Agents that remember can tell stories: Integrating Autobiographic Memory into Emotional Agents

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ABSTRACT
For the past few years many new applications are being developed featuring interactive environments populated with autonomous virtual agents capable of *acting* according to their goals, beliefs and even social relations. Such agents must be able to interact with each other, and more importantly with the user, thus involving the users in an engaging narrative experience. To achieve these, in this paper we describe the essential event structure in an autobiographic memory, event reconstructions in memory retrieval process and the influences of such past events in interpersonal relations.

Categories and Subject Descriptors
I.2.0 [**Artificial Intelligence**]: General – cognitive simulation;
J.4 [**Social and Behavioral Sciences**]: Psychology.

General Terms
Algorithms, Design, Human Factors.

Keywords
Autobiographic Memory and Agents, Believable Characters, Emergent Narrative.

1. INTRODUCTION[1]
Interactive storytelling systems aim at providing virtual environments that make the user feel part of the story. Several approaches to the problem of creating interactive storytelling environments have been investigated over the years, in particular the character-based approach [1] [2] where such environments are populated with virtual agents capable of acting out a story. However, due to the fact that the user's interaction is more or less unpredictable, these characters' behaviours should not be scripted nor completely predetermined. If agents are supposed to exist in virtual environments during long periods of time, interacting with users over these periods, they need to be able to remember past events, reshape their actions accordingly and interact with the user with references to previous memories. Furthermore such memory awareness element should be noticeable through the agent's explicit capability of talking about such events, and the agents' behaviour must reflect the changes in interpersonal relations toward other characters.

This work addresses this problem by exploring the integration of autobiographic memory into an already existing agent architecture that provides the autonomous agents the capacity to experience emotions, and behave believably accordingly to a consistent personality. The application, FearNot! presents episodes where the characters interact with each other, allowing the story to emerge from their interaction. Users, usually children, interact in the environment by watching narrative episodes unfolding as the result of the actions of the synthetic characters. After each episode, the user can interact with one of the characters. At that point the agent is able to summarize what happened previously, thus contextualizing the episode occurred. The user can then give him suggestions on how to cope with the problem, and see the result of his advice on a subsequent episode.

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[1] A demonstration of this system will be available to be shown at the conference.

2. COMPUTATIONAL AUTOBIOGRAPHIC MEMORY
As our agents become part of virtual environments sustaining long term interactions with human users, memory becomes an essential component of the agent architecture. As such we have enhanced the previous emotional agent architecture [3] [4] with a computational autobiographic memory [5] [6] containing the following key features:

- Agents have not only semantic knowledge of the world, which is provided directly from the perceptions of world properties, but they also remember episodic events kept in their autobiographic memory.
- Each event remembered in an agent's memory has a level of significance to the agent, which is represented by the encoded emotional intensity associated with that event. The level of significance is mainly used for representing the priority of an event during the ranking process.
- Event reconstruction takes place in the memory retrieval process. As a result, a context-dependent memory schema is generated when an agent tries to remember events in its

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memory in each situation.

– Autobiographic memory is also used for generating summaries of "personal" history when an agent is interacting with the user. We believe that if agents can actively tell their own summarised experiences as stories to the user, they will be more interactive and believable.

2.1 Event Structure

Inspired from the research on narrative structure in life stories for humans [7], the knowledge structure representing each event in the computational autobiographic memory has three main components: Abstract, Narrative and Evaluation.

In order to describe each of the components we use an illustrative example. Figure 1 shows an example of an event stored in one of the character's memories (the character is named John). The abstract of an event stores a summary of the event containing the most relevant actions and feelings from the narrative component. The actions associated to the highest emotional intensities are the ones selected to build the abstract. In this example, the abstract contains the most relevant event to John, which corresponds to being pushed by Luke and falling which caused him to feel very bad. Therefore, the abstract of a given event for an agent corresponds to the situation (Details and Feeling) that has the strongest emotional impact to itself.

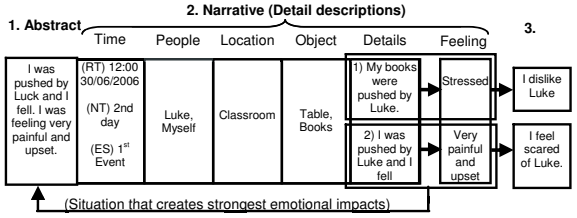

Figure 1. Details of the sample event 1, constructed under an episode where an agent (Luke) hits another agent (John)

Finally, the last component of the autobiographic memory is the evaluation. An event's evaluation corresponds to the agent's psychological evaluation of the effects of remembered actions according to the agent's social relations, i.e., this essentially shows the action's consequence(s) in terms of inter-personal relationships remembered in an agent's memory.

2.2 Event Reconstruction in Memory Retrieval Process

By remembering past significant events, agents are able to generate summaries of relevant events from autobiographic memory thus giving active responses when interacting with users. To achieve these, a simple event reconstruction process will be implemented to form a memory schema which contains events taking place under a specific context in different periods of time. Therefore, memory schema generated from event reconstruction process is context-dependent.

The context acts as a *Search Key* for selecting relevant events to construct the memory schema, in which events are also ranked by their significance – emotional importance. For example, in FearNot!, useful words or phrases can be extracted by the text engine during the interaction session at the end of each story episode. Therefore one type of memory Search Key for schema reconstruction is text extracted from the user's suggestion such as "fight back", "tell someone (friends/teacher/parents)" or "classroom"; another type is generated by the system, preferably the character name, for agents actively generating stories before asking the user for help. The search key (e.g. "fight") is then used to retrieve related events (about physical aggression) that were emotionally significant for the agent.

2.2.1 Generating Summaries of Stories

When using autonomous agents to create stories that emerge from the interaction between themselves and the user, it is not possible to know beforehand all the events that might take place. Therefore an author cannot pre-script the interaction between the characters and the user. This interaction has to be handled by the agent himself that must remember past events, and respond to the user in a way that is consistent with them.

In a scenario where a character has to keep a dialogue with the user regarding past events, it is necessary for that character to be able to select the most important past events. These should then be used to summarize a part of the story whose content will reflect what was important to the character in the story accordingly to his personality.

Having applied the Event Reconstruction mechanism, agents with simplified autobiographic memory are able to generate a memory schema based on a specific context in a given situation. However, creating a story-like summary during the interaction session with users is another important process to realise the meaning of stories in the schema. We expect that it would be more believable to have some random factors influencing the process of summary creation, like humans telling the same story with slightly random contents and lengths. Therefore, an algorithm for constructing a summary of remembered stories randomly is applied here to pick-up contents from some narrative fields and to put them into text templates. These templates contain empty slots for contents randomly selected from the memory schema to fill-in in order to construct story-like conversations from agents to the user.

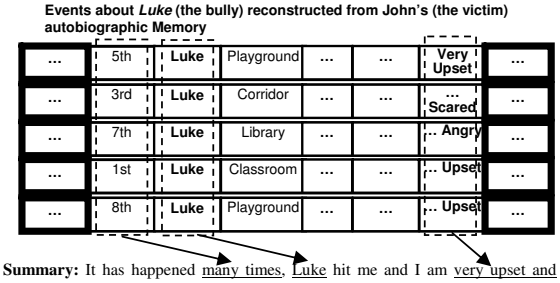

Figure 2. How a summary of the agent past experiences can be generated.

Figure 2 regarding the event reconstruction process. It roughly shows the process of summary generation using events in an agent's memory after the context-based memory schema is reconstructed.

Alternatively, an agent can generate a summary with a specific context to remind the user about events previously happened to him/her. This reminder can encourage the user to give a more appropriate suggestion to the agents. See Figure 3.

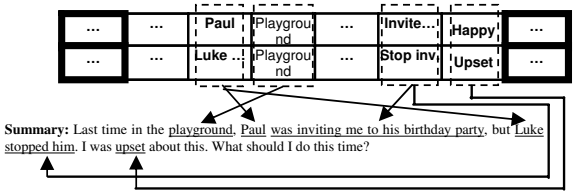

Figure 3. How an agent actively generate a "personal" narrative from its memory.

3. DISCUSSION

Figure 4 shows a screenshot of captured actions and their emotional impacts in an agent's autobiographic memory. These actions are narratively structured, as described in Section 2.1. They are actual events broken down into basic units experienced and remembered by each agent for having impacts on goal processing as well as generating stories to the user during the interaction session.

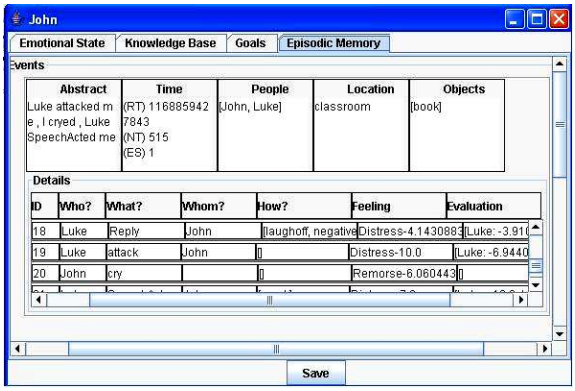

Figure 4. A screenshot of narratively structured contents from an agent's autobiographic memories (John).

With regards to our previous emotional agent architecture, it was impossible to distinguish between events that just occurred and events which the agent experienced a while ago. With the integrated autobiographic memory, there is now a clear separation between different types of information, e.g. events and related actions are stored in this memory, and world properties and agent relations are stored in the knowledge base.

Previously FearNot! agents were influenced by the way they were parameterized. It was up to the author to create the personality of these agents by defining the agents' goals and personality traits which caused them to perform in a way that were in accordance with the author's intentions when they interacted between themselves and with the user. With the implemented autobiographic memory, we believe that agents have been transformed into "good actors" – they react to different situations in stories with appropriate emotional expression *not* based on a fixed group of parameters for instructing agents to "act" in a particular situation, but with more realistic and flexible experiences to shape their "personality". This approach thus 1) allows for the creation of agents which can be "born with" certain types of personality for role-play stories, e.g. via an authoring tool, each agent is generated with certain cohesive autobiographic knowledge to enhance its readiness for acting a specific role; and 2) supports long-term development of virtual actors as they gain new experience from acting in each new situation.

4. CONCLUSION AND FUTURE WORK

In this paper we developed a computational autobiographic memory and integrated it into the emotional agent architecture in FearNot!. With this memory, agents are capable of recognizing and ranking significant events which originate in the agents' own experiences, thus we expect that agents' believability can be increased and the system's interactivity can also be improved.

After the implementation of the enhanced agent architecture we showed in this paper, in early 2007 we plan to carry out an evaluation for validate the design of the computational autobiographic memory in local primary schools. Children whose age is from 9 to 11 in these schools will be invited to use FearNot! twice – agents without autobiographic memory at the first time and with it at the second time.

5. ACKNOWLEDGMENTS

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