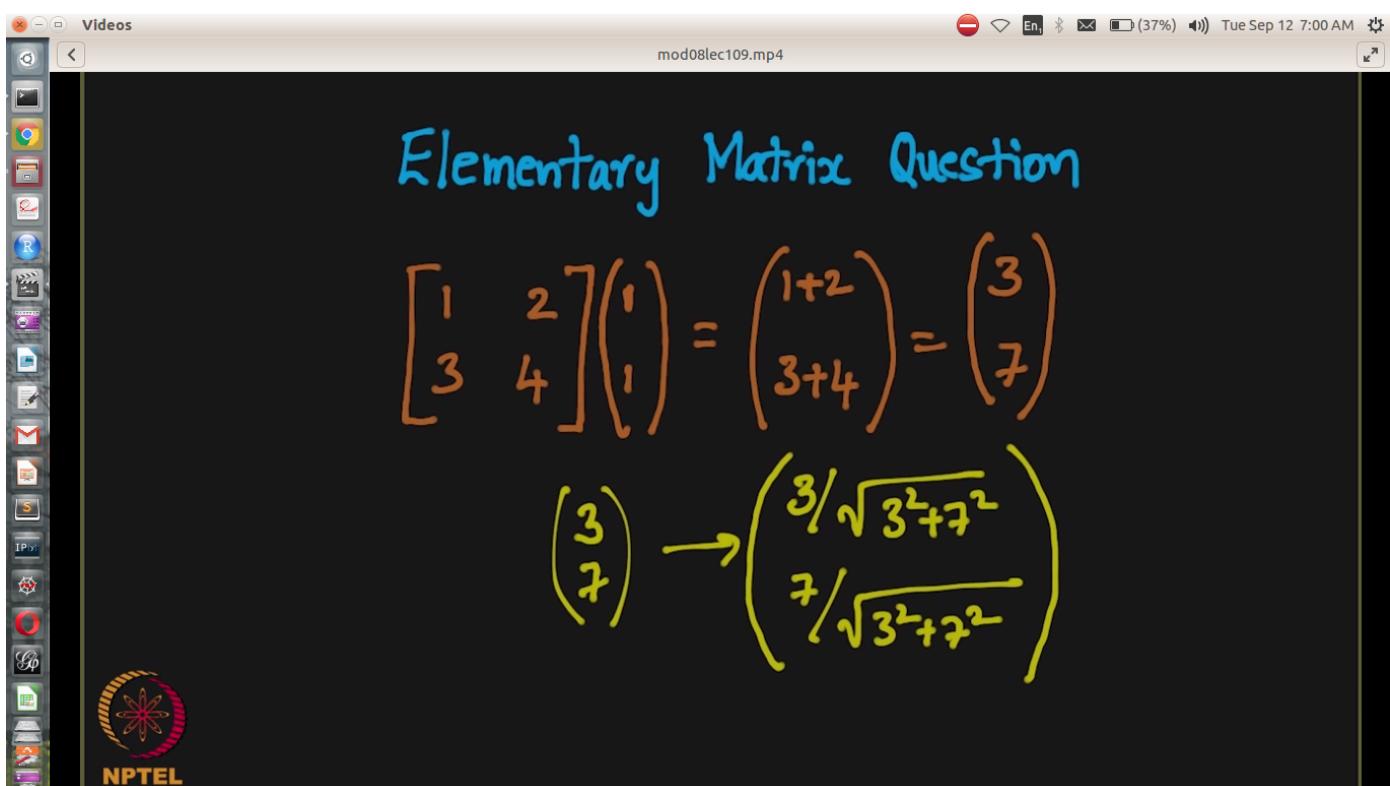
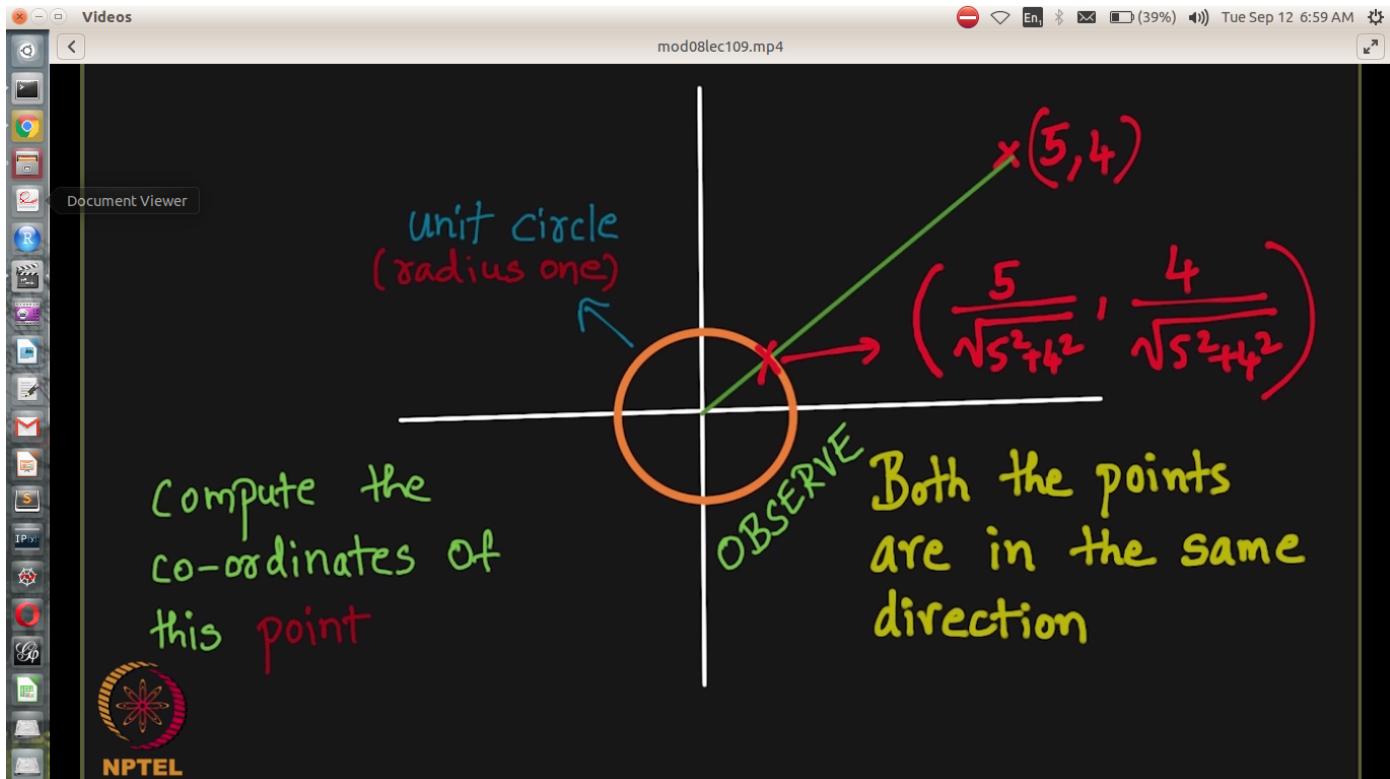


# Lec109 : Link Analysis (Continued) - Matrix Multiplication (Pre-Requisite 1 )



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Tue Sep 12 7:00 AM

$$\begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix} \begin{pmatrix} 0.39 \\ 0.91 \end{pmatrix} = \begin{pmatrix} 2.21 \\ 4.81 \end{pmatrix}$$

$$\begin{pmatrix} 2.21 \\ 4.81 \end{pmatrix} \rightarrow \text{normalise } \& \text{repeat this process.}$$

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6:07 - 2:10

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$$[M] [vec^1] = [vec^2]$$

$$[vec^2] \rightarrow [vec^3]$$

$$[vec^3] \rightarrow [vec^4]$$

Converge?

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8:02 - 0:15

## Lec110 : Link Analysis (Continued) - Convergence in Repeated Matrix Multiplication (Pre-Requisite 1 )

In [4]:

```
import numpy as np  
  
A = np.mat('1 2; 3 4')  
v = np.mat('1; 1')  
  
print A*v
```

```
[[3]  
[7]]
```

In [5]:

```
import numpy as np

A = np.mat('1 2; 3 4')
v = np.mat('1; 1')
print v
print "*"*20
for i in range(10):
    z = A*v
    z = z/np.linalg.norm(z)#denominator sqrt(a^2+ b^2)
    v = z
    print z
    print "*"*20
```

```
[[1]
 [1]]
#####
[[ 0.3939193 ]
 [ 0.91914503]]
*****
[[ 0.41750017]
 [ 0.90867684]]
*****
[[ 0.41586776]
 [ 0.9094251 ]]
*****
[[ 0.41598089]
 [ 0.90937336]]
*****
[[ 0.41597305]
 [ 0.90937694]]
*****
[[ 0.41597359]
 [ 0.90937669]]
*****
[[ 0.41597356]
 [ 0.90937671]]
*****
[[ 0.41597356]
 [ 0.90937671]]
*****
[[ 0.41597356]
 [ 0.90937671]]
```

In [6]:

```
import numpy as np

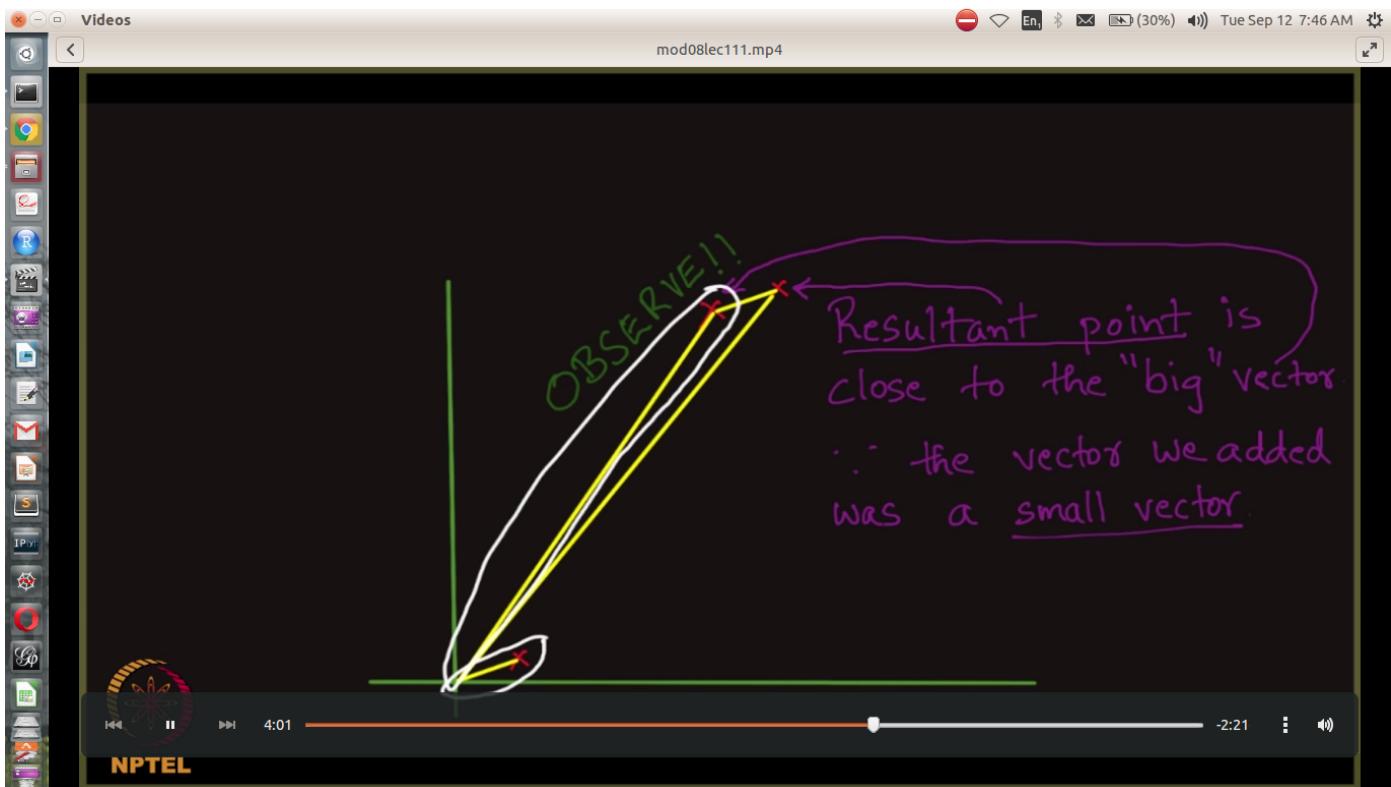
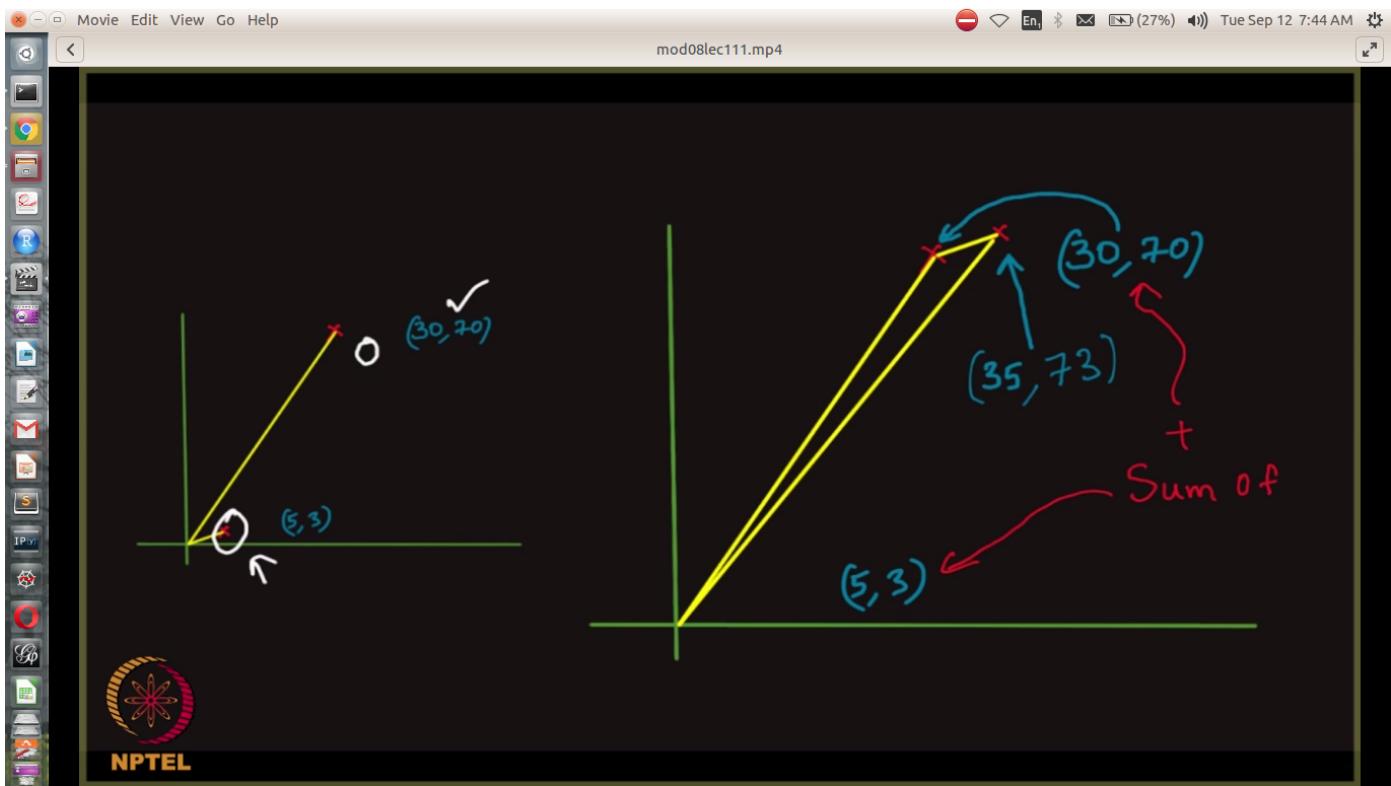
A = np.mat('1 2; 3 4')
v = np.mat('4; 11')
print v
print "*"*20
for i in range(10):
    z = A*v
    z = z/np.linalg.norm(z)#denominator sqrt(a^2+ b^2)
    v = z
    print z
    print "*"*20
```

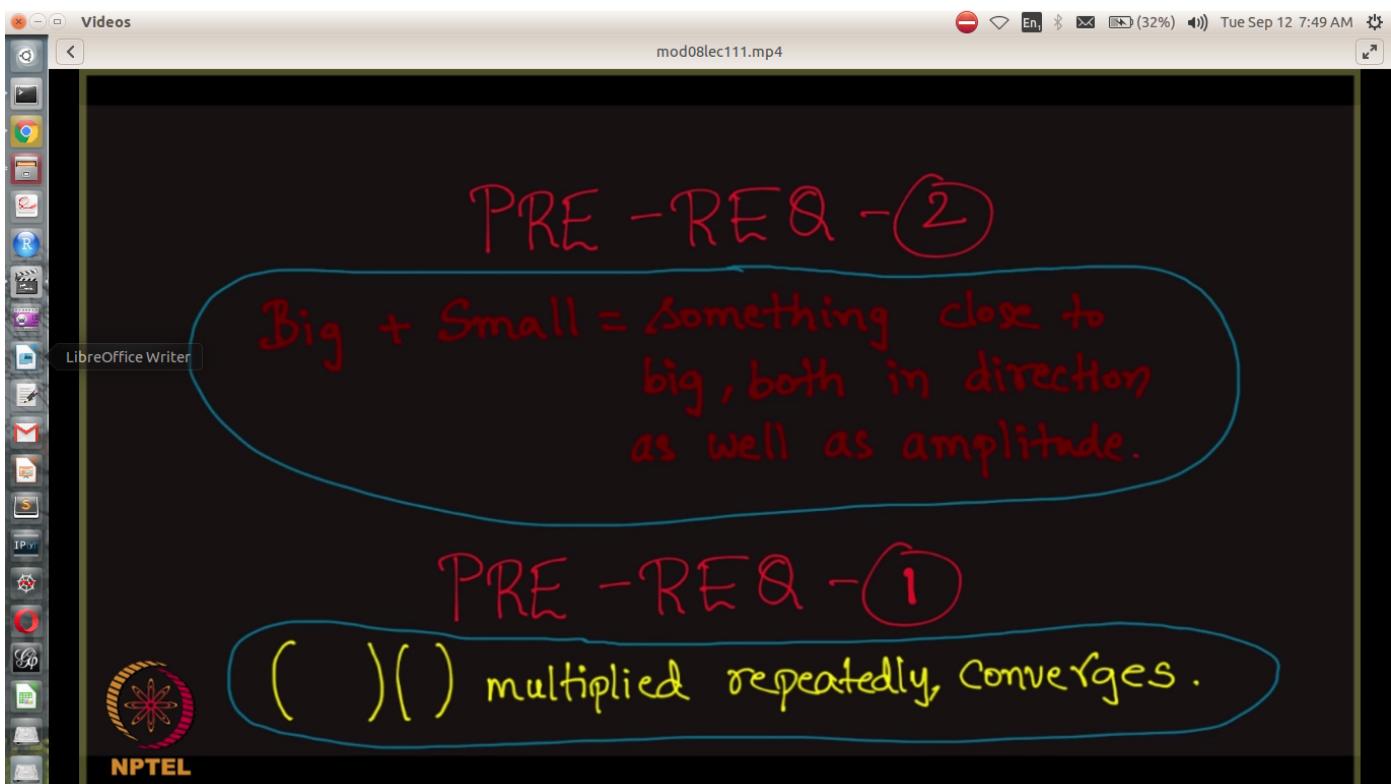
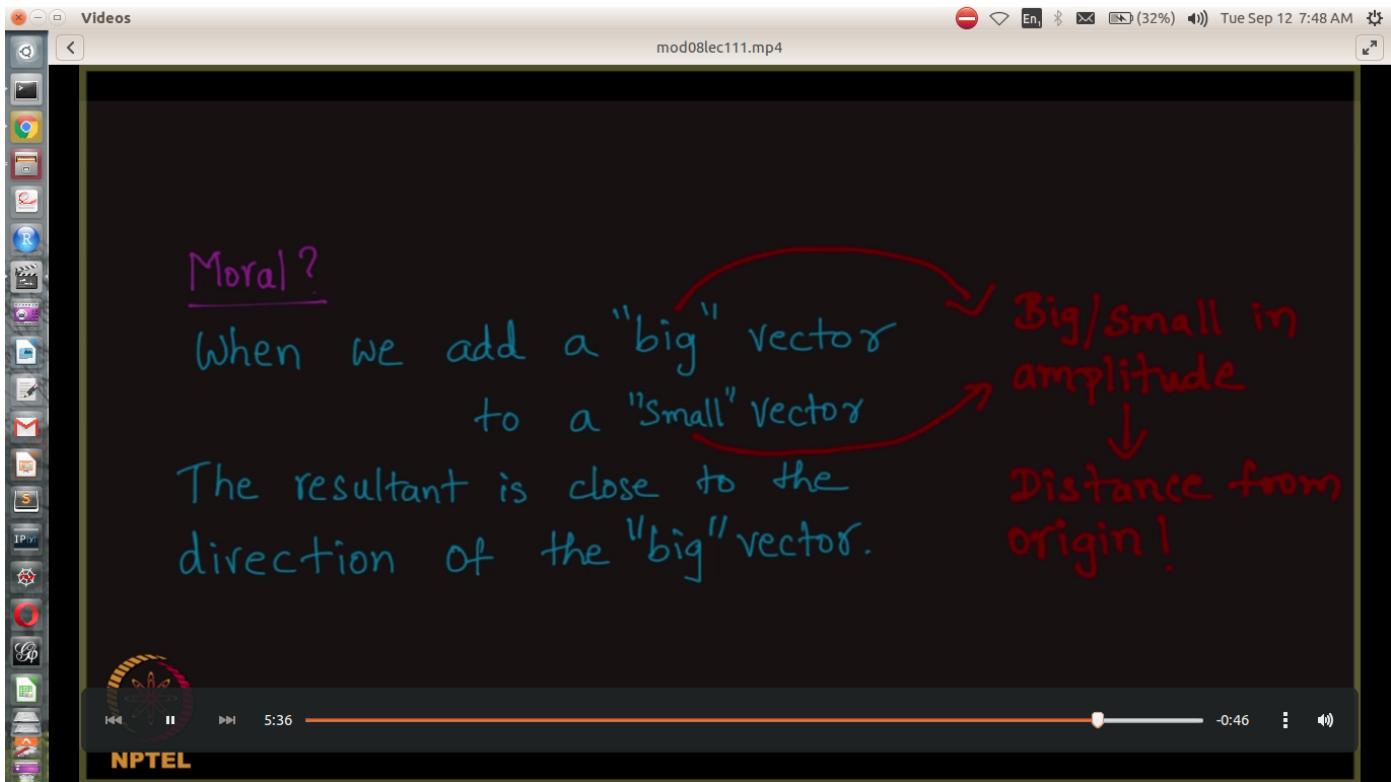
```
[[ 4]
 [11]]
#####
[[ 0.42111131]
 [ 0.90700897]]
*****
[[ 0.41561741]
 [ 0.90953954]]
*****
[[ 0.41599824]
 [ 0.90936542]]
*****
[[ 0.41597185]
 [ 0.90937749]]
*****
[[ 0.41597368]
 [ 0.90937665]]
*****
[[ 0.41597355]
 [ 0.90937671]]
*****
[[ 0.41597356]
 [ 0.90937671]]
*****
[[ 0.41597356]
 [ 0.90937671]]
*****
[[ 0.41597356]
 [ 0.90937671]]
```

- Inference : No matter where we start from(v), A converges to a constant vector

## Lec111 : Link Analysis (Continued) - Addition of two vectors (Pre requisite 2)

- A vector with big amplitude (greater length) is called as the big vector





## Lec112 : Link Analysis (Continued) - Covergence in Repeated Matrix Multiplication - The Details

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# Recollect!

Heard of eigen vectors/values of a matrix?

①  $A\vec{v} = \lambda \vec{v}$

②  $2 \times 2 A'$

③ Any vector  $\vec{v} = \alpha \vec{v}_1 + \beta \vec{v}_2$

Linearly Independent

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(55%) Tue Sep 12 8:17 AM

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# How/Why?

A matrix

$$A\vec{v} = A(\lambda_1 \vec{v}_1 + \lambda_2 \vec{v}_2) =$$

Some vector  $\rightarrow$  Eigen values

$\downarrow$   $\downarrow$  Eigen vectors

$$= \lambda_1 A(\vec{v}_1) + \lambda_2 A(\vec{v}_2) = \lambda_1^2 \vec{v}_1 + \lambda_2^2 \vec{v}_2$$

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$A^K(v) = \lambda_1^K v_1 + \lambda_2^K v_2 \quad (\text{Say } \lambda_1 > \lambda_2)$

Amplitude      Direction

9:06 - 7:47

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Note:

One more than

More than twice

$2^3 = 8, 3^3 = 27 \rightarrow \text{More than thrice}$

$2^{100}, 3^{100} \rightarrow \text{Several folds}$

So much that  $2^{100}/3^{100} \approx 0$ .

Document Viewer

9:06 - 7:47

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$A^K(v) = \lambda_1 v_1 + \lambda_2 v_2$  (Say  $\lambda_1 > \lambda_2$ )

Amplitude      Direction

$\Rightarrow \lambda_1 > \lambda_2$

$\lambda_1 >> \lambda_2$

$\Rightarrow A^K(v) = \boxed{\lambda_1 v_1} + \boxed{\lambda_2 v_2}$

Big                  Small

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$\Rightarrow A^K(v) = \lambda_1 v_1 + \lambda_2 v_2$

random vector

Big

Small

$\Rightarrow A^K(v) \approx \lambda_1 v_1$

It is in the direction of  $v_1$

Independent of  $v$   
WHY?

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## Lec113 : Link Analysis (Continued) - Page Rank as a matrix operation

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Process is a matrix multiplication

$$A \begin{bmatrix} A & B & C \\ 0 & 1/2 & 0 \\ 0 & 0 & 1 \\ C & 1 & 1/2 & 0 \end{bmatrix} \begin{bmatrix} 1/3 \\ 1/3 \\ 1/3 \end{bmatrix} = \begin{bmatrix} 1/6 \\ 1/3 \\ 1/3 + 1/6 \end{bmatrix}$$

Can this process be captured as a matrix multiplication process.

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mod08lec113.mp4

- 1) For a given network, start from  $y_3, y_3, y_3 \rightarrow$  we observe it converges
- 2) We noted that this iterations can be seen as matrix multiplication.  
To be shown next
- 3) Why does it converge?
- 4) PageRank & all the above?

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## Lec114 : Link Analysis (Continued) - Page Rank Explained