A Discussion of Interactive Storytelling Techniques for Use in a Serious Game

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Abstract

This report addresses a collection of interactive storytelling systems to provide an overview of state-of-the-art methods of narrative management and of enabling social interaction between users and virtual agents. This is done to inform the construction of a social cues and training demonstrator (a serious game) that enables its users to improve their social behaviour. In this report, a distinction is made between strong story and strong autonomy approaches to narrative management. The former rely on central management of the narrative through drama managers, not giving their agents much freedom. Inversely, the latter focus on the autonomy of agents, without explicit top-down control over the narrative. The autonomy of such agents allows an unscripted narrative to emerge from the user's interaction with the system. The trade-off between a strict storyline and freedom of action in these approaches is called the narrative paradox.

It is concluded that a strong autonomy approach can feature social behaviour of agents more easily than a strong story one, because it is inherent with this approach that its agents have more complex models. For the demonstrator, some control over the narrative is required to let its users reach given goals in the created scenarios. Therefore, our future work will focus on creating a hybrid approach that enables agents to direct the story autonomously.

Keywords: interactive storytelling, serious games

1 Introduction

This report was written as a deliverable for one of the projects of COMMIT,[1] namely Interaction for Universal Access (IUA). IUA is dedicated to the construction of technologies that let people use both verbal and non-verbal communication in human-computer interaction. One of the deliverables of IUA is a mixed reality training environment that incorporates social behaviour in users' interaction with the system. This report discusses several *interactive storytelling systems* (ISSs) in order to gather techniques for use in this training environment or *serious game*. By implementing interactive storytelling techniques in conjunction with virtual agents that can interpret and respond to social signals, the serious game will feature a realistic environment in which users can train their own social behaviour.

The main goal of interactive storytelling is moving away from the usual linearity in stories by enabling the receiver to influence the narrative. This effects a change in the role of the receiver as he interacts with the narrative instead of merely 'consuming' it passively. By giving a user of an ISS the freedom to interact this results in a larger variety of experiences

[1] See http://www.commit-nl.nl for a detailed description.

than that arising from one linearly authored story as he can progress through multiple storylines.

For our research, we focus on two aspects of ISSs, the first being the approach each ISS takes to enabling storylines that can be influenced by user actions while still delivering a meaningful experience. That is, we describe its way of keeping the story interesting or ascertaining that the user attains desired knowledge. Second, we detail the way in which each ISS implements social signal interpretation and generation, if applicable. The next section details the key subjects of this paper before turning to the various ISSs in section 3. Section 4 discusses the various techniques to determine which are useful for our research and lastly, section 5 provides a conclusion of this report.

2 Interactive Storytelling

At the basis of narratives, we have a small number of important concepts. First, there is the *story*, which is the chronological ordering of events and actions; these are connected by the *plot*, which is the underlying causal and logical structure of the story (Lethbridge & Mildorf, 2003).[2] The *discourse* describes the way in which the story is related, e.g., from whose perspective and whether or not it is in chronological order. Finally, the *narrative* is the conjunction of a story, its plot and a discourse.

Additionally, there is the concept of the *story arc*, which denotes the amount of *dramatic tension* during a story. Some ISSs discussed in the following section explicitly use a story arc to guide the narrative. The archetypical story arc was described by Aristotle, who divided stories into three parts: a beginning, a middle and an end. This idea was later revised by Freytag, who divided dramas into five parts: exposition, rising action, climax, falling action, and dénouement, as is explained in the discussion of Freytag (1863) by Lethbridge and Mildorf (2003). By exposition is meant an introductory state, wherein the reader is familiarised with the story's subjects. Rising action describes the events that occur and actions that are undertaken previously to the story's climax, while building the tension. The climax features the highest peak in dramatic tension. Thereafter, there is falling action, i.e., the decrease of tension by letting the main conflict unravel. Lastly, dénouement addresses the resolution of the conflict and the final release of tension. See figure 1 for a depiction of *Freytag's Pyramid*.

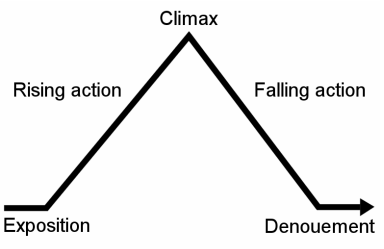

Figure 1: Freytag's pyramid.

While opinions disagree on the precise definition of interactive storytelling (IS), the basis of all definitions rests on the notion that a story can be *influenced* by its user (Murray, 1997). In this report, *interactivity* means having at least some control over the narrative. When a user is able to influence a world so that it responds to his doings—or seems to do so—he can experience the feeling of *agency*. This is the feeling that one is in control of a situation and can exert his will on the world to some extent.[3]

[2] Originally laid out by Forster (1985).

[3] Mateas and Stern (2003) distinguish between local and global agency, respectively denoting the experience of having short- and long-term reactions to one's behaviour.

The most basic example of interactive storytelling is that of presenting the player with a choice at a certain point in the narrative that decides how the story progresses. Extending this example, a story can be constructed that branches at several points, resulting in a larger number of storylines (Lethbridge & Mildorf, 2003). One caveat of this method of static decision points is that each storyline needs to be authored—instead of previously having written one narrative, an author now has to write multiple narratives. Because of this combinatorial explosion of storylines, this task becomes infeasible when a multitude of options is available.

An alternative to authoring every detail of each story is found in the concept of *emergent narratives* (Aylett, 1999). These are narratives in which the story is not strictly pre-authored, but "emerges from interaction between simple components" (Aylett, 1999, p. 84). When one interacts with such a narrative, it will evolve based on the taken actions, thus offering more storylines and possibly increasing agency of the user.

At the start of this section, the important concept of a plot was discussed. Linear stories always feature a plot over which their authors have complete control, yet in emergent narratives, an interesting plot is not necessarily guaranteed. Yet this should be the case, for else the story may become dull and the user may experience a lack of motivation to continue. However, including an explicit storyline contradicts the essence of an interactive storytelling experience because by specifying a plot for it, the user's control over the narrative has to be restricted. This may in term lead to a decrease in the user's agency. This trade-off between plot and freedom is referred to as the *narrative paradox* and is one of the key issues in IS. In the discussion of various IS systems in section 3, the approach of each system to overcoming this issue is described.

These approaches can be divided into two camps, viz. the *strong story* and *strong autonomy* approaches (Mateas & Stern, 2000). To explain these, the concept of virtual agents needs to be made clear. Virtual agents are autonomous entities in a virtual environment that observe and act on it. The focus of strong story approaches lies on maintaining a consistent storyline. If an ISS adopting this approach makes use of autonomous agents, a possible consequence is that they might exhibit inconsistent behaviour, because they are directed to strictly follow the story. The inverse is true for the strong autonomy approach, which gives the agents more freedom to carry out actions, but may result in a discordant narrative, i.e., one that is inconsistent or illogical.

Our research focuses on the inclusion of virtual agents to simulate social interaction for which they need to able to interpret as well as generate social signals. These can take on a verbal or non-verbal form, such as an agent uttering the phrase "Please don't bother me," indicating refusal to converse or having an agent change his posture to indicate that he does not trust someone. Attempts to create such *socially intelligent* agents have also been made in some IS systems; these are discussed in section 3 as well, where applicable.

One of the goals of our research is to implement these socially intelligent agents in a *serious game* which should also feature interactive storytelling. In a broad sense, serious games can be defined as "digital games, simulations, virtual environments and mixed reality/media that provide opportunities to engage in activities through responsive narrative/story, gameplay or encounters to inform, influence, for well-being, and/or experience to convey meaning" (Marsh, 2011). In our research, the serious game that will be designed is a virtual environment that lets players improve their social behaviour. One of the intended effects of implementing emergent narrative in this serious game is that the game can become more *immersive*, because the player experiences a higher degree of agency as his actions influence the narrative. Another desired effect of this approach is that the game's re-playability is increased as well by offering different storylines, lowering the need of explicitly authoring a variety of linear narratives for the game. However, the narrative paradox comes into play for the same reason as above. As each serious game has a definite learning goal, it should have an outcome in which that goal is satisfied in the player. Therefore, there needs to be some control over the plot of the narrative, guiding the player through the game. As said, this

may limit the player so that his feeling of agency diminishes. This calls for an approach that circumvents this problem—in the following section, each ISS's means to do so are discussed.

3 Interactive Storytelling Systems

This section addresses interactive storytelling systems (ISSs) that have implemented an approach to overcoming the narrative paradox or feature an implementation of social behaviour for agents. An overview detailing each system's specifics is presented at the end of this section in tables 1 and 2.

3.1 Façade

Perhaps one of the most well-known interactive storytelling systems is Façade (Mateas & Stern, 2003), a 3D 'interactive drama' which places the player in the role of a person visiting a couple (Grace and Trip) who he has not spoken in a while.[4] There is no concrete goal defined at the beginning of the game—the player can simply interact with the couple by talking to them through text input as well as by performing touch actions through mouse clicks. Mateas and Stern's goal was to create a narrative that evolves over time based on the player's interactions with the characters and the story world. For example, the player may ask the couple how they are doing after which they respond a little bit hesitantly that everything is okay. If the player decides to continue questioning them it may become clear that they in fact have some marital problems. Then, the player can choose to try to comfort them or to take sides in the ensuing discussion. There are no static points at which the player has to choose distinct options as everything happens continuously and the player is able to interrupt the couple when they are saying something.

Central to Façade's design is the drama manager, which manages the narrative progression. It does so by trying to mould the narrative so that it corresponds to a desired story arc such as the one of Freytag's Pyramid, as discussed in the previous section. The components it uses for this process are called *story beats*: instantiations of story situations, e.g., one in which Grace and Trip both ask the player what he wants to drink.[5] These beats have preconditions and effects that serve the purpose of partial ordering of a collection of beats. By sequencing beats based on their correspondence to the story arc, a narrative of the desired form emerges. Beats become (un-)available based on the player's actions, which are first translated into *discourse acts*.[6] These are abstractions of the player's actions, e.g., 'praising' or 'expressing anger'.[7] This happens through natural-language processing, which categorises the meaning of the player's action, after which a potential reaction is chosen based on the beat the story is in. In this manner, the player is able to influence the story's flow and outcome.

Each beat enables certain behaviour on the agents' behalves, for when the player seems to be expressing anger, Grace and Trip need to respond in a natural way. They can for instance react somewhat laconic and ask if the player really meant to react this way; or they can point him to the door if they feel they are tired of the player's behaviour. This behaviour is encoded in a large collection of *joint dialogue behaviours*.

Mateas and Stern note that although their framework enables an emergent narrative to be constructed, a large amount of effort was put into the creation of the characters' behaviours (Mateas & Stern, 2005). That is, responses to situations and utterances still needed to be authored and thus, certain situations had to be foreseen in order to do so. This is against the nature of an emergent narrative as there seems to be a narrative that

[4] Façade is available from `http://www.interactivestory.net`.

[5] A complete overview of the used beats can be found in Mateas and Stern (2005, p. 6).

[6] It should be noted that the 'discourse' meant in this context is the dialogue that is performed, not the way of representation, as in section 2.

[7] A complete list can be found in Mateas and Stern (2003, p. 12).

was constructed beforehand. Yet this is exactly where the crux of the narrative paradox lies, namely in the balancing of authoring beforehand—and thus specifying some plot or outcome—and the multiplicity of possible actions.

Summarising, Façade is able to let two agents interact with themselves and the player through a two-step process. First, the meaning of the player's actions is inferred by categorisation into discourse acts. Second, the agents are guided by a drama manager, based on story beats and a story arc. Thus, this approach can be labelled as a *strong story* approach. Social behaviour performed by the game's agents relies on the interpretation of the player's actions in the form of discourse acts.

3.2 Mimesis

Designed as a module for use in existing game engines, the Mimesis architecture is dedicated to the creation of narratives in games (Young et al., 2004). It takes responsibility for the generation of plans for the game and its agents by (1) enabling the creation of coherent narratives and (2) safeguarding that coherence when situations arise that deviate from the constructed plan. As such, Mimesis is also a drama manager, alike to Façade's implementation.

In Mimesis, narratives are first constructed as plans, which are triggered by plan requests that are behested by the game itself in the form of a certain goal or state the story needs to reach. Plan-construction is a three-stage procedure that consists of story world planning, discourse planning and execution management. Actual story planning is performed by the story world planner: a plan is composed that fulfils the given goal through use of available actions, based on a certain world state. In order to implement narrative techniques—for instance, background music or elements not directly part of the game world—that can be used for this plan, it is fed forward to the discourse planner, which combines the story world plan and its associated narrative elements. The last step in this loop is performed by the execution manager that constructs and monitors a directed acyclic graph of the complete plan. Each action that is to be carried out in the game world represents one node in the graph—when such an action is indeed executed, the corresponding node is removed from the graph. In this manner, the narrative advances according to plan.

In ISSs, it may be considered rule rather than exception that a player does not behave according to any pre-constructed plan. In this case, Mimesis tries to stay one step ahead of the player by detecting actions that may result in possible conflict with one or more steps of the plan.[8] Two approaches have been developed under the denominator *narrative mediation* (Riedl, Saretto, & Young, 2003), that either try to accommodate the plan or intervene, respectively circumventing minor and major conflicts. When the system tries to accommodate the player, an action of his that deviates from the constructed plan is carried out and the rest of the narrative plan is revised to account for conflicts of the action. Intervening on the player's action substitutes its expected outcome by one or multiple effects that do not threaten the constructed plan. Riedl et al. give the example of a player trying to purchase a beverage from a vending machine for which he inserts a coin. However, the coin was brought into the game for a different reason—therefore, the game intervenes and lets the vending machine produce an error so that the coin is not accepted and given back to the player in order to be used for its planned goal. It is important that the effects of interventions do not deviate too much from the player's expectations. For instance, if the same logical action (inserting the coin) fails to produce its usually expected effects (receiving a drink) again and again, this can lead to a decrease in the player's agency.

Narrative mediation has two limitations to its use. One of these lies in the recognition of exceptional[9] actions, because they may also arise as steps in a longer plan of the player and not merely as single constituents of one. In that case, exception recognition needs to expand

[8] More specifically, the action is recognised as being constituent, consistent or exceptional with or to the plan, for which the first two classifications do not pose any danger.

[9] In this case, 'exceptional' denotes an exception to the pre-constructed plan.

its search space in plans, which may result in feasibility problems. Second, intervention has only been designed to replace the effects of one action. Effort could be put in the construction of plans that incorporate more than one action as a substitute, possibly with the help of other agents. This could make the intervention more elaborate by making it seem more realistic. For instance, in the vending machine example from above, an agent may explain to the player that the machine is broken and guide to player to pursue a different goal that is more in line with the plot.

Just like Façade, Mimesis takes control over the story in a central manner, which makes it a strong story approach as well. Because of its abstract orientation on plans, Mimesis does not directly address any social behaviour for agents. Its design does not limit the implementation of such behaviour either, yet this is left to the parties responsible for the creation of the specific game in which Mimesis can be implemented. Narrative mediation seems a useful technique for coping with the narrative paradox, though its limitations imply some possible feasibility problems that have to be overcome before it can be implemented successfully.

3.3 IN-TALE

The Interactive Narrative Tacit Adaptive Leader Experience (IN-TALE) conjuncts the limited autonomous behaviour of Façade's agents with the incorporation of a drama manager alike to that of Mimesis (Riedl & Stern, 2006a). It does this by restricting the agents' behaviour to non-scenario specific activities (*local autonomous behaviour*, *LAB*) and letting the drama manager worry itself about scenario-specific actions (*narrative directive behaviour*, *NDB*). More concretely, an example of an LAB is an 'opening the store' activity, which consists of all the subtasks necessary to achieve its effect. NDBs describe more complex behaviour that is tightly related to a specific scenario, e.g., for a terrorist scenario, 'planting a bomb'. These behaviours are used by a drama manager in the same way that Mimesis used its story world plans in that they are evaluated before execution and checked for possible inconsistencies between the simulation state and the expected narrative. For each inconsistency, an alternative plan is created—Riedl & Stern note that feasibility problems can be overcome by performing the construction of these off-line. However, this only leads to a shift in problems as pre-constructing all possible plans would still lead to a combinatorial explosion of possibilities, hence the need for a dynamically constructed narrative. Thus, on-line computation of plans should remain the focus of this approach for it to be viable.

Further elaboration on the conflict between character actions and planned goals is carried out in Riedl and Stern (2006b), which describes agents that *fail believably*. To do so, the distinction between prescriptive and proscriptive directives is made, which respectively instruct agents which goals to pursue and which story world states to refrain from reaching. When an agent is prescripted to achieve something, it can either merge its current goal with the given goal; complete its current goal and continue with reaching the given goal; or it can abort or suspend its current behaviour and focus on the given goal. In case of the latter situation, an agent needs an 'excuse' in order to make this transition and still remain believable: a *transition behaviour*.

Proscriptive directives entail analysis of the constructed plans in order to check whether a conflicting situation arises as well as failing believably when a conflicting, planned action is inevitable.[10] A *restoration mode* serves as a safety net for the latter as the agent is given the ability to explain why it refrains from continuing performing a conflicting action. This differs from the above transition behaviour in that the agent already is in conflict with a directive.

IN-TALE's focus is on creating consistent stories and is therefore a strong story approach. Transition behaviours and restoration modes seem to be able methods to reach this goal. No specific implementation of social behaviour is discussed.

[10]The former is done through a 'plan synergy approach', see Cox and Durfee (2003).

3.4 Negotiation Training Systems Developed at UCSC

Research has been performed into so-called *tactical language training systems*[11] (TLTSs) in a long line of projects at the University of Californa, Santa Cruz (UCSC). These were all designed in the context of war training, thus resulting in a series of virtual reality demonstrators that have scenarios in which the player is required to negotiate with team members of his squad, civilians of other cultures and enemies in order to bring the game to a peaceful end.

The pedagogical goals of TLTSs can be authored in three different ways of which the first is including them in the world's dynamics. This can be brought about by making the pedagogical goals congruous with the explicit game goals, e.g., for a certain scenario, by requiring the player to establish a character's trust to progress through the game and by making it clear to the player that failure to do so will have its consequences. In other words, it can be done by designing the game so that the player is enforced to go about fulfilling his goals in a particular manner. Second, the agents' intentions can be assigned with the goal of letting the player learn something. Through reasoning about the player's mental model the agent can then infer how to act. Finally, an instance of a drama manager can watch over the proceedings and act on them when necessary, as in Mimesis and IN-TALE.

Negotiation can be defined in the EMotion and Adaptation (EMA) model of emotions (Marsella & Gratch, 2009) that describes how perceptions are *appraised* and *coped* with. That is, the possible effects of a plan are appraised, after which coping strategies are executed. The agents' responses are based on their current stance, e.g., open for negotiation or not, and dialogue state. Trust is an important factor in negotiation that can influence an agent's attitude; it is divided by Traum, Swartout, Marsella, and Gratch (2005) into solidarity, credibility and familiarity. Negotiation strategies influence which (non-)verbal acts of communication an agent performs. A few examples of such strategies are avoidance and disruption of negotiation and willingness to cooperate. The agents are able to produce social behaviour non-verbally by changing their posture or directing their gaze. For instance, if an agent wants to avoid negotiating, he holds his arms crossed in front of him and gazes away from the player. Alternatively, when he is willing to cooperate, he assumes a more relaxed stance.

The first of the TLTSs developed at UCSC was the Mission Rehearsal Exercise (MRE) project (Rickel et al., 2002). A demonstrator was created in which the player assumes the role of a lieutenant in an international peacekeeping scenario. In it, he can interact with three agents, viz. a sergeant and a medic on his team as well as with a local woman. The player's squad has been in a car accident with the woman and her son and it is up to the player to decide how to handle this situation. His squad needs to move ahead, but the woman needs to be comforted, because her son needs help after incurring injuries due to the accident. Thus, the player faces some choices on how to direct his team members which influence the outcome of the story. For instance, when he does not choose to offer any help to the woman and her son, the woman will start complaining and weeping. Alternatively, when he does offer help, his accompanying team may complain—obviously, a correct approach has to be found by the player by negotiating with the agents. The three agents in MRE were outfitted with emotion modelling that consisted of appraising the environment, goals and beliefs, after which coping behaviour directed how to act on those (Gratch & Marsella, 2001).

As a follow-up to the MRE project, the Stability and Support Operations Simulation and Training (SASO-ST) project was established (Traum et al., 2005). SASO-ST focused explicitly on negotiating with a single agent in a TLTS. This project integrated Thespian, an architecture designed to support the encoding of pedagogical goals (Si, Marsella, & Pynadath, 2005). It relies on PsychSim as a framework for the social behaviour of its agents (Marsella, Pynadath, & Read, 2004). PsychSim outfits agents with mental models that give them the capacity to reason about each other's behaviours and goals as well as about the effects of their behaviour on their relationship with other agents and with the player. This

[11] In this context, 'tactical language' means 'negotation'.

way, they can produce more natural, social reactions and plans. Traum et al. extended the Thespian architecture with four enhancements: appraisal of the negotiation; trust modelling; negotiation strategies; and behaviour explanation.

Moving on to a more complex scenario, SASO-EN (Extended Negotiations) (Traum et al., 2008) incorporated an extra agent into the simulation, thus forcing the player to bring a multilateral negotiation to a satisfactory outcome. This enabled more negotiation tactics, such as convincing one agent to cooperate, which would then help the player to convince the remaining agent.

Concurrent with the creation of and research performed in the SASOs, another TLTS called the Operational Language and Culture Training System was brought to life in a spin-off company of UCSC (Johnson & Friedland, 2010). This system was originally built on the PsychSim framework but discarded it in favour of one that was more manageable in terms of agent authoring. It adopts roughly the same approach as that of the SASOs, but as it is a commercial product, not much is published about its inner workings.

The discussed negotiation training systems focus on a domain that is comparable to the Interaction for Universal Access project. They incorporate both verbal and non-verbal social behaviour by agents and enable the player to respond verbally. The agents update their negotiation strategies dynamically based on trust in the player, which is influenced by his own responses throughout the narrative. Therefore, there is no pre-authored storyline—apart from the initial state of the story—yet a collection of possible responses, which may be called a form of emergent narrative. None of the TLTSs explicitly address the narrative paradox, although it is noted that the subjects the agents and the player talk about are limited because of the context of the game so that only a number of responses need to be generated or expected (Swartout, 2010).

3.5 FearNot!

Fun with Empathic Agents to Reach Novel Outcomes in Teaching (FearNot!) is a demonstrator devised for children to evoke awareness of bullying practices and to teach them how to cope with such behaviour (Aylett, Dias, & Paiva, 2006). The player assists the game's protagonist through different scenarios by giving advice to him after conflict with a bully. That is, there is no direct intervention by the player as the protagonist and the bully behave according to their emotions during these episodic conflicts. In each of these scenarios, the bully assumes a dominant stance and tries to overpower the protagonist, e.g., by inducing fear. If the player gives good advice to the protagonist, he may overcome his fear of the bully and stand up to him in successive scenarios.

FearNot!'s agent architecture (FAtiMA, FearNot! Affective Mind Architecture) enables agents, i.e., the protagonist and the bully, to be subject to emotions by implementing a subset of the OCC model, a framework for emotions (Ortony, Clore, & Collins, 1990). Most noticeably FAtiMA features hope and fear, both emotions with a temporal aspect which can influence the creation of plans. When an agent is driven by hope, he may become bolder and more optimistic, whereas fear may affect refraining from carrying out certain plans. Just as the EMA model from the above section, FAtiMA relies on the appraisal of and coping with events to generate emotions. FearNot! also incorporates intensity decay over time because of the dynamic aspect of emotions.

An important property of FAtiMA is that its appraisal mechanism is comprised of a reactive layer[12] and a deliberative layer, respectively accounting for instantaneous emotional responses (e.g., anger) and prospective ones (e.g., hope or fear).[13] The deliberative layer creates and changes plans based on the appraisals of every event it witnesses and checks what the effects are on the agent's goals. The same distinction between reactive and deliberative behaviour is found in the coping mechanism, in which reactive actions are triggered when

[12] Based on the Construal Theory of Elliott (1992).

[13] Aylett et al. note that the eventually generated emotion is also based on one's personality, but do not tread into much detail about this.

certain conditions are met. Deliberative reasoning takes the goal generating the strongest emotion, i.e., the dominant one, as it is assumed to be the most urgent one, and creates a plan that fulfils this goal. Then, the emotions of hope and fear are updated, as corresponding to that plan. In effect, these denote how likely the agent thinks his plan will succeed in conjunction with the effects on his own state. Furthermore, deliberative reasoning has the possibility to use one of three emotion-focused coping strategies: acceptance, acknowledging a plan failure; mental disengagement, lowering one's expectations of a plan; and denial, ignoring possible threats to the plan.

Because of the variety of actions the agents in FearNot! can perform, the narrative paradox poses a difficulty that is to be overcome (Aylett et al., 2008). Two approaches have been researched to manage the narrative, the first being inspired by *plot* or *way points* as in Weyhrauch (1997). The 'Story Facilitator' structures the narrative into different episodes based on the actions taken by the agents in previous episodes. This control is very high level and does not influence the agents in each of the episodes directly.

The second approach to controlling the narrative paradox implements a bottom-up manner, namely by designing the agents so that they are aware of the dramatic impact of their actions, which makes this a strong autonomy approach. This happens through a process called *double appraisal*, in which the standard appraisal as described above is carried out as well. Yet what distinguishes the two is that this appraisal is *re-appraised*, namely by analysing the effects of each of the actions. These are then rated according to their emotional impact after which the most dramatically interesting one, i.e., the one having the highest change in affect in all characters, is selected. This approach can be coined as *out-of-character thinking* (OOC).

As Aylett et al. acknowledge, the emergent story can be compared to a desired story arc, as Mateas and Stern (2003) did in Façade (see section 3.1). FearNot!'s Story Facilitator adopts the same approach as Façade in that they both make central decisions about the plot. However, out-of-character thinking manifests itself in a distributed form, which makes it a strong autonomy approach because the narrative relies solely on the characters.

What FearNot! & FAtiMA offer is an elaborate approach to emotional and social agent behaviour, much alike to the TLTSs discussed above. FAtiMA's unique property resides in the use of OOC thinking, which is completely distributed over the agents.

3.6 EmoEmma

An interactive storytelling system focusing on immersion—references to Star Trek's Holodeck^{TM} are not shunned—is EmoEmma, which was designed to be a virtual reality demonstrator for multi-modal interaction in a 19th century setting in which the player interacts with Emma Bovary (Cavazza, Lugrin, Pizzi, & Charles, 2007). It takes its subject-matter from Gustave Flaubert's novel Madame Bovary, in which Emma is a lady of blue blood who is fed up with her lifestyle and decides to run away. The game in question is mainly influenced by a few chapters in which she decides to have an affair with Rodolphe, another aristocrat. During the game, the player acts as Rodolphe and can interact with an agent representing Emma which does not have a concrete goal, but a set of feelings that it wishes to reach (Pizzi & Cavazza, 2007). This is in line with Flaubert's thoughts about the novel that the narrative should focus on feelings instead of on actions.

As stated above, EmoEmma incorporates some multi-modality, in particular player's voice and posture recognition. The game is played in a virtual reality environment with the in-game characters as large as the player. Physical interaction is limited to recognition of the distance of the player to the characters and whether or not the player is facing a character. A player can influence the story by (dis-)agreeing with Emma which leads to different outcomes. For instance, when Emma says that she "would leave everything behind for you [the player]", the player can turn his back to her which is recognised by the system and to which Emma responds by showing disappointment.

This ISS distinguishes itself from the previous systems in that it refrains from using the appraisal/coping mechanic for emotions and instead focuses on making the agents aware of their situation and letting them infer how to feel through a heuristic search planner. An example given by Pizzi & Cavazza indicates that the emotion of boredom can be recognised by determining the 'distance' of an agent to its goal. For instance, if there has been a lack of progression for some time, the agent will recognise this as boredom and will start to perform an action to overcome its boredom. This type of inference is performed by the interpretation operators, which update the agent's feelings. Agents have two other operators at their disposal, viz. character interaction operators, which modify another agent's mental state; and physical operators, which are used for physical actions. Each agent is motivated by its own feelings—there is no drama manager present, which makes this a strong autonomy approach.

The actual involvement of players in this multi-modal experience was evaluated in an experiment with two conditions (Lugrin, Cavazza, Pizzi, Vogt, & André, 2010), one in which the participant assumed the role of Rodolphe and was thus able to interact with Emma directly, the other in which the player was a 'ghost actor' who could influence the characters by manipulating the physical world and by influencing their thoughts through speech. The latter way of interaction is almost equal to that of FearNot!, the only difference being that in EmoEmma the interaction is continuous instead of interspersed between story episodes. The experimental conditions yielded an equal story length as well as an equal amount of user actions, signifying that they would perhaps be equally suited for further use in ISSs.

In essence, EmoEmma adopts an approach that is much more concerned with a "*narrative* description of characters' psychology rather than *cognitive* models" (Pizzi & Cavazza, 2007). That is, the behaviour of the agents conforms to narrative norms and expectations, but does not necessarily entail natural, real-life behaviour. This makes it suitable for story generation, yet less so for more realistic scenarios.

3.7 Crystal Island

Adopting a detective-style setting, Crystal Island is an educational 3D game in which the player tries to determine the cause of illness in his team of scientists (Mott & Lester, 2006). He does so by inspecting objects, witnessing events and through dialogues with agents. The latter do not feature social signals and are quite simple in nature as they are composed of the player questioning agents about an event or subject, after which the player is free to investigate further.

To construct a storyline with a logical succession of events, an architecture called the U-Director is used, which is designed to maximise the *narrative utility* of the story. This is described as the game aiming to give the player sufficient hints about where he should go next or what actions he should perform. These hints should not be overly explicit, else the player's feeling of agency may drop or the overall challenge of the game is lost.

U-Director's reasoning is based on *dynamic decision networks*, which are Bayesian networks extended with decision processes that incorporate temporal aspects. At each moment in time (a time slice), the U-Director keeps track of the plot progress and the narrative flow (the narrative objectives); the plot focus and the physical state (of the storyworld); and a model of the user's goals, beliefs and expectations (the user state). Effects of director actions and how they influence the narrative are calculated for the next time slice as well as the effects of possible user actions for the time slice thereafter—which is where the dynamic decision networks come into play. These evaluate the available actions to select the director action that enables maximal narrative utility after which the steps are repeated for the successive time slices.[14] This approach takes into account the narrative paradox by guiding the plot in a central manner; thus, the U-Director adopts a strong story approach.

[14]This is computationally heavy, yet approximate Bayesian inference algorithms are able to respond within 10 seconds (Mott & Lester, 2006, p. 983).

Work on the U-Director has been extended by an attempt to formalise a more complete framework for interactive narratives (Rowe, Shores, Mott, & Lester, 2010). Herein, adaptation is divided into three areas: plot-based, discourse-based and user-based. Plot adaptation can either occur directly, by manipulating the order of plot events and the manipulation of players goals, or indirectly, by introducing or removing virtual characters or modifying their internal state, modifying player abilities or by making rewards and incentives more explicit. Discourse adaptation may be done through cinematographic interventions and flashbacks and flashforwards. Lastly, user adaptation has a lot of possibilities, such as cognitive and affective support and tailoring the difficulty of the game. When faltering is detected in the player, new or corrected information can be presented or repeated. It is also an option to have explicit points in the narrative at which the player is obligated to reflect on his actions, possibly with the help of another virtual character. As this work has so far only been focused on the design of the framework with only a few preliminary implementations in the U-Director, few results are available as to its application.

Maximising the narrative utility seems to be analogous to making the storyline conform to a desired story arc. U-Director's approach to this is that the effects of possible actions are taken into account, which happens centrally as opposed to distributed, as was discussed in section 3.5 on FearNot!, where double appraisal was used.

3.8 80Days

The aim of the 80Days project was to design a framework to be used for educational games that is highly adaptive to their players (Göbel, Mehm, Radke, & Steinmetz, 2009). The 3D game that was designed puts the player in the role of someone helping an extraterrestrial life form to learn earth's geography and in the process of doing so, learning about its geography himself as well. The player undertakes several missions to complete this goal, which are adapted to his prowess.

In this project, emergent narrative was acknowledged to have the most potential for adaptivity because of its modular nature and its wide variety of possible story lines. As a guideline for the story, the 'Hero's Journey' structure is used, which denotes the archetypical progression of a story's protagonist as he is called to adventure, accomplishes a selection of tasks and finally completes the story in a climactic end sequence, after which an epilogue wraps it all up.[15] The middle part provides ample room for various sub-storylines and it is here that adaptation can be performed.

Adjustments to the narrative can be carried out on two levels, viz. on a micro level that implements assisting behaviour by agents and on a macro level that adapts the order of learning situations—both are based on the player's interaction with the game (Koidl, Mehm, Hampson, Conlan, & Göbel, 2010). In the 80Days framework, micro adaptivity relies on the use of the *competency-based Knowledge Space Theory* (Kickmeier-Rust et al., 2007), which asserts that prerequisite relationships exist between cognitive skills and the competencies necessary to master defined problems. These skills form a structure that can be updated based on a player's actions and successively be used to determine the player's progress. Based on this progress, micro adaptations can be carried out, such as letting agents, e.g., the alien, provide hints to the player when he seems unable to advance.[16]

The term *narrative game-based learning objects* (NGLOBs) was coined for atomic story units that serve the purpose of 'quests', if the Hero's Journey analogy is followed. These learning objects can be interpreted as enriched versions of Façade's story beats as those also denoted story sequences with particular (dramatic) impact. Each NGLOB has such a dramaturgic function, but additionally offers learning and gaming functions, which respectively denote which skills are covered and which type of gameplay is used. Furthermore, weights are attributed to each of these functions that denote their appropriateness. For macro adap-

[15] The 'Hero's Journey' follows the story arc of Freytag's pyramid (see section 2).
[16] For a more extensive list, see Kickmeier-Rust, Mattheiss, Steiner, and Albert (2011, p. 5).

tivity, the NGLOB that suits the player's behaviour best is chosen, which happens based on its described properties.

An experiment was carried out to evaluate the effects of adaptation on players' learning, in three conditions: the game with (1) micro & macro adaptation, (2) only macro adaptation and (3) no adaptation (Kickmeier-Rust et al., 2011). The experiment did not return significantly differing increases in knowledge between conditions, though, on average, the conjunction of micro and macro adaptation yielded higher knowledge scores than the absence of adaptation. Surprisingly, macro adaptation by itself resulted in somewhat lower scores than the condition with no adaptations. Yet because these results did not differ significantly, nothing can be attributed to them.

Research performed in the 80Days project mainly focused on supplying user-adapted learning curves by conforming to a story arc, which is in line with the notion of strong story approaches. Little emphasis is put on character interaction, because the game's learning goals are directed to attaining geographical knowledge.

3.9 The Virtual Storyteller

Originally designed to focus on story generation through emergent narrative, the Virtual Storyteller (VS) is capable of letting agents create a story in a distributed manner (Swartjes, 2010). That is, they all have goals and possible actions, but they also have the capacity to reason *out-of-character* (OOC) in order to bring the narrative to a satisfactory state and by doing so, overcoming the narrative paradox. This approach adopts the same line of reasoning that was used in FearNot! (section 3.5) as it provides agents with the means to select dramatically interesting actions they could carry out to make the narrative progress. One unique technique used in the VS is that of *framing operators*, which let agents use *late commitment* to decide upon the properties of events, agents and objects that may influence the narrative in a positive, i.e., dramatically interesting, way. This must happen in a way that no conflicts arise—moreover, because of their OOC nature, agents using framing operators are obligated to construct *in-character* (IC) reasons for their choices in order to not let the believability of the story suffer. One example that is given is that of a pirate, who reasons OOC that the treasure he is looking for is in a cave nearby so he 'wants' to go there to make the story progress. However, he needs an IC reason to make his travel seem believable, therefore he uses a framing operator to assert it is raining—if this does not conflict with previous information—so that he may go in search of a place to take shelter, which turns out to be the cave with the treasure.

Agents' reasoning in the Virtual Storyteller is based on the distinction of reactive and deliberative reasoning developed in FAtiMA (see section 3.5). Furthermore, a *fabula model* is constructed of all causally connected events, which agents can access for reasoning OOC and which is used for discourse generation. Explicit modelling of agents' emotions is not implemented in the current version of the VS, though an early foray into this has been performed in a previous version (Theune, Rensen, op den Akker, Heylen, & Nijholt, 2004) which describes how in-game characters' personalities give rise to emotions that have effects on their actions. It is asserted that these effects should still be believable, and thus, explainable, as to prevent the characters switching from one behaviour to another too rapid.

As of late, the Virtual Storyteller has been modified to enable interaction with the story as it thus far was developed to be a story generator (Alofs, Theune, & Swartjes, 2011). This is still in an early state, yet ongoing effort shows that it is possible. Its distributed approach to overcoming the narrative paradox provides extra methods on top of FearNot's means that can be usefol for our research.

3.10 Other Approaches

This subsection describes a collection of interactive storytelling systems that include some basics for narrative management, but are not fleshed out in much detail or do not provide

additional methods.

A fairly early effort into interactive storytelling is that of *Moe*, a framework designed to guide the narrative by taking into account all possible user and agent actions (Weyhrauch, 1997). For the action selection, Moe tries to determine where important plot points occur based on those actions. The important plots points are then compared to the desired story arc after which the most 'fitting' action, i.e., the one corresponding the best to a desired story arc, is chosen to be carried out. In Weyhrauch's implementation, this is particularly demanding in terms of processing because the combinatorial explosion of possible futures. FearNot!'s story facilitator (see section 3.5) implements a more feasible approach that is alike to Moe's. The U-Director (section 3.7) also builds on this work.

Relying on the statement that "drama is conflict", the *Generator of Adaptive Dilemma-based Interactive Narratives* (GADIN) system was developed (Barber & Kudenko, 2008). It takes certain cliché dilemmas—all based on the valenced effects of actions on a pair of characters—as decision points for users to influence the story. Emergence of the narrative is achieved by implementing personalities in all of the game's agents, so that they can influence the story world in a variety of ways. Furthermore, at least one dilemma is inserted at the start of the game, yet it is up to the player whether or not to try to achieve a resolution for it. Consequently, more dilemmas may be added to the narrative dynamically, based on the actions of the player and the agents. As the story progresses, the planning for goals is shortened in order to let the player reach a satisfactory ending to it. Otherwise, the game would be able to continue indefinitely (Barber & Kudenko, 2007). The GADIN system is not developed beyond an implementation in which the player has to solve very limited dilemmas.

Adopting the same setting as the negotiation training systems developed at UCSC (section 3.4), the First Person Cultural Trainer (FPCT) is a 3D serious game designed to explain cultural norms and values for intelligence missions (Zielke et al., 2009). In it, players have to converse with various agents to understand their culture and to gather information about possible explosive devices. The agents have a few psychological motivators with corresponding emotional reactions, based on their valence, and use ontologies for their beliefs. What distinguishes the FPCT from the UCSC negotiation systems is that it features gossip: when the player interacts with an agent, the latter may inform other agents of his findings. Thus, one dialogue can have severe effects for further interaction with the community of agents. Players are given a set of goals to fulfil at the start of the game and can indicate when they feel they have reached these. They are then graded on completeness and success in interaction. As there is no concrete story management, the FPCT is a strong autonomy approach. As of yet, no evaluation of this system has been performed.

An alternative to the strong story and autonomy approaches is the *Point of View* (PoV) approach, as Porteous, Cavazza, and Charles (2010) state. As follows from its name, the story is in this case told from one character's perspective. Depending on the perspective, different actions are available because they have different pre- and post-conditions. The interaction in this approach lies in the ability of the user to switch the PoV to that of a different character, which happens at the next node in the network that features both PoVs. Still, this is only a meagre form of interaction and, as such, this approach seems more focused on narrative generation than on interaction.

Somewhat similar to FearNot! (section 3.5) because of its setting and gameplay is *Prom Week*, a 'social game' that focuses on the relations between high school characters (McCoy, Treanor, Samuel, Wardrip-Fruin, & Mateas, 2011).[17] In Prom Week, it is the player's goal to effect a particular change in a relationship between two characters. It builds on the *Comme il Faut* (CiF) framework and is a spiritual successor to Façade (section 3.1) as it builds on its setting (social relations between people) and interaction mechanism. In the CiF framework, the story world is established through the conjunction of social facts, networks, rules and character personalities. The player can effect changes in the characters'

[17] Prom Week is available from http://www.kongregate.com/games/PromWeekPlaya/prom-week.

relationships by assuming the role of each character in the game and letting them perform small social actions. CiF's social structure is usable for other purposes, yet it is still very basic and only features strict rules to determine the outcomes of actions. Therefore, there is also no form of narrative paradox management present.

Lastly, *cOncienS* [*sic*] was created for game developers to let agents explain their behaviour as to give more insight in their planning (Alvarez-Napagao, Gómez-Sebastià, & Vázquez-Salceda, 2010). The specifics of a real-time strategy game were researched, including its hierarchical agent organisation and how agent roles correspond to different goals. More recent work proposed cOncienS to adopt the framework used in the Virtual Storyteller in order to overcome the latter's lack of both interactivity and social structure representation (Alvarez-Napagao et al., 2011). To do so, an explicit social structure is constructed so that agents are able to reason about each other's roles by looking at their objectives and social rules. Alvarez-Napagao et al. enable the agents in cOncienS to use out-of-character thinking to recognise when plans are feasible no more and allow them to re-plan their approach by using late commitment and framing operators. The method proposed in cOncienS is in an early stage and therefore there are no concrete results as of yet.

4 Discussion of Approaches and Techniques

In section 2, two points of attention were brought forward that were subsequently addressed in the discussion of each ISS in the previous section. These were the approach an ISS uses to manage the narrative and its implementation of social behaviour.

Concerning the narrative paradox, Mateas and Stern (2000) made the distinction between strong story and strong autonomy approaches, which is applicable in the overview of ISSs in the previous section as well. Each of these approaches features the inverse (dis)advantages of the other. That is, the strong story approach makes it possible to let the narrative follow a consistent storyline, while it possibly limits the agents' behaviour to enable this. All the different strong story approaches implement some form of drama manager, while some of these also include a method that makes the emerging story arc conform to some predefined one as in Freytag's pyramid, viz. Façade, Crystal Island and 80Days. The strong autonomy approaches emphasise agents' freedom with less focus on a particular storyline, though they feature two different techniques that give their agents some ability to let the plot progress in a desired manner, either by out-of-character reasoning or by using a heuristic search planner.

Serious games revolve around learning which implies that players of such games should attain certain skills, knowledge or train their behaviour. Thus, serious games need some definite guidance in terms of story, as various scenarios necessary to cover the study material need to be addressed. Furthermore, serious games are also in need of an appropriate learning curve, which can be seen as a sort of story arc, as in 80Days (section 3.8). This means that the strong story approach is better suited for implementation of such storyline management.

Social behaviour of agents is implemented in only a few of the discussed ISSs, most prominently in those that adopt a strong autonomy approach. Here, a distinction can be made between the ISSs that incorporate an appraisal and coping mechanism, following a model for emotions (Ortony et al., 1990; Marsella & Gratch, 2009), and those that have their own inference mechanism and classification. No quantitative analysis of user experience of the implemented social behaviour was performed in any of the discussed projects, so there is no concrete basis on which to rate one approach to social behaviour above the other. This lack of research should be overcome if the goal of having realistic social interaction is to be pursued. Nonetheless, the strong autonomy approach seems more apt for the implementation of social behaviour. This is the case because it is inherent with the strong autonomy approach that its agent implementations have more complex abilities. For instance, the agents can reason about their own and each other's emotions through their personal mental models and use the outcome of this process to carry out a justified emotional of social reaction. How these emotions should be determined and treated is left for future work. Implementing social

interaction in a strong story approach could be done in the form that IN-TALE (section 3.3) proposes, by restricting it to local autonomous behaviour, i.e., non-scenario specific activities. However, our research focuses on social interaction that *does* have profound effects on the scenario, so this method is not usable in our work.

Our research is performed with the goal of creating a serious game that incorporates social interaction. The strong story approach seems better suited for the serious game part, while the strong autonomy approach offers advantages where social interaction is concerned. However, some strong story approaches also feature some methods of narrative management, so these might be extended to have more control over the storyline. The technique of out-of-character reasoning used in FearNot! and the Virtual Storyteller makes the agents able to exert some control over the story, yet the implementations thus far are more basic than what is desired for our new approach. In FearNot!, when the agents reason out of character, they simply select the action that has the highest emotional impact. This may not always result in the best outcome for the story, for instance when the story needs to progress in a more calm way. By using the term 'needs', some pre-constructed story seems to be implied, but this only refers to the sort of events, i.e., to a dramatic story arc, that should happen, not to their instantiations. Thus, when the agents have out-of-character access to the outline of the story, they can select to perform an action that best conforms to that story arc. This somewhat resembles the approach taken in Façade, yet differs because in that approach, a central drama manager explicitly decided which events would come to pass, whereas in this proposal, the agents reason by themselves what to do. Control is in this way handed to the agents which enables this to be a strong autonomy approach, which is useful for social interaction, but which also enables them to let the story follow a desired story arc.

When the agents have a general shape of the story in mind, they can also use techniques from the strong story approaches of Mimesis, IN-TALE and Crystal Island to guide the player in the serious game. These techniques handle players' actions that may constitute exceptions to pre-constructed plots by evading those actions or by explaining why the expected results of the actions do not come to pass. So if the player seems to make an action that would deviate from the story arc too much, the agents would be able to prevent that action or its expected effects from happening. The only technique that tries to determine and evade players' possible 'exceptional' actions beforehand is that of Crystal Island, which uses Bayesian inference to look ahead in time. While in theory a sound approach, it is particularly computationally heavy when the player has lots of available actions, even more so when each agent has the ability to perform this inference. Alternatively, the other techniques for guiding the player try to handle deviant actions just when they are about to happen. Mimesis uses *narrative mediation* to circumvent or intervene on a player's exceptional action by offering an alternate effect of the player's action that is as believable as the expected one. The same idea is found in IN-TALE, which introduces the term *failing believably* that describes how the failure of expected actions of agents and objects is explained to the player, thus alleviating the decrease in agency. The Virtual Storyteller has its own approach to explaining progress of the story in a certain manner. It extends the technique of out-of-character reasoning by enabling agents to use *late commitment*, through which they can assert facts that do not conflict with the story up until that point in time. Thus, alternative effects of actions or events can be made credible.

At this point, it is our opinion that a strong autonomy approach that empowers a serious game to implement social behaviour, but which also warrants the pursuit of a particular dramatic story arc, will result in the most believable, educationally justified serious game. This is the case because the game can present its educational scenarios in the correct order with the correct pace, while offering realistic social interaction.

For overview purposes, a comparison of the various ISSs discussed in this report is presented in tables 1 and 2, that describe the approach to managing the narrative (*strong story* or *strong autonomy*), the implementation of social behaviour and the unique technique(s) of the ISS in question.

Name	Approach	Unique technique
Façade	Strong Story	*Beats*: scene instances that are used by the drama manager to create a story that conforms to a story arc
Mimesis	Strong Story	*Narrative mediation*: a player's action that may introduce an exception to the constructed plot is circumvented or intervened on
IN-TALE	Strong Story	*Failing believably*: a player's action that may introduce an exception to the constructed plot does not occur, which is explicitly justified by the system
Crystal Island	Strong Story	*Dynamic decision networks*: this system checks available actions and their consequences and refrains from performing those that introduce inconsistencies
80Days	Strong Story	*Micro/macro level adaptations*: story episodes are structured based on player performance (macro), hints are given during those episodes (micro)
UCSC Negotiation Systems	Strong Autonomy	These systems feature negotiation tactics for their agents
FearNot!	Strong Autonomy	*Out-of-character* reasoning: agents determine which action to take based on its dramatic impact on the story
EmoEmma	Strong Autonomy	Agent autonomy relies on a heuristic search planner to determine emotions
The Virtual Storyteller	Strong Autonomy	*Late commitment* by using *framing operators*: agents assert facts that do not conflict with the story

Table 1: Overview of discussed ISSs, focusing on their approach to narrative management.

Name	Social behaviour	Unique technique
Façade	Categorisation into *discourse acts*	*Discourse act*: concise representations of the general meaning of the player's action; each beat features a reaction to a discourse act
UCSC Negotiation Systems	Appraisal/coping, with mental model	These systems focus on negotiation to let the agents build trust in the player
FearNot!	Appraisal/coping, with mental model	*Reactive* and *deliberative* layers in social behaviour: short- and long-term emotional responses
EmoEmma	Heuristic search planner	The demonstrator recognises non-verbal social signals

Table 2: Overview of discussed ISSs, focusing on their implementation of social behaviour.

5 Conclusions and Future Work

The Interaction for Universal Access project's focus is on improving social interaction of people. For the social cues and training demonstrator that will be created, this report addresses a variety of interactive storytelling systems with the goal of selecting methods that could be used to enable (1) players' influence on its plot and (2) social interaction with its agents. The discussed ISSs can be divided into two types, namely the strong story and strong autonomy approaches. The former of these rely on controlling the plot in a central manner by having a drama manager that determines which events should happen and which actions should be taken by the system's agents. As its name implies, the strong autonomy approach emphasises the autonomy of the system's agents in that they are responsible for their own actions, without having control imposed on them from higher-up.

In the discussion of the ISSs in the previous section, it became clear that it is the strong autonomy approaches that have put more effort into incorporating social behaviour. This can be explained by the fact that it is inherent with the strong autonomy approach that its agent implementations have more complex abilities. For instance, they can reason about their own and each other's emotions through their personal mental models. Because of this, adopting a strong autonomy approach is a good first step in the creation of the agents for the serious game to be designed in the IUA project.

In order to let players influence the plot, the strong autonomy approaches have the ability to let the narrative emerge from actions taken by them and present agents. However, the agents need to have some idea of which actions could be benevolent to the plot to keep the narrative interesting. An approach to this is found in the concept of out-of-character reasoning first used in the game FearNot!, which enables agents to reflect on the possible dramatic consequences of their actions. Thus, they can couple actions with their effect on the plot, reflect on the consequences and decide which action to take.

As serious games entail that the player should learn something by playing, the emergent narrative should be structured so that it conforms to his progress and leads to the attainment of a desired goal. This calls for more strict guidance of the plot, as can be seen in various strong story approaches. Nonetheless, the strong autonomy technique of out-of-character reasoning in conjunction with late commitment in the Virtual Storyteller system already functions as a foray into plot control, albeit not with a direct focus on conforming to a desired story arc. Thus, this technique needs to be enhanced by enabling agents using it to take into account such a story arc as well. Techniques that may be of use for this are narrative mediation and failing believably which were found in the Mimesis and IN-TALE systems. These techniques contribute to not letting the player experience a decrease in agency when the narrative changes direction.

Future work will focus on adapting the Virtual Storyteller framework to give its agents more control over the plot and letting them interpret and generate social signals. This framework will be implemented in the social cues and training demonstrator to enable efficient training and realistic social interaction.

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