

Temporal bibliographic analysis

V. Batagelj, D. Maltseva

Web of science

WoS networ

Cited work

Tempora

Network

Examples

Bibliography

Temporal bibliographic analysis

Vladimir Batagelj, Daria Maltseva

IMFM Ljubljana, IAM UP Koper and NRU HSE Moscow

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Advances in data science for big and complex data University Paris-Dauphine, January 10-11, 2019



Outline

Temporal bibliographic analysis

V. Batagelj, D. Maltseva

Web of science

WoS networks

TVOS TICEWOTK.

Temporal

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Example

Bibliograph

- 1 Web of science
- 2 WoS networks
- 3 Cited works
- 4 Temporal networks
- 5 Network multiplication
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Vladimir Batagelj: vladimir.batagelj@fmf.uni-lj.si

Daria Maltseva: d_malceva@mail.ru

Current version of slides (January 12, 2019 at 06:07): slides PDF



WoS

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Bibliograph

To the Web of Science (WoS), Clarivate Analytics's multidisciplinary databases of bibliographic information, we put the query

"social network*"

Additionally, all the articles from the following journals were collected:

Social Networks, Network Science, Social Network Analysis and Mining, Journal of Complex Networks

Other network-related journals are **not considered** in WoS:

Computational Social Networks, Applied Network Science, Online Social Networks and Media, Connections, Journal of Social Structure

We limited the search to the Web of Science Core Collection because for other data bases from WoS the CR-fields (containing citation information) can not be exported. The first data set was collected in 2007, second – in June, 2018.



WoS record

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Bibliograph

SK IP

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PT J
AU GRANOVET.MS
TI STRENGTH OF WEAK TIES
SO AMERICAN JOURNAL OF SOCIOLOGY
LA English
DT Article
C1 JOHNS HOPKINS UNIV, BALTIMORE, MD 21218 USA.
CR BARNES JA, 1969, SOCIAL NETWORKS URBA
   BECKER MH, 1970, AM SOCIOL REV, V35, P267
   BERSCHEID E, 1969, INTERPERSONAL ATTRAC
  BOISSEVAIN J, 1968, MAN, V3, P542
  BOTT E, 1957, FAMILY SOCIAL NETWOR
NR. 61
TC 2156
PU UNIV CHICAGO PRESS
PI CHICAGO
PA 5720 S WOODLAWN AVE, CHICAGO, IL 60637
SN 0002-9602
J9 AMER J SOCTOL
JI Am. J. Sociol.
PY 1973
VL 78
IS 6
BP 1360
EP 1380
PG 21
SC Sociology
GA P7726
UT ISI: A1973P772600003
ER
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Converting WoS data into networks

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We applied the program WoS2Pajek 1.5 to the collected data.

The following networks were constructed:

- 1 the authorship network \emph{WA} on works \times authors (from the field AU),
 - 2) the journalship network WJ on works \times journals (from the field CR or J9),
- 3 the keywordship network WK on works \times keywords (from the field ID or DE or TI),
- 4 the citation network *Cite* on works (from the field CR).

We obtained also the following node properties:

- 1 the partition year of works by publication year,
- 2 the *DC* partition distinguishing between works with complete description (DC=1) and the cited only works (DC=0),
- 3 the vector of number of pages NP.



WoS

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We call a terminal node a node without a description in the collected data set – it appears only in the WoS CR field as a reference.

We additionally collected on WoS and Google data for terminal nodes with large indegree in the citation network - highly cited works without description in the collected data set.

If a description of a node was not available in WoS we manually constructed a corresponding description without CR data (using RIS bibliographic format and converting it to WoS).

As the data set of 2007 was already completed, we made this additional search only for works 2008-* in July 2018.



Sizes of Original cleaned and Reduced networks

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Bibliography

	# nodes (sum)	# nodes 1	# nodes 2	# arcs
CiteN	1,297,133			2,753,633
CiteR	70,792			398,199
WAn	1,693,104	1,297,133	395,971	1,442,240
WAr	163,803	70,792	93,011	215,901
WKn	1,329,542	1,297,133	32,409	1,167,670
WKr	103,201	70,792	32,409	1,167,666
WJn	1,366,279	1,297,133	69,146	720,044
WJr	79,735	70,792	8,943	61,741

An important property of all these networks is that they share as the first node set the same set of works (papers, reports, books, etc.) – they are *linked*.



Cite net

The most cited works - indegree

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vveb of science

VVOS HELWORK

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Bibliograp

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28 742 NAHAPIET_J(1998)23:242 58 523 KEMP_D(2003):137	26	757	KAPLÀN_A(2010)53:59	56	537	BRIN_S(1998)30:107
	27	756	*BLONDEL_V(2008):P10008	57	524	MARSDEN_P(1990)16:435
29 740 FORNELL_C(1981)18:39 59 523 KLEINBER_J(1999)46:604	28	742	NAHAPIET_J(1998)23:242	58	523	KEMP_D(2003):137
	29	740	FORNELL_C(1981)18:39	59	523	KLEINBER_J(1999)46:604
30 740 *NEWMAN_M(2006)103:8577 60 517 *BOCCALET_S(2006)424:175	30	740	*NEWMAN_M(2006)103:8577	60	517	*BOCCALET_S(2006)424:175

Labels ending with : represent books





Temporal networks

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A temporal network $\mathcal{N}_{\mathcal{T}} = (\mathcal{V}, \mathcal{L}, \mathcal{T}, \mathcal{P}, \mathcal{W})$ is obtained by attaching the time, \mathcal{T} , to an ordinary network where \mathcal{T} is a set of time points, $t \in \mathcal{T}$.

In a temporal network, nodes $v \in \mathcal{V}$ and links $I \in \mathcal{L}$ are not necessarily present or active in all time points. Let T(v), $T \in \mathcal{P}$, be the *activity set* of time points for node v and T(I), $T \in \mathcal{W}$, the activity set of time points for link I.

Besides the presence/absence of nodes and links also their properties can change through time.



Temporal quantities

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We introduce a notion of a *temporal quantity*

$$a(t) = \left\{ egin{array}{ll} a'(t) & t \in T_a \ rak t \in \mathcal T \setminus T_a \end{array}
ight.$$

where T_a is the *activity time set* of a and a'(t) is the value of a in an instant $t \in T_a$, and \mathbb{X} denotes the value *undefined*.

We assume that the values of temporal quantities belong to a set A which is a *semiring* $(A, +, \cdot, 0, 1)$ for binary operations + and \cdot .

We can extend both operations to the set $A_{\Re} = A \cup \{\Re\}$ by requiring that for all $a \in A_{\Re}$ it holds

$$a + \Re = \Re + a = a$$
 and $a \cdot \Re = \Re \cdot a = \Re$.

The structure $(A_{\mathbb{H}}, +, \cdot, \mathbb{H}, 1)$ is also a semiring.



Operations with temporal quantities

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Let $A_{\mathfrak{H}}(\mathcal{T})$ denote the set of all temporal quantities over $A_{\mathfrak{H}}$ in time \mathcal{T} . To extend the operations to networks and their matrices we first define the *sum* (parallel links) a+b as

$$(a+b)(t)=a(t)+b(t)$$
 and $T_{a+b}=T_a\cup T_b$.

The *product* (sequential links) $a \cdot b$ is defined as

$$(a \cdot b)(t) = a(t) \cdot b(t)$$
 and $T_{a \cdot b} = T_a \cap T_b$.

Let us define the temporal quantities $\mathbf{0}$ and $\mathbf{1}$ with requirements $\mathbf{0}(t)=\mathbb{H}$ and $\mathbf{1}(t)=1$ for all $t\in\mathcal{T}$. Again, the structure $(A_{\mathbb{H}}(\mathcal{T}),+,\cdot,\mathbf{0},\mathbf{1})$ is a semiring.



Addition of temporal quantities

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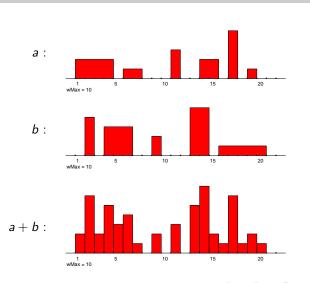
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Multiplication of temporal quantities

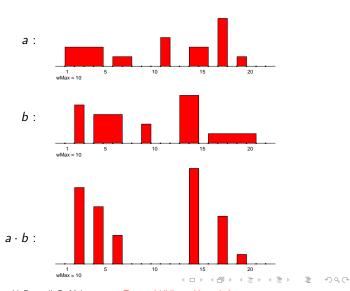
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Creating temporal networks

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Let the binary matrix $\mathbf{A} = [a_{ep}]$ describe a two-mode (or one-mode) network on the set of events E and the set of participants P:

$$a_{ep} = \begin{cases} 1 & p \text{ participated in the event } e \\ 0 & \text{otherwise} \end{cases}$$

The function $d: E \to \mathcal{T}$ assigns to each event e the date d(e) when it happened. $\mathcal{T} = [\mathit{first}, \mathit{last}] \subset \mathbb{N}$. Using these data we can construct two temporal affiliation matrices:

• instantaneous $Ai = [ai_{ep}]$, where

$$ai_{ep} = \left\{ egin{array}{ll} [(d(e),d(e)+1,1)] & a_{ep} = 1 \ [\] & ext{otherwise} \end{array}
ight.$$

• **cumulative Ac** = $[ac_{ep}]$, where

$$ac_{ep} = \begin{cases} [(d(e), last + 1, 1)] & a_{ep} = 1 \\ [] & \text{otherwise} \end{cases}$$



Temporal networks in Nets

```
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```
>>> net = wdir+"/WAins.json"
>>> WAi = N.loadNetJSON(net)
>>> I = WAi.Index()
>>> I["ERDOS P(1959)6:290"]
776
>>> WAi. nodes[776]
[{}, {}, {71246: [1091], 89670: [214562]},
{'mode': 1, 'lab': 'ERDOS_P(1959)6:290', 'act': [[1959, 2019, 1]]}}
>>> WAi. nodes[71246]
[{}, {776: [1091], 11539: [25213], 11540: [25214], 15565: [33820],
42898: [129167]}, {},
{'mode': 2, 'lab': 'ERDOS_P', 'act': [[1894, 2019, 1]]}]
>>> WAi._nodes[89670]
[{}, {776: [214562], 15565: [215596]}, {},
{'mode': 2, 'lab': 'RENYI_A', 'act': [[1894, 2019, 1]]}]
>>> WAi._links[1091]
[776, 71246, True, None, {'tq': [[1959, 1960, 1]]}]
>>> WAi._links[214562]
[776, 89670, True, None, {'tq': [[1959, 1960, 1]]}]
```



Temporal citation networks

```
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```
gdir = 'C:/Users/batageli/work/Pvthon/graph/Nets'
wdir = "C:/Users/batagelj/work/Python/WoS/SocNet/2018/Time/cite"
cdir = "C:/Users/batagelj/work/Python/WoS/SocNet/2018/Time/work/chart"
import sys. os. re. datetime. ison
sys.path = [gdir]+sys.path; os.chdir(wdir)
from TQ import *
from Nets import Network as N
Ci = N.loadNetJSON(wdir+"/CiteIns.ison")
Cu = N.loadNetJSON(wdir+"/CiteCum.json")
L = [ "#WASSERMA_S(1994):", "#GRANOVET_M(1973)78:1360", "WATTS_D(1998)393:440",
      "BARABASI_A(1999)286:509", "FREEMAN_L(1979)1:215", "#BOYD_D(2007)13:210", "MCPHERSO_M(2001)27:415", "BURT_R(1992):"]
I = Ci.Index()
>>> I["#WASSERMA S(1994):"]
>>> TCin = [ (u, Ci.TQnetInDeg(I[u])) for u in L ]
>>> TCuin = [ (u, Cu.TQnetInDeg(I[u])) for u in L ]
>>> TCin[0]
('#WASSERMA_S(1994):', [(1994, 1995, 2), (1995, 1996, 7), (1996, 1997, 12), (1997, 1998, 23),
(1998, 199\overline{9}, 26), (1999, 2000, 41), (2000, 2001, 31), (2001, 2002, 54), (2002, 2003, 38),
 (2003, 2004, 64), (2004, 2005, 76), (2005, 2006, 85), (2006, 2007, 103), (2007, 2008, 220),
 (2008, 2009, 238), (2009, 2010, 313), (2010, 2011, 364), (2011, 2012, 424), (2012, 2013, 459),
 (2013, 2014, 438), (2014, 2015, 504), (2015, 2016, 579), (2016, 2017, 552), (2017, 2018, 528),
 (2018, 2019, 167)])
>>> TCuin[0]
('#WASSERMA_S(1994):', [(1994, 1995, 2), (1995, 1996, 9), (1996, 1997, 21), (1997, 1998, 44),
 (1998, 1999, 70), (1999, 2000, 111), (2000, 2001, 142), (2001, 2002, 196), (2002, 2003, 234)
 (2003, 2004, 298), (2004, 2005, 374), (2005, 2006, 459), (2006, 2007, 562), (2007, 2008, 782),
 (2008, 2009, 1020), (2009, 2010, 1333), (2010, 2011, 1697), (2011, 2012, 2121),
(2012, 2013, 2580), (2013, 2014, 3018), (2014, 2015, 3522), (2015, 2016, 4101),
(2016, 2017, 4653), (2017, 2018, 5181), (2018, 2019, 5348)1)
>>> w = 800: h = 500
>>> p=0; (Tmin, Tmax, tt, TQmax) = TQ. TqSummary(TCin[p][1]); tit = TCin[p][0]
>>> N.TOshow(TCin[p][1].cdir.TOmax.Tmin.Tmax.w.h.tit.fill='red')
```



Temporal citation network

temporal indegrees

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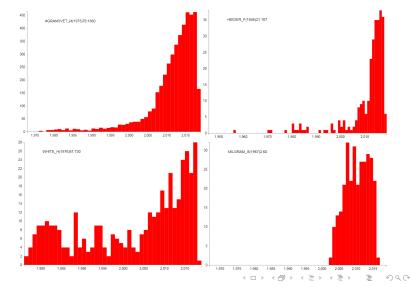
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$$Co = WA^T * WA$$

The weight of the edges between the nodes i and j is equal to total number of works author i and j wrote together.

The values of loops in **Co** are equal to the total number of works that each author have (which is also equal to the indegree values of the **WA** network).

The proposed approach has some *limitations*, such as the overrating of the contribution of works with many authors. To make the contribution of each work equal we have to use the normalized version $n(\mathbf{WA})$ of the network (matrix) (*fractional approach*)

$$n(WA)[w, a] = \frac{WA[w, a]}{\max(1, \text{outdeg}[w])}$$



Multiplication of networks

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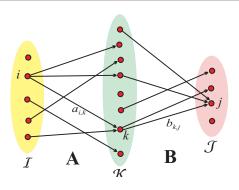
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$$c_{i,j} = \sum_{k \in N_A(i) \cap N_B^-(j)} a_{i,k} \cdot b_{k,j}$$

If all weights in networks \mathcal{N}_A and \mathcal{N}_B are equal to 1 the value of $c_{i,j}$ counts the number of ways we can go from $i \in \mathcal{I}$ to $j \in \mathcal{J}$ passing through \mathcal{K} .



Derived networks

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$AK = WA^T * WK$

The weight of the arc from the node a to the node k is equal to the number of works in which the author a used the keyword k.

$$CiteJ = (WJ)^T * Cite * WJ$$

the value of weight of the element [u,v] is equal to the **number of citations** from journal i to journal j.

$$CiteAn = (WA)^T * n(Cite) * WA$$

The value of element CiteAn[u,v] is equal to the number of **fractional contribution** of citations from works coauthored by u to works coauthored by v.

etc.



Multiplication of co-occurence networks Instantaneous

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Instantaneous **A** on $P \times A$ and **B** on $P \times B$. **C** = \mathbf{A}^T . **B** on $A \times B$.

$$c_{ij}(t) = \sum_{p \in P} a_{pi}(t)^T \cdot b_{pj}(t)$$

 $a_{pi} = [(d_{pi}, d_{pi} + 1, v_{pi})]$ and $b_{pj} = [(d_{pj}, d_{pj} + 1, v_{pj})]$ for t = d we get

$$c_{ij} = [(d, d+1, \sum_{p \in P: d_{ni} = d_{ni} = d} v_{pi}.v_{pj})]_{d \in \mathcal{T}}$$

for $v_{pi} = v_{pj} = 1$ we finally get

$$v_{ij}(d) = |\{p \in P : d_{pi} = d_{pj} = d\}|$$

For binary temporal two-mode networks **A** and **B** the value $v_{ij}(d)$ of the product \mathbf{A}^T . **B** is equal to the number of different members of P with which both i and j have contact in the instant d.



Multiplication of co-occurence networks Cumulative

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D. Maltseva

Cumulative **A** on $P \times A$ and **B** on $P \times B$. **C** = \mathbf{A}^T .**B** on $A \times B$.

$$c_{ij}(t) = \sum_{p \in P} a_{pi}(t)^T \cdot b_{pj}(t)$$

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$$a_{pi} = [(d_{pi}, last + 1, v_{pi})]$$
 and $b_{pj} = [(d_{pj}, last + 1, v_{pj})]$ for $t = d$ we get

$$c_{ij} = [(d, d+1, \sum_{p \in P: (d_{pi} \leq d) \land (d_{pj} \leq d)} v_{pi}.v_{pj})]_{d \in \mathcal{T}}$$

for $v_{pi} = v_{pj} = 1$ we finally get

$$v_{ij}(d) = |\{p \in P : (d_{pi} \leq d) \land (d_{pj} \leq d)\}|$$

For binary temporal two-mode networks **A** and **B** the value $v_{ij}(d)$ of the product $\mathbf{A}^T.\mathbf{B}$ is equal to the number of different members of P with which both i and j have contact in all instants up to including the instant d.



Citations among journals

JCJ and JCJn from WJins, WJcum, CiteIns nets

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$$JCJ = (WJins)^T * CiteIns * WJcum$$

The value of weight of the element JCJ[i,j] is equal to the **number of citations** per year from journal i to journal j.

$$\mathsf{JCJn} = (\mathsf{WJins})^T * n(\mathsf{CiteIns}) * \mathsf{WJcum}$$

where

$$n(CiteIns)[u, v] = \frac{CiteIns[u, v]}{\max(1, \text{outdeg}(u))}$$

The value of element JCJn[i,j] is equal to the number of **fractional contribution** of citations per year from journal i to journal j.



Self-citations of journals

Loops from JCJ network

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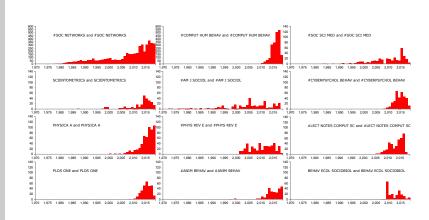
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Citations of Social Networks journal

InSum and OutSum of JCJ network without loops

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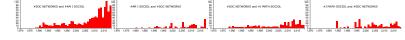
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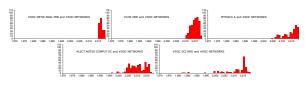




OutSum:



InSum:





Citation of general scientific journals

from JCJ network without loops

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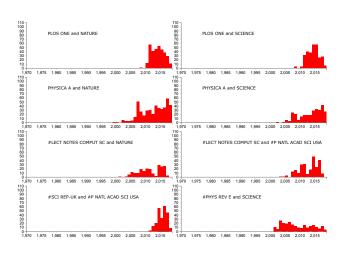
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Citations of other journals

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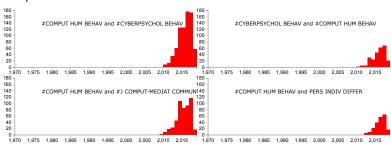
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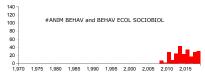
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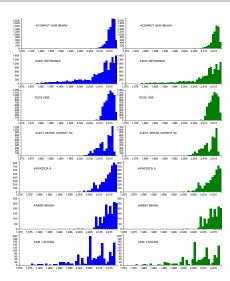
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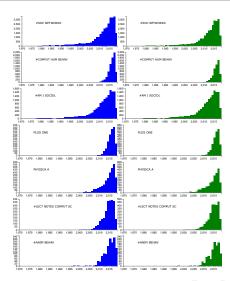
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