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Synthesis of text models with information streams

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Abstract

The methods of synthesis of text models with information streams are researched. In the process of functioning of system of text models, which model systems of social objects the following are implemented: analysis of models of monitoring of information means, used by social objects, control of adequacy of models to objects and objects management. The synthesis of text models with information streams is implemented basing on use of semantic parameters. In process of text forms synthesis of models description and information streams appears necessity to output new text fragments, reflecting synthesis result. Such output processes are procedures based on use of logical schemas and grammar rules.

Introduction

Process of functioning of text models system (STM_i) is not only in implementation of actions, connected to management of social objects (SO_i), being modeled with help of text models (TM_i). This process supposes implementation of following functional possibilities: analysis of current state of TM_i, monitoring of STM_i, management SO_i basing on use of information streams (IP_i) and TM_i, control of adequacy of current state TM_i to corresponding objects SO_i. Monitoring of STM_i is necessary to determine moments of activation of actions, connected to detection of factors, influencing current state of TM_i, which are not caused by managing actions initiated against TM_i. Such factors include: procedures, connected with identifying models TM_i with corresponding objects SO_i; procedures connected to analysis of TM_i; procedures connected t to modification of TM_i, which is not caused by managing actions IP_i etc. Because imagination about management of TM_i is quite wide, let us create definition of such imagination.

Definition 1. As management action on TM_i we mean actions which are determined by following conditions: managing action to TM_i for change of corresponding state of SO_i; managing action is implemented by external relative to TM_i, factors by forming appropriate IP_i; any managing action is caused by target, description of which is included into IP_i.

One of main tasks which is solved with the help of monitoring system is a task of ensuring adequacy between TM_i and SO_i. Solving that task is based on following methods: forming short and long term reverse connections between system of social objects (SSO_i) and STM_i; stand-alone analysis of TM_i; extending interpretations, which are related to SO_i. Reverse connections between SO_i and TM_i are implemented basing on following components: obligatory data about SO_i, which are formed from data of various structures, orientated on work with SSO_i; data from electronic mass media; data from other sources, which appear randomly. Monitoring system solves following tasks: analysis of data about SO_i and forming of image of SO_i and its current state SO_i relative to TM_i; forming process of monitoring of system STM_i and pseudo monitoring SSO_i, which is in definition of process parameters, for example, value of period of one cycle of monitoring of mass media, depth of monitoring, forming additional processes if there is a necessity in their initiation; implementation of processes of modification of TM_i, if last appeared to be necessary because of the results of adequacy check between SO_i and TM_i.

Monitoring system (SM) makes during its function only analysis of data about SO_i. Basing on that analysis a new model TM_i is formed, if it was detected that new SO_i object appeared, or modification of TM_i is conducted, if changes of parameters in corresponding SO_i were detected. Feedback which supplies data to STM_i about SO_i, which is modeled in STM_i, is generally passive because capacity of activation of data transfer from SO_i to STM_i is quite limited. Due to existence of electronic communication means such activation can be implemented but not in determined form. This means that actions implemented by STM_i lead to corresponding reaction from SO_i through some period of time. STM_i system from one side is a system of images SO_i in form of TM_i, and from other side STM_i is a system helping to make modeling of management actions on separate SO_i objects, or on whole system SSO_i. Reliability of results of such modeling is determined by level of distortion or level of inadequacy between SO_i and TM_i.

Components used in process of synthesis and synthesis of text models with information streams

As far as system STM_i describes SSO_i, then besides methods which describe separate SO_i as TM_i, necessary methods which describe relations between TM_i and TM_j in STM_i, which correlate with relations between SO_i and SO_j in SSO_i. Such components should not necessarily be objects separated from TM_i in STM_i. Connections between TM_i and TM_j can be implemented basing on level of similarity between separate TM_i and TM_j, or, basing on similarity of SO_i and SO_j, which is obvious for SSO_i. Such relation is implemented basing on following: level of structural similarity between separate TM_i; level of functional dependence if TM_i and relative SO_i are implementing predefined processes in SSO_i; level of dynamic similarity which can be in functional similarity of semantic; level of activation or other parametric similarity [1, 2].

Let us review method of description of structural connections which are implemented as separate text elements STM_i, which will be marked TZ_i [3, 4]. Keeping in mind imagination about text methods of description let us accept that TZ_i is some text form which dislike model TM_i identify not object SO_i, but describes conditions of activation of connection between TM_i and TM_j. Physical implementation of such connection is in transmission of data from one model TM_i to other TM_j. Function of component TZ_i is implemented by following steps: TM_i and TM_j are determined, which can implement relation in form of exchange of information; basing on analysis of TM_i data for information package IP_i^V are selected in TM_i; corresponding IP_i^V is transmitted to TM_j as information extension in framework of TM_j is made corresponding modification of TM_j.

To analyze more deep processes of functioning, implemented by TZ_i which can be written down as: $TM^*_j = TZ_i(TM_i, TM_j)$, it is necessary to stop on structure of TM_i in projection on subject area, which is described by STM_i and separately by TM_i. In that case structure of TM_i will be characterized by following aspects: own structure aspects; structure aspects connected to subject area; general aspects of structure TM_i.

Existance of structure in TM_i allows to form some rules of conduction of synthesis of TM_i and IP_i, when IP_i extends TM_i in form of usual concatenation $J(TM_i)$. Obviously IP_i must be isomorphic to TM_i not only at the level of language, used to describe TM_i, but also at level of structure and rules of its forming [5, 6]. In that case it can talk about following rules of analysis which are used on separate step of functioning of STM_i, which is defined or activated by management action of IP_i.

PR1: Determination of difference between separate fragments of interacting text descriptions can be formally described by following correlation:

$$\begin{aligned}&\left[S_i^t\left(j\left(tm_i\right)\right)=S_i^t\left(j\left(ip_i\right)\right)\right]\rightarrow\\&\left[j\left(tm_i\right)-j\left(ip_i\right)=R_i^t\left(tm_i,ip_i\right)\right]\end{aligned}\qquad(1)$$

where: $S_i^t(j(tm_i))$ and $S_i^t(j(ip_i))$ – structural characteristics of fragment tm_i and ip_i, correspondingly, $R_i^t(tm_i, ip_i)$ – level of structural correspondence of two interacting objects in STM_i, which are TM_i and IP_i.

PR2: Synthesis of two fragments at level of their phrases is described by following correlation:

$$\begin{aligned}&\left\{\left[R_i^t\left(tm_i,ip_i\right)\le\alpha\left(TM_i\right)\right]\rightarrow\left[tm_i\left(\varphi_{i1}^m,\ldots\varphi_{im}^m\right)\&\right.\right.\\&\left.\left.\&\left(ip_i\left(\varphi_{i1}^p,\ldots,\varphi_{ik}^p\right)=tm_i^*\left(\varphi_{i1}^{m*},\ldots\varphi_{im}^{m*}\right)\right)\right]\right\}\vee\\&\left\{\left[R\left(tm_i,ip_i\right)>\alpha\left(TM_i\right)\right]\rightarrow\left[tm_i^*=\left(tm_i*ip_i\right)\right]\right\}\end{aligned}\qquad(2)$$

where $\alpha(TM_i)$ – threshold of allowed semantic difference between fragments tm_i and ip_i, φ_{ij}^m – phrase, which comes out of tm_i, φ_{ij}^p – phrase which comes out of ip_i, φ_{ij}^{m*} – phrase which comes out of tm_i^*, tm_i^* – fragment which is synthesized at level of phrases from tm_i and ip_i, * – sign of concatenation of two text fragments tm_i and ip_i at level of phrases.

RP3: Rule of reduction of semantically exceeding phrases from text fragment tm_i^*, which is formally written down as following correlation:

$$\exists\left[\left(\varphi_i^m,\varphi_i^p\right)\in tm_i^*\right]\left[S^e\left(\varphi_{ij}^m\right)-S^e\left(\varphi_{ij}^p\right)\le\alpha\left(tm_i\right)\right]\to$$
$$\to\left[\left(\frac{tm_i^*}{\varphi_i^p}\right)\to\left(\varphi_i^p\notin tm_i^*\right)\right] \quad (3)$$

where $S^e(\varphi_{ij})$ – value of semantic significance of phrase φ_{ij}, $\alpha(tm_i)$ – boundary allowed value with which semantic difference between two phrases is allowed or not allowed.

In process of synthesis TM_i from IP_i can appear necessity of output of new phrase. Then with the aim of forming phrase $\varphi^*_i(TM_i)$, which semantically will be equivalent to phrases $\varphi_i(tm_i)$ and $\varphi_i(ip_i)$.

Definition 2. Semantically equivalent phrases φ_i and φ_j are phrases, for which semantic conformity is greater then threshold value $\Delta\sigma^u$.

In case of use of imagination about semantic conformity, it is necessary to take into account following peculiarity of text representation of information which is in fact that semantic content is influenced not only by level of average semantic significance of words in two different fragments, but also a place of some words in corresponding phrases. Some meaning of semantic controversy is accepted as not allowed meaning of its value between words which are part of the same phrase in correlation:

$$\sigma^S\left(\varphi_i,\varphi_j\right)=\left|\sigma^S\left(\varphi_i\right)-\sigma^S\left(\varphi_j\right)\right| \quad (4)$$

Level of semantic conformity can be divided into two types, one of which is a general conformity defined basing on difference $\sigma^S(\varphi_i, \varphi_j)$ relatively to preset threshold of allowed significance of value $\sigma^S(\varphi_i, \varphi_j)$. It does not depend on method of placement of words in φ_i and φ_j, as semantic conformity significantly exceeds value of controversy which is set by word replacement. In framework of $\sigma^u(\varphi_i, \varphi_j)$ appears necessity to take into account influence of words order in φ_i and φ_j, to define level of conformity. Let us review method of definition of $\Delta\sigma^u$, which divides $\sigma^u(\varphi_i, \varphi_j)$ into σ^u and σ^e. Such division is level of conformity of curve which interpolates change of value of meaning $\sigma^S(\varphi_i)$ in framework of one phrase. In that case corresponding line is built on plane in which Ox axis reflects words in order of their placement in phrase φ_i. Each point on Ox which is equal x_i reflects $x_i \in \varphi_i$, and $\Delta x = x_{i+1} - x_i$ means following word x_i. On axis Oy is set value $\sigma^S(x_i, x_{i+1})$, which is integer, as $\sigma^S(x_i, x_{i+1}) = \left|\sigma^Z(x_{i+1}) - \sigma^Z(x_i)\right|$ – where corresponding values can be integers if it is accepted to define $\sigma^Z(x_i)$ by number of words, used to describe interpretation x_i in semantic vocabulary S_C. In case of other approaches to definition of value of $\sigma^Z(x_i)$, for example approach basing on definition of frequency of use of word x_i in texts describing TM_i and IP_i, which interact with them during definite period of time then value $\sigma^Z(x_i)$ can be fractional or rational. Semantic controversy between phrases φ_i and φ_j is defined according to following correlation:

$$\sigma^S\left(\varphi_i,\varphi_j\right)=\left|\frac{\sum_{i=1}^m\sigma^S\left(\varphi_j\right)}{m}-\frac{\sum_{i=1}^n\sigma^S\left(\varphi_i\right)}{n}\right| \quad (5)$$

During definition of semantic conformity $\sigma^u(\varphi_i, \varphi_j)$ it is necessary to take into account semantic differences between φ_i and φ_j, which are conditioned by replacing words for extension or modification of semantics during building of phrases in which semantic controversy is prohibited. In that case, $\sigma^u(\varphi_i, \varphi_j)$ beside general value of $\sigma^S(\varphi_i, \varphi_j)$, which is medium value, must account the above change of semantics which will be called objective change of semantic parameters value. Each segment presenting relation $\sigma^S(x_i, x_{i+1})$ in phrase φ_i, must have same angle as connection described by $\sigma^S(x_j, x_{j+1})$ for phrase φ_j. Formula for definition $\sigma^u(\varphi_i, \varphi_j)$ will be:

$$\sigma^u\left(\varphi_i,\varphi_j\right)=\sigma^S\left(\varphi_i,\varphi_j\right)+\left|\sum_{i=1}^{m-1}\alpha_i-\sum_{j=1}^{n-1}\alpha_j\right| \quad (6)$$

Due to above formula it gets possible basing on a priory data to determine value of possible threshold $\delta\sigma^u$, which divides σ^u from σ^e. Due to use of imagination on interpolation curves, value of equivalence of two phrases can be determined not only as summary or middle deviation of values α_i with $\Gamma_i(\varphi_i)$ and $\Gamma_j(\varphi_j)$, but also as local parameters, localization of which is implemented basing on binding coefficients α_i and α_j to order number of words in phrases φ_i, φ_j. In that case it can determine maximum adequate value σ^u. Formula to determine such value σ_Δ^u will be:

$$\sigma_\Delta^u=\sigma^S\left(\varphi_i,\varphi_j\right)+\sum_{i=1,j=1}^{m,n}\left[\alpha_i\left(x_{i+1},x_i\right)-\alpha_j\left(x_{j+1},x_j\right)\right] \quad (7)$$

In that case it can get dependency $\sigma_\Delta^u = f(x_i, x_j)$, where x_i, x_j are coordinates in φ_i, φ_j.

Method of output of phrases in text models

Changes taking place in SO_i must also take place in TM_i. Speaking about functioning of TM_i, it means functioning of $\{TM_i \,\&\, SO_i\}$ system. To activate processes of modification or any other changes in TM_i, excluding those changes which take place under influence of IP_i on SO_i and TM_i, it can define following factors: changes in objects SO_i; optimization processes in TM_i; results of current analysis of system $\{TM_i \& SO_i\}$. Peculiarity of objects SO_i is in fact that they do not have direct influence on TM_i, as there is no direct links between SO_i and TM_i. Such relations are information only. So, reaction of TM_i on changes in SO_i can be quite complex and can be characterized by following peculiarities: reaction of TM_i on changes in SO_i can have different value of delay, as it is accepted that SO_i and TM_i are informational standalone; such reaction can have different level of adequacy relatively to real changes in SO_i; reaction of TM_i on changes in SO_i can have different level of distortion of one or other changes or states to which comes SO_i as a result of initiation of internal modifications. Specific characteristics of TM_i and STM_i, in general is a level of informational masking of TM_i relatively to SO_i, level of formality of TM_i relatively to SO_i, or level of completeness of reflection of SO_i.

Basing on peculiarities of systems like SSO_i fact of existence or use of systems STM_i must be informational masked [7, 8]. Informational masking in that case means following. Fact of possibility of creation and use of systems STM_i can be known in general. But various methods of implementation of specific STM_i must not be available or known to SSO_i. This parameter is a key one due to following: if it is not used then there could be possibility of direct control of objects SO_i, and directly own whole information on SO_i, and absence of that parameter causes necessity of full control of the whole system SSO_i, that from the point of view of natural conditions of function of SSO_i is a negative factor. Formalization of description of TM_i is fact that elements which are supposed to be formally described are joined into appropriate classes and then the whole class of objects is marked in some formal way, mostly by various symbols [9, 10].

One of basic functions of system STM_i is detection of various critical situations in SO_i and detection of processes which lead SO_i to such situations. After detection of critical situations, system STM_i, at least must activate processes of informing external members of modeling about that. Besides, as functions which can be implemented in STM_i there can be function of counteraction critical situations. As modeling means TM_i do not have direct influence on SO_i then appropriate functions are in forming IP_i, which contain information capable to initiate counteraction of critical situations escalation in SO_i. Such IP_i can be transmitted to external means orientated on execution of such influence directly guiding formed stream to corresponding SO_i to initiate elimination of critical situations in SO_i. Obviously STM_i forms streams that are related to SO_i in general but not streams which could be guided to separate components of SO_i, as analysis in TM_i is made only regarding SO_i. In mentioned cases need of use of methods of output of new phrases φ_i appears, as activation of process of functioning SO_i and respectively, TM_i can require new text descriptions. Let us review some approaches to build output of phrase φ_i^* from some totality of phrases $\{\varphi_{i1},...,\varphi_{in}\}$. In most cases such totality forms one sentence ψ_i or one paragraph π_i.

Procedure of output of text fragments like in most of cases, especially logical, represents itself as sequence of elementary transformations [11, 12]. Despite logical schemas, during output of phrases in text environments there are following peculiarities.

1. On each output step before its realization following types of analysis are made: conducted analysis of semantic parameters of two elements between which transition is implemented, which is interpreted as one step, let us formally describe it as:

$$[\varphi_{i1},..\varphi_{in}] \rightarrow [\varphi_{i1},...,\varphi_{ij}^*,...,\varphi_{in}] \quad (8)$$

where φ_{ij} – random phrase of sending output step, φ_{ij}^* – phrase, which arise in environment as a result of one output step; analysis of grammar correlations between words in new construction of phrase φ_{ij}^* is made, which is formally written down as:

$$\Gamma_i(x_{i1},...,x_{ik}) \Rightarrow \gamma_{ij}(x_{i1}^*,...,x_{ik}^*) \quad (9)$$

where Γ_i – grammar rules, used in natural language of text models, γ_{ij} – separate grammar rule $\gamma_{ij} \in \Gamma_i$, which is schema of use of separate types of words during constructions of phrase φ_{ij}^*; check of built phrase φ_{ij}^* is made if it comply to requirements of normalization, which formally can be written down as follows: $\lambda(\varphi_{ij}^*) \rightarrow N(\varphi_{ij}^*)$, where $\lambda \in \Lambda$ – system of rules of normalization of structure of phrase or paragraph, $N(\varphi_{ij}^*)$ – normalized form of description of phrase φ_{ij}^*.

2. Implementation of output step is in use of one of operations, to which belong: elimination of words from phrase; replacement of one or couple of words with another word or group of words; adding word to phrase which is supposed to be transformed during output; changing places of words in phrase.

3. After execution of section 2 all checks described in section 1 are implemented against new phase, and they are conducted at all levels of trans-

formed elements hierarchy, for example: (level φ_{ij}^*) $\to$ (level ψ_{ik}^*), where ψ_{ik}^* – sentence, containing created phrase.

4. Sections 1, 2, 3 are repeated until output process is complete.

Basing on analysis conducted according to sections 1, 2, 3 are formed some conditions which are considered during implementation of step of evaluation of such analysis on definite criteria. In most simple case for decision making such evaluations could be fixed binary bounds for all values of parameters or characteristics being analyzed. In cases of analysis of text forms of information presentation, making decision basing on such results is sufficient.

Let us review analysis of semantic parameters of text fragments at level of phrases φ_i. First let us write down general analysis procedure $\{\varphi_i \,\&\, \varphi_j\}$:

$$\begin{aligned}&(\varphi_i \,\&\, \varphi_j) \to \left[\sigma^S(\varphi_i, \varphi_j) \le \delta\sigma^S(\varphi_i * \varphi_j)\right] \vee \\ &\vee \left[\sigma^S(\varphi_i, \varphi_j) < \delta\sigma^S(\varphi_i * \varphi_j)\right] \to \exists(\varphi_i * \varphi_j) \to \\ &\to (\varphi_i \,\&\, \varphi_{j+1})\end{aligned} \quad (9)$$

Semantic analysis mostly begins from definition of value of semantic controversy $\sigma^S(\varphi_i, \varphi_j)$. If it is less then $\delta\sigma^S(\varphi_i)$, then takes place transition to next steps of analysis. If $\sigma^S(\varphi_i, \varphi_j)$ is greater then $\delta\sigma^S(\varphi_i)$, then analysis is conducted $\sigma^S(\psi_i, \psi_j)$, which includes appropriate phrases. If $\sigma^S(\psi_i, \psi_j)$ is less then threshold $\delta\sigma^S(\psi_i)$, then next phrase φ_{j+1} is selected instead of φ_j. In that case we accept that φ_i is element from TM_i, and φ_j is element from ψ_j, where ψ_j is sentence from IP_i of some source IP_i (DIP_i), or element IP_i from feedback channel, which in difference from DIP_i we will call KIP_i. Corresponding transition from φ_j to ψ_j is continued until level of paragraph π_j, which can be written down as correlation: $\varphi_j \to \psi_j \to \pi_j$, if it would appear that takes place:

$$\begin{aligned}&\left[\sigma^S(\pi_i, \pi_j) > \delta\sigma^S(\pi)\right] \to \\ &\{[KIP_i \to KR(SO_i)] \vee [KIP_i \to KR(DIP_i)]\}\end{aligned} \quad (10)$$

Value $\delta\sigma^S(\varphi_i)$ can be formed for subject area W_i, or for each separate interaction of TM_i with IP_i, or KI_i, where KI_i – channel stream of information and can depend on level of necessary sensitivity TM_i to changes which take place under influence of IP_i, which like KI_i we will call DI_i.

Phrase φ_i^* received on previous stage is analyzed for compliance to requirements of normalization. If rule of absorption of phrase uses operations of adding words and replacement of words, then rule of normalization uses operations of elimination and replacement of words. In process of analysis of normalization requirements for words or word pairs their semantic values are determined. If $\sigma^Z(x_i^*) - \sigma^Z(x^*_{i+1}) \le \Delta\sigma$, then x_i^* and x^*_{i+1} are checked for excessiveness. Such check is in calculation of same words in $j(x_i^*)$ and $j(x^*_{i+1})$, which are located in semantic vocabulary S_C. If number of different words with $j(x_i^*)$ and $j(x^*_{i+1})$ is less than some threshold $\varepsilon\,[j(x_i^*), j(x^*_{i+1})]$, then words x_i^* and x^*_{i+1} in framework of system of normalization Λ are accepted as synonyms and elimination of one of the words x_i^* or x^*_{i+1}, which belong to TM_i is made. This circumstance is important because it has characteristics of renewing of word reserve which is used in TM_i. According to $\lambda(x_i, x_{i+1})$ it can appear that in S_C exists x_i^D so that exists correlation:

$$\begin{aligned}&\{\{\varepsilon[j(x_i) - j(x_{i+1})] \le \delta\lambda_i\} \,\& \\ &\& \,\exists\left(x_i^D \in S_C\right)\left[j(x_i^D) - j(x_i) < \delta^1\lambda_i\right] \& \\ &\& \left[j(x_i^D) - j(x_{i+1}^D) < \delta^2\lambda_i\right] \& \left(\delta^1\lambda_i > \delta^2\lambda_i\right) \& \\ &\& \,\delta\lambda_i > \left(\delta^1\lambda_i \,\&\, \delta^2\lambda_i\right)\} \to \left[(x_i * x_{i+1}) \to x_i^D\right]\end{aligned} \quad (11)$$

Then two words x_i and x_{i+1} are eliminated, and instead of them is used word x_i^D.

Conclusions

Method of synthesis of text models with text information streams which are orientated on performing managing actions on social objects which are described by text models is developed. Analysis of components of process of text models functioning to which belong: analysis of models; monitoring of mass media, used by social objects; analysis of implementation of processes of model modification etc. is made. The developed methods of synthesis of text models with text images of information streams are based on use of structural characteristics of models and streams and also are based on use of semantic parameters of text images.

It is shown that during synthesis process arises necessity to implement processes of output of new text fragments which own interpretation in subject area of practical tasks of social objects management. Procedure of output of text fragments based on use of logical schemas is developed, interpretation of which does not contradict data, presented in subject area of task and is based on use of semantic parameters which characterize text forms of model presentation.

Main aim of use of text models is description of social objects which are hard to be described in formal way at necessary level of details which is a requirement to effective management of such objects. Results mentioned in work illustrate possible approach to tasks of automation of processes of synthesis and managing social objects.

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