Human-like Memory Retrieval Mechanisms for Social Companions

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ABSTRACT

This paper demonstrates a biologically- and psychologically-inspired human-like computational memory focusing on the retrieval mechanisms – Spreading Activation and Compound Cue for a companion agent's episodic memory that might help the agent to manage it's memory more efficiently and enable it to have a more natural interaction with the user.

Categories and Subject Descriptors

I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence—*Intelligent agents*

General Terms

Algorithms, Design, Human Factors, Theory

Keywords

human-like, episodic memory, retrieval mechanism, spreading activation, compound cue, social companions

1. INTRODUCTION

Social companions research is a growing field and these artifacts have been used as assistive technology in many different areas such as patient therapy, rehabilitation and long-term care. In order to create the so called "companionship", we argue that these companions need to be equipped with certain human-like memory capabilities that will help them to remember past experiences, make predictions and take appropriate actions, hence giving users an impression of behavioural coherence and plausibility. As in the human case, the types of memory retrieval mechanism a companion agent employs may have strong impact on the perception of its intelligence, quality of interaction and more importantly user engagement. Whilst existing projects (e.g. [3, 5]) focus mostly on the performance of memory systems, we emphasise a more natural approach by looking at natural processes of human memory but rely on a technical solution that can actually adjust to the dynamics of social interaction.

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2. RETRIEVAL MECHANISMS IN OUR COMPANION

We investigated two major competing theories on the process of memory retrieval: Spreading Activation (SA) [1] and Compound Cue (CC) [4]. In our opinion, these mechanisms complement each other. Hence, both are implemented in our companion agent, each effective under different episodic memory (EM) retrieval circumstances. The SA mechanism allows retrieval of related events, useful when the companion is trying to find an answer to a query or in storytelling context. This is analogous to memory association in humans' minds as we are reminded by similar events, in particular those closely related to previously experienced phenomena. In contrast, the CC mechanism allows retrieval of the most relevant event(s) based on the degree of similarity. Retrieval is performed by a comparison between a compound item (an event) and all items in the companion's EM, allowing the companion to recall similar but not the same events, hence permitting it to perform more accurate prediction or evaluation of the current situation and react accordingly based on previous similar experiences.

The FAtiMA-PSI architecture [2] has been used as the foundation for the implementation of the EM retrieval mechanisms. Briefly, our companion's memory is made up of a semantic and an episodic memory (EM), each further divided into short-term and long-term components. Each entry in the short-term EM represents an event that has attributes such as *Subject, Intention, Action, Target, Location* and so on. Only significant events (events with emotional impact and events related to goal processing – activation, success, failure) are consolidated into long-term EM in which the events are organised into episodes.

In order to allow retrieval using the CC and SA mechanisms, the companion's EM events are assumed to be nodes that are associated with one another via attributes forming a network. The higher the number of commonly shared attributes between two nodes, the more related are those nodes. These relations between nodes form associative pathways between them. Similarly, associative paths are also formed among attributes in each node. Each attribute has a strength associated with each link, which in the current implementation is a function of its frequency of occurrence (refer Figure 2). These values are strengthened through use.

2.1 Compound Cue

In order for CC to be carried out, each event is treated as a compound item. The similarity between events is proportional to the number of attributes they share. The CC mechanism works through comparison of an event (usually a new incoming event) to existing events in the companion's EM. For example, using the memory snapshot in Table 1, if an event, say *Node X: "John Play Game Evening StudyRoom"* occurs, the CC will match this event against all events in its memory and find that Node 4 has the highest similarity as shown in Figure 1. The numbers in brackets beside the text in rectangular boxes are the numbers of matches. It can then use this event to predict what will or should happen next in the interaction. For instance, if it happened before that John played game until he forgot the time and as a result missed an appointment, then, the companion may try to remind John of any upcoming appointment he might have.

Table 1: Some example events in the companion's EM (simplified for explanation purposes)

	Subject	Action	Target	Time	Location
1	John	watch	TV	Afternoon	LivingRoom
2	John	read	book	Afternoon	StudyRoom
3	John	watch	TV	Morning	LivingRoom
4	John	play	game	Afternoon	StudyRoom

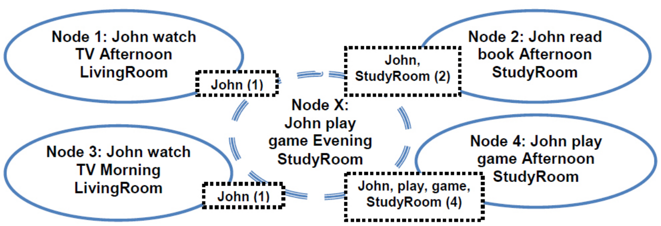

Figure 1: Compound Cue matching in the companion's EM

2.2 Spreading Activation

Applying the SA mechanism, when an attribute in the memory network is activated, activation spreads along the associative pathways to related attributes and nodes. The activation spreads based on attributes known to the companion (when the companion is searching for answer to a query) or predefined rules (when the companion wants to retrieve related information for narrative purposes). Currently, only the spreading based on known information is implemented. For example, let's say it is afternoon now and Jenny is looking for John. She asks the companion if it knows where John is. The companion can "spread activate" through its memory to find an appropriate answer. The known attributes are *John* and *Afternoon* while the query is *location*. So, it starts with *John*, activating node 1, 2, 3 and 4 in Table 1. It then continues to *Afternoon*, deactivating node 3 as it does not satisfy the query requirements. Thus, only nodes that satisfy a preceding phase proceed to the next phase. The next step is to find the *location* of John and since *LivingRoom* is returned with frequency 1 and *StudyRoom* with frequency 2, the companion will chose *StudyRoom* as the answer to Jenny's question as shown in Figure 2.

Besides finding answers to explicit queries from the user, the companion can use the same mechanism to perform implicit spreading. For instance, if the companion needs to remind the user to take his/her medicine and the user is not in its current location, it can implicitly spread activation in its memory to find the user's most likely current location. Based on this information, it may then proceed to look for the user.

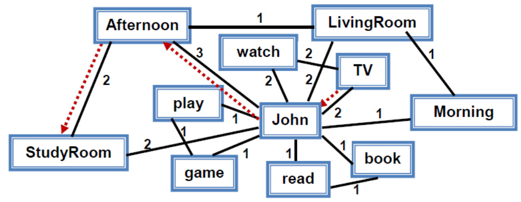

Figure 2: Spreading activation in the companion's EM

3. CONCLUSION AND FUTURE WORK

From the discussion in this paper, it can be observed that through Spreading Activation and Compound Cue mechanisms, the companion will be able to handle a wider range of situations where no exact previous experience existed. With the implementation of the Compound Cue mechanism, the companion's retrieval capability has been extended to the recall of similar but not identical events. This enables the companion to retrieve relevant events that may help it to predict and respond to the current situation more accurately. It can thus react appropriately under different circumstances. The Spreading Activation mechanism on the other hand, allows the companion to form associations between events in its episodic memory and make necessary inferences to achieve a goal.

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