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Reciprocally time correlating objects ranking

Snarskii A.A.[1,2], Dr. of Sciences, Lande D.V.[1,2], Dr. of Sciences,
Zorinets D.I.[1], Levchenko A.V.[3],
[1]NTUU "I. Sikorsky Kyiv Polytechnic Institute", Kiev, Ukraine,
[2]Institute for Information Recording NASU, Kiev, Ukraine,
[3]ROSEN Europe B.V., Kiev, Ukraine,
asnarskii@gmail.com

In the article a new ranking method of correlating in time objects which allows to appreciate the most "influential" and the most "subjected to influence" objects at the given time interval is represented. As an example of the method application a group of leading world politicians (further-personalities) is considered.

Introduction

Ranking is one of the most wide-spread methods of arranging of everyday objects around us, both physical and informative. In the case when to each object of object totality some numerical value may be attributed, formally the task of ranging becomes trivial. Objects may be ranged according to the quantity of this value. The difficulty, however, is first it is not always clear how to determine the numerical value which may be attributed to the object. Secondly there may be many such numerical values and the criterion according to which this or that series of numerical values must be chosen is not always clear. The most complicated part of the ranging problem is the choice of the criterion according to which the numerical value is attributed to the object (formalization of objects).

The method consists of two separate stages. At the first stage for each personality the number of his citations in some pool of printed publications every day is defined according to InfoStream System.

Number series reciprocal temporal correlators

Each value of these time series is standardized by the whole number of citations of all personalities in that day. Standardized series of citations for two personalities (Trump and Clinton) for terminal interval from 01.01 to 20.09 2016 is given in Fig. 1.

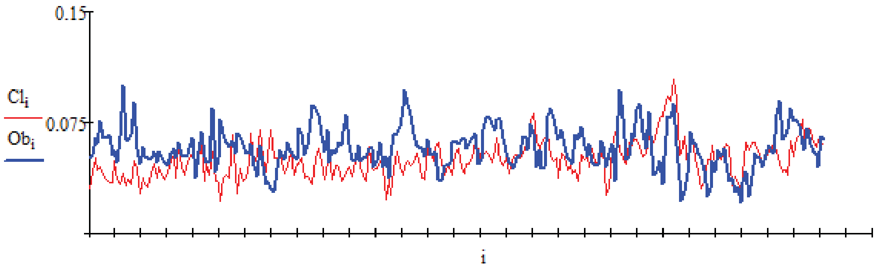

Fig. 1. Standardized series of citations for two personalities – Trump and Clinton for terminal interval from 01.01 to 20.09 2016

To get standardized number series reciprocal temporal correlators are calculated which give an average value for a large number of obtained values for joint distribution of two processes (personalities)

$$Cl\_Ob_k = \frac{\sum_i (Cl_i - \langle Cl \rangle)(Ob_{i+k} - \langle Ob \rangle)}{\sqrt{\sum_i (Cl_i - \langle Cl \rangle)^2} \sqrt{\sum_i (Ob_{i+k} - \langle Ob \rangle)^2}}, \qquad \langle X \rangle = \frac{1}{N} \sum_{i=1}^{N} X_i \ ,$$

where – Cl and Ob – means Clinton and Obama accordingly.

Depending on the shift of temporal interval-k while calculating the correlators, obtained correlator are connected with the probability of the appearance of the citation of one personality with the fact whether the another personality has been cited before.

The cognitive net Correlators obtained for all personalities are introduced as a set of directed graphs (cognitive nets). Every cognitive net represents the set of nodes (personalities), connected by directed relations the weight of which corresponds to the numerical value of the correlator for the given temporal shift-k.

To each net corresponds its own temporal shift (lateness), calculating the correlators-a day, two days and so on. Thus, we get the whole directed graph. The relation directed from one personality to another determines the direct influence (positive or negative, depending on the sign of the numerical value of the correlator) in Fig. 2 a part of cognitive net is represented.

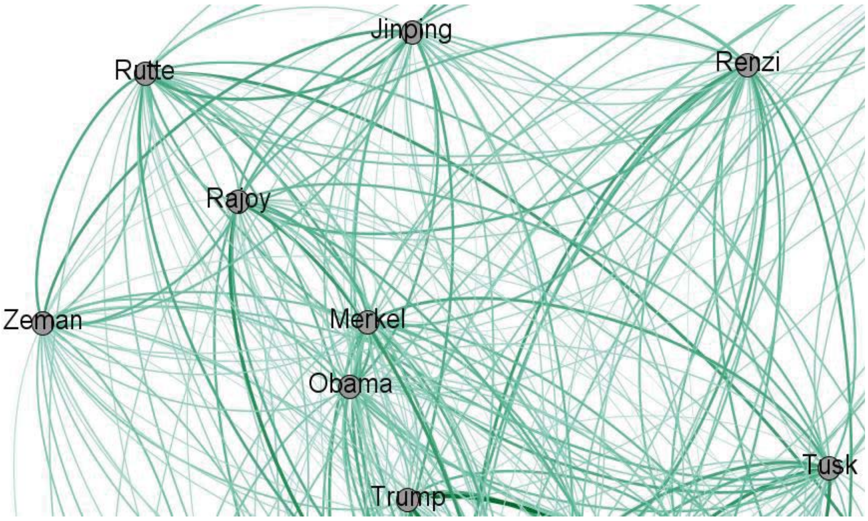

Fig. 2. A part of cognitive net

At the second stage for the determination of the full influence of one personality on another not only direct influence (relation between personalities) is taken into account but also the indirect one through the chain. For this the obtained complicated net is represented as a cognitive map. This cognitive map may be investigated by different methods, for example, so-called impulse-method, fuzzy-method [1,2]. We used K–method [3].

K–method

Algorithm of K – method consists of two stages.

Stage 1.For each directed pair of concepts $\alpha \to \beta$ we select subgraph $G(\alpha \to \beta)$ which consists of all possible ways (with the consideration of relation direction) from concept α to concept β. Thus, to each directed pair of concepts $\alpha \to \beta$ corresponds its own subgraph selected from complete cognitive map graph – $\mathbf{W}$, let us mark the adjacency matrix of this subgraph and subgraph itself $\mathbf{G}(\alpha \to \beta)$.

Stage 2.The stage of calculation of the directed influence of concepts on each other. Stage 2 consists of a number of steps. In the first step subgraph $G(\alpha \to \beta)$ symmetrizes and so symmetrized graph is marked as $B(\alpha \to \beta)$. All its relations become non-directed. So, for example, if in $\mathbf{G}(\alpha \to \beta)$ elements $\mathbf{G}_{km} \neq 0$, a $\mathbf{G}_{mk} = 0$, thus in symmetrized $\mathbf{B}(\alpha \to \beta)$ both elements are not equal to zero $\mathbf{B}_{km} \neq 0$,and $\mathbf{B}_{mk} = 0$ and $\mathbf{B}_{km} = \mathbf{B}_{mk} = \mathbf{G}_{km}$.

Adjacency matrix $\mathbf{B}(\alpha \rightarrow \beta)$ determines non-directed weight graph which further will be represented as net in which current of some preserved quantity, for example, electrical flows. With this analogy weights on relations are interpreted as electromotive force (emf), relations as resistances and quantities on concepts v_i – as electrical potentials – φ_i.

At the second step calculation φ_i for all concepts is done according to Kirchhoff rules. Since potentials are calculated with the accuracy to arbitrary constant, only their difference has got sense. For definiteness it is easy to set it on one of the concepts equal to zero. For subgraph $B(\alpha \rightarrow \beta)$ potential will be counted off from concepts α, that is $\varphi_\alpha = 0$ will be accepted.

Equation for the calculation of potentials for all the rest nodes of net $B(\alpha \rightarrow \beta)$, according to Kirchhoff rules has the form

$$\mathbf{\Omega}(\alpha \rightarrow \beta)\mathbf{Y}\mathbf{\Omega}^T(\alpha \rightarrow \beta)\boldsymbol{\varphi}(\alpha \rightarrow \beta) = -\mathbf{\Omega}(\alpha \rightarrow \beta)\mathbf{YE}.$$

Here $\mathbf{\Omega}(\alpha \rightarrow \beta)$ – incident matrix for subgraph $B(\alpha \rightarrow \beta)$. This matrix is composed in the following way. Number is conferred to each relation and concept. The number of matrix row $\mathbf{\Omega}(\alpha \rightarrow \beta)$ corresponds to the number of relation, and the number of column – the number of concept. Element (i, j) matrix $\mathbf{\Omega}(\alpha \rightarrow \beta)$ - ω_{ij} equals $+1$, if the relation with number i goes out from concept j and -1 – if comes into it. If relation i is not connected with concept j, then $\omega_{ij} = 0$.In addition, since it is accepted $\varphi_\alpha = 0$, α the column of matrix $\mathbf{\Omega}(\alpha \rightarrow \beta)$ is deleted. Matrix $\mathbf{Y}$ – square matrix of resistances of dimension $M \times M$, where M – the number of relations, moreover, each element of the given matrix - y_{ij} is defined as $y_{ij} = R_i \delta_{ij}$. Where R_i – resistance of that relation and, δ_{ij} – Kroneker symbol.

In this paper all relations are accepted with resistances equal one and so $\mathbf{Y} \equiv \mathbf{1}$. In this case $\mathbf{\Omega}(\alpha \rightarrow \beta)\mathbf{Y}\mathbf{\Omega}^T(\alpha \rightarrow \beta) = \mathbf{\Omega}(\alpha \rightarrow \beta)\mathbf{\Omega}^T(\alpha \rightarrow \beta)$, and (6) gets the following form

$$\mathbf{\Omega}(\alpha \rightarrow \beta)\mathbf{\Omega}^T(\alpha \rightarrow \beta)\boldsymbol{\varphi}(\alpha \rightarrow \beta) = -\mathbf{\Omega}(\alpha \rightarrow \beta)\mathbf{E}.$$

Vector $\mathbf{E}$ -vector column consisting of M elements, where M – the number of relations and its element e_i is defined as $e_i = \varepsilon_i$, where e_i– emf on the relation with number i.

Selecting from initial cognitive map subgraph $G(\alpha \rightarrow \beta)$ and corresponding to it subgraph $B(\alpha \rightarrow \beta)$ we just take into consideration that we are studying the influence of initial concept α on concept β, and that with the given (electrical) analogy means the difference of values $\boldsymbol{\varphi}_\beta(\alpha \rightarrow \beta) -$

$\boldsymbol{\varphi}_\alpha(\alpha \to u\beta)$ and since accepted that $\boldsymbol{\varphi}_\alpha(\alpha \to \beta) = 0$, value $\boldsymbol{\varphi}_\beta(\alpha \to \beta)$. That is from the whole vector $\boldsymbol{\varphi}(\alpha \to \beta)$,which is set by solving equation

$$\boldsymbol{\varphi}(\alpha \to \beta) = -[\boldsymbol{\Omega}(\alpha \to \beta)\mathbf{Y}\boldsymbol{\Omega}^T(\alpha \to \beta)]^{-1}\boldsymbol{\Omega}(\alpha \to \beta)\mathbf{YE},$$

For further analysis only one component $\boldsymbol{\varphi}_\beta(\alpha \to \beta)$ is left.

With the same fixed α, giving different values β (and after all calculations) we find a new vector $\boldsymbol{\Phi}_\beta(\alpha \to \beta)$, $\beta = 1,2,\ldots,N$, $\beta \neq \alpha$. It is necessary to note that if the components of vector $\boldsymbol{\varphi}(\alpha \to \beta)$ are related to the same graph set by matrix $\mathbf{B}(\alpha \to \beta)$ $(\boldsymbol{\varphi}_1(\alpha \to \beta), \boldsymbol{\varphi}_2(\alpha \to \beta), \ldots, \boldsymbol{\varphi}_N(\alpha \to \beta))$, then each component of vector $\boldsymbol{\Phi}(\alpha \to \beta)$ is related to its graph $\Phi(\alpha \to \beta)$ $(\boldsymbol{\Phi}_1(\alpha \to \beta), \boldsymbol{\Phi}_2(\alpha \to \beta), \ldots, \boldsymbol{\Phi}_N(\alpha \to \beta))$.

The set of all components of all vectors $\boldsymbol{\Phi}(\alpha \to \beta)$ may be written down in the form of matrix, we may call it $K-$ matrix. To calculate element $K_{\alpha\beta}$ of matrix **K,** we choose two concepts $\alpha \to \beta$ in cognitive map, select subgraph $G(\alpha \to \beta)$ of all possible relations out of concepts α in concept β, graph $G(\alpha \to \beta)$, transform in graph $B(\alpha \to \beta)$, attribute zero potential to concept α and according to (10) calculate the potential of concept β, the value of which is element $K_{\alpha\beta}$.That is, to each element of matrix **K** subgraph of cognitive map corresponds.

Conclusions

Besides that "pair interaction" on the base of **K**–matrix we may introduce and calculate so-called "collective interaction". Here we will introduce two characteristics which we will call pressure – $\boldsymbol{\psi}$ and consequence – $\boldsymbol{\nu}$. It is necessary to note that the arrows on the relations in diagrams, fig. 3 do not mean relations in cognitive map but they mean the existence of corresponding matrix **K** component.

Components of vectors $\boldsymbol{\psi}$ and $\boldsymbol{\nu}$ are connected with **K**–matrix components in the following way

$$\psi_\beta = \sum_\alpha K_{\alpha\beta}, \qquad \nu_\alpha = \sum_\beta K_{\alpha\beta}.$$

Table 1 shows the ranked number of personalities obtained by the proposed method.

Table 1. **Ranked number of personalities by pressure (column on the left) and consequence (column on the right)**

Pressure		Consequence	
Merkel	122.9821	Jinping	99.22736
Hollande	124.1665	Putin	112.7377
Clinton	136.3812	Tusk	123.55
Rajoy	138.1214	Merkel	124.2253
Trump	145.4418	Obama	152.8589
Jinping	148.9195	Rajoy	153.6557
Tusk	149.5888	Clinton	161.0385
Putin	155.5832	Renzi	182.8078
Renzi	184.4093	Hollande	201.8023
Obama	220.7206	Trump	214.4107

Bibliography

1. Roberts F. Weighted digraph models for energy use and air pollution in transporations systems. – Rand, Santa Monica, 1974.
2. Kosko B. Fuzzy cognitive maps // International Journal of Man-Machine Studies, January 1986. – pp. 65-75
3. Snarskii A.A., Zorinets D.I., Lande D.V., Levchenko A.V. K-method of cognitive map analysis // E-preprint ArXiv:1605.08243

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Факультет прикладної математики
ННК "Інститут прикладного системного аналізу"
Російська асоціація штучного інтелекту
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