Computational Eigenvector Simulation

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Example: A Symmetric Stochastic Matrix

```
################################
### Step 0: Setup the matrix ###
################################

# Set seed
set.seed(23)
# Set parameters
M <- 4
# Generate matrix
P <- RM_stoch(M, symm = T, sparsity = F)
if(bool_loud){P}

#################################
#### Step 1: Evolve the batch ####
#################################

# Set evolution parameters
B <- 100
steps <- 10
# Evolve batch
sim <- sim_mixtime(P, B, steps)
batch <- sim[[1]]
evolved_batch <- sim[[2]]
if(bool_loud){head(evolved_batch)}

#################################
#### Step 2: Animate the batch! ####
#################################

# Plot the evolution arrays of the batch elements
batch_data1 <- evolved_batch
batch_scatterplot1 <- .batch_2d_plot(batch_data1)

# Add transition time
batch_animation1 <- batch_scatterplot1 + transition_time(time = time)

# Set me to true!
bool_animate <- F
if(bool_animate){batch_animation1}
```

```
# Step 5: Save the animation!
#anim_save(animation = batch_animation1, "stochastic.gif")
#batch_2d_customplot(batch_data = time_array(batch_data1, at_time = 0), 1,2)
```

Example 2: Normal Matrix

```
################################
### Step 0: Setup the matrix ###
################################

# Set seed
set.seed(23)
# Set parameters
N <- 3
# Generate matrix
P <- RM_norm(N)
if(bool_loud){P}

##################################
#### Step 1: Evolve the batch ####
##################################

# Set evolution parameters
B <- 100
steps <- 10
# Evolve batch
sim <- sim_mixtime(P, B, steps)
batch <- sim[[1]]
evolved_batch <- sim[[2]]
if(bool_loud){head(evolved_batch)}

# Get the final evolved batch elements after all steps
fully_evolved <- by.time(evolved_batch, at_time = steps)
fully_evolved
```

```
##                x1          x2          x3 time element_index        r_x1
## 11    14.03389525  208.842323  123.057199   10             1   2.1889621
## 22    -5.55796952  -71.244830  -40.623796   10             2   2.0238456
## 33     8.59569532  139.128483   81.075621   10             3   1.5998170
## 44     6.04705328   94.038728   57.288056   10             4   3.6519658
## 55    -6.71837857 -111.030860  -64.839788   10             5   1.5743577
## 66     0.07889895   13.702745    8.899852   10             6   0.2676107
## 77    13.63272959  224.914038  131.419436   10             7   1.5896197
## 88    -9.78869871 -156.620628  -93.994579   10             8   2.4663845
## 99     5.29447589   93.715929   54.886264   10             9   1.4303262
## 110   -5.10151440  -86.977809  -49.973168   10            10   1.2620845
## 121    1.12100675   20.816270   11.296134   10            11   0.7395973
## 132    9.80466246  154.058710   92.035188   10            12   2.3829796
## 143   -7.46215355 -128.861252  -74.378809   10            13   1.2884941
## 154   19.87748570  307.660200  181.869478   10            14   2.0988332
## 165   -5.67732315  -81.590395  -47.855067   10            15   2.2211747
## 176  -13.24177496 -203.007544 -118.620499   10            16   1.8389781
```

```
## 187   -0.41741640   -1.644812   -2.829119   10          17  -0.2780643
## 198   18.27020517  278.793900  164.737104   10          18   2.1533952
## 209   -0.44641023  -27.140241  -16.229722   10          19   0.3078207
## 220   -5.13169787  -82.273342  -49.994270   10          20   3.1415678
## 231   18.99762440  299.385958  175.497070   10          21   1.8076157
## 242    7.84667059  137.749235   79.958865   10          22   1.3225135
## 253   -9.17852169 -156.768277  -91.244127   10          23   1.4279071
## 264   -4.31875015  -81.493647  -46.727044   10          24   1.0474647
## 275  -15.32459165 -224.568678 -131.579920   10          25   2.0966105
## 286   -2.53661483  -45.305354  -26.823229   10          26   1.5966579
## 297    2.75366712   35.583694   20.899358   10          27   2.9487333
## 308    0.54421188   14.710537    7.102116   10          28   0.2918137
## 319  -20.34259865 -323.832187 -190.286876   10          29   1.8249645
## 330   17.25823834  267.103850  157.060653   10          30   1.9526061
## 341   -2.32802398  -52.194735  -30.268148   10          31   0.8814749
## 352   -2.58100890  -39.647338  -22.584047   10          32   1.4028313
## 363   13.86538542  220.176833  129.595643   10          33   1.8741441
## 374    6.99669927  113.352030   65.770722   10          34   1.5239654
## 385    3.93949616   62.951499   35.880080   10          35   1.3145959
## 396   -3.08727391  -37.050126  -21.273352   10          36   2.5602160
## 407    7.39841684  127.315467   76.110450   10          37   1.9638446
## 418  -21.45021206 -325.823623 -191.341309   10          38   1.9980757
## 429  -13.36381470 -210.732710 -125.338487   10          39   2.2034223
## 440    5.26751435   99.502253   57.889088   10          40   1.1919617
## 451   -7.20598617  -94.534558  -54.897814   10          41   2.3970551
## 462   -3.27662274  -47.766334  -27.569863   10          42   1.7677608
## 473   -3.44657334  -40.688981  -22.042566   10          43   1.5196832
## 484  -11.45424968 -182.507533 -108.094157   10          44   2.0240113
## 495   15.74149237  249.846679  147.331325   10          45   1.9221222
## 506    1.14281185   17.405467   12.346663   10          46  -1.1475424
## 517   -7.79263756 -117.132259  -70.315801   10          47   2.9056670
## 528    5.61631300   77.235560   45.647088   10          48   2.7744513
## 539   12.46831081  200.986764  119.653929   10          49   2.1271995
## 550   19.28926256  299.006660  176.285574   10          50   2.0161354
## 561   -8.54416680 -149.205330  -88.043244   10          51   1.5999561
## 572    2.58179807   44.581708   27.290957   10          52   3.0321034
## 583  -10.02267170 -142.671868  -82.467357   10          53   1.8867844
## 594   -0.36580378    6.483088    4.144729   10          54  -0.8702939
## 605   26.56393052  409.420989  240.676003   10          55   1.9625401
## 616   20.00102278  304.448454  179.218810   10          56   2.0540600
## 627  -11.51658995 -180.746906 -105.597844   10          57   1.7503298
## 638   -9.35743996 -145.344642  -85.590121   10          58   1.9757786
## 649    9.90297503  154.731930   92.906405   10          59   2.6381454
## 660   26.35490871  408.926929  240.969344   10          60   1.9981818
## 671   11.28611725  172.779515  101.605439   10          61   2.0009414
## 682   18.76750637  300.182902  176.431828   10          62   1.8126505
## 693   -4.74387540  -63.107554  -38.222879   10          63   5.3872415
## 704   -6.48464733 -104.755661  -60.792211   10          64   1.5347173
## 715   10.58515243  171.592285  100.009075   10          65   1.5978810
## 726   -5.07344291  -75.638335  -46.376740   10          66   5.1206149
## 737   -7.13610813 -104.511270  -63.077587   10          67   3.5025637
## 748   13.54101975  205.990484  122.074310   10          68   2.2638550
## 759   10.47651360  166.702396  100.348072   10          69   2.6408478
## 770    1.13680335    7.951743    3.642633   10          70   1.7011445
```

```
## 781   -4.17473667  -70.165879  -40.704547   10            71   1.4210047
## 792    2.65240761   28.128088   15.755777   10            72   2.5759445
## 803    1.02733006   23.930903   13.057554   10            73   0.5582446
## 814  -17.49832286 -273.967500 -161.957091   10            74   2.0474014
## 825    0.38027650   18.753649   10.302616   10            75   0.2325918
## 836   -2.41946566  -41.615269  -24.598951   10            76   1.6836342
## 847   -1.16648095  -17.077753  -10.358066   10            77   3.9525201
## 858  -16.86683633 -251.134500 -147.076879   10            78   2.0126696
## 869   18.64567712  276.105226  161.808319   10            79   2.0544648
## 880    4.18397575   69.942120   39.800680   10            80   1.1996139
## 891   -3.15679923  -52.633376  -30.513056   10            81   1.4320007
## 902   22.31114515  345.884410  203.709327   10            82   1.9872915
## 913    6.87405416   89.840367   51.386147   10            83   2.0082939
## 924   15.53303795  244.349733  144.371278   10            84   2.0115191
## 935   11.32577419  174.483735  104.214114   10            85   2.4893678
## 946  -12.52933910 -197.398030 -118.296347   10            86   2.4970693
## 957   -2.71639199  -27.842344  -17.261451   10            87 -10.2681846
## 968    5.53880110  105.054668   61.643726   10            88   1.2907283
## 979    1.04572375   13.179513    9.360276   10            89  -1.2071477
## 990    3.77134212   46.933822   26.559956   10            90   1.9901784
## 1001  -9.40403322 -133.044916  -76.670441   10            91   1.8467612
## 1012   7.30791437  106.289213   63.272465   10            92   2.7144077
## 1023  -1.70301275  -33.170635  -21.193707   10            93  16.6240504
## 1034   8.25620771  145.081393   84.205098   10            94   1.3186903
## 1045   5.67290234   64.480997   36.514276   10            95   2.4637797
## 1056 -20.13733121 -303.241650 -178.257782   10            96   2.0632726
## 1067  -0.07362067   12.578975    9.206883   10            97   0.1787570
## 1078  -8.12646267 -112.157625  -66.242761   10            98   2.7190573
## 1089  -7.43103354 -116.521407  -70.139774   10            99   2.7403843
## 1100  -6.11950467  -89.220963  -50.744077   10           100   1.5226341
##           r_x2     r_x3 eigen_index
## 11   1.7501101 1.737911           0
## 22   1.8025922 1.670621           0
## 33   1.7618051 1.767823           0
## 44   1.7033138 1.760075           0
## 55   1.7580823 1.775806           0
## 66   1.5880921 2.154490           0
## 77   1.7573781 1.775262           0
## 88   1.7223115 1.768109           0
## 99   1.7515962 1.800745           0
## 110  1.7791910 1.784827           0
## 121  1.8555539 1.808441           0
## 132  1.7291849 1.760748           0
## 143  1.7723842 1.790079           0
## 154  1.7440818 1.753419           0
## 165  1.7579273 1.723477           0
## 176  1.7603176 1.747858           1
## 187  0.7203841 1.519900           0
## 198  1.7452290 1.747988           0
## 209  1.6991801 2.084917           0
## 220  1.7055285 1.770737           0
## 231  1.7548051 1.758802           1
## 242  1.7640484 1.796698           0
## 253  1.7613891 1.787267           0
```

```
## 264  1.7782827 1.820390          0
## 275  1.7584837 1.730928          0
## 286  1.7365801 1.805214          0
## 297  1.7610482 1.680698          0
## 308  2.0115665 1.928843          0
## 319  1.7511007 1.762951          1
## 330  1.7513022 1.752517          0
## 341  1.7574301 1.876950          0
## 352  1.7953573 1.744249          0
## 363  1.7489094 1.762298          0
## 374  1.7676695 1.767502          0
## 385  1.7928502 1.759524          0
## 396  1.7964099 1.643759          0
## 407  1.7248540 1.793534          0
## 418  1.7538422 1.745189          0
## 429  1.7350097 1.761362          0
## 440  1.7583686 1.822326          0
## 451  1.7759417 1.684488          0
## 462  1.7794036 1.726089          1
## 473  1.8802692 1.621501          0
## 484  1.7403157 1.764535          0
## 495  1.7464130 1.762409          0
## 506  1.5092664 1.776232          0
## 517  1.7244068 1.744995          0
## 528  1.7494918 1.707454          0
## 539  1.7328827 1.769594          0
## 550  1.7476326 1.753547          0
## 561  1.7418931 1.796968          0
## 572  1.6930439 1.797816          0
## 583  1.7784769 1.716883          0
## 594  1.5751712 2.820497          0
## 605  1.7518644 1.750897          0
## 616  1.7504734 1.746401          0
## 627  1.7595489 1.756716          1
## 638  1.7491544 1.754112          0
## 649  1.7225759 1.759485          0
## 660  1.7482829 1.753826          0
## 671  1.7516341 1.748403          0
## 682  1.7505911 1.764752          1
## 693  1.7176782 1.699170          0
## 704  1.7675721 1.766460          0
## 715  1.7615320 1.768414          0
## 726  1.6963555 1.745568          0
## 737  1.7182261 1.736080          0
## 748  1.7413819 1.747314          0
## 759  1.7184542 1.766564          0
## 770  2.1904979 1.286610          0
## 781  1.7665030 1.780987          0
## 792  1.8389771 1.580862          0
## 803  1.8401484 1.885455          0
## 814  1.7435782 1.757729          0
## 825  1.8150706 2.065379          0
## 836  1.7400962 1.791865          1
## 847  1.7116204 1.736832          0
```

```
## 858  1.7584329 1.737028          0
## 869  1.7577596 1.735028          0
## 880  1.7932331 1.776210          0
## 891  1.7677350 1.777965          0
## 902  1.7490590 1.753411          0
## 913  1.7972461 1.679553          0
## 924  1.7441149 1.759406          0
## 935  1.7302687 1.753384          0
## 946  1.7248500 1.762231          0
## 957  1.6996405 1.594260          0
## 968  1.7466369 1.824606          0
## 979  1.5142537 1.710914          0
## 990  1.8148123 1.656089          0
## 1001 1.7829498 1.713820          1
## 1012 1.7371738 1.730918          0
## 1023 1.6332823 1.841408          0
## 1034 1.7641720 1.797032          0
## 1045 1.8190771 1.615957          0
## 1056 1.7528430 1.742047          0
## 1067 1.4400039 2.210939          0
## 1078 1.7502281 1.708762          0
## 1089 1.7190481 1.761195          0
## 1100 1.7998339 1.723364          0
```

```
####################################
#### Step 2: Animate the batch! ####
####################################

# Plot the evolution arrays of the batch elements
batch_data2 <- evolved_batch
# Pairwise scatter plots
plot_12 <- .batch_2d_customplot(batch_data2, 1, 2)
batch_animation2_1 <- plot_12 + transition_time(time = time)

plot_23 <- .batch_2d_customplot(batch_data2, 2, 3)
batch_animation2_2 <- plot_23 + transition_time(time = time)

plot_13 <- .batch_2d_customplot(batch_data2, 1, 3)
batch_animation2_3 <- plot_13 + transition_time(time = time)
```

```
# Set me to true!
bool_animate1 <- F
if(bool_animate1){batch_animation2_1}
```

```
# Set me to true!
bool_animate2 <- F
if(bool_animate2){batch_animation2_2}
```

```
# Set me to true!
bool_animate3 <- F
if(bool_animate3){batch_animation2_3}
```