Engaging students with a recommender system.

Or do you like Ed Sheeran too?

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tinyurl.com/4cbk95pe

What is the ICPS?

The Institute for Creative Problem Solving was founded in 1992 to provide a pathway for high-achieving students to further enhance their mathematical and creative thinking skills. Since its inception, more than 3,000 students in grades 5-10 have benefited from the Institute of whom, approximately 70% are underrepresented minorities and/or women.

What is the ICPS?

Principles of The Institute for creative Problem Solving

1. Learning Mathematics Opens Doorways
2. Research in Mathematics
3. Technology Supports Education
4. Robotics Engineering
5. Provide a Conduit for Mathematical Events

Structure of a Class

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4. Take something with them

Some Lessons

Some lessons I give that fall in the structure of a usual class.

[1] Someone else is does this.

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7. PageRank Algorithm
8. Build your Early Chatbots and Build your own image filter (Coming soon)
9. Neural Nets by hand [1]

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Today's lesson

As always, I am busy movies. Hypothetically, a new movie comes out. I hear from Chi-Yao to go watch the movie and David who says to not watch it. What should I do?

In Table 1 we find several movie ratings from friends of mine. Who should I listen to about the new movie? How can we solve this from data in the table?

	Movies											
	The Scorpion King	The Rundown	Tooth Fairy	Pain & Gain	Fast & Furious 6	San Andreas	Moana	Baywatch	Jumanji	Hobbs & Shaw	Moana 2	New Movie
Me	6	5	4	8	8	7	10	3	1	2	2	?
Ashok	5	5	5	1	3	1	9	4	9	1	8	4
Bella	10	5	7	7	7	5	3	8	7	10	3	5
Chi-Yao	3	4	8	2	8	9	2	8	7	6	3	9
David	7	1	6	7	4	2	8	3	1	6	5	3

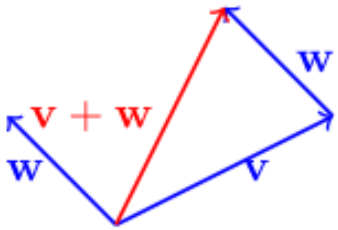
Table 1: A fictional rating of various movies.

We first need to learn a little Linear Algebra and then we should be able to tackle the problem.

:

Vectors

Much of the lesson will be quite ordinary



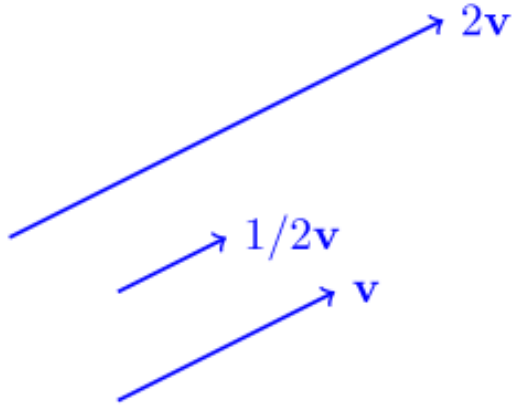


Figure 2:

The Norm of a Vector

But we ask quite different questions

5. We've seen vectors in $\mathbb{R}^2$ and $\mathbb{R}^3$. Does a vector in $\mathbb{R}^4$ make any sense? If so what is $\|(1, 2, -1, 3)\|$? What about $\mathbb{R}^{10}$ or $\mathbb{R}^\infty$? How would the formula change for the norm? Would anything else be different?

6. Does a vector in $\mathbb{R}^{1/2}$ make any sense? Or $\mathbb{R}^{-2}$?

Jump to the Geometry & Fractal

The Norm of a Vector

And other quite different questions

8. We have our norm, $\|(x_1, x_2)\| = \sqrt{x_1^2 + x_2^2}$. This norm is called the ℓ_2 norm and we can write as $\|(x_1, x_2)\|_2$. What would an ℓ_3 norm be? What would an $\ell_{1/2}$ norm be? Or an ℓ_1 norm or ℓ_∞ norm?

9. Graph the points that satisfy $\|(x_1, x_2)\|_2 = 1$. How about for our other norms $\|(x_1, x_2)\|_{1/2} = 1$ or $\|(x_1, x_2)\|_3 = 1$ or $\|(x_1, x_2)\|_\infty = 1$?

Jump to the Norms and Conjecture

The lessons are all straightforward, but aimed at the end goal.

The dot product of two unit vectors is the cosine of the angle between those vectors. What we have done is use that

$$\cos(\theta) = \frac{\mathbf{v} \cdot \mathbf{w}}{\|\mathbf{v}\|\|\mathbf{w}\|} = \frac{\mathbf{v}}{\|\mathbf{v}\|} \cdot \frac{\mathbf{w}}{\|\mathbf{w}\|} = \mathbf{u_v} \cdot \mathbf{u_w}.$$

If you haven't seen cosine yet, that is not a problem. Cosine is a ratio from a right triangle. For a given angle θ.

Matrices

column of matrix B:

$$C_{ij} = \sum_{k=1}^{n} A_{ik} \cdot B_{kj}$$

Example of Matrix Multiplication Consider two matrices

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \end{bmatrix} \quad \text{(dimensions 2x3)}$$

$$B = \begin{bmatrix} 7 & 8 \\ 9 & 10 \\ 11 & 12 \end{bmatrix} \quad \text{(dimensions 3x2)}$$

1. First row, first column

$$C_{11} = 1 \cdot 7 + 2 \cdot 9 + 3 \cdot 11 = 7 + 18 + 33 = 58$$

Link to the Cryptography Lesson

Assume A, B and C are matric
when needed. Solve the followin

1. $AB = C$.
2. $BA = C$.
3. $3A - AB = B$.
4. $3A - BA = A$.
5. $A\mathbf{v} = \lambda\mathbf{v} + \mathbf{b}$.
6. Simplify $(ABA^{-1})^4$.

Jump to the Markov Chains and Process
or
Jump to the PageRank Algorithm

Matrices

Then if $ad - bc \neq 0$ then

$$A^{-1} = \frac{1}{ad - bc} \begin{bmatrix} d & -b \\ -c & a \end{bmatrix}$$

For

$$A = \begin{bmatrix} 4 & 7 \\ 2 & 6 \end{bmatrix}$$

We get

$$A^{-1} = \frac{1}{ad - bc} \begin{bmatrix} d & -b \\ -c & a \end{bmatrix} = \frac{1}{6(4) - 7(2)} \begin{bmatrix} 6 & -7 \\ -2 & 4 \end{bmatrix} = \frac{1}{10} \begin{bmatrix} 6 & -7 \\ -2 & 4 \end{bmatrix} = \begin{bmatrix} 0.6 & -0.7 \\ -0.2 & 0.4 \end{bmatrix}.$$

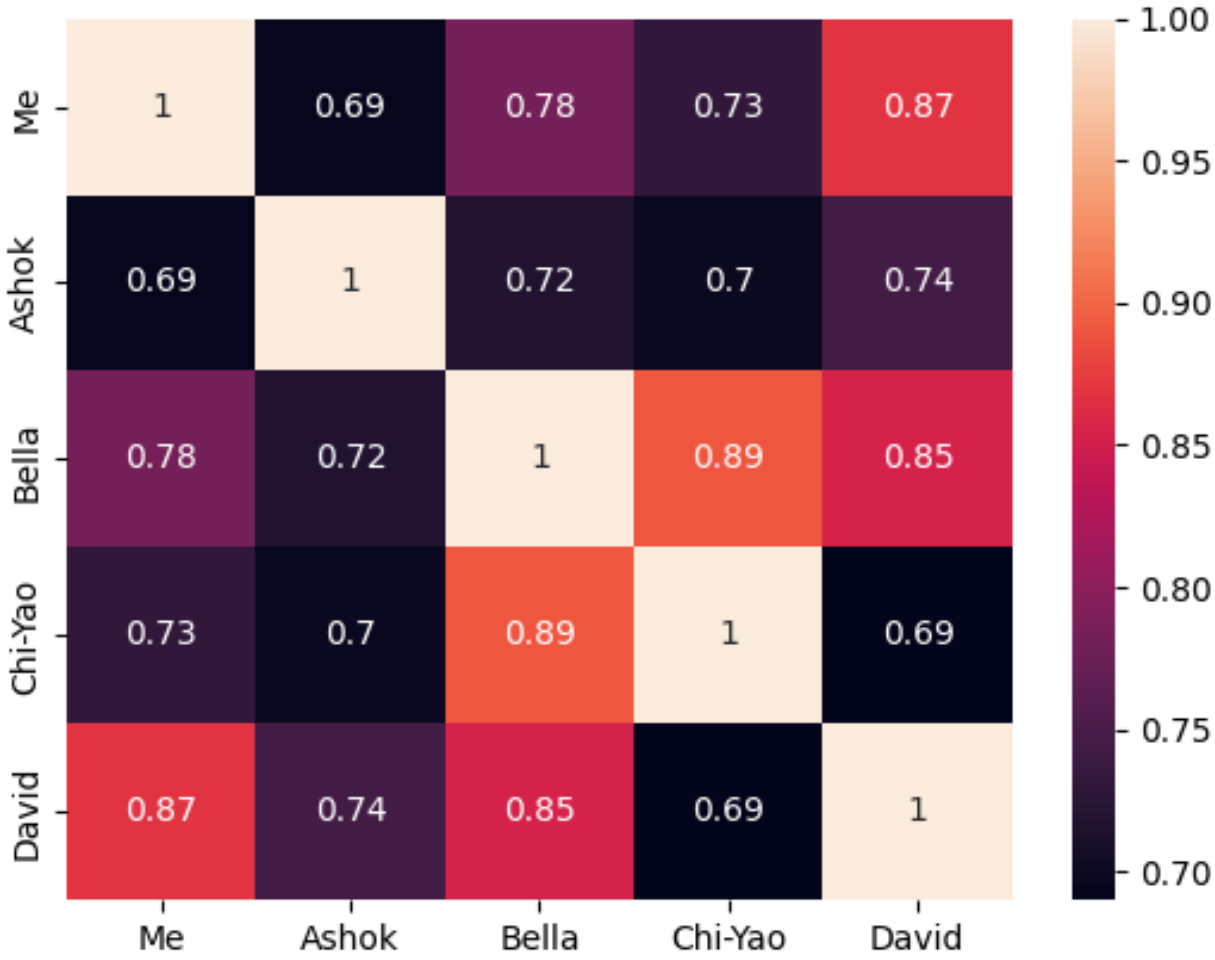
Link to the Game Theory

Some Python

```
urlForm = "https://docs.google.com/forms/d/e/1FAIpQLSdd7at5g6
urlCSV = "https://docs.google.com/spreadsheets/d/e/2PACX-1vQX

df = pd.read_csv(urlCSV, usecols=range(1,20))
df.set_index(df.columns[0], inplace=True)
```

```
newrows = []

#From df we create the peopleSim score table
for index, row in df.iterrows():
    normrow = sum([x**2 for x in row] )**0.5
    newrow = [x/normrow for x in row]
    newrows.append(newrow)

Adf = pd.DataFrame(newrows)
ATdf = Adf.transpose()
peopleSim = Adf @ ATdf
peopleSim.index = df.index
peopleSim.columns = df.index
```

A link to the Neural Nets by hand


Me
Ashok
Bella
Chi-Yao
David
1
0.69
0.78
0.73
0.87
0.69
1
0.72
0.7
0.74
0.78
0.72
1
0.89
0.85
0.73
0.7
0.89
1
0.69
0.87
0.74
0.85
0.69
1
Me
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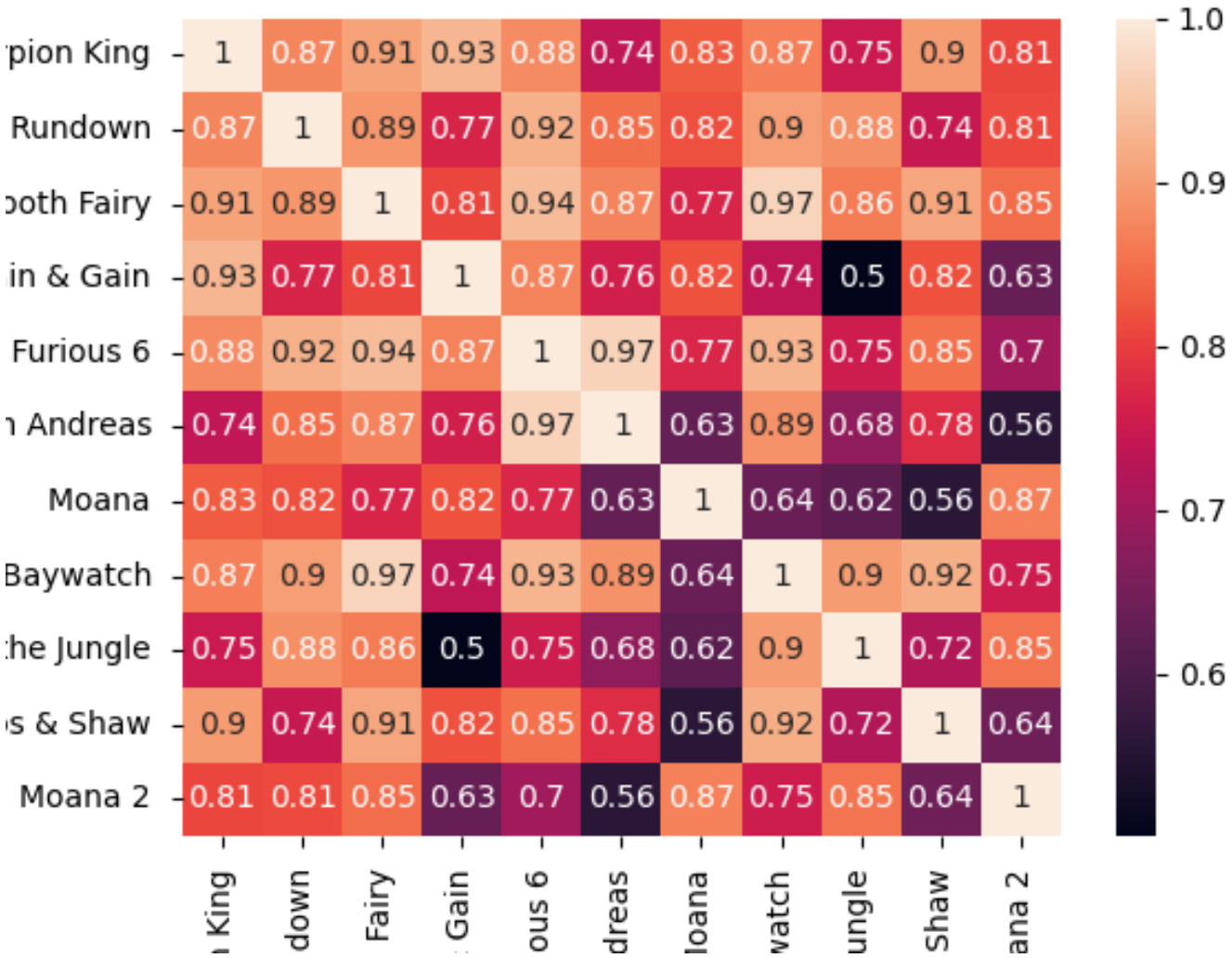
Chi-Yao
David
1.00
0.95
0.90
0.85
0.80
0.75
0.70

Who should I listen to



Link to survey

https://tinyurl.com/4cbk95pe

Now I will do something

`mybinder.org`
https://github.com/sanacoryf/JMM2026

Thanks

- Thank you to the organizers
- Thank you all