The idea of dynamic memory management system based on a forgetting-recalling algorithm with emotive analysis.

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1. Preface.

One of the main goals of the artificial intelligence research is to construct a model of human mind. Hundreds of ideas have been thought of in this matter so far, and it would be the last wish of the author to present another one. However, as it was noticed by such scientists as Markovitch and Scott (1988), among tons of paper used to present ideas about describing a process of human thinking, only a few kilograms treat about one fundamental thing that in particular defines the human mind. The mechanisms of forgetting and its influence to knowledge usage.

2. From language competence to forgetting.

A very popular view about the so-called "formula of human mind" is to convey it into a computer program. However, when we talk about a computer program that would be able to talk with us in a more or less intelligent way (although we might point people who cannot do that at all), or to put it in math-philosophical vocabulary, would be able to pass a Turing test, we should first think about the way that human mind works when it is encoding our thoughts into a language message. This process is defined by so-called language competence. This notion, defined first by Chomsky (1965), and later described widely by Bachman (1990) is, in a very brief description, a kind of knowledge that enables one to produce and comprehend a language. There are different components that build our language competence, from the general grammatical structure rules to sociolinguistic and culture based features revealing in everyday usage of language. Many things influence the way we speak. The way the language was used by our parents, our school colleagues (and their parents and families, etc.), the way our teachers at school taught us, the books we read, films we saw, and so on... All that becomes a part of our own language competence, which, in spite of culture and society based similarities, varies for all of us, just as there are fundamental differences in mentalities between people. In Poland there is a saying, that for every five Polish in one room, there will be at least six ways of thinking. One might think of that as an ironical joke, but if we think closer, it is not that far from reality.

There is no doubt that the system that operates our brains is more less the same for all of us. We could talk about cultural differences in perception, but the main core of human mind works in the same way. In other way we would not be able to create structures like cultures, societies, etc. which involve a large amount of cooperative thinking. On the first glance then, we might see here a paradox. Do we have a common language competence or do we not? However, if we look closely, this paradox is easily solvable.

In spite of differences on the lower social group levels of language usage, like "family", "neighborhood", or "subculture", language competence shows many similarities on the higher levels, like "region", "country", or "culture". Language users of one culture communicate using the same code and language procedures. Furthermore, on the base of the unified language code, we gather our own experiences and constitute our own usage of one language. Furthermore, some things we learn, some we forget. The memories forgotten can also be recalled with all language luggage connected to it. This way a language competence is not a constant state, but rather a constantly changing dynamic database of words and utterance patterns and procedures.

Thinking how to convey a state similar to language competence into conversation software, authors thought of an idea of a dynamic memory management system. The system borrows the most representative features of forgetting mechanism in humans.

3. Past and new view on forgetting.

Forgetting is a process in which parts of knowledge become rearranged, inaccessible or inactive (Anderson, 1983, Markovitch and Scott, 1988). To use neuromedical terms, forgetting is a result of a fact that as living and growing old beings, we cannot keep the neural connections net of our memory in a perfect shape forever. In fact new neural connections we make

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in our brain start decaying right after being settled (Waddell, 2004).

The research about chronological fading of memories was began by Ebbinghaus' (1885) experiment with remembering series of syllables, which revealed that fading of memories is inversely proportional to the time expired.

Zitman (2001) discovered during his observations of patients with mood- and anxiety disorders that memory has much in common with emotions. His further experiments on hormonal transfers confirmed that. Nuray Luk (2002) supported the same thesis in her research on the role of emotions in language acquisition.

Wolfe (2006), although using neurobiological vocabulary states the same thing, saying, that the brain at first seeks to create meaning through establishing or refining existing neural networks (building the database of memory) and furthermore, during the process of learning affecting it by emotions. Memories with stronger emotive affection are harder to forget.

Commonsense thinking makes us find forgetting process a disadvantage or moreover, a defect in the human mind. We get irritated and ashamed when we forget something. However as the research on human brain continues to rush forward, more and more features of our way of thinking undergoes revaluation. When Markovitch and Scott (1988), were stating that forgetting "is a very useful process which facilitates effective knowledge acquisition", and that "mechanisms of forgetting therefore merit study alongside those of acquisition since it is the two together which constitute learning", they tried to give forgetting a logical reasoning. However, it's the freshest results of Kahn et al. (2007) that show that forgetting not only does not have to be a defect, but on the contrary, it actually helps people organize memory and remember about important things.

The idea to convey the language competence notion based on features of forgetting process into conversation software and, as a result, to improve naturalness and adequacy of speech in machines gained shape of a dynamic database management system based on the principles mentioned below:

・Forgetting is a crucial element in the process of learning.

・Memory is an expanding database.

・Forgetting process is dependant on a) frequency of connections in use and b) emotiveness of connections.

・Forgetting is beneficial in organizing knowledge.

Implementing algorithms based on this system should help to process large text databases for a stand-alone conversation software and effect in cutting down the time costs of wide context processing and allow a program to produce more natural utterances. In the final effect ability to process and produce language for a program working on such system should be comparable to previously defined language competence in humans.

4. Description of the system.

In a conversation program supported with an expanding database (DB, see Figure 1) former conversations will be archived just like in an internet messenger. When a user encounters the program a new conversation will start. The program will query the database searching for adequate context keywords (n-grams, conversational procedures) to produce an utterance. If it does not find any, it is considerable to let the program query internet for finding adequate knowledge (associations). Every entry after a query will be treated as a separate Context Unit (CU). For better distinction we can propose a division into Context Units in the form of a dialogue with a user (dCU) and those in the form of an association list gathered from the Internet (aCU). For the program though it will not make a difference what kind of CU is saved in the archive.

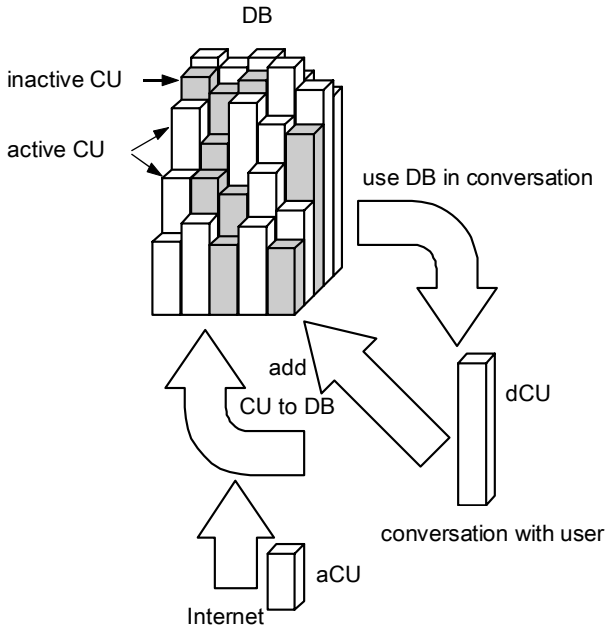

Figure 1 Simplified diagram of the system

However, since the database will expand with every new CU, very soon the program would have to process enormous number of entries. As states Araki (2004), this is one of the difficult problems in processing context-bound sentences. To

avoid it authors propose a system with an implemented algorithm of forgetting and recalling.

4.1 Algorithm of forgetting.

Forgetting means here that, as stated in the previous paragraphs, parts of knowledge will become inaccessible or inactive. Whether to "shade" a CU will be determined on two conditions: frequency of usage and emotive value.

Since there are context connections in the DB used more often and those used rarely, it is easy to base the forgetting process on the frequency of using the connections. That is, if a connection will not be in use for a specified amount of time, an event would be marked as inaccessible.

As mentioned above, forgetting in humans is based also on the emotive strength of neural connections. This mechanism will be transferred into the algorithm by adding emotive values to the archived items during the process of gathering information. This value will be derived from linguistic- and communication sciences based-analysis.

The contents to be forgotten by the program should be selected by taking into account those values along with the frequency of the links in use. The final decision whether to shade a CU would be based on those two conditions.

4.1 Algorithm of recalling.

Although there were proposals of creating an algorithm of forgetting before with some good ideas, it seems that the attention was always concentrated only on forgetting during the learning process. Markovitch and Scott (1988) as well as later Ishikawa (1990) by forgetting meant that the unused links of large knowledge amount were ought to be forgotten in the meaning of deleting them from database. This way the notion of recalling information from faded database was ignored.

In the proposed algorithm the recalling process is nothing more than looping back to the process of gaining knowledge. When a user utters the program, a new conversation starts and the program searches through its database for an appropriate context data to respond for the dialog. If this ends in success, the connection to the used context is renewed. If not, the program starts the process of gaining knowledge (Internet). When a new associative context unit is gained, it is compared to the inactive forgotten archives. If the new gained CU covers or links to the inactive (forgotten) parts of knowledge in the database, those parts would be activated and their connections renewed. If the CU contains a new data, it is added and archived in the database as an active CU.

4.3 Emotive analysis.

Language functions in verbal and nonverbal channels. The emotive function of language, referring to expressing emotions, is realized verbally through exclamations, hypocoristics (endearments), vulgar language or, in Japanese, mimetic expressions (*gitaigo*), or code sophistication (*suru/da* vs *masu/desu*). The key role in expressing emotions is played also by the lexicon of words describing states of emotions. On the borderline of verbality and nonverbality we can talk about elements of language such as, intonation, voice modulation or tone of voice. Nonverbal elements realizing emotive language are body language, with all its components, like gestures, face expressions, eye contact, or pose (Ptaszyński, 2006).

However in conversation systems based on transmission of signals encoded in lines of letters, punctuation marks and symbols, etc. communication channel is limited. Therefore for emotive analysis in conversation programs we need to agree to a compromise of restrictions in the communication channel and base the emotive analysis on its' linguistic part.

A few simple examples of sentences without emotive value (A, B), and those colored with emotions (A', B') are given below. The parts of sentence that constitute its emotiveness were shaded gray.

A: 今日はいい天気です。

Kyō wa ii tenki desu.

It is a good weather today.

A': ああ、今日はええ天気だな！

Aa, ky wa ee tenki dana !

Wow, now today is a fine weather!

B: 彼女は、大きいかさをもってきて、信之介を強く殴った。

Kanojo wa, ookii kasa wo mottekite, Shinnosuke wo tsuyoku nagutta.

She brought a large umbrella and hit strongly Shinnnosuke.

B': あいつぁ でっけーかさをもってきやがって、シンちゃんをひでー ボコボコに しちまった ！

Aitsaa dekkē kasa wo mottekiyagatte, Shin-chan wo hidē bokoboko ni shichimatta !

That slut lugged a huge umbrella with her and beat the shit out of Shin-chan.

Every utterance will be analyzed this way concerning differences in code elaboration and language usage. The general emotive value of a CU will be equal to the approximation of emotive values of each utterance in the CU.

6. Plan of implementation.

Although the system is still in its' theoretical phase, some of elements of it might be thought of as already done. To the preliminary testing phase there can be used already existing conversation software and searching engines (Higuchi, et. al, 2007). The decision in these matters will be taken after thorough review and comparing of the present state of knowledge in the field.

For the part of emotive analysis authors plan to work out and propose an original system based on the linguistic and communication sciences approach towards emotions and feelings recognition in the text (Ptaszyński, 2006). After combining together all parts of dynamic database management system there will be a preliminary test phase, where efficiency and performance of the system with forgetting-recalling algorithm activated and deactivated will be compared. As the results will be found promising, an "in practice" test phase will start. Here there are two considerable ways of performing the test. In the first one, based on the idea of a Turing test, "naturalness of speech" will be tested in a standard way – a user will encounter the program and evaluate its' performance on the spot. In the second idea of the test, which authors thought of, a program will encounter another conversation software and the record of this dialogue will be evaluated by readers.

5. Advantages of implementation.

Fading the unused context connections would improve the speed and performance of the program in processing large databases containing context-bound sentences. Since the database will be renewed according to the present needs, the program will operate on an actual and appropriate database all the time. In the final effect, a program working on such system, should have comparable ability to process and produce language with those in humans.

7. The future perspectives.

Today we are surrounded by various artifacts based on the use of "weak AI", which idea was described widely by Searl (1980, 1998). Card readers, red-eye and handshake effect reduction in our digital cameras, cellular phones, etc. make our lives easier. However, if we wish to create an intelligent interlocutor based on the "weak AI", that is, a program that would be, using Lyons' (1979) nomenclature, able to send messages informative for the receiver, but without knowing its' communicative meaning as a non-thinking machine, our attention should be paid on the fact that the idea is to create something that imitates a human way of thinking with its' originality, as well as with its' all vices and weaknesses. We should not consider the mind as a perfect creation. On the contrary, we should accept it with all its imperfection and defects. It cannot be excluded that some of them will soon turn out to be merits.

References:

[1] Anderson, J.R. (1983) *The Architecture of Cognition*, Harvard University Press

[2] Araki Kenji (2004) *Shizengengoshori kotohajime - kotoba wo oboe kaiwa no dekiru konpyūta* − (Introduction of Natural Language Processing - Can a computer learn language and talk? -), Tokyo: Morikita Publishers

[3] Bachman, Lyle F. (1990) *Fundamental Considerations in Language Testing*, Oxford: Oxford University Press

[4] Chomsky, N. (1965) *Aspects of the theory of syntax*, Cambridge: The MIT Press

[5] Ebbinghaus, Hermann (1885) *Memory A Contribution to Experimental Psychology*, (translated by: Utsugi Tamotsu (1978) *Kioku nitsuite: jikken shinrigaku he no kōken*, Tokyo: Seishinsho Shobō)

[6] Higuchi Shinsuke, Rzepka, Rafal, Araki Kenji (2007) *Web ni yoru tango kyōki hindo oyobi modarithi wo mochiita zatsudan shisutemu* (Chat systems based on occurance frequency of words of in the Web and modality), Sapporo: Graduate School of Information Science and Technology, Hokkaido University (to appear)

[7] Ishikawa Masumi (1990) "A Structural Connectionist Learning Algorithm with Forgetting" (in: *Journal of Japanese Society for Artificial Intelligence* 5(5), The Japanese Society for Artificial Intelligence)

[8] Kahn, I., Dudukovic, N. M., Kuhl, B. A., & Wagner, A. D. (2007) "Decreased demands on cognitive control reveal the neural processing benefits of forgetting" (*Nature Neuroscience*, 10, 908-914)

[9] Lyons, John (1979) *Semantics*, Cambridge: Cambridge University Press

[10] Markovitch, Shaul and Scott, Paul D. (1988) "The Role of Forgetting in Learning", (in: *Proceedings of The Fifth International Conference on Machine Learning*. Ann Arbor, MI: Morgan Kaufmann)

[11] Nuray Luk (2002) “The Role of Emotions in Language Teaching”, (in: *The Journal of the Imagination in Language and Teaching*, vol. VII, 2002.03)

[12] Ptaszyński, Michał (2006) *Moeru gengo - Intānetto keijiban no ue no nihongo kaiwa ni okeru kanjōhyōgen no kōzō to kigōrontekikinō no bunseki - "2channeru" denshikeijiban o rei toshite* - (Boisterous language. Analysis of structures and semiotic functions of emotive expressions in conversation on Japanese Internet bulletin board forum - 2channel -), Poznań: UAM

[13] Searle, John R. (1980) *Minds, brains, and programs. (in: Behavioral and Brain Sciences*, 3 (3): pp. 417-457)

[14] Searle, John R. (1998). *Mind, language and society: Philosophy in the real world*, New York: Basic Books.

[15] Waddell, Scott (2004) *Forgetting Those Painful Moments*, Worcester, USA: Department of Neurobiology, University of Massachusetts Medical School

[16] Wolfe, Pat (2006) “The role of meaning and emotion in learning” (in: *New Directions for Adult and Continuing Education*, Volume 2006, Issue 110, pp 35 - 41)

[17] Zitman, F. G. (2001) *Emotion and memory in mood-anxiety disorders*, Schreuder, BJN