# perturbation_analysis_test

June 14, 2024

[1]:
```
import warnings
warnings.simplefilter(action='ignore', category=FutureWarning)
import sys
import os
_stderr = sys.stderr
null = open(os.devnull,'wb')

import dill
import scanpy as sc
import warnings
warnings.filterwarnings("ignore")
import pandas as pd
import numpy as np

import pyranges
# Set stderr to null to avoid strange messages from ray

from pathlib import Path

import velocyto

NCPUS = 28
```

## 1 Import SCENICPLUS object

[2]:
```
scenic_results_dir = '/media/solvi/solviHDD/worksite1001/MU7/SPLUS'
```

[3]:
```
print("Loading splus object..")
scplus_obj = dill.load( open( os.path.join(scenic_results_dir, 'scenicplus/
  ↪scplus_obj.pkl') , 'rb' ) )
print("done.")
```

```
Loading splus object..
done.
```

[4]:
```
scplus_obj
```

[4]:
```
SCENIC+ object with n_cells x n_genes = 2560 x 23112 and n_cells x n_regions =
2560 x 221933
        metadata_regions:'Chromosome', 'Start', 'End', 'Width',
'cisTopic_nr_frag', 'cisTopic_log_nr_frag', 'cisTopic_nr_acc',
'cisTopic_log_nr_acc'
        metadata_genes:'gene_ids', 'feature_types', 'genome', 'n_cells', 'mt',
'n_cells_by_counts', 'mean_counts', 'pct_dropout_by_counts', 'total_counts'
        metadata_cell:'GEX_n_genes', 'GEX_doublet_score',
'GEX_predicted_doublet', 'GEX_n_genes_by_counts', 'GEX_total_counts',
'GEX_total_counts_mt', 'GEX_pct_counts_mt', 'GEX_CLUSTERING',
'GEX_reference_annotation', 'GEX_Phase', 'GEX_celltype',
'ACC_Total_nr_frag_in_regions', 'ACC_Log_unique_nr_frag',
'ACC_Unique_nr_frag_in_regions', 'ACC_Unique_nr_frag', 'ACC_cisTopic_nr_frag',
'ACC_cisTopic_nr_acc', 'ACC_Log_total_nr_frag', 'ACC_Total_nr_frag',
'ACC_TSS_enrichment', 'ACC_Dupl_rate', 'ACC_Dupl_nr_frag',
'ACC_cisTopic_log_nr_frag', 'ACC_cisTopic_log_nr_acc', 'ACC_FRIP',
'ACC_barcode', 'ACC_n_genes', 'ACC_doublet_score', 'ACC_predicted_doublet',
'ACC_n_genes_by_counts', 'ACC_total_counts', 'ACC_total_counts_mt',
'ACC_pct_counts_mt', 'ACC_CLUSTERING', 'ACC_reference_annotation', 'ACC_Phase',
'ACC_sample_id', 'ACC_celltype'
        menr:'CTX_topics_otsu_All', 'CTX_topics_otsu_No_promoters',
'DEM_topics_otsu_All', 'DEM_topics_otsu_No_promoters', 'CTX_topics_top_3_All',
'CTX_topics_top_3_No_promoters', 'DEM_topics_top_3_All',
'DEM_topics_top_3_No_promoters', 'CTX_DARs_All', 'CTX_DARs_No_promoters',
'DEM_DARs_All', 'DEM_DARs_No_promoters'
        dr_cell:'GEX_X_pca', 'GEX_X_umap', 'eRegulons_UMAP', 'eRegulons_tSNE',
'ArchR_UMAP'
```

## 2 Run PCA on signficiant eRegulons

[5]:
```
from scenicplus.dimensionality_reduction import run_eRegulons_pca
```

[6]:
```
enriched_eRegulons_path = scenic_results_dir+'/SIGNIF_eRegulon_quality_metrics.
↪csv'
df1 = pd.read_csv( enriched_eRegulons_path )
sel_eRegulons = df1.g_cistrome_Id.tolist()
sel_eRegulons[1:30]
```

[6]:
```
['Grhl3_extended_+_(90g)',
 'Nf1_extended_+_(136g)',
 'Hmga2_extended_-_(46g)',
 'Clock_+_(61g)',
 'Yy1_extended_-_(16g)',
 'Bhlhe41_extended_-_(14g)',
 'Zeb1_-_(195g)',
 'Bhlhe40_+_(10g)',
```

```
 'Nfix_+_(143g)',
 'Nfe2l1_+_(168g)',
 'Nfatc1_extended_+_(135g)',
 'Fosl1_+_(70g)',
 'Klf6_extended_-_(36g)',
 'Etv1_+_(10g)',
 'Msc_extended_+_(43g)',
 'Sox5_-_(63g)',
 'Snai1_-_(12g)',
 'Cux1_extended_+_(65g)',
 'Zeb2_-_(65g)',
 'Tcf12_extended_-_(89g)',
 'Bach2_-_(158g)',
 'Bach2_extended_+_(296g)',
 'Smad7_+_(44g)',
 'Bnc2_extended_+_(126g)',
 'Ebf1_extended_+_(80g)',
 'Pitx1_extended_+_(155g)',
 'Pitx1_extended_-_(27g)',
 'Grhl2_+_(161g)',
 'Creb3l1_extended_+_(32g)']
```

[7]:
```
df1
```

[7]:

| | Unnamed: 0 | TF | g_cistrome_Id | \ |
|---|---|---|---|---|
| 0 | Ehf_+ | Ehf | Ehf_+_(15g) | |
| 1 | Grhl3_extended_+ | Grhl3 | Grhl3_extended_+_(90g) | |
| 2 | Nf1_extended_+ | Nf1 | Nf1_extended_+_(136g) | |
| 3 | Hmga2_extended_- | Hmga2 | Hmga2_extended_-_(46g) | |
| 4 | Clock_+ | Clock | Clock_+_(61g) | |
| 5 | Yy1_extended_- | Yy1 | Yy1_extended_-_(16g) | |
| 6 | Bhlhe41_extended_- | Bhlhe41 | Bhlhe41_extended_-_(14g) | |
| 7 | Zeb1_- | Zeb1 | Zeb1_-_(195g) | |
| 8 | Bhlhe40_+ | Bhlhe40 | Bhlhe40_+_(10g) | |
| 9 | Nfix_+ | Nfix | Nfix_+_(143g) | |
| 10 | Nfe2l1_+ | Nfe2l1 | Nfe2l1_+_(168g) | |
| 11 | Nfatc1_extended_+ | Nfatc1 | Nfatc1_extended_+_(135g) | |
| 12 | Fosl1_+ | Fosl1 | Fosl1_+_(70g) | |
| 13 | Klf6_extended_- | Klf6 | Klf6_extended_-_(36g) | |
| 14 | Etv1_+ | Etv1 | Etv1_+_(10g) | |
| 15 | Msc_extended_+ | Msc | Msc_extended_+_(43g) | |
| 16 | Sox5_- | Sox5 | Sox5_-_(63g) | |
| 17 | Snai1_- | Snai1 | Snai1_-_(12g) | |
| 18 | Cux1_extended_+ | Cux1 | Cux1_extended_+_(65g) | |
| 19 | Zeb2_- | Zeb2 | Zeb2_-_(65g) | |
| 20 | Tcf12_extended_- | Tcf12 | Tcf12_extended_-_(89g) | |
| 21 | Bach2_- | Bach2 | Bach2_-_(158g) | |

| | | | |
|---|---|---|---|
| 22 | Bach2_extended_+ | Bach2 | Bach2_extended_+_(296g) |
| 23 | Smad7_+ | Smad7 | Smad7_+_(44g) |
| 24 | Bnc2_extended_+ | Bnc2 | Bnc2_extended_+_(126g) |
| 25 | Ebf1_extended_+ | Ebf1 | Ebf1_extended_+_(80g) |
| 26 | Pitx1_extended_+ | Pitx1 | Pitx1_extended_+_(155g) |
| 27 | Pitx1_extended_- | Pitx1 | Pitx1_extended_-_(27g) |
| 28 | Grhl2_+ | Grhl2 | Grhl2_+_(161g) |
| 29 | Creb3l1_extended_+ | Creb3l1 | Creb3l1_extended_+_(32g) |
| 30 | Nfix_- | Nfix | Nfix_-_(22g) |
| 31 | Klf5_+ | Klf5 | Klf5_+_(89g) |
| 32 | Trp63_+ | Trp63 | Trp63_+_(80g) |
| 33 | Bnc2_extended_- | Bnc2 | Bnc2_extended_-_(117g) |
| 34 | Lcorl_extended_- | Lcorl | Lcorl_extended_-_(15g) |
| 35 | Nfib_+ | Nfib | Nfib_+_(148g) |
| 36 | Nfkb1_+ | Nfkb1 | Nfkb1_+_(62g) |
| 37 | Irf1_+ | Irf1 | Irf1_+_(52g) |

| | r_cistrome_Id | regulonId | TF_g_cistrome_corr | \ |
|---|---|---|---|---|
| 0 | Ehf_+_(15r) | Ehf_+ | 0.609956 | |
| 1 | Grhl3_extended_+_(111r) | Grhl3_extended_+ | 0.561358 | |
| 2 | Nf1_extended_+_(222r) | Nf1_extended_+ | 0.587895 | |
| 3 | Hmga2_extended_-_(61r) | Hmga2_extended_- | -0.518386 | |
| 4 | Clock_+_(68r) | Clock_+ | 0.519863 | |
| 5 | Yy1_extended_-_(28r) | Yy1_extended_- | -0.585263 | |
| 6 | Bhlhe41_extended_-_(18r) | Bhlhe41_extended_- | -0.648223 | |
| 7 | Zeb1_-_(508r) | Zeb1_- | -0.824844 | |
| 8 | Bhlhe40_+_(10r) | Bhlhe40_+ | 0.576513 | |
| 9 | Nfix_+_(275r) | Nfix_+ | 0.625564 | |
| 10 | Nfe2l1_+_(332r) | Nfe2l1_+ | 0.730500 | |
| 11 | Nfatc1_extended_+_(337r) | Nfatc1_extended_+ | 0.704601 | |
| 12 | Fosl1_+_(118r) | Fosl1_+ | 0.555599 | |
| 13 | Klf6_extended_-_(72r) | Klf6_extended_- | -0.545479 | |
| 14 | Etv1_+_(12r) | Etv1_+ | 0.529772 | |
| 15 | Msc_extended_+_(88r) | Msc_extended_+ | 0.568946 | |
| 16 | Sox5_-_(91r) | Sox5_- | -0.737036 | |
| 17 | Snai1_-_(17r) | Snai1_- | -0.648750 | |
| 18 | Cux1_extended_+_(72r) | Cux1_extended_+ | 0.615511 | |
| 19 | Zeb2_-_(85r) | Zeb2_- | -0.799171 | |
| 20 | Tcf12_extended_-_(173r) | Tcf12_extended_- | -0.628983 | |
| 21 | Bach2_-_(466r) | Bach2_- | -0.661311 | |
| 22 | Bach2_extended_+_(661r) | Bach2_extended_+ | 0.734184 | |
| 23 | Smad7_+_(44r) | Smad7_+ | 0.685807 | |
| 24 | Bnc2_extended_+_(281r) | Bnc2_extended_+ | 0.587125 | |
| 25 | Ebf1_extended_+_(105r) | Ebf1_extended_+ | 0.759182 | |
| 26 | Pitx1_extended_+_(175r) | Pitx1_extended_+ | 0.836649 | |
| 27 | Pitx1_extended_-_(30r) | Pitx1_extended_- | -0.825954 | |
| 28 | Grhl2_+_(240r) | Grhl2_+ | 0.885696 | |

| | | | |
|---|---|---|---|
| 29 | Creb3l1_extended_+_(47r) | Creb3l1_extended_+ | 0.521021 |
| 30 | Nfix_-_(25r) | Nfix_- | -0.527400 |
| 31 | Klf5_+_(151r) | Klf5_+ | 0.578755 |
| 32 | Trp63_+_(198r) | Trp63_+ | 0.857497 |
| 33 | Bnc2_extended_-_(275r) | Bnc2_extended_- | -0.503859 |
| 34 | Lcorl_extended_-_(17r) | Lcorl_extended_- | -0.536457 |
| 35 | Nfib_+_(353r) | Nfib_+ | 0.470803 |
| 36 | Nfkb1_+_(99r) | Nfkb1_+ | 0.327119 |
| 37 | Irf1_+_(73r) | Irf1_+ | 0.420811 |

| | TF_r_cistrome_corr | cistrome_cistrome_corr | method1_pass | method2_pass |
|---|---|---|---|---|
| 0 | 0.518921 | 0.295000 | True | False |
| 1 | 0.481951 | 0.472230 | True | False |
| 2 | 0.370165 | 0.433508 | True | False |
| 3 | -0.142682 | 0.393504 | True | False |
| 4 | 0.403181 | 0.549790 | True | True |
| 5 | -0.015611 | 0.277987 | True | False |
| 6 | -0.311871 | 0.290136 | True | False |
| 7 | -0.806216 | 0.821712 | True | True |
| 8 | 0.259239 | 0.250321 | True | False |
| 9 | 0.570398 | 0.544886 | True | True |
| 10 | 0.633516 | 0.398879 | True | False |
| 11 | 0.661040 | 0.764861 | True | True |
| 12 | 0.026143 | 0.363387 | True | False |
| 13 | -0.251915 | 0.231538 | True | False |
| 14 | 0.371418 | 0.210154 | True | False |
| 15 | 0.347774 | 0.435924 | True | False |
| 16 | -0.624423 | 0.244235 | True | False |
| 17 | -0.475944 | 0.325481 | True | False |
| 18 | 0.440892 | 0.584566 | True | True |
| 19 | -0.643254 | 0.701142 | True | True |
| 20 | -0.613520 | 0.406595 | True | False |
| 21 | -0.130250 | 0.502497 | True | True |
| 22 | 0.623521 | 0.531218 | True | True |
| 23 | 0.549200 | 0.507054 | True | True |
| 24 | 0.491025 | 0.443792 | True | False |
| 25 | 0.689229 | 0.642157 | True | True |
| 26 | 0.806846 | 0.438860 | True | False |
| 27 | -0.839684 | 0.707230 | True | True |
| 28 | 0.847961 | 0.803956 | True | True |
| 29 | 0.447731 | 0.563318 | True | True |
| 30 | -0.410786 | 0.371123 | True | False |
| 31 | 0.481583 | 0.488036 | True | False |
| 32 | 0.662012 | 0.515202 | True | True |
| 33 | -0.450369 | 0.479170 | True | False |
| 34 | -0.486706 | 0.307799 | True | False |
| 35 | 0.357558 | 0.537127 | False | True |

| | | | | |
|---|---|---|---|---|
| 36 | 0.266618 | 0.597751 | False | True |
| 37 | 0.251980 | 0.628352 | False | True |

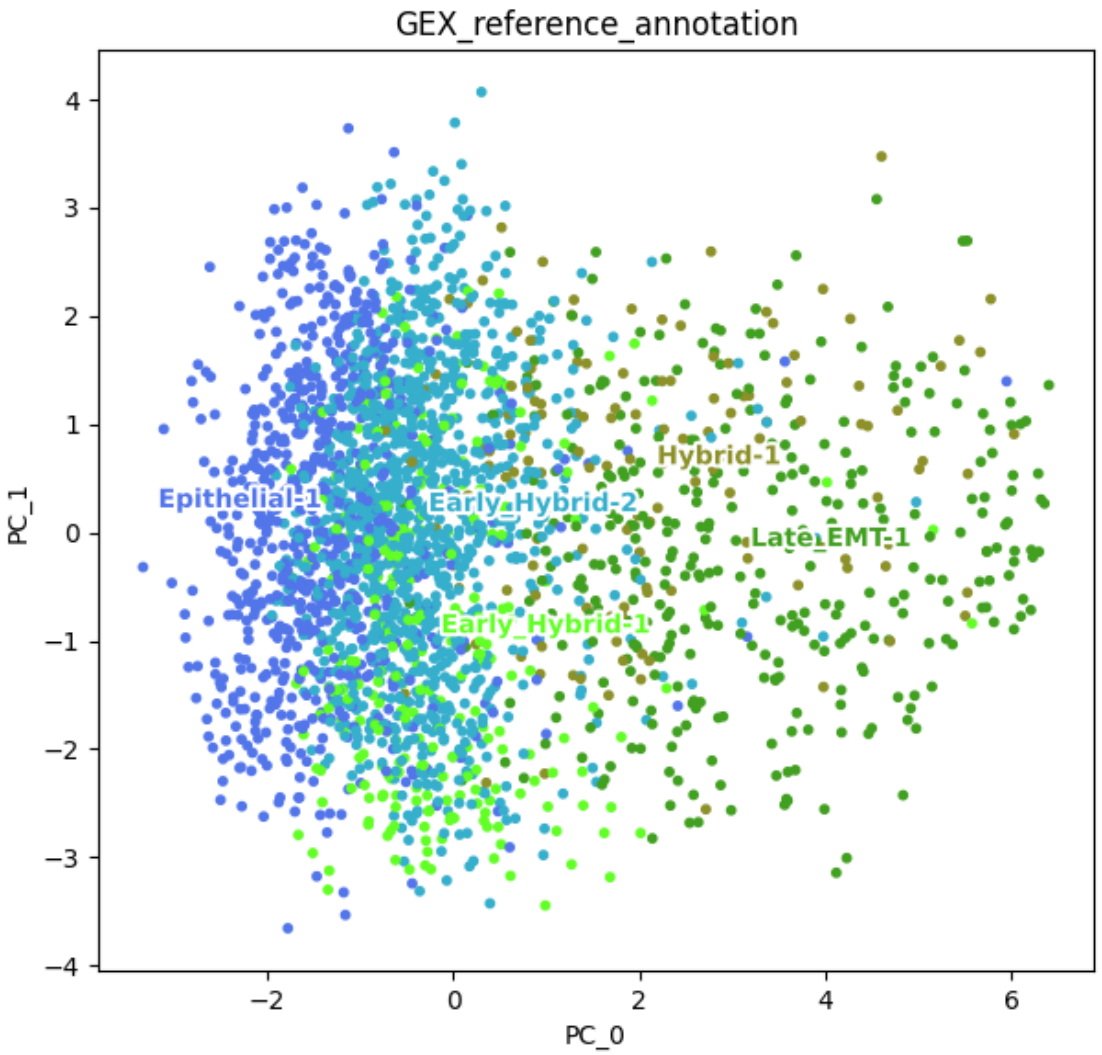
[8]:
```
len(sel_eRegulons)
```

[8]: 38

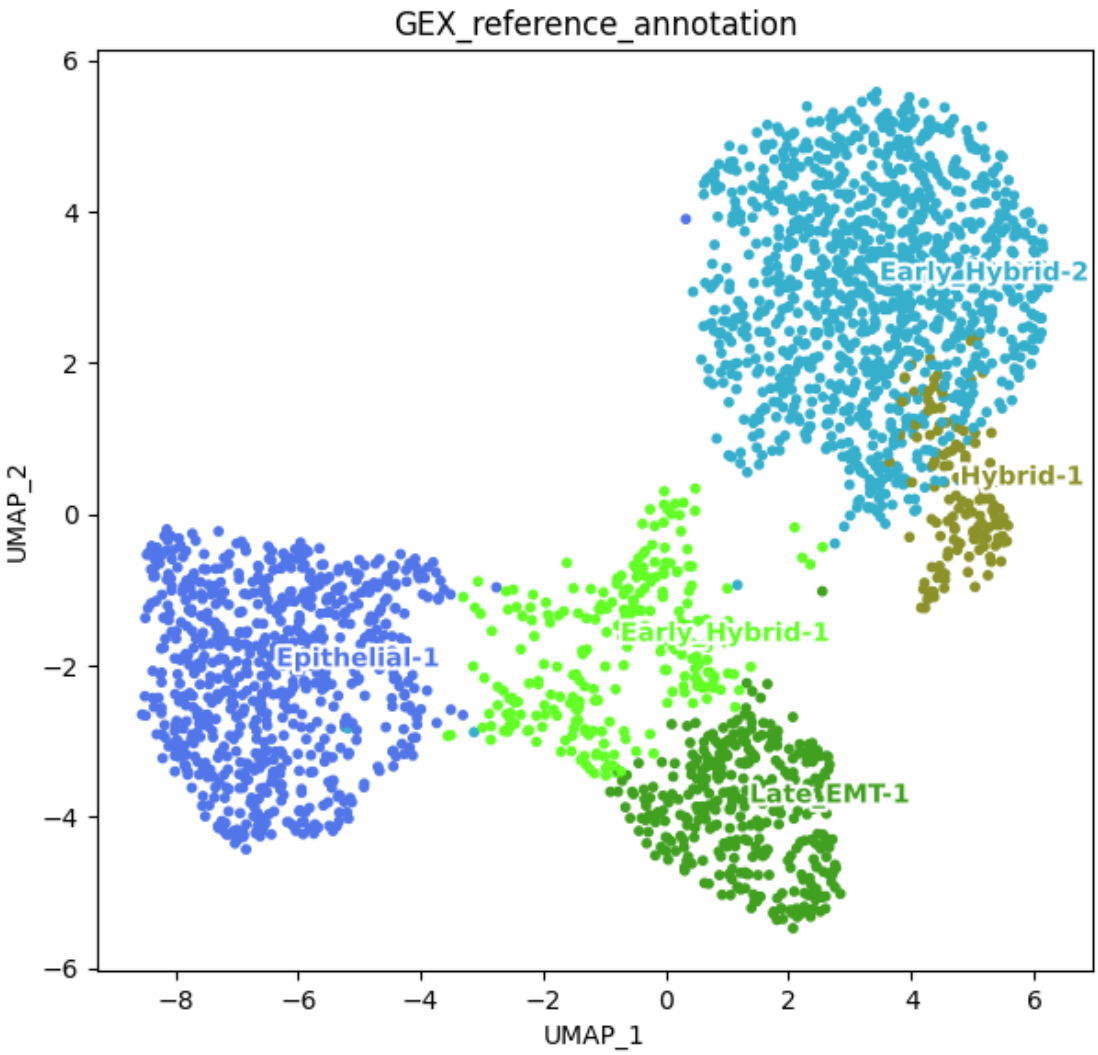
[9]:
```
run_eRegulons_pca(
        scplus_obj ,
        auc_key = 'eRegulon_AUC_filtered' ,
        reduction_name = 'eRegulons_PCA_gene_based' ,
        n_pcs = 20 ,
        selected_regulons = sel_eRegulons
)
```

[10]:
```
from scenicplus.dimensionality_reduction import plot_metadata
```

[11]:
```
plot_metadata(
    scplus_obj=scplus_obj,
    reduction_name = 'eRegulons_PCA_gene_based',
    variables = [ 'GEX_reference_annotation' ] ,
    figsize = (7.0,6.5)
)
```




[12]:
```
plot_metadata(
    scplus_obj=scplus_obj,
    reduction_name = 'ArchR_UMAP',
    variables = [ 'GEX_reference_annotation' ] ,
    figsize = (7.0,6.5)
)
```




## 3 Get HVGs

[13]:
```
from pycisTopic.diff_features import find_highly_variable_features
hvg = find_highly_variable_features(scplus_obj.to_df('EXP')[list(set(scplus_obj.
↪uns['eRegulon_metadata_filtered']['Gene']))].T, n_top_features = 500, plot =␣
↪False)
```

```
2024-06-14 06:58:15,791 cisTopic     INFO     Calculating mean
2024-06-14 06:58:15,796 cisTopic     INFO     Calculating variance
2024-06-14 06:58:15,868 cisTopic     INFO     Done!
```

```
<Figure size 640x480 with 0 Axes>
```

[14]:
```
flatten_list = lambda t: [item for sublist in t for item in sublist]
```

[15]:
```
DEGs = list(set(flatten_list([list(scplus_obj.uns['DEGs'][␣
↪'GEX_reference_annotation'  ][k].index) for k in scplus_obj.uns['DEGs'][␣
↪'GEX_reference_annotation'  ].keys()])))
```

[16]:
```
len(DEGs)
```

[16]:
```
975
```

[17]:
```
DEGs[1:20]
```

[17]:
```
['Atp2b4',
 'Ank',
 'Hoxc8',
 'Nrg1',
 'Ptprd',
 'Tnfrsf23',
 'Fbln5',
 'Syne1',
 '8030451A03Rik',
 'Crtac1',
 'Parp14',
 'Lsr',
 'Nebl',
 'Lama3',
 'Mgst1',
 'Prl2c2',
 'Dsc2',
 'Psapl1',
 'Fxyd4']
```

[18]:
```
from scenicplus.simulation import plot_perturbation_effect_in_embedding
import seaborn as sns
from scenicplus.simulation import *
from scenicplus.simulation import _make_rankings
```

[19]:
```
regressors = train_gene_expression_models(
        scplus_obj,
        eRegulon_metadata_key = 'eRegulon_metadata_filtered', #␣
↪eRegulon_metadata_filtered eRegulon_metadata
        genes = DEGs )
```

```
100%|
```

```
| 975/975 [05:21<00:00,  3.04it/s]
```

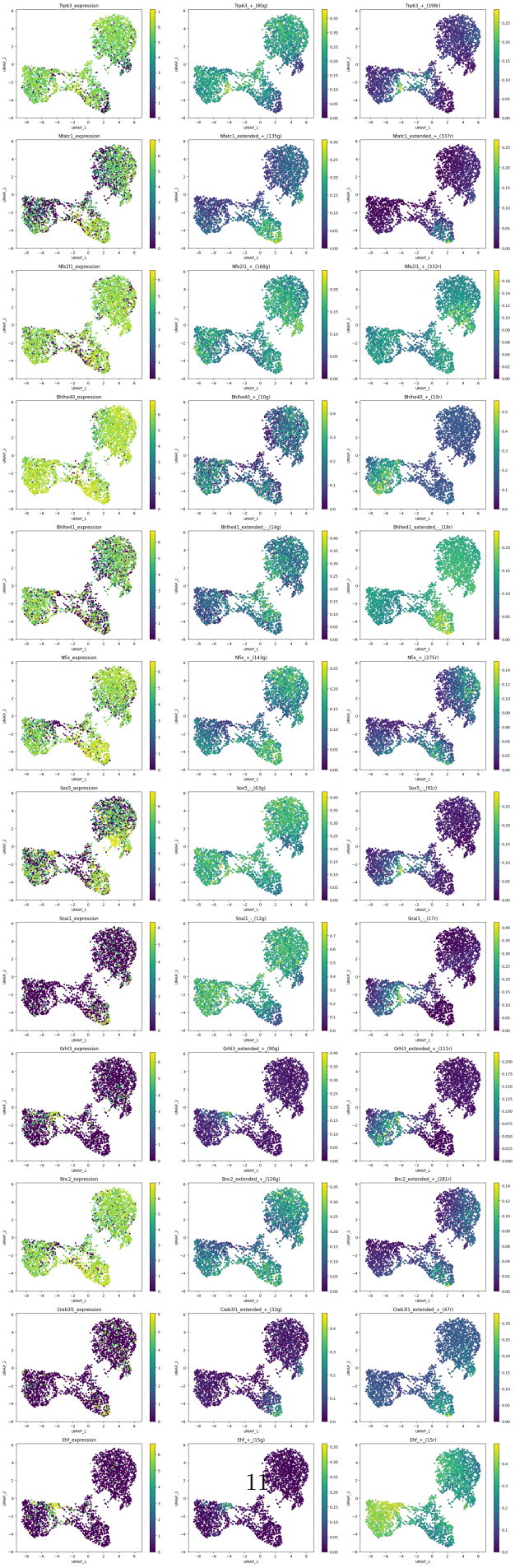
# 4 Run the perturbation Analysis for two TFs that should act in different directions

[20]:
```
TFs_of_interest = ['Trp63' , 'Nfatc1', 'Nfe2l1' , 'Bhlhe40' , 'Bhlhe41' , ␣
 ↪'Nfix', 'Sox5' , 'Snai1' , 'Grhl3' , 'Bnc2' , 'Creb3l1' , 'Ehf' ]
corresponding_regulons_of_interest = ['Trp63_+' , 'Nfatc1_extended_+',␣
 ↪'Nfe2l1_+' , 'Bhlhe40_+', 'Bhlhe41_extended_-',  'Nfix_+', 'Sox5_-' ,␣
 ↪'Snai1_-' , 'Grhl3_extended_+' , 'Bnc2_extended_+' , 'Creb3l1_extended_+' ,␣
 ↪'Ehf_+' ]
```

[21]:
```
from scenicplus.dimensionality_reduction import *
# https://github.com/aertslab/scenicplus/blob/old/docs/
 ↪Scenicplus_step_by_step-RTD.ipynb
# scplus_obj.uns.keys()
# scplus_obj.uns['eRegulon_AUC_filtered']
# scplus_obj.uns['eRegulon_AUC_filtered'].keys()
```

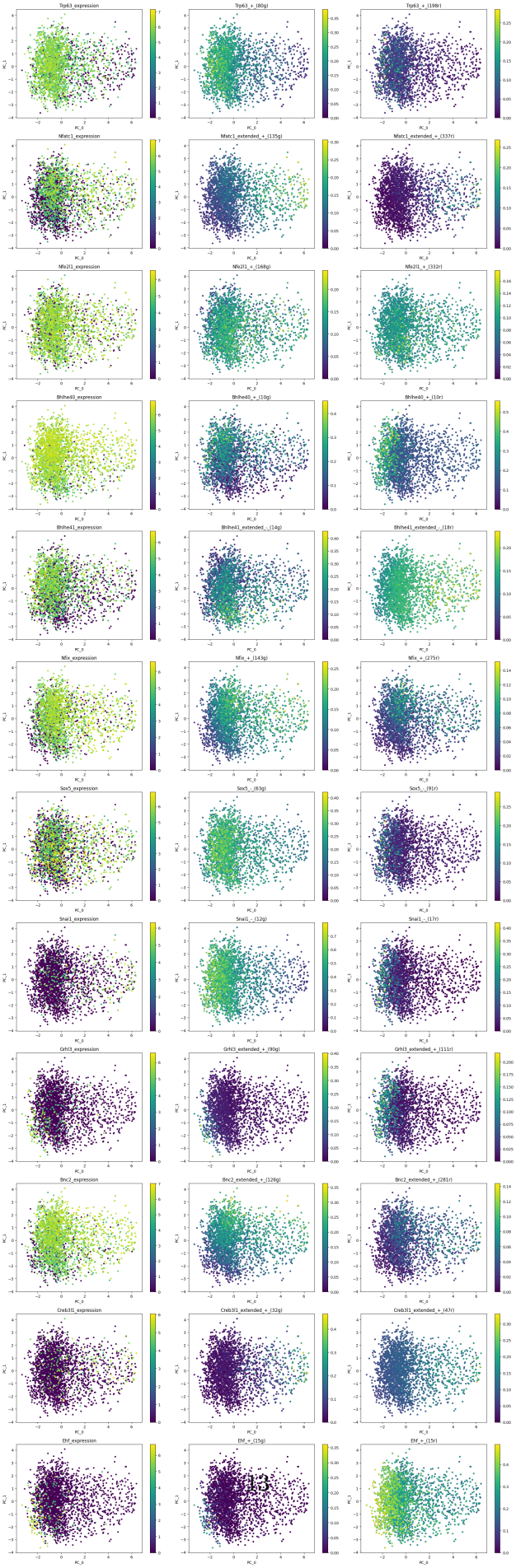
## 4.1 eRegulon plots on original embedding

[23]:
```
plot_eRegulon(scplus_obj,
              reduction_name='ArchR_UMAP',
              auc_key='eRegulon_AUC_filtered' ,
              selected_regulons=corresponding_regulons_of_interest,
              normalize_tf_expression=True)
```


Trp63_expression
Trp63_+_(80g)
Trp63_+_(198r)
Nfatc1_expression
Nfatc1_extended_+_(135g)
Nfatc1_extended_+_(337r)
Nfe2l1_expression
Nfe2l1_+_(168g)
Nfe2l1_+_(332r)
Bhlhe40_expression
Bhlhe40_+_(10g)
Bhlhe40_+_(10r)
Bhlhe41_expression
Bhlhe41_extended_-_(14g)
Bhlhe41_extended_-_(18r)
Nfix_expression
Nfix_+_(143g)
Nfix_+_(275r)
Sox5_expression
Sox5_-_(63g)
Sox5_-_(91r)
Snai1_expression
Snai1_-_(12g)
Snai1_-_(17r)
Grhl3_expression
Grhl3_extended_+_(90g)
Grhl3_extended_+_(111r)
Bnc2_expression
Bnc2_extended_+_(126g)
Bnc2_extended_+_(281r)
Creb3l1_expression
Creb3l1_extended_+_(32g)
Creb3l1_extended_+_(47r)
Ehf_expression
Ehf_+_(15g)
Ehf_+_(15r)
UMAP_1
UMAP_2

### 4.2 eRegulon plots on PCA embedding

[24]:
```
plot_eRegulon(scplus_obj,
              reduction_name='eRegulons_PCA_gene_based',
              auc_key='eRegulon_AUC_filtered' ,
              selected_regulons=corresponding_regulons_of_interest,
              normalize_tf_expression=True)
```


Trp63_expression
Trp63_+_(80g)
Trp63_+_(198r)
Nfatc1_expression
Nfatc1_extended_+_(135g)
Nfatc1_extended_+_(337r)
Nfe2l1_expression
Nfe2l1_+_(168g)
Nfe2l1_+_(332r)
Bhlhe40_expression
Bhlhe40_+_(10g)
Bhlhe40_+_(10r)
Bhlhe41_expression
Bhlhe41_extended_-_(14g)
Bhlhe41_extended_-_(18r)
Nfix_expression
Nfix_+_(143g)
Nfix_+_(275r)
Sox5_expression
Sox5_-_(63g)
Sox5_-_(91r)
Snai1_expression
Snai1_-_(12g)
Snai1_-_(17r)
Grhl3_expression
Grhl3_extended_+_(90g)
Grhl3_extended_+_(111r)
Bnc2_expression
Bnc2_extended_+_(126g)
Bnc2_extended_+_(281r)
Creb3l1_expression
Creb3l1_extended_+_(32g)
Creb3l1_extended_+_(47r)
Ehf_expression
Ehf_+_(15g)
Ehf_+_(15r)
PC_0
PC_1
PC_3

### 4.3 Perturbation Plots

[25]:
```
for TF in tqdm(TFs_of_interest, total = len(TFs_of_interest)):
        _ = plot_perturbation_effect_in_embedding(
                scplus_obj = scplus_obj ,
                reduction_name = 'eRegulons_PCA_gene_based' ,
                regressors = regressors ,
                n_cpu = NCPUS ,
                perturbation = { TF : 0} ,
                variable = 'GEX_reference_annotation' ,
                genes_to_use = hvg , # hvg DEGs
                figsize = (10, 10) )
```

```
  0%|
| 0/12 [00:00<?, ?it/s]
```

```
2024-06-14 07:03:57,043 perturbation INFO     Caclulating perturbation matrix
for: {'Trp63': 0} over 5 iterations.
```

```
  0%|
| 0/602 [00:00<?, ?it/s]
  1%|
| 4/602 [00:00<00:15, 37.70it/s]
  2%|
| 14/602 [00:00<00:11, 50.59it/s]
  6%|
| 34/602 [00:00<00:05, 101.82it/s]
  9%|
| 56/602 [00:00<00:04, 130.10it/s]
 13%|
| 81/602 [00:00<00:03, 166.38it/s]
 21%|
| 126/602 [00:00<00:01, 240.57it/s]
 32%|
| 192/602 [00:00<00:01, 324.57it/s]
 46%|

| 274/602 [00:00<00:00, 459.15it/s]
 53%|

| 322/602 [00:01<00:00, 352.82it/s]
 60%|

| 362/602 [00:01<00:00, 256.78it/s]
 75%|
```

```
| 451/602 [00:01<00:00, 338.50it/s]
 82%|

                                     | 491/602 [00:01<00:00, 283.30it/s]
 87%|

                                 | 524/602 [00:02<00:00, 239.39it/s]
 95%|

                           | 574/602 [00:02<00:00, 264.48it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
  5%|
| 33/602 [00:00<00:02, 246.60it/s]
 10%|
| 58/602 [00:00<00:05, 102.32it/s]
 12%|
| 73/602 [00:00<00:07, 71.74it/s]
 18%|
| 109/602 [00:00<00:04, 115.99it/s]
 21%|
| 126/602 [00:01<00:04, 108.98it/s]
 27%|
| 163/602 [00:01<00:02, 154.27it/s]
 31%|
| 184/602 [00:01<00:02, 152.59it/s]
 34%|
| 203/602 [00:01<00:03, 116.56it/s]
 37%|
| 220/602 [00:01<00:03, 110.02it/s]
39%|
| 234/602 [00:02<00:03, 94.72it/s]
 44%|

| 266/602 [00:02<00:02, 130.99it/s]
 47%|

| 283/602 [00:02<00:02, 137.04it/s]
 50%|

| 300/602 [00:02<00:03, 100.26it/s]
 52%|

| 313/602 [00:02<00:02, 105.03it/s]
 54%|
```

```
| 326/602 [00:03<00:03, 72.78it/s]
 57%|

| 345/602 [00:03<00:02, 91.51it/s]
 59%|

| 358/602 [00:03<00:02, 92.91it/s]
 62%|

| 374/602 [00:03<00:02, 100.22it/s]
 66%|

| 395/602 [00:03<00:01, 120.61it/s]
 69%|

| 413/602 [00:03<00:01, 126.31it/s]
 73%|

| 437/602 [00:03<00:01, 145.20it/s]
 75%|

| 454/602 [00:03<00:00, 149.71it/s]
 78%|

| 470/602 [00:04<00:00, 149.74it/s]
 85%|

                                    | 510/602 [00:04<00:00, 202.69it/s]
 88%|

                                 | 531/602 [00:04<00:00, 174.99it/s]
 91%|

                               | 550/602 [00:04<00:00, 126.40it/s]
 94%|

                             | 565/602 [00:04<00:00, 130.49it/s]
 96%|

                           | 580/602 [00:04<00:00, 125.04it/s]
 99%|

                        | 594/602 [00:04<00:00, 108.85it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
  0%|
| 2/602 [00:00<00:31, 19.31it/s]
```

```
  1%|
| 6/602 [00:00<00:28, 21.24it/s]
  3%|
| 20/602 [00:00<00:09, 59.32it/s]
  6%|
| 35/602 [00:00<00:07, 71.33it/s]
  8%|
| 47/602 [00:00<00:06, 80.17it/s]
  9%|
| 56/602 [00:00<00:10, 54.44it/s]
 11%|
| 64/602 [00:01<00:09, 58.63it/s]
 12%|
| 71/602 [00:01<00:08, 60.99it/s]
 13%|
| 78/602 [00:01<00:08, 60.84it/s]
 15%|
| 88/602 [00:01<00:08, 59.28it/s]
 16%|
| 95/602 [00:01<00:09, 51.55it/s]
 17%|
| 103/602 [00:01<00:09, 51.54it/s]
 18%|
| 109/602 [00:01<00:10, 48.25it/s]
 21%|
| 124/602 [00:02<00:06, 70.31it/s]
 22%|
| 132/602 [00:02<00:06, 71.15it/s]
 23%|
| 140/602 [00:02<00:06, 66.14it/s]
 25%|
| 148/602 [00:02<00:06, 69.15it/s]
 26%|
| 156/602 [00:02<00:08, 53.32it/s]
 27%|
| 163/602 [00:02<00:09, 47.02it/s]
 28%|
| 169/602 [00:02<00:08, 49.25it/s]
 29%|
| 175/602 [00:03<00:09, 42.85it/s]
 30%|
| 183/602 [00:03<00:09, 43.27it/s]
 33%|
| 196/602 [00:03<00:07, 55.22it/s]
 34%|
| 205/602 [00:03<00:07, 55.00it/s]
 36%|
| 217/602 [00:03<00:06, 60.04it/s]
```

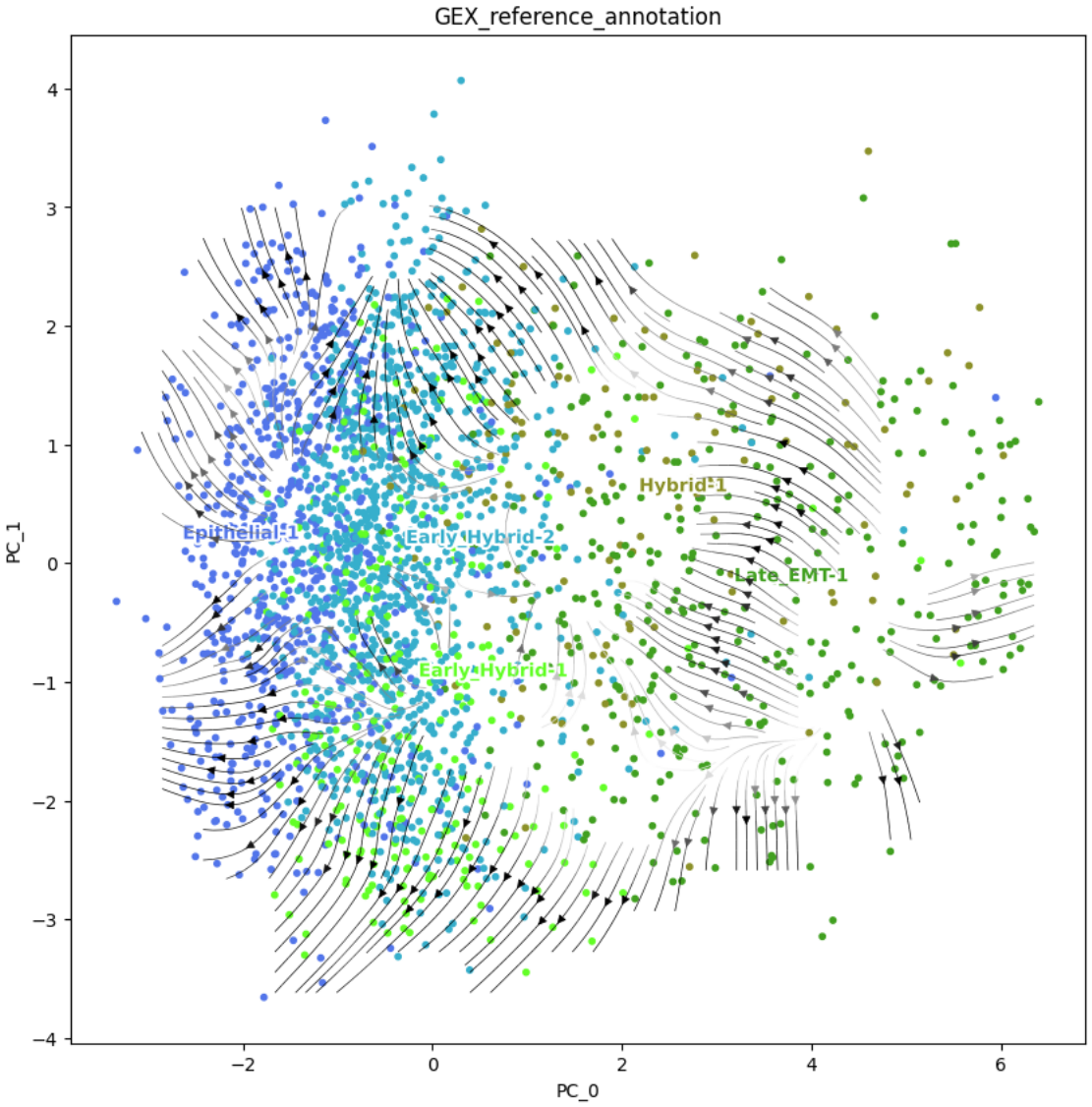
```
 37%|
| 224/602 [00:04<00:08, 45.21it/s]
 41%|

| 247/602 [00:04<00:04, 77.74it/s]
 43%|

| 259/602 [00:04<00:04, 75.74it/s]
 45%|

| 269/602 [00:04<00:04, 77.35it/s]
 46%|

| 279/602 [00:04<00:04, 69.21it/s]
 48%|

| 287/602 [00:04<00:04, 69.53it/s]
 49%|

| 295/602 [00:05<00:05, 59.23it/s]
 50%|

| 302/602 [00:05<00:05, 54.09it/s]
 51%|

| 308/602 [00:05<00:06, 48.45it/s]
 52%|

| 314/602 [00:05<00:08, 34.46it/s]
 53%|

| 322/602 [00:05<00:07, 37.43it/s]
 54%|

| 328/602 [00:05<00:06, 39.67it/s]
 56%|

| 338/602 [00:06<00:05, 44.70it/s]
 59%|

| 354/602 [00:06<00:04, 59.30it/s]
 60%|

| 361/602 [00:06<00:04, 54.74it/s]
 61%|

| 367/602 [00:06<00:04, 48.57it/s]
 65%|
```

```
| 391/602 [00:06<00:02, 77.54it/s]
 66%|

| 400/602 [00:07<00:03, 65.78it/s]
 68%|

| 412/602 [00:07<00:02, 67.50it/s]
 71%|

| 428/602 [00:07<00:02, 74.47it/s]
 72%|

| 436/602 [00:07<00:02, 64.51it/s]
 74%|

| 443/602 [00:07<00:03, 50.76it/s]
 75%|

| 449/602 [00:07<00:03, 46.26it/s]
 76%|

| 459/602 [00:08<00:02, 49.21it/s]
 77%|

| 465/602 [00:08<00:02, 50.26it/s]
 79%|

| 477/602 [00:08<00:01, 64.62it/s]
 81%|

                                      | 486/602 [00:08<00:01, 60.51it/s]
 82%|

                                     | 493/602 [00:08<00:02, 46.50it/s]
 83%|

                                    | 499/602 [00:09<00:02, 37.98it/s]
 85%|

                                  | 510/602 [00:09<00:01, 48.52it/s]
 87%|

                                | 523/602 [00:09<00:01, 55.32it/s]
 90%|

                              | 542/602 [00:09<00:00, 74.78it/s]
 92%|
```

```
                              | 551/602 [00:09<00:00, 65.65it/s]
 93%|

                             | 559/602 [00:09<00:00, 58.03it/s]
 94%|

                            | 566/602 [00:10<00:00, 50.53it/s]
 96%|

                           | 578/602 [00:10<00:00, 63.32it/s]
 98%|

                         | 587/602 [00:10<00:00, 63.12it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
  1%|
| 8/602 [00:00<00:09, 64.55it/s]
  2%|
| 15/602 [00:00<00:10, 57.75it/s]
 16%|
| 96/602 [00:00<00:01, 266.26it/s]
 20%|
| 120/602 [00:00<00:02, 235.72it/s]
 32%|
| 192/602 [00:00<00:01, 367.56it/s]
 38%|
| 231/602 [00:00<00:01, 235.46it/s]
 43%|

| 261/602 [00:01<00:01, 198.25it/s]
 54%|

| 328/602 [00:01<00:00, 286.87it/s]
 61%|

| 366/602 [00:01<00:00, 288.95it/s]
 67%|

| 402/602 [00:01<00:00, 291.47it/s]
 72%|

| 436/602 [00:01<00:00, 210.05it/s]
 77%|

| 463/602 [00:01<00:00, 214.12it/s]
 83%|
```

```
                                    | 502/602 [00:02<00:00, 239.47it/s]
 88%|

                                  | 532/602 [00:02<00:00, 229.20it/s]
 93%|

                               | 558/602 [00:02<00:00, 187.65it/s]
 97%|

                            | 582/602 [00:02<00:00, 184.88it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
  6%|
| 36/602 [00:00<00:01, 340.93it/s]
 12%|
| 71/602 [00:00<00:02, 203.64it/s]
 21%|
| 125/602 [00:00<00:01, 304.45it/s]
 32%|
| 193/602 [00:00<00:00, 421.01it/s]
 40%|

| 242/602 [00:00<00:01, 332.29it/s]
 49%|

| 293/602 [00:00<00:00, 375.89it/s]
 56%|

| 337/602 [00:01<00:00, 265.23it/s]
 62%|

| 374/602 [00:01<00:00, 275.13it/s]
 69%|

| 413/602 [00:01<00:00, 288.43it/s]
 75%|

| 454/602 [00:01<00:00, 313.55it/s]
 85%|

                                      | 512/602 [00:01<00:00, 359.10it/s]
 92%|

                                 | 551/602 [00:01<00:00, 346.13it/s]
 98%|
```

```
| 588/602 [00:01<00:00, 350.02it/s]

2024-06-14 07:04:20,951 perturbation INFO     Generating ranking based on
perturbed matrix.
2024-06-14 07:04:27,469 perturbation INFO     Scoring eRegulons.
2024-06-14 07:04:34,254 perturbation INFO     Projecting perturbation effect in
embedding: eRegulons_PCA_gene_based
2024-06-14 07:04:35,156 perturbation INFO     Calculating grid of arrows
2024-06-14 07:04:35,295 perturbation INFO     Plotting
```



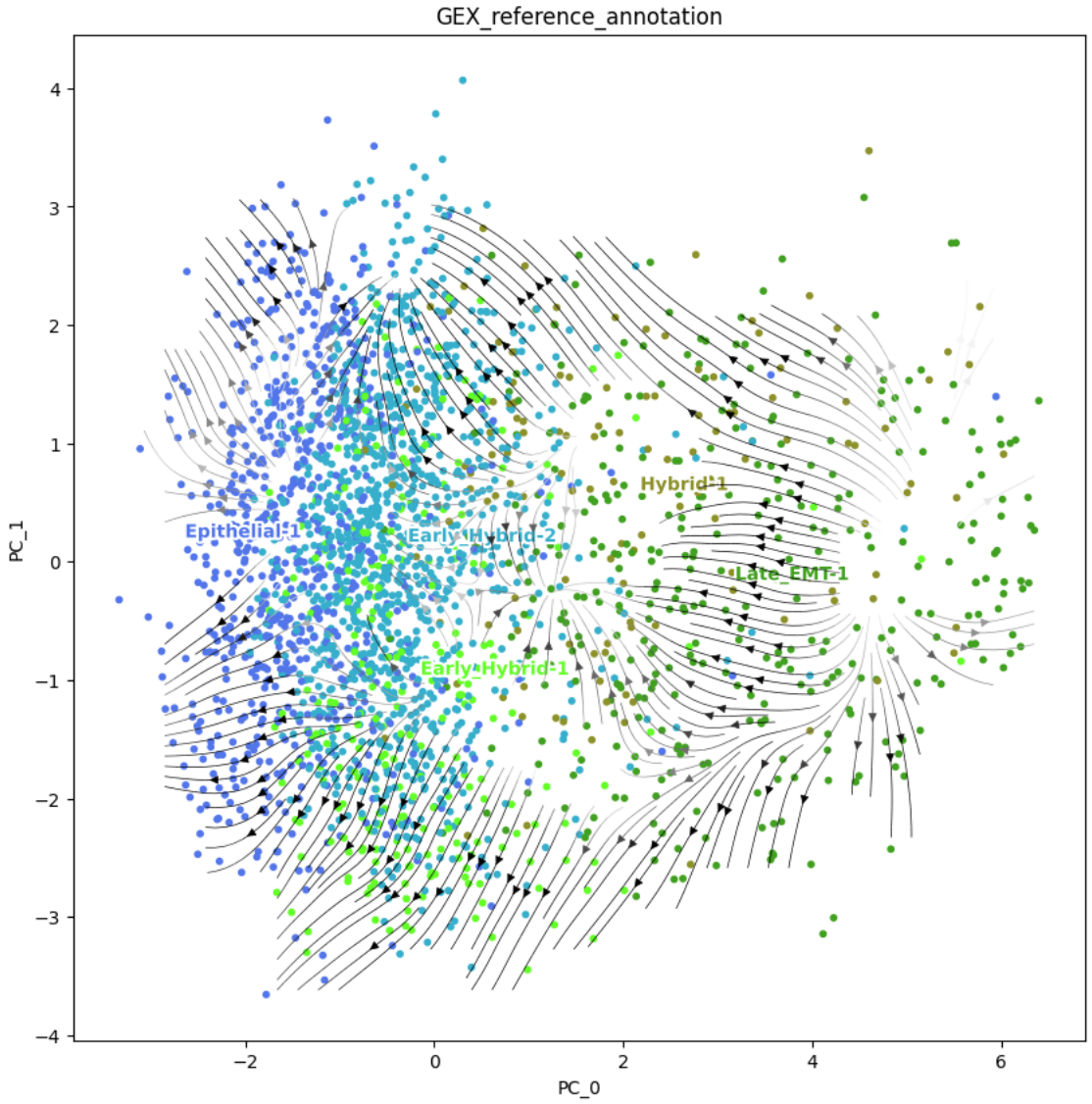

```
  8%|
| 1/12 [00:41<07:31, 41.01s/it]
```

```
2024-06-14 07:04:38,058 perturbation INFO     Caclulating perturbation matrix
for: {'Nfatc1': 0} over 5 iterations.


  0%|
| 0/602 [00:00<?, ?it/s]
  1%|
| 5/602 [00:00<00:13, 43.55it/s]
  3%|
| 21/602 [00:00<00:05, 108.10it/s]
  5%|
| 33/602 [00:00<00:05, 106.50it/s]
  7%|
| 44/602 [00:00<00:05, 106.24it/s]
  9%|
| 55/602 [00:00<00:10, 54.34it/s]
 11%|
| 67/602 [00:01<00:09, 57.77it/s]
 12%|
| 75/602 [00:01<00:08, 60.73it/s]
 15%|
| 92/602 [00:01<00:06, 84.13it/s]
 17%|
| 103/602 [00:01<00:05, 84.94it/s]
 19%|
| 113/602 [00:01<00:06, 74.25it/s]
 21%|
| 128/602 [00:01<00:06, 79.00it/s]
 25%|
| 151/602 [00:01<00:04, 105.38it/s]
 27%|
| 163/602 [00:02<00:04, 88.72it/s]
 29%|
| 173/602 [00:02<00:04, 88.81it/s]
 30%|
| 183/602 [00:02<00:05, 75.86it/s]
 32%|
| 194/602 [00:02<00:05, 79.82it/s]
 34%|
| 205/602 [00:02<00:05, 74.36it/s]
 35%|
| 213/602 [00:02<00:05, 74.06it/s]
 37%|
| 221/602 [00:02<00:07, 53.58it/s]
 38%|
| 228/602 [00:03<00:06, 56.07it/s]
 45%|
```

```
| 273/602 [00:03<00:02, 123.69it/s]
 48%|

| 286/602 [00:03<00:02, 106.41it/s]
 50%|

| 300/602 [00:03<00:02, 107.88it/s]
 52%|

| 312/602 [00:03<00:04, 72.04it/s]
 53%|

| 321/602 [00:04<00:04, 63.54it/s]
 55%|

| 329/602 [00:04<00:04, 64.09it/s]
 59%|

| 354/602 [00:04<00:02, 87.33it/s]
 60%|

| 364/602 [00:04<00:03, 77.59it/s]
 62%|

| 373/602 [00:04<00:02, 79.84it/s]
 63%|

| 382/602 [00:04<00:02, 81.95it/s]
 66%|

| 397/602 [00:04<00:02, 97.67it/s]
 68%|

| 412/602 [00:05<00:01, 106.71it/s]
 72%|

| 432/602 [00:05<00:01, 117.58it/s]
 74%|

| 445/602 [00:05<00:01, 85.85it/s]
 76%|

| 459/602 [00:05<00:01, 84.12it/s]
 78%|

| 469/602 [00:05<00:01, 85.20it/s]
 80%|
```

```
| 479/602 [00:05<00:01, 86.76it/s]
 81%|

                                      | 490/602 [00:05<00:01, 78.75it/s]
 83%|

                                    | 499/602 [00:06<00:01, 57.98it/s]
 85%|

                                  | 510/602 [00:06<00:01, 59.32it/s]
 89%|

                               | 538/602 [00:06<00:00, 99.03it/s]
 92%|

                              | 551/602 [00:06<00:00, 84.12it/s]
 95%|

                           | 574/602 [00:06<00:00, 112.12it/s]
 98%|

                         | 589/602 [00:07<00:00, 102.58it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 14%|
| 83/602 [00:00<00:00, 827.91it/s]
 30%|
| 181/602 [00:00<00:00, 914.57it/s]
 50%|

| 301/602 [00:00<00:00, 1042.18it/s]
 67%|

| 406/602 [00:00<00:00, 1035.80it/s]
 87%|

                                 | 526/602 [00:00<00:00, 1094.23it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 21%|
| 125/602 [00:00<00:00, 1240.02it/s]
 42%|

| 250/602 [00:00<00:00, 1208.18it/s]
 62%|
```

```
| 371/602 [00:00<00:00, 1058.83it/s]
 80%|

| 484/602 [00:00<00:00, 1083.93it/s]
 99%|

                    | 594/602 [00:00<00:00, 1055.91it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 20%|
| 123/602 [00:00<00:00, 1222.99it/s]
 41%|

| 246/602 [00:00<00:00, 1212.19it/s]
 61%|

| 368/602 [00:00<00:00, 1205.43it/s]
 81%|

                                   | 489/602 [00:00<00:00, 1203.52it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 14%|
| 83/602 [00:00<00:00, 824.71it/s]
 30%|
| 180/602 [00:00<00:00, 906.18it/s]
 47%|

| 280/602 [00:00<00:00, 947.95it/s]
 66%|

| 399/602 [00:00<00:00, 1043.10it/s]
 84%|

                                 | 504/602 [00:00<00:00, 989.65it/s]

2024-06-14 07:04:48,679 perturbation INFO     Generating ranking based on
perturbed matrix.
2024-06-14 07:04:55,285 perturbation INFO     Scoring eRegulons.
2024-06-14 07:05:02,202 perturbation INFO     Projecting perturbation effect in
embedding: eRegulons_PCA_gene_based
2024-06-14 07:05:03,074 perturbation INFO     Calculating grid of arrows
2024-06-14 07:05:03,192 perturbation INFO     Plotting
```




```
 17%|
| 2/12 [01:08<05:32, 33.22s/it]
```

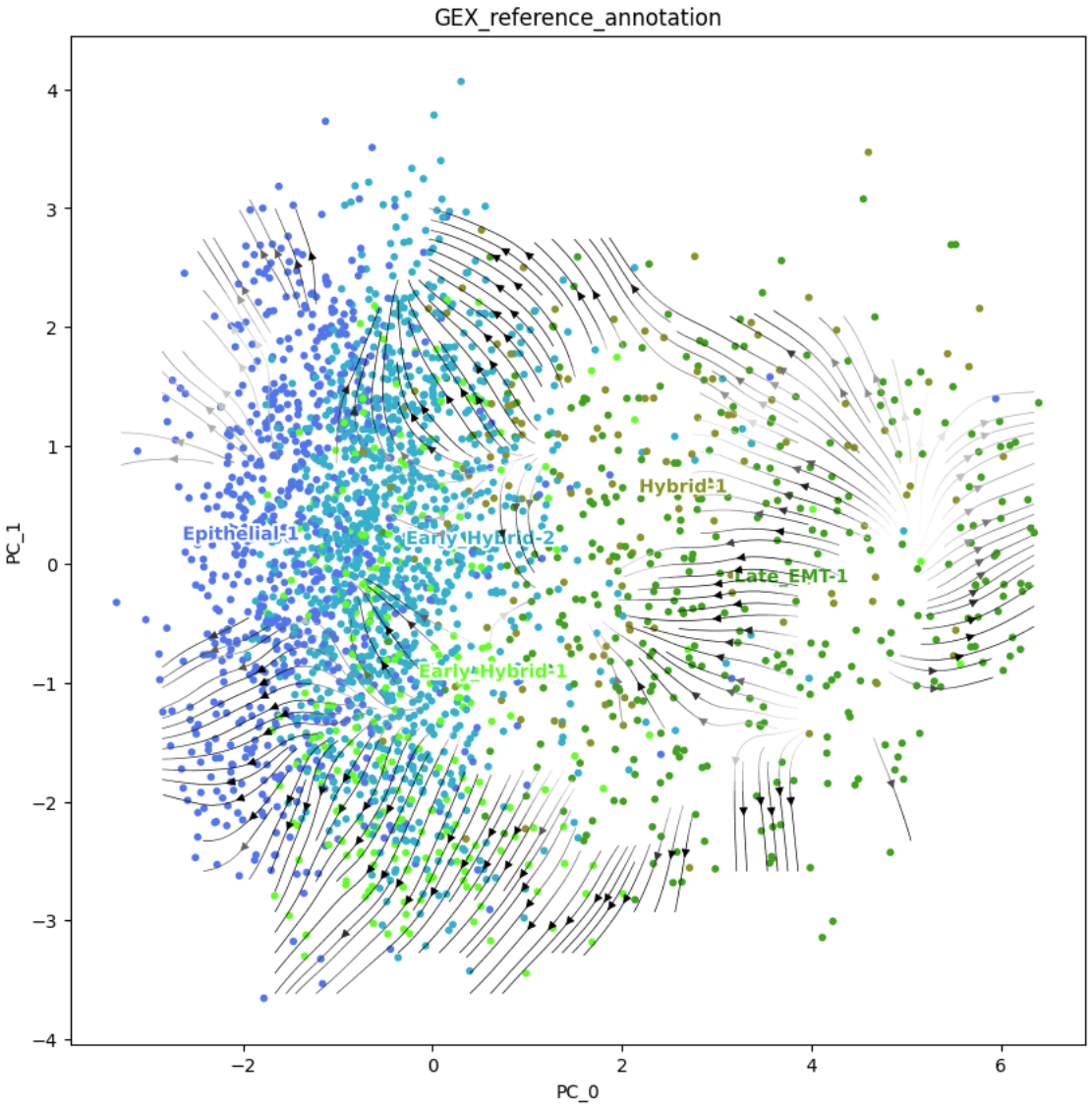
```
2024-06-14 07:05:05,825 perturbation INFO     Caclulating perturbation matrix
for: {'Nfe2l1': 0} over 5 iterations.
```

```
  0%|
| 0/602 [00:00<?, ?it/s]
  3%|
| 21/602 [00:00<00:02, 199.81it/s]
  7%|
| 44/602 [00:00<00:02, 207.39it/s]
 12%|
```

```
| 72/602 [00:00<00:02, 212.66it/s]
 28%|
| 171/602 [00:00<00:00, 490.60it/s]
 37%|
| 223/602 [00:00<00:00, 465.08it/s]
 45%|

| 272/602 [00:00<00:00, 415.30it/s]
 56%|

| 340/602 [00:00<00:00, 414.23it/s]
 64%|

| 383/602 [00:01<00:00, 294.96it/s]
 69%|

| 418/602 [00:01<00:00, 274.69it/s]
 81%|

                                     | 485/602 [00:01<00:00, 329.89it/s]
 87%|

                                | 522/602 [00:01<00:00, 305.83it/s]
 92%|

                            | 555/602 [00:01<00:00, 293.50it/s]
 97%|

                        | 586/602 [00:01<00:00, 295.19it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 19%|
| 112/602 [00:00<00:00, 1113.02it/s]
 37%|
| 224/602 [00:00<00:00, 1069.58it/s]
 57%|

| 345/602 [00:00<00:00, 1130.54it/s]
 76%|

| 459/602 [00:00<00:00, 1086.13it/s]
 94%|

                          | 568/602 [00:00<00:00, 1002.34it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
```

```
 14%|
| 83/602 [00:00<00:00, 825.74it/s]
 33%|
| 200/602 [00:00<00:00, 1026.63it/s]
 53%|

| 320/602 [00:00<00:00, 1103.94it/s]
 72%|

| 431/602 [00:00<00:00, 951.23it/s]
 90%|

                           | 544/602 [00:00<00:00, 1009.51it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 19%|
| 112/602 [00:00<00:00, 1117.57it/s]
 39%|
| 234/602 [00:00<00:00, 1174.15it/s]
 58%|

| 352/602 [00:00<00:00, 1136.30it/s]
 77%|

| 466/602 [00:00<00:00, 1068.08it/s]
 95%|

                       | 574/602 [00:00<00:00, 1003.74it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 19%|
| 114/602 [00:00<00:00, 1137.37it/s]
 38%|
| 228/602 [00:00<00:00, 974.10it/s]
 54%|

| 327/602 [00:00<00:00, 913.14it/s]
 70%|

| 420/602 [00:00<00:00, 884.89it/s]
 86%|

                               | 520/602 [00:00<00:00, 921.47it/s]

2024-06-14 07:05:11,267 perturbation INFO     Generating ranking based on
```

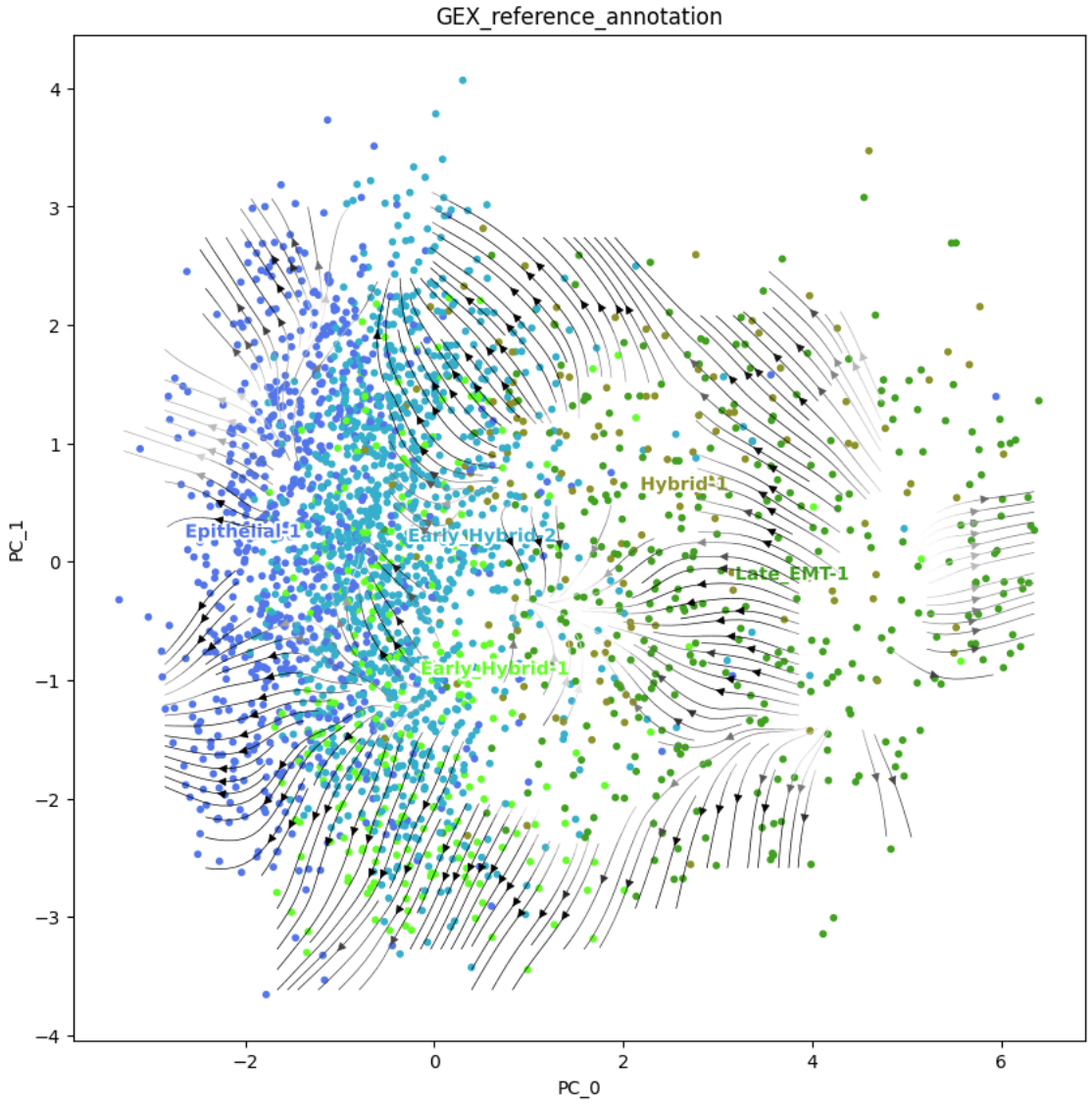
```
perturbed matrix.
2024-06-14 07:05:17,880 perturbation INFO     Scoring eRegulons.
2024-06-14 07:05:24,959 perturbation INFO     Projecting perturbation effect in
embedding: eRegulons_PCA_gene_based
2024-06-14 07:05:25,864 perturbation INFO     Calculating grid of arrows
2024-06-14 07:05:25,970 perturbation INFO     Plotting
```




```
 25%|
| 3/12 [01:31<04:16, 28.48s/it]
2024-06-14 07:05:28,666 perturbation INFO     Caclulating perturbation matrix
for: {'Bhlhe40': 0} over 5 iterations.
```

```
  0%|
| 0/602 [00:00<?, ?it/s]
 17%|
| 103/602 [00:00<00:00, 1021.13it/s]
 36%|
| 214/602 [00:00<00:00, 1071.80it/s]
 53%|

| 322/602 [00:00<00:00, 796.47it/s]
 68%|

| 409/602 [00:00<00:00, 815.02it/s]
 84%|

                                  | 506/602 [00:00<00:00, 862.72it/s]
 99%|

                     | 598/602 [00:00<00:00, 879.59it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 20%|
| 123/602 [00:00<00:00, 1229.12it/s]
 41%|

| 246/602 [00:00<00:00, 1217.51it/s]
 61%|

| 369/602 [00:00<00:00, 1220.72it/s]
 82%|

                                    | 492/602 [00:00<00:00, 1126.00it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 21%|
| 124/602 [00:00<00:00, 1231.68it/s]
 41%|

| 248/602 [00:00<00:00, 1217.89it/s]
 61%|

| 370/602 [00:00<00:00, 1127.74it/s]
 82%|

                                    | 491/602 [00:00<00:00, 1156.26it/s]

  0%|
```

```
| 0/602 [00:00<?, ?it/s]
 15%|
| 90/602 [00:00<00:00, 894.47it/s]
 35%|
| 211/602 [00:00<00:00, 1071.44it/s]
 53%|

| 319/602 [00:00<00:00, 990.42it/s]
 70%|

| 419/602 [00:00<00:00, 983.21it/s]
 89%|

                              | 535/602 [00:00<00:00, 1042.92it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 17%|
| 100/602 [00:00<00:00, 997.20it/s]
 34%|
| 206/602 [00:00<00:00, 1032.59it/s]
 54%|

| 325/602 [00:00<00:00, 1103.62it/s]
 74%|

| 448/602 [00:00<00:00, 1152.08it/s]
 94%|

                         | 567/602 [00:00<00:00, 1162.60it/s]

2024-06-14 07:05:32,711 perturbation INFO     Generating ranking based on
perturbed matrix.
2024-06-14 07:05:39,296 perturbation INFO     Scoring eRegulons.
2024-06-14 07:05:46,277 perturbation INFO     Projecting perturbation effect in
embedding: eRegulons_PCA_gene_based
2024-06-14 07:05:47,212 perturbation INFO     Calculating grid of arrows
2024-06-14 07:05:47,335 perturbation INFO     Plotting
```



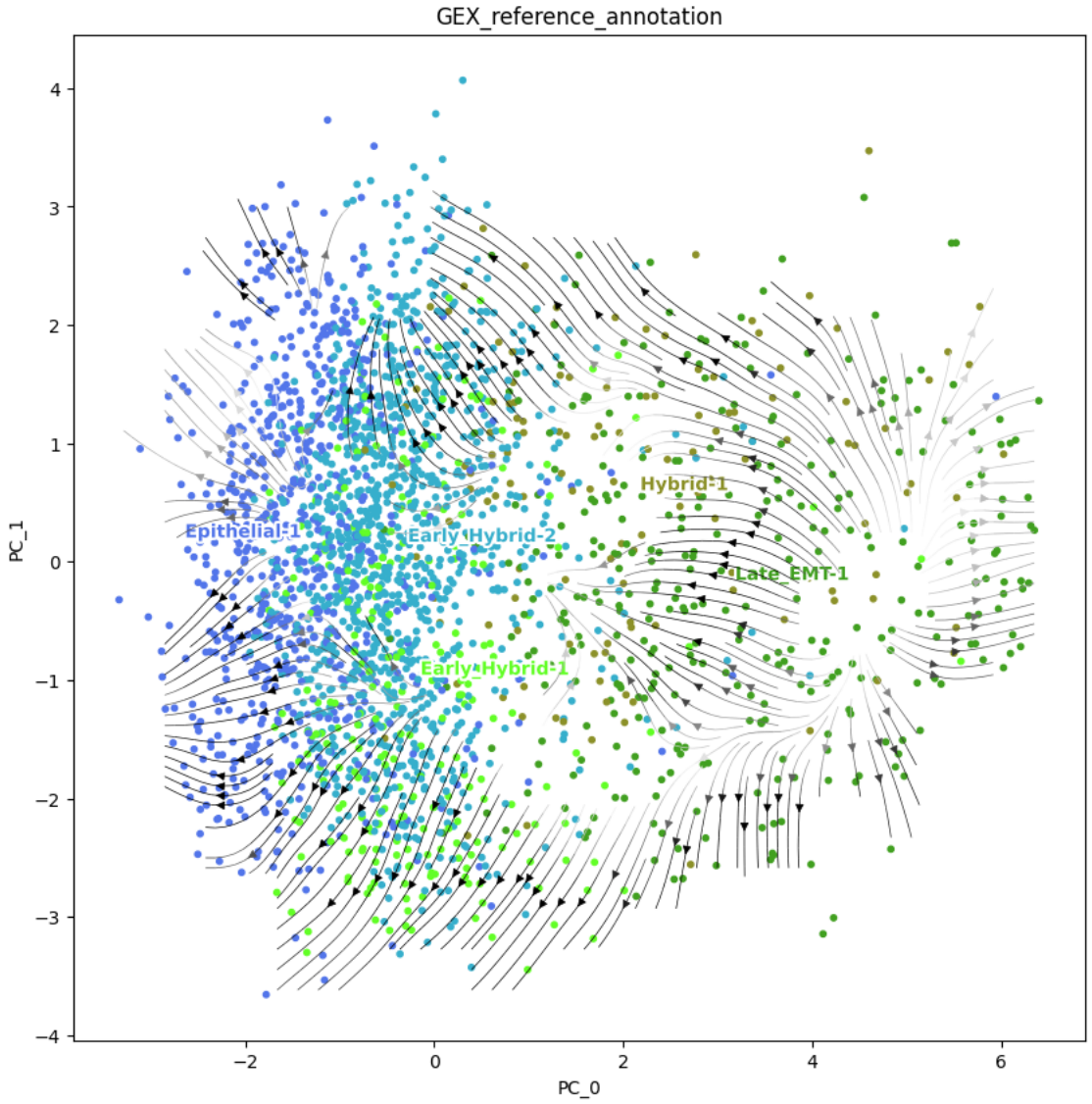

```
 33%|
| 4/12 [01:52<03:25, 25.67s/it]
```

```
2024-06-14 07:05:50,034 perturbation INFO     Caclulating perturbation matrix
for: {'Bhlhe41': 0} over 5 iterations.
```

```
  0%|
| 0/602 [00:00<?, ?it/s]
  1%|
| 4/602 [00:00<00:18, 31.57it/s]
 21%|
| 126/602 [00:00<00:00, 659.81it/s]
 33%|
```

```
| 199/602 [00:00<00:00, 573.62it/s]
 47%|

| 281/602 [00:00<00:00, 525.37it/s]
 57%|

| 344/602 [00:00<00:00, 498.73it/s]
 78%|

| 468/602 [00:00<00:00, 692.71it/s]
 95%|

                        | 572/602 [00:00<00:00, 786.72it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 15%|
| 91/602 [00:00<00:00, 907.43it/s]
 35%|
| 208/602 [00:00<00:00, 1057.59it/s]
 52%|

| 314/602 [00:00<00:00, 985.01it/s]
 69%|

| 414/602 [00:00<00:00, 940.40it/s]
 86%|

                                | 519/602 [00:00<00:00, 976.78it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 21%|
| 124/602 [00:00<00:00, 1234.54it/s]
 41%|

| 248/602 [00:00<00:00, 1112.22it/s]
 60%|

| 361/602 [00:00<00:00, 1096.05it/s]
 78%|

| 471/602 [00:00<00:00, 1093.09it/s]
 98%|

                    | 592/602 [00:00<00:00, 1125.66it/s]

  0%|
```

```
| 0/602 [00:00<?, ?it/s]
 16%|
| 95/602 [00:00<00:00, 943.42it/s]
 32%|
| 195/602 [00:00<00:00, 975.48it/s]
 49%|

| 293/602 [00:00<00:00, 867.80it/s]
 69%|

| 413/602 [00:00<00:00, 988.57it/s]
 85%|

                                  | 514/602 [00:00<00:00, 963.52it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 16%|
| 98/602 [00:00<00:00, 973.19it/s]
 33%|
| 196/602 [00:00<00:00, 970.83it/s]
 49%|

| 294/602 [00:00<00:00, 971.36it/s]
 66%|

| 397/602 [00:00<00:00, 994.19it/s]
 85%|

                                  | 514/602 [00:00<00:00, 1055.51it/s]

2024-06-14 07:05:54,546 perturbation INFO     Generating ranking based on
perturbed matrix.
2024-06-14 07:06:01,115 perturbation INFO     Scoring eRegulons.
2024-06-14 07:06:08,063 perturbation INFO     Projecting perturbation effect in
embedding: eRegulons_PCA_gene_based
2024-06-14 07:06:08,959 perturbation INFO     Calculating grid of arrows
2024-06-14 07:06:09,065 perturbation INFO     Plotting
```




```
 42%|

| 5/12 [02:14<02:49, 24.24s/it]

2024-06-14 07:06:11,744 perturbation INFO     Caclulating perturbation matrix
for: {'Nfix': 0} over 5 iterations.


  0%|
| 0/602 [00:00<?, ?it/s]
  0%|
| 3/602 [00:00<00:20, 28.57it/s]
  1%|
| 6/602 [00:00<00:21, 27.83it/s]
```

```
  4%|
| 23/602 [00:00<00:06, 89.87it/s]
  6%|
| 37/602 [00:00<00:06, 85.80it/s]
  8%|
| 46/602 [00:00<00:08, 66.87it/s]
  9%|
| 54/602 [00:00<00:08, 66.99it/s]
 10%|
| 62/602 [00:00<00:09, 57.48it/s]
 14%|
| 85/602 [00:01<00:05, 94.87it/s]
 16%|
| 96/602 [00:01<00:06, 80.94it/s]
 20%|
| 123/602 [00:01<00:03, 122.55it/s]
 23%|
| 138/602 [00:01<00:05, 91.96it/s]
 25%|
| 150/602 [00:01<00:04, 92.41it/s]
 27%|
| 162/602 [00:01<00:05, 80.15it/s]
 29%|
| 174/602 [00:02<00:04, 87.95it/s]
 31%|
| 185/602 [00:02<00:05, 79.62it/s]
 32%|
| 195/602 [00:02<00:05, 72.66it/s]
 40%|

| 241/602 [00:02<00:02, 147.16it/s]
 44%|

| 263/602 [00:02<00:02, 150.64it/s]
 47%|

| 280/602 [00:02<00:02, 131.26it/s]
 49%|

| 295/602 [00:03<00:02, 105.23it/s]
 51%|

| 308/602 [00:03<00:03, 90.36it/s]
 54%|

| 328/602 [00:03<00:02, 96.13it/s]
 56%|
```

```
| 339/602 [00:03<00:03, 84.55it/s]
 60%|

| 364/602 [00:03<00:02, 111.32it/s]
 63%|

| 377/602 [00:03<00:02, 111.59it/s]
 65%|

| 390/602 [00:04<00:01, 114.42it/s]
 69%|

| 418/602 [00:04<00:01, 145.78it/s]
 72%|

| 434/602 [00:04<00:01, 142.86it/s]
 77%|

| 463/602 [00:04<00:00, 177.16it/s]
 80%|

| 482/602 [00:04<00:00, 168.03it/s]
 83%|

                                    | 501/602 [00:04<00:00, 173.31it/s]
 86%|

                                  | 519/602 [00:05<00:00, 90.23it/s]
 89%|

                                | 537/602 [00:05<00:00, 102.21it/s]
 93%|

                              | 558/602 [00:05<00:00, 106.95it/s]
 99%|

                        | 597/602 [00:05<00:00, 150.07it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
  1%|
| 6/602 [00:00<00:11, 50.04it/s]
  3%|
| 20/602 [00:00<00:06, 83.75it/s]
  5%|
| 33/602 [00:00<00:07, 77.09it/s]
  7%|
| 41/602 [00:00<00:10, 55.87it/s]
```

```
  8%|
| 48/602 [00:00<00:11, 46.74it/s]
  9%|
| 54/602 [00:00<00:11, 49.24it/s]
 10%|
| 60/602 [00:01<00:11, 49.18it/s]
 11%|
| 66/602 [00:01<00:14, 36.56it/s]
 12%|
| 71/602 [00:01<00:15, 34.11it/s]
 12%|
| 75/602 [00:01<00:15, 34.52it/s]
 15%|
| 88/602 [00:01<00:09, 53.75it/s]
 17%|
| 100/602 [00:01<00:07, 68.83it/s]
 18%|
| 108/602 [00:01<00:07, 68.25it/s]
 19%|
| 116/602 [00:02<00:08, 56.85it/s]
 20%|
| 123/602 [00:02<00:08, 59.38it/s]
 22%|
| 130/602 [00:02<00:08, 52.48it/s]
 25%|
| 148/602 [00:02<00:05, 78.71it/s]
 26%|
| 159/602 [00:02<00:05, 85.99it/s]
 28%|
| 169/602 [00:02<00:05, 73.86it/s]
 30%|
| 178/602 [00:03<00:07, 57.45it/s]
 32%|
| 194/602 [00:03<00:05, 73.51it/s]
 34%|
| 203/602 [00:03<00:06, 66.17it/s]
 35%|
| 211/602 [00:03<00:07, 53.46it/s]
 36%|
| 218/602 [00:03<00:07, 48.48it/s]
 37%|
| 224/602 [00:04<00:08, 42.33it/s]
 38%|
| 229/602 [00:04<00:09, 39.10it/s]
 40%|

| 240/602 [00:04<00:08, 45.20it/s]
 42%|
```

```
| 254/602 [00:04<00:05, 59.97it/s]
 44%|

| 266/602 [00:04<00:04, 71.57it/s]
 46%|

| 275/602 [00:04<00:05, 61.16it/s]
 47%|

| 284/602 [00:05<00:05, 59.18it/s]
 49%|

| 294/602 [00:05<00:05, 58.33it/s]
 50%|

| 301/602 [00:05<00:07, 42.83it/s]
 51%|

| 307/602 [00:05<00:07, 40.02it/s]
 52%|

| 312/602 [00:05<00:08, 35.61it/s]
 52%|

| 316/602 [00:06<00:10, 27.83it/s]
 53%|

| 320/602 [00:06<00:10, 27.00it/s]
 54%|

| 323/602 [00:06<00:11, 23.77it/s]
 55%|

| 331/602 [00:06<00:08, 31.06it/s]
 56%|

| 337/602 [00:06<00:07, 35.89it/s]
 58%|

| 351/602 [00:06<00:04, 56.04it/s]
 59%|

| 358/602 [00:07<00:06, 38.26it/s]
 60%|

| 364/602 [00:07<00:05, 41.78it/s]
 62%|
```

```
| 374/602 [00:07<00:04, 48.50it/s]
 66%|

| 395/602 [00:07<00:02, 79.46it/s]
 67%|

| 405/602 [00:07<00:02, 69.48it/s]
 69%|

| 414/602 [00:07<00:03, 61.84it/s]
 71%|

| 428/602 [00:08<00:02, 67.14it/s]
 72%|

| 436/602 [00:08<00:02, 67.51it/s]
 74%|

| 444/602 [00:08<00:03, 47.36it/s]
 75%|

| 450/602 [00:08<00:03, 42.37it/s]
 76%|

| 456/602 [00:08<00:03, 39.87it/s]
 77%|

| 461/602 [00:09<00:03, 36.65it/s]
 81%|

                                     | 486/602 [00:09<00:01, 69.33it/s]
 82%|

                                    | 494/602 [00:09<00:01, 63.63it/s]
 83%|

                                   | 501/602 [00:09<00:01, 56.26it/s]
 85%|

                                  | 512/602 [00:09<00:01, 59.30it/s]
 86%|

                                 | 519/602 [00:09<00:01, 60.32it/s]
 88%|

                                | 528/602 [00:10<00:01, 66.79it/s]
 90%|
```

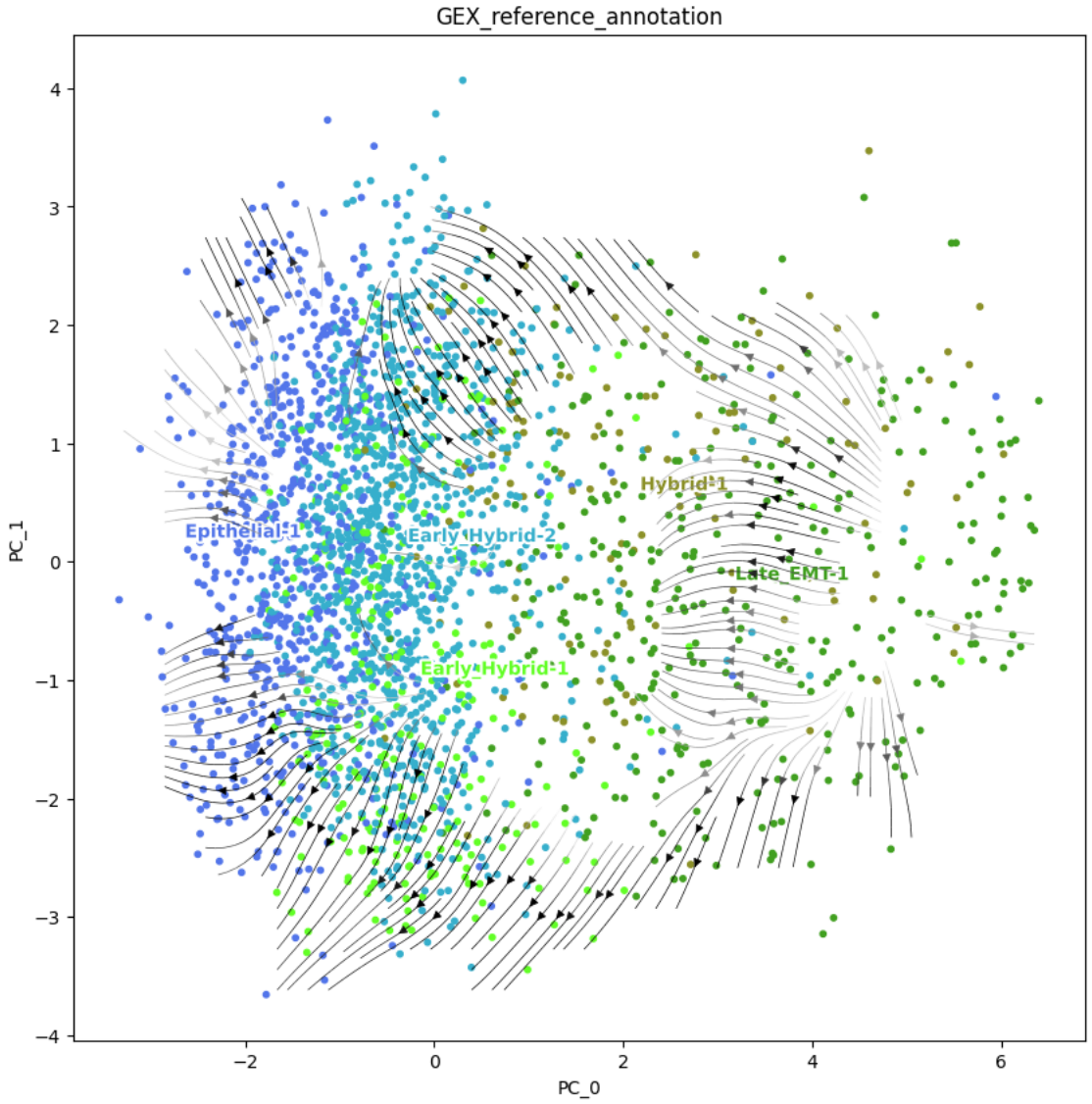
```
                                | 539/602 [00:10<00:00, 65.73it/s]
 91%|
                                | 546/602 [00:10<00:00, 57.26it/s]
 92%|
                                | 553/602 [00:10<00:00, 58.91it/s]
 94%|
                                | 563/602 [00:10<00:00, 57.93it/s]
 95%|
                                | 569/602 [00:10<00:00, 55.88it/s]
 96%|
                                | 578/602 [00:10<00:00, 63.57it/s]
 97%|
                                | 585/602 [00:10<00:00, 64.25it/s]
 98%|
                                | 592/602 [00:11<00:00, 47.11it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
  1%|
| 6/602 [00:00<00:11, 50.63it/s]
  8%|
| 46/602 [00:00<00:02, 230.46it/s]
 12%|
| 70/602 [00:00<00:03, 139.72it/s]
 15%|
| 88/602 [00:00<00:04, 128.33it/s]
 17%|
| 103/602 [00:00<00:05, 94.44it/s]
 22%|
| 132/602 [00:01<00:03, 133.12it/s]
 25%|
| 150/602 [00:01<00:03, 120.82it/s]
 27%|
| 165/602 [00:01<00:04, 97.57it/s]
 30%|
| 178/602 [00:01<00:04, 94.07it/s]
 33%|
| 196/602 [00:01<00:04, 98.68it/s]
 34%|
| 207/602 [00:01<00:04, 96.92it/s]
```

```
 37%|
| 222/602 [00:02<00:03, 96.84it/s]
 43%|

| 259/602 [00:02<00:02, 142.77it/s]
 46%|

| 277/602 [00:02<00:02, 149.73it/s]
 50%|

| 300/602 [00:02<00:01, 167.58it/s]
 53%|

| 318/602 [00:02<00:02, 125.50it/s]
 55%|

| 333/602 [00:02<00:02, 128.36it/s]
 58%|

| 348/602 [00:02<00:01, 130.33it/s]
 60%|

| 363/602 [00:03<00:02, 107.01it/s]
 65%|

| 391/602 [00:03<00:01, 130.34it/s]
 68%|

| 409/602 [00:03<00:01, 130.72it/s]
 70%|

| 423/602 [00:03<00:01, 123.75it/s]
 72%|

| 436/602 [00:03<00:01, 115.82it/s]
 74%|

| 448/602 [00:03<00:01, 109.57it/s]
 76%|

| 460/602 [00:03<00:01, 106.91it/s]
 80%|

| 483/602 [00:04<00:01, 118.33it/s]
 82%|

                                    | 495/602 [00:04<00:01, 96.66it/s]
 84%|
```

```
                                    | 506/602 [00:04<00:01, 94.79it/s]
 86%|

                                   | 517/602 [00:04<00:00, 92.69it/s]
 89%|

                                 | 538/602 [00:04<00:00, 117.43it/s]
 92%|

                                | 551/602 [00:04<00:00, 103.80it/s]
 93%|

                               | 562/602 [00:04<00:00, 83.99it/s]
 97%|

                            | 584/602 [00:05<00:00, 112.25it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
  1%|
| 8/602 [00:00<00:10, 58.83it/s]
  2%|
| 14/602 [00:00<00:10, 54.15it/s]
  9%|
| 56/602 [00:00<00:03, 176.89it/s]
 16%|
| 96/602 [00:00<00:02, 233.05it/s]
 20%|
| 120/602 [00:00<00:02, 211.81it/s]
 32%|
| 191/602 [00:00<00:01, 352.36it/s]
 38%|
| 230/602 [00:01<00:01, 224.39it/s]
 43%|

| 260/602 [00:01<00:01, 175.64it/s]
 52%|

| 314/602 [00:01<00:01, 238.92it/s]
 58%|

| 347/602 [00:01<00:01, 245.97it/s]
 63%|

| 382/602 [00:01<00:00, 257.73it/s]
 70%|
```

```
| 422/602 [00:01<00:00, 274.47it/s]
 75%|

| 453/602 [00:02<00:00, 196.01it/s]
 84%|

                                    | 505/602 [00:02<00:00, 256.99it/s]
 89%|

                                | 538/602 [00:02<00:00, 212.85it/s]
 94%|

                            | 566/602 [00:02<00:00, 206.21it/s]
 98%|

                        | 591/602 [00:02<00:00, 174.77it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
  8%|
| 47/602 [00:00<00:01, 365.86it/s]
 14%|
| 84/602 [00:00<00:01, 295.65it/s]
 21%|
| 125/602 [00:00<00:01, 314.81it/s]
 30%|
| 178/602 [00:00<00:01, 376.70it/s]
 36%|
| 217/602 [00:00<00:01, 346.81it/s]
 43%|

| 256/602 [00:00<00:00, 358.46it/s]
 49%|

| 296/602 [00:00<00:00, 361.71it/s]
 55%|

| 333/602 [00:01<00:01, 264.96it/s]
 62%|

| 374/602 [00:01<00:00, 291.82it/s]
 72%|

| 431/602 [00:01<00:00, 359.85it/s]
 78%|

| 471/602 [00:01<00:00, 355.97it/s]
 86%|
```

```
                                  | 515/602 [00:01<00:00, 369.41it/s]
 92%|

                               | 554/602 [00:01<00:00, 373.44it/s]
 99%|

                           | 593/602 [00:01<00:00, 330.77it/s]

2024-06-14 07:06:39,801 perturbation INFO     Generating ranking based on
perturbed matrix.
2024-06-14 07:06:46,332 perturbation INFO     Scoring eRegulons.
2024-06-14 07:06:53,151 perturbation INFO     Projecting perturbation effect in
embedding: eRegulons_PCA_gene_based
2024-06-14 07:06:54,039 perturbation INFO     Calculating grid of arrows
2024-06-14 07:06:54,151 perturbation INFO     Plotting
```




```
 50%|

| 6/12 [02:59<03:07, 31.32s/it]

2024-06-14 07:06:56,794 perturbation INFO     Caclulating perturbation matrix
for: {'Sox5': 0} over 5 iterations.


  0%|
| 0/602 [00:00<?, ?it/s]
  2%|
| 13/602 [00:00<00:04, 129.60it/s]
  7%|
| 43/602 [00:00<00:02, 211.77it/s]
```

```
 21%|
| 125/602 [00:00<00:01, 473.67it/s]
 31%|
| 186/602 [00:00<00:00, 423.01it/s]
 38%|
| 230/602 [00:00<00:00, 379.83it/s]
 45%|

| 270/602 [00:00<00:00, 338.38it/s]
 52%|

| 315/602 [00:00<00:00, 321.30it/s]
 59%|

| 356/602 [00:01<00:00, 320.20it/s]
 76%|

| 459/602 [00:01<00:00, 493.81it/s]
 85%|

                                  | 514/602 [00:01<00:00, 387.19it/s]
 97%|

                       | 581/602 [00:01<00:00, 399.63it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
  5%|
| 33/602 [00:00<00:02, 238.50it/s]
  9%|
| 57/602 [00:00<00:05, 97.99it/s]
 12%|
| 71/602 [00:00<00:08, 64.43it/s]
 18%|
| 109/602 [00:01<00:04, 113.41it/s]
 21%|
| 128/602 [00:01<00:04, 105.80it/s]
 27%|
| 163/602 [00:01<00:02, 146.45it/s]
 31%|
| 184/602 [00:01<00:02, 148.67it/s]
 34%|
| 203/602 [00:01<00:03, 114.52it/s]
 36%|
| 219/602 [00:01<00:03, 119.09it/s]
39%|
| 234/602 [00:02<00:04, 91.97it/s]
 44%|
```

```
| 266/602 [00:02<00:02, 128.12it/s]
 47%|

| 283/602 [00:02<00:02, 134.85it/s]
 50%|

| 300/602 [00:02<00:02, 104.99it/s]
 52%|

| 314/602 [00:02<00:02, 104.40it/s]
 54%|

| 327/602 [00:03<00:03, 71.26it/s]
 57%|

| 345/602 [00:03<00:02, 88.18it/s]
 59%|

| 358/602 [00:03<00:02, 93.23it/s]
 62%|

| 374/602 [00:03<00:02, 102.08it/s]
 66%|

| 395/602 [00:03<00:01, 118.84it/s]
 69%|

| 414/602 [00:03<00:01, 134.66it/s]
 73%|

| 437/602 [00:03<00:01, 155.72it/s]
 76%|

| 455/602 [00:03<00:00, 159.96it/s]
 79%|

| 473/602 [00:04<00:00, 159.55it/s]
 85%|

                                    | 510/602 [00:04<00:00, 203.04it/s]
 88%|

                                  | 531/602 [00:04<00:00, 165.25it/s]
 91%|

                                | 549/602 [00:04<00:00, 118.39it/s]
 94%|
```

```
                          | 564/602 [00:04<00:00, 123.82it/s]
 97%|

                        | 582/602 [00:04<00:00, 135.61it/s]
 99%|

                      | 598/602 [00:05<00:00, 116.08it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
  1%|
| 5/602 [00:00<00:19, 30.63it/s]
  3%|
| 19/602 [00:00<00:07, 81.59it/s]
  5%|
| 29/602 [00:00<00:06, 83.17it/s]
  6%|
| 39/602 [00:00<00:07, 70.60it/s]
  8%|
| 47/602 [00:00<00:07, 69.69it/s]
  9%|
| 55/602 [00:00<00:10, 50.77it/s]
 11%|
| 64/602 [00:01<00:09, 57.66it/s]
 12%|
| 71/602 [00:01<00:09, 58.19it/s]
 13%|
| 81/602 [00:01<00:08, 58.11it/s]
 15%|
| 93/602 [00:01<00:08, 62.13it/s]
 17%|
| 102/602 [00:01<00:08, 60.34it/s]
 18%|
| 109/602 [00:01<00:09, 52.33it/s]
 21%|
| 128/602 [00:02<00:06, 70.23it/s]
 23%|
| 137/602 [00:02<00:06, 71.58it/s]
 24%|
| 146/602 [00:02<00:06, 73.71it/s]
 26%|
| 154/602 [00:02<00:08, 55.39it/s]
 27%|
| 161/602 [00:02<00:07, 58.03it/s]
 28%|
| 168/602 [00:02<00:08, 50.96it/s]
 29%|
```

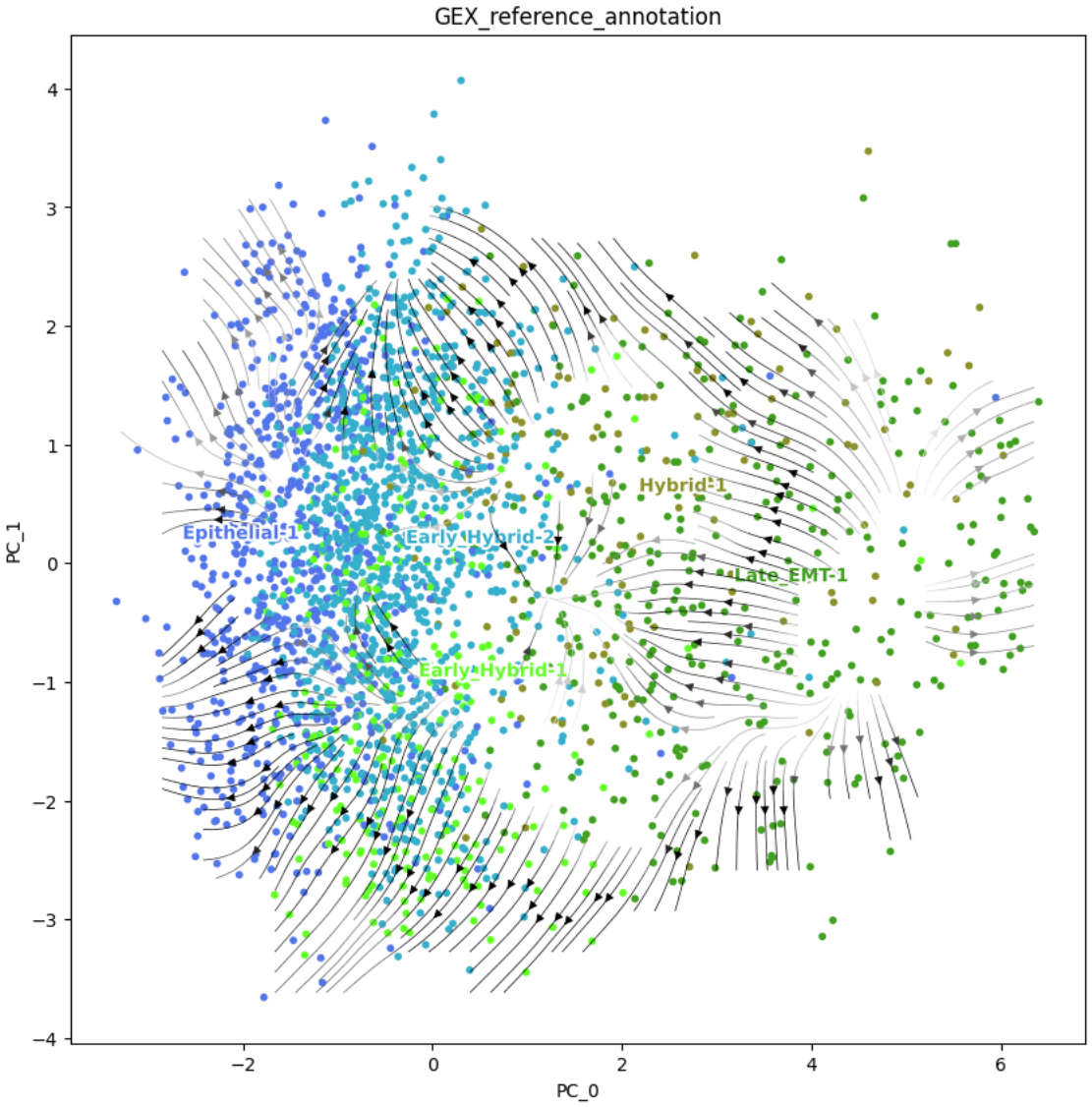
```
| 174/602 [00:02<00:09, 45.80it/s]
 30%|
| 179/602 [00:03<00:09, 45.58it/s]
 32%|
| 191/602 [00:03<00:06, 62.05it/s]
 33%|
| 198/602 [00:03<00:07, 56.57it/s]
 34%|
| 205/602 [00:03<00:08, 48.22it/s]
 35%|
| 211/602 [00:03<00:07, 49.60it/s]
 36%|
| 218/602 [00:03<00:08, 46.07it/s]
 37%|
| 223/602 [00:03<00:09, 40.79it/s]
 38%|
| 228/602 [00:04<00:08, 41.77it/s]
 42%|

| 254/602 [00:04<00:03, 89.93it/s]
 44%|

| 267/602 [00:04<00:04, 81.07it/s]
 46%|

| 277/602 [00:04<00:04, 68.89it/s]
 47%|

| 285/602 [00:04<00:04, 71.14it/s]
 49%|

| 294/602 [00:04<00:04, 71.96it/s]
 50%|

| 302/602 [00:05<00:05, 59.25it/s]
 51%|

| 309/602 [00:05<00:05, 49.89it/s]
 52%|

| 315/602 [00:05<00:08, 34.21it/s]
 53%|

| 320/602 [00:05<00:07, 35.41it/s]
 54%|

| 325/602 [00:05<00:07, 37.70it/s]
 55%|
```

```
| 330/602 [00:05<00:06, 39.03it/s]
 56%|

| 338/602 [00:06<00:06, 41.27it/s]
 58%|

| 350/602 [00:06<00:04, 55.56it/s]
 59%|

| 357/602 [00:06<00:04, 50.55it/s]
 60%|

| 363/602 [00:06<00:05, 46.44it/s]
 61%|

| 368/602 [00:06<00:05, 44.90it/s]
 65%|

| 391/602 [00:06<00:02, 82.09it/s]
 66%|

| 400/602 [00:07<00:02, 70.69it/s]
 68%|

| 412/602 [00:07<00:02, 71.05it/s]
 71%|

| 428/602 [00:07<00:02, 77.50it/s]
 72%|

| 436/602 [00:07<00:02, 67.71it/s]
 74%|

| 443/602 [00:07<00:03, 52.85it/s]
 75%|

| 449/602 [00:07<00:03, 46.01it/s]
 75%|

| 454/602 [00:08<00:03, 44.95it/s]
 76%|

| 459/602 [00:08<00:03, 45.57it/s]
 78%|

| 471/602 [00:08<00:02, 52.61it/s]
 81%|
```

```
                                      | 486/602 [00:08<00:01, 62.97it/s]
 82%|
                                     | 493/602 [00:08<00:02, 48.70it/s]
 83%|
                                    | 499/602 [00:09<00:02, 39.99it/s]
 84%|
                                   | 504/602 [00:09<00:02, 41.22it/s]
 86%|
                                 | 517/602 [00:09<00:01, 56.78it/s]
 87%|
                                | 524/602 [00:09<00:01, 57.84it/s]
 90%|
                              | 542/602 [00:09<00:00, 78.23it/s]
 92%|
                             | 551/602 [00:09<00:00, 66.67it/s]
 93%|
                            | 559/602 [00:09<00:00, 61.48it/s]
 94%|
                           | 566/602 [00:10<00:00, 51.03it/s]
 97%|
                         | 582/602 [00:10<00:00, 72.37it/s]
 98%|
                        | 591/602 [00:10<00:00, 69.68it/s]

  0%|
|  0/602 [00:00<?, ?it/s]
  1%|
|  8/602 [00:00<00:07, 79.94it/s]
  3%|
| 16/602 [00:00<00:08, 72.10it/s]
  9%|
| 56/602 [00:00<00:03, 177.06it/s]
 16%|
| 96/602 [00:00<00:02, 224.43it/s]
 20%|
| 118/602 [00:00<00:02, 219.93it/s]
```

```
 32%|
| 192/602 [00:00<00:01, 365.08it/s]
 38%|
| 230/602 [00:01<00:01, 235.34it/s]
 43%|

| 260/602 [00:01<00:01, 222.79it/s]
 57%|

| 344/602 [00:01<00:00, 353.43it/s]
 65%|

| 389/602 [00:01<00:00, 297.96it/s]
 71%|

| 427/602 [00:01<00:00, 223.87it/s]
 76%|

| 457/602 [00:01<00:00, 231.40it/s]
 83%|

                                    | 502/602 [00:02<00:00, 260.85it/s]
 89%|

                                | 533/602 [00:02<00:00, 212.05it/s]
 93%|

                            | 559/602 [00:02<00:00, 214.98it/s]
 97%|

                        | 584/602 [00:02<00:00, 197.66it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
  7%|
| 40/602 [00:00<00:01, 350.27it/s]
 13%|
| 76/602 [00:00<00:02, 230.57it/s]
 21%|
| 125/602 [00:00<00:01, 305.13it/s]
 30%|
| 178/602 [00:00<00:01, 354.28it/s]
 36%|
| 216/602 [00:00<00:01, 334.25it/s]
 42%|

| 251/602 [00:00<00:01, 321.56it/s]
 49%|
```

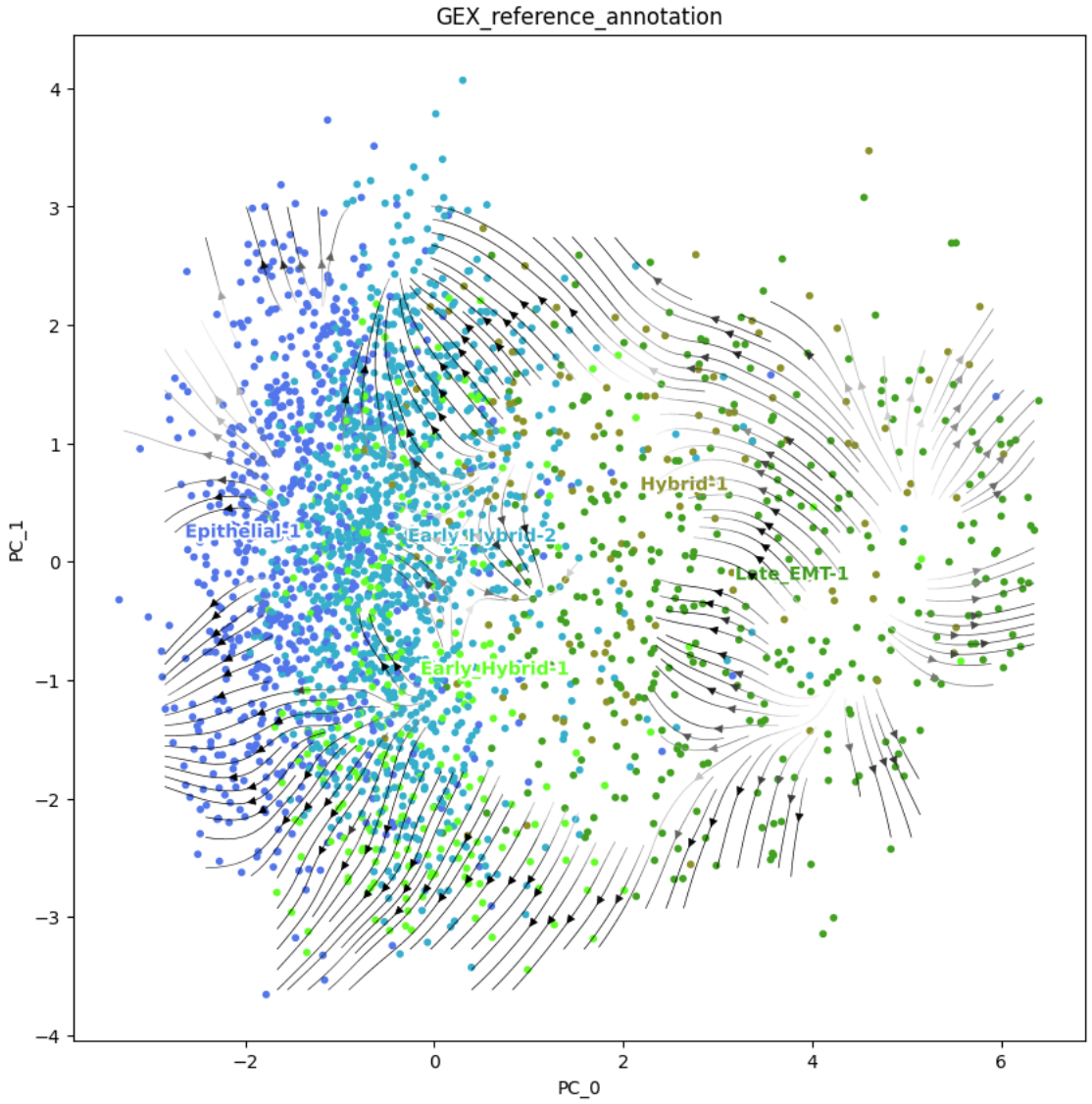
```
| 296/602 [00:00<00:00, 345.52it/s]
 55%|

| 332/602 [00:01<00:01, 268.84it/s]
 60%|

| 362/602 [00:01<00:00, 270.32it/s]
 69%|

| 413/602 [00:01<00:00, 312.75it/s]
 76%|

| 456/602 [00:01<00:00, 314.81it/s]
 85%|

                                | 512/602 [00:01<00:00, 368.16it/s]
 92%|

                            | 551/602 [00:01<00:00, 349.31it/s]
 98%|

                        | 588/602 [00:01<00:00, 327.36it/s]

2024-06-14 07:07:19,853 perturbation INFO     Generating ranking based on
perturbed matrix.
2024-06-14 07:07:26,450 perturbation INFO     Scoring eRegulons.
2024-06-14 07:07:33,295 perturbation INFO     Projecting perturbation effect in
embedding: eRegulons_PCA_gene_based
2024-06-14 07:07:34,212 perturbation INFO     Calculating grid of arrows
2024-06-14 07:07:34,321 perturbation INFO     Plotting
```




```
 58%|

| 7/12 [03:39<02:51, 34.21s/it]

2024-06-14 07:07:36,951 perturbation INFO     Caclulating perturbation matrix
for: {'Snai1': 0} over 5 iterations.


  0%|
| 0/602 [00:00<?, ?it/s]
 15%|
| 92/602 [00:00<00:00, 914.98it/s]
 31%|
| 184/602 [00:00<00:00, 671.02it/s]
```

```
 43%|

| 259/602 [00:00<00:00, 545.83it/s]
 62%|

| 375/602 [00:00<00:00, 727.86it/s]
 76%|

| 456/602 [00:00<00:00, 750.78it/s]
 93%|

                          | 560/602 [00:00<00:00, 836.37it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 19%|
| 116/602 [00:00<00:00, 1151.43it/s]
 39%|
| 232/602 [00:00<00:00, 1083.25it/s]
 57%|

| 341/602 [00:00<00:00, 1069.44it/s]
 75%|

| 452/602 [00:00<00:00, 1084.21it/s]
 96%|

                       | 577/602 [00:00<00:00, 1140.00it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 11%|
| 65/602 [00:00<00:00, 647.12it/s]
 30%|
| 182/602 [00:00<00:00, 954.10it/s]
 50%|

| 301/602 [00:00<00:00, 1061.24it/s]
 68%|

| 408/602 [00:00<00:00, 1040.12it/s]
 85%|

                                | 513/602 [00:00<00:00, 1037.11it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 20%|
```

```
| 121/602 [00:00<00:00, 1205.21it/s]
 40%|

| 242/602 [00:00<00:00, 1197.52it/s]
 60%|

| 362/602 [00:00<00:00, 1049.58it/s]
 80%|

| 484/602 [00:00<00:00, 1110.93it/s]
100%|

                    | 601/602 [00:00<00:00, 1129.02it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 15%|
| 92/602 [00:00<00:00, 917.74it/s]
 34%|
| 205/602 [00:00<00:00, 1042.24it/s]
 54%|

| 327/602 [00:00<00:00, 1120.55it/s]
 73%|

| 440/602 [00:00<00:00, 1115.36it/s]
 92%|

                          | 552/602 [00:00<00:00, 1083.71it/s]

2024-06-14 07:07:41,198 perturbation INFO     Generating ranking based on
perturbed matrix.
2024-06-14 07:07:47,705 perturbation INFO     Scoring eRegulons.
2024-06-14 07:07:54,735 perturbation INFO     Projecting perturbation effect in
embedding: eRegulons_PCA_gene_based
2024-06-14 07:07:55,685 perturbation INFO     Calculating grid of arrows
2024-06-14 07:07:55,791 perturbation INFO     Plotting
```

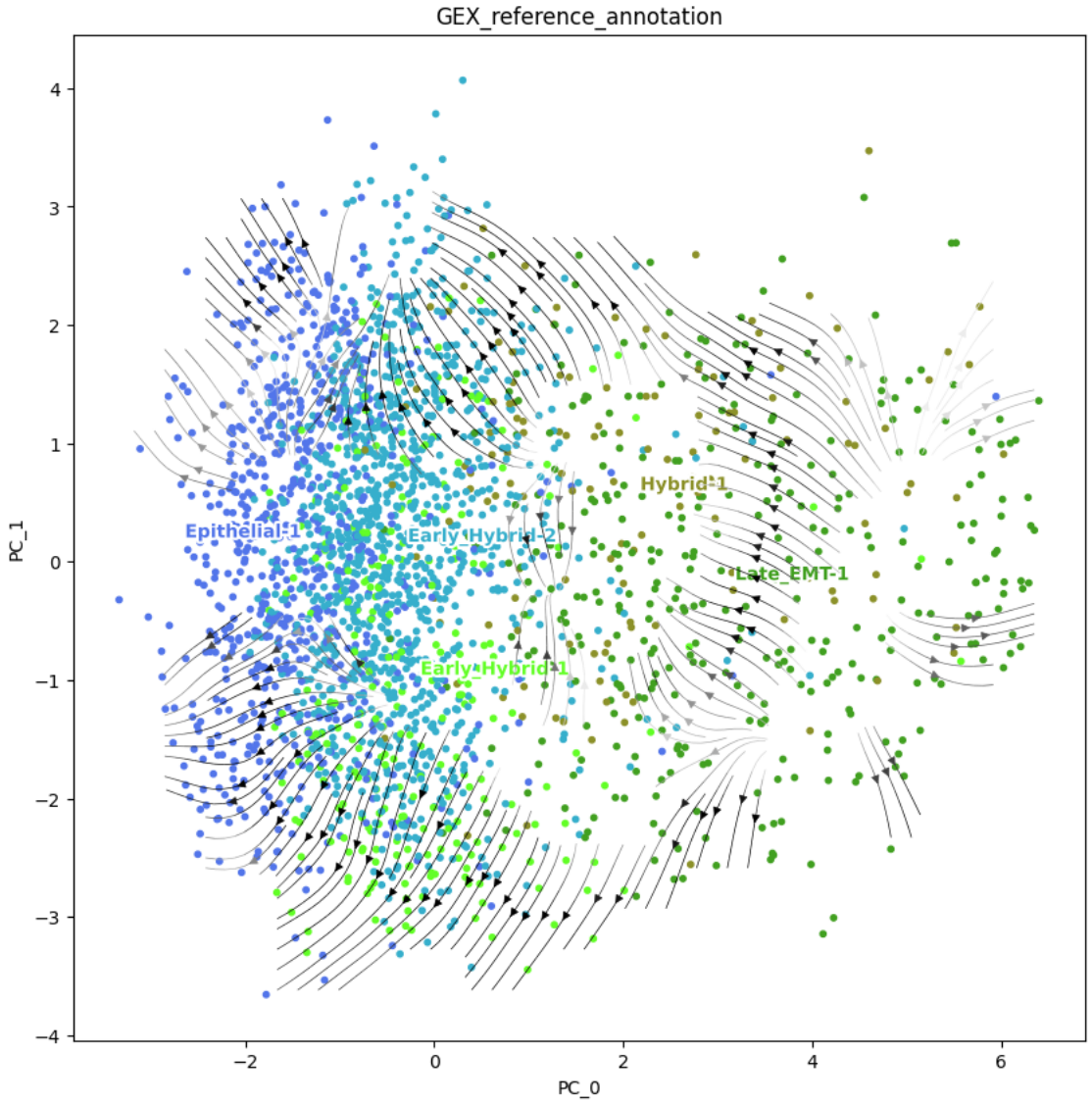



```
 67%|

| 8/12 [04:01<02:00, 30.22s/it]

2024-06-14 07:07:58,627 perturbation INFO     Caclulating perturbation matrix
for: {'Grhl3': 0} over 5 iterations.


  0%|
| 0/602 [00:00<?, ?it/s]
 14%|
| 83/602 [00:00<00:00, 562.34it/s]
 23%|
| 140/602 [00:00<00:02, 159.41it/s]
```

```
 28%|
| 171/602 [00:00<00:02, 170.40it/s]
 33%|
| 201/602 [00:01<00:02, 190.17it/s]
 38%|
| 227/602 [00:01<00:02, 155.84it/s]
 41%|

| 248/602 [00:01<00:02, 163.80it/s]
 46%|

| 274/602 [00:01<00:01, 183.28it/s]
 49%|

| 297/602 [00:01<00:01, 187.68it/s]
 53%|

| 319/602 [00:01<00:02, 117.59it/s]
 56%|

| 340/602 [00:02<00:01, 133.18it/s]
 64%|

| 383/602 [00:02<00:01, 180.82it/s]
 68%|

| 411/602 [00:02<00:00, 192.74it/s]
 72%|

| 434/602 [00:02<00:01, 145.10it/s]
 75%|

| 453/602 [00:02<00:01, 146.54it/s]
 78%|

| 471/602 [00:02<00:01, 117.58it/s]
 82%|

                                    | 492/602 [00:03<00:00, 118.61it/s]
 84%|

                                  | 506/602 [00:03<00:00, 122.53it/s]
 87%|

                                | 522/602 [00:03<00:00, 128.34it/s]
 89%|

                              | 537/602 [00:03<00:00, 128.24it/s]
```

```
 93%|

                           | 557/602 [00:03<00:00, 137.98it/s]
 95%|

                         | 573/602 [00:03<00:00, 140.67it/s]
 98%|

                       | 588/602 [00:03<00:00, 118.77it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
  1%|
| 4/602 [00:00<00:19, 31.30it/s]
 21%|
| 124/602 [00:00<00:00, 645.61it/s]
 34%|
| 202/602 [00:00<00:00, 691.84it/s]
 46%|

| 276/602 [00:00<00:00, 547.37it/s]
 57%|

| 344/602 [00:00<00:00, 483.68it/s]
 67%|

| 405/602 [00:00<00:00, 474.75it/s]
 78%|

| 468/602 [00:00<00:00, 512.86it/s]
 92%|

                           | 553/602 [00:01<00:00, 524.27it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 12%|
| 70/602 [00:00<00:00, 696.57it/s]
 32%|
| 193/602 [00:00<00:00, 1006.15it/s]
 49%|

| 294/602 [00:00<00:00, 869.92it/s]
 64%|

| 383/602 [00:00<00:00, 791.91it/s]
 83%|
```

```
                                  | 502/602 [00:00<00:00, 915.68it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 17%|
| 101/602 [00:00<00:00, 1001.55it/s]
 36%|
| 215/602 [00:00<00:00, 1078.14it/s]
 55%|

| 332/602 [00:00<00:00, 1119.21it/s]
 74%|

| 444/602 [00:00<00:00, 1067.38it/s]
 92%|

                            | 552/602 [00:00<00:00, 977.49it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 17%|
| 101/602 [00:00<00:00, 1003.84it/s]
 36%|
| 217/602 [00:00<00:00, 1090.33it/s]
 55%|

| 333/602 [00:00<00:00, 1118.44it/s]
 75%|

| 453/602 [00:00<00:00, 1148.43it/s]
 95%|

                         | 572/602 [00:00<00:00, 1163.03it/s]

2024-06-14 07:08:06,755 perturbation INFO     Generating ranking based on
perturbed matrix.
2024-06-14 07:08:13,310 perturbation INFO     Scoring eRegulons.
2024-06-14 07:08:20,030 perturbation INFO     Projecting perturbation effect in
embedding: eRegulons_PCA_gene_based
2024-06-14 07:08:20,952 perturbation INFO     Calculating grid of arrows
2024-06-14 07:08:21,070 perturbation INFO     Plotting
```



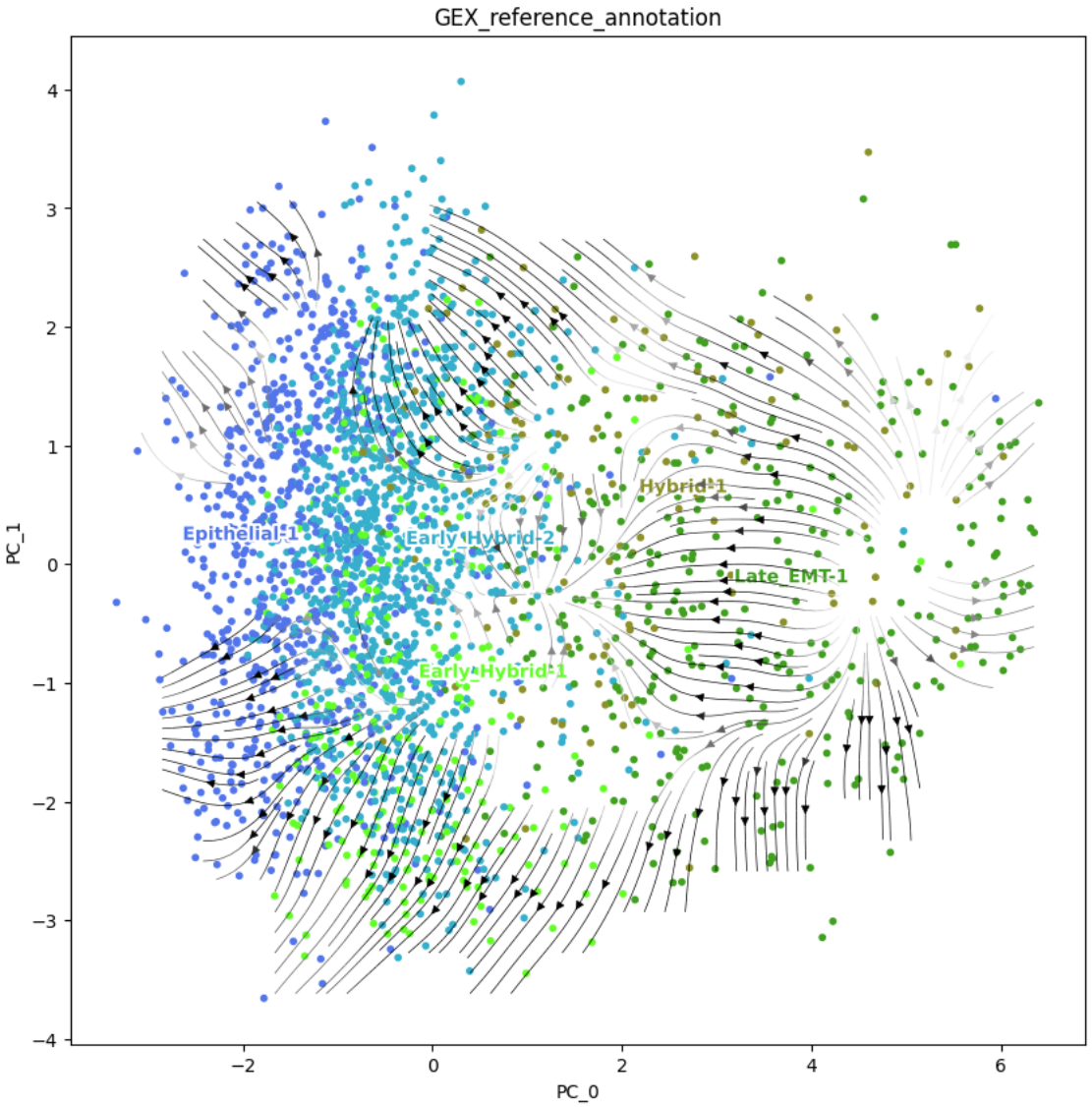

```
 75%|

| 9/12 [04:26<01:25, 28.64s/it]

2024-06-14 07:08:23,794 perturbation INFO     Caclulating perturbation matrix
for: {'Bnc2': 0} over 5 iterations.


  0%|
| 0/602 [00:00<?, ?it/s]
  2%|
| 15/602 [00:00<00:06, 86.19it/s]
 11%|
| 64/602 [00:00<00:02, 239.63it/s]
```

```
 15%|
| 91/602 [00:00<00:02, 185.28it/s]
 22%|
| 135/602 [00:00<00:01, 242.02it/s]
 27%|
| 162/602 [00:01<00:03, 117.85it/s]
 32%|
| 192/602 [00:01<00:02, 146.05it/s]
 36%|
| 215/602 [00:01<00:03, 100.64it/s]
 39%|
| 233/602 [00:01<00:03, 109.16it/s]
 42%|

| 250/602 [00:01<00:03, 105.38it/s]
 45%|

| 271/602 [00:02<00:02, 118.36it/s]
 48%|

| 287/602 [00:02<00:03, 97.60it/s]
 50%|

| 300/602 [00:02<00:03, 90.00it/s]
 52%|

| 311/602 [00:02<00:04, 70.34it/s]
 55%|

| 331/602 [00:02<00:03, 81.19it/s]
 60%|

| 364/602 [00:03<00:02, 118.77it/s]
 63%|

| 379/602 [00:03<00:02, 108.42it/s]
 65%|

| 393/602 [00:03<00:01, 110.46it/s]
 67%|

| 406/602 [00:03<00:02, 97.93it/s]
 69%|

| 417/602 [00:03<00:01, 99.94it/s]
 71%|

| 428/602 [00:03<00:02, 81.95it/s]
```

```
 75%|

| 452/602 [00:04<00:01, 112.60it/s]
 77%|

| 466/602 [00:04<00:01, 112.28it/s]
 80%|

| 479/602 [00:04<00:01, 99.45it/s]
 82%|

                                     | 491/602 [00:04<00:01, 85.37it/s]
 84%|

                                    | 504/602 [00:04<00:01, 91.36it/s]
 86%|

                                   | 515/602 [00:04<00:01, 78.49it/s]
 87%|

                                 | 525/602 [00:04<00:01, 72.48it/s]
 92%|

                            | 551/602 [00:05<00:00, 109.16it/s]
 94%|

                          | 564/602 [00:05<00:00, 111.68it/s]
 99%|

                     | 595/602 [00:05<00:00, 158.59it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 19%|
| 115/602 [00:00<00:00, 1142.29it/s]
 38%|
| 230/602 [00:00<00:00, 1013.82it/s]
 56%|

| 336/602 [00:00<00:00, 1033.17it/s]
 75%|

| 454/602 [00:00<00:00, 1085.77it/s]
 96%|

                       | 576/602 [00:00<00:00, 1131.21it/s]

  0%|
```

```
| 0/602 [00:00<?, ?it/s]
 21%|
| 127/602 [00:00<00:00, 1266.17it/s]
 42%|

| 254/602 [00:00<00:00, 1222.39it/s]
 63%|

| 377/602 [00:00<00:00, 1214.61it/s]
 83%|

                                    | 499/602 [00:00<00:00, 1207.02it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 21%|
| 124/602 [00:00<00:00, 1238.20it/s]
 41%|

| 248/602 [00:00<00:00, 1088.03it/s]
 59%|

| 358/602 [00:00<00:00, 1076.43it/s]
 80%|

| 481/602 [00:00<00:00, 1132.37it/s]
 99%|

                     | 595/602 [00:00<00:00, 1048.90it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 14%|
| 87/602 [00:00<00:00, 864.84it/s]
 34%|
| 207/602 [00:00<00:00, 1059.23it/s]
 52%|

| 313/602 [00:00<00:00, 1041.90it/s]
 69%|

| 418/602 [00:00<00:00, 980.00it/s]
 86%|

                                  | 517/602 [00:00<00:00, 952.39it/s]

2024-06-14 07:08:32,634 perturbation INFO     Generating ranking based on
```

```
perturbed matrix.
2024-06-14 07:08:39,163 perturbation INFO     Scoring eRegulons.
2024-06-14 07:08:45,919 perturbation INFO     Projecting perturbation effect in
embedding: eRegulons_PCA_gene_based
2024-06-14 07:08:46,836 perturbation INFO     Calculating grid of arrows
2024-06-14 07:08:46,958 perturbation INFO     Plotting
```

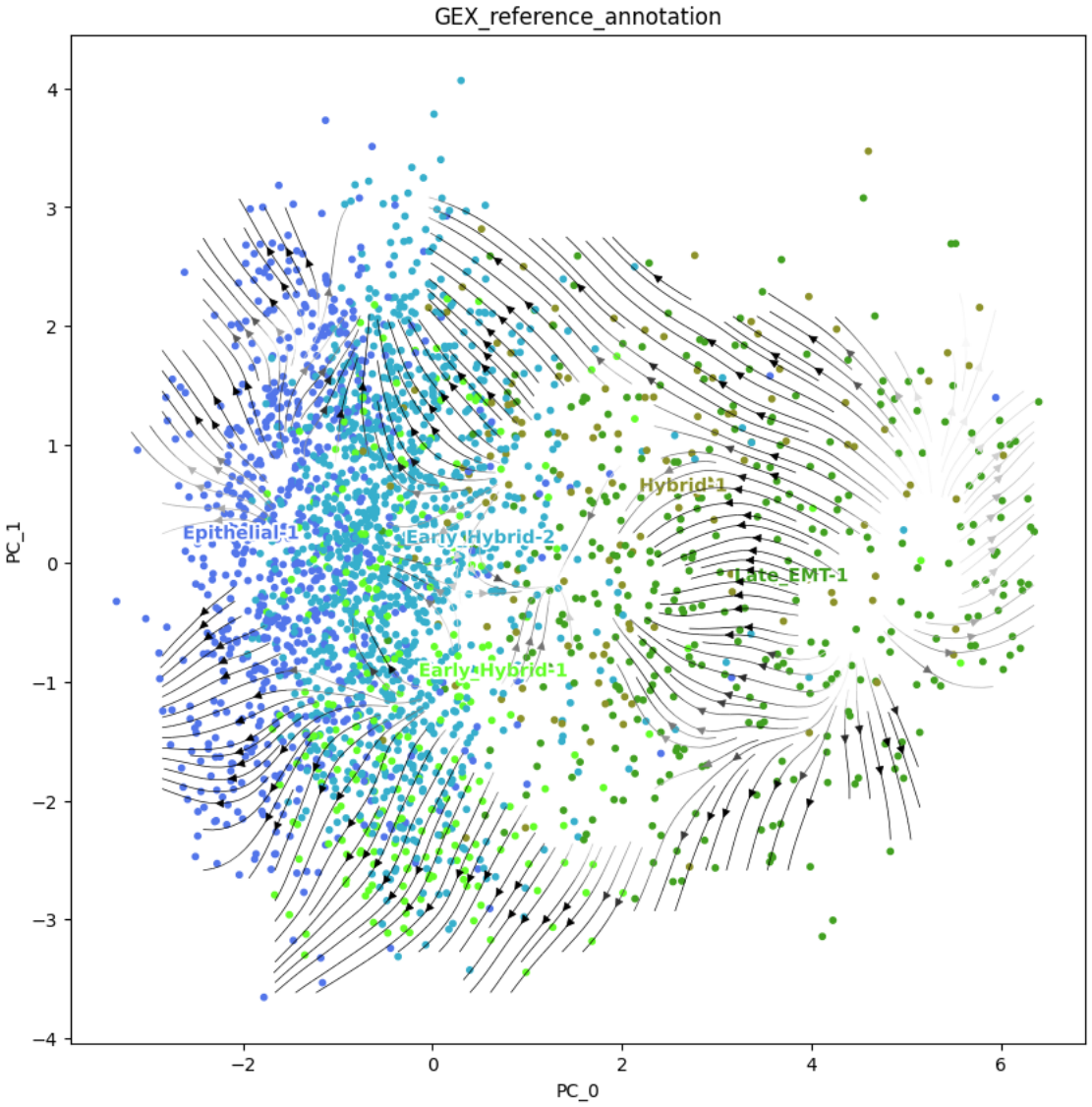



```
 83%|
                                    | 10/12 [04:52<00:55, 27.78s/it]
2024-06-14 07:08:49,658 perturbation INFO     Caclulating perturbation matrix
for: {'Creb3l1': 0} over 5 iterations.
```

```
  0%|
| 0/602 [00:00<?, ?it/s]
 10%|
| 63/602 [00:00<00:01, 502.40it/s]
 19%|
| 114/602 [00:00<00:01, 255.92it/s]
 25%|
| 149/602 [00:00<00:01, 269.79it/s]
 30%|
| 180/602 [00:00<00:01, 276.84it/s]
 36%|
| 215/602 [00:00<00:01, 294.76it/s]
 41%|

| 247/602 [00:00<00:01, 293.98it/s]
 46%|

| 278/602 [00:00<00:01, 293.00it/s]
 59%|

| 355/602 [00:01<00:00, 382.52it/s]
 65%|

| 393/602 [00:01<00:00, 359.99it/s]
 73%|

| 439/602 [00:01<00:00, 360.90it/s]
 81%|

                                    | 487/602 [00:01<00:00, 358.24it/s]
 90%|

                              | 542/602 [00:01<00:00, 376.71it/s]
 96%|

                         | 580/602 [00:01<00:00, 262.03it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 21%|
| 124/602 [00:00<00:00, 1232.37it/s]
 41%|

| 248/602 [00:00<00:00, 959.37it/s]
 58%|

| 348/602 [00:00<00:00, 958.36it/s]
```

```
 74%|

| 446/602 [00:00<00:00, 933.69it/s]
 94%|

                        | 565/602 [00:00<00:00, 1016.48it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 13%|
| 78/602 [00:00<00:00, 772.21it/s]
 33%|
| 199/602 [00:00<00:00, 1026.99it/s]
 50%|

| 302/602 [00:00<00:00, 985.56it/s]
 70%|

| 424/602 [00:00<00:00, 1073.61it/s]
 91%|

                           | 545/602 [00:00<00:00, 1121.03it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 20%|
| 122/602 [00:00<00:00, 1215.66it/s]
 41%|

| 244/602 [00:00<00:00, 1001.94it/s]
 59%|

| 357/602 [00:00<00:00, 1052.77it/s]
 80%|

| 480/602 [00:00<00:00, 1117.21it/s]
 99%|

                    | 594/602 [00:00<00:00, 1070.37it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 14%|
| 85/602 [00:00<00:00, 846.35it/s]
 34%|
| 205/602 [00:00<00:00, 1049.65it/s]
 54%|
```

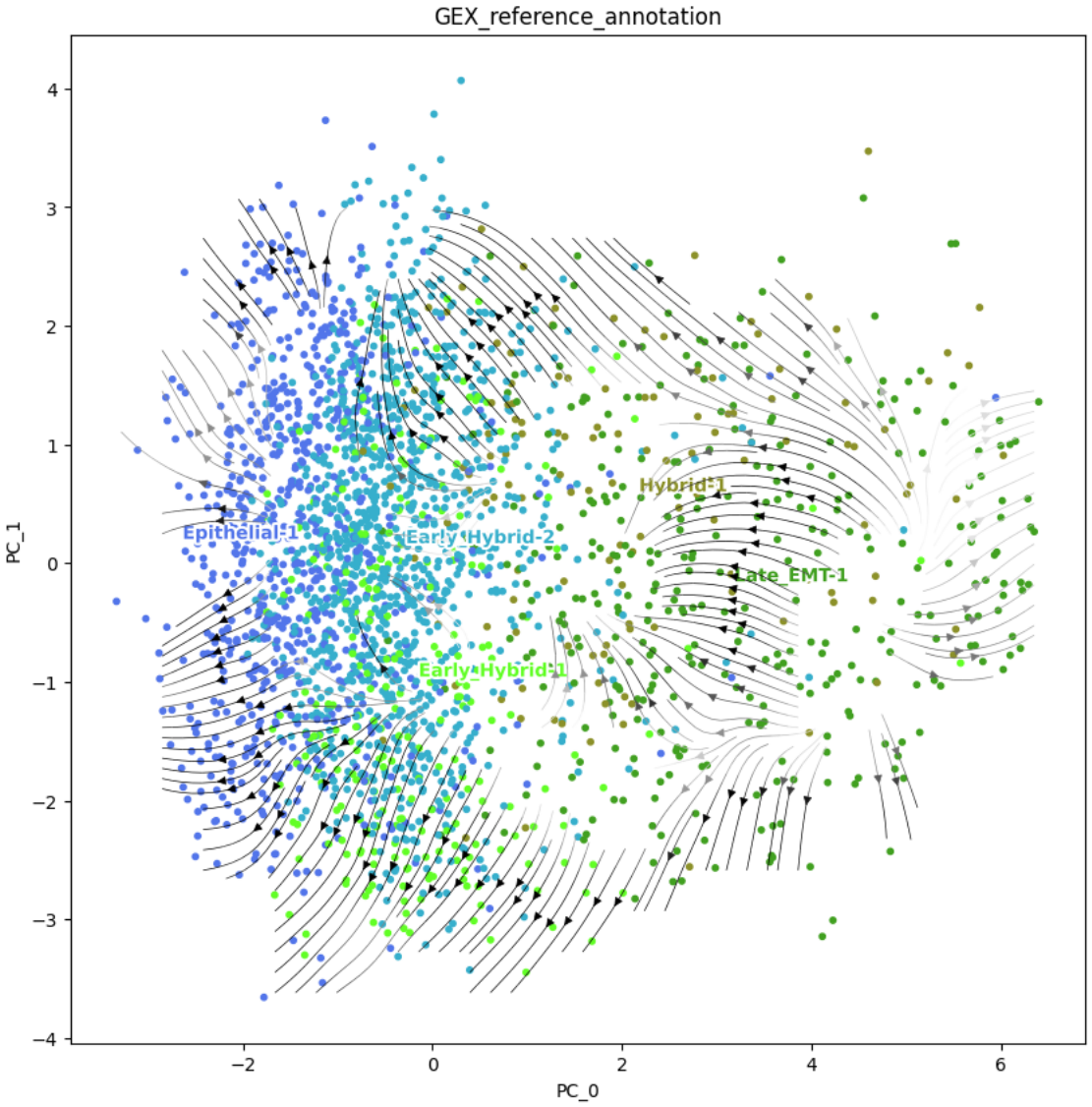
```
| 328/602 [00:00<00:00, 1129.97it/s]
 75%|

| 449/602 [00:00<00:00, 1160.37it/s]
 95%|

                                   | 570/602 [00:00<00:00, 1176.88it/s]

2024-06-14 07:08:55,018 perturbation INFO     Generating ranking based on
perturbed matrix.
2024-06-14 07:09:01,692 perturbation INFO     Scoring eRegulons.
2024-06-14 07:09:08,628 perturbation INFO     Projecting perturbation effect in
embedding: eRegulons_PCA_gene_based
2024-06-14 07:09:09,519 perturbation INFO     Calculating grid of arrows
2024-06-14 07:09:09,635 perturbation INFO     Plotting
```



```
 92%|

                                | 11/12 [05:15<00:26, 26.20s/it]
2024-06-14 07:09:12,275 perturbation INFO     Caclulating perturbation matrix
for: {'Ehf': 0} over 5 iterations.


  0%|
| 0/602 [00:00<?, ?it/s]
 21%|
| 125/602 [00:00<00:00, 1249.30it/s]
 42%|

| 250/602 [00:00<00:00, 873.17it/s]
 57%|

| 344/602 [00:00<00:00, 748.70it/s]
 70%|

| 423/602 [00:00<00:00, 650.99it/s]
 82%|

                                      | 491/602 [00:00<00:00, 572.43it/s]
 92%|

                               | 551/602 [00:00<00:00, 505.07it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
  2%|
| 11/602 [00:00<00:05, 109.23it/s]
 22%|
| 131/602 [00:00<00:00, 748.75it/s]
 40%|

| 241/602 [00:00<00:00, 671.07it/s]
 53%|

| 321/602 [00:00<00:00, 711.31it/s]
 66%|

| 395/602 [00:00<00:00, 575.52it/s]
 82%|

                                      | 493/602 [00:00<00:00, 681.64it/s]
```

```
 94%|

                         | 567/602 [00:00<00:00, 696.86it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 14%|
| 87/602 [00:00<00:00, 864.72it/s]
 35%|
| 211/602 [00:00<00:00, 1080.67it/s]
 53%|

| 320/602 [00:00<00:00, 1015.25it/s]
 70%|

| 422/602 [00:00<00:00, 933.96it/s]
 90%|

                            | 543/602 [00:00<00:00, 1022.73it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 21%|
| 126/602 [00:00<00:00, 1256.35it/s]
 42%|

| 252/602 [00:00<00:00, 1028.32it/s]
 59%|

| 358/602 [00:00<00:00, 1010.42it/s]
 77%|

| 461/602 [00:00<00:00, 950.46it/s]
 93%|

                           | 560/602 [00:00<00:00, 963.10it/s]

  0%|
| 0/602 [00:00<?, ?it/s]
 16%|
| 98/602 [00:00<00:00, 976.17it/s]
 33%|
| 196/602 [00:00<00:00, 879.90it/s]
 47%|

| 285/602 [00:00<00:00, 790.57it/s]
 64%|
```

```
| 385/602 [00:00<00:00, 864.15it/s]
 79%|

| 473/602 [00:00<00:00, 806.73it/s]
 96%|

                                  | 579/602 [00:00<00:00, 883.48it/s]

2024-06-14 07:09:17,451 perturbation INFO     Generating ranking based on
perturbed matrix.
2024-06-14 07:09:24,009 perturbation INFO     Scoring eRegulons.
2024-06-14 07:09:30,540 perturbation INFO     Projecting perturbation effect in
embedding: eRegulons_PCA_gene_based
2024-06-14 07:09:31,439 perturbation INFO     Calculating grid of arrows
2024-06-14 07:09:31,554 perturbation INFO     Plotting
```



```
100%|
                                    | 12/12 [05:37<00:00, 28.09s/it]
```

## 5 List loaded software versions

[26]:
```
sys.version
```

[26]:
```
'3.8.18 (default, Sep 11 2023, 13:40:15) \n[GCC 11.2.0]'
```

[27]:
```
pip list
```

```
Package                       Version              Editable project location
----------------------------- -------------------- -------------------------
accessible-pygments           0.0.4
adjustText                    0.8
aiohttp                       3.9.1
aiohttp-cors                  0.7.0
aiosignal                     1.3.1
alabaster                     0.7.13
anndata                       0.9.2
annoy                         1.17.3
anyio                         4.1.0
appdirs                       1.4.4
arboreto                      0.1.6
argon2-cffi                   23.1.0
argon2-cffi-bindings          21.2.0
arrow                         1.3.0
asttokens                     2.4.1
async-lru                     2.0.4
async-timeout                 4.0.3
attr                          0.3.2
attrs                         23.1.0
Babel                         2.13.1
backcall                      0.2.0
backports.zoneinfo            0.2.1
bbknn                         1.6.0
beautifulsoup4                4.12.2
bidict                        0.22.1
bioservices                   1.11.2
bleach                        6.1.0
blessed                       1.20.0
blosc2                        2.0.0
bokeh                         3.1.1
boltons                       23.1.1
```

| | |
|---|---|
| bs4 | 0.0.1 |
| cachetools | 5.3.2 |
| cattrs | 23.2.3 |
| certifi | 2023.11.17 |
| cffi | 1.16.0 |
| charset-normalizer | 3.3.2 |
| click | 8.1.7 |
| cloudpickle | 3.0.0 |
| colorama | 0.4.6 |
| colorful | 0.5.5 |
| colorlog | 6.8.0 |
| comm | 0.2.0 |
| contourpy | 1.1.1 |
| cryptography | 41.0.7 |
| ctxcore | 0.2.0 |
| cycler | 0.12.1 |
| Cython | 0.29.36 |
| cytoolz | 0.12.2 |
| dask | 2023.5.0 |
| dataclasses-json | 0.6.3 |
| debugpy | 1.8.0 |
| decorator | 5.1.1 |
| defusedxml | 0.7.1 |
| dill | 0.3.7 |
| distlib | 0.3.8 |
| distributed | 2023.5.0 |
| docutils | 0.19 |
| easydev | 0.12.1 |
| entrypoints | 0.4 |
| et-xmlfile | 1.1.0 |
| exceptiongroup | 1.2.0 |
| executing | 2.0.1 |
| fastjsonschema | 2.19.0 |
| fbpca | 1.0 |
| filelock | 3.13.1 |
| fonttools | 4.46.0 |
| fqdn | 1.5.1 |
| frozendict | 2.3.10 |
| frozenlist | 1.4.0 |
| fsspec | 2023.12.2 |
| future | 0.18.3 |
| gensim | 4.3.2 |
| geosketch | 1.2 |
| get-annotations | 0.1.2 |
| gevent | 23.9.1 |
| globre | 0.1.5 |
| google-api-core | 2.15.0 |
| google-auth | 2.25.2 |

| | |
|---|---|
| googleapis-common-protos | 1.62.0 |
| gpustat | 1.1.1 |
| greenlet | 3.0.2 |
| grequests | 0.7.0 |
| grpcio | 1.60.0 |
| gseapy | 0.10.8 |
| h5py | 3.10.0 |
| harmonypy | 0.0.9 |
| idna | 3.6 |
| igraph | 0.10.8 |
| imageio | 2.33.1 |
| imagesize | 1.4.1 |
| importlib-metadata | 7.0.0 |
| importlib-resources | 6.1.1 |
| interlap | 0.2.7 |
| intervaltree | 3.1.0 |
| ipykernel | 6.27.1 |
| ipympl | 0.9.3 |
| ipython | 8.12.3 |
| ipython-genutils | 0.2.0 |
| ipywidgets | 8.1.1 |
| isoduration | 20.11.0 |
| jedi | 0.19.1 |
| Jinja2 | 3.1.2 |
| joblib | 1.3.2 |
| json5 | 0.9.14 |
| jsonpickle | 3.0.2 |
| jsonpointer | 2.4 |
| jsonschema | 4.20.0 |
| jsonschema-specifications | 2023.11.2 |
| jupyter | 1.0.0 |
| jupyter_client | 8.6.0 |
| jupyter-console | 6.6.3 |
| jupyter_core | 5.5.0 |
| jupyter-events | 0.9.0 |
| jupyter-lsp | 2.2.1 |
| jupyter_server | 2.12.1 |
| jupyter_server_terminals | 0.5.0 |
| jupyterlab | 4.0.9 |
| jupyterlab_pygments | 0.3.0 |
| jupyterlab_server | 2.25.2 |
| jupyterlab-widgets | 3.0.9 |
| kaleido | 0.2.1 |
| kiwisolver | 1.4.5 |
| lazy_loader | 0.3 |
| lda | 2.0.0 |
| leidenalg | 0.10.1 |
| Levenshtein | 0.23.0 |

| | |
|---|---|
| llvmlite | 0.41.1 |
| locket | 1.0.0 |
| loompy | 3.0.7 |
| loomxpy | 0.4.2 |
| lxml | 4.9.3 |
| lz4 | 4.3.2 |
| MACS2 | 2.2.9.1 |
| MarkupSafe | 2.1.3 |
| marshmallow | 3.20.1 |
| matplotlib | 3.7.4 |
| matplotlib-inline | 0.1.6 |
| mistune | 3.0.2 |
| mizani | 0.9.3 |
| msgpack | 1.0.7 |
| mudata | 0.2.3 |
| multidict | 6.0.4 |
| multiprocessing-on-dill | 3.5.0a4 |
| mypy-extensions | 1.0.0 |
| natsort | 8.4.0 |
| nbclient | 0.9.0 |
| nbconvert | 7.12.0 |
| nbformat | 5.9.2 |
| nbsphinx | 0.9.3 |
| nbsphinx-link | 1.3.0 |
| ncls | 0.0.68 |
| nest-asyncio | 1.5.8 |
| networkx | 3.1 |
| notebook | 7.0.6 |
| notebook_shim | 0.2.3 |
| numba | 0.58.1 |
| numexpr | 2.8.6 |
| numpy | 1.24.4 |
| numpy-groupies | 0.9.22 |
| numpydoc | 1.6.0 |
| nvidia-ml-py | 12.535.133 |
| opencensus | 0.11.3 |
| opencensus-context | 0.1.3 |
| openpyxl | 3.1.2 |
| overrides | 7.4.0 |
| packaging | 23.2 |
| pandas | 1.5.0 |
| pandoc | 2.3 |
| pandocfilters | 1.5.0 |
| papermill | 2.5.0 |
| parso | 0.8.3 |
| partd | 1.4.1 |
| patsy | 0.5.4 |
| pbr | 3.1.1 |

| | |
|---|---|
| pexpect | 4.9.0 |
| pickleshare | 0.7.5 |
| Pillow | 10.1.0 |
| pip | 23.3.1 |
| pkgutil_resolve_name | 1.3.10 |
| platformdirs | 3.11.0 |
| plotly | 5.18.0 |
| plotnine | 0.12.4 |
| plumbum | 1.8.2 |
| ply | 3.11 |
| polars | 0.19.19 |
| progressbar2 | 4.2.0 |
| prometheus-client | 0.19.0 |
| prompt-toolkit | 3.0.41 |
| protobuf | 4.25.1 |
| psutil | 5.9.6 |
| ptyprocess | 0.7.0 |
| pure-eval | 0.2.2 |
| py-cpuinfo | 9.0.0 |
| py-spy | 0.3.14 |
| pyarrow | 14.0.1 |
| pyasn1 | 0.5.1 |
| pyasn1-modules | 0.3.0 |
| pybedtools | 0.9.1 |
| pyBigWig | 0.3.22 |
| pybiomart | 0.2.0 |
| pycistarget | 1.0.3.dev1+g3fde1ce |
| pycisTopic | 1.0.3.dev21+ge9b0e1a |
| pycparser | 2.21 |
| pydantic | 1.10.13 |
| pydata-sphinx-theme | 0.14.4 |
| pyfasta | 0.5.2 |
| pygam | 0.9.0 |
| Pygments | 2.17.2 |
| pynndescent | 0.5.11 |
| pyOpenSSL | 23.3.0 |
| pyparsing | 3.1.1 |
| PyQt5 | 5.12 |
| PyQt5_sip | 4.19.19 |
| pyranges | 0.0.127 |
| pyrle | 0.0.38 |
| pysam | 0.22.0 |
| pyscenic | 0.12.1+6.g31d51a1 |
| python-dateutil | 2.8.2 |
| python-igraph | 0.10.8 |
| python-json-logger | 2.0.7 |
| python-Levenshtein | 0.23.0 |
| python-utils | 3.8.1 |

```
pytz                          2023.3.post1
pyvis                         0.3.2
PyWavelets                    1.4.1
PyYAML                        6.0.1
pyzmq                         25.1.2
qtconsole                     5.5.1
QtPy                          2.4.1
rapidfuzz                     3.5.2
ray                           2.8.1
referencing                   0.32.0
requests                      2.31.0
requests-cache                1.1.1
rfc3339-validator             0.1.4
rfc3986-validator             0.1.1
rpds-py                       0.13.2
rsa                           4.9
scanorama                     1.7.4
scanpy                        1.9.6
scenicplus                    1.0.1.dev4+ge4bdd9f  /home/solvi/scenicplus/src
scikit-image                  0.21.0
scikit-learn                  1.3.2
scipy                         1.10.1
scrublet                      0.2.3
seaborn                       0.12.2
Send2Trash                    1.8.2
session-info                  1.0.0
setuptools                    68.0.0
six                           1.16.0
smart-open                    6.4.0
sniffio                       1.3.0
snowballstemmer               2.2.0
sorted-nearest                0.0.39
sortedcontainers              2.4.0
soupsieve                     2.5
Sphinx                        6.2.1
sphinx-book-theme             1.0.1
sphinx-rtd-theme              2.0.0
sphinxcontrib-applehelp       1.0.4
sphinxcontrib-devhelp         1.0.2
sphinxcontrib-htmlhelp        2.0.1
sphinxcontrib-jquery          4.1
sphinxcontrib-jsmath          1.0.1
sphinxcontrib-qthelp          1.0.3
sphinxcontrib-serializinghtml 1.1.5
stack-data                    0.6.3
statistics                    1.0.3.5
statsmodels                   0.14.0
stdlib-list                   0.10.0
```

```
suds-community                1.1.2
tables                        3.8.0
tabulate                      0.9.0
tblib                         3.0.0
tenacity                      8.2.3
terminado                     0.18.0
texttable                     1.7.0
threadpoolctl                 3.2.0
tifffile                      2023.7.10
tinycss2                      1.2.1
tmtoolkit                     0.12.0
tomli                         2.0.1
toolz                         0.12.0
tornado                       6.4
tqdm                          4.66.1
traitlets                     5.14.0
tspex                         0.6.3
types-python-dateutil         2.8.19.14
typing                        3.7.4.3
typing_extensions             4.9.0
typing-inspect                0.9.0
umap-learn                    0.5.5
uri-template                  1.3.0
url-normalize                 1.4.3
urllib3                       2.1.0
velocyto                      0.17.17
virtualenv                    20.21.0
wcwidth                       0.2.12
webcolors                     1.13
webencodings                  0.5.1
websocket-client              1.7.0
wheel                         0.41.2
widgetsnbextension            4.0.9
wrapt                         1.16.0
xlrd                          2.0.1
xmltodict                     0.13.0
xyzservices                   2023.10.1
yarl                          1.9.4
zict                          3.0.0
zipp                          3.17.0
zope.event                    5.0
zope.interface                6.1
Note: you may need to restart the kernel to use updated packages.
```

[ ]: