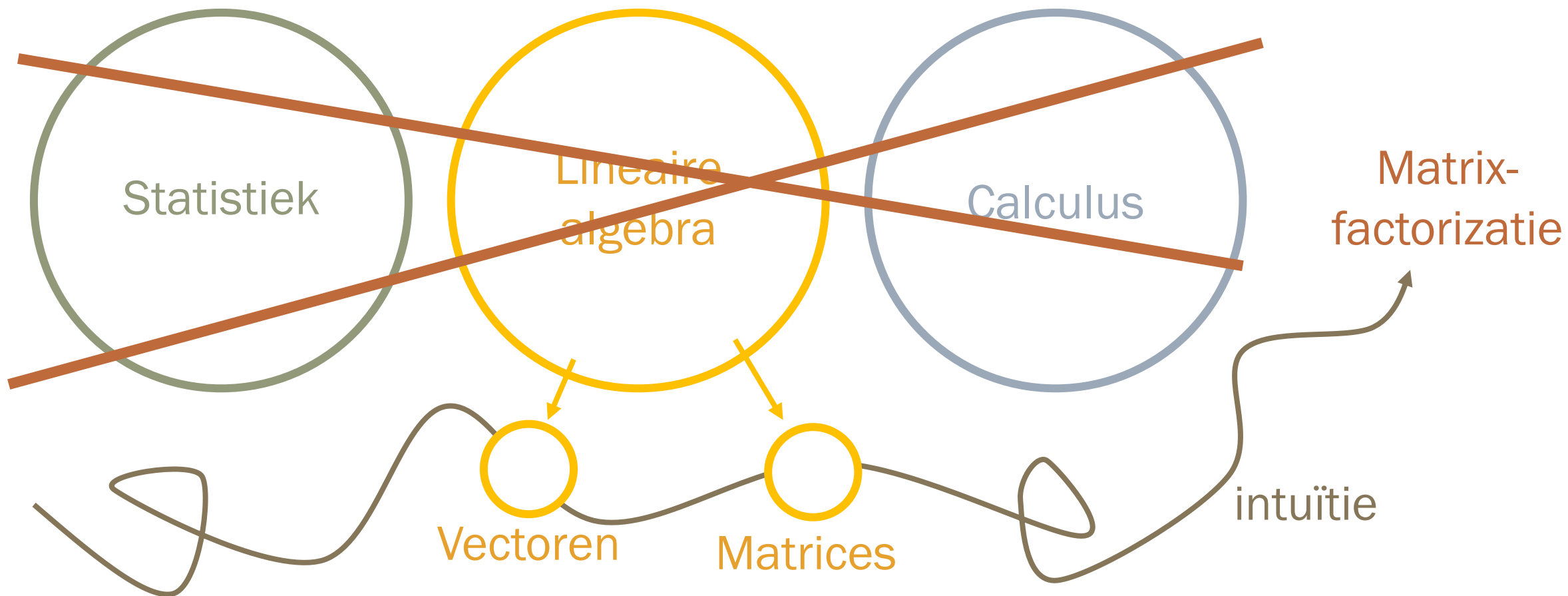# Collectieve Intelligentie

SIMON PAUW

MATRIXFACTORISATIE

Vandaag

Module 3:
- Films die lijken op films die je goed vind, vind je waarschijnlijk ook goed

Module 4:
- Mensen die van het genre comedy houden, vinden comedy films waarschijnlijk goed

Module 5:
- Mensen die comedy films goed vinden, houden waarschijnlijk van het genre comedy

Uitgangspositie, vorige week:

movieName	drama	thriller	comedy
Babe	0.74	0.22	0.43
Inception	0.63	0.92	0.44
A.I. Artificial Intelligence	0.67	0.46	0.22
Ace Ventura: Pet Detective	0.05	0.18	0.95
Bad Boys	0.71	0.42	0.78
Changing Lanes	0.44	0.41	0.38
Dumb & Dumber	0.00	0.17	1.00
Event Horizon	0.00	0.74	0.08
Full Metal Jacket	0.66	0.53	0.00
I, Robot	0.34	1.00	0.35

userId	drama	thriller	comedy
6	0.71	-0.65	0.56
7	0.85	0.22	0.18
8	0.89	-0.75	0.71
10	-0.02	0.20	0.02
11	0.94	0.33	0.07
12	0.94	0.18	0.29
13	0.75	0.75	0.29
14	0.07	0.04	0.49
15	0.52	0.42	-0.13
16	0.51	0.42	-0.31

userId	6	7	8	10	11	12	13	14	15	16
drama	0.71	0.85	0.89	-0.02	0.94	0.94	0.75	0.07	0.52	0.51
thriller	-0.65	0.22	-0.75	0.20	0.33	0.18	0.75	0.04	0.42	0.42
comedy	0.56	0.18	0.71	0.02	0.07	0.29	0.29	0.49	-0.13	-0.31

movieName	drama	thriller	comedy
Babe	0.74	0.22	0.43
Inception	0.63	0.92	0.44
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Changing Lanes	0.44	0.41	0.38
Dumb & Dumber	0.00	0.17	1.00
Event Horizon	0.00	0.74	0.08
Full Metal Jacket	0.66	0.53	0.00
I, Robot	0.34	1.00	0.35

movieName / userId	6	7	8	10	11	12	13	14	15	16
Babe	0.62	0.75	0.80	0.04	0.80	0.86	0.84	0.27	0.42	0.34
Inception	0.10	0.82	0.18	0.18	0.93	0.89	1.29	0.30	0.66	0.57
A.I. Artificial Intelligence	0.30	0.71	0.41	0.08	0.80	0.78	0.91	0.17	0.51	0.47
Ace Ventura: Pet Detective	0.45	0.25	0.58	0.05	0.17	0.35	0.45	0.48	-0.02	-0.19
Bad Boys	0.67	0.84	0.87	0.09	0.86	0.97	1.07	0.45	0.44	0.30
Changing Lanes	0.26	0.53	0.35	0.08	0.58	0.60	0.75	0.23	0.35	0.28
Dumb & Dumber	0.45	0.22	0.58	0.05	0.13	0.32	0.42	0.50	-0.06	-0.24
Event Horizon	-0.44	0.18	-0.50	0.15	0.25	0.16	0.58	0.07	0.30	0.29
Full Metal Jacket	0.12	0.68	0.19	0.09	0.80	0.72	0.89	0.07	0.57	0.56
I, Robot	-0.21	0.57	-0.20	0.20	0.67	0.60	1.11	0.24	0.55	0.48

```
1  user_matrix_transposed = user_matrix.T
2  predicted_ratings = movie_matrix @ user_matrix_transposed
```

Doel

Doel

movieName			
Babe	?	?	?
Inception	?	?	?
A.I. Artificial Intelligence	?	?	?
Ace Ventura: Pet Detective	?	?	?
Bad Boys	?	?	?
Changing Lanes	?	?	?
Dumb & Dumber	?	?	?
Event Horizon	?	?	?
Full Metal Jacket	?	?	?
I, Robot	?	?	?

userId	6	7	8	10	11	12	13	14	15	16
	?	?	?	?	?	?	?	?	?	?
	?	?	?	?	?	?	?	?	?	?
	?	?	?	?	?	?	?	?	?	?

Vaak hebben we geen genre informatie

Doel

movieName	userId 6	7	8	10	11	12	13	14	15	16
Babe	0.80		1.00							
Inception									0.70	0.60
A.I. Artificial Intelligence		0.90							0.80	
Ace Ventura: Pet Detective	0.60							0.40		
Bad Boys	0.80									
Changing Lanes										
Dumb & Dumber	0.60		0.80					0.60		
Event Horizon							0.80			
Full Metal Jacket										0.90
I, Robot								0.70		

Maar wel *een deel* van de ratings

Stap 1

userId	6	7	8	10	11	12	13	14	15	16
	?	?	?	?	?	?	?	?	?	?
	?	?	?	?	?	?	?	?	?	?
	?	?	?	?	?	?	?	?	?	?

movieName			
Babe	?	?	?
Inception	?	?	?
A.I. Artificial Intelligence	?	?	?
Ace Ventura: Pet Detective	?	?	?
Bad Boys	?	?	?
Changing Lanes	?	?	?
Dumb & Dumber	?	?	?
Event Horizon	?	?	?
Full Metal Jacket	?	?	?
I, Robot	?	?	?

userId / movieName	6	7	8	10	11	12	13	14	15	16
Babe	0.80		1.00							
Inception									0.70	0.60
A.I. Artificial Intelligence		0.90							0.80	
Ace Ventura: Pet Detective	0.60							0.40		
Bad Boys	0.80									
Changing Lanes										
Dumb & Dumber	0.60		0.80					0.60		
Event Horizon							0.80			
Full Metal Jacket										0.90
I, Robot									0.70	

$$M \cdot U^T = \hat{R}, \text{ gegeven } \hat{R} \text{ wat zijn } M \text{ en } U?$$

Stap 1

userId	6	7	8	10	11	12	13	14	15	16
drama	0.71	0.85	0.89	-0.02	0.94	0.94	0.75	0.07	0.52	0.51
thriller	-0.65	0.22	-0.75	0.20	0.33	0.18	0.75	0.04	0.42	0.42
comedy	0.56	0.18	0.71	0.02	0.07	0.29	0.29	0.49	-0.13	-0.31

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Ace Ventura: Pet Detective	0.60							0.40		
Bad Boys	0.80									
Changing Lanes										
Dumb & Dumber	0.60		0.80					0.60		
Event Horizon							0.80			
Full Metal Jacket										0.90
I, Robot									0.70	

Stap 1

userId	6	7	8	10	11	12	13	14	15	16
drama	0.71	0.85	0.89	-0.02	0.94	0.94	0.75	0.07	0.52	0.51
thriller	-0.65	0.22	-0.75	0.20	0.33	0.18	0.75	0.04	0.42	0.42
comedy	0.56	0.18	0.71	0.02	0.07	0.29	0.29	0.49	-0.13	-0.31

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movieName / userId	6	7	8	10	11	12	13	14	15	16
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Ace Ventura: Pet Detective	0.60							0.40		
Bad Boys	0.80									
Changing Lanes										
Dumb & Dumber	0.60		0.80					0.60		
Event Horizon							0.80			
Full Metal Jacket										0.90
I, Robot								0.70		

Stap 2

userId	6	7	8	10	11	12	13	14	15	16
drama	0.71	0.85	0.89	-0.02	0.94	0.94	0.75	0.07	0.52	0.51
thriller	-0.65	0.22	-0.75	0.20	0.33	0.18	0.75	0.04	0.42	0.42
comedy	0.56	0.18	0.71	0.02	0.07	0.29	0.29	0.49	-0.13	-0.31

movieName	drama	thriller	comedy
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Changing Lanes	0.44	0.41	0.38
Dumb & Dumber	0.00	0.17	1.00
Event Horizon	0.00	0.74	0.08
Full Metal Jacket	0.66	0.53	0.00
I, Robot	0.34	1.00	0.35

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Ace Ventura: Pet Detective	0.45	0.25	0.58	0.05	0.17	0.35	0.45	0.48	-0.02	-0.19
Bad Boys	0.67	0.84	0.87	0.09	0.86	0.97	1.07	0.45	0.44	0.30
Changing Lanes	0.26	0.53	0.35	0.08	0.58	0.60	0.75	0.23	0.35	0.28
Dumb & Dumber	0.45	0.22	0.58	0.05	0.13	0.32	0.42	0.50	-0.06	-0.24
Event Horizon	-0.44	0.18	-0.50	0.15	0.25	0.16	0.58	0.07	0.30	0.29
Full Metal Jacket	0.12	0.68	0.19	0.09	0.80	0.72	0.89	0.07	0.57	0.56
I, Robot	-0.21	0.57	-0.20	0.20	0.67	0.60	1.11	0.24	0.55	0.48

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Event Horizon	0.00	0.74	0.08
Full Metal Jacket	0.66	0.53	0.00
I, Robot	0.34	1.00	0.35

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11	0.94	0.33	0.07
12	0.94	0.18	0.29
13	0.75	0.75	0.29
14	0.07	0.04	0.49
15	0.52	0.42	-0.13
16	0.51	0.42	-0.31

movieName \ userId	6	7	8	10	11
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Changing Lanes	0.26	0.53	0.35	0.08	0.58
Dumb & Dumber	0.45	0.22	0.58	0.05	0.13
Event Horizon	-0.44	0.18	-0.50	0.15	0.25
Full Metal Jacket	0.12	0.68	0.19	0.09	0.80
I, Robot	-0.21	0.57	-0.20	0.20	0.67

Stap 1
(matrixfactorisatie)

Stap 2
(voorspellen)

Step 1 (training)

	7	8	10	11	12	13	14	15	16
		1.00							
								0.70	0.60
	0.90							0.80	
							0.40		
		0.80					0.60		
					0.80				
									0.90
							0.70		

movieName	~~drama~~	~~thriller~~	~~comedy~~
Babe	0.74	0.22	0.43
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Bad Boys	0.71	0.42	0.78
Changing Lanes	0.44	0.41	0.38
Dumb & Dumber	0.00	0.17	1.00
Event Horizon	0.00	0.74	0.08
Full Metal Jacket	0.66	0.53	0.00
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7	0.85	0.22	0.18
8	0.89	-0.75	0.71
10	-0.02	0.20	0.02
11	0.94	0.33	0.07
12	0.94	0.18	0.29
13	0.75	0.75	0.29
14	0.07	0.04	0.49
15	0.52	0.42	-0.13
16	0.51	0.42	-0.31

Step 2 (prediction)

movieName \ userId	6	7	8	10	11
Babe	0.62	0.75	0.80	0.04	0.80
Inception	0.10	0.82	0.18	0.18	0.93
A.I. Artificial Intelligence	0.30	0.71	0.41	0.08	0.80
Ace Ventura: Pet Detective	0.45	0.25	0.58	0.05	0.17
Bad Boys	0.67	0.84	0.87	0.09	0.86
Changing Lanes	0.26	0.53	0.35	0.08	0.58
Dumb & Dumber	0.45	0.22	0.58	0.05	0.13
Event Horizon	-0.44	0.18	-0.50	0.15	0.25
Full Metal Jacket	0.12	0.68	0.19	0.09	0.80
I, Robot	-0.21	0.57	-0.20	0.20	0.67

Stap 1 (training)

Stap 2 (prediction)

Tussenstap

userId	6	7	8	10	11	12	13	14	15	16
	?	?	?	?	?	?	?	?	?	?
	?	?	?	?	?	?	?	?	?	?
	?	?	?	?	?	?	?	?	?	?

movieName	drama	thriller	comedy
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Inception	0.63	0.92	0.44
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Event Horizon	0.00	0.74	0.08
Full Metal Jacket	0.66	0.53	0.00
I, Robot	0.34	1.00	0.35

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Babe	0.80		1.00							
Inception									0.70	0.60
A.I. Artificial Intelligence		0.90							0.80	
Ace Ventura: Pet Detective	0.60							0.40		
Bad Boys	0.80									
Changing Lanes										
Dumb & Dumber	0.60		0.80				0.60			
Event Horizon							0.80			
Full Metal Jacket										0.90
I, Robot									0.70	

$$M \cdot U^T = \hat{R}, \text{ gegeven } \hat{R} \text{ en } M \text{ wat is } U?$$

Vraag 1: ~~matrix~~factorisatie

$x \cdot b = y$

$x = 2$ en $y = 6$

wat is b?

Matrixfactorisatie

$X \cdot B = Y$

matrices X en Y zijn bekend: $X = \begin{bmatrix} 1 & 1 \\ 2 & 3 \\ 3 & 1 \end{bmatrix}, \qquad Y = \begin{bmatrix} 4 \\ 10 \\ 12 \end{bmatrix}$

wat is B?

Matrixfactorisatie

$$X \cdot B = Y \qquad X = \begin{bmatrix} 1 & 1 \\ 2 & 3 \\ 3 & 1 \end{bmatrix}, \qquad B = \begin{bmatrix} a \\ b \end{bmatrix}, \qquad Y = \begin{bmatrix} 4 \\ 10 \\ 12 \end{bmatrix}$$

Wat zijn a en b?

Matrixfactorisatie kan niet

$$X \cdot B = Y \qquad X = \begin{bmatrix} 1 & 1 \\ 2 & 3 \\ 3 & 1 \end{bmatrix}, \qquad B = \begin{bmatrix} a \\ b \end{bmatrix}, \qquad Y = \begin{bmatrix} 4 \\ 10 \\ 12 \end{bmatrix}$$

Bevat geen oplossing!

Wat zijn a en b?

Waarom geen exacte oplossing?

Matrix factorisatie is niet hetzelfde als factorisatie van getallen

$X \cdot B = Y$ is niet hetzelde als $x \cdot b = y$

Waarom geen exacte oplossing?

$$X = \begin{bmatrix} 1 & 1 \\ 2 & 3 \\ 3 & 1 \end{bmatrix}, \quad B = \begin{bmatrix} a \\ b \end{bmatrix}, \quad Y = \begin{bmatrix} 4 \\ 10 \\ 12 \end{bmatrix}$$

$X \cdot B = Y$

$$\begin{bmatrix} 1 & 1 \\ 2 & 3 \\ 3 & 1 \end{bmatrix} \cdot \begin{bmatrix} a \\ b \end{bmatrix} = \begin{bmatrix} 4 \\ 10 \\ 12 \end{bmatrix} \quad \Rightarrow \quad \begin{bmatrix} 1 \cdot a + 1 \cdot b \\ 2 \cdot a + 3 \cdot b \\ 3 \cdot a + 1 \cdot b \end{bmatrix} = \begin{bmatrix} 4 \\ 10 \\ 12 \end{bmatrix}$$

Waarom geen exacte oplossing?

$$X = \begin{bmatrix} 1 & 1 \\ 2 & 3 \\ 3 & 1 \end{bmatrix}, \quad B = \begin{bmatrix} a \\ b \end{bmatrix}, \quad Y = \begin{bmatrix} 4 \\ 10 \\ 12 \end{bmatrix}$$

$X \cdot B = Y$

$$\begin{bmatrix} 1 & 1 \\ 2 & 3 \\ 3 & 1 \end{bmatrix} \cdot \begin{bmatrix} a \\ b \end{bmatrix} = \begin{bmatrix} 4 \\ 10 \\ 12 \end{bmatrix} \Rightarrow \begin{array}{l} 1 \cdot a + 1 \cdot b = 4 \\ 2 \cdot a + 3 \cdot b = 10 \\ 3 \cdot a + 1 \cdot b = 12 \end{array}$$

Vraag 3

$1 \cdot a + 1 \cdot b = 4$

Vraag 4

$$1 \cdot a + 1 \cdot b = 4$$
$$2 \cdot a + 3 \cdot b = 10$$

Ga naar **wooclap.com** en gebruik de code **CI04**

4: Wat is een oplossing voor a en b?
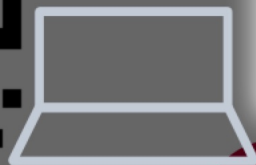
Klik op het geprojecteerd scherm om de vraag te activeren

wooclap

Vraag 5

$$1 \cdot a + 1 \cdot b = 4$$
$$2 \cdot a + 3 \cdot b = 10$$
$$3 \cdot a + 1 \cdot b = 12$$

Waarom geen exacte oplossing?

$$X = \begin{bmatrix} 1 & 1 \\ 2 & 3 \\ 3 & 1 \end{bmatrix}, \; B = \begin{bmatrix} a \\ b \end{bmatrix}, \; Y = \begin{bmatrix} 4 \\ 10 \\ 12 \end{bmatrix}$$

$$X \cdot B = Y$$

$$\begin{bmatrix} 1 & 1 \\ 2 & 3 \\ 3 & 1 \end{bmatrix} \cdot \begin{bmatrix} a \\ b \end{bmatrix} = \begin{bmatrix} 4 \\ 10 \\ 12 \end{bmatrix} \Rightarrow \begin{array}{l} 1 \cdot a + 1 \cdot b = 4 \\ 2 \cdot a + 3 \cdot b = 10 \\ 3 \cdot a + 1 \cdot b = 12 \end{array}$$

⟶ Bevat geen oplossing!

Tussenstap

userId	6	7	8	10	11	12	13	14	15	16
	?	?	?	?	?	?	?	?	?	?
	?	?	?	?	?	?	?	?	?	?
	?	?	?	?	?	?	?	?	?	?

movieName	drama	thriller	comedy
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Full Metal Jacket	0.66	0.53	0.00
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userId / movieName	6	7	8	10	11	12	13	14	15	16
Babe	0.80		1.00							
Inception									0.70	0.60
A.I. Artificial Intelligence		0.90							0.80	
Ace Ventura: Pet Detective	0.60							0.40		
Bad Boys	0.80									
Changing Lanes										
Dumb & Dumber	0.60		0.80					0.60		
Event Horizon							0.80			
Full Metal Jacket										0.90
I, Robot									0.70	

$M \cdot U^T = R$, gegeven R en M wat is U? $\longrightarrow$ Bevat geen oplossing!

$$M \cdot U^T = R$$

$$M = \begin{array}{c} movie\ 1 \\ movie\ 2 \\ movie\ 3 \end{array} \begin{bmatrix} 0.5 & 0.5 \\ 1.0 & 1.5 \\ 1.5 & 0.5 \end{bmatrix},$$

drama thriller

$$U^T = \begin{bmatrix} score\ drama \\ score\ thriller \end{bmatrix},$$
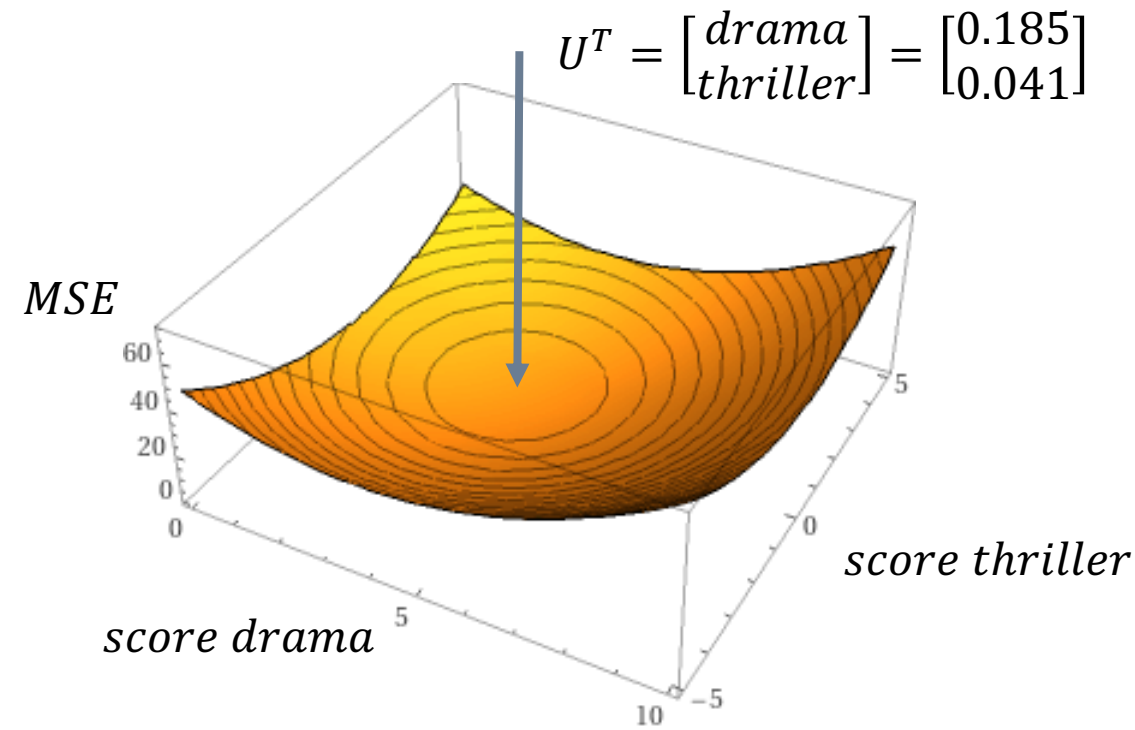
$$R = \begin{bmatrix} 0.4 \\ 1.0 \\ 1.2 \end{bmatrix}$$

user 11

Wat is U^T?

bevat geen oplossing

$$M \cdot U^T = R$$

$$M = \begin{matrix} movie\ 1 \\ movie\ 2 \\ movie\ 3 \end{matrix} \begin{bmatrix} 0.5 & 0.5 \\ 1.0 & 1.5 \\ 1.5 & 0.5 \end{bmatrix}, \qquad U^T = \begin{bmatrix} score\ drama \\ score\ thriller \end{bmatrix}, \qquad R = \begin{bmatrix} 0.4 \\ 1.0 \\ 1.2 \end{bmatrix}$$

drama *thriller* *user 11*

Wat is U^T? 　　　　　　　　　　　　　　　bevat geen oplossing
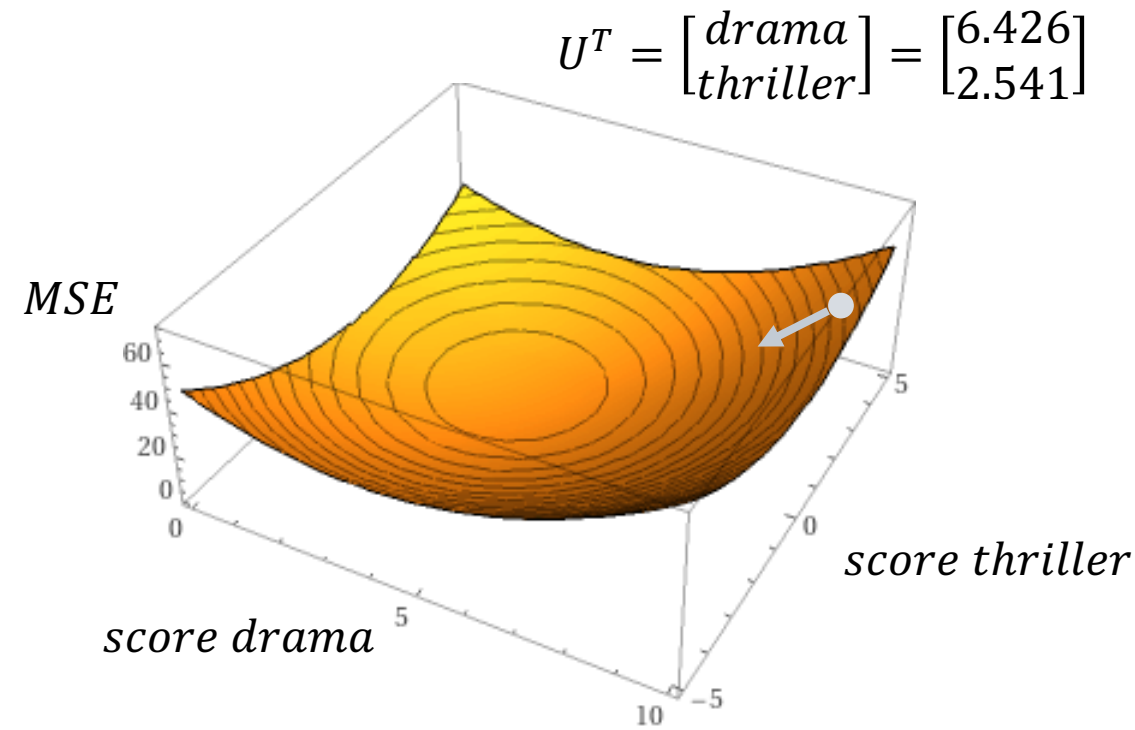

$$M \cdot U^T = \hat{R}$$

$$M = \begin{bmatrix} 0.5 & 0.5 \\ 1.0 & 1.5 \\ 1.5 & 0.5 \end{bmatrix}, \qquad U^T = \begin{bmatrix} score\ drama \\ score\ thriller \end{bmatrix}, \qquad R = \begin{bmatrix} 0.4 \\ 1.0 \\ 1.2 \end{bmatrix}$$

Voor welke U^T ligt $\hat{R}$ zo dicht mogelijk bij R?

Minimaliseer: $\text{MSE}(\hat{R}, R)$
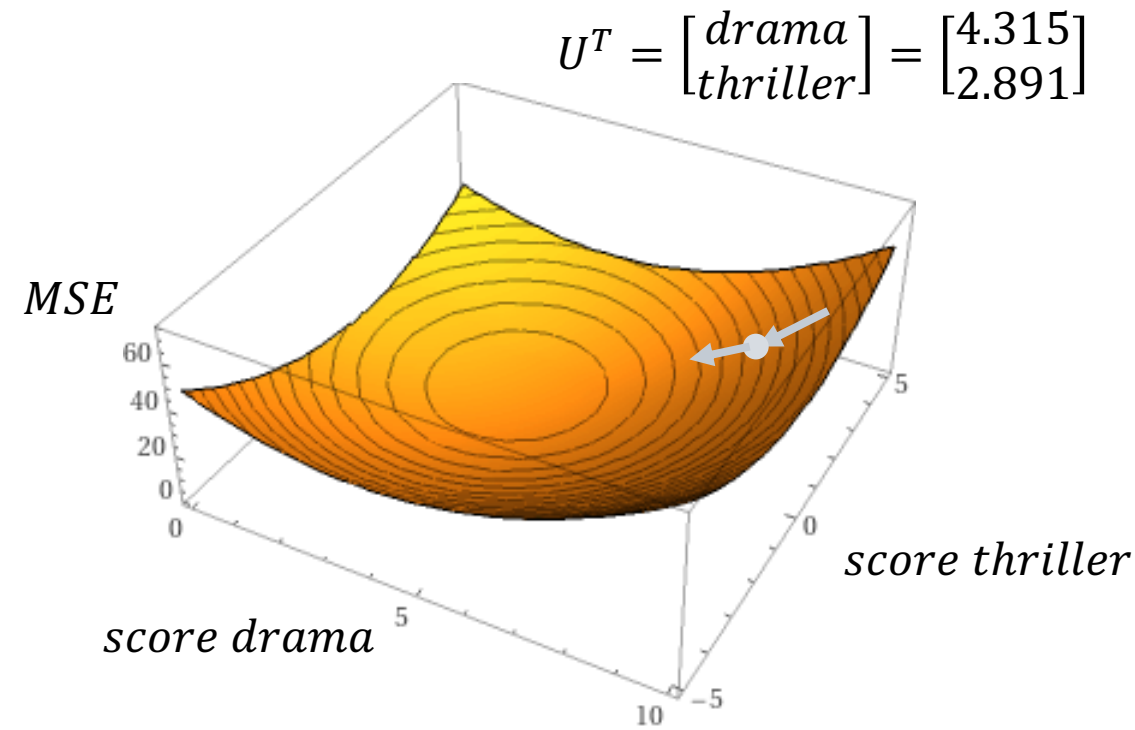
$$M \cdot U^T = \hat{R} \qquad M = \begin{bmatrix} 0.5 & 0.5 \\ 1.0 & 1.5 \\ 1.5 & 0.5 \end{bmatrix}, \qquad U^T = \begin{bmatrix} score\ drama \\ score\ thriller \end{bmatrix}, \qquad R = \begin{bmatrix} 0.4 \\ 1.0 \\ 1.2 \end{bmatrix}$$

Voor welke U^T ligt $\hat{R}$ zo dicht mogelijk bij R?

Gradient descent

$$U^T = \begin{bmatrix} drama \\ thriller \end{bmatrix} = \begin{bmatrix} 0.185 \\ 0.041 \end{bmatrix}$$

$$M \cdot U^T = \hat{R} \qquad M = \begin{bmatrix} 0.5 & 0.5 \\ 1.0 & 1.5 \\ 1.5 & 0.5 \end{bmatrix}, \qquad U^T = \begin{bmatrix} score\ drama \\ score\ thriller \end{bmatrix}, \qquad R = \begin{bmatrix} 0.4 \\ 1.0 \\ 1.2 \end{bmatrix}$$

Minimaliseer: $\text{MSE}(\hat{R}, R)$

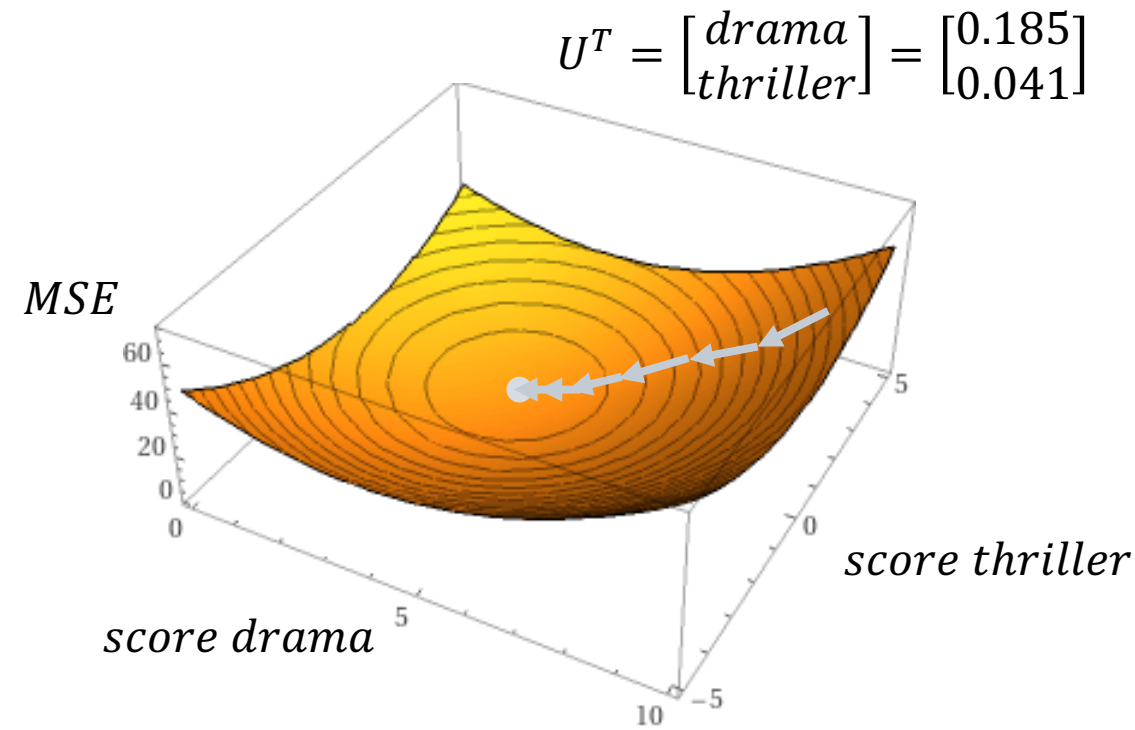# Gradient descent

$$U^T = \begin{bmatrix} drama \\ thriller \end{bmatrix} = \begin{bmatrix} 8.324 \\ 3.754 \end{bmatrix}$$

MSE

$score\ thriller$

$score\ drama$

$$M \cdot U^T = \hat{R} \qquad M = \begin{bmatrix} 0.5 & 0.5 \\ 1.0 & 1.5 \\ 1.5 & 0.5 \end{bmatrix}, \qquad U^T = \begin{bmatrix} score\ drama \\ score\ thriller \end{bmatrix}, \qquad R = \begin{bmatrix} 0.4 \\ 1.0 \\ 1.2 \end{bmatrix}$$

Minimaliseer: $MSE(\hat{R}, R)$

Gradient descent

$$U^T = \begin{bmatrix} drama \\ thriller \end{bmatrix} = \begin{bmatrix} 6.426 \\ 2.541 \end{bmatrix}$$

MSE

score thriller

score drama

$$M \cdot U^T = \hat{R} \qquad M = \begin{bmatrix} 0.5 & 0.5 \\ 1.0 & 1.5 \\ 1.5 & 0.5 \end{bmatrix}, \qquad U^T = \begin{bmatrix} score\ drama \\ score\ thriller \end{bmatrix}, \qquad R = \begin{bmatrix} 0.4 \\ 1.0 \\ 1.2 \end{bmatrix}$$

Minimaliseer: $\text{MSE}(\hat{R}, R)$

Gradient descent

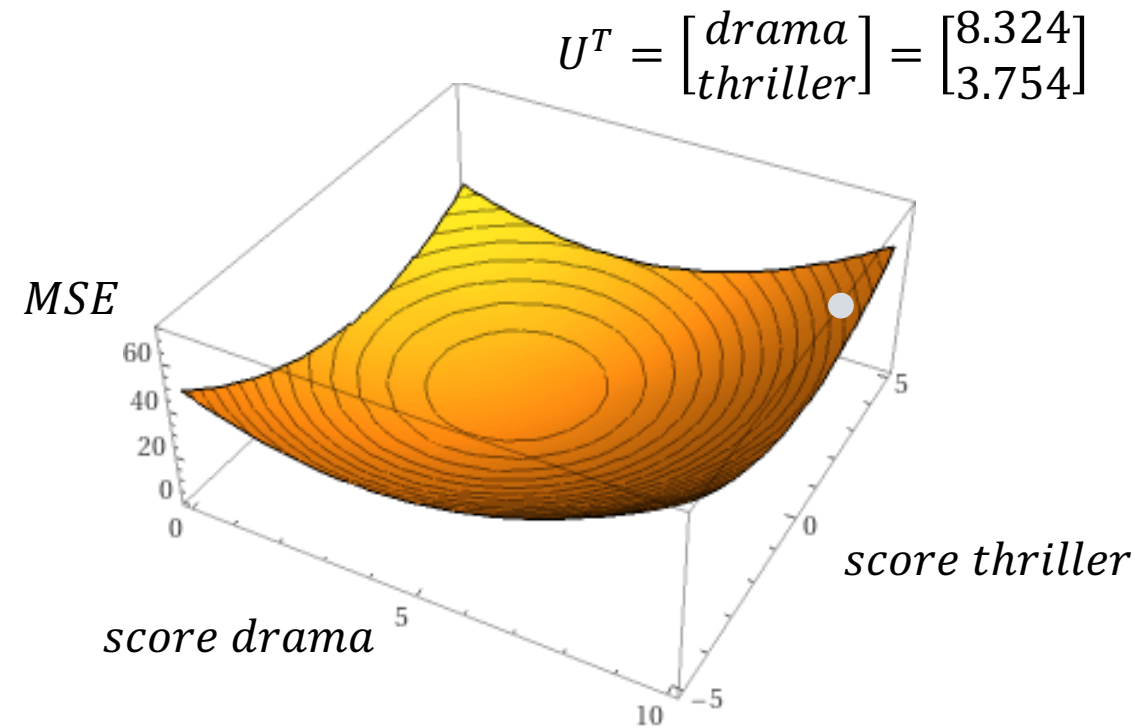$$U^T = \begin{bmatrix} drama \\ thriller \end{bmatrix} = \begin{bmatrix} 4.315 \\ 2.891 \end{bmatrix}$$

$$M \cdot U^T = \hat{R} \qquad M = \begin{bmatrix} 0.5 & 0.5 \\ 1.0 & 1.5 \\ 1.5 & 0.5 \end{bmatrix}, \qquad U^T = \begin{bmatrix} score\ drama \\ score\ thriller \end{bmatrix}, \qquad R = \begin{bmatrix} 0.4 \\ 1.0 \\ 1.2 \end{bmatrix}$$

Minimaliseer: $MSE(\hat{R}, R)$

Gradient descent

$$U^T = \begin{bmatrix} drama \\ thriller \end{bmatrix} = \begin{bmatrix} 0.185 \\ 0.041 \end{bmatrix}$$

MSE

score thriller

score drama

$$M \cdot U^T = \hat{R} \qquad M = \begin{bmatrix} 0.5 & 0.5 \\ 1.0 & 1.5 \\ 1.5 & 0.5 \end{bmatrix}, \qquad U^T = \begin{bmatrix} score\ drama \\ score\ thriller \end{bmatrix}, \qquad R = \begin{bmatrix} 0.4 \\ 1.0 \\ 1.2 \end{bmatrix}$$

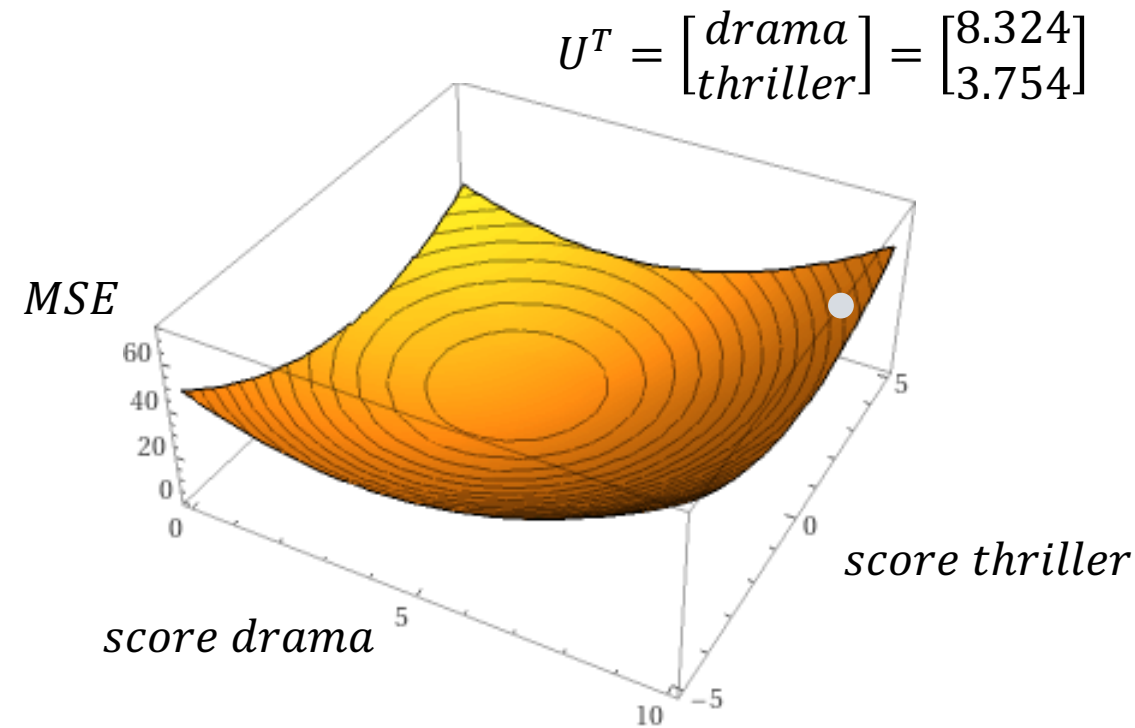Minimaliseer: $\text{MSE}(\hat{R}, R)$

Gradient descent

$$U^T = \begin{bmatrix} drama \\ thriller \end{bmatrix} = \begin{bmatrix} 8.324 \\ 3.754 \end{bmatrix}$$

Algoritme:

    Begin met random waardes voor U^T.

    Herhaal:

        Bereken $\hat{R}$

        Bereken error (MSE)

        Update: pas U een beetje aan

$$M \cdot U^T = \hat{R} \qquad M = \begin{bmatrix} 0.5 & 0.5 \\ 1.0 & 1.5 \\ 1.5 & 0.5 \end{bmatrix}, \qquad U^T = \begin{bmatrix} score\ drama \\ score\ thriller \end{bmatrix}, \qquad R = \begin{bmatrix} 0.4 \\ 1.0 \\ 1.2 \end{bmatrix}$$

Minimaliseer: $MSE(\hat{R}, R)$

Gradient descent

$$U^T = \begin{bmatrix} drama \\ thriller \end{bmatrix} = \begin{bmatrix} 8.324 \\ 3.754 \end{bmatrix}$$

Algoritme:

Begin met random waardes voor U^T.

Herhaal:

    Bereken $\hat{R}$

    Bereken error (MSE)

    Update: pas U een beetje aan

MSE

score thriller

score drama

$$M \cdot U^T = \hat{R}$$

$$M = \begin{bmatrix} 0.5 & 0.5 \\ 1.0 & 1.5 \\ 1.5 & 0.5 \end{bmatrix}, \quad U^T = \begin{bmatrix} 8.324 \\ 3.754 \end{bmatrix}, \quad R = \begin{bmatrix} 0.4 \\ 1.0 \\ 1.2 \end{bmatrix}$$
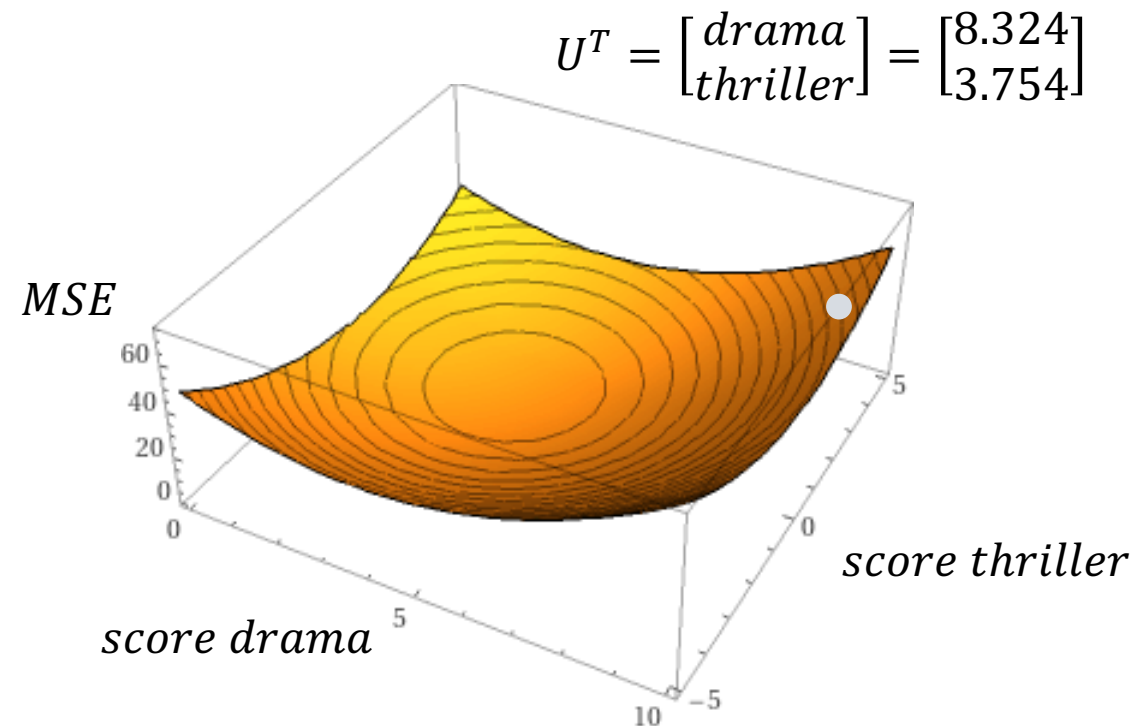
Minimaliseer: $\text{MSE}(\hat{R}, R)$

Gradient descent

$$U^T = \begin{bmatrix} drama \\ thriller \end{bmatrix} = \begin{bmatrix} 8.324 \\ 3.754 \end{bmatrix}$$

Algoritme:

Begin met random waardes voor U^T.

Herhaal:

Bereken $\hat{R}$

Bereken error (MSE)

Update: pas U een beetje aan
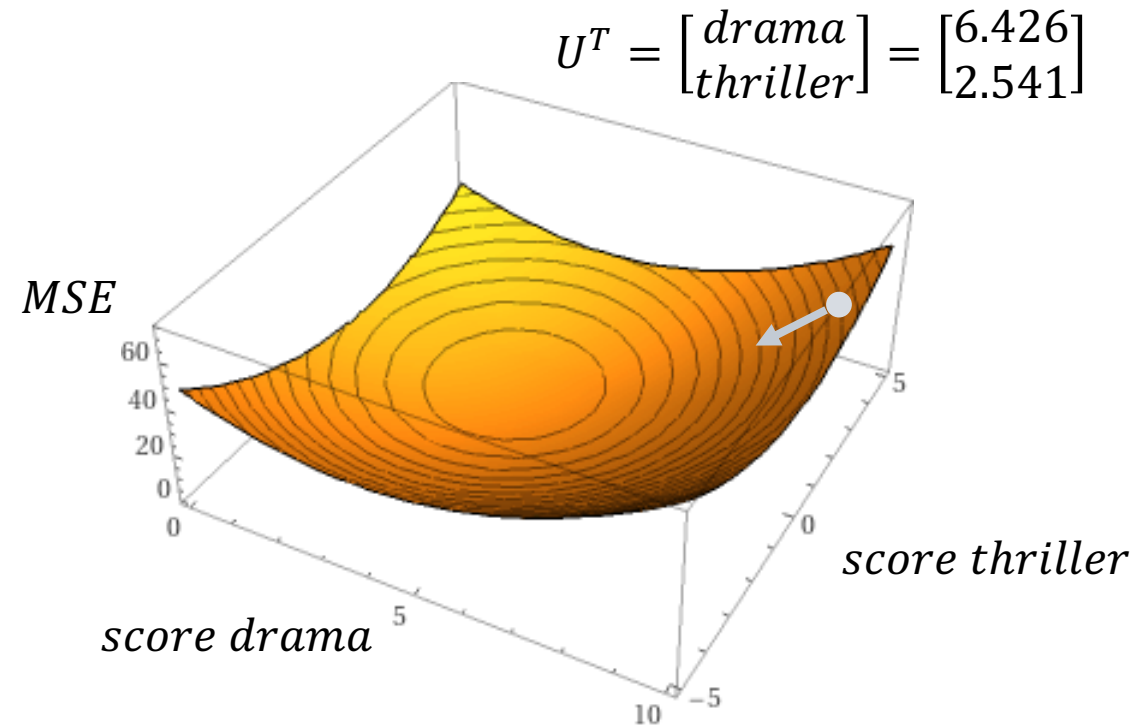

MSE

$score\ thriller$

$score\ drama$

$$M \cdot U^T = \hat{R} = \begin{bmatrix} 5.813 \\ 14.34 \\ 14.01 \end{bmatrix}$$

$$M = \begin{bmatrix} 0.5 & 0.5 \\ 1.0 & 1.5 \\ 1.5 & 0.5 \end{bmatrix}, \qquad U^T = \begin{bmatrix} 8.324 \\ 3.754 \end{bmatrix}, \qquad R = \begin{bmatrix} 0.4 \\ 1.0 \\ 1.2 \end{bmatrix}$$

Minimaliseer: $\text{MSE}(\hat{R}, R)$

Gradient descent

$$U^T = \begin{bmatrix} drama \\ thriller \end{bmatrix} = \begin{bmatrix} 8.324 \\ 3.754 \end{bmatrix}$$

Algoritme:

    Begin met random waardes voor U^T.

    Herhaal:

        Bereken $\hat{R}$

        Bereken error (MSE)

        Update: pas U een beetje aan

MSE

$score\ thriller$

$score\ drama$

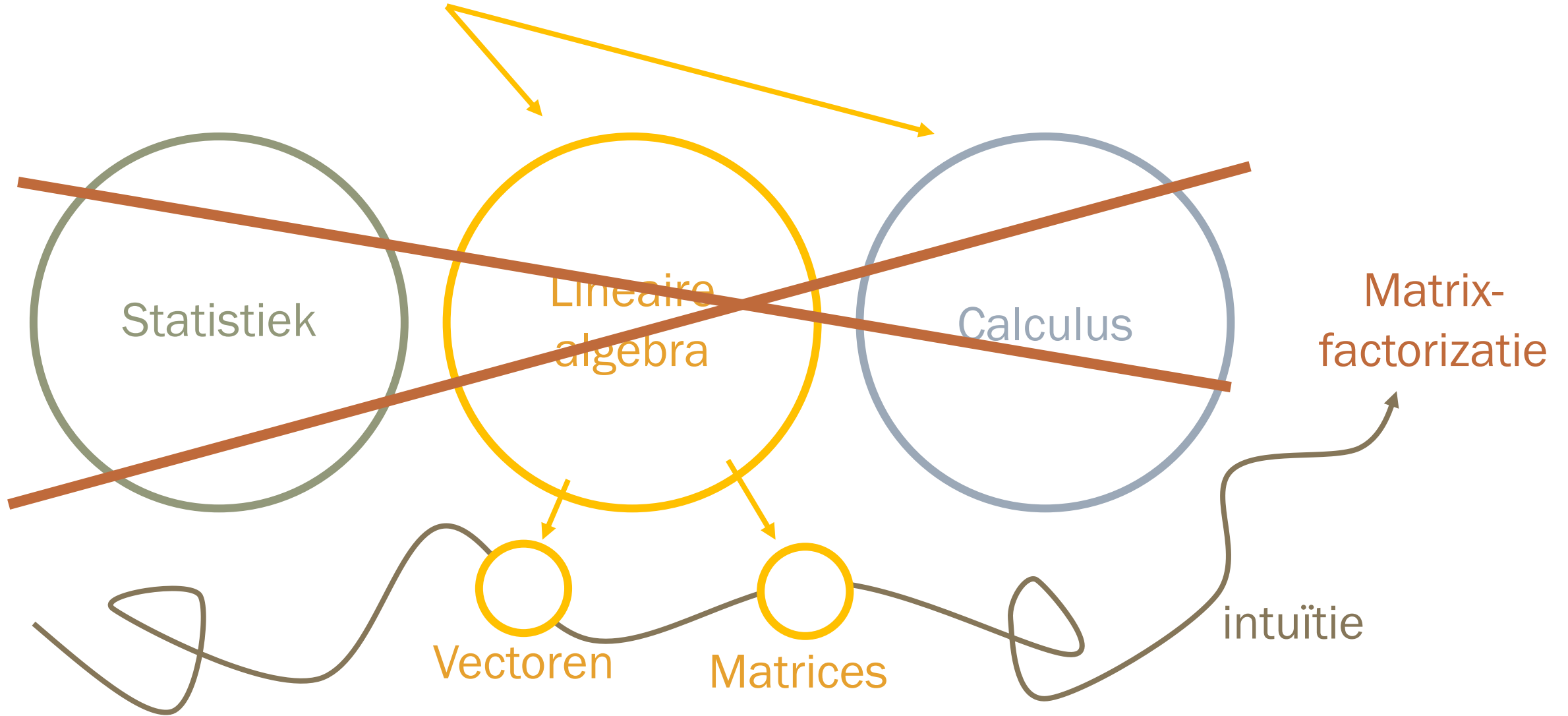$$M \cdot U^T = \hat{R} = \begin{bmatrix} 5.813 \\ 14.34 \\ 14.01 \end{bmatrix} \qquad M = \begin{bmatrix} 0.5 & 0.5 \\ 1.0 & 1.5 \\ 1.5 & 0.5 \end{bmatrix}, \qquad U^T = \begin{bmatrix} 8.324 \\ 3.754 \end{bmatrix}, \qquad R = \begin{bmatrix} 0.4 \\ 1.0 \\ 1.2 \end{bmatrix}$$

Minimaliseer: $\mathrm{MSE}(\hat{R}, R) = ((5.813 - 0.4)^2 + (14.34 - 1.0)^2 + (14.01 - 1.2)^2)/3 = 123.8$

Gradient descent

$$U^T = \begin{bmatrix} drama \\ thriller \end{bmatrix} = \begin{bmatrix} 6.426 \\ 2.541 \end{bmatrix}$$

Algoritme:

    Begin met random waardes voor U^T.

    Herhaal:

        Bereken $\hat{R}$

        Bereken error (MSE)

        Update: pas U een beetje aan

$$D = R - \hat{R}$$

$$U := U + \alpha \cdot D^T \cdot M$$

MSE

score thriller

score drama

$$M \cdot U^T = \hat{R} = \begin{bmatrix} 5.813 \\ 14.34 \\ 14.01 \end{bmatrix} \qquad M = \begin{bmatrix} 0.5 & 0.5 \\ 1.0 & 1.5 \\ 1.5 & 0.5 \end{bmatrix}, \qquad U^T = \begin{bmatrix} 8.324 \\ 3.754 \end{bmatrix}, \qquad R = \begin{bmatrix} 0.4 \\ 1.0 \\ 1.2 \end{bmatrix}$$

Minimaliseer: $\text{MSE}(\hat{R}, R) = ((5.813 - 0.4)^2 + (14.34 - 1.0)^2 + (14.01 - 1.2)^2)/3 = 123.8$

Gradient descent

$$U^T = \begin{bmatrix} drama \\ thriller \end{bmatrix} = \begin{bmatrix} 6.426 \\ 2.541 \end{bmatrix}$$

Algoritme:

Begin met random waardes voor U^T.
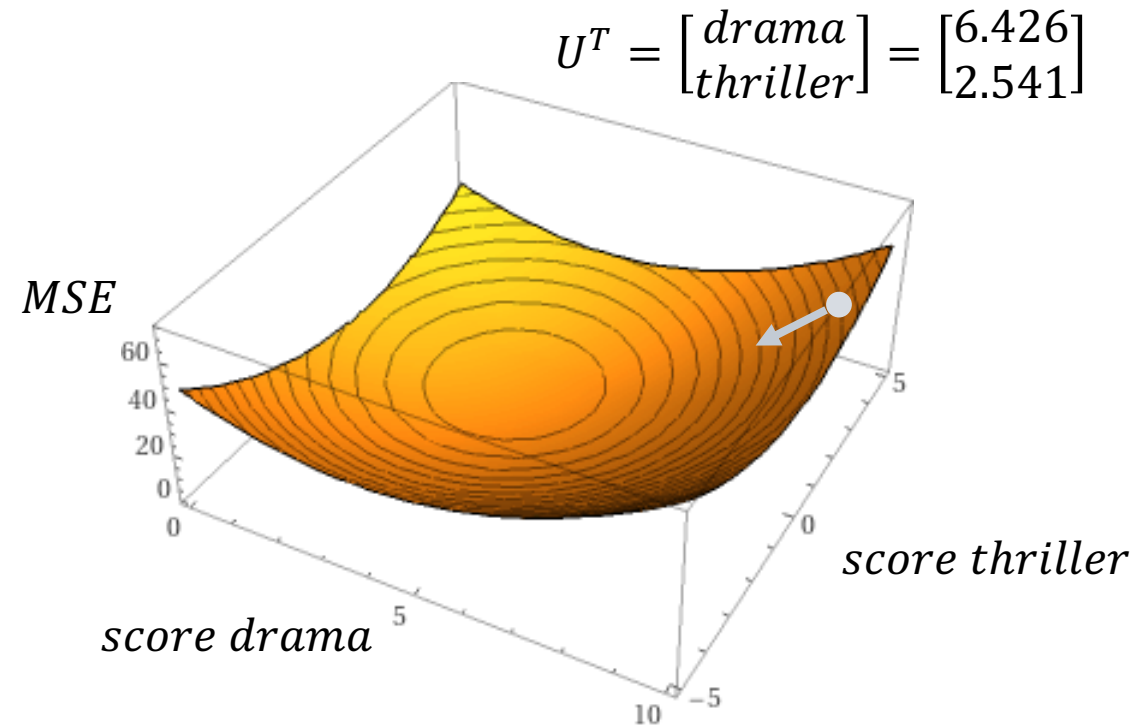
Herhaal:

Bereken $\hat{R}$

Bereken error (MSE)

Update: pas U een beetje aan

$$D = R - \hat{R} = \begin{bmatrix} 0.4 \\ 1.0 \\ 1.2 \end{bmatrix} - \begin{bmatrix} 5.813 \\ 14.34 \\ 14.01 \end{bmatrix} = \begin{bmatrix} -5,413 \\ -13.34 \\ -12,81 \end{bmatrix}$$

MSE

score thriller

score drama

$$M \cdot U^T = \hat{R} = \begin{bmatrix} 5.813 \\ 14.34 \\ 14.01 \end{bmatrix} \qquad M = \begin{bmatrix} 0.5 & 0.5 \\ 1.0 & 1.5 \\ 1.5 & 0.5 \end{bmatrix}, \qquad U^T = \begin{bmatrix} 8.324 \\ 3.754 \end{bmatrix}, \qquad R = \begin{bmatrix} 0.4 \\ 1.0 \\ 1.2 \end{bmatrix}$$

Minimaliseer: $\mathrm{MSE}(\hat{R}, R) = ((5.813 - 0.4)^2 + (14.34 - 1.0)^2 + (14.01 - 1.2)^2)/3 = 123.8$

Gradient descent

$$U^T = \begin{bmatrix} drama \\ thriller \end{bmatrix} = \begin{bmatrix} 6.426 \\ 2.541 \end{bmatrix}$$

Algoritme:

    Begin met random waardes voor U^T.

    Herhaal:

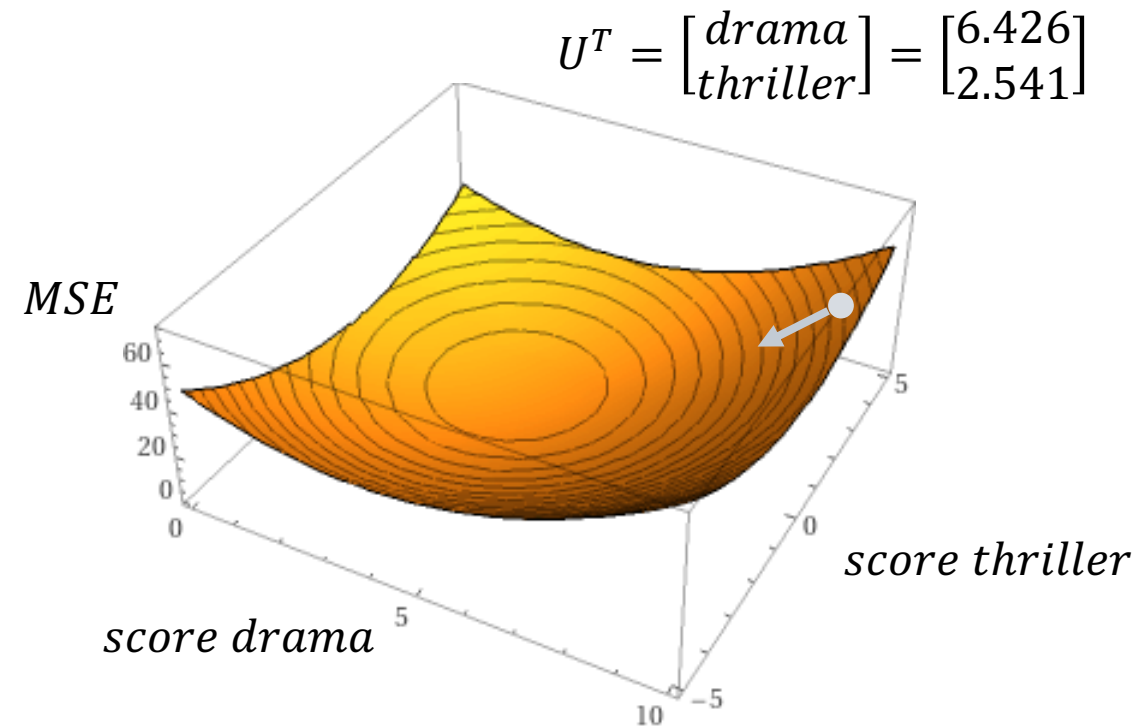   Bereken $\hat{R}$

        Bereken error (MSE)

        Update: pas U een beetje aan

$$D = \begin{bmatrix} -5,413 \\ -13.34 \\ -12,81 \end{bmatrix} \qquad U := U + \alpha \cdot D^T \cdot M$$

MSE

score thriller

score drama

$$M \cdot U^T = \hat{R} = \begin{bmatrix} 5.813 \\ 14.34 \\ 14.01 \end{bmatrix} \qquad M = \begin{bmatrix} 0.5 & 0.5 \\ 1.0 & 1.5 \\ 1.5 & 0.5 \end{bmatrix}, \qquad U^T = \begin{bmatrix} 8.324 \\ 3.754 \end{bmatrix}, \qquad R = \begin{bmatrix} 0.4 \\ 1.0 \\ 1.2 \end{bmatrix}$$

Minimaliseer: $\text{MSE}(\hat{R}, R) = ((5.813 - 0.4)^2 + (14.34 - 1.0)^2 + (14.01 - 1.2)^2)/3 = 123.8$

Gradient descent

$$U^T = \begin{bmatrix} drama \\ thriller \end{bmatrix} = \begin{bmatrix} 6.426 \\ 2.541 \end{bmatrix}$$
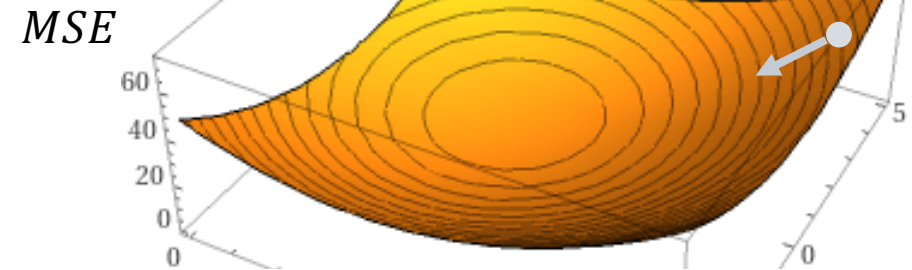
Algoritme:

Begin met random waardes voor U^T.

Herhaal:

Bereken $\hat{R}$

Bereken error (MSE)

Update: pas U een beetje aan

MSE

$$D = \begin{bmatrix} -5,413 \\ -3.34 \\ -12,81 \end{bmatrix} \quad U := U + \alpha \cdot D^T \cdot M = [8.324 \quad 3.754] + 0.01 \cdot [-5,413 \quad -13.34 \quad -12,81] \cdot \begin{bmatrix} 0.5 & 0.5 \\ 1.0 & 1.5 \\ 1.5 & 0.5 \end{bmatrix}$$

$$M \cdot U^T = \hat{R} = \begin{bmatrix} 5.813 \\ 14.34 \\ 14.01 \end{bmatrix} \qquad M = \begin{bmatrix} 0.5 & 0.5 \\ 1.0 & 1.5 \\ 1.5 & 0.5 \end{bmatrix}, \qquad U^T = \begin{bmatrix} 8.324 \\ 3.754 \end{bmatrix}, \qquad R = \begin{bmatrix} 0.4 \\ 1.0 \\ 1.2 \end{bmatrix}$$

Minimaliseer: $\text{MSE}(\hat{R}, R) = ((5.813 - 0.4)^2 + (14.34 - 1.0)^2 + (14.01 - 1.2)^2)/3 = 123.8$

Gradient descent

$$U^T = \begin{bmatrix} drama \\ thriller \end{bmatrix} = \begin{bmatrix} 6.426 \\ 2.541 \end{bmatrix}$$

Algoritme:

Begin met random waardes voor U^T.

Herhaal:

Bereken $\hat{R}$
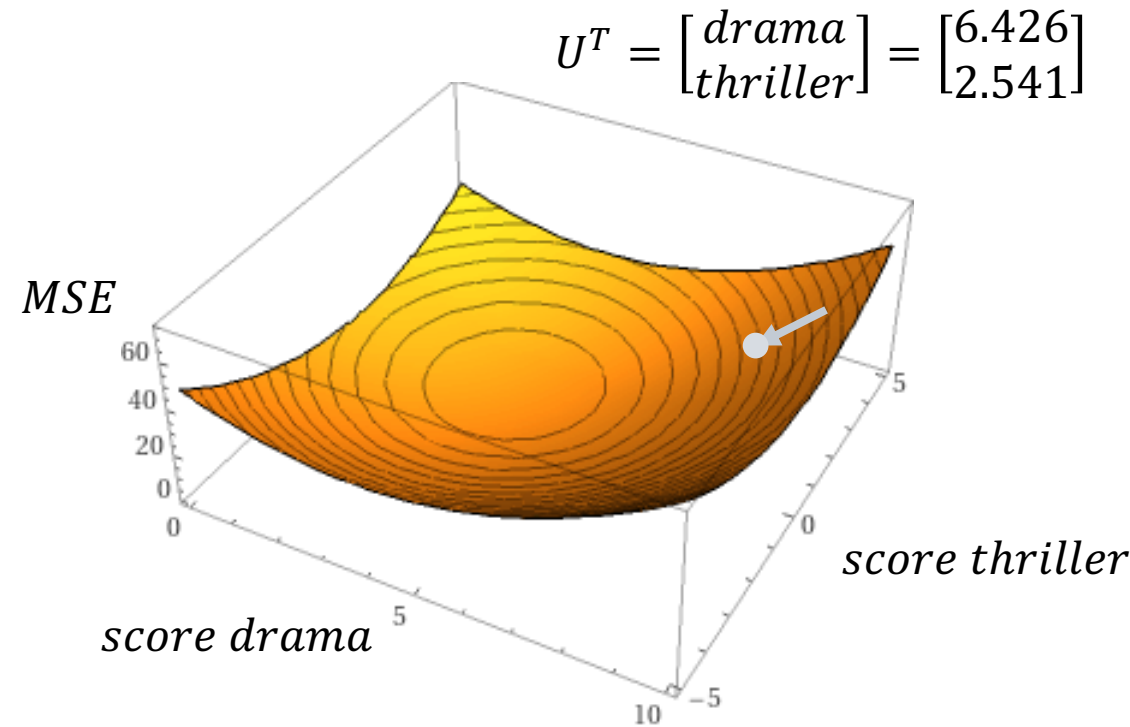
Bereken error (MSE)

Update: pas U een beetje aan

$$D = \begin{bmatrix} -5{,}413 \\ -3.34 \\ -12{,}81 \end{bmatrix} \qquad U := U + \alpha \cdot D^T \cdot M = \begin{bmatrix} 6.426 \\ 2.541 \end{bmatrix}$$

MSE

score thriller

score drama

$$M \cdot U^T = \hat{R} = \begin{bmatrix} 5.813 \\ 14.34 \\ 14.01 \end{bmatrix} \qquad M = \begin{bmatrix} 0.5 & 0.5 \\ 1.0 & 1.5 \\ 1.5 & 0.5 \end{bmatrix}, \qquad U^T = \begin{bmatrix} 6.426 \\ 2.541 \end{bmatrix}, \qquad R = \begin{bmatrix} 0.4 \\ 1.0 \\ 1.2 \end{bmatrix}$$

Minimaliseer: $\text{MSE}(\hat{R}, R) = ((5.813 - 0.4)^2 + (14.34 - 1.0)^2 + (14.01 - 1.2)^2)/3 = 123.8$

Gradient descent

$$U^T = \begin{bmatrix} drama \\ thriller \end{bmatrix} = \begin{bmatrix} 4.315 \\ 2.891 \end{bmatrix}$$

Algoritme:

    Begin met random waardes voor U^T.

    Herhaal:

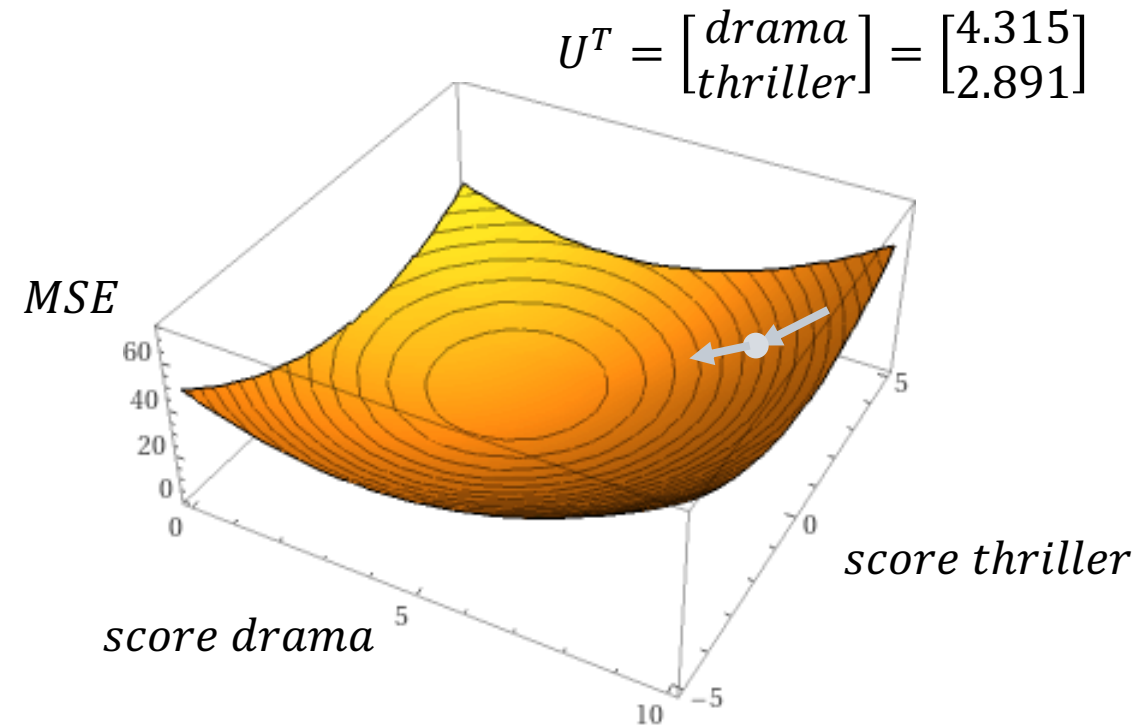   Bereken $\hat{R}$

        Bereken error (MSE)

        Update: pas U een beetje aan

$$D = R - \hat{R}$$
$$U := U + \alpha \cdot D^T \cdot M$$

MSE

score thriller

score drama

$$M \cdot U^T = \hat{R} = \begin{bmatrix} 5.813 \\ 14.34 \\ 14.01 \end{bmatrix} \qquad M = \begin{bmatrix} 0.5 & 0.5 \\ 1.0 & 1.5 \\ 1.5 & 0.5 \end{bmatrix}, \qquad U^T = \begin{bmatrix} 4.315 \\ 2.891 \end{bmatrix}, \qquad R = \begin{bmatrix} 0.4 \\ 1.0 \\ 1.2 \end{bmatrix}$$

Minimaliseer: $\text{MSE}(\hat{R}, R) = ((5.813 - 0.4)^2 + (14.34 - 1.0)^2 + (14.01 - 1.2)^2)/3 = 123.8$

Gradient descent

$U^T = \begin{bmatrix} drama \\ thriller \end{bmatrix} = \begin{bmatrix} 0.185 \\ 0.041 \end{bmatrix}$
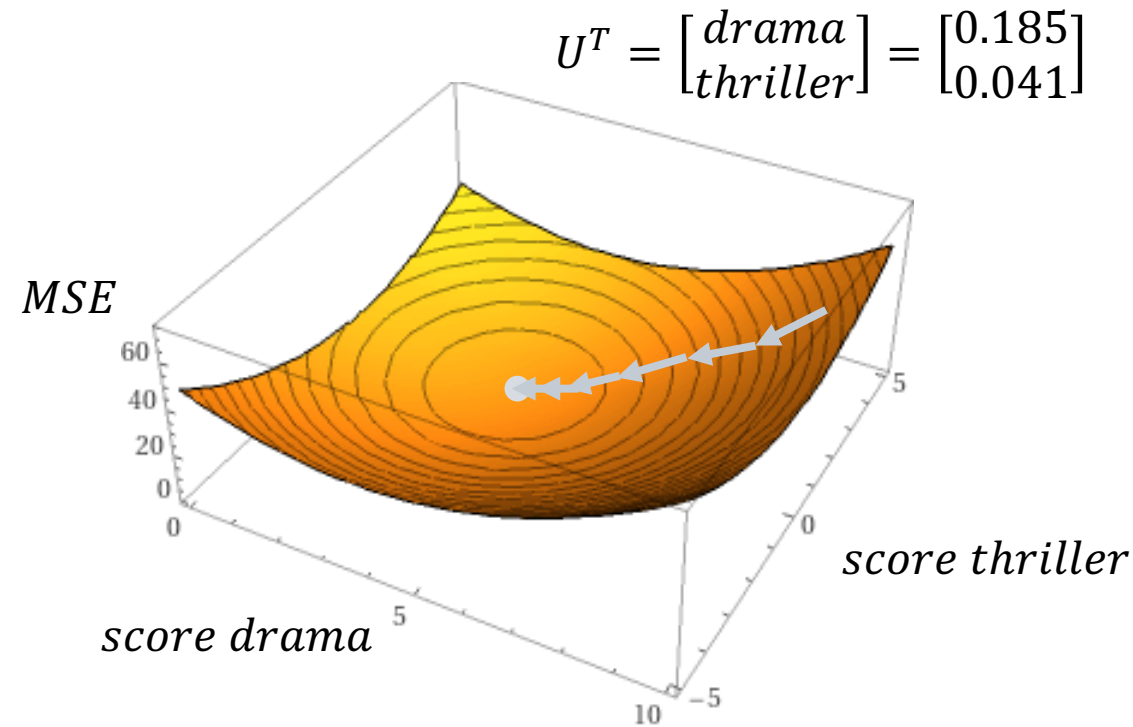
Algoritme:

Begin met random waardes voor U^T.

Herhaal:

Bereken $\hat{R}$

Bereken error (MSE)

Update: pas U een beetje aan

$D = R - \hat{R}$

$U := U + \alpha \cdot D^T \cdot M$

MSE

score thriller

score drama

$M \cdot U^T = \hat{R} = \begin{bmatrix} 5.813 \\ 14.34 \\ 14.01 \end{bmatrix}$
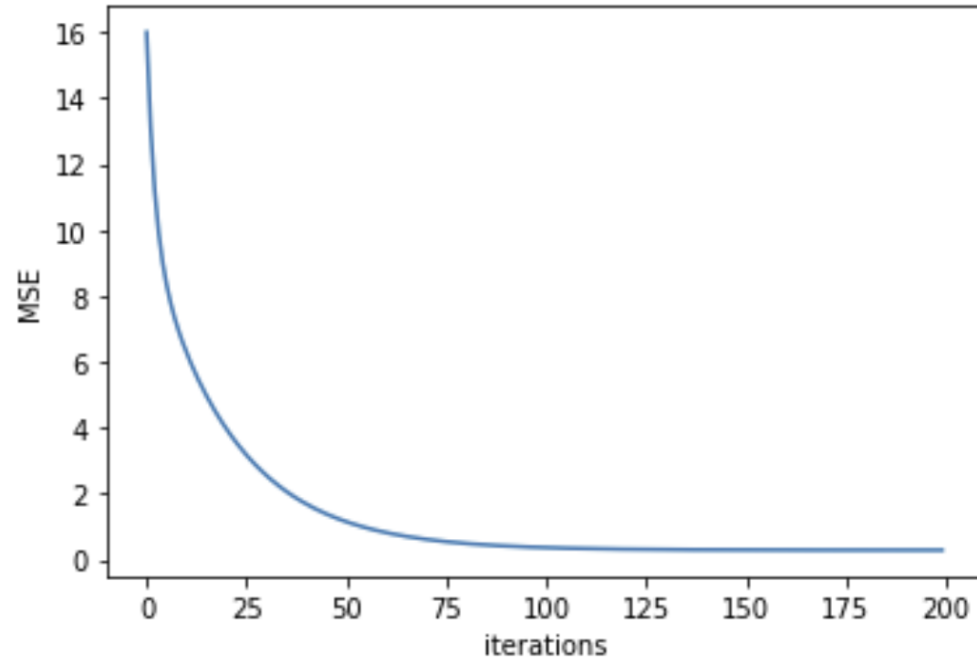$\qquad M = \begin{bmatrix} 0.5 & 0.5 \\ 1.0 & 1.5 \\ 1.5 & 0.5 \end{bmatrix}, \qquad U^T = \begin{bmatrix} 0.185 \\ 0.041 \end{bmatrix}, \qquad R = \begin{bmatrix} 0.4 \\ 1.0 \\ 1.2 \end{bmatrix}$
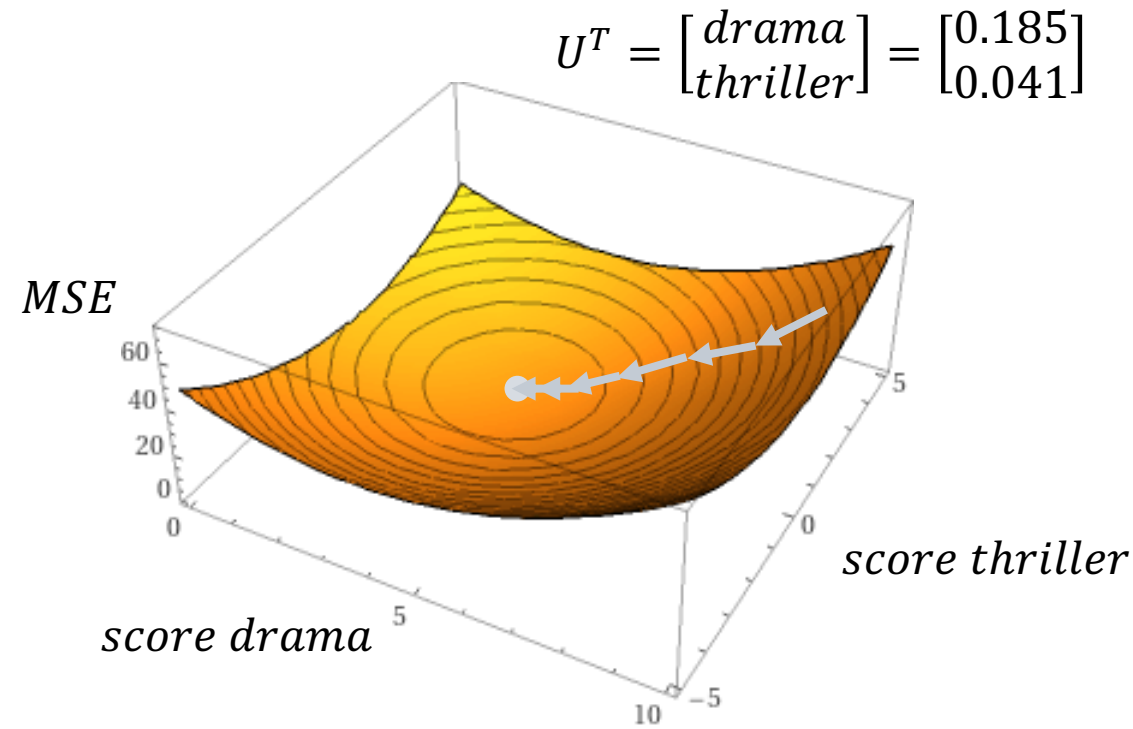
Minimaliseer: $\text{MSE}(\hat{R}, R) = ((5.813 - 0.4)^2 + (14.34 - 1.0)^2 + (14.01 - 1.2)^2)/3 = 123.8$

Learning rate

$$U^T = \begin{bmatrix} drama \\ thriller \end{bmatrix} = \begin{bmatrix} 0.185 \\ 0.041 \end{bmatrix}$$

MSE

score thriller

score drama

$$D = R - \hat{R}$$
$$U := U + \boxed{\alpha} \cdot D^T \cdot M$$

0.01

Learning rate

$$U^T = \begin{bmatrix} drama \\ thriller \end{bmatrix} = \begin{bmatrix} 0.185 \\ 0.041 \end{bmatrix}$$
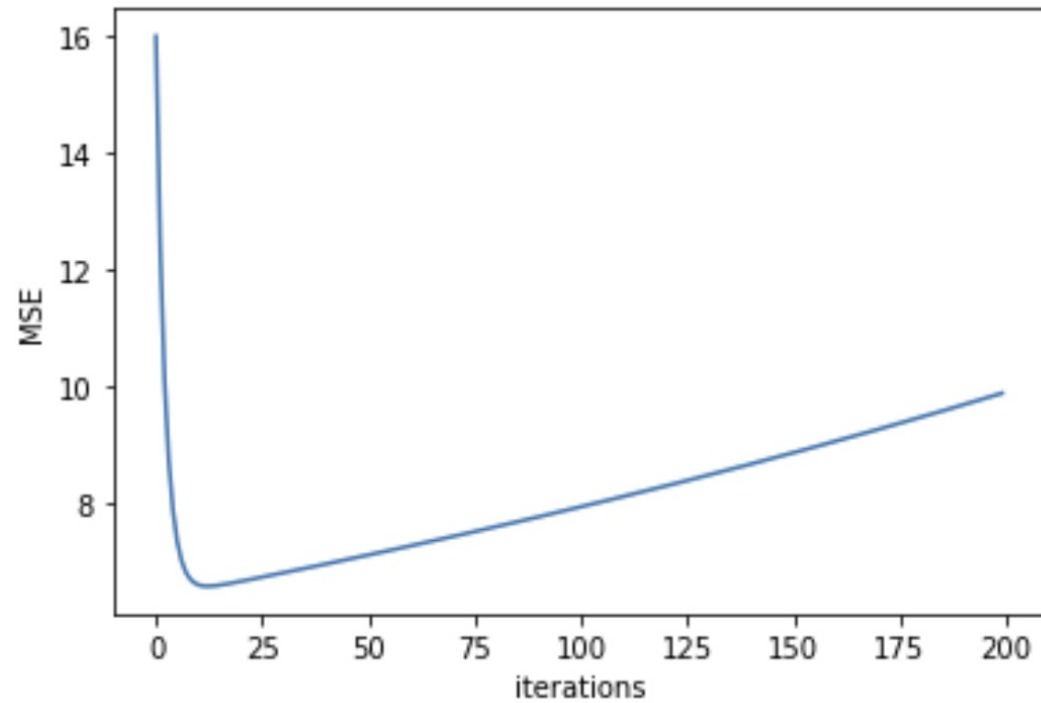
$$D = R - \hat{R}$$
$$U := U + \boxed{\alpha} \cdot D^T \cdot M$$

0.1

Tussenstap

userId	6	7	8	10	11	12	13	14	15	16
	?	?	?	?	?	?	?	?	?	?
	?	?	?	?	?	?	?	?	?	?
	?	?	?	?	?	?	?	?	?	?

movieName	drama	thriller	comedy
Babe	0.74	0.22	0.43
Inception	0.63	0.92	0.44
A.I. Artificial Intelligence	0.67	0.46	0.22
Ace Ventura: Pet Detective	0.05	0.18	0.95
Bad Boys	0.71	0.42	0.78
Changing Lanes	0.44	0.41	0.38
Dumb & Dumber	0.00	0.17	1.00
Event Horizon	0.00	0.74	0.08
Full Metal Jacket	0.66	0.53	0.00
I, Robot	0.34	1.00	0.35

userId / movieName	6	7	8	10	11	12	13	14	15	16
Babe	0.80		1.00							
Inception									0.70	0.60
A.I. Artificial Intelligence		0.90							0.80	
Ace Ventura: Pet Detective	0.60							0.40		
Bad Boys	0.80									
Changing Lanes										
Dumb & Dumber	0.60		0.80					0.60		
Event Horizon							0.80			
Full Metal Jacket										0.90
I, Robot									0.70	

$M \cdot U^T = R$, gegeven R en M wat is U? $\longrightarrow$ Bevat geen oplossing!

Vervolg

userId	6	7	8	10	11	12	13	14	15	16
	?	?	?	?	?	?	?	?	?	?
	?	?	?	?	?	?	?	?	?	?
	?	?	?	?	?	?	?	?	?	?

userId	6	7	8	10	11	12	13	14	15	16
movieName										
Babe	0.80		1.00							
Inception									0.70	0.60
A.I. Artificial Intelligence		0.90							0.80	
Ace Ventura: Pet Detective	0.60							0.40		
Bad Boys	0.80									
Changing Lanes										
Dumb & Dumber	0.60		0.80				0.60			
Event Horizon							0.80			
Full Metal Jacket										0.90
I, Robot								0.70		

movieName			
Babe	?	?	?
Inception	?	?	?
A.I. Artificial Intelligence	?	?	?
Ace Ventura: Pet Detective	?	?	?
Bad Boys	?	?	?
Changing Lanes	?	?	?
Dumb & Dumber	?	?	?
Event Horizon	?	?	?
Full Metal Jacket	?	?	?
I, Robot	?	?	?

$M \cdot U^T = \hat{R}$, gegeven $\hat{R}$ wat zijn M en U?

Vragen?

PYPROG@PROGLAB.NL