MAY: my Memories Are Yours

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Abstract. In everyday conversations we constantly share not only experiences but also memories. This type of behaviour is important to maintain relationships with our peers and it is grounded in cognitive features of memory. Aiming at creating agents that sustain long-term interactions, we developed MAY, a conversational virtual companion that gathers memories shared by the user into a three layer knowledge base, divided in Lifetime Periods, General Events and Event-Specific-Knowledge. We believe that its cue sensitive structure increases agent adaptability and gives it capabilities to perform in a social environment, being able to infer about the user's activities. We evaluated interactions with the system to measure if the agent's knowledge is temporally grounded. Results also suggest that our approach enhanced two of the five dimensions of a friendship questionnaire: intimacy and companionship.

Key words: virtual companion, autobiographical memory, shared memory

1 Introduction

In human interactions, memory is fundamental to hold up conversations and to sustain long-term relations. Without noticing we constantly choose from our memories of experiences the best fit for the current situation, either to make a decision or to communicate with other people. Fiedler et al [9] emphasize that an individual's older knowledge interacts with new input information, acknowledging its impact in social environment.

During social interactions people exchange facts of their personal experiences, commonsense or acquaintance of each other's lifes, and such facts are essential to enrich and carry out a dialogue. Schank [23] refers that the mind can be considered a collection of stories or experiences one has already had. And as stories constitute our knowledge, our intelligence is the ability to use that experience and reminding is the process that make it all work together.

The importance of memory in agents is undeniable and many researchers have recently focused their agents' architectures on its relation to long-term believability[13]. In artificial companions systems, particularly episodic memory based architectures, are believed to be essential [26,16,11,19], as they aim to reflect the agent's experience. More recently, Ho et al [12] emphazise that

Autobiographical Memory(AM), can increase believability of intelligent agents, thanks to its capacity to increase agents' adaptability to the environment or new situations. This suggests that if we want to create more pleasant and acceptable agents to users, capable of carrying on with more engaging interactions [10] and consequently maintain the relationship for a longer period of time, we need to consider the memory aspect.

Aiming at creating agents that sustain long-term interactions with humans, we focus on mechanisms to retain, over multiple interactions, shared information. This is, stories of experiences that the user had told to the agent. Artificial companions capable of indexing user's "experiences" in their memory and at the same time able to show aquaintance of user's life, are likely to lead to the development of attachment. To try to achieve that goal, we have explored an AM architecture suggested by M.A. Conway [7].

Our purpose is to exploit whether the level companionship between the user and agent through a conversational interface correlates with the memory model or not. It is also of our concern, if the collected facts of user's life, in past interactions, are recognized as experiences of the self and memories of the agent. That means, the agents' behaviour is recognized as intentional and temporally grounded [10]. As such, our purpose is to exploit if MAY, an agent capable of shape its memory for user's events, can provide appropriate responses using that knowledge and influence the *'feeling of familiarity'* between them.

This paper is organized as follows. First, we discuss some work in the area of companions system, as well as, the recent research on memory architectures. Next, we present some background on memory cognitive features, particularly the Conway's view. In section 4, we describe the AM architecture implemented and we present a brief example of how the information flows within the system's components. Following this, in section 5, we present the results of a between-groups study in which participants analysed interactions of a fictitious character with the system, under two different conditions. Finally, we will discuss the obtained results and present some future work.

2 Related Work

The area of intelligent agents that act as companions is fastly growing. An example is LIREC[1] and COMPANIONS[2] projects, which focus is creating technology to support long-term relationship between humans and computers. Most artificial companion systems, so far, have focused on capturing the user attention by endowing the agent with empathetic behaviour [3] and robust dialogue capabilities[25]. Although they already have some social skills, however they lack from believable memory mechanisms, which result in a limited engagement with the agent over long periods of time.

Studies show that autobiographic memory (AM) in humans empower the integration of the past in the future. Agents endowed with such characteristics

[1] http://www.lirec.org/
[2] http://www.companions-project.org/

would be able to form social relationships due to AM flexible nature. To step forward in creating more user adaptable agents, research has been carried by others in the autobiographical memory field.

Some memory architectures for Artificial Life companions have been previously developed and evaluated by Ho et al[14]. The architectures capturedmodels from research in psychology: Short-Term Memory(STM), Long-Term Memory(LTM), Purely Reactive (PR) agents (agents that do not remember past experiences)and also LTM with events classified positively or negatively. The carried simulation showed that AM outperform PR memory models, and also that LTM with significant events improved agents performance and chances to survive in a dynamic environment.

In following studies [12], was defined AMIA (Autobiographical Memory for Intelligent Agents) framework – an autobiographical knowledge base of significant events sensed by the agent, based on psychological models suggested by M.A. Conway [6]. Inspired in this framework, Ho et al. [15] integrate a simplified AM (based only on episodes) into an agent architecture capable of experience emotions that was embedded on FearNot! application - an educational anti-bullying software. Preliminary results of this ongoing study showed that the agents are capable now of converting the memory contents into agents' 'life story' [13]. Recently, [26] emphasize the need to develop generic memory architectures capable of deal with complexity, independent of the future use of the system.

A different approach was taken by Mei Yii Lim et al [17], where an initial prototype for a social companion generic memory was developed. The aim was to create mechanisms reflecting human memory characteristics to allow companions to identify, characterize and distinguish experiences[11]. The main aim of this research was to accomplish the maintenance of a long-term interaction focusing on adaptability to preferences and to the environment. Additionally, the model includes forgetting mechanisms not only to discard information no longer useful, but to also address privacy issues, that is, retaining information that cannot be said/showed in some circumstances.

The mentioned autobiographical mechanisms have showed several improvements in intelligent agents, yet they have not been tested in convertional companions systems, in which AM dynamics might improve reasoning skills in real-time. Further, none of the these systems considers the creation of a "shared" memory element, but concentrates more on the agents' biographical memory.

3 Memory's anatomy

Usually we say that memory is the mental faculty of retaining information about stimuli of some sort when those stimuli are no longer present, the term is also used to refer the contents of a storage system rather than the system itself [21]. Oppositely to what we are tempted to think, human memory is not just one system. Humans have multiple memory systems to respond differently to diverse kinds of information and give the illusion of a single mechanism.

Focusing on long-term memory, it can be distinguished between explicit (or declarative) and implicit (or non-declarative) memory [2]. Explicit memory can be divided into two separate systems as Tulving [27] proposed, episodic and semantic memory. Semantic memory registers and stores information about the world and makes it available for retrieval. It is knowledge about the society and way it functions. Like, for example, knowing that Paris is the capital of France or knowing the spicy taste of a chilli pepper. Differently, episodic memory is oriented to the past and is purely 'what' happened 'where' and 'when'. A memory system for personally experienced events in a subjective space and time.

In Conway's [7] view , episodic memory is seen as a system which contains sensory-perceptual details of recent experiences, and those memories only are retained in memory when linked to a more permanent type of memory – *autobiographical memory*. Autobiographical Memory (AM) persists over long time periods and retains knowledge of the self at different levels of abstraction. In his perspective, episodic memories coupled with one's beliefs and attitudes, form conceptual autobiographical knowledge. In other words, autobiographical memory can be seen as "semantic knowledge" about one's life, retaining knowledge about progress of personal goals, a 'life story'. According to [7], "semantic knowledge" has three levels of specificity :

Lifetime Periods can be seen has temporal and thematic knowledge. Often those periods last for years, for example "When I was at school" or "When I was 15", and can be grouped by themes. Themes consist in outstanding situations in a higher abstraction view, such as "relationships" or "work".

General events are linked to life time periods and cover single events that could last for few days or months, for example, "vacations in Italy" or "study for algebra exam".

Event-Specific Knowledge (ESK) Detailed information concerned with a single event.They are often accompanied by "images that pop into mind" and have the duration of seconds or hours.

Neisser[20] claims that the social function of AM is the most fundamental. Individuals always talk about the past and *share* their experiences when others are no present at the original event [1]. The *memory-sharing* [1] process is influenced by responsiveness, that is, listeners make empathetic and contextually grounded responses to what the speaker is saying. Not only memory-sharing enhanced believability of conversations, as serve engagement and intimacy in relations [4]. Talking about the past (*sharing*) it is the process by which autobiographical memories are socially construted [22].

4 Conceptual model for *Shared Memories*

According to M.A. Conway[7], autobiographical memories can be seen as mental constructions generated from an underlying knowledge base (or regions), which are sensitive to cues, and patterns of activation. Autobiographical memories contain knowledge at three levels of specificity: *Event-specific knowledge (ESK)*, *General Events* and *Lifetime periods.*

While *lifetime periods* identify thematic and temporal knowledge, *general events* are related to actions, happenings and situations in one's life. *ESK*'s details are contextualized within a general event that in turn is associated with one or more lifetime periods, linking self autobiographical memory as a whole (see Fig.1).

In this section we explain how we have mapped these concepts onto a virtual companion's memory system as a way to capture factual and emotional events experienced by the user.

4.1 Structure of the knowledge base

Knowledge base's architecture is like a small ontology of semantic relations, which describe the main cues for triggering one's memories. As Conway[7] and others researches refer, anything can be a cue. In our model we only considered cues that could be represented by text and syntactically inferred from it.

Based on theoretical concepts[7], the memory is constructed in three independent levels, using RDF. The underlying structure of this framework is a collection of triples, each consisting of $< subject, predicate, object >$. These triples are organized in graphs. With this way of representing the information, we have a simple data model for inference.

The knowledge base consists of 3 subgraphs, each one representing one level of specificity (Figure 1)- lifetime periods, general events and ESKs. They act as specific views the knowledge base and all graphs(levels) are interrelated, yet can be evaluated separately.

Base level - memory line This level tries represent ESKs. The main idea is to capture a timeline over which the details of memories are stored, in other words, for each chronological position we have a node linked by a predicate to text objects. These objects are the associated details of the memory. The predicates are date, text (the personal description of the experience), image, and sound, and they allow the retrieval of one memory at the less abstract level.

Middle level - general event General events capture the main action of one memory and allow retrieval by small pieces of text syntactic inferred from text. They are "what", "where", "when" and "who". The edge "when" links to a different and more detailed object than the predicate "date" in the level below. It could have a string related to the time of the day. Further, a general event can be within one or more lifetime period, thus an edge should be included to this feature. For example, the event "Holiday in Rome with Sam" can linked to the lifetime period "Year 2008" and at the same time "Relationship with Sam", because it was an event that happenned during these periods of life.

By definition general events can be linked to other general events creating mini-stories. In this model, this view of memory will be represented by linking events that have the same context. For instance, the general event "Holiday in Rome" (master event) can be connected to other events like "Visit to the coliseum" or "Lunch in Vatican".

Top level - lifetime period For any given chronological period there may be a number of lifetime periods, which probably overlap in time. That is why, as M.A. Conway describes, thematic knowledge is associated with temporal knowledge to index different parts of the memory and fix the overlap problem. The lifetime period graph is organized by context or theme, this is, a generic concept that specifies the content of a lifetime period. For example, the theme "School" may comprise lifetime periods like "primary school", "high school" and "university". Each node in the graph is a lifetime period inserted into a context, which have a bidirectional link to a general event.

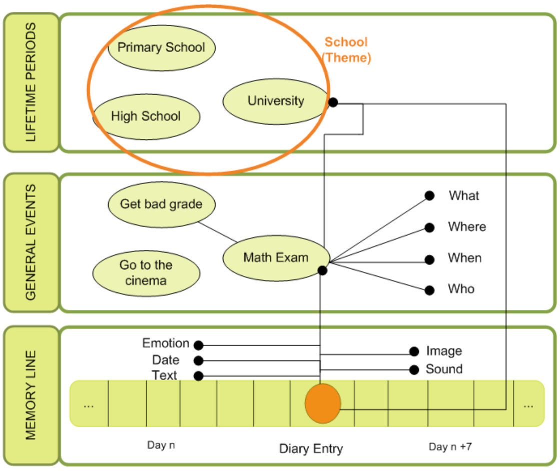

Fig. 1. Agent's Memory System

5 Assembling MAY

The model just described was embedded in the design of a virtual companion agent MAY(my Memories Are Yours). MAY is an agent created to assist a teenager user on self-reflection and daily companionship about what happens in his/her life. The interaction between MAY and the user is through dialogue. The dialogues allow the agent to collect user's experiences and save them in a diary form (or a timeline).The memories stored in MAY constitute a kind of "shared memory" between MAY and the user. MAY is like an *affective diary* [24].

5.1 How it flows

Fig. 2. Screenshot of MAY's interface. In blue is accentuated a relevant event to retain in memory. Highlighted in green is a user's utterance refering to the event in blue.

Figure 2 shows a screenshot of a chat like interface during an interaction between a user(Amy) and MAY. At the bottom stands one can see the *Memory Line*, which represents the base level of the memory hierarchy. Each cloud represents an entry in the 'diary'.

The interaction is text-based and all the information extracted is syntactically inferred from it. When the user introduces the sentence "I went to the cinema with Lyam" the system recognizes the verb (to go) as relevant, and proceeds to encoding the experience's memory (Fig. 3). This event is encompassed in three overlapped *Life Time Periods*(LTP) – (1) dating with Lyam, (2) 18 years old and (3) the year of 2010. The last two refer to more general and broad periods of time that are common in memories' division in all people. The first is personally meaningful and activated by the participants (who) in the event.

Those LTPs are linked to the event 'go to the cinema' that is indexed also by 'who', 'where' and 'when'. The normalized date is computed and the event is connected to the memory line along with the introduced text (personal description of the event), and the image (the displayed camera indicates that an image was attached to the event, like a visual representation of the memory).

The utterance, "The film was really great! Leonardo Di Caprio plays a great role", does not have an inherent (relevant) event. However, the system verifies if two sentences in different lines of dialogue are somehow related using ConceptNet's (see next section) analogy mechanisms. Thus, as "film" and "cinema" are significantly related to each other, the text of the event is actualized. Note that the sentence does not have any other aspect relevant to the event.

The levels are interrelated, but they also operate separately, this memory can be accessed by one of the three LTPs, by date, by who, where or the event itself.

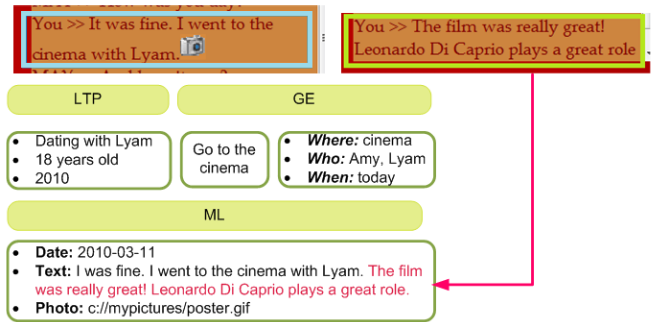

Fig. 3. Example of the encoding process. The event and its details are organized in the three levels of abstraction

5.2 How it works

The system architecture in shown in Fig. 4. This model is composed by four main modules: *Autobiographical Memories*, *Data Analyser*, *Agent's cognitive features* and *Dialogue Kernel*.

Autobiographical Memories Module accounts for the shared memories between agent and user and was explained in detail in the previous section. It is worth notice, however, the sub-model - active goals. It refers to the future events, that the user set as a possibility or a scheduled event in his/her life.

As the user writes a sentence is given to the *Data Analyser* responsible for extracting the event descriptors - what, when, where, who - and the event itself. This work is accomplished using a *Natural Language Module* and a *Knowledge Base*, which up to now, have tools to map human-time into a normalized form. Not only are these tools capable of recognising named time entities, but also recognise broad periods of time like life time periods (sometimes with undefined limits), hich are frequently personally meaningful.The normalized data is then transferred to the *Event Processor* responsible for saving relevant events into the AM module respecting its hierarchy levels. If the event takes place in the future is saved, with the same structure, into the active goals set.

When an event is created the *Agent's Cognitive Module* 'senses' if any internal stimulus arose a pattern in data. This is, if any pattern was activated by one of the possible cues attached to events. It enables three views of data:

Tracking goals is responsible for process the events 'suspendend' in the active goals set. The agent's notion of time enables it to know when a goal has already occurred and starts the process of encoding or definitely erase it from memory. This is done using user's feedback when asked about the specific situation.

Virtual Sensing view determines when some sentence or resulting event, has missing data. Then the agent verifies if has enough information in memory to take an assumption about it and that belief is transferred to the Natural Language Adaptor to be transformed in output (as a question).

Forecast view is a pro-active behaviour and it is used to carry on with the dialogue. It uses patterns of information based on date and day of the week to infer common events in user's life and generate responses consistent with agent's beliefs. All the results generated by the cognitive module are transferred to natural language adaptor. The data is normalized into a format that 'fits' the dialogue scripts structure.

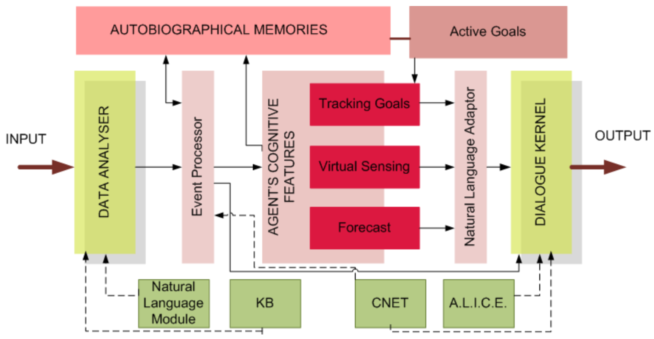

Fig. 4. System components and information flow

The *Dialogue Kernel* uses a modified version of A.L.I.C.E[3], an engine that uses AIML (Artificial Intelligence Markup Language) to create responses to questions and inputs. The dialogue is pro-active and adapted to the main goals of a teenager user – school, love and play. The agent leads the dialogue through a set of states to get specific responses from the user (like a diary), but at any moment the user can take turn and change the subject for whatever it likes. To preserve situations of which the agent does not have an appropriate answer, we use ConceptNet to endow the system with dynamical capabilities to adapt to unpredictable input. ConceptNet is the largest freely available, machine-useable commonsense resource [18]. It aims to create a network of relationships, which represent the facts that each of us know about the world [8]. It is used essential to find relations between concepts (words) in written sentences, to relate events and to produce 'intelligent' replies to the user and conduct the dialogue.

[3] http://alicebot.org/

6 Evaluating Memories in Memory

We conducted a experiment to evaluate if is perceived some sort of relationship that the agent can establish with the user. To do that we used a friendship questionnaire to measure the quality of the relationship. The results showed that when the agent manifests acquaintance about the user's life, even little details of common events, the users classified more positively the *intimacy* and *companionship* dimensions of friendship. These outcomes corroborate Nelson argument about how the social function of the sharing process contributes to development of intimacy and consequently maintenance of a relationship. For more details please see [5].

7 Conclusions and Future Work

This companion prototype enhances some social aspects possible by having a memory structure capable of indexing user's memories of experiences. Its functionalities and its efficiency on retrieval gives the agent the ability to perform in a social environment. We explored how acquaintance about one's life can influence positively a relationship and we introduced such characteristic into a conversational companion. Yet, this memory structure may offer many others possibilities that can be explored in future work. For instance, the use of previous knowledge to make more complex analogies and more informed forecasts.

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