АНАЛИЗ ДАННЫХ

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MEASURE OF MUTUAL INFLUENCE AMONG MEMBERS OF A SOCIAL NETWORK

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Among the factors that determine an individual's learning of new skills within a common interest group (in the local society) are: the strength of the character of the individual to be influenced by other members of the group or other groups and the individual's motivation. The first one of these two factors is analyzed here. To measure the influence that some members of a group have over others, and the individual's level of conformism, we use a semantical-logical analysis with quantitative output in the messages of a forum which contains a discussion about problems and innovations. We use a cluster analysis technique to find similarities and discrepancies among the members of the forum and classify them in this manner, revealing which of them are leaders and have influence over the others.

Среди факторов, которые определяют обучаемость индивидуума новым навыкам в группе с общими интересами (в местном сообществе) являются: сила характера личности, находящейся под влиянием других членов группы или других групп и мотивация индивидуума. В этой статье мы рассматриваем первый из этих двух факторов. Чтобы измерить влияние, которое некоторые члены группы оказывают на других и уровень конформизма индивидуума, мы используем семантического логический анализ с количественным выходом в сообщениях форума, который содержит обсуждение проблемы и инновации. Мы используем методику кластерного анализа, чтобы выявить сходства и различия между членами форума и классифицировать их и таким образом выявить среди них лидеров, имеющих влияние на других членов группы.

KEYWORDS
Social science, cluster, organizational studies.

1. INTRODUCTION. NOTIONS AND ANTECEDENTS

1.1. Types of Social Networks and Their Missions

There are groups of people which have formal organization (political parties, businesses, educational institutions, etc.). There are also many whose members belong to them voluntarily for their own enjoyment and for the amount of time that they desire. Such groups are not organized with the level of formality necessary to have this name. But these groups are more or less stable and have influence over the people around them; they have an exchange of information that influences their conduct and vision of the “state of things.” These groups are called social networks. Previously there were only local (physical, material) social networks in each community. There were generally hierarchical social networks [Makagonov P, Liliana Eneida Sánchez Platas (2008-a)], separated by ages, and/or sex and social status. [Makagonov P, Celia Bertha Reyes Espinosa (2008-b)]. Now, there

are many virtual social networks (on the Internet) whose membership is not redistricted (distributed) by space but rather by zones of common interest.

Recently, a new way for people to interact with each other (over the Internet) appeared that is generally known as a social network. This is a form of communication in which users can exchange photos, messages, an application or a text file. Some consider(s) it to be a new paradigm of social organization [1] in which there is not only exchange of information, but also an analysis and reinforcement of common topics. In this way, social networks not only allow their members to know each other and to share information about their activities, but also organize groups, events and offer services.

Social networks enable their members to meet people whom it would be difficult for them to meet face- to-face. Each one can produce their own content, allowing them to have professional contacts which can help businesses (to spread knowledge) and form bonds or even working groups among its members. They allow their participants to create a feeling of self-fulfillment.

1.2. Measurements in Social Networks

As Javier Godoy says, “The problem is that we need to change the paradigms. When the Internet was a place of anonymous navigation where people came to consume content, what we were interested in measuring was the consumption of content, not who consumed it. Now, the Internet is social environments where the principal content we consumer are the users themselves, so what we are interested in measuring are the users.” [2]

In social networks there are different Key Perfomance Indicators (KPI) and some tools such as Google Analytics which allow us to gather information about the traffic on websites. Other tools such as Google Alerts or Social mention allow us to follow, via email, which appears on social networks about a topic, a business or a person. But these only let us know the general parameters of the network but not the influence that its members have over others.

There are also corporate social networks in which social network’s technology are applied within the scope of organizations to increase productivity [3]. It can help the business because it will obtain, first hand, the opinions of the users and potential clients about its products, which can be used in the creation of new products or services. On the other hand it helps the client to improve his self-fulfillment. And that in turn, gives better feedback to the business.

There are social technologies which are very close to social network’s technologies.

1.3. Social Technology

There are many definitions of social technologies, but mostly they either belong to the parcial sector of activity, or unclear, vague. Most suitable for our study the following definitions [6]: **Social technology** is a set of methods and techniques to deliver results in problems of interaction between people, or **social technology** is the communicative structure influences that change the social system or situation. Social technologies-solutions to social problems, to shape the living conditions and development of societies, social relations, social structures in order to ensure human needs, create conditions for the realization of his potential abilities and interests, taking into account that are sanctioned by society's value system and the interdependence between social progress and economic development.

There is also the notion of Humanitarian technology: Humanitarian technology-social technology based on practical use of knowledge about a person in order to create conditions for the free and all-round development of the individual.

It is considered educational one interesting example of social technology that can be found in the history of the introduction of the potato crop to France, it is an example of an astute plan to implement an idea [5].

Antoine Augustin Parmentier, a French military pharmacist and agronomist, introduced the potato to France. Parmentier got Luis XVI to allow the potato to be planted in the outskirts of Paris, in the plains of Les Sablons, known for their infertility. Later, he got them planted in the plains of Grenelle, what is now Champ de Mars. A skillful publicity stunt allowed the definitive introduction of the planting and consumption of potatoes to be accepted by even the most doubtful people.

The farm that the King gave to Parmentier to plant with potatoes was guarded by a heavy military presence during the day, which gave the impression that what was going on there had to do with a very valuable product. But the guard was deliberately let down at night, allowing people from the surrounding area a chance to sneak in and steal the precious product from the field at night, converting that into the best advertising for the new crop. At a reception given by King Luis XVI, his majesty presented Parmentier with a bouquet of potato flowers saying, “One day France will thank you for having found the bread for it's pour.”[5]

It is known that new technologies penetrate vital activities through the achievements of natural science for example: the laws of physics allow for the development of machines and tools that can substitute for human labor. At the same time methodologies from natural sciences can assist in the development of methodologies in social sciences, which in turn, develop knowledge about human beings, society, and social wellbeing. The knowledge about social customs and about the processes in which new ideas (innovations) and paradigm can be converted into popular ideas and find a place in popular opinion as economically and socially useful, without contradiction to traditional culture.

It is known, that new paradigm is made up of three components:

- New technologies developed by science in sufficient quantities.
- New resources (including human resources with new skills) or resources which are not new but respond to new demands of production of technological innovation.
- The population and specialists accepted the ideas and technologies of ершы new paradigm to follow and develop as guidelines.

For this third component, the creative group should draw up or accept from scientists, human (social) technologies to persuade citizens to accept the technological innovations. The human technologies do not reduce the training of the population. Its function is to reorganize the community, creating new social structures that can act to fulfill the new demands of the super-system and produce additional values.

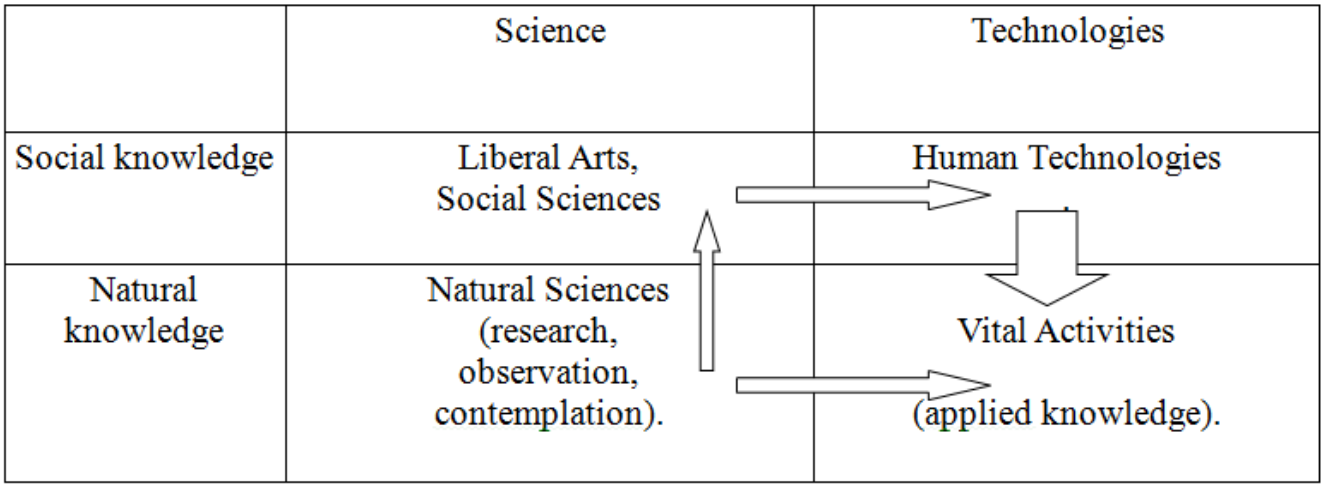

Figure 1. Influence of natural sciences in vital activities.

In Figure 1 we can see that technological innovations are developed from natural sciences. It's methods help to develop social sciences and humanities. Social sciences create human technologies when the demand for them is arising for implementation of a new technical paradigm in the vital activities.

1.4. System of equations of mutual influence in social networks or a simple model of human behavior in the enterprise

Let us consider a model of human behavior in the working group with a stable external environment (without taking into account the influence of the environment), as proposed by Krasnoschekov P.S. y Petrov A.A. (2000).

We call as the State «A» the situation where a person accepts the idea of the system (enterprise): his/her behavior is in concordance with discipline, (s)he shares the goals of the work, (s)he is interested in the outcome, is involved in the process improvement, product development and support of certain innovations or paradigms, etc. and (s)he likes to be a member of the working group.

The individual makes the decision (to accept or to reject state (status) A), in two stages: before and after an exchange of opinions with other people of enterprise, or we could say: individually or under the influence of colleagues

Let us call:

a(j) – a priori probability to accept the State A,
P(j) – a posteriori probability to accept State A,
μ_j – probability of an independent behavior:
μ_j =1 absolute individualist,
μ_j =0 absolute conformist,
$P^{ind}(j)$- a posteriori probability for an absolutely independent individual,
$P^{conf}(j)$- a posteriori probability for an absolutely dependent individual (conformist).
Evidently $P^{ind}(j)=a(j)$

To calculate $P^{conf}(j)$ let λ_{ij} be the probability that an individual (person) “j” behave the same (manner) as the individual “i” because individual “i” exerts influence over individual “j”.

Then the complete probability for accept the State A for the absolutely dependent individual “j”, is determined by the following formula:

$$P^{conf}(j) = \sum_{i=1}^{N} P_i \bullet \lambda_{ij} \qquad (1)$$

i =1

where N= the number of members

$$\sum_{i=1}^{N} \lambda_{ij} = 1 \qquad (2)$$

$$\lambda_{ij} > 0,\ i \neq j, \qquad (3)$$

$$\lambda_{jj} = 0$$

For the random individual in concordance with the complete probability formula we have:

$$P(j) = \mu_j\ P^{ind}(j) + (1-\mu_j)\ P^{conf}(j) \qquad (4)$$

$j = 1, 2.....N$

Criticism of the results. The model's authors analyzed the partial cases which are important, but have very simple schemes of interchange of opinion where the coefficients λ_{ij} and μ_j are assigned not more than two different values. For example:

$$\lambda_{ij} = \frac{1}{N-1} \quad j \neq i \quad \lambda_{jj} = 0 \tag{5}$$

Equal values of lambda mean that the individuals in the interaction process do not have personal preferences. Then $\mu_1 = 1$ (which means that individual number one is the leader of the group) and $\mu i = 0.5$ for $i \neq 1$ (equality of other members of the group). This simplification can be explained by using the Bayes hypothesis since an explorer does not have information about the character of the person at this time. Other cases analyzed by Krasnoschekov, are also simplified, because the authors (Krasnoschekov et al.) did not give any method to calculate λ_{ij} or μ_j. This problem is still open.

1.4. Case Study of OTVETY

The site "otvety.ru" is a very popular social network (semi-network) in Russia. It has characteristics that allow us to see the level of influence that some users have over other users through questions, answers and comments. The level of influence can be evaluated by comparing the content of dialogues; one person destroys the argument of an opponent with their votes in favor or against the messages and a system of votes for questions and answers. Furthermore, it has a system of ranking of participants based on their level of activity and number of votes for them.

This system of ranking is on one hand a motivation to increase their activity and on the other hand the high rank to the author of a message influences morally the other users – massage receiver. The system has a level of defense against bad words, swearing, and lie, especially with incorrect links or advertising.

These characteristics can be found in other forums but in OTVETY they are more complete. Some of these characteristics can be used for an analysis of the mutual influence in discussions.

2. CHARACTERISTICS OF THE FORUM "SOCIAL AND CULTURAL ASPECTS OF THE MIXTECA" FOR THE EXPERIMENT

For the analysis of mutual influence of visitants of platforms for debate in the internet we used (created by us) forum "Social and Cultural Aspects of the Mixteca (ASCM in its Spanish initials). Forum members can make comments and propose solutions to the topics of discussion. Furthermore they can express their consent or disagreement with a comment made by other members of the forum. In the forum, topics are discussed concerning problems in the city and possible directions that would be beneficial to the city or ways for the city to obtain more resources or income. Problems relating to city traffic and transportation and ecology are also discussed.

This article we only use the data collected in the topic of transportation for our case study.

From the members of the forum we picked out one group of members who proposed different alternatives to the transportation problem. This group was divided into three: invited experts who we call "Teachers", a second group of independent active experts "uncertain" who accept (with criticism) but… didn't reject a priori everything, these usually proposed by the Teachers. And a third group made up of independent individual experts "independent Opinion" with their own (specific) opinions.

With their messages, we created a matrix which allows us to calculate μ and λ in relation to each one of the other members of the forum (passive experts). This matrix has a structure that logically follows from the algorithm of the calculation of μ and λ.

3. ANALYSIS AND CALCULATION OF THE COEFICIENT OF THE CONFORMITY μ AND THE COEFFICIENT OF MUTUAL INFLUENCE λ

We return to the system of equations (4) to create an algorithm to calculate the coefficients μ and λ from the material of the forum:

$$P(j) = \mu_j \, P^{ind}(j) + (1-\mu_j)\, P^{conf}(j)$$
$$j = 1, 2.....N$$

P^{ind} is the probability to accept state A a priori, before the exchange of individual's opinion with other members of forum. In the case of μ=1 the second member of expression in right part of formula (4) is eliminated and this makes sense because it means that the person is not influenced by the arguments of other people. For this probability there is an index ^{ind}, which means the probability for individualist. And in this case the posteriori probability is equal to P^{ind}.
On the other hand if μ=0 then the final probability is formed only from the second member of formula 4. This means that the person does not follow in their previous state and is totally influenced by other people. For this probability the second member is called conformist probability and is denoted with the index ^{conf}. That is to say not dependent on his priori state.
In the general case μ has a value between 0 and 1. But common people are neither conformist nor individualist, this is the most common situation, because experts also listen to other people and can change their opinion at least somewhat.

In the forum, which is a soft educational tool, we have a group of forum owners or the experts (carrier of state A) or business leaders who are not uncertain (unsure in their opinion) nor influenced by the arguments of other members of the forum. In this case the owners of the forum should have μ=1. They can only stimulate other members with phrases such as "your opinion is important, interesting, etc." only to motivate these people and not because they are in agreement with their opinion. This possibility needs to be considered in the evaluation of State A of the members of the forum.

3.1. Calculation of μ

To obtain μ in the general case, we use the following algorithm:

We assign N_{exp} as the amount of active experts and "i" as the expert's number considered to be $1 \le i \le N_{exp}$; $M_{i,k}$ as the message number k of expert number i . Then n_i is the amount of messages from expert i($1 \le k \le n_i$).

For each message we have the logical characteristic (A_{ik}), 1 or -1, which is equal "1" if the message is in agreement with State A and -1 when it is counter to State A. If the message M_{ik} cannot be classified, we eliminate it as a noise which has not be considering. This is possible to do by assigning a weight of zero in the rows of logical characteristics in forming table.

We can consider the series $\{A_{11}\ldots A_{ik}\ldots A_{Nexp,ni}\}$ as a vector with the components 1, -1 and 0. This vector has groups of components $\{A_{i1}\ldots A_{ik}\ldots A_{i,\,ni}\}$ which belong to only one active expert with number "i". We have N_{exp} groups of components where $1 \le i \le N_{exp}$. We also have the group of "passive" experts who did not send messages, but evaluated the Nexp groups of messages. We present this evaluation as a row vector with the number j - V_j ($M_{j,i,k}$.). The number of rows is m ($1 \le j \le m$), where *m* is the amount of passive experts (the second group). These components $M_{j,k}$ have the values 1, -1 and 0 which correspond with choose: accept the message as the state A (1), do not accept

as the state A (-1) and refuse to evaluate (0). So we have a vector of evaluations of passive expert V_j for each of the components in series $\{A_{ik}.\}$.

Now we have the possibility to count the number of messages evaluated by the j-th expert*:* $S_M(j)= S_N-S_0$, where S_N is the sum of the total messages.

$$S_N=\sum_{i=1}^{Nexp}\sum_{k=1}^{ni} abs(Aik)\,.$$

S_0=the sum of all the zeros in row *j*.

In case of discrepancies between the values of A_{ik} in the corresponding column that belongs to the expert number i and the evaluation of the expert j (V_j), we have discrepancies of type (1,-1) or (-1, 1) and each one of these discrepancies are added to sum S_{contr}. These are amounts of contradictories between opinions of active expert ‘‘i” and passive j-th expert (S_{contr}).

We perform this operation for each of the messages and for all the passive experts. Then for each passive expert j we have a measure of independence of opinion μ which we use for formula 4.

$$\mu_j= S_{contr}(j)/S_M$$

We can do this only if the passive experts are sincere and responsible for analysis what they are produced, and not placed randomly their results of estimates. People don't change their opinion too often, so μ reflects the nature of the individual and this feature can be used with measurements in other discussions with them.

Therefore, to calculate the μ in Excel, we use the following algorithm:

- Find words in all messages "pro state A" or "against state A" ($\bar{A}$).
- In the row below the row of messages we put a logical feature in form 1 for condition A and “-1”for condition $\bar{A}$.
- We ask the participants (the same as appraisers, assessors, evaluators) to express their opinion and assessment in the form of a "1" in the event of consent, "0", if their opinion is not formed, and -1 if they do not agree with the idea of the state A.
- If the appraiser fully supports all the statements of active experts (evaluation coincides) then the appraiser is a complete a conformist and its coefficient of μ should equate to zero.
- If the assessor does not agree with all the statements, then it's coefficient of μ is equal to 1.
- If we compare the K pairs of estimations and there are differences among them, then μ is equal to the sum of all differences divided by K (quantity of pairs).

What changes should be made in the algorithm, if the evaluator himself expressed their opinions on each issue, which had not yet been discussed with the experts?

In this case, we can predict the behavior of the evaluator for different statements of an expert. Then we can capture only the deviations from these predictions, and they will determine the impact of active experts in the opinion of the evaluator.

3.2. Calculation of λ

To calculate the parameter λ we divide table of assessments at the n_i groups of columns. In each group (the number i) contains n_{ki} columns. We exclude the columns with a state $A_{ki}=0$ (or that contain value A_{ki} in the row of encoding of a logical expression of active expert which is equal 0).

Then we form a vector of Boolean values to each j-th row by comparing passive expert assessment to sayings of active expert, adding next component of the vector with the same logical units (1 or -1 in rows A_{ki} and j).

We call (denote) by λ^*_j the sum of positive component of formed vector, divided by the total number of nonzero values of n_{ki} columns from the specified group.

(In this situation we measure only a positive impact and leave a negative impact for future consideration.)

Now, in accordance with demands to the coefficients of the system (4), the coefficients λ* should be normalized dividing by the sum of all λ* in the j -th row.

We fulfilled the computing experiment in which we gathered all the questions and answers of the forum, and we have calculated all coefficients μ and λ. In the future to analyze more numerous data we will use statistical methods.

3.3. Calculation of the initial probabilities and the coefficients

The semantic analysis of the messages of the user k, allows us to determine the amount of them in which user k:

- Accepts State A given the arguments in favor of an idea that is discussed and developed. (State MA)
- Does not accept the idea or State A (negates or rejects) and has doubts about it and arguments against it. (State MĀ)
- Expresses ambiguity or confusion that does not permit an interpretation of his sentence as for or against an idea (State M0).

The last situation (case) should be excluded from the following analysis and the first two cases should be taken into account for calculating the probability of case that user k accepts state A.
P(A)=amount of cases A(MA) /(sum of amounts of cases A and Ā)
P(A)=sum of MA/(sum of MA + sum of MĀ)

Also P(A) could be assigned value "1" if the user, in his latest message, accepts the idea A), when argues with other members of the forum. Even if in the process of the discussion this participant with number «k" could say something against idea A, but finally accepts the idea then his decision to accept it could still influence other participants in the discussion, for example the passive participants.

This indecision of participant k should be taken in account when calculating μ.

μ= (the amount of sentences pro A)/
(the sum of the common amount of all his sentences type MA and MĀ).

Therefore through P(A) and μ we can measure the influence of user k over other users in the discussion and vice versa for k-th user.

Sometimes the State A cannot be expressed in a single affirmation but it can be formulated as a group of ideas, which express a paradigm. We can have the total results of the exchanges of opinions for the different topics expressed in State A through simple sums. In this case, formula 4 could be more complete.

4. RESULTS OF THE APLICATION OF THE DEVELOPED METHOD IN THE EVALUATION OF PARTICIPANTS IN THE FORUM ASCM

For the calculation of μ and λ for integrated experts "teacher" and for experts with independed opinions (see part 2 of present article) we accept that $\mu_{teacher}$ and $\mu_{independed\_Opinion}$ have values of 1.

For $\mu_{uncertain}$ we calculated for the method provided in 3.1 and we received a value of 0.86

The application of the method to calculate μ and λ gives us the matrix presented in table 1. In which we have grouped the experts (active and passive). Each of these groups corresponds to their own row of the table. These were obtained by clustering from the matrix where we have objects (Experts) and as attributes (coefficients μ and λ for each expert). The Visual Heuristic Cluster Analysis (VHCA) method was used. [Makagonov, P. and Sboychakov, K (1998).] In the result (table 1) we have 6 groups of participants from the evaluation of the messages in the forum.

Table 1.

Group\Attribute	μ	$\lambda_{Teacher, Gr(i)}$	$\lambda_{uncertain, Gr(i)}$	$\lambda_{independed\_Opinion, Gr(i)}$	∑λ
Gr.1	0,779	0,417	0,000	0,583	1
Gr.2	0,378	0,380	0,285	0,336	1
Gr.3	0,304	0,387	0,390	0,223	1
Gr.4	0,162	0,387	0,374	0,239	1
Gr.5	0,515	0,303	0,422	0,275	1
Gr.6	0,647	1,000	0,000	0,000	1

Group 1: 1 active participant (doubtful) and 1 passive expert
Group 2: 1 anonymous participant, 6 passive experts and 1 member of the city council
Group 3: 7 passive experts and 2 members of the city council
Group 4: 3 passive experts
Group 5: 2 passive experts and 1 member of the city council
Group 6: 3 members of the city council

Members of group 1, group 6, and (more or less) group 5 are the most independent in their opinions. Meanwhile members from group 4 and to lesser extent groups 2 and 3 are more influenced by other's opinions.

The sum of influence of the active experts is equal to 2.873 (Teacher), 1.471 (doubtful expert) and 1.657 (Independent Expert). In this case we obtain the influence of the group of "teachers" which function as a team (with μ=1 and λ=0) have nearly the same effectiveness as the sum of the other participants.

5. CONCLUSIONS

The method that was developed here can be applied to research any social network that meets the following conditions:

- The network has an exchange of ideas among the participants and evaluation of those opinions by different members of discussion;
- The network has set of topics for discussion.

The proposed method allows measuring a level of effectiveness of the educational mission of the forums through the comparison of influence of the teaching team members to other (independent) participants of the educational forum.

It was shown that the proposed method allows us to know who in a given group of people are leaders and who are followers through the calculation of μ and λ. With the results of the measurement of μ and λ, we can correct the soft educational strategy through the forum, which we consider to be an educational tool of humanitarian technologies.

REFERENCES

1. Makagonov P, Liliana Eneida Sánchez Platas (2008-a). Some Toolkits Useful for Urban and Regional Problems Rapid-Analysis. International Workshop on Social Networks and the Application Tools. September 19-21, 2008. University of Central Europe and SoNet Research Center Skalica, Slovakia (European Union).
2. Makagonov P., Celia Bertha Reyes Espinosa (2008-b). Developing Website of Regional Culture Center and Social Networks. International Workshop on Social Networks and the Application Tools. September 19-21, 2008. University of Central Europe and SoNet Research Center Skalica, Slovakia (European Union).

3. Краснощеков П.С., Петров А.А. Принципы построения моделей. – Серия «Математическое моделирование». Изд-во ФАЗИСМ. 2000.
4. Makagonov P. Sánchez Platas L. (2011) Modernización de la ciudad: Desarrollo urbano con enfoque sistémico y modelos matemáticos (en edición).
5. Makagonov, P. and Sboychakov, K (1998). Man-machine methods for solution of weakly formalized problems in humanitarian and natural fields of knowledge (visual heuristic cluster analysis). – In: Proceedings of International Computer Symposium CIC'98, pp.346-358. IPN, México.

Consulting sites

1. http://www.fundacionccb.org/index.php?option=com_content&view=article&id=63&Itemid=63 14.06.2011.
2. http://javiergodoy.com/metricas-para-medir-las-redes-sociales/ 17.11.2011
3. http://josepvila.wordpress.com/2011/05/28/social-business-media-o-redes-sociales-corporativas/ 19.08.2011.
4. http://es.wikipedia.org/wiki/Tecnolog%C3%ADa_social. 19.08.2011
5. http://www.pasqualinonet.com.ar/la_papa.htm 17.08.2011
6. www.glossary.ru/cgi-bin/gl_sch2.cgi?RRu.ogr;t:l!yl)turujoo

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