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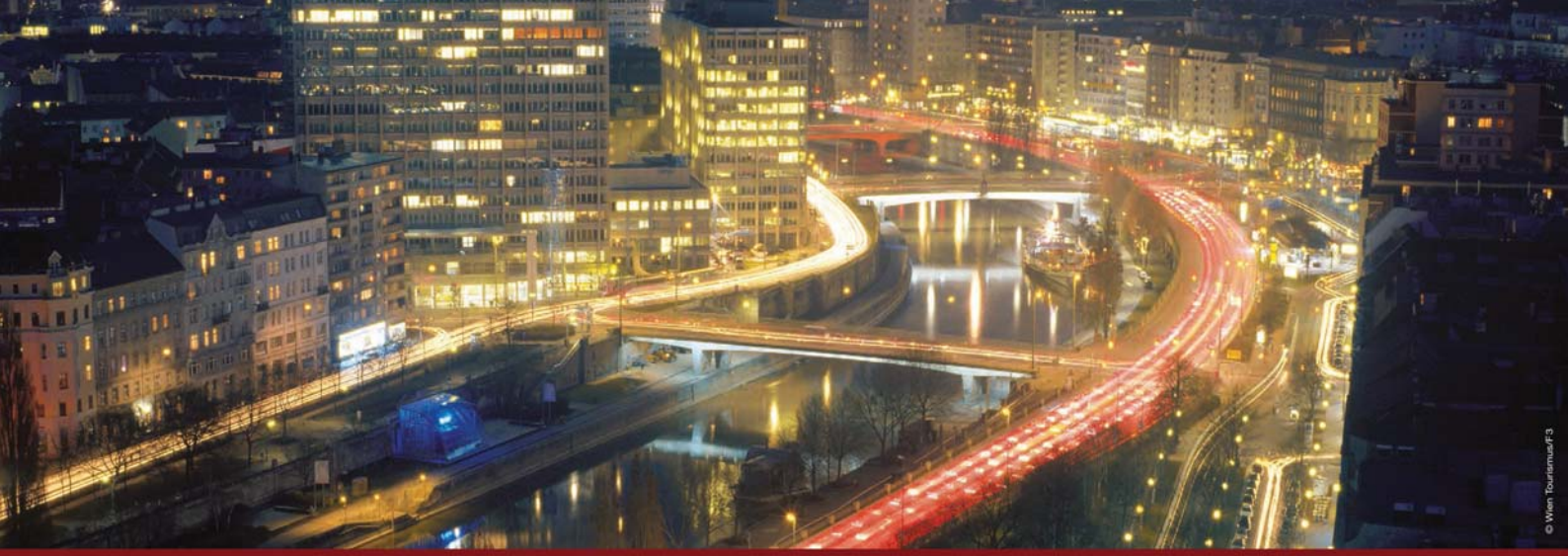

IECON 2013 November 10–13 2013, Vienna, Austria

Conference Booklet

IECON 2013

39th Annual Conference of the IEEE Industrial Electronics Society

in conjunction with

ICELIE 2013: 7th International Conference on e-Learning in Industrial Electronics

IWIES 2013: 1st International Workshop on Intelligent Energy Systems (14.11.2013)

Austria Center, Vienna, Austria
10-13 November 2013

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IEEE Industrial Electronics Society

MONDAY 11th of November

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Usage of Spreading Activation for Content Retrieval in an Autonomous Agent

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***Abstract* — For cognitive agents that decide based on experiences, memory retrieval is a significant issue. In this article a contribution to this field is made by introducing the concept of psychic spreading activation for memory retrieval in an autonomous agent. Using the psychoanalytical foundation of that as a constraint, a variant of spreading activation was created to regard perceptional as well as motivational inputs and considering the emotional component of a situation. Results show how this type of memory retrieval can influence the decision making process.**

Keywords—cognitive architecture, artificial recognition system, artificial intelligence, artificial general intelligence, spreading activation, memory retrieval, image, database, psychic spreading activation, ARS

I. INTRODUCTION

A significant feature of a cognitive architecture is its memory. Depending on design constraints of the respective architectures, memories are differently conceptualized and implemented. An important issue is the retrieval of memories [6], [13]. The problem is how to retrieve relevant memories in an efficient way. Normally, there should be some limitation of how many memories can be retrieved within a single cycle. This is finally a matter of resource handling, because the more memories are activated, the more processing power is required if too much processing power is needed, the architecture cannot fulfill its tasks in a dynamic environment [19]. The problem can be divided into two sub problems: At first, it has to be found out, which memories are relevant for decision making in a certain situation. In a second stage, it has to be decided, which of the relevant memories shall be activated as all relevant memories may not be activated. In this paper, a concept for retrieving memories in the cognitive architecture ARS (Artificial Recognition System) will be introduced, which gives one solution to the stated problem.

II. RELATED WORK

Described as a model of memory activation in the human mind [11], [17], the concept of spreading activation is generally used as a model for information retrieval in generic network architectures [18]. In particular, it models how activation spreads from a network-node to associated nodes. This process is also described as associated retrieval [18]. The most frequent representation used for spreading activation is a semantic network, but the principle is valid for all kind of networks. An advantageous feature which is often used in such networks is the weighting of associations. A spreading activation process is able to consist of multiple iterations, also called pulses, which can be distinguished in three steps [18], namely (1) Preadjustment, (2) Spreading and (3) Postadjustment. A pulse is ended in case a termination condition is reached. Pre- and postadjustment steps are optional and usually implement some form of activation reduction to regulate the spreading of activation. This may be used to regulate the overall network activation. The spreading step consists of the calculation of the incoming activation from associated nodes [18] with the consideration of the association weights. After calculating the input value, the output value, i.e. the node's activation value, is computed, where different activation functions may be used. The node's activation value is then spread to all associated nodes, usually sending the same value to each node. The overall result is the assignment of activation values to the activated network nodes. The activation value represents the significance of the node for the information retrieval process.

Spreading activation is used by different cognitive architectures for information retrieval and for the consideration of various effects, amongst them priming-based processes such as regency and frequency effects (i.e. the impact of recent or frequent input on cognitive processes), but also for representing capacity constraints in cognitive processing [18]. An important task in agent systems is to prioritize tasks and goals and to store and schedule goals, which cannot be reached immediately. Such goals are called delayed intentions in the cognitive architecture SOAR [6]. Furthermore, it must be decided how the agent proceeds with concurrent or conflicting goals. Li and Laird propose spreading of activation as a selective decision tool to determine which goal or intention will be pursued with higher priority. The mechanism Intention Superiority Effect is suggested to select and prioritize delayed intentions [7]. It is a mechanism within human cognitive processes, which gives higher priority to the activation of intended actions. Those actions are closer associated with present perceptions and therefore retrieved easier than other parts of memory by using spreading activation. In [8], four models are presented, which demonstrate control schemes for handling delayed intentions. The four models are implemented by using the ACT-R framework [9]. All four models operate on ACT-R's declarative memory representation scheme. One piece of memory in ACT-R is called a chunk. Hence, delayed intentions are stored in an intention chunk. Elio compares his

four models to test results obtained by a series of trials on humans memorizing different words. These trials were carried out by R. E. Smith at the Department of Psychology at the University of North Carolina in 2003 [10].

A concept for cognitive architectures, which helps reducing memory access and brings cognitive capabilities to software agents is the usage of an episodic memory [11], [12]. Episodic memories store whole sequences of experienced events. As a whole sequence of events is retrieved in one step, memory access is reduced compared to a retrieval of each event separately [13]. In ARS, all situations are only stored in an episodic memory instead of a semantic memory treating each situation separately like a skill memory [20].

III. The Cognitive Architecture ARS

The ARS model [1] implements a cognitive architecture that is intended for use in robotics and automation [2] for handling complex tasks. It bases all processing on its experience, which is a subjective approach of cognitive modeling. Such an approach emphasizes the significance of memory and its activation. The theory behind is psychoanalysis, a functional psychological theory about human feeling, thinking, and acting [3]. The model is hierarchically divided in three layers, inspired by neurology, viz. neural layer, neuro-symbolic layer [4], and mental layer or psyche.

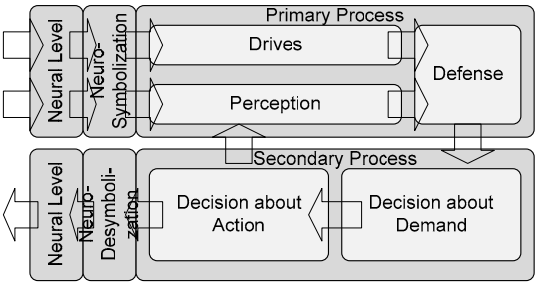

Fig. 1: The ARS model

The constraints for the concept of organizing memory in ARS are given by psychoanalysis, which states that the human mind operates in two fundamentally different modes, the primary process and the secondary process. The *primary process* represents the unconsciousness and prescribe unstructured memory activation based on similarity and simultaneity. Different in the the secondary process, where activated memory is logically structured and fits comfortably with modern notions of functional brain architectures [14]. According to psychoanalystical theory, in the unconscious primary process, information in the memory is represented by patterns, which can be activated, for example by perception. They are connected by associations and an understanding of the world evolves out of activated memory traces [15]. Further, they are connected networks created by experience. During the memory activation process, associations are activated by expanding from one memory element to another [16]. This activation of associations has a strong analogy to spreading of electric potentials on surfaces with different resistances. Later, this process was described as activated items that "spread" its active status to associated items within the mind and named spreading activation in [11].

In the primary process, drives and perceptions are processed. *Drives* represent the motivations of the system. Their intensity or importance is measured in *quota of affect*. Perceived features from sensors are used to recognize objects in the perception. Collections of perceived objects together with their positions form situations, which are expressed as images. *Images* can be seen as experienced snapshots of perception and form the memories and situational experiences of the agent. They are comparable to non-inferred beliefs in other architectures [19]. A *perceived image* is a specialization of an image and represents the perception in a model cycle. The term *stored image* is used for images in the long term memory. Objects in images are evaluated regarding their usefulness for the subject in terms of possibility to satisfy a drive. Therefore, images, which represent past experiences, are evaluated in terms of the possibility to fulfill a certain drive or of expressing emotions. Each recognized object is associated with a certain memorized drive. The *memorized drive* tells the agent how well a perceived object did satisfy the agent in a certain situation. Images can also contain *memorized emotions*, which tells the agent how it did feel in that situation. The difference between a memorized drive and a memorized emotion is that the memorized drive represents the possibility to satisfy a certain drive for an agent and a memorized emotion represents the ability of some object or situation to affect the agent emotionally. The intensity or importance is measured in *memorized quota of affect*. An example is the situation of another agent besides of a food source. The food source satisfies the drive "hunger", but the situation as a whole may be scary for the agent due to the emotional component invoked by the other agent. This situation is captured in an image.

The *secondary process* represents the conscious part of the system. While images are independent of each other in the primary process, they form sequences in the secondary process, which are the base of decision making and action planning [5]. The simplest sequence would be an image as precondition and another one as postcondition and where the execution of a certain action would bring the agent from the first image to the next. This sequence would be related to the term skill in other architectures [20]. It contains a decision engine, which reasons about the activated sequences.

IV. Concept of Psychic Spreading Activation

Due to the similarities of the technical concept spread activation [11], [18] and the psychoanalytical theory about memory activation [15], [16], spreading activation was chosen as a concept for memory retrieval in ARS. However, the original concept was created for semantical networks, where the concepts of the network are connected by weighted associations. Therefore, the associations alone decide about the importance of a related concept and whether it can be activated or not. In ARS, which is not a semantic network, the concepts are replaced by images. In the primary process, similarity and simultaneousness creates associations between the images. In that way similar images, which were experienced within a similar timeframe will have stronger

associations between each other than other images. So far, the network of images is similar to the original spreading activation. The difference lays in the fact, that the images themselves have some importance to the agent and therefore have an impact on their own activation. The subjective importance is given by the memorized drives and memorized emotions. Therefore, both the association as well as the image itself have to be considered at the stage of activation. Another adaption of spreading activation to the psychoanalytical theory is that the current drives and their intensity have an impact on the importance of an image. Therefore, at the start of the spreading activation, the current drive state is considered at the calculation of the importance of an image. Further, as the spreading activation is made, in order to activate memories, based on perception, the network of associations is not static. The starting point of the spreading activation is either an existing memory or perception. As the image, which represents perception, the perceived image, is not a part of the memory, it is associatied to related images in the memory during the activation. In the following, these features are described in detail. The original spreading activation together with its modifications are called *psychic spreading activation*. The first ideas were originally presented in [5], but are developed into a working system here.

A. Interfaces to other components

Within this process, a network of images connected by associations are available in the long term memory. This is the first input to the system. In order to activate the relevant images, a starting image has to be selected. This is the second input. In the case of perception, the perceived image is the input to the spreading activation. As the perceived image shall become the starting position of spreading activation, it has to be connected to the network. This is done by an image matching and association process. Actually, any other image could be used as a starting point. Then, after the starting image is defined and integrated, the spreading can start. The resource, which is spread along the associations is called psychic energy. It provides the third input. *Psychic energy* origins from the drives and influences how many associations are activated during the process. The input image is assigned an amount of psychic energy. How much psychic energy that is available depends on how many drives are active and on their intensity. The perceived image is now able to activate situations related to the perceived environment. The psychic energy spreads through the associations. At each activation of an image, some of it is consumed. The forth input is the current drive state, which influences which images are considered as important, e.g. an image with a food source will be considered as important if the agent is hungry (high intensity of the drive "hunger"). As output of the spreading activation is the input image with the activated network of images from the memory attached to it.

B. Process of the Memory Activation

As the inputs of the memory itself, the perceived image, psychic energy and the drive state are provided, the process of activation can start. Fig. 2 shows the starting setup. All psychic energy is assigned to the perceived image. The bolder the arrows, the higher the association weight and the darker the color in the circles, which are representing images, the more important they are for the agent. In a first step, all stored images are compared to the perceived image and associations are created between them, if the match percentage exceeds a defined threshold. In case a stored image is identical to the perceived image, the association weight is set to 1.0. All associations, which are created in the matching process between the perceived image and any other image is called a *direct association*. All associations, which already exist in the memory and are connecting the stored images are called *indirect associations*, see Fig. 2. These terms are used to differ images, which are directly linked to the input and those, which are indirectly linked over another image. The direct associations represent the first level of activation from the starting point.

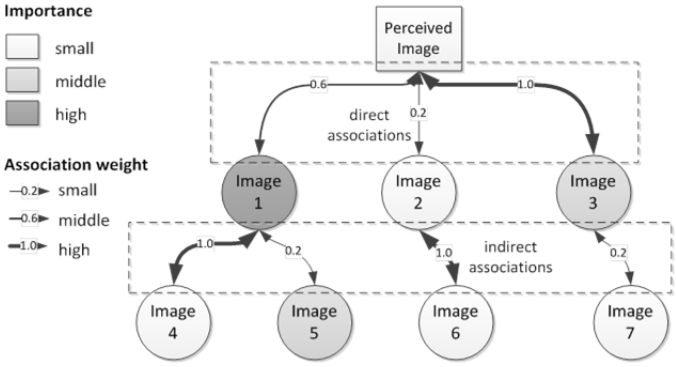

Fig. 2: An example of how a network (undirected graph) of images could look like, where the starting point of spread activation is the perceived image and the difference between direct and indirect associations is shown

Then, starting from the perceived image, psychic energy is spread through the direct associations (directly linked images). In order to decide how the psychic energy is split between the images, a quantity called psychic potential is defined. The idea behind it is that associated stored images, which are similar to the perceived image and are of high importance to the agent shall get a higher amount of psychic energy assigned than other stored images. Psychic potentials act like a sort of attraction potentials, which are attracting psychic energy. In the competition for psychic energy, the relative attraction between psychic potentials decides how the psychic energy is distributed. The *psychic potential* ψ_j is calculated as a function of the association weight w_{jk} between the perceived image k and a matching stored image j and the importance A_j from the stored image in (1). *Importance* is here used a term summarizing the memorized quota of affect of memorized emotions and memorized drives of an image. In Fig. 2, the image k is the perceived image and e. g. stored image j is e. g. image 1, image 2 or image 3.

$$\psi_j = w_{jk}\left(1 + \left|A_j\right|\right) \tag{1}$$

The psychic energy E_j, which is allocated to a stored image (j) from the available psychic energy E_k of the perceived image (k) is calculated with the following formula:

$$E_j = \frac{\psi_j}{\sum_0^n \psi_i} E_k \tag{2}$$

The psychic potential ψ_j of the stored image j forms a quote from the sum of the psychic potentials $\sum_0^n \psi_i$ of all directly associated images (i=0..n), which can be activated by the perceived image k. In Fig. 2, this sum is the sum of the psychic potentials of image 1, image 2 and image 3.

As a stored image is activated, it consumes some psychic energy. If no psychic energy would be consumed by the activated images during this process, the whole memory network in the memory would be activated. Therefore, the availability of psychic energy at the perceived image and the consumption of it at activation of stored images limit the activation. The *consumption value* of a stored image works as a threshold for activation as simultaneously removes some psychic energy from the spreading activation. If the value is high, it requires more psychic energy to activate the stored image than if it would be low. Eventually, after distributing all psychic energy in the network, the available psychic energy for a stored image is lower than its required consumption value and the spreading activation stops in this branch.

A consequence of the consumption value, is the case, in which no stored image would be activated although enough psychic energy is available. This would be the case if a perceived image has several direct associations to stored images. The psychic energy would be distributed between several stored images and the necessary amount of psychic energy would not be reached. In the decision unit, it does not make sense that no memories are available to the decision unit because the perceived situation could activate too many of them. Without activated memories, the decision unit cannot take any decisions. Therefore, it has to be considered that if enough psychic energy is available for the stored image with the highest psychic potential, at least this image shall be activated. In order to do that, it has to be calculated how many stored images can be activated at most, in order to still be able to activate at least one stored image. In (3), the condition is defined that the consumption value E_j^c of the stored image j has to be smaller than allocated psychic energy E_j from (2).

$$E_j^c \leq \frac{\psi_j}{\psi_j + P_j} E_k \tag{3}$$

As E_j depends on the quote of the psychic potential ψ_j of the stored image j and the sum of all psychic potentials of the directly associated images $P_j + \psi_j$, the goal is to calculate the maximum value of all other psychic potentials P. P therefore limits the number of other images that can be activated. (3) can be rewritten as (4) in the following way:

$$P_j \geq \psi_j \left(\frac{E_k}{E_j^c} - 1 \right) \tag{4}$$

For each stored image j, P_j is calculated. (4) shows the relationship between consumption value of the stored image j, available psychic energy from the perceived image k, the psychic potential of the stored image j and the psychic potential of all other stored images, which are competing for psychic energy.

In order to calculate, which stored images are actually activated, after calculation of the psychic potentials of each directly associated image, the psychic potentials of all other stored images P_j, is calculated. The potential activations are sorted starting with the highest psychic potential and descending. By doing that, the stored image with the highest psychic potential will always be activated if enough psychic energy is available. Each stored image will then be activated where the P_j of this image is higher than the accumulated activated psychic potential. At the first stored image, where this is not the case, the activation stops.

Now, the process of activating direct associations is completed. The allocated psychic energy minus the consumption value is allocated to the activated stored images. The remaining psychic energy is available for activation of further images in an equivalent way. The input image of the process is now one of the activated stored images and not the perceived image. As the input is a stored image, it already has associations to other stored images through the indirect associations. Therefore, no matching process is necessary. The process starts by calculating the psychic potentials of the associated not already activated stored images and so the activation spreads until there is no image, where enough psychic energy is available to reach the consumption value of a stored image. Fig. 3 shows the same figure as in Fig. 2, but with a theoretical activation according to the described process.

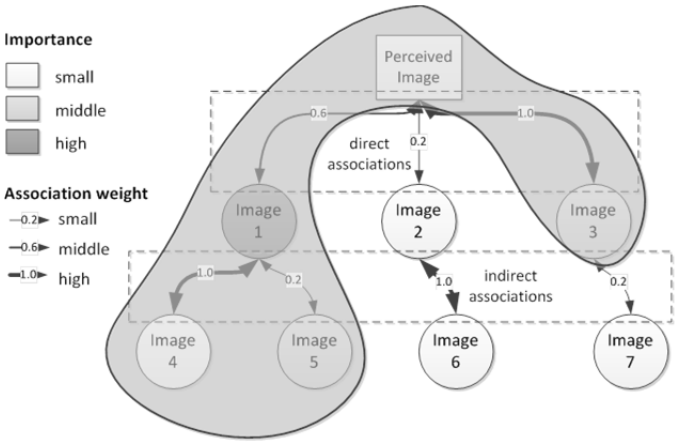

Fig. 3: Activation of images by psychic spreading activation

The activation is not only limited by the available psychic energy and the drive state, but also through the limitation of the maximum number of stored images, which can be activated. The minimum is by one stored image as explained previously. If the maximum is set high like in Fig. 4 A, the available psychic energy will be spread widely through all available direct associations, which means that several stored images direct related to the perceived image can be activated but not much on the depth. This is a good method, in order to get an overview, to see what previous experiences are related to the current situation without going into detail. In the case that the maximum number of stored images that can be activated is set very low, as in Fig. 4 B, all psychic energy is split among a few stored images, making it possible to activate on the depth.

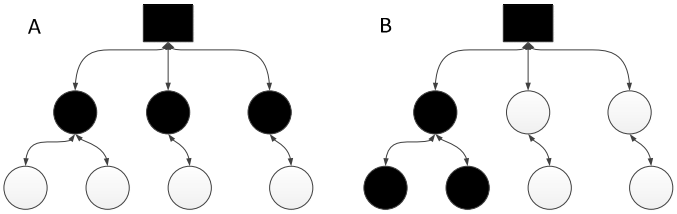

Fig. 4: Activation width vs. activation depth

Psychic spreading activation can also be triggered by already stored images. In this case, no matching needs to be done, as associations to other stored images are already present. This is the typical case is if these stored images are a part of a sequence. One of them is sent back to activate more related stored images of the sequence. By doing that, the psychic energy does not have to be split among other unrelated images. This is a powerful tool to activate complete sequences, if for instance an important part of a sequence is missing, if available that part can be activated for the next model cycle in this process.

V. RESULTS

In the following experiments, the functionality of psychic spreading activation is demonstrated in an example implementation. In order to compare different input settings, only three different, symmetric branches of stored images were used as shown in Fig. 5. The measurement for the allocation of psychic energy can be demonstrated by the number of indirectly activated stored images in the corresponding branch. All branches are independent of each other. Each branch contains five stored images. The first branch "GETFOOD" (Image L1I1, L2I1 … L5I1) would fulfill the drive "Hunger", as it could help the agent to find food. The stored images in the branch "GOTOWC" (Image L1I2, L2I2 … L5I2) fulfill the drive "deposit" and could provide information where the agent could find a WC to execute its needs. The third branch "ENEMY" (Image L1I3, L2I3 … L5I3) does not fulfill any drive, but instead tells the agent about an enemy, harmful agent, causing a reaction on external stimuli.

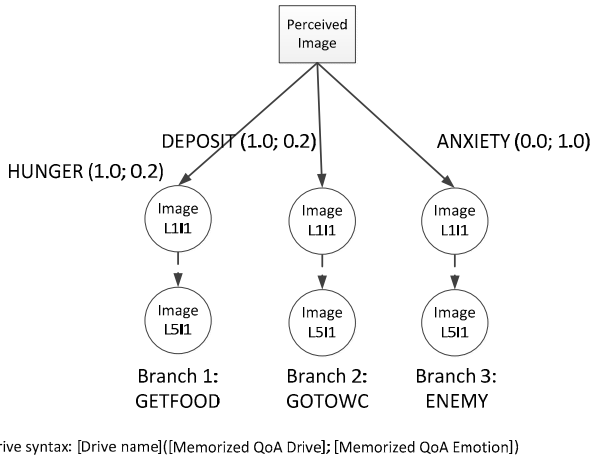

Fig. 5: Example image structure with three symmetrical branches of connected images for demonstrating the functionality of psychic spread activation

The interpretation of the activation process is that branches, which allocate much *psychic energy*, activate more *images* and provide the agent a better decision base in that matter.

The test setup was implemented in a separate simulator. The same concept was also implemented in the operational ARS model, for use in its memory retrieval. The following static settings are used in all tests:

- Each stored image consumes 0.2 units of psychic energy
- The psychic energy input to the system through the perceived image is 1.4, i.e. which could theoretically activate 7 stored images with the consumption value above
- Drive state: Drive "Hunger" with quota of affect=1.0 and "Deposit" with quota of affect=0.3

Table I shows all memorized drive and memorized emotion settings of all stored images in their respective branches, i.e. all images 1..5 of a branch have the same image settings.. Each row defines the memorized quota of affects.

TABLE I. MEMORIZED QUOTA OF AFFECT VALUES FOR IMAGES IN THE BRANCHES

Branch	***Image (LnIx)***			
	Drive "Hunger"	***Drive "Deposit"***	***Emotion "Joy"***	***Emotion "Anxiety"***
GETFOOD	1.0	0.0	0.2	0.0
GOTOWC	0.0	1.0	0.2	0.0
ENEMY	0.0	0.0	0.0	1.0

In table II, the measured activations are shown as the number of activated images (# Act.). The only variable input parameter in the tests is the environment or the match of the individual branches with the environment (Match).

TABLE II. TEST RESULTS OF THREE PERFORMED TESTS

Branch	***Test 1***		***Test 2***		***Test 3***	
	Match	***# Act.***	***Match***	***# Act.***	***Match***	***# Act.***
GETFOOD	**1.0**	**5**	0.4	**2**	1.0	3
GOTOWC	0.4	1	**1.0**	**3**	0.4	1
ENEMY	0.0	0	0.0	0	**0.5**	**1**

Test 1 shows that all stored images of the "GETFOOD" branch in Fig. 5 are activated as both the match of the perceived image to the first Image of the branch is high as well as the memorized quota of affect for "Hunger" (1.0). It also shows that images without any association to the perceived image cannot be activated. In Test 2, the matches between the "GETFOOD" branch and the "GOTOWC" branch are flipped, meaning that the "GOTOWC" branch allocates more psychic energy because of the high match to the environment. It means that the perceived image activates a lot of images for the not so important drive "Deposit", because of the situational conditions. The agent may use this

opportunity to satisfy the drive "Deposit", although "Hunger" is more urgent. On the other side, it is shown that the drive "Hunger" still has a high influence on the activation due to the its importance. Finally, in test 3, the partial match of the branch "ENEMY" with the perceived image recalls an emotional strong experience and activates one of the images of that branch. In the following processing in the decision unit, the emotional memorized quota of affect will influence the selection of goals. Strong memorized emotions may lower the importance of fulfilling drives in favor of the reaction on the activated stored images of a situation.

VI. Conclusion and Outlook

Psychic spreading activation is a concept for retrieval of memories in the cognitive architecture ARS. It is based on spreading activation [11], [18] but extends the concept as it considers the psychoanalytical constraints of the project. As in ARS not only the associations between concepts play a role in the activation, but also the memories themselves. The importance of the memories are decided by their ability to fulfill a certain drive or emotion. Psychic spread activation is the answer of ARS on how memories related to a certain situation are efficiently retrived. It is interesting to notice that psychoanalytical statements about memory retrieval perfectly match the general concept of spreading activation. Therefore, it offers a bionically plausible approach. It allows a proper way of querying stored images and is able to activate related stored images without direct querying. Further, the activation of stored images is controlled through the input of psychic energy, which represents a limited system resource.

Psychic spreading activation offers many possibilities of controlling the activation of stored images. If a stored image is similar to the perceived image, its association weight is very high. Then, that stored image can allocate psychic energy. Similar, if the importance of it is high instead, the stored image can still allocate psychic energy. The more psychic energy allocated by a particular stored image, the more of its associated stored images can be activated through spreading activation. This is a good method to activate temporal near stored images without ordering them into sequences.

The implementation shows that psychic spreading activation can be easily implemented in the memory retrieval layer of an agent, but that it is hard to integrate into a database concept. All associated stored images have to be loaded from the database, in order to decide, which of them will actually be activated. As this costs performance it is not suited for a large data set as long as no pre-activation mechanism is used; i.e. only a subset of all available stored images. The rest of the activation should be done through indirect associations. This will also emphasize the main advantage, as it allows related stored images to be activated without querying the whole memory at once. This is the first concept and implementation of the biological and psychoanalytical founded memory retrieval in the ARS agent. Although there are some technical challenges to solve, the concept of psychic spreading activation is a development in the right way for building a human-like agent.

References

[1] D. Dietrich, G. Fodor, G. Zucker, and D. Bruckner (Editors), "Simulating the Mind, A Technical Neuropsychoanalytical Approach", Springer Wien New York, 2008.

[2] D. Bruckner, H. Zeilinger, and D. Dietrich, "Cognitive Automation – Survey of Novel Artificial General Intelligence Methods for the Automation of Human Technical Environments", IEEE Transactions on Industrial Informatics, vol. 8, nr. 2, p. 206-215, 2012.

[3] D. Dietrich, D. Bruckner, G. Zucker, B. Müller, and A. Tmej, "Psychoanalytical Model for Automation and Robotics", Proceedings of the 9th IEEE AFRICON, p. 1-8, 2009.

[4] R. Velik, "A Bionic Model for Human-like Machine Perception", Dissertation Thesis, Vienna University of Technology, 2008.

[5] C. Muchitsch, A. Wendt, K. Doblhammer, D. Bruckner, J. Machajdik, "Perceptual Prediction for Bionically Inspired Autonomous Agents", AFRICON 2011, Zambia, 2011.

[6] J. Li, J. Laird, "Preliminary Evaluation of Long-term Memories for Fulfilling Delayed Intentions", University of Michigan, USA, 2011.

[7] C. Lebiere, F. J. Lee, "Intention superiority effect: A context-switching account", Cognitive Systems Research 3(1):57–65, 2002.

[8] R. Elio, "On modeling intentions for prospective memory performance", In Proceedings of the 28th Annual Conference of the Cognitive Science Society (CogSci), 1269–1274, 2006.

[9] J. R. Anderson, C. Lebiere, "The atomic components of thought", Mahwah, NJ: Erlbaum, 1998.

[10] R. E. Smith, "The Cost of Remembering to Remember in Event-Based Prospective Memory: Investigating the Capacity Demands of Delayed Intention Performance", JEP: Learning, Memory, and Cognition, 29, 347–361, 2003.

[11] J. R. Anderson, "A spreading activation theory of memory", Journal of verbal learning and verbal behavior, vol. 22, pp. 261–295, 1983.

[12] A. M. Nuxoll, J. E. Laird, "A Cognitive Model of Episodic Memory Integrated With a General Cognitive Architecture", University of Michigan, USA, 2004.

[13] A. M. Nuxoll, J. E. Laird, "Extending Cognitive Architecture with Episodic Memory", University of Michigan, USA, 2007.

[14] R. L. Carhart-Harris, K. J. Friston, "The Default-mode, Ego-functions and Free-energy: a Neurobiological Account of Freudian Ideas." Brain 133, no. 4: 1265–1283, 2010.

[15] S. Freud, "The Unconscious" Vol. XIV, On the History of the Psycho-Analytic Movement, Papers on Metapsychology and Other Works. Vintage, 1915.

[16] S. Freud, "Zur Psychologie der Traumvorgänge", Vol. II/III, Gesammelte Werke Chronologisch Geordnet, 2008.

[17] A. M. Collins, E. F. Loftus, "A Spreading-Activation Theory of Semantic Processing", Psychological Review 82, no. 6: 407–428, 1975.

[18] F. Crestani, "Application of spreading activation techniques in information retrieval", Artificial Intelligence Review, vol. 11, pp. 453–482, 1997.

[19] J. Wendler, M. Hannebauer, H. Burkhard, H. Myritz, G. Sander, T. Meinert, "BDI Design Principles and Cooperative Implementation in RoboCup", in Proceedings of RoboCup-99: Robot Soccer World Cup III, pp. 531-541, Springer Verlag, London, UK, 2000.

[20] P. Langley. An adaptive architecture for physical agents. In in Proceedings of IEEE/WIC/ACM International Conference of Intelligent Agent technologies, Compiegne, France, pages pp. 18–25, Compiegne, France, 2005.