

## Linear Algebra Assignment – 2

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1) Algorithm used for eigen-values and eigen vectors : QR Algorithm

This algorithm transforms matrix into tridiagonal form and end result is eigen values on principle diagonal elements.

Let  $Q_i$ ,  $R_i$  be QR-factorization of matrix  $A_i$  at  $i$ th iteration and  $n$  be no of iterations -

FUNCTION qr\_algorithm(A,n):

  a=A

  U = give\_me\_identity(len(A))

  for i = 0 to n-1

    q,r = grahm\_sch(a)                   //QR factorization using Grahm-Schmidt process

    U = matrix\_mul(U,q)

    a\_1 = matrix\_mul(r,q)

    a=a\_1

  return a,U

Diagonals of returned matrix A = eigen-values of A

Columns of U = eigen vectors of A

2) Centrality measures for train el-classico graph -

-----a) Degree Centrality-----

Stegan=4.0

Roberto=5.0

Pique=7.0

Lenglet=6.0

Alba=5.0

Dejong=3.0

Busquets=4.0

Arthur=3.0

Messi=10.0

Suarez=3.0

Griezmann=5.0

Courtois=4.0

Marcelo=4.0

Ramos=8.0

Varan=6.0

Nacho=4.0

Isco=4.0

Casemiro=5.0

Modric=4.0

Ronaldo=6.0

Benzama=6.0

Bale=4.0

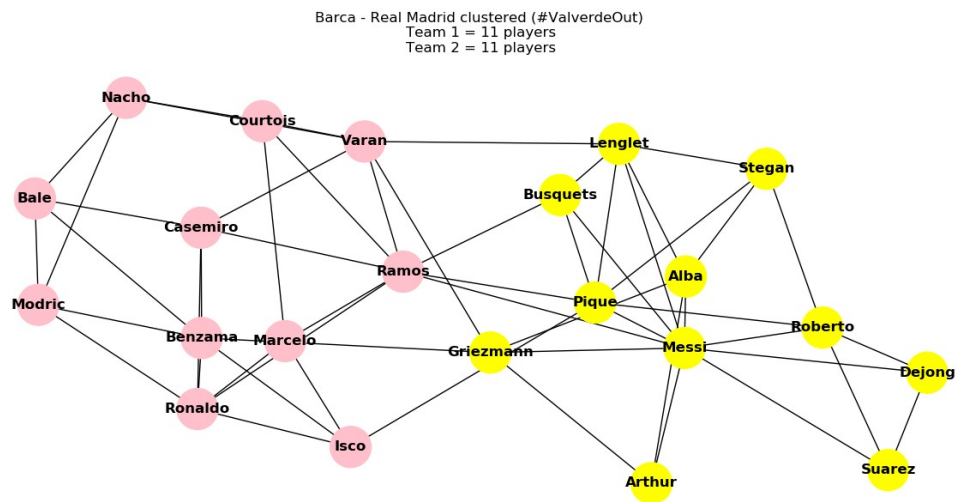
-----b) Closeness Centrality (lesser the value, closer to others & hence more central)-----

Stegan=48.0  
Roberto=49.0  
Pique=38.0  
Lenglet=41.0  
Alba=45.0  
Dejong=52.0  
Busquets=42.0  
Arthur=47.0  
Messi=35.0  
Suarez=52.0  
Griezmann=38.0  
Courtois=45.0  
Marcelo=47.0  
Ramos=34.0  
Varan=40.0  
Nacho=51.0  
Isco=44.0  
Casemiro=43.0  
Modric=52.0  
Ronaldo=43.0  
Benzama=43.0  
Bale=53.0

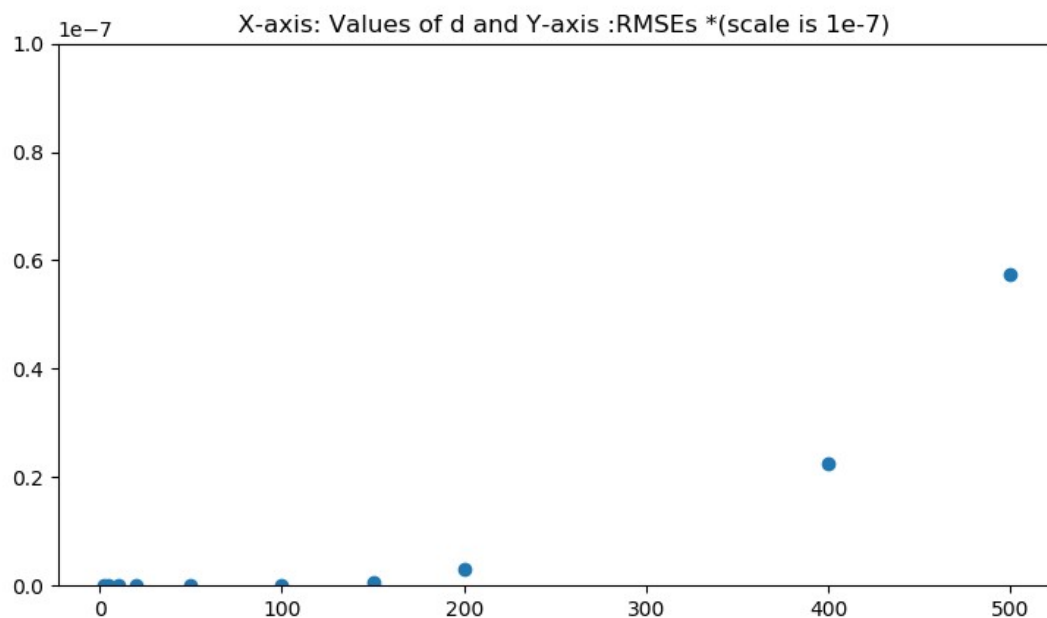
-----c) Eigenvector Centrality (influential neighbours)-----

Stegan=0.18766469447457443  
Roberto=0.21237096340004152  
Pique=0.32558605384923806  
Lenglet=0.2878249947378583  
Alba=0.22173842700127813  
Dejong=0.1343915242800445  
Busquets=0.242083473417908  
Arthur=0.14949611699262644  
Messi=0.4033938802362691  
Suarez=0.1343915242800445  
Griezmann=0.20933600291065227  
Courtois=0.14520213276461078  
Marcelo=0.14749653569171597  
Ramos=0.334474269892616  
Varan=0.2261360057146156  
Nacho=0.10239317300895148  
Isco=0.14956771669811314  
Casemiro=0.18303201729746627  
Modric=0.10094181688993517  
Ronaldo=0.1940629466845778  
Benzama=0.16772258371408613

### 3) Spectral clustering result for lclassico train graph -



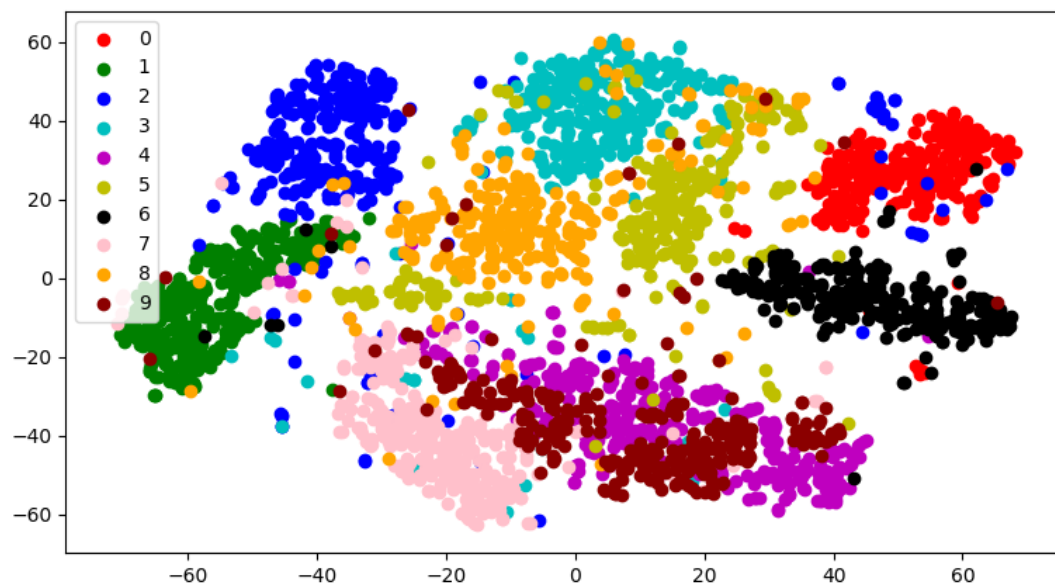
### 4a) RMSE Plot for truncated SVD



Plot may vary while running as I am using random starting point for a particular d (as dataset is a highly sparse matrix we can get lot of 0 values) i.e,  
e.g d=2,  
in python notation,  
`extracted_matrix = mnist_train[:10000, n:n+2]` where n is random between (50,100) and so as to generalise the results better we can run the code several times to see the upper and lower bounds of error. I observed upper bound of rmse for d=500 to be 1e-7.

#### 4b) t-SNE plot for MNIST

Plot is for 3000 samples



We observe that every number is getting clustered together (approximately) to its unique cluster and hence digit recognition problem is quite feasible here.