 0.01217426646707725
step: 32, hamming: 0.010159934842999263
```

```
step: 33, hamming: 0.008450015826353949
step: 34, hamming: 0.007008327003644892
step: 35, hamming: 0.005799561059886949
step: 36, hamming: 0.004790636812690914
step: 37, hamming: 0.003951524989153562
step: 38, hamming: 0.0032556177779712583
step: 39, hamming: 0.0026797643542427973
step: 40, hamming: 0.0022040957228296318
step: 41, hamming: 0.0018117341418863388
step: 42, hamming: 0.0014884536410248769
step: 43, hamming: 0.0012223335797172294
step: 44, hamming: 0.0010034296580480636
step: 45, hamming: 0.0008234746634137485
Running panda took: 1.63 seconds!
Elapsed time: 1.63 sec.
Saving LIONESS network 42 to lioness_output using npy format:
Elapsed time: 0.03 sec.
Running LIONESS for sample 43:
Computing coexpression network:
Elapsed time: 0.02 sec.
Normalizing networks:
Elapsed time: 0.03 sec.
Inferring LIONESS network:
step: 0, hamming: 0.644052761896358
step: 1, hamming: 0.6068467935854113
step: 2, hamming: 0.6107288577190169
step: 3, hamming: 0.5877376684115262
step: 4, hamming: 0.5538142766265394
step: 5, hamming: 0.5133115341098062
step: 6, hamming: 0.46908987086502824
step: 7, hamming: 0.4234332320104306
step: 8, hamming: 0.3781623554018538
step: 9, hamming: 0.33464371916895425
step: 10, hamming: 0.29382891080082413
step: 11, hamming: 0.25630804132509455
step: 12, hamming: 0.22238058991015805
step: 13, hamming: 0.1921244069073419
step: 14, hamming: 0.1654581795748105
step: 15, hamming: 0.14219255890384128
step: 16, hamming: 0.12206981536725257
step: 17, hamming: 0.10479308912740204
step: 18, hamming: 0.09004682418382233
step: 19, hamming: 0.07751094005916007
step: 20, hamming: 0.06687044755283782
step: 21, hamming: 0.057823710017225756
step: 22, hamming: 0.05009090857316944
step: 23, hamming: 0.04342352724644388
step: 24, hamming: 0.03761374284334517
step: 25, hamming: 0.032500717866233104
step: 26, hamming: 0.027970567103492504
step: 27, hamming: 0.023949145946046777
step: 28, hamming: 0.020389814594208796
step: 29, hamming: 0.01726038967332538
step: 30, hamming: 0.014532948325301727
step: 31, hamming: 0.012178073966408829
step: 32, hamming: 0.010163053860804863
step: 33, hamming: 0.00845257088969216
```

```
step: 34, hamming: 0.007010420899916855
step: 35, hamming: 0.005801277650771889
step: 36, hamming: 0.0047920442777004526
step: 37, hamming: 0.003952679304999426
step: 38, hamming: 0.0032565646292526955
step: 39, hamming: 0.0026805410775311805
step: 40, hamming: 0.002204732881227192
step: 41, hamming: 0.001812256795704004
step: 42, hamming: 0.0014888823408190444
step: 43, hamming: 0.0012226851824785948
step: 44, hamming: 0.0010037179959729236
step: 45, hamming: 0.0008237110939490818
```

Running panda took: 1.40 seconds!

Elapsed time: 1.40 sec.

Saving LIONESS network 43 to lioness_output using npy format:

Elapsed time: 0.03 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: 0.6455018706675433
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: 0.4688357436456271
step: 7, hamming: 0.4232060516712834
step: 8, hamming: 0.3779651681944427
step: 9, hamming: 0.3344757818245871
step: 10, hamming: 0.29368699908851514
step: 11, hamming: 0.25618810836906636
step: 12, hamming: 0.22227915239937626
step: 13, hamming: 0.19203863188744116
step: 14, hamming: 0.16538554120286303
step: 15, hamming: 0.1421309400195572
step: 16, hamming: 0.12201736565539252
step: 17, hamming: 0.10474825814801286
step: 18, hamming: 0.09000844987911948
step: 19, hamming: 0.07747797083444699
step: 20, hamming: 0.06684205040520512
step: 21, hamming: 0.057799246297848224
step: 22, hamming: 0.05006983470329826
step: 23, hamming: 0.0434054377789933
step: 24, hamming: 0.03759830798077482
step: 25, hamming: 0.032487644623876356
step: 26, hamming: 0.027959585227725074
step: 27, hamming: 0.02393999328159403
step: 28, hamming: 0.020382235303793003
step: 29, hamming: 0.017254142326846075
step: 30, hamming: 0.0145278165923739
step: 31, hamming: 0.012173865559254836
step: 32, hamming: 0.010159605065697939
step: 33, hamming: 0.008449745022944615
step: 34, hamming: 0.0070081047551232775
```

```
step: 35, hamming: 0.005799378660948919
step: 36, hamming: 0.004790486921682077
step: 37, hamming: 0.003951402165785128
step: 38, hamming: 0.00325551714323014
step: 39, hamming: 0.002679681888018422
step: 40, hamming: 0.002204028114908212
step: 41, hamming: 0.0018116787055630656
step: 42, hamming: 0.0014884081765578659
step: 43, hamming: 0.0012222962914605212
step: 44, hamming: 0.0010033990729403487
step: 45, hamming: 0.0008234495793931098
Running panda took: 1.11 seconds!
```

Elapsed time: 1.11 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: 0.01 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: 0.5536474918555494
step: 5, hamming: 0.5131464111654228
step: 6, hamming: 0.46893531465023547
step: 7, hamming: 0.4232953952543082
step: 8, hamming: 0.3780435892681105
step: 9, hamming: 0.33454365128594754
step: 10, hamming: 0.29374508748769934
step: 11, hamming: 0.25623779090891435
step: 12, hamming: 0.22232178821340307
step: 13, hamming: 0.1920751280646255
step: 14, hamming: 0.16541683124420956
step: 15, hamming: 0.1421577806735096
step: 16, hamming: 0.12204047685598642
step: 17, hamming: 0.10476822857697907
step: 18, hamming: 0.09002567471379645
step: 19, hamming: 0.07749288793781219
step: 20, hamming: 0.06685499297134434
step: 21, hamming: 0.05781044528986368
step: 22, hamming: 0.050079503532131836
step: 23, hamming: 0.043413743732357984
step: 24, hamming: 0.037605400712792725
step: 25, hamming: 0.032493655647963006
step: 26, hamming: 0.027964640608281126
step: 27, hamming: 0.02394421340556936
step: 28, hamming: 0.02038573503818736
step: 29, hamming: 0.01725703100015745
step: 30, hamming: 0.014530192108341453
step: 31, hamming: 0.012175817632282378
step: 32, hamming: 0.010161208009430479
step: 33, hamming: 0.008451061098622103
step: 34, hamming: 0.007009185612316628
step: 35, hamming: 0.00580026658609169
```

```
step: 36, hamming: 0.004791216556223985
step: 37, hamming: 0.003952001550810154
step: 38, hamming: 0.003256009551690285
step: 39, hamming: 0.0026800863984453036
step: 40, hamming: 0.0022043604008479102
step: 41, hamming: 0.0018119516331865852
step: 42, hamming: 0.001488632316391934
step: 43, hamming: 0.001222480334695352
step: 44, hamming: 0.001003550166649101
step: 45, hamming: 0.0008235735965779479
```

Running panda took: 1.10 seconds!

Elapsed time: 1.10 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: 0.01 sec.

Normalizing networks:

Elapsed time: 0.03 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: 0.553588190940493
step: 5, hamming: 0.513091592106618
step: 6, hamming: 0.46888363850009035
step: 7, hamming: 0.42324816999840126
step: 8, hamming: 0.3780016536091072
step: 9, hamming: 0.3345068620657478
step: 10, hamming: 0.2937130015631493
step: 11, hamming: 0.2562101677520667
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: 0.10475621059832578
step: 18, hamming: 0.09001529971582535
step: 19, hamming: 0.07748388708610993
step: 20, hamming: 0.06684718843182245
step: 21, hamming: 0.05780369052361184
step: 22, hamming: 0.05007369620781047
step: 23, hamming: 0.04340879060521527
step: 24, hamming: 0.0376012098195711
step: 25, hamming: 0.03249013651071767
step: 26, hamming: 0.027961701647830434
step: 27, hamming: 0.023941767943218586
step: 28, hamming: 0.020383707109450016
step: 29, hamming: 0.01725535251678685
step: 30, hamming: 0.014528803438411068
step: 31, hamming: 0.01217466719343373
step: 32, hamming: 0.010160255136051028
step: 33, hamming: 0.008450271975505554
step: 34, hamming: 0.0070085325302855425
step: 35, hamming: 0.005799726752184737
step: 36, hamming: 0.004790770756328508
```

```
step: 37, hamming: 0.003951633741495327
step: 38, hamming: 0.003255706284492107
step: 39, hamming: 0.002679836512915268
step: 40, hamming: 0.0022041546289165003
step: 41, hamming: 0.001811782285088026
step: 42, hamming: 0.0014884930203235185
step: 43, hamming: 0.0012223658117307841
step: 44, hamming: 0.001003456049299198
step: 45, hamming: 0.0008234962794548331
Running panda took: 1.19 seconds!
Elapsed time: 1.19 sec.
Saving LIONESS network 46 to lioness_output using npy format:
Elapsed time: 0.02 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: 0.6067224879320419
step: 2, hamming: 0.6104855876766591
step: 3, hamming: 0.5874302260560214
step: 4, hamming: 0.5534812095958548
step: 5, hamming: 0.5129821856517685
step: 6, hamming: 0.46878098398796686
step: 7, hamming: 0.42315657041730403
step: 8, hamming: 0.3779239978979505
step: 9, hamming: 0.3344427227132656
step: 10, hamming: 0.29366102731476706
step: 11, hamming: 0.25616821630801284
step: 12, hamming: 0.22226395137122443
step: 13, hamming: 0.19202681658475132
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: 0.07747470953904385
step: 20, hamming: 0.06683930742299432
step: 21, hamming: 0.0577968871587979
step: 22, hamming: 0.050067790022936765
step: 23, hamming: 0.04340365566162159
step: 24, hamming: 0.03759676223186337
step: 25, hamming: 0.03248631716762015
step: 26, hamming: 0.027958452078804107
step: 27, hamming: 0.023939028616903366
step: 28, hamming: 0.020381419449167232
step: 29, hamming: 0.017253456558720872
step: 30, hamming: 0.014527240970954446
step: 31, hamming: 0.012173384845798182
step: 32, hamming: 0.010159205498888376
step: 33, hamming: 0.008449414288126912
step: 34, hamming: 0.007007832514285143
step: 35, hamming: 0.005799155320694112
step: 36, hamming: 0.0047903042325213785
step: 37, hamming: 0.003951252628490434
```

```
step: 38, hamming: 0.0032553948817023257
step: 39, hamming: 0.0026795820184424913
step: 40, hamming: 0.0022039466024797332
step: 41, hamming: 0.0018116122118621097
step: 42, hamming: 0.001488353952046178
step: 43, hamming: 0.001222520794900526
step: 44, hamming: 0.0010033630290072102
step: 45, hamming: 0.0008234201909991941
Running panda took: 1.47 seconds!
Elapsed time: 1.47 sec.
Saving LIONESS network 47 to lioness_output using npy format:
Elapsed time: 0.02 sec.
Running LIONESS for sample 48:
Computing coexpression network:
Elapsed time: 0.04 sec.
Normalizing networks:
Elapsed time: 0.04 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6450729208857102
step: 1, hamming: 0.6063501512150873
step: 2, hamming: 0.6103715026046174
step: 3, hamming: 0.5874284484527396
step: 4, hamming: 0.5535259596516843
step: 5, hamming: 0.513054704775382
step: 6, hamming: 0.4688708582148043
step: 7, hamming: 0.42325992634308324
step: 8, hamming: 0.37803721253202954
step: 9, hamming: 0.33456092176953284
step: 10, hamming: 0.29377908789293194
step: 11, hamming: 0.25628124480181685
step: 12, hamming: 0.22236874382375207
step: 13, hamming: 0.19212159497551798
step: 14, hamming: 0.165460467724724
step: 15, hamming: 0.1421972940894272
step: 16, hamming: 0.12207523597375464
step: 17, hamming: 0.10479810759599201
step: 18, hamming: 0.09005092233539186
step: 19, hamming: 0.07751386224984219
step: 20, hamming: 0.06687216133585415
step: 21, hamming: 0.05782432168099327
step: 22, hamming: 0.050090599604048575
step: 23, hamming: 0.04342254449049325
step: 24, hamming: 0.03761235473029859
step: 25, hamming: 0.03249915130287423
step: 26, hamming: 0.027968991909988243
step: 27, hamming: 0.023947673742928513
step: 28, hamming: 0.02038850792929859
step: 29, hamming: 0.01725926821592624
step: 30, hamming: 0.01453200904050933
step: 31, hamming: 0.012177299988630045
step: 32, hamming: 0.010162422517800813
step: 33, hamming: 0.008452059415929542
step: 34, hamming: 0.007010008256905795
step: 35, hamming: 0.005800945322716098
step: 36, hamming: 0.004791776880461754
step: 37, hamming: 0.003952464204685849
step: 38, hamming: 0.003256391557054846
```

```
step: 39, hamming: 0.002680401761524582
step: 40, hamming: 0.0022046206611944417
step: 41, hamming: 0.0018121663562190118
step: 42, hamming: 0.0014888093898348762
step: 43, hamming: 0.0012226262844574846
step: 44, hamming: 0.0010036704002436745
step: 45, hamming: 0.0008236725986009702
Running panda took: 1.82 seconds!
Elapsed time: 1.82 sec.
Saving LIONESS network 48 to lioness_output using npy format:
Elapsed time: 0.10 sec.
Running LIONESS for sample 49:
Computing coexpression network:
Elapsed time: 0.04 sec.
Normalizing networks:
Elapsed time: 0.03 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6450184972229365
step: 1, hamming: 0.6068240235253974
step: 2, hamming: 0.6105965948530254
step: 3, hamming: 0.5875567675582667
step: 4, hamming: 0.5536089018867548
step: 5, hamming: 0.5130991941025522
step: 6, hamming: 0.4688833696500004
step: 7, hamming: 0.42324358671229345
step: 8, hamming: 0.3779936855263689
step: 9, hamming: 0.334497167054918
step: 10, hamming: 0.29370268379408965
step: 11, hamming: 0.2561996389154925
step: 12, hamming: 0.22228779180603883
step: 13, hamming: 0.19204512280533334
step: 14, hamming: 0.165390605047534
step: 15, hamming: 0.14213514394319682
step: 16, hamming: 0.12202099792941379
step: 17, hamming: 0.1047515095155968
step: 18, hamming: 0.09001138629352734
step: 19, hamming: 0.07748073876203371
step: 20, hamming: 0.06684470509459198
step: 21, hamming: 0.057801763448754456
step: 22, hamming: 0.05007220261612099
step: 23, hamming: 0.043407622810912906
step: 24, hamming: 0.03760028270759244
step: 25, hamming: 0.03248939173711593
step: 26, hamming: 0.027961098540398806
step: 27, hamming: 0.023941274385556592
step: 28, hamming: 0.020383301206956795
step: 29, hamming: 0.01725501788997063
step: 30, hamming: 0.014528528671629803
step: 31, hamming: 0.012174442900517382
step: 32, hamming: 0.010160072735999443
step: 33, hamming: 0.008450124179654742
step: 34, hamming: 0.007008412715800017
step: 35, hamming: 0.005799629423267298
step: 36, hamming: 0.004790691480475807
step: 37, hamming: 0.003951568960336357
step: 38, hamming: 0.0032556533190094545
step: 39, hamming: 0.002679793182593864
```



```
step: 40, hamming: 0.0022041191628976997
step: 41, hamming: 0.0018117532364711271
step: 42, hamming: 0.0014884692131398446
step: 43, hamming: 0.0012223462917056505
step: 44, hamming: 0.0010034400411097599
step: 45, hamming: 0.0008234831485799553
Running panda took: 1.69 seconds!
Elapsed time: 1.69 sec.
Saving LIONESS network 49 to lioness_output using npy format:
Elapsed time: 0.02 sec.
Running LIONESS for sample 50:
Computing coexpression network:
Elapsed time: 0.03 sec.
Normalizing networks:
Elapsed time: 0.05 sec.
Inferring LIONESS network:
step: 0, hamming: 0.6452671619076494
step: 1, hamming: 0.6066848794849177
step: 2, hamming: 0.610527587312023
step: 3, hamming: 0.5875201390790639
step: 4, hamming: 0.5535905216591732
step: 5, hamming: 0.5130937685955773
step: 6, hamming: 0.46888589482515114
step: 7, hamming: 0.42325035103333314
step: 8, hamming: 0.3780020754008558
step: 9, hamming: 0.33450587862635867
step: 10, hamming: 0.29371071766895035
step: 11, hamming: 0.2562069560043886
step: 12, hamming: 0.22229411692149156
step: 13, hamming: 0.1920505169749237
step: 14, hamming: 0.16539508199998465
step: 15, hamming: 0.14213872037052777
step: 16, hamming: 0.12202392388371457
step: 17, hamming: 0.10475390584465225
step: 18, hamming: 0.09001338394595736
step: 19, hamming: 0.07748237123447736
step: 20, hamming: 0.0668460176169171
step: 21, hamming: 0.0578028088348542
step: 22, hamming: 0.050073032857744684
step: 23, hamming: 0.04340828693081746
step: 24, hamming: 0.03760082097488881
step: 25, hamming: 0.03248982737352425
step: 26, hamming: 0.027961447158616017
step: 27, hamming: 0.02394155483809075
step: 28, hamming: 0.020383526490059086
step: 29, hamming: 0.017255198122503472
step: 30, hamming: 0.014528673059252924
step: 31, hamming: 0.01217455915612517
step: 32, hamming: 0.01016016655328855
step: 33, hamming: 0.008450200171028089
step: 34, hamming: 0.00700847469606477
step: 35, hamming: 0.005799679944846653
step: 36, hamming: 0.004790732721068612
step: 37, hamming: 0.003951602686458481
step: 38, hamming: 0.003255680919601843
step: 39, hamming: 0.002679815808328271
step: 40, hamming: 0.0022041377219136423
```

```
step: 41, hamming: 0.0018117684679712833
step: 42, hamming: 0.0014884817149678213
step: 43, hamming: 0.001222356555124916
step: 44, hamming: 0.0010034484651433174
step: 45, hamming: 0.0008234900629489587
Running panda took: 1.50 seconds!
Elapsed time: 1.50 sec.
Saving LIONESS network 50 to lioness_output using npy format:
Elapsed time: 0.02 sec.
```

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 :

```
In [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>.co
rrelation_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.

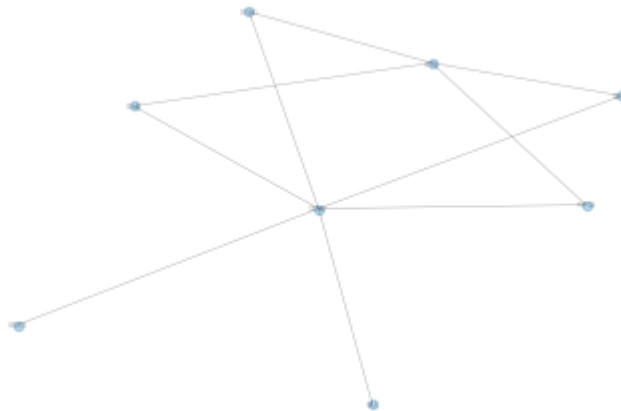
```
Running LIONESS for sample 44:
Computing coexpression network:
  Elapsed time: 0.05 sec.
Normalizing networks:
  Elapsed time: 0.06 sec.
Inferring LIONESS network:
  Elapsed time: 0.00 sec.
Saving LIONESS network 44 to lioness_output using npy format:
  Elapsed time: 0.05 sec.
Running LIONESS for 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.
```

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.

```
In [19]: analyze_lioness_obj = AnalyzeLioness(lioness_obj)  
analyze_lioness_obj.top_network_plot(top = 10, file = "lioness_top_1  
0.png")
```



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.

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

```
Out[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 × 4 columns

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

References

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