A Critical Review of Interactive Drama Systems

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Abstract. This paper provides a critical review of existing interactive drama systems. An interactive drama takes place within a virtual world in which the user has a high degree of freedom to physically and mentally interact with non-player characters and objects within a dramatically interesting experience which is different on every play, and adapts to the user's interactions. Those criteria which should provide the basis of interactive drama are detailed and discussed in this paper. The main existing interactive drama systems are then surveyed. The techniques used in each system are discussed, as are the contributions, and shortcomings, of each system. There is great potential for interactive drama systems, and this paper considers how best to achieve this.

1 INTRODUCTION

Storytelling is appreciated by many people, as both teller and audience. In the past stories were only told orally, with audience participation. It is still true that listening to a friend narrating a story is an enjoyable way to spend time. However, as storytelling has evolved - through drama, writing, print, film and television - interactivity has been neglected. Receivers (listeners, readers or viewers) of a story will often want to become more involved in the storyworld, perhaps even to become a character. An interactive drama offers a world in which the participant can have a real effect - both long and short term - on the drama which they are experiencing.

Many computer games involve a story, which in most cases is an essentially linear story or series of stories (multi-linear). The most complete stories can typically be found in Role-Playing Games (RPGs), First-Person Shooters (FPSs) and Adventure Games (AGs). This linear element constrains game development because it limits the user to following one of the pre-defined story-lines. However, the incorporation of a story enriches the game, by providing a cause and a motive for the game and the user's actions, thus greatly increasing the potential for immersion and engagement.

A linear or multi-linear story is clearly not an interactive drama, because it cannot satisfy the need for interaction which has a clear effect on the drama development a sufficently large number of times (the number of fundamentally different narratives which can be generated is very limited). There are games with no explicit story structure (simulations) in which the user is encouraged to perceive their own stories within the world. These stories are truly interactive, but lack the structured drama development required to ascertain satisfaction of the need for a dramatically interesting experience. This tends also to lead to a lack of ability to emphathise with characters, an ability which may increase immersion.

There are various terms used for the research field, for example 'interactive drama', 'interactive storytelling' and 'interactive narrative'. The term used by each research group tends to reflect their short-term presentation technique, for example 'interactive narrative' is often used for systems which currently generate a high-level plot outline. These systems can be discussed within the same evaluation as their core aims are the same. The term 'interactive drama' is used here as this was the term which was first used, and thus is the most reflective of the extensive coverage of systems by this paper, which incorporates systems which have been developed throughout the course of research in this field. As discussed in section 2, drama is also the most appropriate term for the ultimate aims of research in this field.

The paper provides a critical review of the current state of the art in interactive drama. There is a great disparity in the field and a lack of consolidation. With a basis such as that provided by this paper it is possible to consider the state of research in this area in a more unified manner. This should enable research in the field to move forward with a basis in common understanding. An evaluation of this type enables researchers to be able to easily identify the shortcomings and contributions of previous research in the field, which they will then be able to build upon in their own future research and contributions.

Since Mateas's 1997 Oz-centric review of interactive drama systems [40] there has not been a comprehensive summary of the main research in this area despite this having been extensive. Roberts et al [56] summarised that subset of interactive drama systems which utilise a drama manager, but does not take into consideration the other methods which can be used to generate interactive dramas.

This paper begins by defining interactive drama as it is ultimately required to be (section 2). In this discussion the major aspects which should be considered essential in creating an interactive drama system are discussed in detail and justified. These are: a virtual world in which the narrative will take place; interaction with objects; social interaction; dramatic structure (which supports dramatic interest); fundamental difference in the narratives generated. This is followed by an overview of existing interactive drama systems (sections 3 and 4) with similar aims. Each system uses its own technique for drama generation. However there are fundamental similarities between many of these methods. A plot graph structure is often used, as discussed in section 3. This may be used in combination with planning techniques. Those systems which use other methods for generating interactive drama are discussed in section 4. This is followed by a discussion of those systems which do not allow the user to have first person control of a character (section 5). Each system's level of achievement in accordance with the basic requirements discussed in section 2 is summarised in section 6. The paper finishes by considering the possible future for interactive drama and research in this area.

2 INTERACTIVE DRAMA

There are various definitions and conceptions of interactive drama (or narrative), which provide the basis for research in the field. These

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include those found in the following work: DED [4], FatiMA [8], NOLIST [9], GADIN [10], the OZ project [16], I-storytelling [18], Erasmatron [19], OPIATE [24], Virtual Theater Project [29], Laurel [32], IDA [37], Façade [41], U-DIRECTOR [44], Murray [46], SASCE [47], Bards [50], IN-TALE [55], Ryan [57], DEFACTO [59], IDtension [64], PaSSAGE [65], and Mimesis [69].

The various definitions have core similarities and identify the same essential requirements. Having considered these, as well as definitions found in narratology and drama theory, interactive drama as it will be considered in this research can be defined. This identifies the ideally required components of an interactive drama system, and is given and elaborated on here.

An interactive drama takes place within a virtual world in which the user has a high degree of freedom to physically and mentally interact with non-player characters and objects within a dramatically interesting experience which is different on every play and adapts to users interactions.

Drama when used in this paper refers to "moment by moment action, a scenic rendering of speech and behaviour of characters, careful detailing of specific events, commonly contrasted by panorama" [51].

Virtual worlds The exact depiction of the world will depend on the genre of story to be experienced. For example a *Dungeons and Dragons* RPG needs to include dungeons and monsters. The world in which the drama will take place needs to have an appearance of completeness which is sufficently high to allow the users to feel that they are experiencing freedom within the virtual world.

There are many existing virtual worlds in which an interactive drama could take place. These include game worlds, such as Fallout 3 [34] and Neverwinter Nights [17]; and virtual realities, such as Second Life [31] – in which the user creates their own avatar and is considered to be a resident of the world. The use of an open source 3D environment for an interactive drama would give the programmer greater overall control, but may not be compatible with other virtual worlds.

Interaction with objects The user of an interactive drama is likely to become frustrated if they do not perceive themselves to be able to freely select their actions within the virtual world, within reasonable limitations. At a minimum this freedom should be adequate for user-friendly interaction with characters, objects and scenes of the drama. As Laurel [32] explains, it "is difficult to imagine life, even a fantasy life, in the absence of any constraints at all", for example gravity within a game world is not seen as limiting a user's freedom. Providing that any constraints are consistent with the user's perception of the game world the user will still believe that they are free within that world.

This can include interaction with other characters as if they were objects. This is a representation of actual physical interactions in the 'real' world. There is not a clearly defined boundary between this requirement and the next, that of social interaction. Many actions may combine both, for example assaulting another character involves interacting with them as an object, but also has a strong underlying social component.

Social interaction Social interaction involves interaction with other characters within the virtual world on a social level. For example gestures, spoken and emotional communication and expressions are all forms of social interaction. These should all be available to characters within the virtual world. Each character should be able to interact with all of the other characters in each of these ways. The use of language communication is discussed further in this section, as this is the most frequently researched of the social interactions.

The user will ideally be able to communicate freely within the virtual world, and be understood. This is frequently interpreted as requiring natural language processing (NLP), as for example in Façade [41]. This relies on the assumption that NLP provides the highest level of freedom and interactivity. However, this is not necessarily true. Current NLP technology will not allow characters to fully understand natural language, which means that only a restricted set of sentences will have the expected interpretation and thus the user must either know, or guess, the required input for their desired action.

A method which presents the user with a clear set of possible options may be considered to be more user friendly. These options must cover a wide range, to allow the user to identify a suitable representation of their desired action, otherwise it will be seen as limiting the user's freedom. An additional advantage of this method is that the user will be presented with options which they may not otherwise have considered, and thus supplements their imagination. This means that the user is still free to act but is not relying solely on their own creativity. In addition this method increases the level of mutual understanding between characters.

Within the drama other characters will mentally interact with one another. They should also initiate interaction with the user. This is as would be expected in a natural unfolding of a drama, whether interactive or otherwise.

Dramatic structure For the interactive drama to be successful the experience must be dramatically interesting for the user. The use of a dramatic structure supports the dramatic interest of the experience. Through history, storytelling and drama have captured the interests of many theorists. This began with Aristotle [5] in ancient Greece, and has continued with modern theorists including: Barthes [14], Esslin [21], Propp [52], and Todorov [66].

As a result of this research there are structures which can be used to aid in the development of an interesting drama. Freytag [27] proposed a graphical form for the analysis of plots, which is known as Freytag's Pyramid, as shown in figure 1. This referred to as a 'dramatic arc' [32] in this paper. The dramatic arc outlines the basic rise and fall typically found in an interesting drama. This begins with an inciting incident, which provides the mood and motive for the drama (*a*). The suspense will then be expected to steadily climb due to the increase in complications in the unfolding plot (*b*). This will cease at the 'climax' point (*c*). Following this the dramatic arc steadily descends (*d*) as the complications are resolved, and the drama reaches closure (*e*).

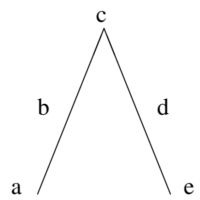

Figure 1. Freytag's plot structure (as given in [27]).

It is possible for an interesting drama to occur without a dramatic arc being followed, for example there may be a lack of closure. However, the more closely a drama conforms to the dramatic arc the more difficult it becomes to claim that it is not dramatically interesting.

Dramatic arcs have been utilised in previous interactive drama research. For example the Oz Project and IDtension require generated narratives to follow a dramatic arc [16, 64]. Façade uses a structure which they call neo-Aristotelian, an adaptation of the Aristotelian structure to interactivity [5].

Propp's morphology of the Russian folktale [52] provides a structure for Russian folktales, in the Aarne index [1], using a specific set of functions and characters. Propp's functions have been exploited by many systems, such as OPIATE [24]. With the exception of [3] very little attempt has been made to extract the morphology of a different set of tales, or story genre, to aid in the unfolding of interactive drama.

Although not all interesting dramas conform to a specific morphology, it is more likely that a drama which does conform to a well known dramatically interesting strcture will be of interest to a wide audience. For example the Field's [25] morpohology has helped to provide the structure of Hollywood films for many years, and is still one of the most used script structures in that domain.

Esslin [21] explains that any drama needs to capture and maintain the involvement of the audience by being constantly interesting. The audience are likely to frequently lose interest in the main storyline. It is thus essential to have sub-stories within the overall story, as these will ensure the continued attention of the audience. Such sub-stories will add to the complication of the plot, thus increasing the overall suspense within the drama. The events within these sub-stories must also follow a clear structure, as this will ensure the continued engagement of the audience. Sub-stories may be nested.

For example there may be a science fiction in which the main plot involves rescuing a spaceship and its crew, who are stranded in deep space. Possible sub-stories which could occur within this drama include: two crew members falling in love; or the captain's quest for a novel solution to reduce the energy consumption of the spaceship. The structure of the second sub-story could involve the engineer proposing a new way of conserving energy (the inciting event), a discussion of this method (the rise), the captain's decision as to whether to follow this proposal (the climax), and possibly the reasoning behind this decision (the closure).

Fundamental difference Each time the user participates in an interactive drama they should identify the story which they experience as being an essentially a new story. To achieve this the main storyline will need to significantly differ every time the user participates, which requires changes in the background and the inciting incident. Insignificant changes, such as only the ending differing, or characters having a different trivial conversation, will not be sufficient. The unfolding story should vary each time the user participates, in such a way that the user would identify it as essentially a new story each time. The difference in the story needs to be apparent from the outset of the drama.

For example, in a murder mystery the uniqueness of the drama occurs in the set-up, the characters, murder and scenes. This means that two mysteries with the same set of characters, but with a different character being the victim, will be essentially different stories, as this will cause a fundamental change to the actions of the characters, the identity of the murderer, and the clues required to discover the murderer and their motive. A change to the set of characters, or the scene, will also lead to a fundamentally different story. However if the set of characters, the scene and the murder remain constant, with the only difference occuring in the identity of the murderer, then the stories cannot be considered to fundamentally differ. As there will only have been subtle difference in the drama which determines that character's identity as the murderer rather than another.

The variation in the story must be highly responsive to the user's interactions. The user is essentially finding a narrative path through the storyworld in which an unnoticed dramatic interest guide will be the computerised playwright. The user should be able to act as and when they desire in ways which will have a perceivable long and short term effect on the narrative.

3 PLOT GRAPH STRUCTURE

A plot graph structure can be used to generate an interactive narrative. In this there are certain stages of interaction. These vary in length depending on the specifications of the system, but can be whole scenes or only a few seconds of action. Following these stages there will be pre-defined actions or sequences of actions which will lead to a new stage of interaction. Different actions (by the user or other characters) will cause variance in the narrative, as they may result in a different stage of interaction being the next to occur.

The major shortcoming of all systems which use a plot graph structure is their lack of extendability and generality. This means that there is also a lack of replayability. Each possibility for the narrative must be pre-defined, in itself and in the context of the stages of interaction which can precede or follow it. This involves a large amount of pre-definition. There will also only be a limited number of possible paths through the storyworld, as the plot graph must be followed. Repetition will occur after only a few experiences with the system, and thus the requirement of a fundamentally different narrative cannot be realistically satisfied – as such a large volume of material will need to be pre-defined.

3.1 The Oz Project

This was the first main interactive drama research group. The Oz Project [16] group created simple characters known as woggles. Research focused mainly on the creation of believable agents. The user could give instructions to one of these characters and play with them. These characters interacted with each other in the game world.

The group's work also included generation of interactive stories which were based on a plot graph structure. The path which the user took through this structure was dependent both on the user's choices and a pre-defined evaluation function, which biased the experience towards 'good' story-lines.

3.2 Virtual Theater Project

The work of the Virtual Theater Project uses the concept of 'directed improvisation', in which improvisational actors follow directions (and constraints), and provide the detail. For example an actor could be instructed to walk to a table, and if they are playing an energetic character they may rush there. The virtual worlds are populated by actors who take the part of characters.

The group worked on a number of different projects. In the Little Red Riding Hood system the user could destroy the story but would not be presented with a new story as a result, instead they were able to observe how their actions would move the story away from its predetermined course. The group's Master-Servant scenarios involved the servant, through a series of postures, switching places with the master [29]. In the cybercafé scenario there are a number of customers and a waiter in a café. The user gives directions to one of the characters, which they will improvise (in accordance with the individualities of their assigned character) to follow. The actions of the characters, whether instructed by the user or the system, are incorporated into the plot graph structure.

3.3 Façade

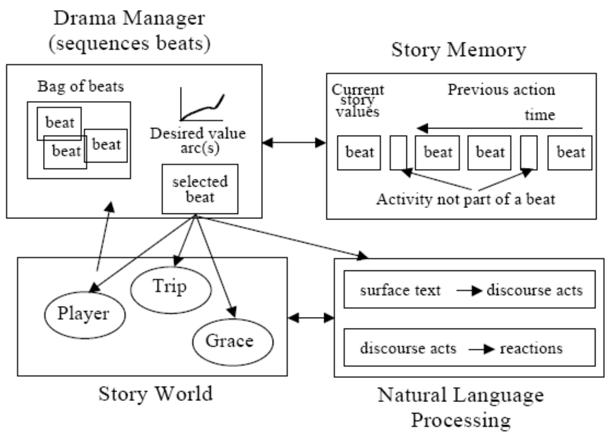

Figure 2. The Façade architecture [41]

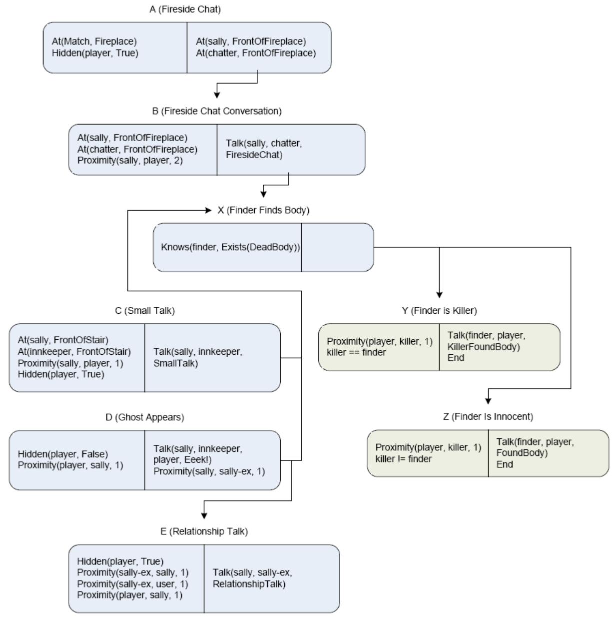

Figure 3. The partial-ordered plan for IDA [36]

In the Façade [41] system the user is invited to the house of some friends, a couple. While there they become immersed in the couple's marital difficulties and battles. The user is able to speak to the other characters and what they say - as well as how and when they say it - will affect the story they experience. The user's actions will determine the outcome of the story and thus the final state of the couple's marriage.

Façade comprises: a drama manager, beats, characters, story values, actions and natural language processing, see figure 2. Beats are short sequences of action which occur throughout the drama. They are explicitly pre-authored, with all actions within the beat being fully defined, and the actions of all roles being assigned to allow for multi-agent coordination [38]. The order in which beats occur can vary, but each has preconditions and effects of other beats. This is a plot graph structure in which each of the plot points is very short.

All higher level goals and behaviours that drive a character are located in the beats. The characters retain autonomy in achievement of base-level goals and in performing actions such as facial expressions or personality moves [38]. The authoring of Façade took 3 man-years and included 27 beats [39]. This has led to a game which lasts between 20 and 25 minutes and which can be experienced 3 to 5 times while still experiencing novelty in the story.

3.4 IDA

At the start of an experience with the Interactive Drama Architecture (IDA) [37] system, the user finds their own dead body. As a ghost they must find their murderer and subsequently manipulate another character into finding the body and also realising who committed this murder. The user has become a ghost, thus explaining their lack of freedom.

In IDA the author is required to pre-define: the story, any domain dependent functions of the director, the environment and art content, and character behaviours. The characters are semi-autonomous in that they will act while they have no instructions from the director, for example drinking. Following commands from the director takes priority over all of their other goals. These commands can be high level, for example 'explore', or very specific, for example 'perform dialogue #131 with John in the library and then run away to another room' [36].

The story consists of plot points in a partially ordered graph, see figure 3. This uses STRIPS with pre- and post-conditions. There is limited variation in these plot points, such as where a certain scene can take place. The user's murderer is pre-determined and fixed.

The user is modelled to enable the drama manager to guide them through the storyworld as subtly as possible. Director actions that modify the plot to accommodate user actions are:

- Deniers, which permanently or temporarily make certain plot points inaccessible.
- Causers, in which the system initiates a plot point.
- Creations, which cause the appearance of new things in the game to replace destroyed items.
- Shifters, which move plot points.
- Hints, such as some noise from a room.

3.5 SASCE

SASCE [47] is an adapted TD-learning method for interactive drama. This method determines, based on a pre-defined evaluation function, the apparent best route for the story, depending on the actions the user is expected to take at each stage, and thus that which will lead to the highest overall score. The routes for the drama are selected from the possible routes through a pre-defined plot graph. The actions the user is expected to take are determined by a computer simulated user. These simulations provide the training data.

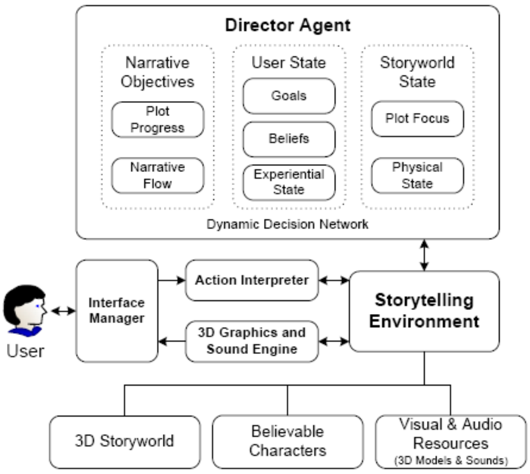

Figure 4. The U-DIRECTOR architecture [44]

3.6 U-DIRECTOR

U-DIRECTOR [44] uses HTN planning and dynamic decision networks to implement a medical mystery story that takes place on a secluded island, see figure 4. The story is pre-authored and follows a fairly strict plot. A Bayesian inference mechanism is used to decide how to manipulate the user into following the plot. This enables achievement of the desired ending, the solution of the mystery.

The director attempts to engage the user in the drama by providing hints which will lead them towards following the plot. If the hints are not sufficient then the director will become less subtle, for example by instructing another character to take the initiative in the required action. The director uses extended Bayesian networks to select a directive action based on the aim of maximising expected narrative utility.

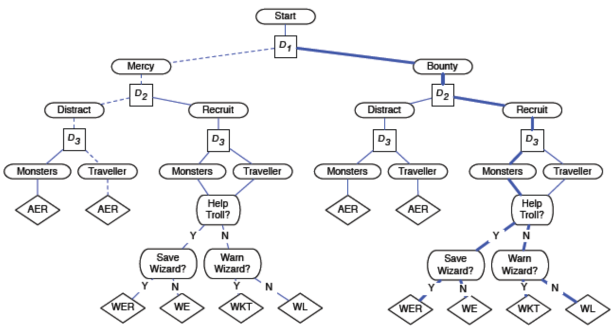

Figure 5. The current PaSSAGE plot graph [65]

3.7 PaSSAGE

(Player-Specific Stories via Automatically Generated Events) [65] focuses on the user-specific adaptation of the story. There are a number of possible 'encounters' which involve characters in interactions with one another. These follow a particular order depending on their type. The encounter chosen depends on which type of game player the user has been modelled to be, which is based on their choices in an introductory phase.

The encounters form a plot graph, see figure 5. However since the path taken is dependent on the user model there is likely to be a linear story experienced by the same user on subsequent experiences.

3.8 IN-TALE

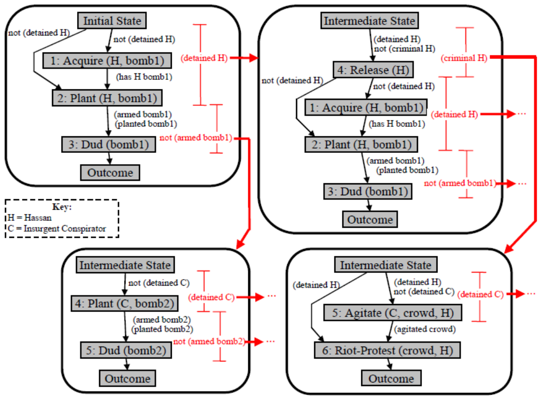

Figure 6. The narrative plan for the current IN-TALE training scenario [55]

The IN-TALE (Interactive Narrative Tacit Adaptive Leader Experience) [55] system is designed for training soldiers. The user will find themselves in a scenario which could occur in the line of duty. They will be able to act as freely as they would in reality and their actions will determine whether they are able to successfully diffuse the situation. The ending will adapt to ensure that the problematic events will always occur – however the user chooses to act.

The drama is generated based on a plot graph. Planning is used to determine whether the current path being followed is likely to be successful or if this needs to change, and the action adjusts appropriately, see figure 6.

3.9 Mimesis

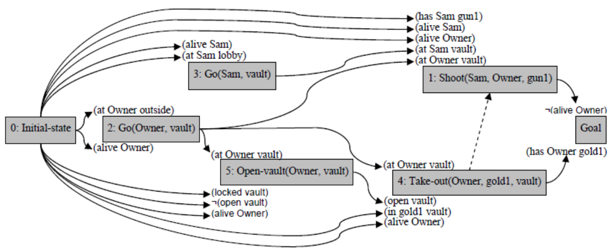

Figure 7. The narrative plan for a bank robbery in Mimesis [53]

The Mimesis [68, 53, 69] system was created as part of the work of the Liquid Narrative Group. It is designed as a general architecture and thus to work with any game engine.

An attempt is made to give the user of the Mimesis system the illusion of complete freedom. Following each user action not in accordance with the current plan the system decides whether the user's action can be "accommodated" or must be "intervened" with. An accommodated action must be incorporated into a new plan to achieve the story's goal. In the group's bank robbery scenario if the user opens the bank vault – which the plan requires another character to open – re-planning can accommodate this inconsistency by creating a plan in which that character does not open the vault but finds it open, see figure 7. If accommodation is not possible the system must intervene with the user's action. This could mean causing the user to miss when they attempt to shoot a character who must perform some role for the story's goal to be achieved, or perhaps a nuclear reactor's "control dial momentarily jamming ... [to] preserve the apparent consistency of the user's interaction while also maintaining safe energy levels in the story world's reactor system." [69]

When the Mimesis system receives a plan request it creates a directed acyclic graph (DAG) to achieve the story ending. This is a plot graph structure in which the plot graph can be redrawn within the narrative, but this variation is not sufficient for fundamentally different dramas to be generated.

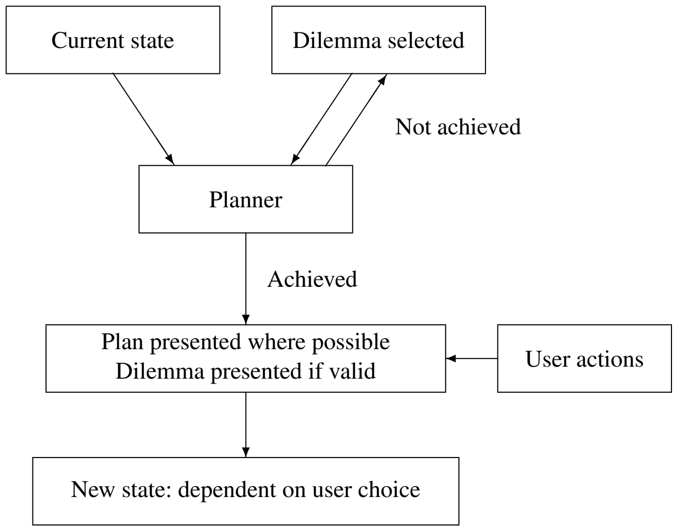

Figure 9. An overview of the GADIN system moving between states dependent on plans, dilemmas and user decisions [10]

4 OTHER TECHNIQUES

This section discusses those systems which do not use a plot graph structure for the generation of interactive drama. There are various other methods which have been used. The strengths and shortcomings of each of these methods, and the systems, are discussed here.

4.1 NOLIST

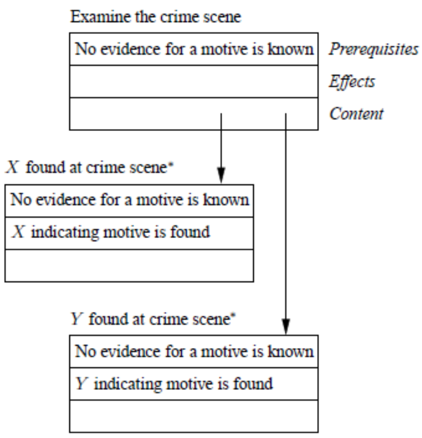

Figure 8. The action hierarchy for examining a crime scene in NOLIST [9]

In the non-linear interactive storytelling game engine (NOLIST) [9] a Bayesian network is utilised in creating a murder mystery. The Bayesian network dynamically changes in response to actions and observations made by the user. It is not preset but combines the user's actions and logical inference to determine details of the story, including the identity of the murderer. For example if the user finds a body and a gun lying beside the body then the probability that the murder weapon was the gun increases. Thus NOLIST creates the past of the story in response to the user's interactions.

NOLIST is highly adaptive to user interaction. However since users are likely to play games in a similar manner each time (in accordance with their player type [15]) they will probably experience a story with insignificant differences on subsequent experiences.

4.2 GADIN

The generator of adaptive dilemma-based interactive narratives (GADIN) system [10] generates narratives based on dilemmas. These represent fundamentally difficult decisions for characters within the storyworld, who can include the user. These dilemmas provide dramatic interest within the narrative.

GADIN uses planning to achieve dilemmas within the course of a story. When presented, such a plan constitutes a sub-story of the generated narrative. The user is able to freely select their own actions, which are incorporated where possible into the plan. If this is not possible then re-planning will occur. The user is able to freely make their own decisions when presented with dilemmas. A user model is employed to increase the dramatic interest of the dilemmas for the individual user [12].

Figure 9 shows an overview of GADIN's narrative generation process. Depending on the domain in which the narratives are to be generated this will continue indefinitely (for example in soaps [11]) or until a storygoal has been achieved [13]. This storygoal is dynamically selected and the user may cause it to change throughout the narrative, although it will always provide a clear and satisfactory ending.

The disadvantage of this system is in the planning bottleneck. With an increased number of actions, dilemmas and characters the planning becomes too slow for a real-time experience of the narrative.

4.3 Erasmatron

Chris Crawford's Erasmatron [19] system presents the user with a number of action options, generally relating to specific speech acts. Once the user has made their choice, the system or a character responds appropriately. This turn based action selection continous until the story is finished. This is a text-based system.

This system has a range of storyworlds available. Within these the user can become involved in the creation of a story by choosing from low-level action options. Characters have emotions and personalities. There is a drama manager which acts as "Fate".

As the user is being presented with a list of low-level action options in the Erasmatron system they will be unlikely to feel that they are free to act or to become immersed, particularly since the stories tend to return to the same choice points multiple times within the same experience.

4.4 DEFACTO

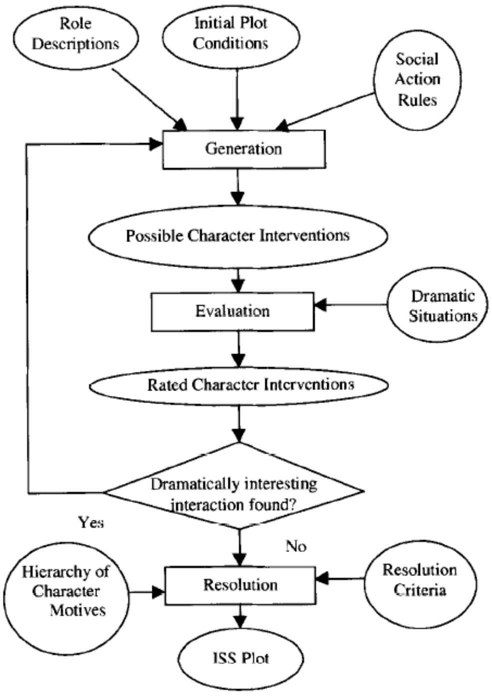

Figure 10. The plot manager architecture of DEFACTO [58]

While in the DEFACO [59] system the user becomes a character in an Ancient Greek world. They are able to specify their actions within that world and will then be shown graphically the story created. Until the graphical output is produced the user will not know the consequences of their actions.

DEFACTO allows the user to participate in stories incorporating murder, marriage, sacrifice and gods. A series of rules control the drama generation within the world, see figure 10. These stories are dynamically created in a text-based system, with user interaction. Following the interaction phase the drama is presented graphically with a twist to the user – after all of their action choices have been made, but they will not discover the outcome of their actions until the presentation phase.

The specificity of the DEFACTO system to a particular storyworld limits its applicability to other domains and the nature of its twist means that the outcome will be predictable on subsequent experiences.

4.5 OPIATE

The open ended Proppian interactive adaptive tale engine (OPIATE) [24] system creates stories based on Propp's [52] general structures for fairy tales, see figure 11. Characters other than the user have flexible roles in the story. In each state the system chooses appropriate Proppian functions using case-based planning. The story director guides the actors by giving them goals relevant to the selected function[23, 22]. The user's actions are integrated into this wherever possible.

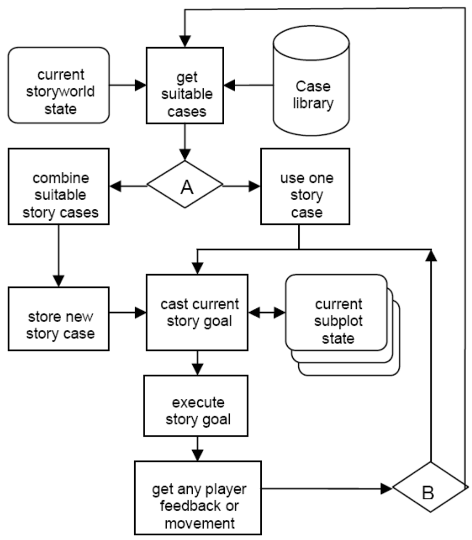

Figure 11. A flowchart showing the OPIATE planning process [24]

The story emerges from character interactions and events initiated by the story director. The engine has a gossip system which connects the characters, and spreads news and opinions about the user and their actions. The characters also communicate news of storyworld events between themselves.

The test bed for OPIATE was fairly limited with pre-scripted puzzles. It is thus unknown how it would scale, particularly given the complexity of the planning algorithm. OPIATE has a strong reliance on the generality of Propp's functions, both within the scope of a restricted fairy tale and in its potential for applicability to further domains, which is unlikely to be the case.

4.6 DED

The directed emergent drama (DED) [4] engine has a director agent that uses schemas to structure an emergent drama. There is a set of actor agents, who play characters in the unfolding drama using the schemas as a guide. Schemas are structures which contain: goals, a knowledge base; and actions for the actors and the user of the drama. The basic DED architecture can be seen in figure 12. This figure shows that all communication between the director and the actors is through schemas. The director never interacts directly with the user or actors. The user will have all the same options for interaction as the actors have. All of the interaction options available to other characters will also be possible for the user.

The characters of the drama are played by autonomous actor agents who use belief networks as their core decision mechanism.

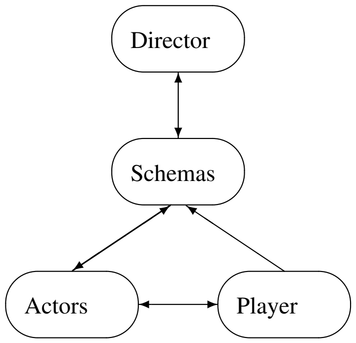

Figure 12. The DED architecture [4]

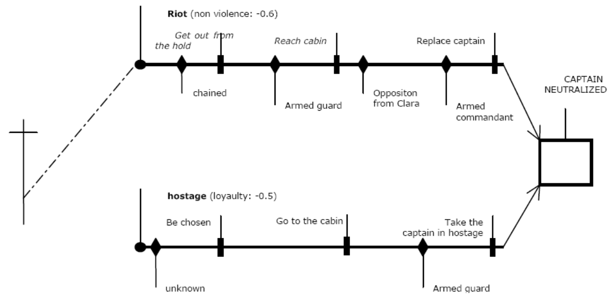

Figure 13. This figure shows the IDtension task-goal structure [63]

The actor agents use the Rational Dialog (RD) engine introduced in [2] which has now been extended and optimised for use by the actors in DED. The RD engine uses extended object-oriented Bayesian networks and Multi-Agent Influence Diagrams [30]. This is a game theoretic approach to a single agent decision problem in a multi-agent environment which provides linear growth with respect to the number of actions considered.

The schemas structure the emergent drama by giving actors goals, a knowledge base and appropriate actions to choose from. Schemas are generic structures which used by the director to structure improvisational acting, they are not small pre-authored stories. This means that an actor receives goals to accomplish and relevant actions from which they can choose. The actions are further supported by a knowledge base which the actor can use to determine appropriate actions with respect to the character's emotion, situation and personality. This facilitates the emergence of a drama in which a user can interact with the actors and storyworld freely and directly influence the unfolding drama.

The drama emerges from the interaction of the user and the actors interactions within the schemas deployed by the director. At the outset DED draws a basic plot, using the dynamic plot generating engine (DPGE) [3] to create a past for characters and their relationships. This provides a background story for the drama.

This is recent research and has jet to be fully implemented with a complete drama, set of characters and a user.

5 RELATED WORK

Not all interactive drama systems allow the user to have first-person control of a single character. Such systems are not able to achieve the requirements detailed in section 2, but the techniques should still be considered. These are discussed in sections 5.1 - 5.4. Section 5.5 briefly introduces systems which focus solely on non-interactive story generation.

5.1 IDtension

IDtension [63, 64, 62] bases its approach on narratology such as Propp's functions [52], Bremond's process, Greima's actant model and Todorov's transformations [64]. The interactive narrative is divided into three layers [64]:

- The *discourse* layer, which contains the message or theme of the story.
- The *story* layer, which gives the succession of events and character actions, following rules based on structuralism and narrative sequences.
- The *perception* layer, which determines how the narrative is presented to the user.

The IDtension system is authored by defining and scripting a set of tasks that need to be completed, in a causal order, to complete a certain goal, as shown in figure 13 when writing a novel the author will often envision a certain type of reader. Similarly, IDtension utilises a user model which contains the following criteria [64]:

- "*Ethical consistency:* The action is consistent with previous actions of the same character, with respect to the system of values."
- "*Motivational consistency:* The action is consistent with the goals of the character."
- "*Relevance:* The action is relevant according to the actions that have just been performed. This criterion corresponds to one of the Grice's maxims."
- "*Cognitive load:* The action opens or closes narrative processes, depending on the current number of opened processes and the desired number of opened processes (high at the beginning, null at the end)."
- "*Characterization:* The action helps the user to understand characters' features."
- "*Conflict:* The action either exhibits directly some conflict (like for example an incentive that is in conflict with the inciting character's values), or the action pushes the user towards a conflicting task (for example by blocking a non-conflicting task, if a conflicting task exists)."

5.2 I-Storytelling

A user of the I-Storytelling [18] system will see a graphically depicted story. They can make suggestions to characters which may or may not be followed, and can move certain key objects. This group's system equips characters with Hierarchal Task Networks (HTNs). The characters are initially positioned in random locations around the storyworld. The story is then created through the characters' interactions.

5.3 BARDS

The BARDS system uses a Heuristic Search Planner (HSP) with RTA* to plan for emotional development in the characters, rather than for actions [50, 49]. The group use an ontology created by Gustave Flaubert as the basis for the planner. Flaubert's novel, *Madame Bovary* [26], provides the test scenario. The user can use natural language to make comments which may cause other characters to react

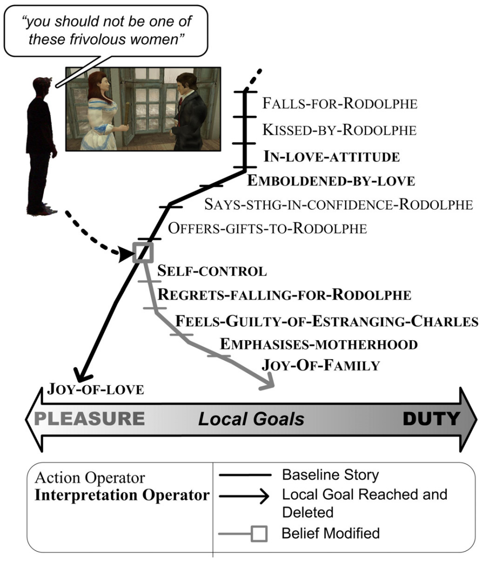

Figure 14. The influence of a NL utterance in BARDS [49]

emotionally and thus change the story, see figure 14. For instance a woman in love with a character other than her husband may feel guilt when reminded of her children. The effect will vary depending on the characters' feelings.

This is a novel approach, in which the user takes the role of an audience rather than a user, but an audience able to influence the generated story.

5.4 FAtiMA

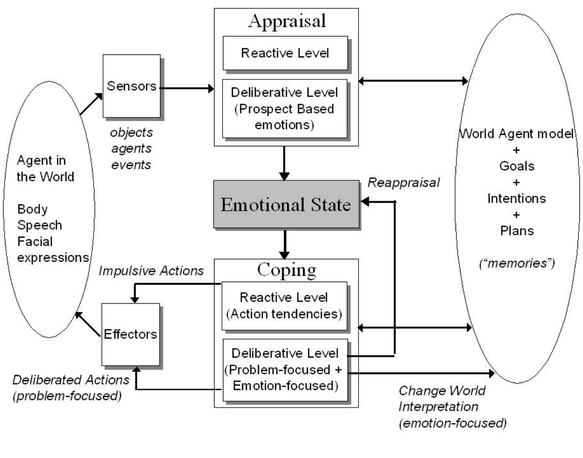

Figure 15. The FAtiMA architecture [8]

FAtiMA (FearNot! affective mind architecture), see figure 15, is a character based emergent drama system [8, 48]. The drama emerges around character actions. The test base is FearNot!, an educational game which helps children aged between 6 and 12 to learn to cope with bullying situations. The characters are reactive to the interactions of other characters, the environment and the user.

When reacting, characters use a set of emotional reaction rules, based on appraisal values such as: desirability, desirability-for-other, and praiseworthiness [8, 20]. The rules have preconditions which are compared to the current situation and the optimal match is chosen.

The characters are also goal driven. For this a STRIPS-based partial-order continuous planner is used. Characters evaluate the probability of success and the importance of the actions in accordance with whether the actions are expected to generate hope or fear. The action likely to generate the strongest emotion is chosen.

FAtiMA employs a Game Manager (GM) which uses 'narrative actions'. These affect the environment and are primarily dedicated to story management [7]. Narrative actions select episodes with respect to a plan of episodes that can be represented as a state machine. The episodes are structured as follows [7]:

- " *Name*, a unique name for the episode.
- *Set*, the set is the location in the virtual environment where the events of this episode will take place.
- *Characters*, the characters of the story, defined through a set of properties like their name, position on the set, etc
- *Preconditions*, a set of conditions that specify when is the episode eligible for selection.
- *Goals*, character goals that are communicated to the agents in this particular episode.
- *Triggers*, a condition that when satisfied will cause the execution of a set of narrative actions.
- *Finish Conditions*, a set of conditions similar to the preconditions that when satisfied indicate that the episode is finished.
- *Introduction*, a set of narrative actions introducing the episode and characters, some introductory text."

FAtiMA also applies *theory of mind* [6, 35]. This consists first of a 'double appraisal', which means that when the agent has chosen the action that would cause the strongest emotion, all of the generated actions are returned to the appraisal system, to determine which of the actions evokes the strongest emotional response from that agent. Additionally, the agent performs a 're-appraisal' by testing the actions against the emotional systems of all other characters in the scenario, to determine which action causes the strongest emotional reaction in others.

Fear Not was tested by an empirical study on 345 children, 172 male (49.9%) and 173 female (50.1%) between the ages of 8 and 11 [28]. The results showed that the children were able to empathise with the characters. There was a positive correlation between the children believing in the characters and whether they found them interesting, empathising with the characters. If the users believed that they had an high impact on the characters' behaviour then they were more likely to empathise with them. Girls were more likely than boys to feel sorry for victims that they were successful in helping.

5.5 Story generation systems

There have been various attempts to design a computer which is capable of writing stories. The major contributing systems to this research area are discussed here.

The first of these was James Meehan's Tale-Spin [42] in 1980. This system produces original fairy tales with morals. These are purely text-based and have a large number of inconsistencies. There is still dramatic interest to the stories generated by the system, all of which are set in a standard fairy tale world – with, for example, trees, rivers and fields. The system contains a large amount of background knowledge of possibilities for the world, which is created as the story is told. Characters have goals, emotions and relationships and are semi-autonomous within the game world.

Planning was used to create infinite soap opera style stories in Lebowitz's UNIVERSE [33]. In this it was necessary for the author to provide goals to the story-telling system. UNIVERSE used these goals and existing plot fragments to create a summary of a soap opera plot. System-created stereotypical characters are dynamically assigned roles in these fragments, with new characters being added if no existing character is able to take on a particular role. Character relationships are central to the interwoven storyline. The system is reliant on the reader assuming characters' motivations.

Turner's Minstrel [67] uses case-based reasoning to generate stories about knights and ladies in the days of King Arthur. The cases are existing stories and these are matched to desired stories – replacing variables where necessary – and recombined to create new stories. The system utilises its awareness of what is consistent within a world to ensure that the generated stories have this feature, and tries to present a twist at the end of each story. Both the characters and the story have goals, which are entered by the user before story generation begins.

More recent story generation research [54] has similarly focussed on generalising story segments. The system makes use of a number of short story segments, known as vignettes, which are assumed to be good. It then uses pre-defined mappings to apply these segments to new domains, where they can be joined in the generation of a new story. This technique strongly relies on the undemonstrated generality and dramatic interest of the story segments.

The Virtual Storyteller [60, 61] generates emergent stories from character interactions. Autonomous character agents have individual emotions and beliefs. The characters improvise using techniques from improvisational theatre. The stories emerge from character interactions, which are guided by a plot agent. The resulting story is then sent to a narrative agent. The story is processed by a natural language processor and then synthesised. Special rules have been developed to transform the synthesised speech to be presented, for example with the expected emphasis that a storyteller would use to provide suspense or excitement.

Although it is not strictly a story generation system, Daydreamer [45] is a system which creates daydreams. The idea is that these will be generated when a computer is idle. These daydreams will be affected by previous events and will either reflect on these – to rationalise or learn from the experiences – or create idealised alternatives to them. Experiences are at this stage input by the user. Relaxed planning is used by Daydreamer, in combination with goals and domain knowledge.

6 SUMMARY

Table 1 shows the level of satisfaction by existing systems of each of the components which are required in the creation of an interactive drama system (as discussed in section 2). This does not include story generation systems as these do not allow the user to interact within the world. The first column, (interaction with objects), shows whether or not it is possible for the user to interact with objects (which can include interacting with characters as objects) within the virtual world. In the second column, (social interaction), the ability to socially interact is identified. The dramatic interest of the drama is supported by the dramatic structures used, and the third column, (dramatic structure), identifies the structure used by each existing system. In the third column the method of presentation of the virtual world, and actions within that world, to the user is given. The final column, (fundamental difference), shows the number of fundamentally different narratives which the system is capable of creating within an application domain. It is not possible to give an exact figure for this, so an order is instead given, for example a system which is able to produce 15 fundamentally different narratives would be able to generate different narratives in the order of magnitude of 10, this is given in the table as O(10). These figures are overestimates of the potential, as exact numbers are not known.

7 FUTURE WORK

There are many possible directions in which interactive drama may develop in the next few years, or decades. It is not possible to predict the future, but in this section promising approaches and possible applications are speculated on.

Thus far there has been an strong emphasis on plot graph and planning-based approaches. Alternative decision algorithms, such as Bayesian networks, have not often been utilised. Taking advantage of alternative approaches, as is common in many other areas of Artificial Intelligence, could significantly advance interactive drama. The problems which are associated with the scaling-up of most existing systems could be successfully resolved by investigating approaches beyond the confines of symbolic planning.

Another potential way to overcome scaling-up problems would be to move from centrally generated to distributed and emergent drama. In the latter approach, decision-making is distributed amongst autonomous actors, and thus the computational bottleneck of fully centralised control is removed. To achieve a consistent story with a dramatic progression some control over the actors' actions needs to be retained. Hybrid approaches combining both perspectives on decision control, such as those suggested by [4, 6], show great promise.

The creation of interfaces for interactive drama is another area which has received very little attention thus far. Natural language appears to be the most natural choice, but the technology available today is far from perfect. Using natural language (NL) interfaces can lead to reduced enjoyment of the drama experience and frustrate the user, as has been noted in the evaluation of systems such as Façade (see for example [43]). However, future advances in NL research should make this technology more applicable to interactive drama.

An increased focus on human-computer interaction (HCI) aspects should also lead to an advance in the state of the art in system evaluation. Thorough evaluations of systems has not been easily achievable, and as a result (and as this paper shows), comparisons between interactive drama systems are not a trivial task. Nevertheless, it is to be hoped that evaluation will become more standardised and expected in this research area as it develops.

While research in interactive drama is flourishing (judging by the high number of conference and workshop submissions), very little (if any) developed technology has been incorporated into commercial games. The main reason is that this is still a relatively new research area, and that there is a question of reliability. Trust is also a major factor. Game developers are very reluctant to give control of the final product to an automatic narrative generator which cannot guarantee a consistently high story quality. In addition there has not as yet been proposed a convincing method of integrating storytelling into existing game genres, such as first-person shooters. Perhaps the best way to move forward in this is to create a whole new game genre – a method which shows great promise, judging by the attention the Façade system [41] generated both in the research and the player community.

System	Virtual world	Interaction with objects	Social interaction	Dramatic structure	Fundamental difference
Oz	Simple graphics	Yes	Some	Plot graph	O(10)
Virtual Theater Project	Text	Some	Yes	Plot graph	O(1)
Façade	Simple graphics	Some	Some	Plot graph	O(10)
IDA	Simple graphics	No	Some	Plot graph	O(1)
SASCE	None	Some	Some	Plot graph	O(10)
U-DIRECTOR	Simple graphics	Some	Some	Bayesian networks	O(1)
PaSSAGE	Neverwinter Nights graphics	Yes	No	Plot graph	O(10)
IN-TALE	Graphics	Yes	Some	Plot graph	O(10)
Mimesis	Simple graphics	Yes	No	Plot graph	O(1)
NOLIST	Text-based	Yes	Some	Bayesian networks	O(∞)
GADIN	Text-based	Some	Yes	Planning and dilemmas	O(∞)
Erasmatron	Text-based	No	Yes	Dramatic interest rules and general patterns	O(10)
DEFACTO	Text-based and simple graphics	Some	Some	Dramatic interest rules and general patterns	O(10)
OPIATE	Simple graphics	Yes	Some	Proppian structures	O(10)
DED	Second Life	Yes	Yes	Schemas and emergence	O(∞)
IDtension	Text-based	No	No	Planning and tasks	O(10)
I-Storytelling	Simple graphics	No	Some	Character HTNs	O(10)
BARDS	Virtual reality	No	Some	HSP	O(10)
FAtiMA	Simple graphics	No	Yes	Character goals and emergence	O(10)

Table 1. Summary table

This research additionally has high applicability to education, therapy and entertainment which could be investigated further.

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