

Online Dating Recommender Systems: The Split-complex Number Approach

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Friend Recommendation

Find friends from different parts of your life

Use the checkboxes below to discover people you know from your hometown, school, employer and more.

Hometown

Berlin, Germany

Enter another city



Andreas Mu

🎓 University of Georgia

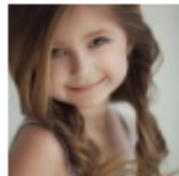
Bernhard Szudra and 3 other mutual friends

+1 Add Friend

Current City

Koblenz, Germany

Enter another city



Nusrat Jahan Ritu

+1 Add Friend

High School

Französisches Gymnasium

Enter another high school



Frank Bohdanowicz

Anja Hissnauer and 6 other mutual friends

+1 Add Friend

Mutual Friend

Steffen Staab

Matthew Rowe

Gabi Mähias

Enter another name



Thombo Haui

Stephan Spiegel and 7 other mutual friends

+1 Add Friend

College or University

Berlin Institute of Technology

Friend/Foe Recommendation

Slashdot

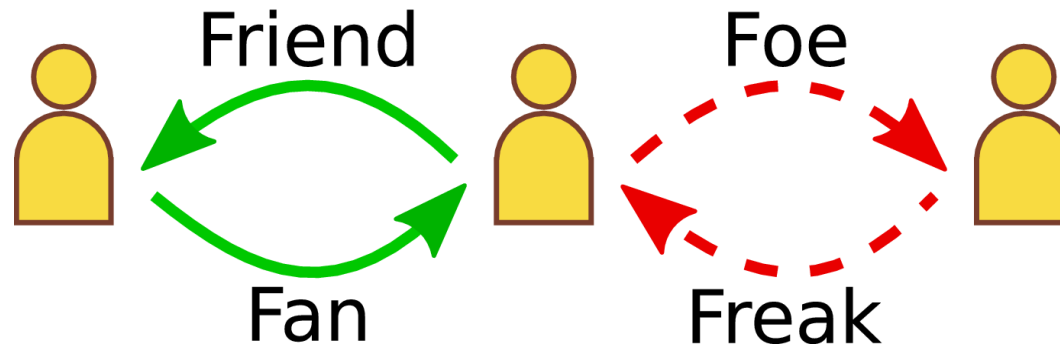
News for Nerds. Stuff that matters.

Your Relationship with eldavojohn (898314) ●

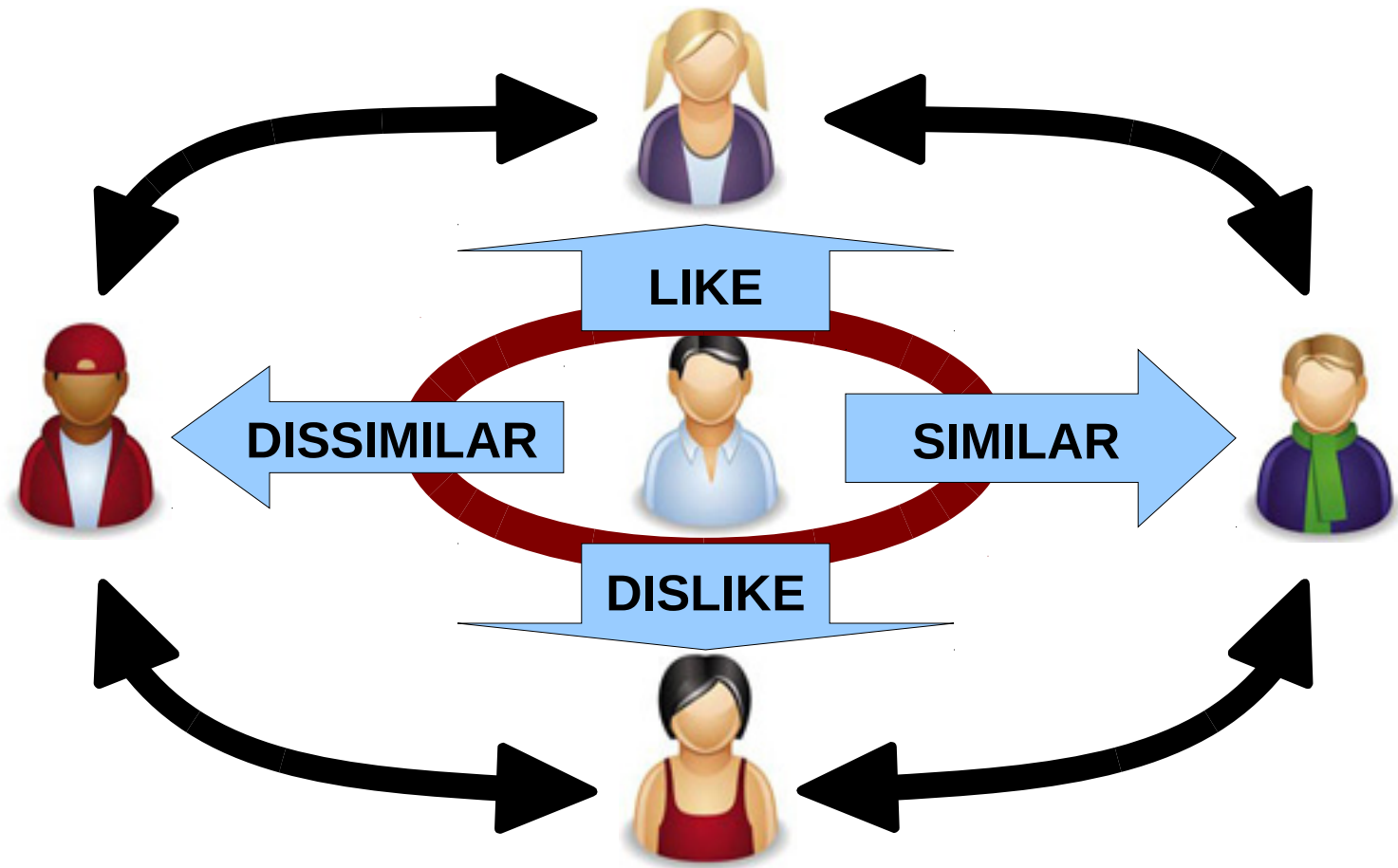
[Info](#) | [Relation](#) | [Journal](#) | [Firehose](#) | [Friends](#) | [Fans](#) | [Foes](#) | [Freaks](#)

[Friends of Friends](#) | [Foes of Friends](#)

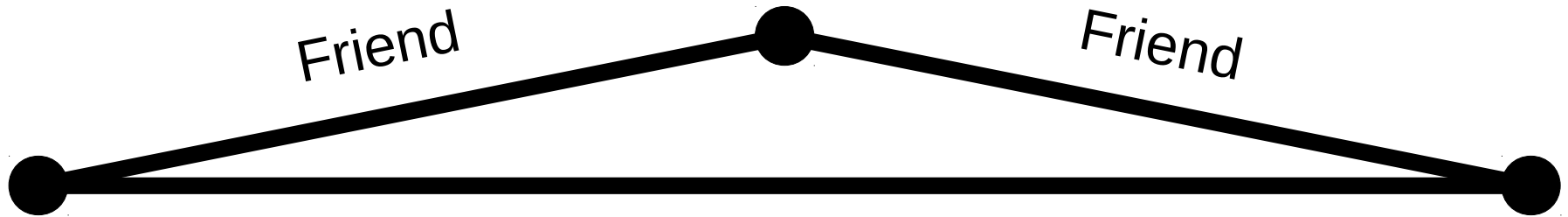
○ ● Friend
Change this? ● ○ Neutral
○ ● Foe



Dating Recommendation

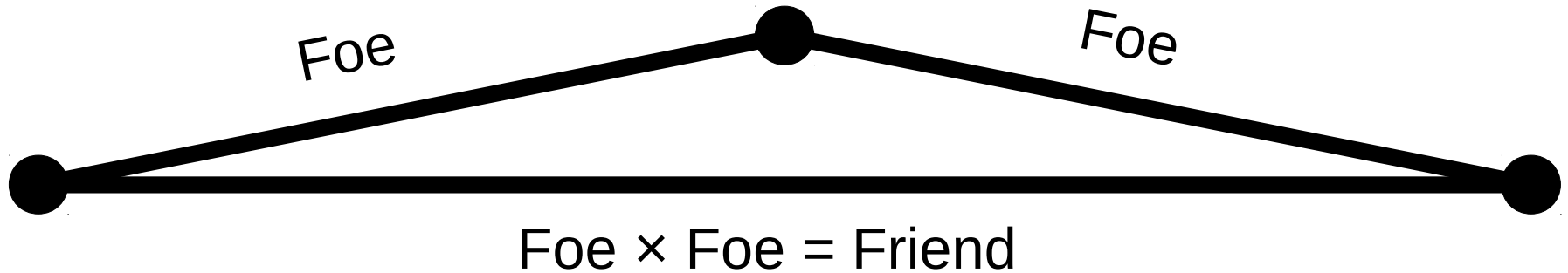


Triangle Closing



Friend × Friend = Friend

“The Enemy of My Enemy”



Friend = +1

Foe = -1

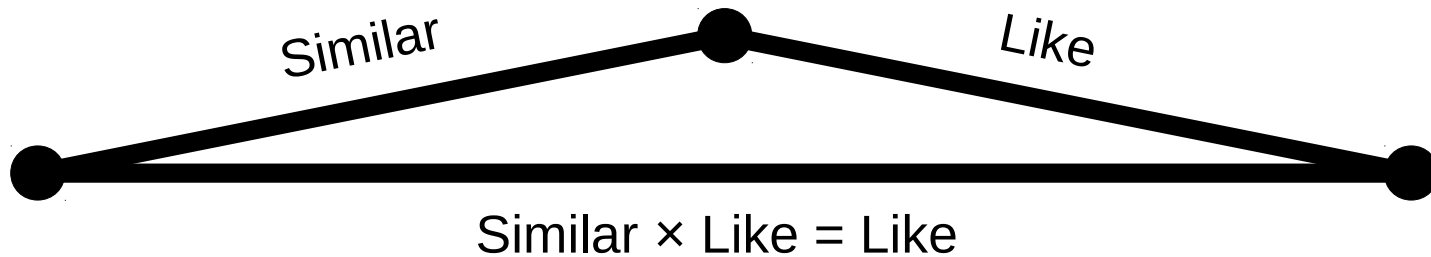
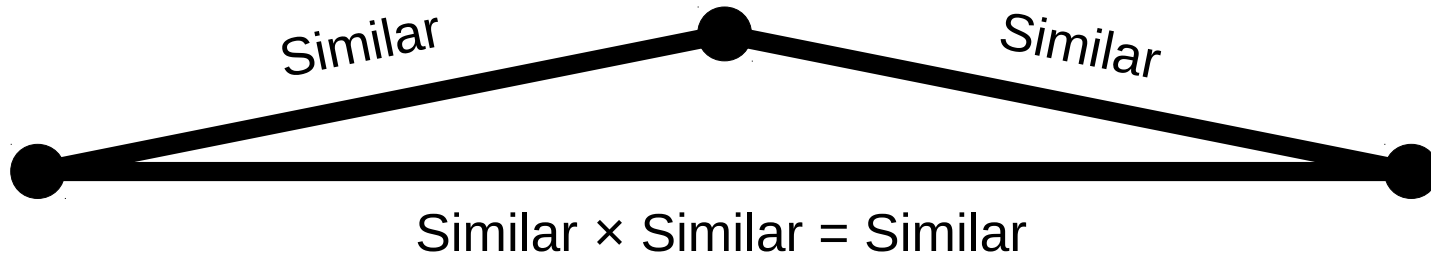
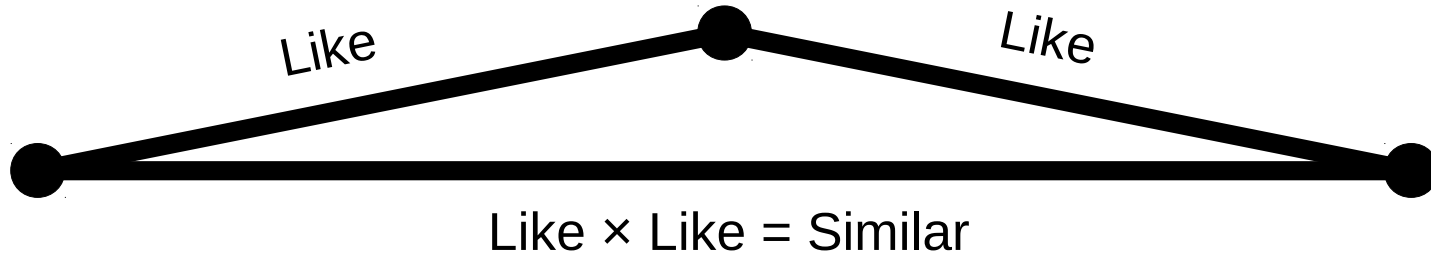
$$+1 \times +1 = +1$$

$$-1 \times +1 = -1$$

$$-1 \times -1 = +1$$

(Kunegis et al. 1999)

Dating Recommendation



Split-complex Numbers

$$z = a + bj$$

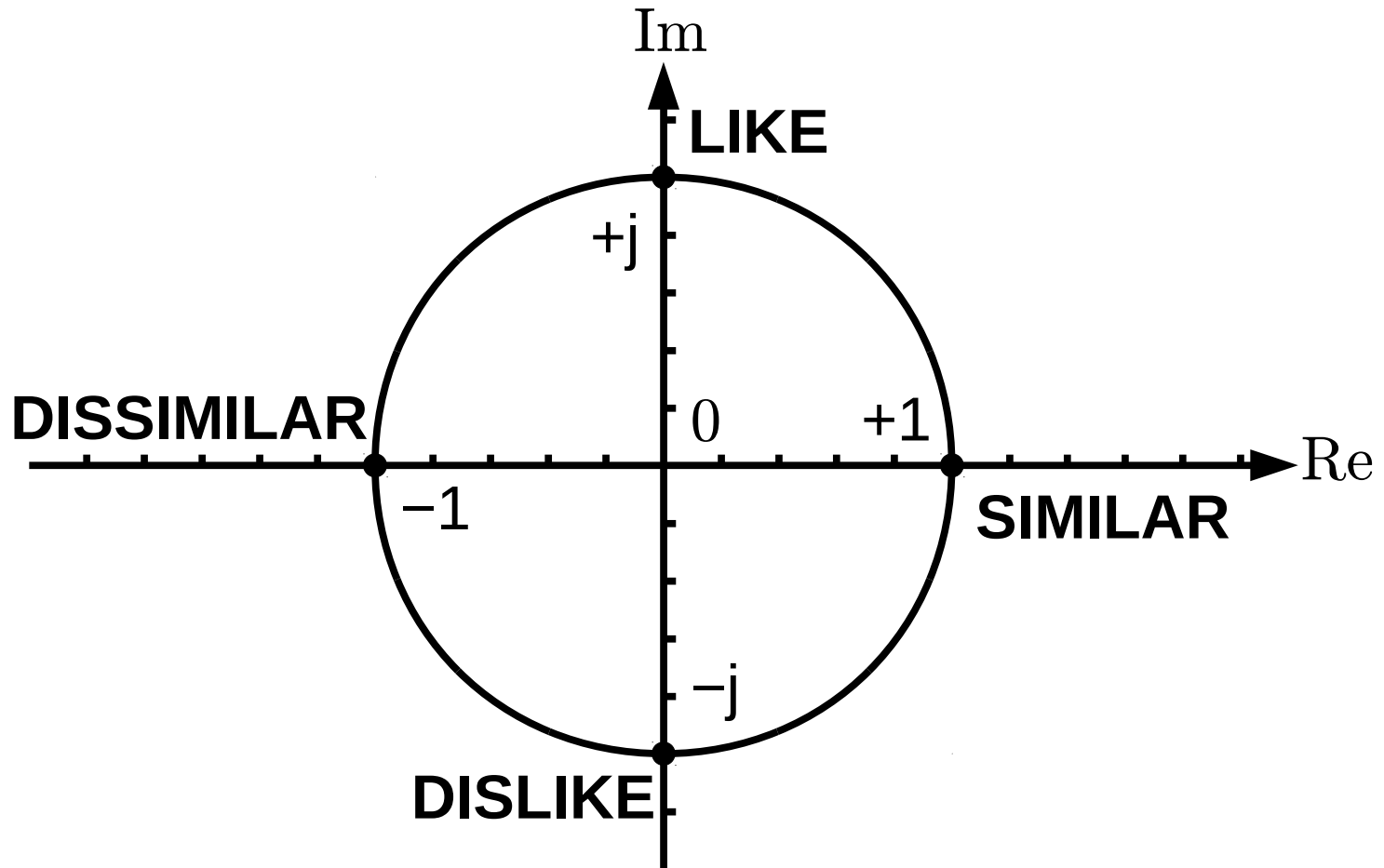
$$j \times j = +1$$

$$(a + bj) + (c + dj) = (a + c) + (b + d)j$$

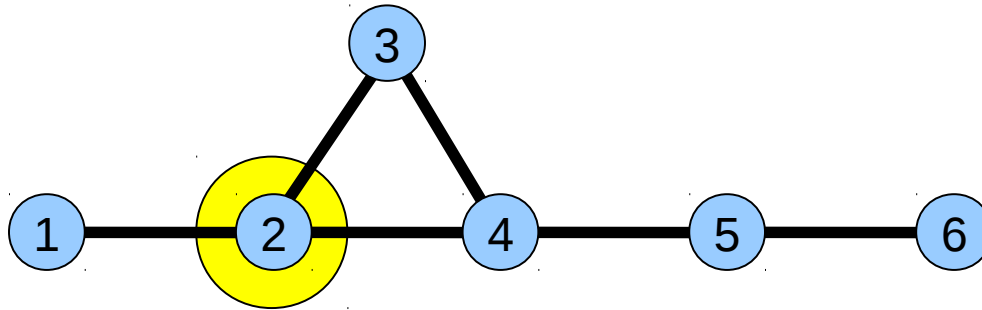
$$(a + bj) \times (c + dj) = (ac + bd) + (ad + bc)j$$

Not a field: $(1 + j)(1 - j) = 0$

Introduced as *real tessarines* (Cockle 1848)



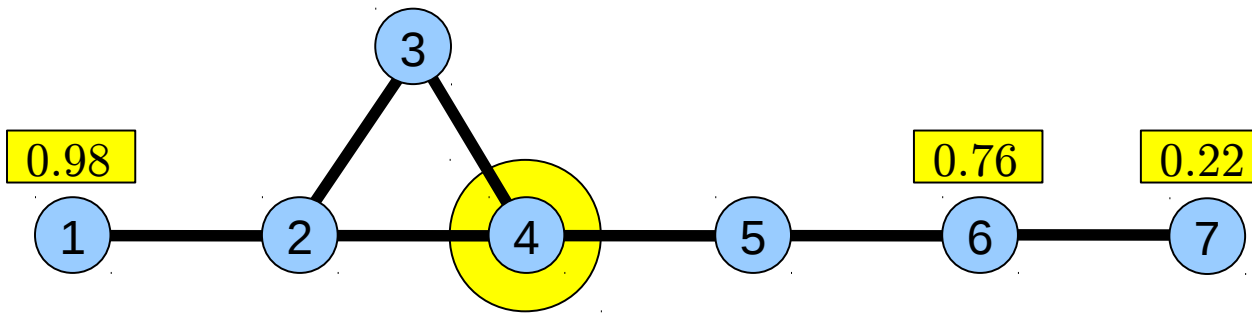
Adjacency Matrix


$$A = \begin{array}{c|cccccc} & \textcircled{1} & \textcircled{2} & \textcircled{3} & \textcircled{4} & \textcircled{5} & \textcircled{6} \\ \textcircled{1} & 0 & 1 & 0 & 0 & 0 & 0 \\ \textcircled{2} & 1 & 0 & 1 & 1 & 0 & 0 \\ \textcircled{3} & 0 & 1 & 0 & 1 & 0 & 0 \\ \textcircled{4} & 0 & 1 & 1 & 0 & 1 & 0 \\ \textcircled{5} & 0 & 0 & 0 & 1 & 0 & 1 \\ \textcircled{6} & 0 & 0 & 0 & 0 & 1 & 0 \end{array}$$

$A_{uv} = 1$ when u and v are connected

$A_{uv} = 0$ when u and v are not connected

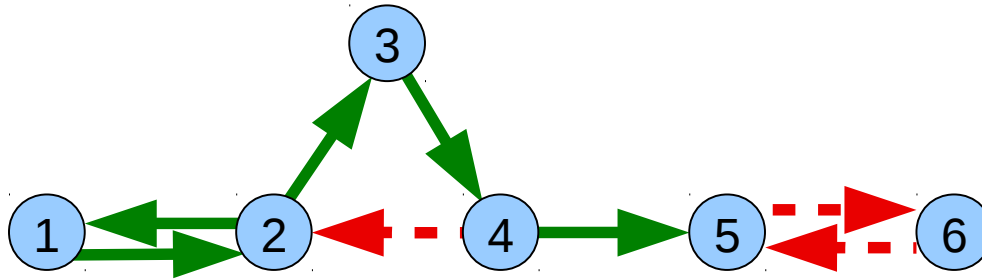
Recommender Functions



$$\exp(\mathbf{A}) = \mathbf{I} + \mathbf{A} + \frac{1}{2} \mathbf{A}^2 + \frac{1}{6} \mathbf{A}^3 + \dots$$

$$\exp \begin{pmatrix} 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{pmatrix} = \begin{matrix} \textcircled{1} & \textcircled{2} & \textcircled{3} & \textcircled{4} & \textcircled{5} & \textcircled{6} & \textcircled{7} \\ \begin{pmatrix} 1.66 & 1.72 & 0.93 & 0.98 & 0.28 & 0.06 & 0.01 \\ 1.72 & 3.57 & 2.70 & 2.93 & 1.04 & 0.29 & 0.06 \\ 0.93 & 2.70 & 2.86 & 2.71 & 0.99 & 0.28 & 0.06 \\ \mathbf{0.98} & \mathbf{2.93} & \mathbf{2.71} & \mathbf{3.63} & \mathbf{1.95} & \mathbf{0.76} & \mathbf{0.22} \\ 0.28 & 1.04 & 0.99 & 1.95 & 2.35 & 1.59 & 0.64 \\ 0.06 & 0.29 & 0.28 & 0.76 & 1.59 & 2.23 & 1.38 \\ 0.01 & 0.06 & 0.06 & 0.22 & 0.64 & 1.38 & 1.59 \end{pmatrix} \\ \textcircled{1} \\ \textcircled{2} \\ \textcircled{3} \\ \textcircled{4} \\ \textcircled{5} \\ \textcircled{6} \\ \textcircled{7} \end{matrix}$$

Split-complex Adjacency Matrix



$B_{uv} = +j$ when u likes v

$B_{uv} = -j$ when u dislikes v

$B_{uv} = 0$ when u and v are not connected

$$\mathbf{B} = \begin{matrix} & \begin{matrix} \textcircled{1} & \textcircled{2} & \textcircled{3} & \textcircled{4} & \textcircled{5} & \textcircled{6} \end{matrix} \\ \begin{matrix} \textcircled{1} \\ \textcircled{2} \\ \textcircled{3} \\ \textcircled{4} \\ \textcircled{5} \\ \textcircled{6} \end{matrix} & \left| \begin{array}{cccccc} & & +j & & & \\ +j & & & +j & & \\ & & & & +j & \\ -j & & & & & +j \\ & & & & & & -j \\ & & & & -j & & \end{array} \right. \end{matrix}$$

$\mathbf{B} = j\mathbf{A}$

Split-complex Numbers as 2x2 Matrices

$$a + bj \equiv \begin{vmatrix} a & b \\ b & a \end{vmatrix}$$

$$\begin{vmatrix} a & b \\ b & a \end{vmatrix} + \begin{vmatrix} c & d \\ d & c \end{vmatrix} = \begin{vmatrix} a+c & b+d \\ b+d & a+c \end{vmatrix}$$

$$\begin{vmatrix} a & b \\ b & a \end{vmatrix} \times \begin{vmatrix} c & d \\ d & c \end{vmatrix} = \begin{vmatrix} ac+bd & ad+bc \\ ad+bc & ac+bd \end{vmatrix}$$

Computation

$$\mathbf{B} \equiv \begin{vmatrix} & \mathbf{A} \\ \mathbf{A}^T & \end{vmatrix}$$

$$\exp(\mathbf{B}) \equiv \begin{vmatrix} \cosh(\mathbf{A}) & \sinh(\mathbf{A}) \\ \sinh(\mathbf{A}) & \cosh(\mathbf{A}) \end{vmatrix}$$

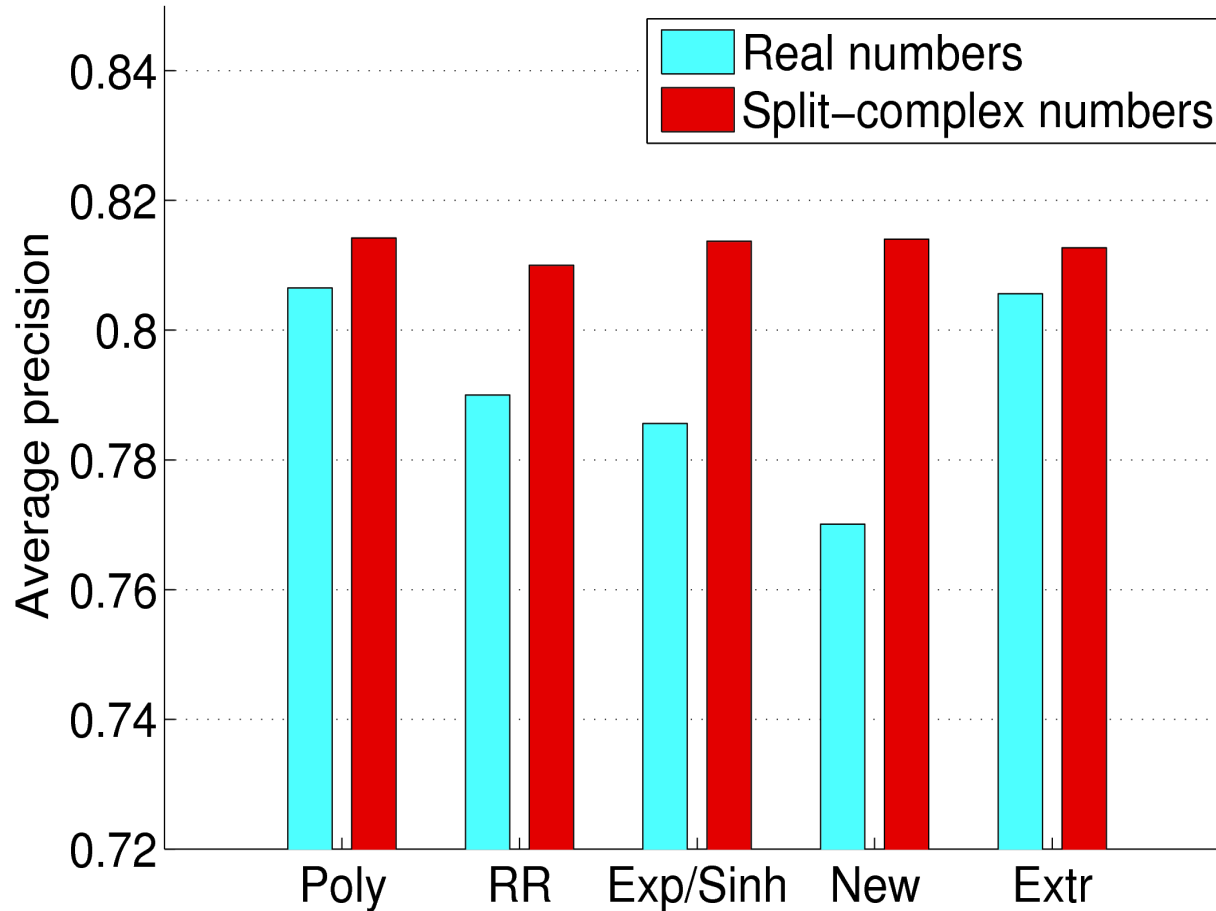
Evaluation

Libum.se ti.cz

(“Do you like me”) – Czech dating site

Gender	Count	Unknown	Rating counts		
			Male	Female	Total
Unknown	83,164	366,180	891,550	445,115	1,702,845
Male	76,441	937,684	682,710	3,232,064	4,852,458
Female	61,365	2,460,765	7,099,688	1,243,590	10,804,043
All	220,970	3,764,629	8,673,948	4,920,769	17,359,346

Evaluation



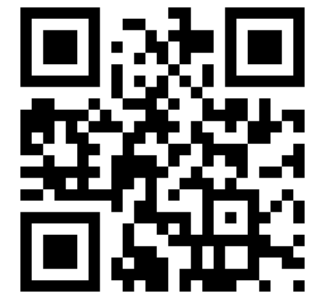
Thank You

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Thanks go to Václav Petříček for providing the Libimseti.cz dataset. The research leading to these results has received funding from the European Community's Seventh Framework Programme under grant agreement n° 257859, ROBUST.

konect.uni-koblenz.de/networks/libimseti



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