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I-Shadows - An Affective Interactive Drama Experience

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Resumo

As histórias fazem parte do ser humano desde sempre, ajudam a estruturar ideias, pensamentos e ajudam-nos construir a perspectiva do mundo que nos rodeia. Ouvir, assistir e interpretar uma história está longe de ser um processo passivo, pois cada ouvinte tende a fazer uma leitura a partir da sua própria perspectiva.

O desenvolvimento tecnológico dos últimos anos, e em particular o desenvolvimento de sistemas de narrativas interactivas tem permitido encontrar novas formas de contar histórias que incluem a intervenção utilizador no seu próprio desenrolar.

Uma abordagem usada nestes sistemas é o Drama Interactivo, que recorre a princípios teatrais para estruturar histórias em que o utilizador assume o papel de uma personagem. O sistema tenta influenciar o desenvolvimento da história de forma a garantir uma intensidade dramática.

No entanto, o utilizador é livre de aceitar ou não a influência do sistema de acordo com a sua perspectiva sobre o desenrolar da história. Quando esta perspectiva não corresponde à perspectiva do sistema gera-se um conflito cuja resolução normalmente tende a diminuir o poder de intervenção do utilizador.

Nesta tese propomos um modelo que tenta equilibrar este conflito, acrescentando uma nova perspectiva sobre o desenvolvimento de dramas interactivos baseada em emoções.

Palavras-Chave: Narrativa Interactiva, Drama interactivo, Narrativa Emergente, Agentes Autónomos, Personagens Sintéticas, Computação Afectiva, Interacção Afectiva, interacção Pessoa Máquina.

Abstract

Stories are a part of us, we use them to build knowledge thought and a perspective of all that surrounds us. Viewing, listening our interpret stories is not a passive process, because one reads it according to his/her own perspective. Recent technological advances, in particular the advances in Interactive Storytelling Systems, created new ways of telling stories that try to allow users to intervene in its development.

One approach to build these systems is Interactive-Drama, which uses theatrical concepts to structure stories in which a user takes on a character role. Such systems try to influence the story development on order to create a dramatic tension.

Nevertheless, the user is free to allow or reject this influence, according to his/her own perspective of the story overcome. When the user perspective does not match with the system perspective occurs a conflict. Attempts to resolve this conflict tend to empower one perspective over the other, either losing structure or user's intervention.

In this thesis we propose to balance this conflict, adding a new perspective on story development based on the affective development of the story.

Keywords: Interactive Narrative, Interactive Drama, Emergent Narrative, Autonomous Agents, Synthetic Characters, Affective Computing, Affective interaction, Human Computer Interaction.

Acknowledgments

Once upon a time a student lived inside a square world. He loved that world! He spent a lot of time studying it with his friends, family and masters. He was also very curious about other worlds and wanted to know them better, but the words on the street were that "one should just care about his own square, because that is all that you are going to need once you are strong enough to leave this square."

After four years of fighting in vain against the borders of the square, someone came and presented him a very strange idea: "the things you learn in this square can be massively empowered by the ideas of the other worlds" he took a chance and is currently enjoying it.

Today this student feels the need to express his gratitude to all those that allowed him to look beyond the square: My first thanks are addressed to my supervisor Prof. Ana Paiva for offering me the chance to participate in an idea where the initial blurs were presented as very attractive challenges, and for believing that I could overcome these challenges. I also thank all the people that were directly involved in I-Shadows Mafalda Fernandes, Pedro Sequeira (Toca o Hino!), Ricardo Cruz and António Leonardo thank you for your commitment. All the people in GAIPS, that transform the long individual journey of a master student in a pleasant and confident walk in the most difficult times Afonso, Patricia, Paula, João G., Rui F., Marco, Rui F., Guilherme, João D., Rui P., Carlos, Nuno, André, Iolanda and all the others. For those that teach me to live outside the square, my best men Pedro and Pedro, Vinagre, Pedro B., Marcelo, Paulo, Henrique, M. João, Zé, Margarida, Nuno, Franciscos, Alice and Carla, Nuria and all the Verbum Dei community, especially in Lisboa and Belo-Horizonte.

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Chapter 1

Introduction

Stories are part of us since childhood, are par of our daily activities, and even part of our dreams. Young children construct their first stories by imitating their parents' daily routine or even their actions. Using toys as elements of their make-believe activities, children start to explore the novelty that surrounds them, and simultaneously confronting their own fears [18]. Under such conditions, children afford to induce some variations in their imaginative play, acquiring knowledge about the external and mysterious world that surrounds them. Many psychologists and educators have investigated the influence of narratives and stories during child development phases. It is now clear that narrative can be an important vehicle to structure knowledge and to help in the process of meaning making. According to Malone's [57], narrative plays a central role in memory by providing an organized structure for the knowledge. In Poetics, Aristotle suggests that all literary works are imitations "Mimesis" of the reality [1], and this is why we all tend to interpret stories projecting our inner structures and thoughts, and through that, reading or listening to a story is an active process.

What if we could really influence the development of the stories that we watch or listen to? This question is in the basis of Interactive Storytelling, a research field that pursuits the development of systems that allows story spectators to intervene and transform its development. Story media developed along with technology from oral tradition, cave pictures, writing, choose your own adventure books, to all kinds of theater and movies. Today with the outcome of computer technologies we are provided with a

new media that urges to be explored. But to bring interactivity into storytelling one needs to investigate models of interaction.

HCI (Human Computer Interaction) is a discipline that has experienced a tremendous development on what concerns to task optimization and users' acceptance, turning interfaces more attractive and effective to humans. However, it often assumes that humans must leave their natural communication paradigm and adapt to a fully rational interface that is fully task oriented. Until recently all implicit information in interaction like emotional cues were inexistent or limited in Human Computer Interaction.

Yet, good storytellers are not restrained to actions, they also express their emotions. When we force a storyteller out of its natural communication paradigm we are reducing his expressiveness, therefore it is desired for Storytelling Systems to include interpret and react to this expressiveness.

This brings us to one of the links between Affective Interaction and Interactive Storytelling: can we bring traditional task oriented computer-to-human interaction paradigms in a storytelling environment to a more natural human-to-human approach including implicit information?

1.1 The Problem

Telling a story to an audience may sometimes be a daunting challenge. When one tries to do it in cooperation with someone this challenge grows even more. Acting is one way of overcoming this challenge. Each of the actors play at least one role and develop the story according to the characters' personalities and their perspective of the story development. But what happens when these perspectives diverge? What happens when these perspectives diverge from the perspective of the author of the story?

Interactive Storytelling systems that combine autonomous agents face this problem. Cooperation often leads to an unbalanced state between the user's expectations of the story development and the system's plans. One way of overcoming this problem is to limit the goals of each character and user according to the author's perspective of the story development. This approach has shown some good results [31, 35], but it partially

removes the creative influence of the user in the story development.

Approaches that allow this intervention were made in Teatrix[52], where the user was involved in the set up phase that conditioned the rest of the story, similar was the approach taken in the Interactive-Theatre[6, 53] where agents were free to improvise their actions under the influence of the user. However, this influence was achieved at a very high-level. Both of these systems did not show enough flexibility to change directly an on-going story. The use of autonomous characters as the ones developed by M. Cavazza[26], brought some flexibility to this research area, and the agents proposed by Aylett et.al.[45] allowed more freedom of interaction to the users.

In the context of Interactive Storytelling with autonomous characters we can formulate these questions into a single question: How can we balance the expectations of an author, a set of autonomous characters, the user and an audience in order to produce a creative and structured story?

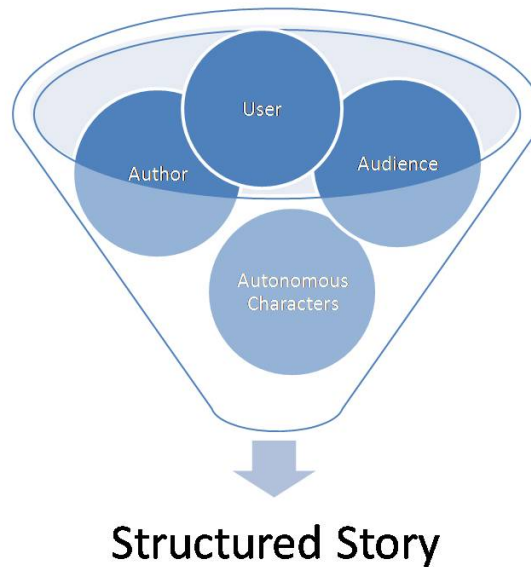


Figure 1.1: Motivation

1.2 Research Goals

In the development of this research several goals were pursued. The goals were:

- To create an approach to interactive storytelling where the user and the system are seen as collaborators in a collaborative story creation process.
- Study the impact that a tangible interface for virtual storytelling has in the creation and emergence of stories.

1.3 Outline

The remainder of this document is divided into 8 different chapters and 4 appendix.

Chapter 2 (Affective Interaction and Interactive Storytelling) provides a background on the works that influenced the the concepts of this thesis in Affective Interaction and in the Interactive Storytelling context.

Chapter 3 (Theater and Literature Theory) describes the main artistic theories that inspired the work.

Chapter 4 (I-Shadows Concept) describes the conceptual model for the proposed system based on the principles presented in the earlier chapter.

Chapter 5 (Proposed Architecture) describes the architecture that implements the proposed model.

Chapter 6 (Non-Functional Prototype) describes the implementation and tests of the first prototype.

Chapter 7 (Functional Simulation Prototype) describes the first functional prototype used for early tests.

Chapter 8 (Complete Prototype) describes the complete prototype that implements the proposed model.

Chapter 9(Conclusions and Future Work) gives a brief overview of the work that was developed and ends with suggestions on how to improve the work done.

Appendix A (AAAI Fall Symposium Series) Paper presented at the AAAI 2007 Fall Symposium on Intelligent Narrative Technologies, Westin Arlington Gateway, Arlington,

Virginia, November 9-11, 2007.

Appendix B (AAMAS ABSHLE) Paper presented at the Agent Based Systems for Human Learning and Entertainment AAMAS 2007 workshop.

Appendix C (HUMAINE WP9) Paper presented at the Work Package 9 workshop.

Chapter 2

Affective Interaction and Interactive Storytelling, a Background

Our proposal to use Affect as an input to an Interactive Drama System, builds a bridge between two very recent research fields, *Affective Interaction* and *Interactive Storytelling*. In this chapter we present and discuss some significant examples from both these areas that have contributed directly or indirectly for the current work. It is not our goal to present a complete and very detailed report, but to present an overview summarizing the concepts and development process that most significantly contributed to the work here presented.

2.1 Affective Interaction

Affective Interaction is the sub area of the *Affective Computing* research field proposed ten years ago by Picard [50] that focus on the aspects of emotion and *Human Computer Interaction*(HCI). "Affective Computing is computing that relates to, arises from, or deliberately influences emotions" [51]. Because of its nature, Affective Computing is a multidisciplinary field and involves different kinds of knowledge and approaches other than Computer Science. It is in fact a very rich research area that is influenced by human sciences such as psychology or literature and art studies such as design, music, dance and theater. In what concerns computing, the main research areas of interest are

Human Computer Interaction, Artificial Intelligence and Signal Processing.

Most *Affective Interaction* studies are based on Picard's concepts of *Affective Bandwidth* and *Affective Loop*[50]. Affective Interaction can be seen as a continuous circular communication between two or more subjects, using an *Affective Chanel*, i.e any kind of medium or combination of media (e.g. speech, sound, gestures and other), to transmit their messages with an affective meaning. Each medium has the capability to transmit affective content such as emotional cues, or subjective feelings. This capability differs from medium to medium, and it is called *Affective Bandwidth*. The major goal of Affective Interaction is to enlarge the *Affective Bandwidth* of the media used in HCI and find new useful ways to apply it. These concepts are described in Figure 2.1.

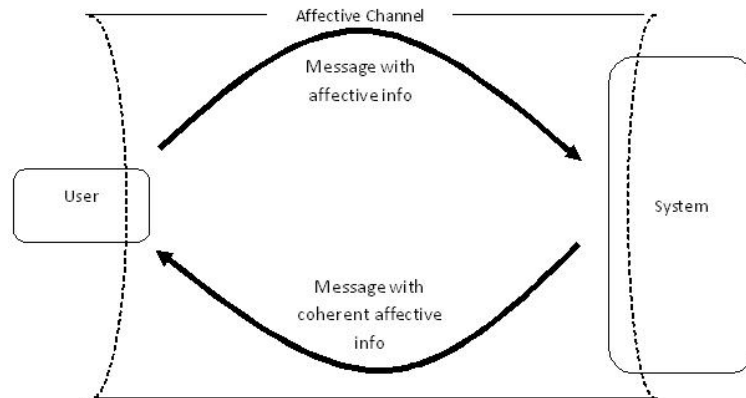


Figure 2.1: Affective Loop

In the following text we will address some relevant examples of Affective Interaction systems. We will dedicate special attention to the design process and to the discussion of specific Affective Computing issues raised by each work. We will also focus on research where tangible interfaces are used to extend the affective communication with users.

2.1.1 FEELTRACE

One of the major problems of Affective Interaction is the difficulty to express subjective emotional information, like happiness or sadness, on a quantified and deterministic way. One approach to solve this problem was taken by FEELTRACE [46].

FEELTRACE was a user tool developed to track the emotional content of a stimulus

as they perceive it. It uses the activation-evaluation space [56], and Russel’s circumplex theory [19], to define a two dimensional space for emotional evaluation using *Activation* and *Evaluation*. The *Activation* dimension measures how dynamic the emotional state is, e.g., instance exhilaration involves a high level of *Activation* and boredom a very low one. The *Evaluation* dimension is a measure of a positive or negative feeling associated with the emotional state Happiness involves a very positive *Evaluation*, anger involves a very negative one.

2.1.1.1 Design Process

Using the above mentioned two dimensional space the FEELTRACE defined an easy to use circular display, where any user could express an emotion to be quantified. The semantics of the display was reinforced by the color code of the cursor that was activated according to its position in the display, according to Plutchik’s color palette[44]. The final result of the tool display is shown on Figure 2.2.

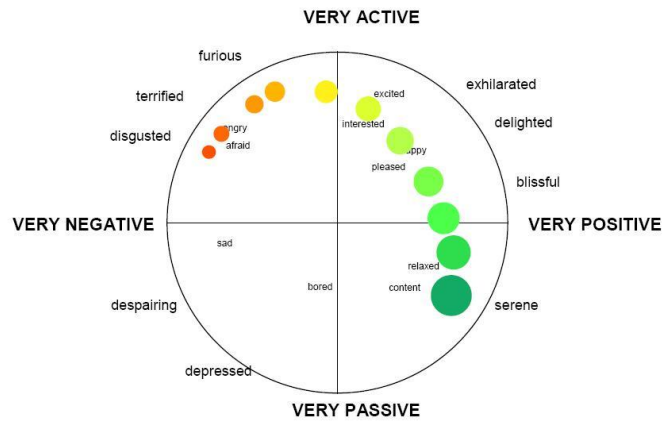


Figure 2.2: Feeltrace Display

2.1.1.2 Tests and Discussion

FEELTRACE was tested with users that were asked to evaluate the emotional stimulus of 16 short video clips, 15 to 30 seconds long, taken from real TV Programs interactions thus not acted. Results were analysed according to cursor positioning(see Figure 2.3). Results are reliable in intensity (distance from the center of the circle), due to the

differences between the evaluation of emotional and neutral scenes. There are also some reliable results when comparing different emotional scenes. This reliability allows us to conclude that FEELTRACE is a successful tool for user, to express emotions in a quantified way.

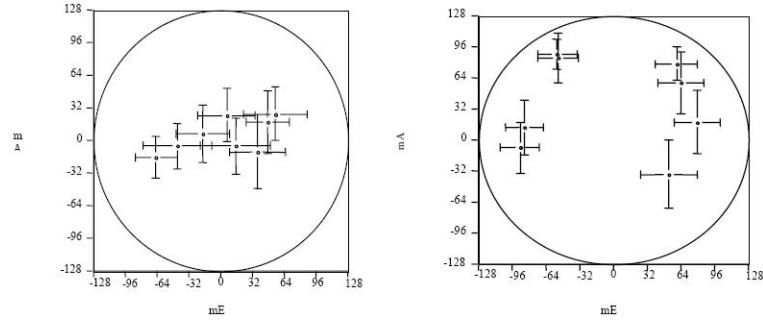


Figure 2.3: Feeltrace Result

2.1.2 Affective Diary

Using affective information in the interaction process often raises the question whether users provide real information or acted emotions? This topic will always haunt Affective Interaction field. Some researchers even argue that it is not possible to report an emotional engagement while it occurs, but only after it has occurred[22]. Nevertheless efforts are being made to reduce its influence. One way of addressing this problem is to improve traditional HCI design, implementing new and less intrusive forms of integrating the user in the design process, looking for the user's cooperation rather than his/her help. The Affective Diary [28] project is a good example of this approach.

2.1.2.1 Design Process

The concept of this project developed by SICS and Microsoft is an interactive diary where users report their emotional experiences during the day, empowering them to reflect upon these experiences. The inputs to this diary are named *Affective Body Memorabilia*, which stands for all physical and bodily aspects of experiences and emotions. The inputs are captured using an extension of a mobile telephone equipped with a camera

and that includes bio-sensors capable of measuring pulse and skin conductivity, and accelerometers for and body posture. At the end of the day the data gathered is presented to the user in the form an interactive log. (see Figure 2.4)



Figure 2.4: Affective Diary Display

The Affective Diary display presents a storyline where a humanlike character, shaped as an abstract body replays the users day, using poses, shapes and colours. Attached to the body representations is the data collected from the mobile, such as SMS, MMS, photographs and Bluetooth records during day. This way the user can associate his emotional experiences with the system's representations and day events. The user is also free to adjust the representations according to his perception of events and experienced emotions.

2.1.2.2 Tests and Discussion

The project[27] used a particular user-centered approach requisites evaluation method called *Cultural Probes*[5]. Each test user received a package (probe) full of materials such as postcards with questions a photo camera and others. Users were invited to share their experiences *in loco* using the materials contained in the probe and then send them to the project team. This approach allowed users to provide quite intimate information, in their own environments without felling invaded by the cold and intrusive eye of a lab or test room. Users were free to provide whatever information they wanted without being observed and, as a consequence, this information was less affected by the user's attempts of masking inner feelings or thoughts that he does not want to show.

Cultural Probes tests raise several issues to the traditional HCI evaluation processes. One of these issues, and perhaps the most important of them, is the uncontrolled environment factors during the experience. The design team has to believe that the information provided by the users is trustworthy. Nevertheless, this trust is an important trade off between having users under pressure in an intrusive environment and users relaxed in their own environment. HCI, and more particularly *Affective Interaction*, seem to have a lot to profit from it in mainly in the beginning of the design process.

2.1.3 eMoto

As mentioned earlier, one of main goals of Affective Interaction is to extend the Affective Bandwidth of traditional interaction systems. eMoto [40] is a project where this goal is pursued in the context of Short Message Service (SMS) messages.



Figure 2.5: eMoto

2.1.3.1 Description

Using eMoto to write a text message to someone the user can add expressive content to the message in the form of background shapes, colours and animations. These shapes and colours can be manipulated indirectly by moving around a special stylus equipped with accelerometers, a pressure sensor and a Bluetooth that are able to detect user's expressive gestures and send the information to the phone set (see Figure 2.6).

There is no direct correspondence between specific gestures and results. Instead, gestures are transposed to Labans's dimensions of emotional gestures [43] in terms of movement and pressure, then these terms are transposed to a bi-dimensional emotional

space of Valence and Arousal (see Figure 2.6). This way user gestures can be more fluid and detached from any specific gesture code restricting expressive power.

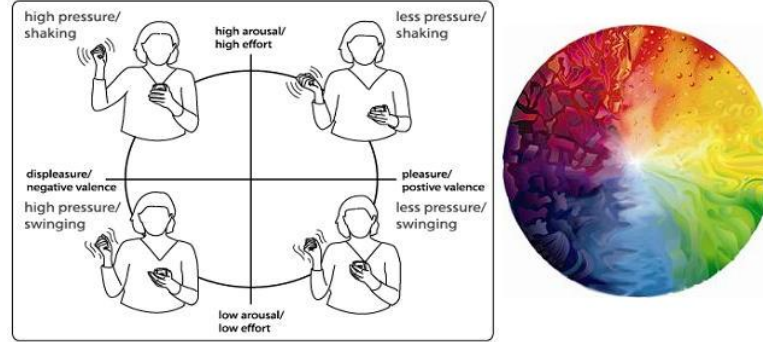


Figure 2.6: eMotoSpace

2.1.3.2 Tests and Discussion

From eMoto’s large evaluation and user studies there are two methods that are more significant: the Scenarios Method[41] and the Experience Clips[42].

Scenarios Method In this method an early eMoto prototype was tested with 18 users that acted four different emotional scenarios[41]. The goal was to test if the idea of capturing the underlying dimensions of the expressive movements was enough to engage the user in an affective loop. This experiment was followed by a small questionnaire and allowed for the team to study the most common gestures of the group as well to conclude that involvement was very much dependent on the skill and will of the subjects to express themselves using gestures.

Experience Clips A later prototype was tested by a combination of Cultural Probes with Experience Clips[34]. This time the written scenarios were substituted by the user’s real life situations. A small group of people was selected from the personal relations of one of the users, all women between 24 and 26 years of age. Each user received a Probe that included a video camera. This way they could ask someone of trust to record small video clips of them using the system. Besides taking out the artificial environment of an experience lab, another advantage of this test was that its duration was extended to a

15 day period. This way the team was able to analyze the whole affective loop in a real environment. Results include the analysis of 96 eMoto messages, who sent to whom, the success or insuccess of the emotions transmitted, and clips of the interactions. All this data allowed to perceive how users learned to use eMoto and used it in real life as well as to see which kind of messages were sent, among other results.

In our perspective, eMoto showed that it is possible to combine both classical in lab evaluation methods such as the *Scenarios Method* and the new *in loco* methods like *Experience Clips* in order to achieve more detailed design and test results.

2.1.4 SenToy and Fantasya

Due to its capability of embracing the user and his actions, gaming is an excellent research context for HCI and Autonomous Agents, hence a very important ground for Affective Interaction. In this context GAIPS[11] and SICS[37] developed SenToy, a doll that can be used as an Affective Interface to control an Autonomous Character with Emotions in a game called Fantasya.



Figure 2.7: Mages spell duel in Fantasya

In Fantasya the user is challenged to help a mage in a series of magical duels against other mages (see Figure 2.7). There is no direct manipulation of the avatar representing the player. Instead, the user transmits emotions to his character, expressing them using a doll (SenToy). These expressions are perceived by the character and influence its

emotional state. Because the character implements an emotional model, its decisions are influenced by its emotional state.

The following text summarizes the design process of the SenToy interface in the context of Fantasya.

2.1.4.1 Design Process

According to the authors, the design of SenToy posed some major questions:

- What kind of gestures best express the set of emotional states needed for the game?
- What kind of doll is most appropriate for this kind of interface?
- Will players like it?

To provide a head start on the gestures question, the design team defined a set of six emotions based in Ekman's emotions[39]. The developers chose these emotions for two main reasons. "First, people independent of culture recognize these emotions from facial expressions. Second, this set of emotions was considered as the minimum for the game to have enough variety so that the player can see the influence of different emotions in the development of the game." [15].

The developers also found solid connections between expressive movements and actions (see Table 2.1), that provided a safe ground to begin defining the movements corresponding to the expressions performed by the user.

Based on these, the design process of this interface was followed by a series of tests that are described next.

2.1.4.2 Tests and Discussion

SenToy design was submitted to a Wizard of Oz Test (see [15] for details). In this test the main goals were to provide data on the best Sentoy shape and movements that would allow users to express the 6 chosen emotions in a natural way. Users were asked to perform the 6 emotions in front of a video camera and a screen with an avatar using three different dolls: a puppet, a Barbie Doll (Ken) and a Teddy Bear. These expressions were

Emotion	Gestures	Reference
FEAR	Put SenToy's hands in front of its eyes and move it backwards vigorously.	According to Lazarus [10] fear is associated with avoidance.
ANGER	Place SenToy's arms crosswise or shake it vigorously.	According to Lazarus [10] anger is associated with "tendency to attack".
SURPRISE	Putting SenToy's arms backwards inclining its torso slightly backwards.	According to Laban [12] surprise is associated with attention and with a sudden event and inclination of the torso backwards.
SADNESS	Bend down SenToy's neck or bend down the entire torso.	According to Scherer [24] sadness is expressed through slow movement inwards and head down.
HAPPINESS	Swing SenToy (make it dance) and/ or play with its arms.	Hoy is portrayed with open arms, movements such as clapping or rhythmic movement according to Darwin[8].
DISGUST	Moving SenToy backwards (squeezing it slightly).	According to Lazarus[10] action tendencies for disgust include "move away", nausea and even vomiting.

Table 2.1: Sentoy - Expressions used in Fantasya

perceived by a hidden observer that knew which emotion was asked and manipulated the response of an avatar seen by the user.



Figure 2.8: SenToyDols

The results of these tests showed that subjects preferred dolls with a neutral facial expression. Also the puppet softness was a very important factor because it allowed users to bend the doll any way they wanted, and small puppets were more hard to manipulate. In terms of emotional expressions, Happiness, Surprise and Sadness movements corresponded to the teams' expectations. Anger seemed like very fast boxing movements, Fear was either expressed by placing the hands over the eyes or turning the doll away from the camera. All testers felt Disgust emotion very hard to express and created a gesture based on "vomiting" (see Table 2.2).

Emotion	Most common action	Occurrences	Second most Common Action	Occurrences
Anger	Boxing with its arms	12	Shake the doll	6
Fear	Hands in front of the eyes	8	Turn the doll away from the camera	7
Disgust	Arms in front of face as if wiping something away	10	"Vomiting"	4
Happiness	Dancing/Jumping continuous movement	16	Arms in the air, waving back and forth	11
Sadness	Bending down its trunk	16	Hands in front of the eyes	8
Surprise	Arms in the air, frozen position	16	Lifting the doll into a frozen position	4

Table 2.2: Sentoy - Expressions Results

Based on these results developers rethought the movements for each expression, as well as the doll design. (see Figure 2.9)

Fantasya's final version was tested in terms of gameplay and usability [21] by a group of 30 subjects who tested the game in a cooperatively in groups of two. This way after, learning the basics of the game, users could discover the rest of the game by discussing it with each other. The tests were filmed, and followed by a satisfaction questionnaire and an informal chat.

Results show that players identified themselves with SenToy and found it fun to use.



Figure 2.9: SenToy



Figure 2.10: sentoy

Children were more enthusiastic about it than adults.

SenToy is a mature example of the power that Affective interfaces can have in game-play interaction. It is also an example of a good design process that overcame the difficult task of implementing easy to use emotional expressions.

2.2 Interactive Narrative and Drama

Interactive story generation systems, more commonly known as *Interactive Storytelling Systems (ISS)* are systems that let one or more users interact with and use such interaction to influence the development of a story. The oldest examples of an ISS are adventure like books, in which the reader can make decisions upon some characters options influencing the outcome of the story. The game industry is also filled with some very interesting examples of story generation, mainly adventure games.

Sometimes the border that distinguishes ISS from a common interactive game may be a little fuzzy. A way of drawing the line is to evaluate the user's experience of the

system. To do this we should consider Murray's Three Aesthetic Categories[20]:

- **Immersion** - A user is immersed in the system when he totally accepts the logic of it.
- **Agency** - Agency is the users' possibility of influencing the story development. A high level of *Agency* is achieved when the users' actions produce high impact in the story development.
- **Transformation** - The system capability of transforming each users' experience of the system in an unique experience. There is great *transformation* when the system is able to produce enough variety of stories avoiding the felling of *déjà vu* by the user.

One can say that all these categories can be present in a game, although they are not essential to make it work. Traditional games tend to propose specific goals to the user that tends to repeat the most successful strategies to achieve these goals. It is easy to find examples in which the user is not able to influence the outcome beyond his capability of overcoming the proposed tasks. Interactive Games and ISS have many things in common, in fact we can argue that ISS is a particular Game niche. Nevertheless there are too many details in ISS research that allow to consider it as a new research area.

Compiling the above mentioned categories one can state that whenever a user interacts with an ISS, he should feel that he can have decisive influence on story development, by changing the world where it is being developed, and that this influence generates a new development of the story.

The following sections summarize several works in the ISS field. The reader will face some different terminologies for very similar concepts such as *Interactive Narrative* and *Interactive Drama*. This terminology is not very clear or even consensual in the research area. We will distinguish between the two using Mateas' Neo-Aristotelean proposal that Intractive Drama should be considered a special niche of Interactive Narrative inspired by the properties of Aristotelian drama[36], such as:

- **Enactment of Situations** instead of its **Description**.
- **Intensification** of actions and emotions instead of its **Extensification** through different perspectives.
- **Unity of Action** around a central theme.

Interactive Storytelling will be used as an umbrella that encapsulates these two kinds of interactive stories.

In this area some techniques and systems will be analyzed.

2.2.1 Mimesis

The integration of interactive narrative system in games introduces a major advantage to traditional fixed and predefined scripts. Systems become more flexible to context change and take off the developer's need for predicting every possible story development. This way interactive narrative environments tend to be more flexible to users actions thus empowering agency.

In spite of its impact, the integration of interactive systems in game engines is not straightforward and presents important challenges. The work developed by the Liquid Narrative Group of the North Carolina State University[16] in the Mimesis project illustrates the effort that has been done in this context. This project's aim was to build a generic interactive narrative architecture designed to integrate with game engines. Mimesis examples of integration can be found in a series of articles such as [33, 49], that relate to the integration of Mimesis with the Unreal Tournament 2003 (UT) game engine.

UT is a popular multi-player first-person shooter game distributed by Epic Games since 1999. Its commercial success and longevity is commonly attributed to its characters superior AI, and to the ease with which players can create and release modifications to the game by adding new characters and maps. UT uses a client-server architecture where the client side is responsible by managing user input and the server is responsible for maintaining worlds consistency. The UT provides stable high-quality graphics,

networking, database and process execution support for virtual environments, which provides a safe environment for Mimesis.

2.2.1.1 Implementation

Integrating a game engine like UT with an AI based Interactive Narrative system poses several challenges that must be considered in the architecture of the system:

- Provide a well defined bridge between the procedural representation used in most engine games, and the explicit declarative models of action found in most AI systems.
- Provide an API for game developers that can be readily integrated with a typical game engine design.
- Facilitate the integration of new intelligent modules that allow researchers to extend functionality.

2.2.1.2 Architecture

The implementation of Mimesis architecture is shown on Figure: 2.11. In this, the

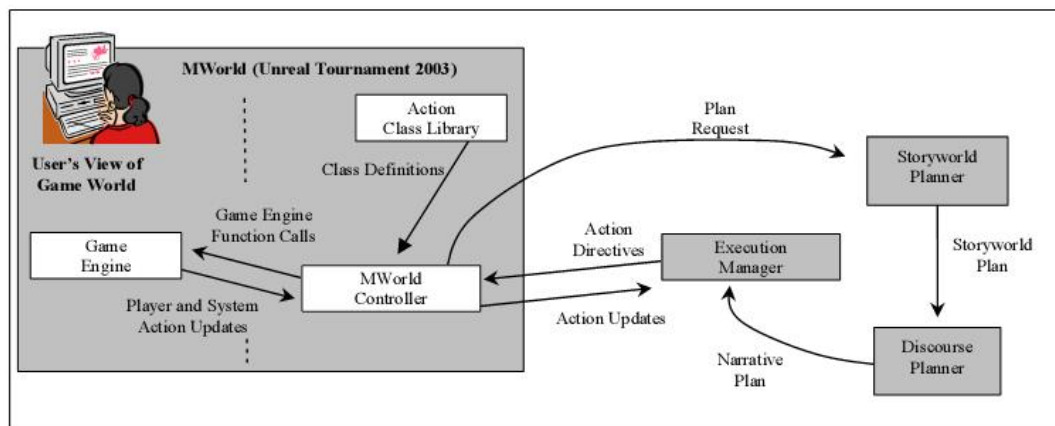


Figure 2.11: Mimesis Architecture

activity within Mimesis is initiated when the game engine sends a message with a plan request to the Storyworld Planner. This request includes a specific story problem that

needs to be solved. The planner receives this problem and creates a new plan (Storyworld Plan) to control an action within the game, designed in order to achieve the story's goal. This plan is sent to the Discourse Planner that builds a discourse plan, which is a structure used to control the camera, background music and other media resources of the game world during the execution of a plan. The discourse Planner integrates both Storyworld and Discourse plans onto an integrated narrative plan which describes all system and user activity that will be executed in response to the game engine's request. Afterwards the Narrative Plan is sent to the Execution Manager, which builds a Direct Acyclic Graph, and starts acting like a process scheduler selecting the actions for execution according to plan. These actions are sent to the MWorld in the form of Action Directives that include all the information of the action to be executed.

The MWorld component that receives the Action Directives is the MWorld Controller. When this component receives an input it maps the information contained in the Action Directives onto their respective Function Calls in the Game Engine. In order to do this, the Controller uses the Action Class Library with all class definitions and a look-up table. After sending the functions for execution, the MWorld Controller receives a notification whenever an action is halted either by successful or unsuccessful completion and communicates it to the Execution Manager. The system keeps looping until the end of the plan is reached.

Problems arise in these systems whenever the user executes actions that conflict with the active plan. More precisely, whenever a player decides to perform an "action that changes the world in a way that conflicts with the causal constraints of the story plan". In Mimesis these actions are monitored via user's action commands, prior to its execution. When an exception is signaled the system chooses between two strategies:

- *Intervention* - The system intervenes by causing the action to fail.
- *Accommodate* - The system adjusts the structure of the plan to accommodate the new activity if the user.

The option between these two strategies takes in consideration the computational cost of generating new plans and the break of the user's sense of agency in the world.

To optimize this process of choosing, the execution manager analyzes each plan prior to execution, looking for points where enabled user actions can threaten its plan structure.

2.2.1.3 Discussion

Both AI Interactive Narrative and Game Engines gain with their integration. Interactive Narrative researchers are provided with consistent virtual world and interaction modules, and at the same time games get more functionalities and adapt to the users non previewed options. The Mimesis integration with UT produced two major functionalities:

- The generation of intelligent, plan-based characters/system behavior at run-time.
- The automatic execution-monitoring and response generation within the context of the plans that it creates.

Intelligent plan/based characters are more engaging then scripted characters that will always be non-believable when faced with non predicted situations. Every time the system *Accommodates* a user action, it provides a greater sense of Agency. This same sense is reduced when the system *Intervenes* and consequently the Gaming Experience is reduced. Nevertheless, one can argue that this is a minor trade-off when faced with the users' engagement and with a more dynamic real-time game experience.

2.2.2 FAçaDE

According to Mateas and Stern [30], there are two traditional approaches to create an interactive narrative experience. One is to build a pre-defined story path in a form of a DAG (Direct Acyclic Graph) or flowchart, like in adventure games or choose-your-own-adventure books. The other is to create a procedural simulation, where the user is placed in a rich virtual world with lots of interactive objects and agents. FAçaDE is the result when its authors tried to build an hybrid solution of both approaches from scratch.

2.2.2.1 Overview

When playing FAçaDE the user takes the roll of a guest in a friends' house. The couple that invites the user is going through a marriage crisis, and tries to convince him to take a side in the conflict. The story develops as the user interacts with them. Interaction is achieved by walking around the house (living-room and kitchen) and using some interactive objects. It is also possible to interact with the other characters, Grace and Trip, which are behavior-based agents, either by using natural language text or by selecting special actions like kissing, comfort and hug. (see Figure 2.12)



Figure 2.12: FAçaDE snapshot

Because of its simulated virtual world of objects and agents FAçaDE can be seen as a simulation, where many things can happen at any time. FAçaDE provides the user with a considerable degree of Agency and freedom of expression, although this freedom is bound to the virtual scenario and natural language processing limitations. In opposition to this perspective, a Drama Director is continuously updating the simulation selecting the best behaviors and discourse acts for the actors (Trip and Grace), so FAçaDE can also be seen as a DAG that moves the story development according to the perspective of the authors.

2.2.2.2 Action Beats

FAçaDE was totally built from scratch. It has several components like 3d-World generation, Natural Language Process Story Memory and Drama Manager (see Figure 2.13).

All these components are important in such a system, but on the context of this work we will focus on the Drama Manager and Story Memory components.

The screenwriting theory concept of *Beat* is used to define “the smallest unit of dramatic action that moves the story forward” [48] FAçaDE used this concept to encapsulate story states with preconditions and effects, behaviors and discourse acts for the behavioral agents, in a structure named Story Beats. Beats’ rules are defined by the authors and tell the Drama Manager when to use each. The overall beats collection creates a notion of dramatic narrative-plot at some high level. One should note that *Story Beats* do not script exact action sequences but just define behaviors and goals for each given moment “not offering a non-trivial simulation space” [30]. This way only one beat can be active at a given time.

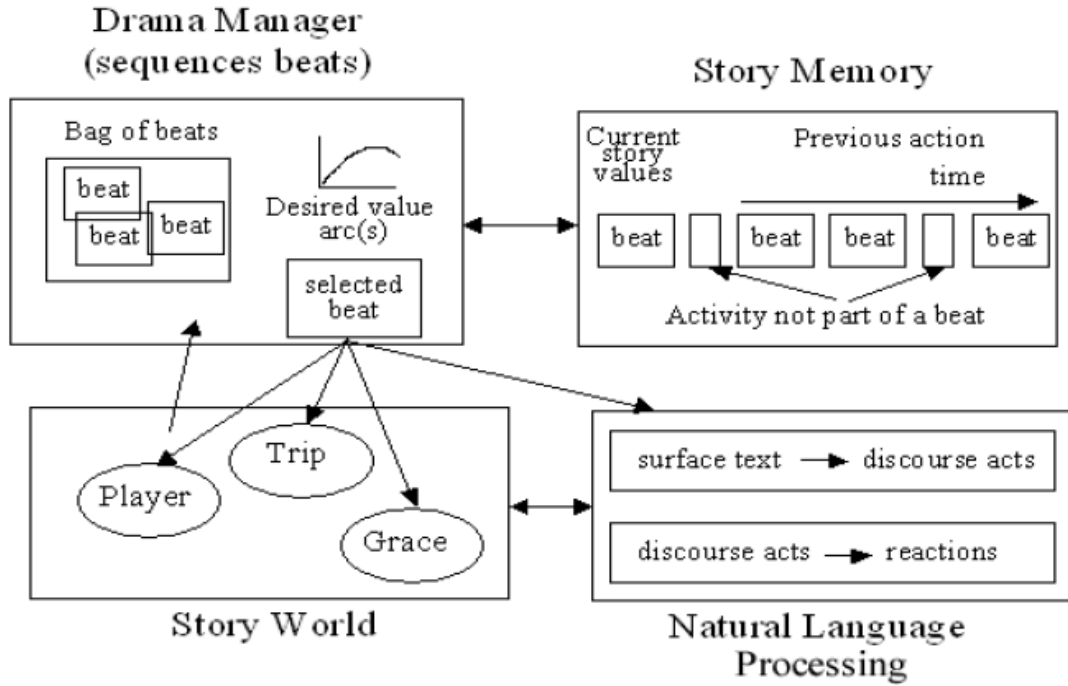


Figure 2.13: FAçaDE Architecture

Programming a Story Beat requires programming some very important variables used by the Beat selection algorithm besides preconditions and effects:

- weight - a value that modifies the probability of a given beat to be selected.

- weigh-test - if the test of this value is true the probability that this beat is selected is multiplied by its weight.
- priority - beats are selected for sequencing by a weighted random draw from beats in the highest priority tier.
- priority-test - if the test of this value is true then the beat has its specified priority.

2.2.2.3 Implementation

Given a collection of beats the Drama manager selects a beat for sequencing. The goal of the director is to perform this selection in such a way that the story development produces an authored Story Arc that represents the story development in terms of Tension, a value that represents the expected tension of the scene, and Time (see Figure 2.14). This selection is made whenever a beat successfully finishes or aborts, using the following algorithm:

1. Initialize any beat-specific state that may play a role in beat selection.
2. Evaluate the preconditions for all the unused beats. This computes the *Satisfied* set with all beats with satisfied preconditions.
3. Evaluate the priority tests of each beat in *Satisfied*. Collect the those with higher priority into the set *ScoredHighestPriority*.
4. Score each beat in the *HighestPriorityTest* using its effects to compare the beat with the desired story arc. This score evaluates the effects of a beat in a story variable named Tension. The result of this step is *ScoredHighestPriority*
5. Multiply each Beats score by its weight. Produces the *WeightedScoreHighestPriority*.
6. Select a beat randomly from the previous set according to a probability distribution defined in the weighted score.

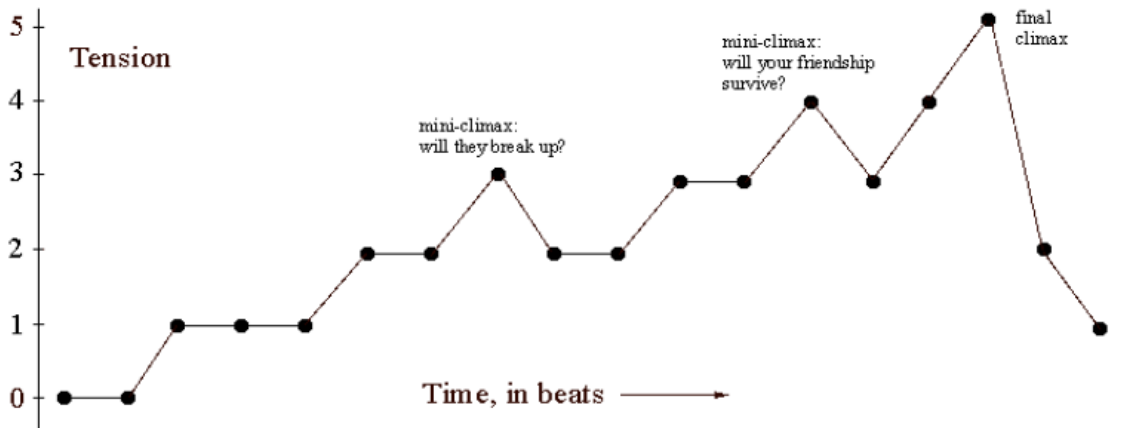


Figure 2.14: FAçaDE Story Arc

2.2.2.4 Discussion

During each beat users are allowed to improvise and expect some coherent reactions from the other characters. Nevertheless, user's *Agency* is bound to the story authored limits. This way one can argue that the user is free to act in the environment, but is also expected to take on the proposed role so that the story develops. An user is not expected to go off-character presenting any new problem to the scene. To illustrate this point we can say that if you tell the other characters things like: "There is a bomb in the building!" or "I have bigger problem than you...", they will change the subject to their problem. There are also some other technical issues like the Natural Language engine natural limitations, or the large time consuming task of authoring the agents behaviors.

Nevertheless FAçaDE is a very successful experience on interactive drama. It's contributions go beyond closing the bridge between scientific Interactive Drama and artistic Drama Theory, introducing some very important concepts such as *Action Beats* and *Story Arc*. Although no scientific user evaluation is available at this time, FAçaDE is recognized in both scientific and game communities as a very entertaining experience and it has been downloaded for free more than 500000 times according to its authors [29].

2.2.3 Interactive Storytelling Prototypes

For the past seven years M.Cavazza et al.[26] have been developing a *Character-Based* approach on *Interactive Narratives* in a series of prototypes called *Interactive Storytelling*. This *Character Based* approach [25, 14], follows Michael Young’s proposal[32] that stories can be dynamically generated by the interaction between characters that use real-time planning systems, as long as the character’s plans implement well defined roles.

In Interactive Storytelling prototypes (see Figure 2.15)the user is invited to assist to a generated story in a interactive way, i.e. the user can influence the story directly in an outsiders perspective, without taking any role as a character. Because the system is implemented using the Unreal Tournament engine, the user is free to manipulate his perspective of the story and move around the story set in real time. It is also possible for the user to manipulate objects and change their positions and give advice to characters using speech recognition.

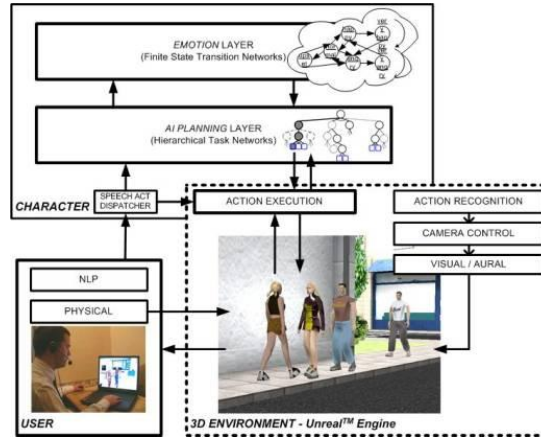


Figure 2.15: Interactive Storytelling Architecture

2.2.3.1 Implementation

The above mentioned *Character-Based Approach* is implemented according to the the idea that character’s roles can be formalized as plans. It is the on-stage interaction between these plans ”that has the potential to create situations of narrative relevance”[14].

This assumption defines two special requisites for the character's planning function:

- Consistency with the characters' role in the story, so that actions maintain a narrative meaning.
- Real-Time adaptability to non-determined on-stage events. Characters should be ready to face a dynamic world, where unexpected things can happen.

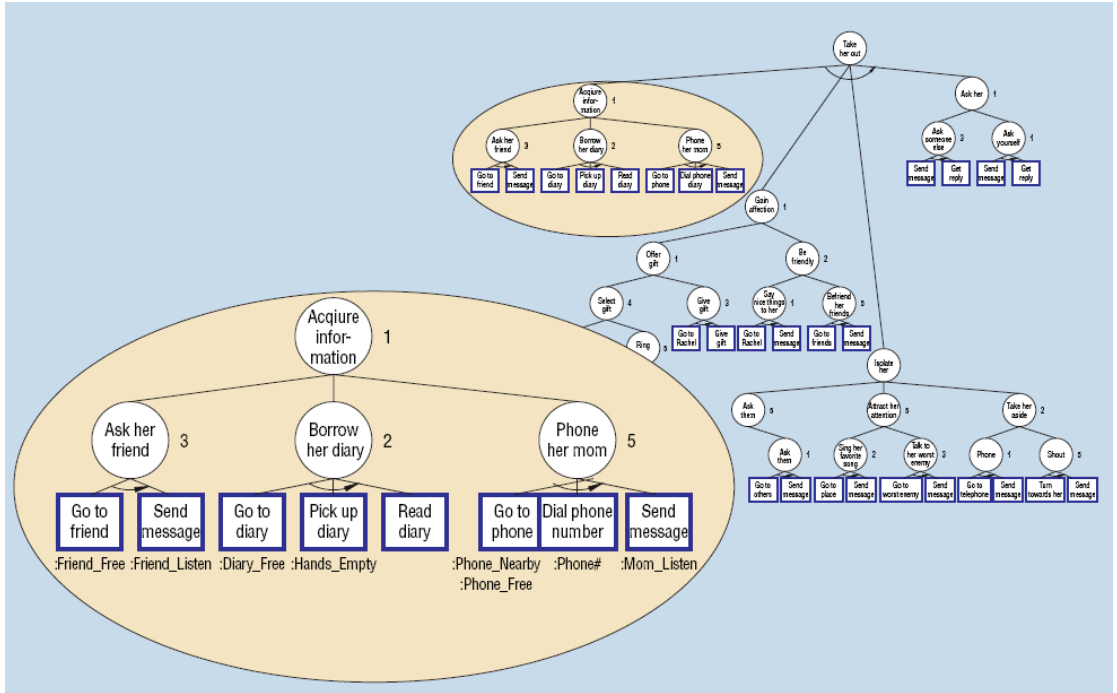


Figure 2.16: Hierarchical Task Network example

In order to fulfill these requirements the authors decided to implement a planning system based on *Hierarchical Task Networks*(HTN)(see Figure 2.16) in which each characters' goals are decomposed into alternative actions. Since each action has its own preconditions, one can define several ways of achieving a goal according to environment conditions. This way, it is possible to define different sets of actions for each goal, creating a diversity of solutions. Characters gain the ability of adapting their plans to the environment. Nevertheless, this adaptability can generate inconsistencies in character behavior, as well as lead to blocking situations when a character is faced with an unexpected environment state for which there is no alternative plan.

To avoid the problems mentioned above authors turned their effort to the hard task of authoring each action and sub-action of the HTNs. The first thing they needed to perform this task was a safe testbed, so they decided to simplify the plot, finding inspiration in a famous american sitcom *Friends*, where as they observed, "story ending and intermediate situations are equally relevant"[14]. Simplifying the plot meant that each character's goals were clear to the user, easy to execute and easy to represent. Nevertheless, the authors did not want to lose story diversification, so beyond allowing user's intervention the system randomizes the initial positions of each character on stage, and some actions' effects,

2.2.3.2 Situated Reasoning and Action Repair

When using these character-character interactions as the origin of an emergent story, researchers are using a bottom-up approach for story development, where characters act to pursue their own goals. In such approaches, unplanned situations emerge from the characters' interactions, raising the need to develop strategies to overcome these without losing narrative significance. For this the development team created two strategies: *Situated Reasoning* and *Action Repair*.

Situated Reasoning happens when the world conditions do not correspond to the character expectations to perform a task without causing it to fail. In such conditions, the character maintains its initial plan but finds a way of doing it with under the actual conditions. If by any chance the initial plan of the previous character fails, he drops the failed plan and creates a new one. This is called *Action Repair*. An example shown in [14] is that of a character (man) that wants to perform a secret task (know more about the woman he likes) and decides to go to her room and read her PDA. When he is moving to the room he sees her coming toward him. Using *Situated Reasoning*, this character finds a way of to be unseen, waits for the other to go away and resumes plan execution (walking through the corridor). If when performing the secret task, he notices that it is impossible to execute it (someone, maybe the user, has hidden the PDA and there is no way to find it), he builds a new plan (talk to a friend).

2.2.3.3 Conclusions and Discussion

The Interactive Storytelling Prototypes have been reporting some considerable contributions to the field. The basis reported in this text has been used to research evaluation factors for storytelling systems, more precisely scalability factors on Interactive Storytelling[13] such as the number or feature or secondary characters, HTN depth and HTN width as more actions for each plan or more variations of it. At the moment of writing, the first affective add ons are being reported [9] using predefined emotional values to enrich character-character interaction although it does not implement a dynamic model for emotional content. The solid development method and continuous contributions make this work a mandatory reference in the field.

2.3 Summary

This chapter presented works of both *Affective Interaction* and *Interactive Storytelling*, that provide a significant background on both research fields present in this work.

The *Affective Interaction* goal of enlarging *Affective Bandwidth* as been addressed by several approaches in very different contexts, from the evaluation of clips (FEEL-TRACE Section 2.1.1), to game interaction (Sentoy and Fantasya Section 2.1.4) passing through expressive SMS text (eMoto Section 2.1.3) and a personal diary (Affective Diary Section 2.1.2). While in the first two works this goal was achieved by defining a direct match between user actions and emotion, other works were more concerned on providing an interaction with a wider expressive space choosing to improve user expressive power over computer comprehension. Nevertheless, there is a common background to all these approaches such as, the activation-evaluation space of emotions and the Laban's dimensions of gestures. Another important conclusion that should be taken from these works is the need for early user involvement in the project using non-intrusive evaluation tests when possible.

In what concerns to *Interactive Storytelling* we can conclude that to start developing such systems, requires a large preparation defining scenarios, graphic environment, character development and HCI models. It also requires a large interdisciplinary back-

ground including theater and literature principles. Plot centered approaches such as FAçaDE(see Section 2.2.2) or Mimesis(see Section 2.2.1), provide story development consistency that captures the user attention although, it can be seriously reduced when the system chooses to *Intervene* in or block user actions. In the other hand *Character Centered* approaches (see 2.2.3) enrich character believability but may reduce story consistency as well as it increases the authoring effort. It seems clear that there is still a lot of discussion and work to develop in both approaches in this field and that both face the same problem of trying to integrate unexpected user actions in a coherent story development.

Chapter 3

Theater and Literature Theory

In the past few years, drama theory has been a good source of knowledge and inspiration for interactive storytelling researchers. Good examples of this are the Neo-Aristotelian Theory of Interactive Drama, proposed by Mateas[36] or the effort to implement *Improv* theories as in Interactive Theatre[6]. I-Shadows is not an exception to this quest for theoretical and artistic background. In this Chapter we will provide an overview some aspects of the theories that have influenced our work. We present those theories and next we will describe the Freytag Pyramid, which served as basis for this work.

3.1 Neo-Aristotelean Theory of Interactive Drama

In an attempt to merge both IS and Theater knowledge Mateas proposed a new theoretical base for Interactive Drama called Neo-Aristotelean Theory of Drama. This proposal presents the impact of user interaction in the classic Aristotelian Theory of Drama. In the classical theory Dramas are analyzed in terms of six hierarchical categories: *Action(Plot)*, *Character*, *Thought*, *Language(Diction)*, *Pattern* and *Enactment(Spectacle)* (see Figure 3.1). These categories are related through two causes:

- **Formal Cause-** relates the six categories from an authorial perspective. The author defines an *Action(Plot)* where *Characters'* relations and intentions are identified. This definition determines each *Characters Thought* that determines their

Language (mainly actions). These actions define behavior *Patterns* that altogether create a *Spectacle* for an audience.

- **Material Cause** - that emerges from the audience perspective of the play. It is the influence of the *Spectacle* in the overall *Action* going through all the other categories.

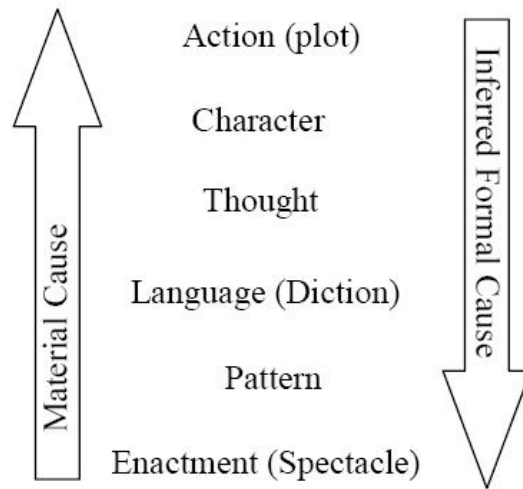


Figure 3.1: Aristotelean Theory

When a user engages and interacts with this model at the level of a *Character* two new Causes can be added to the earlier model defining a new one. (see Figure 3.2).

In this model, *User Intention* is a new *Formal Cause* because in spite of taking part on the plot, the user adds his own perspective while acting in the Drama. There is also a new *Material Cause* that derives from the system limitations in terms of scenario and virtual world that limits the users actions influencing his character from a bottom-up perspective.

3.2 Improv Theater

The first major reference to *Improv*(Improvisational Theater) goes back to Europe's Renaissance period when Comedia Dell'Arte troupes traveled through Europe presenting plays based on open narratives with well defined characters, and narrative structure.

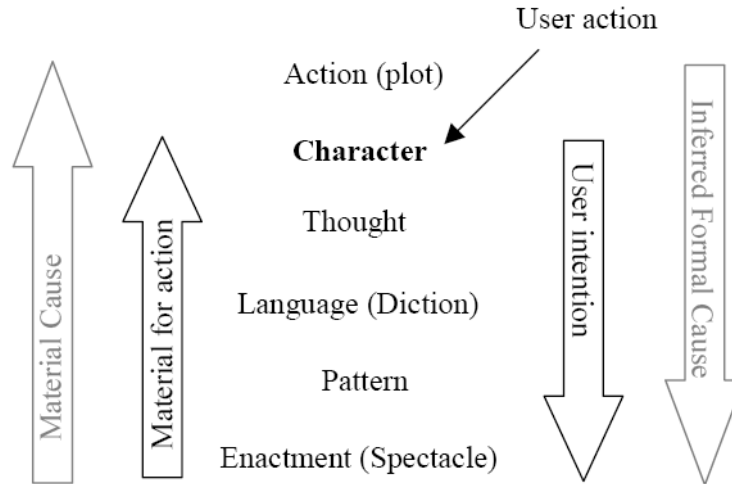


Figure 3.2: Neo-Aristotelean Theory for Interactive Drama proposed by Mateas[36]

The idea of these companies was to let some surprise developments emerge from actors interaction on stage.

More recently theater teachers such as Viola Spolin and Keith Johnston created new techniques that launched the growth of several Improvisational Theater companies, such as Compass. Most *Improv* directors agree on the following basic principles for actors improvising on stage:

- Always accept information given from others.

Otherwise we say the actor is "Blocking" the scene.

- All interventions must add story to the scene.
- Scene Beginnings should be short and objective.
- Enter, stay and exit scene with purpose.
- Maintain character's point of view.

According to Spolin "Improvisational theatre requires very close group relationships because it is from group agreement and group playing that material evolves from scenes to plays". This suggests that in order to achieve a successful interactive drama, the user must take part in this group relationship.[59, 23]

3.3 Freytag Pyramid

In 1863, Freytag defined the Freytag Pyramid and stated that drama (based on his studies,) in general, follows a development variable called tension.[60]

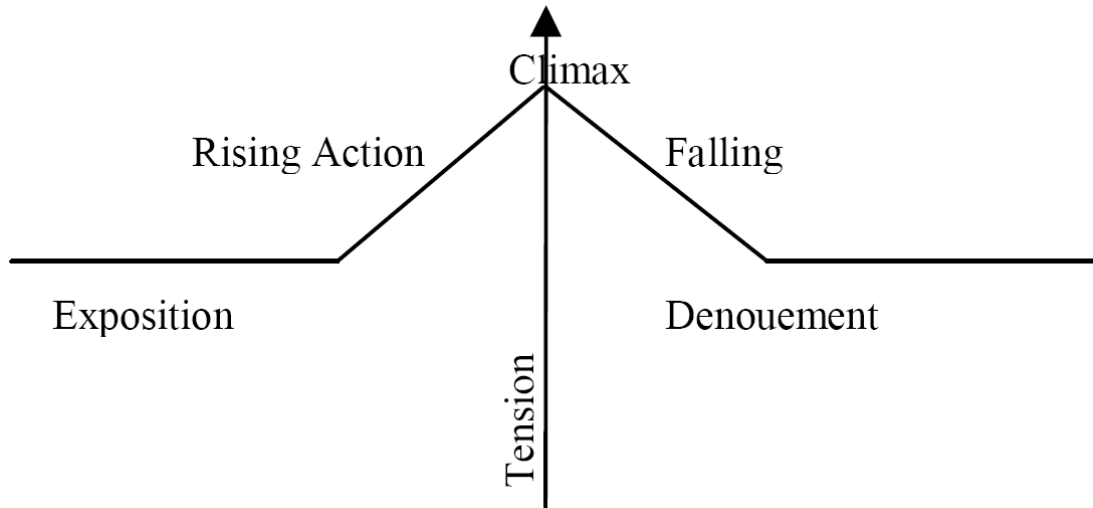


Figure 3.3: Freytag's Pyramid

Following the storyline on Figure 3.3 from left to right, there are 5 acts. In Exposition provides the information about the environment, the characters and their relations. Rising action is the reaction to some negative events that are preventing the protagonist from reaching his or her goals. Climax is a turning point, usually to a positive solution. Falling Action brings everything back to normal. Finally, Denouement is the conclusion of the story. From an emotional point of view we can somehow associate the story start with a positive mood, which then suffers a negative impact and, reacts with a positive conclusion.

3.4 Propps' Functions

In 1928, after an exhaustive study upon the narrative structures of Russian traditional fairy tales, Vladimir Propp presented his work *Morphology of the Folk Tale*[58]. This study divided the tales into their smallest units (narratemes). He also analyzed the types of characters and kinds of actions. Using this method Propp concluded that all

the fairy tales structure analyzed could be defined by using 31 generic functions that he defined (see Table 3.1 and Table 3.2).

	a	Initial Situation
1	β	Abstention. One member of family absents himself or herself
2	γ	Interdiction. An interdiction is addressed to the Hero—a command, request, suggestion, etc.
3	δ	The interdiction is violated. At this point the Villain, enters the story.
4		Reconnaissance. The Villain makes an attempt to gather information.
5	ζ	Delivery. The Villain receives information about his or her Victim.
6	η	Trickery. The Villain attempts to deceive his Victim.
7	θ	Complicity. The Victim submits to this deception.
8a	A	Villainy. The Villain causes harm or injury to a member of a family.
8b	A	Lack. Some tales may initiate complication through lack or insufficiency rather than villainy.
9	B	Mediation. Misfortune or Lack is made known; the Hero is approached.
10	C	Counteraction. The Hero agrees to take action to counter the misfortune or lack.
11	\uparrow	Departure. The Hero leaves home.
12	D	First Donor Function. The Hero is tested, which prepares for his receipt of a magical help.
13	E	Hero's Reaction. The Hero reacts to the actions of the future Donor
14	F	Receipt of Agent. Hero acquires use of magical agent or helper
15	G	Guidance. Hero is led or guided to the object of search

Table 3.1: 1-15 Propps' Functions

16	H	Struggle. Villain and Hero engage in direct combat
17	J	Marking. The hero is branded or marked.
18	I	Victory. The Villain is defeated.
19	K	Liquidation. The misfortune or lack is now liquidated.
20	↓	Return. The Hero returns.
21	Pr	Pursuit. The Hero is pursued.
22	Rs	Rescue. The Hero is rescued from pursuit. Many narratives end here.
23	O	Unrecognized arrival. Hero arrives, unrecognized, home or elsewhere.
24	L	Unfounded Claims. A False Hero presents unfounded claims.
25	M	Difficult Task . A difficult task is presented to the Hero.
26	N	Solution. Task is solved.
27	Q	Recognition. Hero is recognized.
28	Ex	Exposure. False Hero or Villain exposed.
29	T	Transfiguration. Hero given new appearance.
30	U	Punishment. Villain is punished.
31	W	Wedding. Hero is married and/or ascends the throne.

Table 3.2: 16-31 Propps' Functions

This study also included an analysis on the typical characters present in Fairy Tales that identified seven different kinds of characters that could be present in a story. Each of these character participated in a special set of functions that defined its *Sphere of Action*(see Table 3.3).

Kind of Character	Functions
Villain	A, H, Pr
Donor	D, F
Helper	G, K, Rs, N, T
Princess (and father)	M, j, Ex, U, W
Dispatcher	B
Hero	C, E, W
False hero	C, E, L

Table 3.3: Spheres of Action

Propp proposes that the characters of Table 3.3 are always present in Fairy Tales , although their presence may not always be straightforward. Sometimes a single character in a story may aggregate two different kinds of characters, such as a character that is simultaneously a *Princess* and a *Helper*, or a *Villain* character that also tries to impersonate a *False Hero*.

Propps' function continue to be used as a reference not only in structuralist approaches but also as a script writing and analysis framework. Other IS projects also reference this work[52].

3.5 Summary

The four theories presented in this chapter are a strong inspiration to our work. From the Neo-Aristotelean Theory of Drama (Section 3.1) we retain the impact of the *User Intention* in an interactive drama structure and its possible conflict with *Formal Cause*. From *Improv* (Section 3.2) we take some basic principles for autonomous characters to

create stories in cooperative way. These principles gain special importance if we consider the interaction between user and characters in Interactive Storytelling systems where the user takes on the role of a character.

Tension development along a drama (Section 3.3) provides us a new perspective over the story other than just action itself. One can infer the state of a story by observing the evolution of Tension in a small period. Finally, Propp's formalism (Section 3.4) provides us safe background to author characters roles and actions in the context on fairy tales.

Chapter 4

I-Shadows Concept, a Proposal to Affective Interactive Drama

The work presented in this thesis is connected with the development of *I-Shadows*, an ISS system that aims at creating stories in cooperation with one or more users in the context of a Chinese shadows theater. This chapter presents a description of this system including its Installation, the Conceptual Model of the Installation, the Goals and the major Challenges that these goals imply. This presentation is followed by a Motivation to study the challenges mentioned earlier and the definition of the Affective Interactive Drama Concepts, used in our proposal to address these issues, called Affective Interactive Drama Model, that is fed by an Affective Loop.

4.1 Installation

I-Shadows installation was inspired by one of the oldest forms of theater: Chinese Shadows Theater. There are however some important differences:

1. In I-Shadows a user is a puppeteer in the play (thus physically manipulating his/her shadow puppets).
2. Some of the characters in the play are automatically controlled by a computer system. The play emerges as a collaborative process between the user (puppeteer)

and the system (I-Shadows).

The system monitors the action on the screen using a vision component, and participates in it by projecting characters onto the screen. The drama emerges from the interaction between the projected characters and the users, that physically manipulate other characters' puppets. (See Figure 4.1)

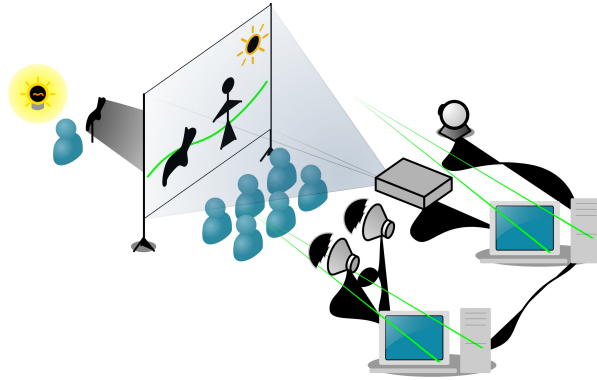


Figure 4.1: Installation

4.2 Installation Conceptual Model

Going back to ancient Chinese Shadows Theater Installations, actors used to manipulate opaque, often articulated figures behind an illuminated screen (see Fig. 4.1). I-Shadows uses the same concept to define its *Puppets*, and in order to provide a cooperative environment between users and the system, two different kinds of *Puppets* are defined:

- *Real Puppet* (See Fig. 4.2) - Puppets that are physically manipulated by the user, behind the illuminated screen in order to project a shadow.
- *Virtual Puppets* (See Fig. 4.2) - Graphical virtual characters manipulated by the system, that are projected directly onto the screen. These *Puppets*' activities are detected in real-time by the system's Vision Component that uses a video camera in real-time.

It is from the interaction between these two kinds of puppets that a collaborative story emerges and is watched by an audience. Because this cooperation is done in



Figure 4.2: Puppets used in I-Shadows (Real Puppet at right, Virtual Puppet at left)

the context of acting, both user and system are encouraged to act using *Emotional Expressions*, which are expressions with emotional content. Adding these expressions to the interactive cooperation, we can say that this interaction gains the shape of an *Affective Loop*.

I-Shadows is a Chinese Shadow Theater where stories emerge on a screen from the interaction between *Real Puppets* controlled by the user, and *Virtual Puppets* controlled by the system. Because this interaction includes *Emotional Expressions* I-Shadows is also an Affective System.

4.3 Goals

Stories are part of us since early childhood. By using toys as elements of make-believe activities, children start to explore the novelty that surrounds them, and simultaneously confront their own fears[18]. An environment like I-Shadows should promote story creation, creativity and allow children to develop memory, sense of perspective, and empathy, thus promoting the emergence of emotional intelligence.

The main goal of I-Shadows is to provide a cooperating environment where children can act with a high degree of freedom in a story in front of an audience.

4.4 Challenges

The challenges imposed by this project are numerous and derive from the challenges of the research areas presented earlier (see Chapter 2). In this section we will present the two most important challenges that are addressed in by I-Shadows.

4.4.1 Building the Affective Loop

Building an affective loop presents three problems:

- How can computers identify emotions?
- How can they compute it?
- How can they express them in a perceptible way?

Mapping these questions to the bi-dimensional world of I-Shadows raise the following:

- How can I-Shadows identify the emotions expressed through puppet manipulation?
- How can I-Shadows process an intelligent response to emotions detected?
- How can I-Shadows express the computed emotions in an understandable way?

4.4.2 Users Expectations vs System Expectations

One of the main challenges in I-Shadows is necessarily one of the major challenges in ISS, the balance between Transformation and the other two Aesthetic Categories for ID, Immersion and Transformation. This challenge goes back to the fundamentals of interactive drama presented in Section 2.2.

When we state that in I-Shadows "children can act with a high degree of freedom" (Section 4.3), we are saying that we want to ensure (as much as possible) that their creative options are not limited by pre-defined settings of the system, that all their efforts are taken into consideration in story development. When a user moves a puppet around the set, his/her actions are immediately exposed in the system and perceived by an audience. This way users can experience a high level of Agency.

Immersion depends on the level of cooperation achieved between user and system. The more the user and the system engage on the creation of a story, the more the user gets the experience of being a member of the system.

A direct consequence of feeding the user's freedom to express and develop a story will be the feeling of Transformation, i.e. the user will feel that a cooperation with the system does not mean a loss of control over the story development.

It is in this context that we can pose the most important challenge for I-Shadows:

How can we promote collaborative story construction without restricting the flexibility, creativity and emotional expression of the children, and at the same time, guarantee some coherence in the stories produced? It is the same to ask: How can we balance the user's and the system's expectations on the story development?

In the following section we present a Motivation to address this question.

4.5 Motivation

As presented earlier I-Shadows and all IS systems face the problem of having to balance users and authors influence in generated stories, and generally they tend to privilege one of these elements over the other (see Section 4.4.2).

Until recently most IS systems implemented script-based or plot-based approaches, either by manipulating each characters goals or by limiting its' planning decisions or actions. These approaches do not allow the creative participation of the user in the story. The user is limited by predefined plots, thus favoring the authors perspective. On the other hand, the introduction of Autonomous Characters in IS brought new flexibility to the characters decisions. However, this flexibility does not ensure safe story development and implies direct manipulation and the treatment of exceptions which again limit actions and plans.

It seems clear that to guarantee safe story development systems tend to limit the participants (either Autonomous Characters or Users) actions in a more or less pre-determined action sequence. Stories are repeatedly analyzed in terms of satisfied or unsatisfied conditions and plans. These approaches produce very good and consistent

results in terms of story generation. Nevertheless they tend to reinforce authors influence in the story over the users' creativity.

Our proposal, Affective Interactive Drama, suggests that a way to overcome this limitation and empower the user's creativity is to analyze stories beyond a sequence of actions and start looking at it as an Affective process, where users and system engage expressing affectively their contribution to the story. Based on this belief we defend that stories can be analyzed at two levels:

- **Action Level** - consists on all the actions performed by the characters.
- **Affective Level** - consists of emotions that the story development raises.

We propose to address the problem of giving more creative power to the user by implementing this Affective Level perspective in our *Affective Interactive Drama* approach. The following Section explains the major concepts of this proposal.

4.6 Affective Interactive Drama Concepts

The main concepts behind *Affective Interactive Drama* are the *Affective Guideline* and the *Affective Process*.

- *Affective Guideline*, is a pre-defined high level perspective of the authors over story, that determines the desired affective evolution of it.
- *Affective Process*, represents the story's real affective development.

To better explain these concepts we will use the following story example:

"... nothing seemed to bother the happy Princess that day while she watered her flowers, but suddenly a Dragon appeared and started breathing fire toward her..."

Instead of analyzing the story as an *Action Development*: (Princess watering plants → Dragon enter scene → Dragon breathe fire), *Affective Process* analyzes the affective development: (Happy Princess → Angry Dragon → Scared Princess). Using this perspective as an input the system can compare it with the *Affective Guideline* and detect

if the story is going according to the guideline or diverging. In this case we say that the story is *Consistent*, otherwise it is *Inconsistent*. In both cases the system must decide whether there is the need to exert any *influence* or not, either to maintain *Consistency* or to correct *Inconsistency*. The system is always active in both situations. There is no concept of exception, right or wrong development, since both cases are parts of the story and of creative liberty.

We use term *influence* to distinguish between the actions performed at the affective level from the actions performed directly in the action level. The system should not manipulate any action directly. Instead, it is expected to induce an affective development into the story according to its perception.

Following the main concepts of Affective Interactive Drama, we next present our model that combines these concepts in order to provide the dramatic evolution of a story.

4.7 Affective Interactive Drama Model

The design of the Affective Interactive Drama Model poses three questions:

- How can we measure the *Affective Process*?
- Which *Affective Guideline* should the system use?
- How should the system exert its *influence*?

The following describes the approach taken in each of these questions.

4.7.1 Affective measurement

Going back to the Freytag's pyramid (see Section 3.3), Drama develops along a variable called *Tension*. There is no rigorous consensus around the meaning of this concept, but one should notice that in the context of Drama it is a direct consequence of the emotions raised and experienced around a story. Based on this principal we assume that *Tension*

can be related to the evolution of the *Affective Process* of a story. Using this assumption we defined a variable called *Mood* to represent this measurement at any given time.

Our model uses *Mood* as a discrete component of the *Affective Guideline*. This value will be calculated from the emotional states of the characters (including virtual and manipulated characters), according to their roles and relevance in the story.

4.7.2 Affective Guideline

Using *Mood* as a reference, the affective evolution of the stories generated by our model should be similar to the evolution of *Tension*. This way users should experience a dramatic development along the story. Using the bi-dimensional space for emotions of Arousal vs. Valence (see Section 2.1), we can define the proposed *Affective Guideline* as a mapping of *Tension* in a Valence vs. Arousal space. (see Figure 4.3)

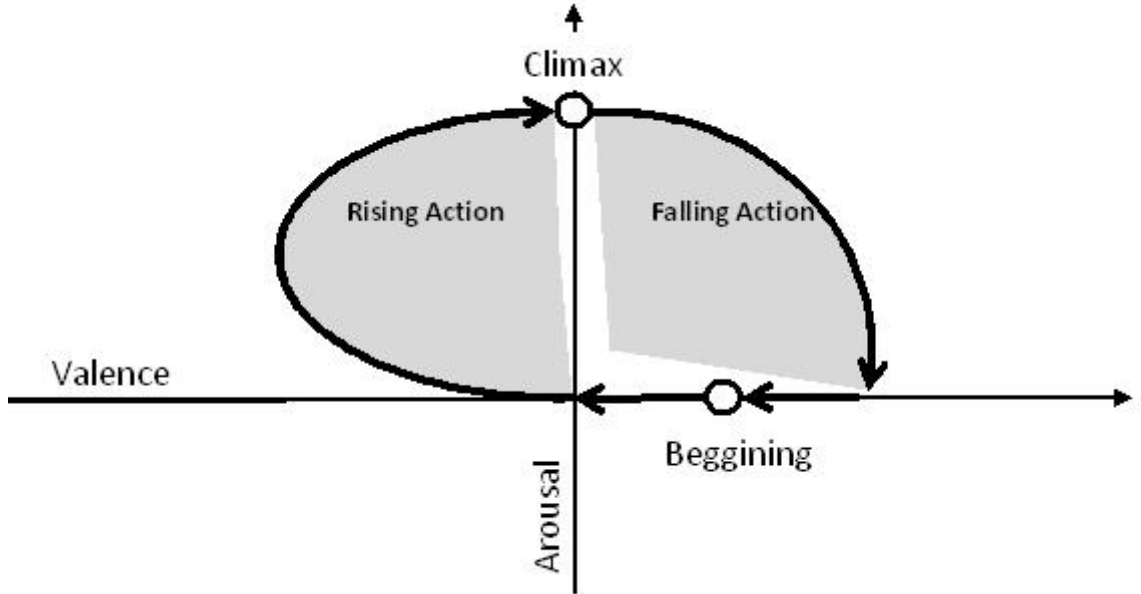


Figure 4.3: Affective Guideline

The *Affective Guideline* should start with a positive *Mood* when all the characters live peacefully, with neutral arousal. As the story develops, someone or something subtly unbalances peace (similar to the villainy function of Propp[58]). Once good and evil are identified, the villain will express his or her evil again but this time with enough impact

to change the *Mood* of the action into negative values. The hero's response, assuming a hero is already known to the audience rises the arousal until the decisive moment of climax, when the valence of the story changes definitively and the villainy's defeat seems inevitable. Then follows the falling action, and there will be a return to normality, ending with the denouement.

4.7.3 Using Influence

Using this model and trying to capture the emotional state of the scene, the system should be able to decide how to intervene at each moment of a story in order to exert its *influence* in the *Affective Process*. Nevertheless we stated earlier that one of the major goals of this approach is to give more creative freedom to the characters, internalizing their actions instead of correcting them. So how can we exert this influence without directly manipulating the actions on the story?

The approach taken to answer this question found inspiration in the *IMPROV* theories mentioned earlier (see Section 3.2). In her theories Spolin states that "...it is from group agreement and group playing that material evolves from scenes to plays..."[59]. This statement suggests that our model should consider the interpersonal relations between characters. Our characters should be able to build interpersonal relations that have direct impact in their emotional states and, as a consequence, in the story *Mood*.

Using the information about each characters relations our system should be able to preview whether the characters on scene at a given moment are able to provide the desired affective output or not. If so, the system should rely the story development to them, letting it emerge from their interactions. If not, the system should intervene. Since we do not want to manipulate actions, and the direct manipulation of emotional states would lead to ambiguities, this intervention should be constrained to the selection of the characters on scene at the moment, i.e. the system should be able to order any character to enter or leave scene, except for the character controlled by the user. More details about this process will be explained in the *Implementation* chapter.

4.8 Affective Loop

This section presents our proposal to develop the *Affective Loop* that will be used to feed our model. The basics of this proposal are strictly confined to the context of the I-Shadows installation referred on Chapter 4.

From the Affective Interactive Drama model presented above it is already known that this loop should be developed between the characters of the story, which in the I-Shadows context means that it will be developed between *Real Puppets* and *Virtual Puppets*. Increasing the *Affective Bandwidth* in this scenario requires for both of its players to be able to identify and express emotions. We address this issue by posing two questions:

- Which emotions can be used in I-Shadows?
- How can emotions be expressed?

4.8.1 Which emotions can be used in I-Shadows?

An approach to this question has already been successfully applied in Fantasya (see Section 2.1.4) which used the 5 Ekman's emotions (Anger, Fear, Disgust, Sadness and Happiness), and should provide a good starting framework. Nevertheless, although the success of these emotions remains uncontested with adults, there is no scientific evidence to guarantee its success with children. However, studies like that of Boone and Cunningham[54], already aim at presenting a correlation between adults and eight year old children successful recognition of Happy, Sad, Anger and Fear body expressions.

Based on these facts the I-Shadows *Affective Loop* should include the expression and detection of *Happiness*, *Sadness*, *Anger* and *Fear*.

4.8.2 How can emotions be expressed?

The particularities of the I-Shadows installations promotes several possible means of interactions, which in the best case scenario are only limited to all the possible things that someone can do with a puppet, from its manipulation, to speech, music or noise.

In order to guarantee safe development start we decided to start by isolating only one of these possibilities. Because of the expressive body, and gestures background already addressed we propose to focus on movement, and develop a bi-dimensional framework of moves that associates patterns of movements with the four proposed emotions.

Bi-dimensional movements should be quantified in both Vertical and Horizontal categories. This quantification should include the parameters of *Speed*, *Amplitude* and *Frequency*. A summary of this framework is presented in Table 4.1.

	Direction	Speed	Amplitude	Frequency
Happy	Horizontal	Very High, High, Slow	Very Wide, Wide, Short	Very High, High, Low
	Vertical	Very High, High, Slow	Very Wide, Wide, Short	Very High, High, Low
Sad	Horizontal	Very High, High, Slow	Very Wide, Wide, Short	Very High, High, Low
	Vertical	Very High, High, Slow	Very Wide, Wide, Short	Very High, High, Low
Angry	Horizontal	Very High, High, Slow	Very Wide, Wide, Short	Very High, High, Low
	Vertical	Very High, High, Slow	Very Wide, Wide, Short	Very High, High, Low
Scared	Horizontal	Very High, High, Slow	Very Wide, Wide, Short	Very High, High, Low
	Vertical	Very High, High, Slow	Very Wide, Wide, Short	Very High, High, Low

Table 4.1: Movement Analysis Framework

This framework should not only be used for the interpretation of users expressions using *Real Puppets* but also for to generate the expressive movements of system controlled *Virtual Puppets*.

4.9 Summary

In this chapter we presented I-Shadows Installation details, Goals and Challenges. These Challenges were formalized into question: "How can we promote collaborative construction without restricting the flexibility, creativity and emotional expression of the children, and at the same time, guarantee some coherence in the stories produced?". We proposed to address this question using the Affective Interaction Drama model, which

uses emotional information of the story as an input to monitor story development.

In the next Chapter we present the architecture used to implement the Affective Interactive Drama model in I-Shadows.

Chapter 5

Proposed Architecture

This chapter presents an architecture proposal for the complete I-Shadows application. It is a top-down description which starts with a requirements analysis and ends with the agent's architectures.

5.1 Requirements

This section is an overall analysis of the system requirements. This analysis was defined in order to obtain a global approach to the architecture to be used as a reference to the rest of the project development.

5.1.0.1 Setup Requirements

The material needed for an installation is:

- Screen for shadows projection.
- Projector
- Detector / Video Camera + Computer

5.1.0.2 User Requirements

Puppets are to be expressively manipulated by children so they must be:

- Funny - attractive to play with.
- Resistant - to resist to the expressive movements impact.

5.1.0.3 Functional Requirements

Puppets have to be identified through a vision algorithm. This algorithm must identify:

- Each puppet individually.
- Puppet's relative position on the set.

According to this, our vision algorithm approach Physical requires that the design should consider:

- Large dimensions.
- An unique color for each character.

Figure 5.1 presents some puppets that are currently in use according to the requirements above.

5.2 Global Architecture

I-Shadow's components are divided into two worlds, the real world and the virtual world.

Children interact with the system by manipulating puppets on the Set, producing colored shadows. These shadows are detected by the vision component, that acts as a bridge between reality and the virtual world. In the virtual world there is a virtual set with the representation of what is happening in the real world, and a Director who is responsible for adding elements to the story, to ensure continuity to the story. The Cast is the group of elements available to enter the story (see Figure 5.2). It will be detailed further on.



Figure 5.1: Puppets created by Mafalda Fernandes

5.2.1 Real World

Each component whose existence does not depend on the functionality of the system belongs to the *Real World*; much of it is already described in the requirements analysis. This section includes an architecture proposal of the bridge between the two worlds: the *Vision Component*.

5.2.1.1 Vision Component

The *Vision Component* (Figure 5.3) is the bridge between the set in reality and the Virtual World's set and has two major functions:

1. Capture - detect which characters are on set and their relative positions.
 - Inputs - Image
 - Outputs - Puppet names and positions
2. Projection - projecting the virtual elements added by the Virtual World to the scene.

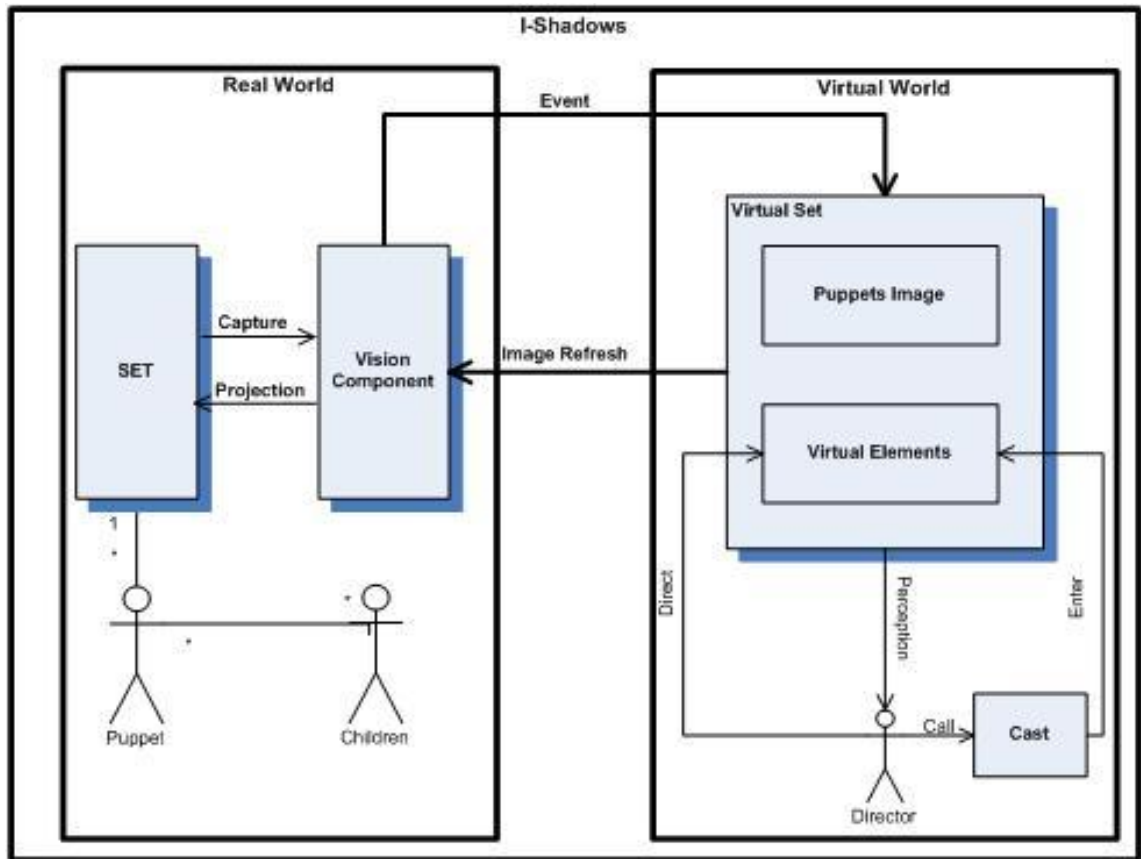


Figure 5.2: Architecture Overview

- Inputs - Name and Position (if graphic)
- Outputs - Image and/or SoundFX

5.2.2 Virtual World

Each component whose existence depends on the system's functionality belongs to the Virtual World (see Figure 5.4). These components are:

- Virtual Set
- Virtual Puppets
- Director

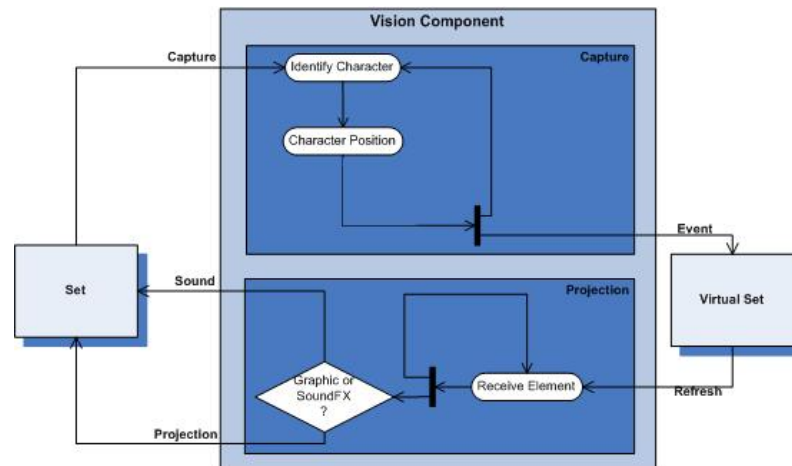


Figure 5.3: Vision Component

5.2.2.1 Virtual Set

The Virtual Set is a virtual image of the real world that consists of an autonomous agent environment where each of the elements of the story, characters and other physical elements such as clouds or trees are directly represented by an autonomous agent. All other elements are mapped into the environment variables.

5.2.2.2 Virtual Puppets

In the virtual world the scene is acquired by Autonomous Agents named Virtual Puppets. There are two kinds of Virtual Puppets:

- Puppet's Image - Represents the puppets manipulated by the users
- Virtual Elements - Represent the elements added to the scene by the Director. These elements can be objects or sounds.

5.2.2.3 Director

This is the component responsible for managing the narrative flow, by adding or removing elements to the scene in order to build a logic narrative that can be understood by the audience.

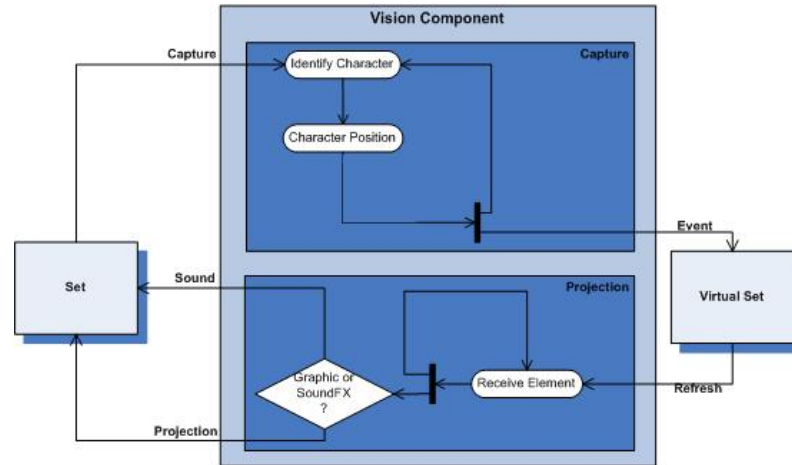


Figure 5.4: Virtual World

The architecture for this component (see Figure 5.5) considers the model proposed in the previous chapter, where it is suggested that the system should consider the *Affective Process* of the story as an input, and exert its *Influence* by adding or removing elements to scene. When a story begins the *Cast* includes all the available *Virtual Puppets* and the *Director* knows the state of all characters relations. As the story starts to develop the *Director* gathers all the affective information coming from the characters and processes it in the *Mood Processor*, which is responsible for calculating the story *Mood* and send updates to the *Director's* knowledge of all the characters relations. Using the calculated *Mood* and this knowledge the *Director* decides how to exert its *Influence* regarding the *Affective Guideline*, by ordering active characters to exit, or inactive character to enter or by letting the story develop for a while.

This architecture requires that characters implement a dynamic relation and emotional model in order to produce the desired inputs for the director. This subject will be addressed in the next section.

5.2.3 Agent Description

In I-Shadows stories emerge from the interaction between the *Real Puppets* and *Autonomous Virtual Characters* (Section 4.2). Next we present a description of the agents

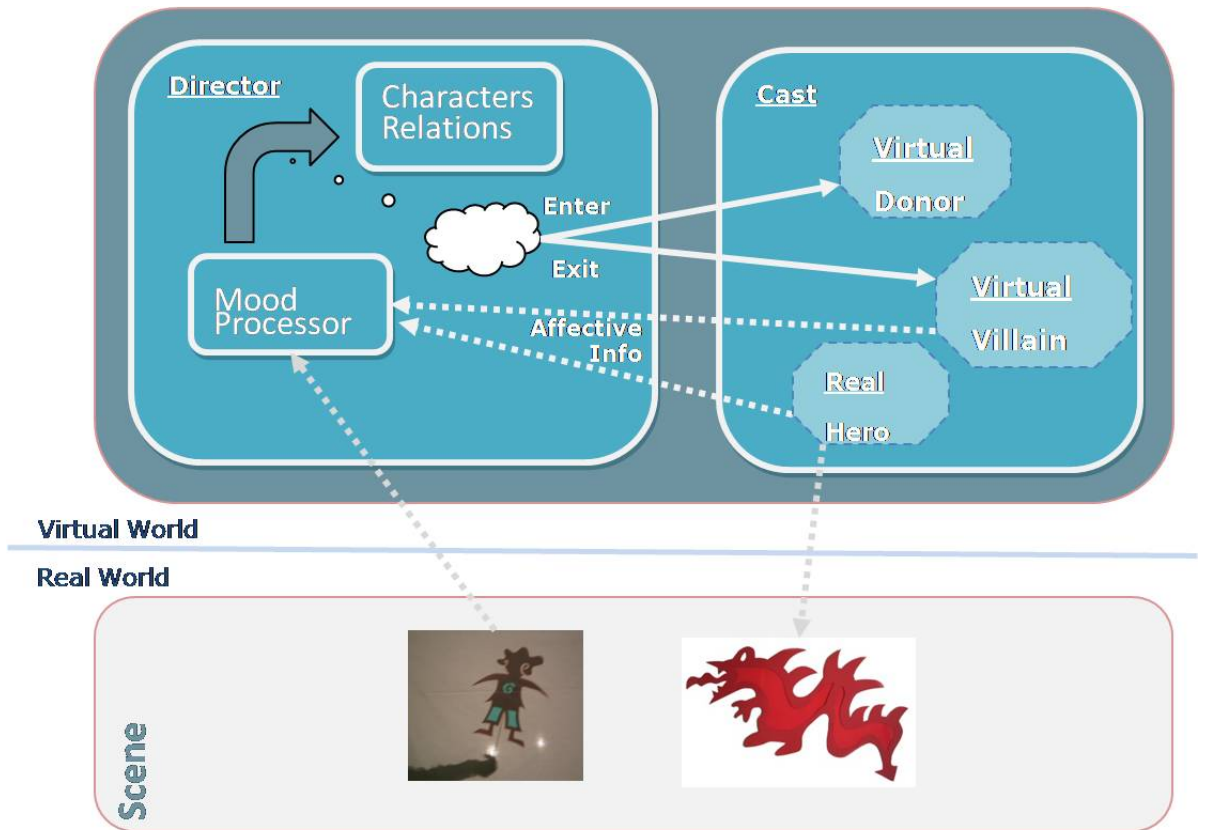


Figure 5.5: Director

implemented to represent autonomous characters in this context. We describe the *Environment* in which the agents interact, their *Requisites* and *Architecture*.

5.2.3.1 Environment

One of I-Shadows's main goals is to allow free narrative development, where the user has unlimited action freedom to interact with the other characters and exert his influence over the story outcome. Adding to this all the characters have access to the world changes and story is continuously moving forward to new states that result from the combination of each character state and the user unpredicted actions. The Environment properties (see Table 5.1) are directly related to this concept.

	Accessible Vs Inaccessible	Deterministic Vs Non-Deterministic	Static Vs Dynamic	Discreet Vs Continuous
I-Shadows Environment	Accessible: Agents limitations to access the world state only depend on his perceptions.	Non-Deterministic: Environment's states depend on action development.	Dynamic: The action never stops.	Continuous: The action only de- pends on the user's creativity.

Table 5.1: Enviroment Properties

5.2.3.2 Puppets

Based on the propose model of Affective Interactive Drama (see Chapter 4) virtual puppets should follow the following requisites:

- Autonomous Behavior - since they should represent characters that should be able to "improvise" while they are on scene receiving as only input their perception of the story development and the orders to leave or enter scene.
- Dynamic Relations - relations should evolve along the story development and should be provided to the *Director*.
- Personality- agents should act their characters in a believable way, showing personality consistency.

According to the above we want to implement agents that can act autonomously in a believable way in the context of a story. Instead of reinventing the wheel, we propose to use a special agent architecture designed specially to allow the generation of emergent and unscripted narratives through believable agents, FAtiMA[17]. This agents architecture is detailed in the following section.

5.2.3.3 FAtiMA

FAtiMA is an agent architecture development at GAIPS by João Dias[17]. It is strongly based on OCC cognitive theory of emotions, where emotions are defined as valanced

(good or bad) reactions to events. The assessment of this relationship between events is called the appraisal process. In order to achieve believable and expressive agents, their behavior is influenced by their emotional state and personality. FAtiMA provides two distinct levels in both appraisal and coping. The reactive level provides a fast mechanism to appraise and react to a given event, while the deliberative level takes longer to react but allows more complex goal-driven behaviour.

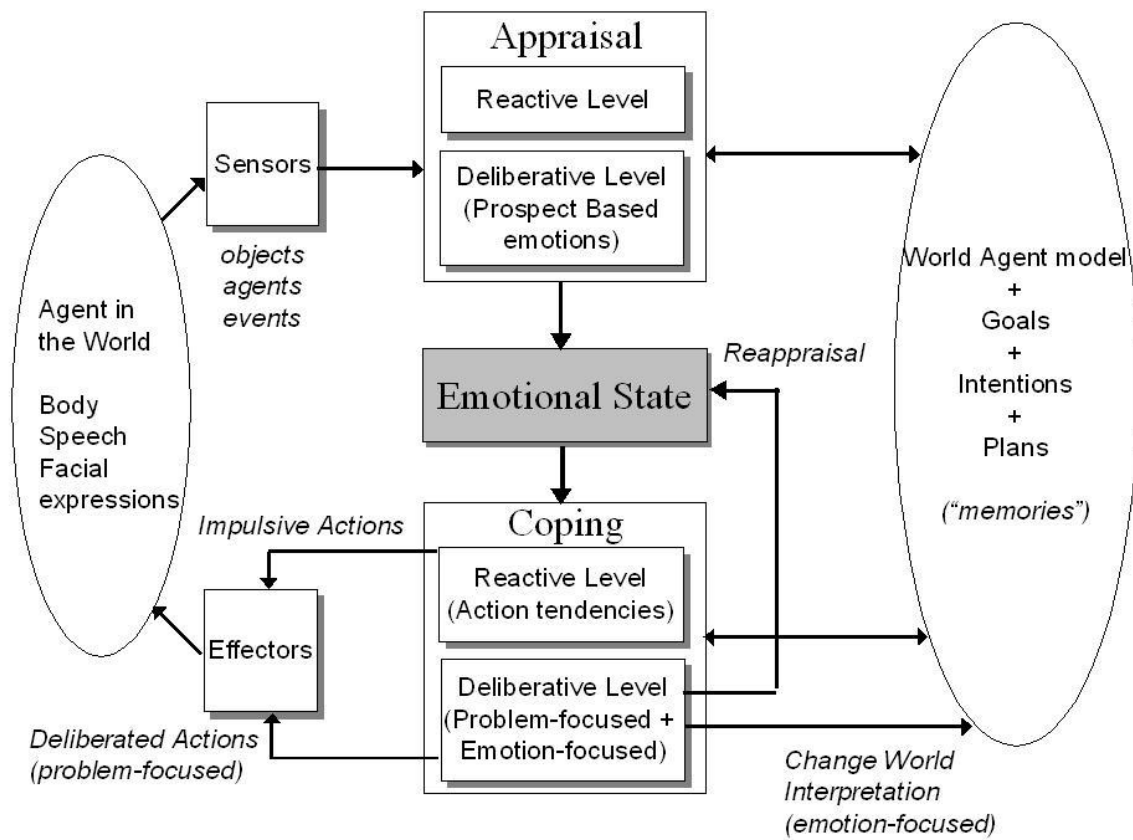


Figure 5.6: FAtiMA architecture

In order to build agents in FAtiMA one has to define the actions available for the domain (they will be used by the planner in the deliberative layer), and then to individually define each of the characters. The character's personality is strongly based on OCC and is defined by: a set of goals; a set of emotional reaction rules; the character's action tendencies; emotional thresholds and decay rates for each of the 22 emotion types defined by OCC.

The emotional reaction rules assess how generic events are appraised and represent the character's standards and attitudes. Since the appraisal process is clearly subjective, these rules must be very dependent on personality. The emotional rules are also important because they are used to influence interpersonal relations that are also modeled in FAtiMA. For instance, if an agent performs an action that triggers negative emotions in another agent, the relation of the latter with the former will deteriorate. These relations are stored explicitly in the agent's model of the world and can be used to activate goals and other type of behavior.

Action tendencies represent the character's impulsive and hardwired actions which he performs without thinking (reactive actions). Action tendencies correspond to simple action rules triggered by particular emotions. For example, we can have a character crying when very distressed. Specifying action tendencies for characters is very important to convey the viewer a well defined personality. Loyall[7] pointed out that in order to achieve believability, characters must exhibit very particular details of movements, mannerisms and reactions.

OCC specifies for each emotion type an emotional threshold and decay rate. An emotional threshold specifies a character's resistance towards an emotion type, and the decay rate assess how fast does the emotion decay over time. When an event is appraised, the created emotions are not necessarily "felt" by the character. The appraisal process determines the potential of emotions. However such emotions are added to the character's emotional state only if their potential surpasses the defined threshold

So, in addition to goals, standards and attitudes, these emotional thresholds and decay rates are used to complement a character's personality. For example, a peaceful character will have a high threshold and a strong decay for the emotion type of Anger, thus its anger emotions will be short and low. Thus, it is possible to have two characters with the same goals, standards and behaviors that react with different emotions to the same event (by having different thresholds). The definition of all the parameters present in this architecture in order to define a character is called *Authoring Process* and it will be detailed further ahead.

Further information about FAtiMA can be found in [17].

5.2.4 Summary

I-Shadows architecture integrates many different components from different research fields that support the environment requisites presented at the beginning of this Chapter and also the requisites for the *Affective Drama Model* using Autonomous Characters based on an FAtiMA. The hard task of implementing each of these components and bringing them all to work together will be presented in the next Chapters.

Chapter 6

Non-Functional Prototype

The development of I-Shadows followed a user-centered approach which included fast prototyping. Along this process three distinct kinds of prototypes were developed and tested. In this Chapter we present the development and testing of the Non-Functional prototype. Some of these experiments conclusions were included in [3, 2].

6.1 Setup

The non functional prototype was a simple Chinese shadows theater, shown on Figure 6.1.



Figure 6.1: First Non Functional Prototype

The setup consisted of a white backlight sheet. A video camera captured the test. The only special requisite for this prototype was that it had to be located in a darkened room. The following sections report the two experiments carried out with

this non-functional prototype. Each experiment had its own goals. However, the overall intention was to include users at an early stage of development to gather their suggestions and reactions.

The following reports the physical description, users identification, goals to be tested, action performed to carry out the experiment, general observations, conclusions and suggestions to be tested on future work.

6.1.1 First Test

This test took place at a local school, during children's free time activities.

Users Five nine-year-old children including 3 girls and 2 boys. All children were volunteers and chose to participate in the tests as in any other school activities.

Goals Study the children acceptance of:

- Shadows in general - Is the concept of Chinese Shadows attractive?
- Characters - Are these characters any useful?
- Story development - How do stories develop in this context?

Action

Available Characters - Boy, Girl, Woman, Man Sun, Moon, Dragon, Candy, Zebra, Turtle, Elephant, Fairy and Musical Flower.

1st Experiment Characters were showed one at a time, and the following was asked:

- Who is he / she?
- What does he / she do?
- What does he / she like?

2nd Experiment - Children were divided in two groups, actors and audience. After listening to the beginning of a story, the actors were free to use any of the available characters to continue the story. The groups switched places and repeated the experiment at the end of the story.

3rd Experiment - After presenting the stories, each children choses his / hers favorite character and explained his choice in an informal talk. Questions asked were:

- Who have you chosen?
- What do you like in him?
- What would you change?

Observations

1st Experiment - All the characters were easily identified.

2nd Experiment - Observations were very much focused on narrative development:

- The story's beginnings were repeated by the users.
- There was no real story development, children played with the characters instead.
- All the characters were used in the stories.
- Small conflicts occurred between users when children had to decide the continuation of the story.
- The end of the play had to be suggested, otherwise stories would never end.
- The Candy character was much used as a treasure or reward.

3rd Experiment - All children provided a lot of feedback, some of the comments are described in Table 6.1.

User	Puppet	Comments
Boy 1	Sun	Loves astronomy.
Boy 2	Turtle	Doesn't like turtles but loves that one.
Girl 1	Zebra	"Looks like a real cartoon!"
Girl 2	Dragon	"The dragon can create many stories", other children wanted the dragon but she wouldn't take her hands off, "I like the color"
Girl 3	Girl	Liked the color and the heart. " I like the girl because I'm a girl too".

Table 6.1: IShadows - User Comments

Conclusions - The conclusions from the experiments were divided between users acceptance of shadows, designed characters and the story development :

- Shadows acceptance - The children loved the show, wanted to be a part of it and use a lot o movements.
- Characters Acceptance - Easily identified.
- Story development - The only consistent part of the stories was the beginning because it corresponded to the suggestion given. From that point on, the story became a result of their plays.

We also concluded from observation that the size of the group telling the story as well as the large number of characters available are probably the reasons why conflicts occurred. These conditions should be more controlled. Also to develop a consistent story these children need small suggestions that lead the story in order to guarantee an coherent development for the audience.

Future Tests - Based on the early conclusions we decide that the following aspects should be considered in future testings:

- Smaller users group

- Introduction of elements to suggest story development (Characters, Sounds and Objects)
- Study of expressions

6.1.2 Second Test

This test took place at a local school, during children's free time activities.

Users Five nine-year-old children, including 3 girls and 2 boys. All children were volunteers and choose to participate in the tests the same way they can chose any other school activities.

Goals The main goals for this test were to maintain contact with users and study how they expressed emotions with the characters.

Action

Available Characters - Boy, Girl, Woman, Man, Sun, Moon, Dragon, Candy, Zebra, Turtle, Elephant, Fairy and Musical Flower, but children could only use 4 of them in each story.

1st Experiment - The beginning of a story was presented to the children. Then they were given full freedom to develop the outcome.

2nd Experiment - When the story started loosing some interest, an outsider entered the play to suggest ideas.

3rd experiment - This experiment worked like a game. A user chose to express an emotion and the audience tried to guess what emotion it was.

Observations and Results

1st Experiment

- The story beginning was performed as if it was a real script.
- The outcome showed a logical sequence with the beginning for some time. Then the users started playing with the characters just for fun.

2nd Experiment

- The ideas were easily accepted , and reproduced.

3rd Experiment The results were analyzed several times using the video recording. We tried to find a movement pattern for each expression and fit it in the table proposed earlier (see Table 4.1) that included as parameters: Speed, Amplitude and Frequency, in both horizontal and vertical dimensions. The following table describes these purely qualitative results.

Emotion	Direction	Speed	Amplitude	Frequency
Happy	Horizontal	Slow	Short	Low
	Vertical	High	Short	High
	Horizontal	Slow	Very Long	High
	Vertical	Slow	Very Long	High
Sad	Horizontal	Very Slow	??	??
	Vertical	Very Slow	??	??
Angry	Horizontal	Very High	Wide	Low
	Vertical	Very High	Wide	High
Scared	Horizontal	Very High	Short	High
	Vertical	Very High	Short	High

Table 6.2: Qualitative Evaluation of emotional Expressions

With the exception of Sadness, all the other expressions appeared to have a clear pattern. Happiness presented two possible patterns which were included in the results.

Conclusions The two first experiments provided some good feedback on acceptance and on the need to help create narrative coherence. The third experiment provided a good framework to study the expressive movements.

Stories Beginnings - Good acceptance by the users, but they were not enough to ensure a logic development.

Suggestions - Same conclusions as to Stories Beginnings.

Future tests From the results we took some decisions for the next experiments.

- Reproduce the analysed expressions and quantify movement.
- Introduction of elements to suggest story development should be considered.

6.2 Summary

In this Chapter we reported our first contact with the users in two experiments. Children reactions to the prototype were very enthusiastic and motivative, and allowed us to work on the definition of qualitative emotional patterns. Next we report how we used these patterns as first step on the definition of the quantified user expressions that were used to feed the *Affective Loop* on the *Affective Interactive Drama*.

Chapter 7

Functional Simulation Prototypes

After discussing the qualitative results gathered with the Non-Functional Prototype we created a Functional Simulation prototype that was used to quantify the previous results. In this chapter we present the user-centered process of building this prototype, which was divided in two steps:

- First Functional Prototype - able to quantify movement and integrated with an agent framework.
- Second Functional Prototype - which implement a simple mind architecture.

7.1 First Functional Prototype

This subsection describes the implementation of the first functional prototype that we named *I-Simulate*.

7.1.1 Requirements

I-Simulate is a software application that simulates the *I-Shadows* system. The same is to say that this prototype is the first implementation of all the *I-Shadows* software components, the exception being the absence of the vision algorithms and the emotional model for the agents minds.

This implementation of *I-Simulate* had two major goals:



Figure 7.1: I-Simulate screenshot. The Girl is user controlled and the Elephant repeats her expressions.

- Implement the software framework that would support *I-Shadows*.
- Allow quantitative testing of emotional expression patterns.

Functional Requirements Puppets were to be manipulated by children through mouse interaction.

Technical Requirements There were two main technical requirements to consider:

- Integration with an agents framework.
- Integration with the designed vision component.

7.1.2 Architecture Overview

We can visualize the I-Simulate architecture as an approach to the I-Shadows architecture that bypasses the vision component.

Children interacted with the system using a mouse control over their character directly on the virtual set, bypassing the real set. The rest of the architecture was necessarily similar to I-Shadows architecture to enable future direct development of the application.

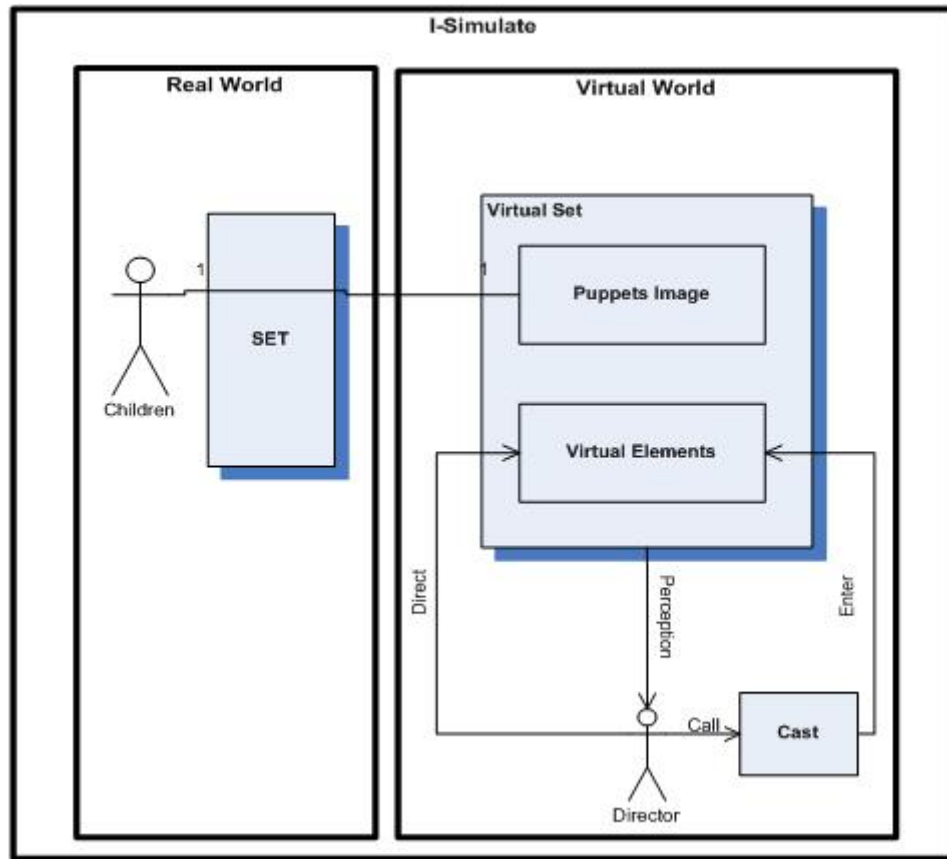


Figure 7.2: I-Simulate Architecture

The main elements that composed I-Simulate affective loop, starting from the users point of view and crossing the whole system in the loop sequence, were divided into four conceptual layers: (see Figure 7.3)

- **Real World** - this layer corresponds to the physical elements of the system: the user and the projection of the application.
- **Interpretation** - this layer is responsible for two symmetrical processes:

Movement Interpretation - the process responsible for mapping movements into emotions.

Movement Generation - the process responsible for defining Virtual Puppets movements according to emotions.

- **Agents** - encapsulates the entities corresponding to the virtual representation of

each puppet, real and virtual.

- **Minds** - this layer consisted of the separation between the agent's mind and representations. This separation allowed a more dynamic definition of minds and characters.

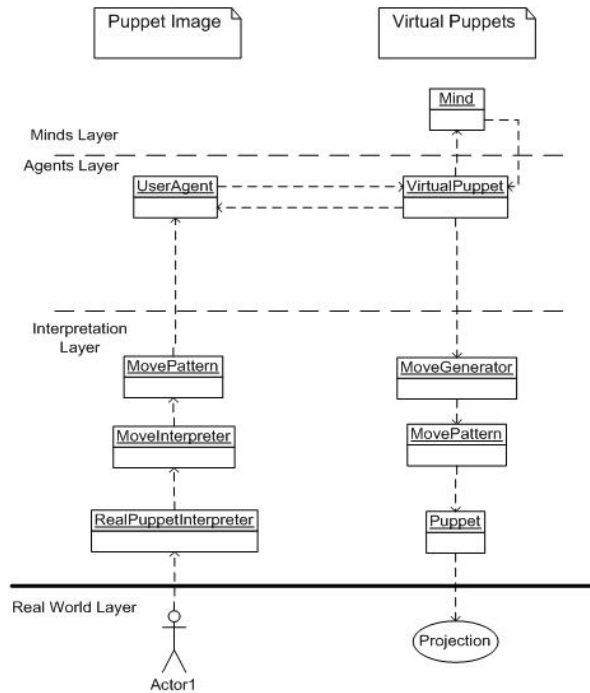


Figure 7.3: I-Simulate components

A more detailed explanation on each one of the layer elements follows.

7.1.2.1 Real Puppet Interpreter

This element is responsible for reading user movements and collect them in a collection of movements called Movement List.

Each movement has three elements for each dimension (horizontal and vertical):

- Direction
- Speed
- Position

7.1.2.2 Move Interpreter

This element is responsible for mapping the movement data into the parameters and categories for movement classification, proposed earlier in this document. (See Table 6.2) A Move Interpreter then does the mapping between movement classification and the corresponding emotion. After receiving a Movement List from the Real Puppet Interpreter, Move Interpreter performs three steps:

- **Create a pattern** - Move Interpreter reads the movement list and calculates three parameters:

Average Speed

Average Amplitude

Frequency

The results are saved in a Move Pattern

- **Analyze the pattern created** - after quantifying parameter values, the *Move Interpreter* compares the obtained values to some reference values and classifies the movements according to the categories proposed earlier in the text.
- **Analyze Emotion** - the last step of the interpreter is comparing the obtained pattern with the patterns that are known to the system. Every match obtained identifies an emotion.

7.1.2.3 Move Pattern

The Move Pattern can be seen as an elementary structure composed of the elements that are proposed to analyze movements' expressions:

- Frequency
- Speed
- Amplitude

- Emotion
- Reference Values
 - Slow Speed
 - High Speed
 - Low Frequency
 - High Frequency
 - Short Amplitude
 - High Amplitude

7.1.2.4 Agents

In this prototype the term agent was used as a simple formalism to identify the classes that would be used in the future as interfaces between AI future components and the graphical system. This interface includes two concepts:

- **Real Agent** - responsible for updating the state of the agent that represents the *Real Puppet* in the virtual world.
- **Virtual Puppet** - responsible for three actions:
 - Identify changes in the virtual world (agent environment).
 - Deliberate according to its own behavior.
 - Update its own changes on the interpretation layer.

In this prototype *Real Agent* sent a low level pattern directly to the *Virtual Puppet*, but these two elements were ready to be integrated with the Minds layer.

7.1.2.5 Move Generator

Its behavior was symmetrical to one defined in the *Movement Interpreter*. Using the same pre-defined values, the generator defined a pattern whose parameters are categorized according to the emotion sent from the upper layer.

7.1.2.6 Puppet

Using the values kept in his *Movement Pattern*, Puppets calculated their interpolated positions by themselves.

7.1.3 Development Tools and Frameworks

The choice of the development tools followed some considerations:

- Integration with the agent framework - ION [4], developed in C# .Net.
- Portability.
- Powerful and simple graphic generation.
- Extensibility.

The agent framework chosen for this project was the ION framework that is under development at our research lab. We chose this framework in order to allow future extensibility and integration with other projects being developed in it.

More than a simple consideration, the integration with the ION framework was a project requisite. This integration was the main critical point of the project, since ION was still under development. An efficient way of reducing such an impact, was to adopt the same development environment.

As for graphic generation four technologies were considered:

- .Net tools
- wxWindows
- TAO.OpenGL
- DirectX 3D

The first two technologies were discarded under the extensibility argument, because of their limited 2D engines. And we wanted to keep the 3D window open for future

improvements. When comparing TAO.OpenGl, an OpenGL library for C# , with DirectX 3D, the argument was experience. Previous experiences with positive results with OpenGL, encouraged us to use this tool and learn more about its adaptation to C#. Later this option raised some serious issues.

7.1.4 Methodology

The main priority of the implementation decisions was to ensure consistency between the Interpretation and the Generation processes. Keeping the focus on this priority, it was decided that the best way to ensure it was to adopt an iterative bottom-up implementation that would always maintain the interpretation and the generation processes at the same level of development connected through a bypass. The iteration consisted of two steps:

- **Puppet Bypass** - the virtual puppet reproduced all user movements. With this bypass it was possible to calculate movements' properties.
- **Low-Level Pattern Bypass** - the bypass between the two processes included only a low-level pattern corresponding to an emotion. When an emotion was detected the virtual puppet would generate the movement that corresponded to it.

In order to build a pattern it was fundamental to have a quantitative reference to evaluate user movements. To calculate these values some testing had to be carried out.

7.1.5 Tests

This section reports the tests made to the first functional prototype.

7.1.5.1 Emotional Patterns Definition - Bodystorming

At this moment in the project, the prototype could not guarantee an efficient testing environment for children due to the lack of funny elements and graphic quality. Tests with children would take time and would not guarantee efficient results, so we took

the liberty of following a bodystorming[38] approach of playing with our puppets and reproduce the movements that children had used in early testing.

Goals - Obtain a first set of emotional patterns to be used as reference for development.

Users - Since this was a Bodystorming session, the users were the developers themselves.

Action

Material - One computer.

Available Characters - Boy, Girl, Dragon and Fairy

Experiment - Repeat the patterns identified with the non-functional prototype.

Results The results of this test are presented next. The samples were taken with an interval of 2 seconds. The analysis addressed the following:

- Study of the samples distributions
- Sorting of the average values by ascending order.
- Definition of intervals with a small error margin.

Speed - The results obtained for speed are described on Table 7.1. Each result sample was analyzed according to their minimum (Min), maximum (Max), average (Avg), standard deviation (STDEV), and confidence interval that consisted in the interval limited by the addition or subtraction of the STDEV to the average.

After ordering some of the results were not consistent with the qualitative evaluation made earlier in the first test, these results are shown in bold.

Speed values were categorized into the proposed categories with the values of:

- Very Slow Speed -]0; 0,2[

- Slow Speed - $[0,2; 7[$
- High Speed - $[7; 105[$
- Very High Speed - $[105; \dots[$

Speed	Min	Max	Average	STDEV	Avg-STDEV	Avg + STDEV
SadX	0,29	1,77	0,98	0,43	0,55	1,03
SadY	0,33	1,38	0,72	0,31	0,41	1,40
ScaredX	12,86	35,13	20,99	7,42	13,57	28,41
ScaredY	0,55	2,74	1,49	0,70	0,79	2,19
HappyX	1,38	3,14	2,25	0,57	1,67	2,82
HappyY	38,90	98,29	78,89	17,03	61,87	95,92
AngryX	15,57	31,20	22,87	4,99	17,87	27,86
AngryY	116,77	154,77	138,44	12,58	125,86	151,02

Table 7.1: Speed Values (Points / Second)

This categorization is detailed in Table 7.2.

Speed	Observation Level	Calculated Level	Min Prop	Error	Max Prop	Error	Total Error
SadX	VerySlow	Slow	0,2	O	7	0	0%
SadY	VerySlow	Slow	0,2	O	7	0	0%
ScaredX	VeryHigh	High	7	O	105	0	0%
ScaredY	VeryHigh	Slow	0,2	O	7	0	0%
HappyX	Slow	Slow	0,2	O	7	0	0%
HappyY	High	High	7	O	105	0	0%
AngryX	VeryHigh	High	7	O	105	0	0%
AngryY	VeryHigh	VeryHigh	105	0	<i>infy</i>	0	0%

Table 7.2: Speed Categories

We considered as an error all the values that were not in the confidence interval defined earlier $[(avg - Stdev); (avg + Stdev)]$.

Frequency - Frequency values are shown on table 7.3. The results show that there was not enough dispersion for the four categories proposed earlier, and so they were collapsed to two categories only.

Frequency	Min	Max	Average	STDEV	Avg-STDEV	Avg + STDEV
SadX	2,00	3,00	2,30	0,48	1,82	2,78
SadY	1,00	6,00	3,20	1,32	1,88	4,52
ScaredX	23,00	30,00	27,10	2,33	24,77	29,43
ScaredY	7,00	19,00	12,20	3,82	8,38	16,02
HappyX	4,00	13,00	8,80	2,57	6,23	11,37
HappyY	4,00	14,00	12,70	3,09	9,61	15,79
AngryX	15,00	19,00	17,50	1,43	16,07	18,93
AngryY	17,00	19,00	18,10	0,57	17,53	18,67

Table 7.3: Frequency Values (Points / Second)

Speed	Observation Level	Calculated Level	Min Prop	Error	Max Prop	Error	Total Error
SadX	??	Low	1	O	15	0	0%
SadY	??	Low	1	O	15	0	0%
ScaredX	High	High	15	O	0	0	0%
ScaredY	High	Low	1	2	15	0	20%
HappyX	Low	Low	1	O	15	0	0%
HappyY	High	Low	1	O	15	0	0%
AngryX	Low	High	15	O	0	0	0%
AngryY	High	High	15	0	$+\infty$	0	0%

Table 7.4: Frequency Categories

The value attributed to the categories limit was 15. The result was presented in Table 7.4

- Low Frequency - $]0; 15[$

- High Frequency - $[15; \dots[$

All the frequency results showed great credibility except for Scared Y with an error percentage of 20.

Amplitude - Amplitude values showed concordance with those expected, except for Angry X and Happy Y. As in the frequency case, the results demonstrated the lack of need for four categories. The sample allowed a simple two intervals categorization: Short and Wide.

Amplitude	Min	Max	Average	(Avg - STDEV)	(Avg + STDEV)
ScaredX	0	0	0	0	0
ScaredY	0	0	0	0	0
HappyX	0	1	0,2	0,42	-0,22
AngryX	0	2	0,6	0,84	-0,24
SadY	0	3	1	1,05	-0,05
SadX	0	8	4,4	2,84	1,56
AngryY	0	13	4,9	3,81	1,09
HappyY	1	14	8,2	4,37	3,83

Table 7.5: Amplitude Values (Points)

The proposed value for amplitude limits was 3. However this value generates a small error margin. The option for this value took under consideration the combination of these values with the other parameters whose success margin offered a bigger confidence. The result was:

- Low Amplitude $]0; 3[$
- High Amplitude $[3; +\dots[$

7.1. FIRST FUNCTIONAL PROTOTYPE

Amplitude	Observation Level	Calculated Level	minProp	Error	maxProp
ScaredX	Short	Short	0	0	3
ScaredY	Short	Short	0	0	3
HappyX	Short	Short	0	0	3
AngryX	Wide	Short	0	0	3
SadY		Short	0	0	3
SadX		Wide	3	2	
AngryY	Wide	Wide	3	2	
HappyY	Short	Wide	3	1	

Table 7.6: Amplitude Categories

Conclusions - From the categories defined in the testing a new pattern table was built that was not much different from the original. However, now we had quantitative references for each parameter, as well as a success margin that would help us choose the more accurate parameters for each pattern.

Patterns	Speed	Frequency	Amplitude
HappyX	Slow	Low	Short
HappyY	High	Low	Wide
SadX	Slow	Low	Wide
SadY	Slow	Low	Short
AngryX	High	High	Short
AngryY	VeryHigh	High	Wide
ScaredX	High	High	Short
ScaredY	Slow	Low	Short

Table 7.7: Calculated Patterns

As it is shown in Table 7.7, each expression has a less accurate parameter. This helped us define a simpler pattern for each expression, by discarding those less accurate parameters.

7.1.5.2 Second Emotional Pattern Tests - with users

This test took place at IDEIA School in Tires, during children free time activities.

Users - Eight eight-year-old children including 4 girls and 4 boys. All children were volunteers and choose to participate in the tests the same way they could choose any other activity.

Goals The basis for these tests was to evaluate and improve the patterns developed by the team and can be expressed as follows:

- Study the children's expression with the characters, through mouse manipulation.
Test the acceptance of the current patterns,
- Find values for new patterns
- Evaluate the overall acceptance of the I-Simulate display and interface.

Action

Installation - Projection of I-Simulate on a wall.

Material - One computer, one projector and a wall.

Available Characters - Boy, Girl, Dragon and Fairy.

Introduction - The children were invited to play a mime game between them. "This mime game has some special words. These words are emotions like Happiness, Sadness, Fury and Fear". Once the game started to slow down, we started the first experiment.

1st experiment - After choosing two virtual puppets, a character to manipulate and friend to play with, the experiment works like the previous mime game, but it was up to the "friend" to recognize their emotion and repeat it.

2nd experiment - Everyone one tried to show their "friend" how he should move when he is angry.

Results Each test produced the following results.

1st Experiment - This experiment had two result sets. The first set (see Table 7.8) corresponds to the very first interaction with the system. The second set (see Table 7.9) corresponds to the results of a second round of tests. Each successful attempt to recognize the expression is identified with a '1', unsuccessful ones with a '0'.

	Boy1	Boy2	Boy3	Boy4	Girl1	Girl2	Girl3	Girl 4	Success
Happy	0	1	0	1	0	1	1	1	63%
Sad	1	1	1	1	1	0	1	1	88%
Scared	1	1	1	1	0	1	0	1	75%
Angry	0	0	0	1	0	0	0	0	13%

Table 7.8: First Round

	Boy1	Boy2	Boy3	Boy4	Girl1	Girl2	Girl3	Girl 4	Success
Happy	1	1	1	1	1	1	1	1	100%
Sad	1	1	1	1	1	1	1	1	100%
Scared	1	1	1	1	0	1	1	1	88%
Angry	0	0	0	1	0	0	0	0	13%

Table 7.9: Second Round

2nd Experiment - At the end we had 71 sets of movements. Table 7.10 presents the average values, and the respective standard deviation value.

	Frequency X	Speed X	Amplitude X	Frequency Y	Speed Y	Amplitude Y
Average	14,5	187,75	17,5	14,39	140,43	17,61
STDEV	5,18	149,03	19,2	5,25	86,14	35,72

Table 7.10: Anger Pattern 2 - Raw results

The results presented on Table 7.10 were inconclusive because they included the values for movements that did not correspond to Anger, but to the transitions between users or pauses. Our approach was to exclude those values whose range was outside the order of magnitude of the rest of the values. Finally we obtained a list of 22 result sets (see Table 7.11) that showed some consistency.

7.1. FIRST FUNCTIONAL PROTOTYPE

	Frequency X	Speed X	Amplitude X	Frequency Y	Speed Y	Amplitude Y
Values	16	104,17	16,125	16	193,657	29,44
	14	131,48	16,125	16	218,55	14,36
	12	138,85	13,67	12	183,64	11,58
	12	112,91	20,5	12	168,34	35,83
	14	168,74	27,71	14	209,03	35,64
	12	150,79	11,42	12	330,88	28,42
	16	139,32	10,19	16	269,53	21,19
	16	142,63	18,06	16	250,94	19,69
	14	132,79	17,71	14	225,67	25,93
	17	158,89	15,53	14	140,32	21,93
	17	274,74	13,06	17	192,38	11,76
	18	303,606	16,72	18	163,7	11,61
	18	249,74	13,22	18	166,53	14
	18	303,6	16,72	18	163,7	11,61
	18	249,74	13,22	18	166,53	14
	19	457,911	62,32	19	223,65	15,42
	14	324,94	46,36	13	237,6	13,23
	19	600	26,89	17	118,26	15,18
	18	85,33	13,5	18	125,76	10,72
	20	172,41	24,7	20	213,8	32,65
	16	159,79	8,69	15	198	10,4
	16	168,27	21,19	16	213,42	29,06
Average	16,09090909	215,0294	20,165	15,86364	198,813	19,71136
Stdev	2,38864558	124,8763	12,3763	2,356257	48,77498	8,694803

Table 7.11: Anger Pattern 2 - Treated Results

When we merged these values with the qualitative pattern evaluation table (see Table 6.2), we got the following results presented in Table 7.12:

Patterns	Speed	Frequency	Amplitude
HappyX	Slow	Low	Short
HappyY	High	Low	Wide
SadX	Slow	Low	Wide
SadY	Slow	Low	Short
AngryX	High	High	Short
AngryY	VeryHigh	High	Wide
ScaredX	High	High	Low
ScaredY	Slow	Low	Low
Angry2 X	Very High	Low	Wide
Angry2 Y	Very High	Low	Wide

Table 7.12: New Pattern Table

As it can be seen on table 7.12, the only similarities between the Angry and Angry2 patterns are the very high speeds. Frequency and amplitude show two completely different categories.

Observations The children responded enthusiastically to the 1st experiment. Sometimes less expressive kids showed some difficulty at the beginning. However, they adapted to the game very fast by watching how others did it. The results were very well in line with the expected for all patterns except for Angry. One of the factors that may have influenced this situation is the fact that the early observations were made to puppet manipulation instead of the I-Simulate mouse manipulation.

Anger was sometimes expressed by attacking the other character.

Conclusions I-Simulate showed a very positive impact in children. Characters and set design were very well accepted. Children were really enthusiastic.

The simplistic approach to the quantified values showed good results for all patterns

except for Anger. It also allowed the definition of an efficient testing framework that revealed to be of extreme importance when results on the Anger pattern started to show less success.

The obtained pattern for Anger consists on high speed and wide movements.

Future Tests The new pattern that resulted from this experience should be validated in future testings.

Discussion The main topic for discussion at this point was whether the new Anger pattern was suitable for a dramatic context. Since movements may be too wide for the actors to express an intention in an explicit way.

Based on the observations of the children that expressed anger by attacking the other character, we proposed that the next prototype should include another Anger pattern consisting on short attacking movements.

This difficulty raised the issue of implementing High Level Patterns which should consist on the implementation of a multimodal interface whose modalities are: Emotions and Actions. Following this approach we believe that we could reduce the ambiguity of some results. This belief comes from Sharon Oviatt's studies in multimodal interfaces [55], where studies demonstrate how multimodal interfaces can be used to disambiguate context.

7.2 Second Functional Prototype

The goal of this prototype was to implement the High-Level pattern bypass. Its implementation included the integration of the previous prototype.

7.2.1 High Level Patterns

At this point the goal was to make the emotional bypass go through the agent layer. This step had to include the definition of the High Level Patterns presented earlier. Our first proposal for these High Level patterns came from direct observations of children playing

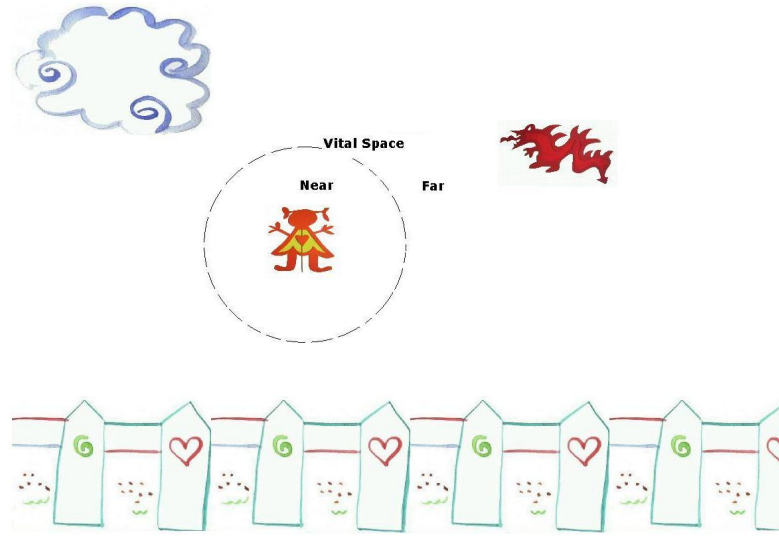


Figure 7.4: Vital Space

recorded in the previous tests. From these observations we concluded that character reactions to emotions could be evaluated in two cases, distance and speed.

7.2.1.1 Distance - Vital Space

Our approach to evaluate Near and Far consists on the inclusion of a new concept: Vital Space. We say that something is near when that something is inside our vital space. An far when something is far when it is outside the vital space. (See Figure 7.4)

The reference value used to calculate the Vital Space radius is 1.5 times the character's width. As a result of this approach a relating between Vital Space and Emotions was built(see Table 7.13).

Vital Space		
	In	Out
Happy	Talk	Play
Sad	Cry	Cry
Angry	Attack	Threat
Scared	Calling for Help	Calling for help

Table 7.13: High Level Pattern

At this time the only emotions that shown a conclusive behavior when combined with the Vital Space were Happiness and Anger. Other behaviours would have to be studied and would be an essential component for each character's personality.

7.2.1.2 Relative Speed

Another variable to consider when building High Level Patterns was Relative Speed. Relative Speed allows each character to detect whether something is moving in or away and at what speed. Relative speed is positive when the target element moves away from a character and negative when it moves closer. High absolute values correspond to higher speeds and are interpreted as running to or from the character.

	High Negative	Low Negative	Stop Near	Stop Far	Low Positive	High Positive
	Run To	Walk To	Near	Far		Run From
Happy	Play	Play	Talk	Play	Play	Play
Sad	Cry	Cry	Cry	Cry	Cry	
Angry	Attack	Threat	Attack	Threat		
Scared	Calling for Help		Calling for Help	Calling for Help		Run From Threat

Table 7.14: High Level Pattern - Relative Speed

Table 7.14 displays the relations observed between relative speed and actions. An angry character can be seen as a threat when he is far away, or as an aggressor when he is near.

7.2.2 Implementation

The implementation of this prototype consisted in raising the pattern bypass of the previous prototype on to the Minds layer as it is described in the following Figure 7.5.

7.2.2.1 Puppet Image

UserAgent The UserAgent is responsible for updating to variables in the Minds layer:

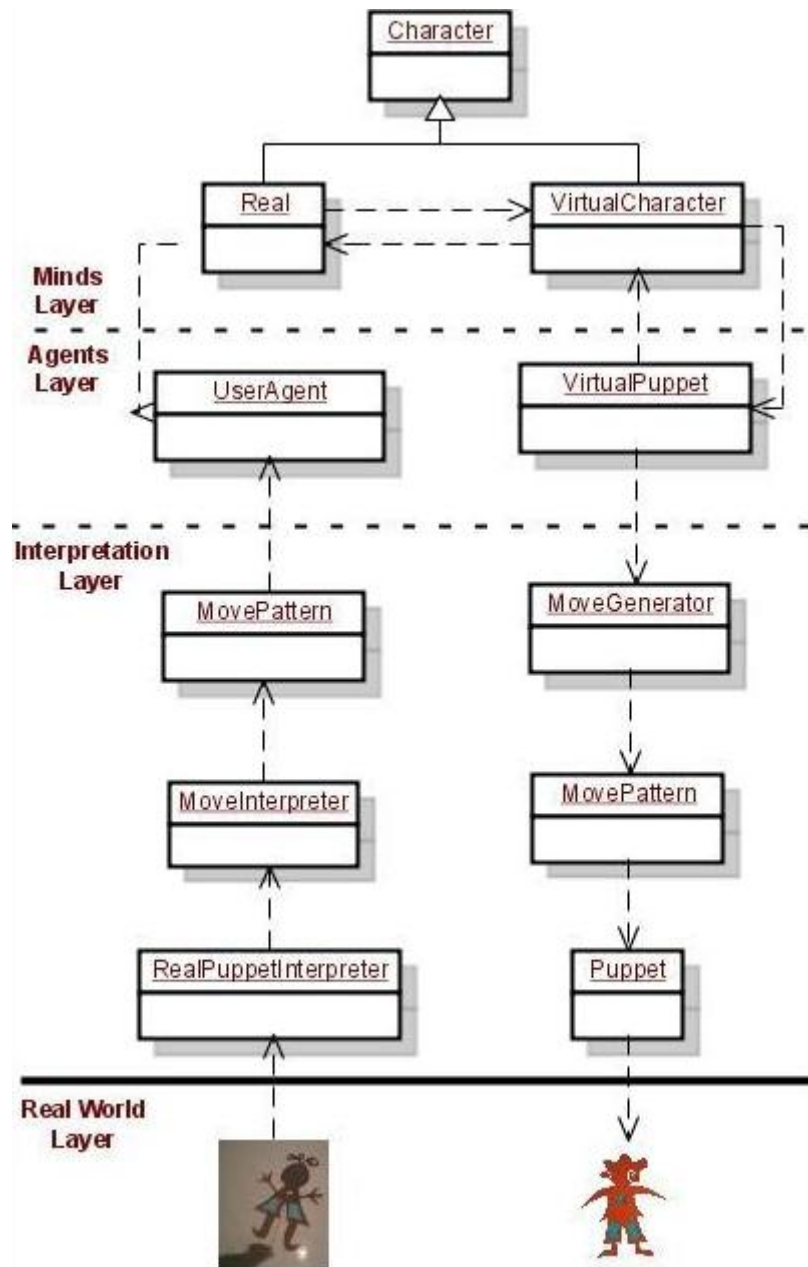


Figure 7.5: I-Simulate, Second Functional Prototype Architecture

- Puppets Position - During each OpenGL interpolation cycle UserAgent sends a position array to the Minds layer that includes position in vertical and horizontal axes.
- Puppets Emotion - At the end of each expressive movement UserAgent receives a Low-Level pattern. After receiving it, UserAgent sends to the Minds layer the emotion corresponding to the received pattern.

Real is a simple mind with no actions defined that simply works as an image of the real puppet in the virtual world.

Virtual Character is the entity responsible for detecting High-Level patterns by crossing the real puppet's emotional state with its behavior in the environment.

At each interpolation it performs the cycle shown in Figure 7.6:

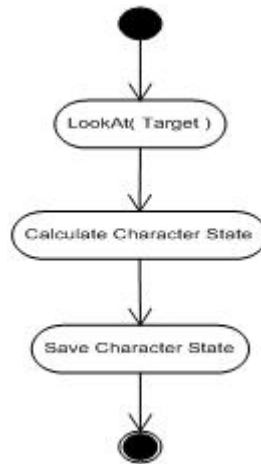


Figure 7.6: Virtual Character's Interpolation Cycle

LookAt (target): this method allows UserAgent to detect target (other character) position and emotional state.

Calculate character state: this is where userAgent detects the High-Level patterns. Crossing the information gathered in the lookAt action with his own information about

the target, it builds a `characterState` which consists of a collection of position, relative speed, emotion and distance.

Save Character State: The obtained character state is saved in a queue containing the last 20 evaluations. Virtual characters gather this information for every other character.

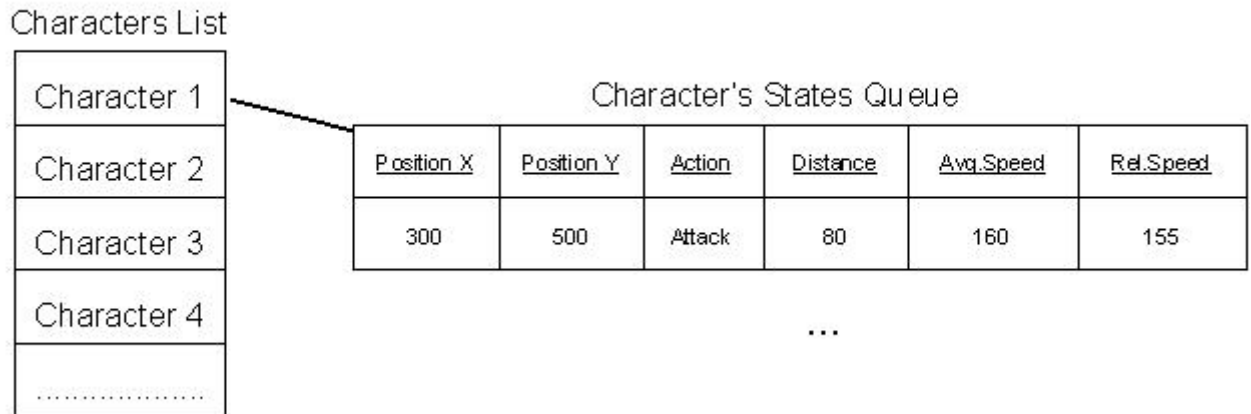


Figure 7.7: Saving Other Characters States

Figure 7.7 shows the information structure of the Virtual Character entity. The elements of `characterState` are:

- Position X and Y - target horizontal and vertical positions.
- Action - The action interpreted through High-Level patterns (ex: Attack or Threat).
- Distance - The distance between two characters' geometrical centers.
- Average Speed - The average speed is calculated at each iteration.
- Relative Speed - Character's speed between each interpolation.

Virtual Puppet This entity is responsible for monitoring the Virtual Characters evolution and report it to the Interpretation layer. It encapsulates the execution of each virtual puppet actions. Its behavior is symmetric to user Agent's behavior.

7.2.2.2 Tests

At this point of development tests were not a priority because we did not have any reference for each characters behavior yet. The same is to say that for testing this prototype we must first develop some deliberative engines from each character according to its own personality and role on the narrative . Nevertheless a minimalist engine was implemented with the following reactions (see Table 7.15):

Action	Threat	Attack	Sad	Happy
Reaction	Scared	Run Scared	GoTo	Happy

Table 7.15: Reactions

The results allowed us to observe the framework working and ready to receive detailed deliberation processes.

7.2.2.3 Technical Issues

Some technical issues were detected in this prototype in graphic generation. The technology adopted (TAO.OpenGL) proved to be less documented then what it seemed at the beggining and small improvements in graphical aspects such as image manipulation and Alpha Blending techniques raise to many issues and increased development time, without rewarding results.

7.2.2.4 Conclusions

This prototype was prepared to understand high-level patterns and react to them. Each character was able to gather enough information to use as input for future implementation of deliberation engines.

The issues raised by the graphic generation posed the question of a possible change of the graphic generation technology, but in the another perspective, the goal for this prototype was to achieve a functional framework to allow the I-Shadows development and we can say that the prototype's goal was achieved.

7.3 Summary

In this Chapter we presented the development of a prototype that simulates IShadows without the Vision Component, and with a very simple mind architecture. This prototype allowed us to quantify and improve the users movement patterns establishing an *Affective Loop*. Next we will present the final prototype of our system that will integrate all the components presented in the initial architecture.

Chapter 8

Complete Prototype

In this Chapter we present the final I-Shadows prototype which includes a ready to test implementation of all the components defined in the *Proposed Architecture* chapter.

8.1 Requirements

In the previous prototype it was raised the need for a new graphical engine. Since the main goal for this prototype was to provide a final test environment for the complete I-Shadows installation, we found this implementation to be the best moment to integrate all the changes needed to the system. The requirements for this Prototype were detected considering all these changes, the proposed model for *Affective Interactive Drama* presented in Chapter 4 and the architecture presented in Chapter 5.

8.1.1 Functional Requirements

As to functionality the following requirements were defined:

- Real Puppets are to be physically manipulated by children.
- Virtual Puppets are expected to act autonomously.

8.1.2 Technical Requirements

- The inclusion of physical puppets requires the integration of I-Shadows with the Vision Component.
- Integration with FAtiMA to generate autonomous behavior.
- Integration with OGRE engine.

8.2 Components

Conceptually there were no big changes to the components architecture of the previous prototypes. Nevertheless the addition of the new components required some remarks.

8.2.1 Interpretation Layer

This layer was kept almost without any change except for the introduction of two components:

- **PuppetList** - contains the last position of all the real characters detected on scene by the vision component. It provides the necessary vision input for exactly the same *RealPuppetInterpreter* of the earlier model.
- **Overlay** - is the representation of a *Virtual Puppet* in the graphic engine.

8.2.2 Agents Layer

At this level some changes had to be considered due to the implementation of the new agent architecture. Because FAtiMA was already integrated with the ION framework the work of integrating the agents' actions was facilitated. This way there was no need for creating elements representing the entities in the framework. We could use them directly just modeling their actions and behaviors. But there were some changes.

- **UserAgent** - responsible for providing a communication between the *Interpretation Layer* and its respective *Entity* in the ION Framework.

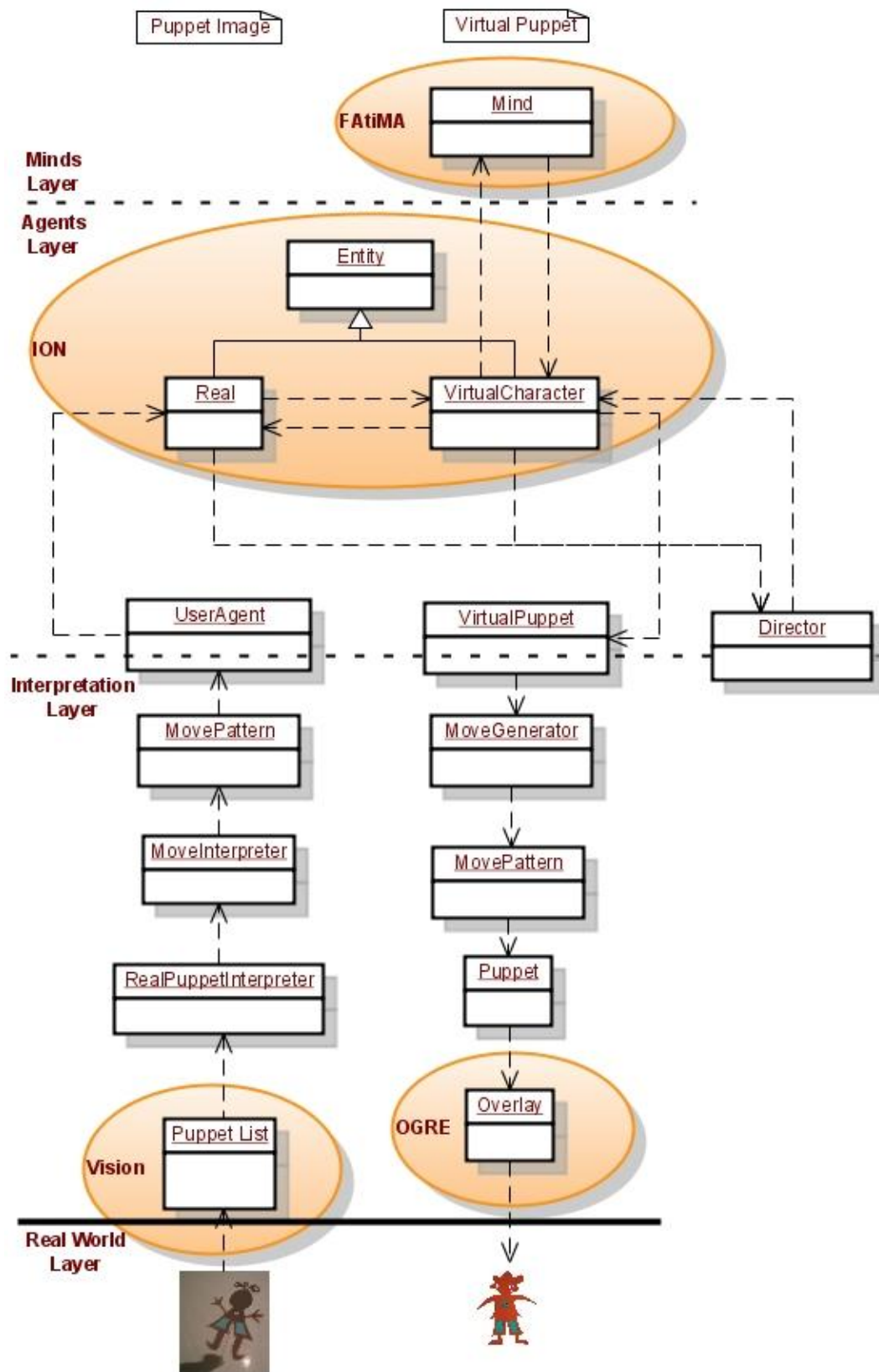


Figure 8.1: I-Shadows final prototype

- **VirtualCharacter** - receives the actions steps executed by the entities in the agent framework and sends them to the *Interpretation Layer* to be executed.
- **Director** - responsible for managing the *Affective Process* of the stories. It receives the *Affective Input* coming from the entities representing the characters of the story.

8.3 Development Tools and Framework

In this section we detail the technological options taken in the development of this prototype.

8.3.1 OGRE

We considered OGRE to be a best choice for a new graphical engine in this context specially because of two main reasons:

1. It had already been successfully used and tested with the ION framework in other projects.
2. It provided large documentation which included solutions for the technical issues raised in the earlier prototype.

8.4 Methodology

The implementation of this final prototype included several steps:

- Integrate the Vision Component
- Integrate OGRE
- Implement an Affective User Model
- Authoring FAtiMA Agents

- Implement the *Director*

The integration of the Vision Component and OGRE were almost straightforward. The architecture of the early prototypes proved to have enough flexibility to support these changes.

The Authoring of FAtiMA agents in the context of I-Shadows, and the *Director* implementation deserve some special attention and will be presented in the following sections.

8.5 User Model

Although the previous prototypes detected the emotions expressed by the user, the model that associated these expressions to a possible user emotional state was a simple direct relation. This simplistic approach was very helpful to study the emotional expressions at very specific moments, but it is easy to conclude that it is not very stable or coherent model because it stops abruptly and does not include the natural decay of emotions along time.

Based on the notion that emotions decay naturally over time unless they are re-stimulated[50], we implemented a user model that included an activation threshold and a decay for each of the user emotions. Using these elements our user model computes the intensity for each of the user's emotions that correspond to the patterns studied earlier.

8.6 Authoring

In this section we report the authoring process created for I-Shadows using FAtiMA.

8.6.1 Requisites

Following the *Affective Interactive Drama Model* proposed in sections 4.7 and 4.6 that uses each character's emotional state and interpersonal relations as the input to analyze

the story development and decide which character should enter or leave scene, one can conclude that this process is extremely important to guarantee the reliability of the *Affective Process*.

To allow this the emotional states and interpersonal relations should develop dynamically and consistently not only with the story development but also with their role on the story.

Another factor that contributes to the importance and complexity of using this model is the almost total absence of story manipulation on the Director side, which relies on the characters to guarantee a consistent story development, so all the structural knowledge of a story at the action level will be present in the characters autonomous behavior.

Another requisite for this process was to define the *Domain Actions*, i.e., the actions that agents use directly on the environment (such as *goTo(position)*, *grab(object)*, *hit(character)*).

After defining the domain of actions and expression of the characters, the authoring process had four main steps: Identify Characters and Goals, Define Relations, Define Action Tendencies, Define Multiple Emotional "Personality", which we detail below. (See Figure 8.2)



Figure 8.2: Authoring Process

8.6.2 Identify Characters and Goals

Assuming children's preference for Fairy Tales the choice of adapting Propp's work (See section 3.4) seemed inevitable to both fulfill user expectations and story consistency, because it provided a structured bridge between users and author expectations. Based on this fact we decided that the roles of the different virtual characters should be inspired on elements or combination of elements from Propp's character list (Hero, Villain, Princess, Relative, Friend, Dispatcher, Donor, Helper and False Hero) and their respective story

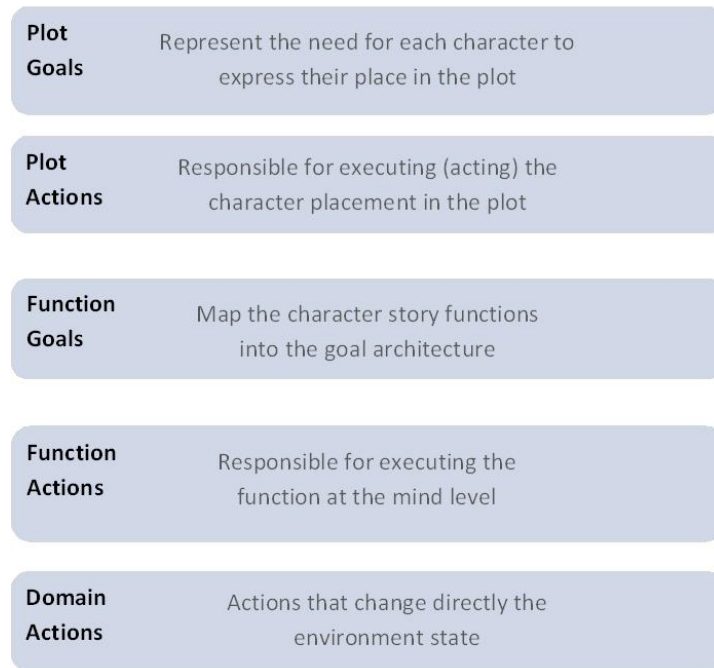


Figure 8.3: Goals and Actions Hierarchy

functions. Since the early user testings we found that we should not use too many characters in each story, thus we decided to implement the two more important roles: Hero (which can include friend functions) and Villain. Other characters are more simple and reactive and do not take initiative on the story unfold, and are used for testing scenarios.

The implementation of these two roles followed the goal and actions hierarchy defined in Figure 8.3

8.6.2.1 Plot Goals and Plot Actions

The implementation of these special goals and actions come from one of the IMPROV rules presented in Section 3.2 "‘Enter stay and exit scene with purpose’", which can be seen as the need to clarify each characters’ role in the plot. Following this approach we decided that every character should follow this goal before any other by expressing his relation with the other characters.

8.6.2.2 Function Goals

The goals and actions that map story functions into the characters behaviors. These goals and action are not intend to be direct implementations of Propps' functions, but Propp inspired functions adapted to the I-Shadows context . Some examples of these actions are presented in table 8.1.

Role	Story Functions
Villain	Small Villainy, Struggle and Pursuit
Hero	Show Love, Counteraction and Wedding

Table 8.1: Story Functions

Another interesting aspect of these goals is that they obey to the story sequential structure without depending directly on the execution of the previous *Function Goals*, because they depend on the state of the characters relations. This mechanism is based on the assumption that relations tend to be more intense along the story development.

Figure 8.4 shows the Goals and Actions hierarchy for a Villain. The example illustrates that the Villain uses his relation value with the target to decide which story function to execute. The same is to say that if he knows that their relation is very bad, he assumes that bad things have already happen and that he should move forward to the next story functions.

8.6.2.3 Function and Domain Actions

Function Actions provide a connection to the *Domain Actions* without breaking an abstraction layer between the mind decisions and their representation on the domain.

8.6.3 Define Relations and Action Tendencies

The relations between characters are established in consistency with the roles. The following example shows the initial relations of a Hero with the other characters. Each relation can be quantified in a $[-10, 10]$ range, where "-10" represents a very negative dislike relation, and 10 represents a strong like relation.

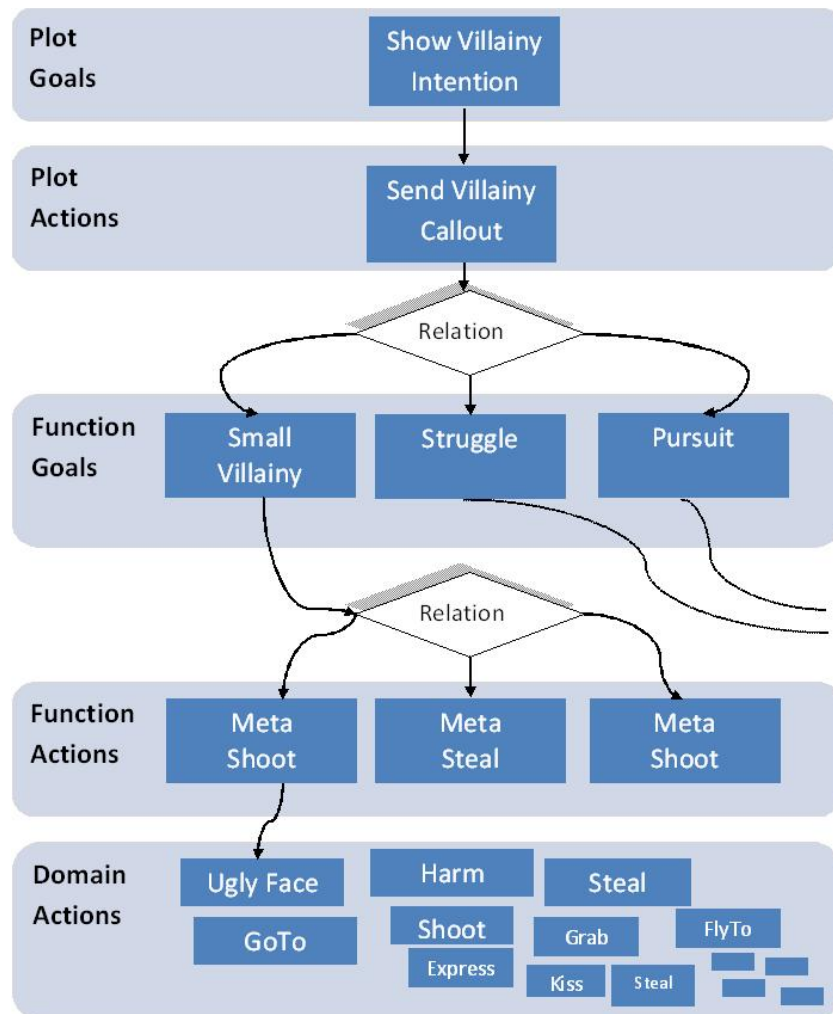


Figure 8.4: Villain Goal Structure Sample

```
<Relation target="Villain" like="0"/>
<Relation target="Victim" like="3"/>
<Relation target="Donor" like="3"/>
<Relation target="Helper" like="3"/>
```

Figure 8.5: Hero's Relations

For example, let's consider that we have John (a boy shadow) and he is a hero. As can be seen on the example (see Figure 8.5) above the hero starts acting with a neutral relation toward the villain. However this relation is not static, and will evolve according to the emotional reactions of John to the actions of Villain. To do that, the character's minds include a set of action tendencies which are the actions that are executed as an immediate reaction to a change in the environment. An author may give John (the hero) an action tendency of running to his friends whenever he feels sad, or attacking a Villain whenever a Villain attacks him. By modeling these actions and relations it is possible to author different kinds of characters in the same role, which means that it is possible to define a more or less aggressive Hero, that will influence the Valence development of the story.

8.6.4 Define Multiple Emotional "Personalities"

Another important step for authoring different personalities for the same role is to manage the emotional "personality" of each character. Manipulating the values of activation and decay of the 22 emotions provided by FAtiMA it is possible to build a hero that has low emotional thresholds and easily falls in love, or Hero with high emotional thresholds that likes to be a lone ranger.

8.6.5 Final Cast

The need to provide the best characters for unpredictable *Affective Process* states in the *Valence Vs. Arousal* space raised some issues. First that the cast of characters should be rich enough to provide more active or passive personalities that influence the

Affective Process Arousal. Second the same cast should also provide characters that tend to experience more positive or negative relations in order to influence the *Valence* of this process. We tackled this issue by creating two potentials to define a character:

- *Activation Potential* - the potential of generating intense emotions. Depends directly of the Emotional Personality of the character,.
- *Valence Potential* - the potential of generating positive or negative emotions. Depends directly on the relations of the character with the other characters on scene and follows the average value of the characters relations at a given moment.

Combining different categories of these potentials with the roles identified earlier, we created the 6 autonomous characters.(Tables 8.2 and 8.3)

	Very Negative	Negative
VeryActive	VillainVeryNegativeVeryActive	VillainVeryActive
Active	VillainVeryNegative	

Table 8.2: Villains Cast - Three Villains with different personalities that combine Very Active or Active Arousal with Very Negative or Negative Valence

	Positive	Very Positive
VeryActive	HeroVeryPositive	HeroVeryActiveVeryPositive
Active		HeroVeryPositive

Table 8.3: Heroes Cast - Three Heroes with different personalities that combine Very Active or Active Arousal with Very Positive or Positive Valence

As a simplifications we did not implemented characters with low marks at both potentials, because we considered that those characters would only be used in situations in which the Affective Process was very close to the Affective Guideline and in our opinion in those moments the best option is not to influence story so that the user doesn't feel that he is being guided.

8.7 Director

The *Director* was implemented following the architecture proposed earlier in Chapter 5. Its functionality is event driven and includes two major functions:

- Scene Mood Calculation
- Relations Update

These functions are called by an event mechanism that alerts the *Affective Director* whenever any character updates any emotional information, or relation information. Based on this mechanism the *Affective Director* is capable of maintaining an up to date information about all the characters Affective Information and Relations.

Using this information the *Affective Director* runs a cycle to evaluate the *Scene Mood* and compares it with his *Affective Guideline* before taking any decision.

8.7.1 Affective Guideline

Our first experimental *Affective Guideline* is defined using an adaptation of the model proposed (see Chapter4) and is quantified using nine *Control Points* that define eight *Scenes*. (see Figure 8.6).

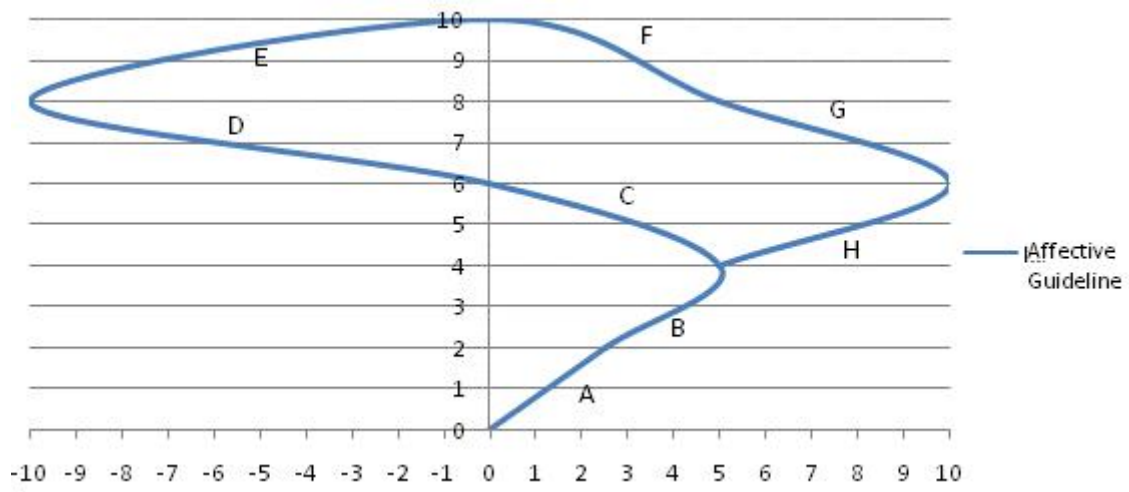


Figure 8.6: Affective Guideline Division

The main difference between this guideline and the original model is that it includes the neutral initial situation where nothing has occurred instead of starting in positive valence, and the concept of *Scene* which is a transition between two predefined Guideline points that has a specific time length. Scene A corresponds to this transition. The remaining of the story is quantified in the other 8 *Scenes*.

Scene	Valence	Arousal
A	↗	↗
B	↗	↗
C	↘	↗
D	↘	↗
E	↗	↗
F	↗	↘
G	↗	↘
H	↘	↘

Table 8.4: Story intervals

8.7.2 Affective Process

The *Affective Process* is calculated in the same two dimensions of the Affective Guideline using the mood of the character's that are on scene (active characters). We take *Valence* as the average mood value of all the active characters, where the villain characters mood is converted to the symmetric value because we want to measure the Valence of the presented story, and *Intensity* is the average of the active characters mood absolute values.

8.7.3 Director Actions

The story mood is constantly being calculated and compared with the expected values defined by the *Affective Guideline*. The difference between these two values is represented by an *Affective Distance* vector, which corresponds to the tuple $(\Delta Valence, \Delta Intensity)$.

At the middle of each scene the Director compares the *Affective Distance* length to a predefined threshold to determine if the Affective Process is *converging* or *diverging* from the *Affective Guideline*. As it was mentioned earlier, the Director exerts his influence by adding or removing characters from the scene. The mixture of these actions with the available cast defined in the previous section (see Section 8.6.5), defines the set of Director Actions. (See Table 8.5)

Insert(Character) I(H)	I(H.VP.),I(H.VA.VP.),I(H.VA.),I(V.VN.), I(V.VA.VN.),I(V.VA.)
Remove(Character) R(H)	R(H.VP.),R(H.VA.VP.),R(H.VA.),R(V.VN.), R(V.VA.VN.),R(V.VA.)

Table 8.5: Director Actions: H - Hero, V - Villain, VP.-VeryPositive, VN.-VeryNegative, VA.-VeryActive

When the *Affective Process* is *converging* the *Affective Director* takes no action at all. When it is *diverging* the Director may chose to exert influence to the story by adding or removing characters from the scene. In order to decide which action is more adequate to influence *convergence* the director takes some assumptions for each dimension:

- Valence - can be positively influenced by adding characters with greater *Valence Potential* or removing characters with more negative *Valence Potential*, and negatively influenced by adding negative characters or removing positive characters.
- Intensity - can be positively influenced by adding characters with a greater *Activation Potential* to the scene, and negatively by removing with greater *Activation Potential* characters from the scene.

The use of these concepts along with the cast defined earlier allows the Director to chose if at given moment it prefers to influence more directly Valence, Arousal or both, by adding or removing characters with different *Activation Potential* and *Valence Potential*. This decision is based on the quotient between the *Affective Distance* dimensions and follows the model presented in Figure 8.7.

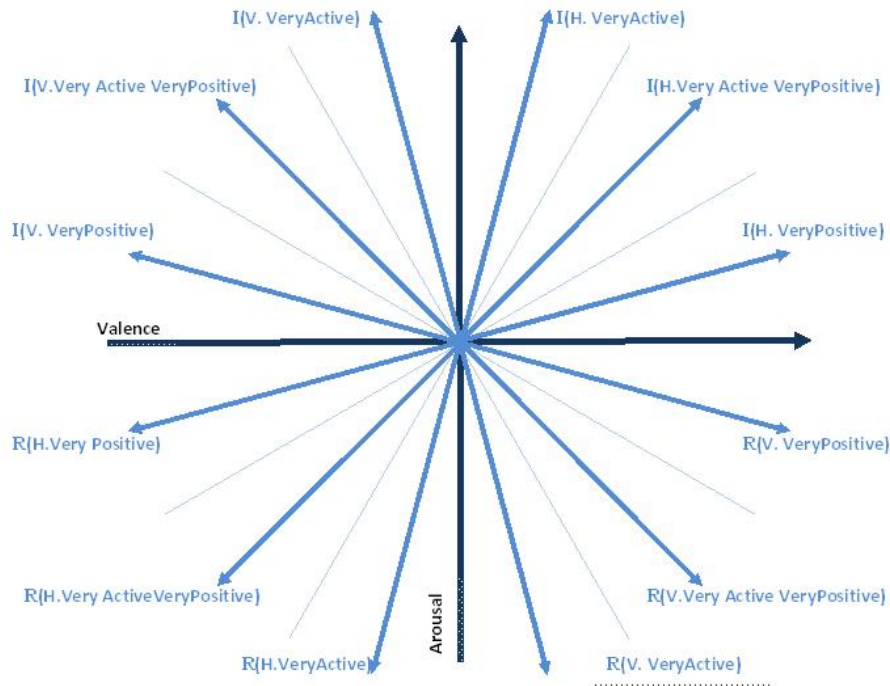


Figure 8.7: Influence of Director Actions

8.8 Results

So far, we have shown how we approached the construction of a narrative drama application, where stories emerge as a collaboration process between the users and the agents. To achieve that, we gave the agents a rich set of behaviours supported by an agent architecture that allows for affective and social behaviour.

The authoring process of I-Shadows combined elements of acting and fairy tales (by creating heroes, victims, or villains) and of acting itself. As the system was designed as a close collaboration between children and teachers, some good results in terms of expression detection and emotion expression were achieved.

8.8.1 Authoring Results

The authoring process requires a lot of tuning and testings, in this section we present two examples of tests to goals and actions implementation, and their consistency with a structured story.

8.8.1.1 Love Goals

To test this goal structure we defined a scenario with a Princess (that implemented the same goal structure than the hero) and one Hero. The following illustrates some elements of this process, with an interaction between these two characters. At the beginning the Princess loves the Hero with an intensity corresponding to the initial value of 2. When she sees the Hero, a Show Love intention is activated by the Show Love *Plot Goal*. According to her emotional state, the Princess decides that the way of Showing Love for the hero is to offer him a Candy. This action generates a Joy emotion in the Hero that triggers a Smile.

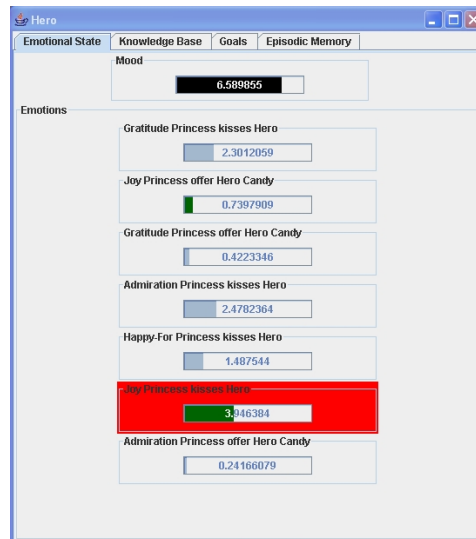


Figure 8.8: Hero feels Joy

The Hero's smile is appraised by the Princess as a positive action. This appraisal has a positive impact on the relation with the Hero. As a consequence, the next time the princess intends to show love she will consider a more intense relation with the Hero that will activate a kiss intention.

8.8.1.2 Hero Goals

For this test we added a Villain character to the previous scenario, with the intention of allowing him to perform villainies that activate Hero functions.

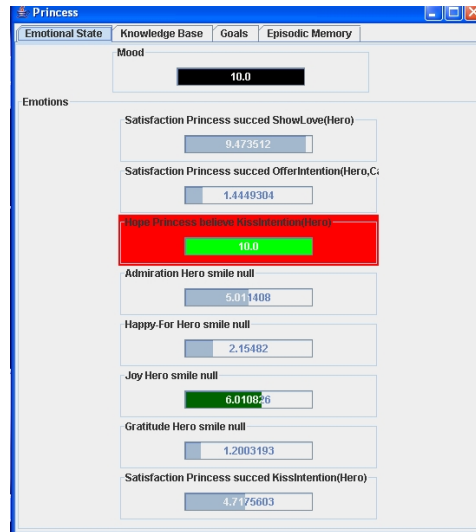


Figure 8.9: Change in the Princess's relation

Figure 8.10 shows the actual hero's emotional state after failing to defend the Princess. The hero was in a very positive mood because of the joy he felt when the victim expressed her love for him. Suddenly the villain hits the victim. The hero appraised this event as a very negative action, and felt disappointed, this appraisal generated resentment and reproach toward the action and toward his subject (Villain). As a consequence of these events, his "Like" relation will decrease toward the villain and will increase toward the victim. And because of this he will try to protect the victim the next time.

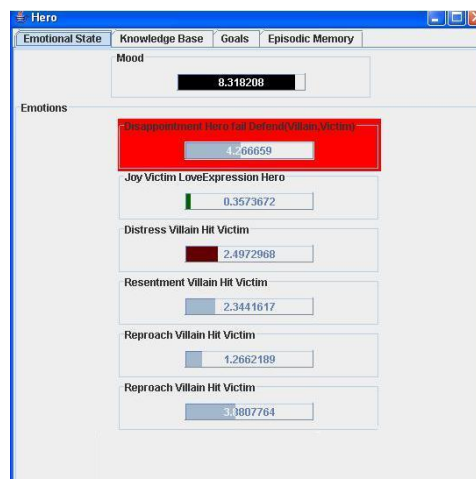


Figure 8.10: Hero's emotional state

8.8.2 Director Results

The *Affective Director* is completely integrated within the system and ready to use. Informal testings allow us to say that it implements the *Affective Model* proposed. It provides real time feedback on the state of story Scenes, the *Affective Process* state and the current *Affective Distance*.

Affective Guideline Expected Values		Affective Process Real Values	
Valence	4,333333	Valence	1,323183
Intensity	4,266667	Intensity	1,323183
<input type="button" value="clear"/>	<input type="button" value="submit"/>	<input type="button" value="clear"/>	<input type="button" value="submit"/>

Director					
Valence Difference	-3,0101	Current Scene	C	Time	0, 3
Intensity Difference	-2,9434			TotalTime	1, 63
Director Action					
<div style="border: 1px solid black; height: 20px;"></div>					

Figure 8.11: Director Interface

We also implemented a log module that collects all that story affective data which will be very helpful for statistical analysis in future testings. Figure 8.12 illustrates the Affective Process collected from a generated story along time.

8.9 Conclusions

The *Affective Director* offers a very important glance over the emotional process of a story, and encourages us to continue to explore its potential in balancing user and author expectations in an Interactive Storytelling System, nevertheless it is too much dependent on the affective output of the characters.

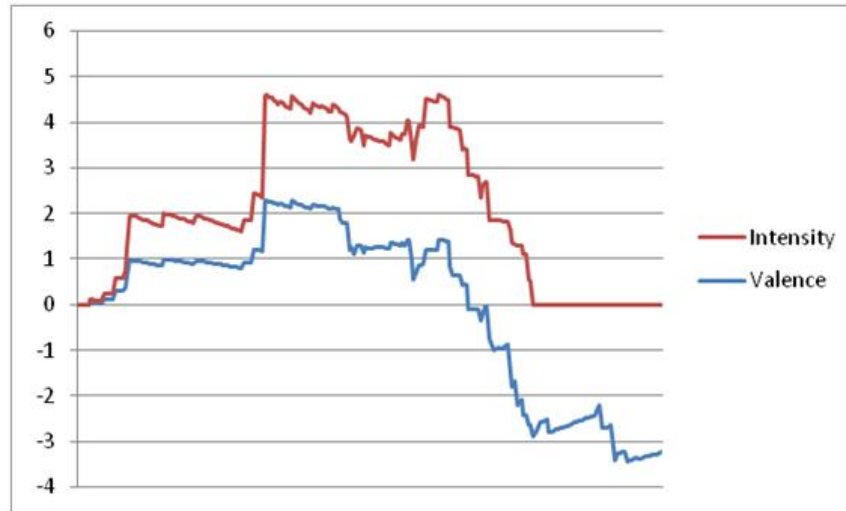


Figure 8.12: Affective Process: Vertical axis represents each dimensions value, horizontal axis represents time

8.10 Future Tests

IShadows main goal is to build stories in cooperation with user. Following the I-Shadows concepts presented earlier we defend that a way of testing this in the future would be to evaluate two elements:

- Story Development- Study if exists a relation between the *Affective Process* of the stories created by the users and the pre-defined *Affective Guideline*. More precisely we want to see if they generate Tension points and if they correspond to the dramatic moments of the story.
- User Satisfaction - Study the satisfaction of the users that experiment the system. We want to know if the user expectations during the story are satisfied during the story.

8.11 Summary

In this Chapter we defined the final requisites for I-Shadows, and used them to implement the first prototype that completely integrates all the architecture components. We

reported our experience in authoring affective autonomous characters in the context of our project, and also presented the first implementation of an *Affective Drama Director*. For the preliminary results we created a test framework that allows us to come up with very interesting questions for future testings.

Chapter 9

Conclusions and Future Work

This thesis explores a new concept for directing *Interactive Storytelling* applications based on trading the traditional action monitoring of a story with an affective monitoring of its development. The main challenge is to "promote collaborative story construction without restricting the flexibility, creativity and emotional expression of the children, and at the same time, guarantee some coherence in the stories produced" (See Chapter 4.4.2).

To achieve this we followed an hybrid approach, that is character-centered and has a mediator. This approach consists on giving structural story knowledge to Autonomous Affective Characters that are included in an *Affective Loop* with the user, and monitored by an Affective Director that observes the story development at the emotional level.

The implementation of this model is dependent on the evolution of I-Shadows that is being built using a prototype methodology. The prototypes developed along this process provided some very interesting results. An important example of this is the definition of the four Emotional Expressions set using bi-dimensional movements, that support *the Affective Loop*. Another very important conclusion is that the users integration in the development cycle provided very early user feedback that was essential for design and development.

At the moment of writing, the stories generated although interesting, do not have yet the structure desired. We believe that this is due to the fact that the authoring process proved to be harder than planned. Authoring characters for interactive storytelling is

not easy due to the lack of a real methodical authoring approach for building agents for interactive narrative, and to the high amount of tuning and tests that it requires. Nevertheless our characters are acting according to their roles and have dynamic relations which have a consistent impact in the characters decisions. Although we find the results so far to be positive, we believe that to really obtain a good play and good affective output in a real storytelling application, the characters need to be further improved.

9.1 Contributions

Together with this thesis and with the development of the I-Shadows prototypes, contributions of the work performed also include the following papers:

- Figueiredo, R., Brisson, A., Aylett, R., Paiva, A. "Emergent Stories Facilitated - An architecture to generate stories using intelligent synthetic character" submitted to Interactive Storytelling 2008
- Brisson, A., Paiva, A., Are we Telling the Same Story?, AAAI Fall Symposium on Narrative Intelligence Technologies, Westin Arlington Gateway, Arlington, Virginia, November 9-11, 2007
- Cruz, R., Brisson, A., Paiva, A., Lopes, E., I-Sounds - Emotion-Based Music Generation for Virtual Environments, Proceedings 2nd International Conference on Affective Computing and Intelligent Interaction (ACII-2007), Lisboa, Portugal, 2007, pp. 766-767, Springer
- Brisson, A., Dias, J., Paiva, A., "From Chinese Shadows to Interactive Shadows: Building a storytelling application with autonomous shadows", Workshop on Agent-Based Systems for Human Learning and Entertainment (ABSHLE)AAMAS ACM 2007, 11-02-2007
- Paiva, A., Fernandes, M., Brisson, A. "Children as Affective Designers, IShadows Development Process", Proceedings of the HUMAINE WP9 Workshop 9-11,v January 2006

- Paiva A., Fernandes A., Brisson, A., "Designing Affect in an Interactive Chinese Shadows Theater" Proceedings of the WP6 Workshop 10-11 March 2005, Paris

The *Affective Interactive Drama* model presents new concepts to the field that are theoretically founded and that establish a theoretical grounding between *Interactive Storytelling* and *Affective Computing*. The implementation of this model allows us to believe that it has great potential to test and quantify the dramatic intervention, development, expression and impact of interactive stories in an audience.

9.2 Future Work

The work presented in this thesis presents a good starting point for some very interesting research questions in *Interactive Storytelling* and also in the synthesis of Affective Content.

Future tests to evaluate Story Development, that compare the *Affective Process*, the *Affective Guideline* and action development, may allow us to explore more authoring techniques and relate the emotional output with relevant action elements such as tension points.

Undergoing projects in our group (I-Sounds [47]) are using the Affective Process as input for generating emotional content, this allows is a concrete example of the an application that uses the bridge that I-Shadows provides between two very active and rich research fields such as Interactive Storytelling and Affective Computing has very concrete application examples.

9.3 Final Remarks

The challenge of creating this thesis enabled a good research and personal experience in the context of a very challenging and exciting project. The I-Shadows concept provides the breed of new ideas and consequently new research challenges that tend to promote the creation of new projects and partnerships with other colleagues. This why I-Shadows continues to be a very gratifying project.

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Appendix A

AAAI Fall Symposium 2007

Are we telling the same story?

Balancing real and virtual actors in a collaborative story creation system

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Abstract

Interactive Drama applications aim at offering interactive experiences to the participants by empowering them with active participation and engagement in the development and solution of a story. However, introducing this interactivity leads to a natural conflict between the participant's freedom of interaction and the system's control, or, more precisely, the author's expectations in the development of the story. As such, favouring one over the other, leads to different experiences and perhaps even different genres. This balance has been extensively discussed amongst researchers in the community, and yet achieving such balance is still regarded not only as a challenge but also as an art itself. In this paper we discuss a system, I-Shadows that is an Interactive Drama based on Autonomous Affective Characters and Drama theory. In this system we tried to reach such balance through considering the storytelling experience as the "collaboration" that emerges from the real actors (the users) and the virtual actors (some Chinese shadow puppets). Supported by improvisation theory, our actors (shadows) act as if they are collaborating with the user in achieving the story. However, to achieve that, the virtual actors need to have an agent architecture that supports emotion reactions, goal oriented behaviour and social interactions. Aspects such as role taking, waiting for the right time to say their line, have a coherent personality, turn taking, and others, are considered in the minds of the virtual actors, allowing for this balance to be reached. Furthermore, and to complement this aspect of autonomy of the agents, the coordination problem between the actors is also helped by the presence of a specific agent (a story director) that allows for agents to appear or disappear from the scene of the story.

This approach was used in the construction of I-shadows, which, although not yet evaluated, has revealed its power.

Introduction

Improvising a story to an audience is perhaps one of the greatest challenges the actors pursue. Stand up comedy and Improvisation is regarded as a definite major test for actors. Further, when there is more than one actor, the improvisation needs to be done in cooperation, often posing other interesting difficulties. Each of the actors play

at least one role and develop the story according to each character's personality and their perspective of the story development. However, how is improvisation going to result from these perspectives divergences? What happens if one of the actors does not respect the turn taking?

Interactive Drama systems that combine autonomous agents face this problem. In reality, if we see such systems as cooperation between the user and a system in the process of telling a story, this cooperation often leads to an unbalanced state between the user's expectations of the story development and the system's plans. One way of overcoming this problem is to limit the goals of each character and user according to the author's perspective of the story development. This approach has shown some good results [1][2], but it partially removes the creative influence of the user in the story development.

Approaches that allow for this intervention were made in Teatrix[3], where the user was involved in the set up phase that conditioned the rest of the story, and in the Interactive-Theatre[4][5] where agents were free to improvise their actions under the influence of the user. However, this influence was achieved at a very high level. These systems did not show enough flexibility to directly change an on-going story.

The use of autonomous characters as the one developed by M. Cavazza[6], has brought some flexibility to this research area, and the agents proposed by Aylett et.al.[7] allowed for more freedom of interaction to the users. Users interact with agents and stories emerge from this interaction.

In I-Shadows we are building a system that looks at the process as cooperation between the user and the characters, while the story is being presented to an audience. In this paper we present the foundations of this project as well as some preliminary results.

The paper is organized as follows: first we present the theories which support this work. Then, we briefly describe I-Shadows starting with a short presentation followed by some implementation details. A theoretical proposal to close the gap between the user and the characters is then presented and some details of the implementation of the

Characters and the Director agent are given. To finalize we present some preliminary results and main conclusions.

Foundations

A significant part of the research on interactive drama is strongly focused on the user interaction problem. The dominance of this problem is not without a reason. Users mess up the well grounded linear story, and interactive drama becomes to some extent a user interaction challenge. As a consequence the user is a critical element of the evaluation of such systems. The principles for evaluating the users' role in an Interactive Drama system are presented in Murray's three aesthetic categories [8]: Immersion, Agency and Transformation. Immersion is achieved when the user totally accepts the logic of the environment. Furthermore, and according to Mateas [9] this acceptance can be noticed when a player assumes the role of a first-person character in a dramatic story. Differently, Agency is defined as the influence that the user's actions might have on the unfolding of the story. Transformation is achieved when the combination of Immersion and Agency provide a unique users' experience each time he or she uses the system. [9][10]

One should note that there is a conflict between Agency and the other two categories. This conflict can be related to the conflict between the author's need to guarantee a safe story development, thus following a drama structure, and the Characters' and users' need to act autonomously.

The approaches taken to combine these categories always end up with a dilemma of choosing between reinforcing user's autonomy versus reinforcing characters' autonomy. In our approach we are not interested in solving the problem or in taking any side in this dilemma. Instead, we are aiming at improving the communication between characters (that act autonomously in an interactive drama application) and the user, by combining them in a form of a collaborative task. A way to think about the combination of these two approaches would be to try to pass some of the structural knowledge of the play from the Author to the Characters.

As such, we seek inspiration in the work of improv theatre companies where the actors try to develop plays from an initial scene based only on pre-defined relations and their own creativity. The first major reference to his theatrical method goes back to Europe's Renaissance period when Comedia Dell'Arte troops travelled around Europe presenting plays based upon open narratives with well defined characters, and narrative structure. More recently theatre teachers such as Viola Spolin and Keith Johnston created new techniques that launched the growth of several Improvisational Theatre companies, such as Compass. Most Improv directors agree on the following basic principles for an improv actor's actions on stage:

- Always accept information given by others.

- Otherwise we say the actor is "Blocking" the scene
- Always add history to the scene
- Scene Beginnings should be short and objective
- Enter, stay and exit scene with purpose
- Maintain character's point of view

According to Spolin "Improvisational theatre requires very close group relationships because it is from group agreement and group playing that material evolves from scenes to plays". This suggests that in order to achieve a successful interactive drama, the user must take part in this group relation.[11] [12]

Our research on interactive drama was inspired by this seminal works on trying to integrate the user in an affective environment, where he or she can interact with emotional characters that act like real actors adapting the play to what is happening. Relations are established between the user and the characters according to their roles in the story and a consistent emotional behaviour. It is from the richness of these interactions, where the user is immersed, that we expect to bring real interactive drama to life, with surprising but structured story developments.

I-Shadows

Description

The I-Shadows' installation was inspired by one of the oldest forms of theatre: Chinese Shadows Theatre. There are however some important differences: (1) in I-shadows a user is a puppeteer in the play (thus manipulating physically his/her shadow puppets), and (2) some of the characters in the play are automatically controlled by a computer system. The play emerges as a collaborative process between the user (puppeteer) and the system (I-Shadows). The system monitors the action on the screen using a vision component, and participates in it by projecting characters onto the screen. The drama emerges from the interaction between the projected characters and the users, that physically manipulate other characters' puppets.

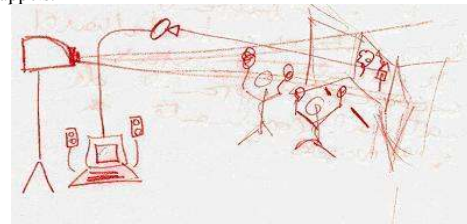


Figure 1 – I-Shadows installation

One of the goals of I-shadows is to provide an environment where children can learn how to create stories and act them

out in character, in front of an audience. So, we expect that the audience will be able to watch a play improvised by a child (or group of children) in cooperation with autonomous characters.

To contextualize I-Shadows in children's fantasy world, we found inspiration in the most common infant stories: Fairy Tales. The set of characters developed were based on typical fairy tales stories, thus including fairies, goodies, a boy, a girl, a witch, a dragon (among other characters), but with modern elements added to it (like cookies, houses, and others).

The challenges imposed by this project are numerous. Going back to the fundamentals of interactive drama, and in terms of Agency there are no severe restrictions on the actions of the user (a child's actions have direct impact on the story) as long as he or she uses his/her puppet. Immersion will depend on the level of cooperation achieved between the user and the system. Transformation is achieved if the user feels that this cooperation does not monopolize his own decisions.

Installation

The I-Shadows' installation merges the real world with the virtual world in the sense that the user, the real shadows and the screen exist in the real world (see Figures 2 and 5), but what is projected is a result of a virtual world, where the characters' shadows are controlled by agents' minds and decide upon the events of the story. In this paper we will mainly focus on the aspects of mind in the virtual world although some aspects of the user interaction in the real world are essential for the whole system.

The *virtual world* is modelled symbolically (using a tool-ION developed in GAIPS for that purpose) and has two main components: the *Virtual Set* which is a virtual representation of the real set that compounds all the active characters (all the characters in the scene, including an image of the real characters), and the *Cast* which aggregates all the inactive characters (characters that are ready to be used but are not on the scene). In the *Virtual Set*, the user (controlling one or more characters) decides on the actions to do, and those actions are captured through the vision system and transformed into symbolic representations, which are then symbolically represented. All the other agents acting in that virtual set perceive the actions of the others and act accordingly. To manage the transfers of characters between these two components there is also a *Director Agent*, that perceives the emotional parameters of the scene and decides which characters could or should enter the scene, thus moving characters from the cast to the virtual set, or the opposite, forcing characters to leave the scene, moving from the virtual set to the cast.

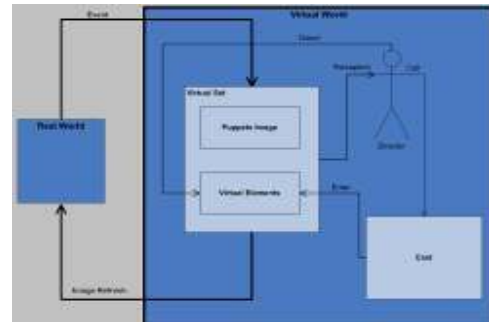


Figure 2 - High level architecture for I-Shadows

Closing the gap between user and characters

As mentioned earlier, our approach to Interactive Drama intends to achieve surprising and partially structured story developments. At a first glance, surprise and structure may seem hard to conciliate. One should note that there can be a big gap between the surprise added by the user's actions and the plans of the virtual characters. To try to close this gap we found inspiration in Freytag's Drama Theory.[13]

In 1863, Freytag defined the Freytag Pyramid and stated that drama (based on what he had studied) in general followed the same pattern of development along a variable that he called tension.[14]

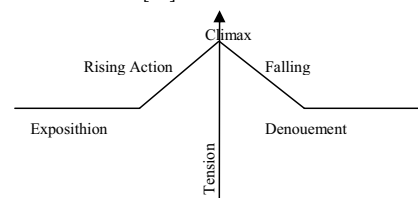


Figure 3 - Freytag Pyramid

Following the storyline from left to right, there are 5 acts. The Exposition provides the information about the environment, the characters and their relations. The Rising Action is the reaction to some negative events that are preventing the protagonist from reaching his or her goals. The Climax is a turning point, usually leading to a positive solution. The Falling Action brings everything back to normal. Finally, the Denouement is the conclusion of the story. From an emotional point of view we can somehow associate the story start with a positive mood, which then suffers a negative impact and ends with a positive conclusion. We call this process a Valence Loop, and it is this valence loop that we will try to create in the I-shadow episodes.

Note that tension is a direct consequence of the emotional mood of the play. Emotions with a high arousal such as

anger or surprise, will contribute positively to the increase of the tension. Using arousal and valence, we propose an emotional reaction model as a form of monitoring an Interactive Drama emotional state, which will somehow be the application of Freytag's storyline onto an emotional Valence vs. Arousal system (see Figure 4).

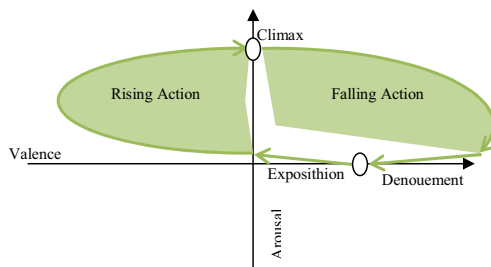


Figure 4 - Emotional Model for Interactive Drama

As such, the storyline would start with a positive mood when all the characters live peacefully, in neutral arousal. As the story develops someone or something subtly disturbs the peace (similar to the villainy function of Propp[14]). Once that happens, and the good and evil are identified, the villain will express his or her evil again but this time with enough impact to change the mood of the action into negative values. A hero will react to this (similar to the hero response function of Propp[14]), rising the arousal until the decisive moment of climax, when the valence of the story changes definitively and the villain's defeat seems inevitable. Then we will achieve the falling action, and there will be a return to normality, ending with the denouement.

Using this model, while capturing the emotional state of the scene, our system should be able to identify at which moment of a storyline the interactive drama is, and decide how to intervene in order to guarantee a story development around the proposed storyline. At the same time, the system guarantees that the pace goes in a way that promotes the collaboration between the story intervenients (users and autonomous characters). Since our goal is to let the story emerge from the relations between characters, the intervention in the action will include telling characters to enter or leave the scene, as well as sounds, and indications to the actors of what direction to take. To sum up, the proposed model adapts to the user's actions, not only through the interpretation of some patterns of behaviour but also through the adjustment of the storyline as the emotional state of the story progresses.

The Characters in I-Shadows

Based on the preference demonstrated by our users in Fairy Tales stories, both the behaviour and the body of our characters are inspired by this type of stories. The next

three sections present the implementation of two kinds of characters: Real Characters manipulated by the user and Virtual Autonomous Characters implemented in our system. The Director aims at conciliating both the Real and the Virtual Characters' perspective in the story development.

Real Characters

Real Characters are puppets manipulated by the user that are detected by the system using a vision component. The algorithm that interprets the movements of these characters including their emotional expressions was developed in close collaboration with children from a local school (the training of the component was done with stories created by the children).



Figure 5 - Real Characters (Puppet)

The design of these characters was also influenced by them. In early acceptance tests, users were invited to express their opinions upon each puppet's shape, colour, size and personality. The results of these tests were several puppets accepted by the users in their imagination and in their stories. More information about this work can be found in [16].

Creating Autonomous Virtual Actors

Based on the proposed model, I-Shadows implements a very rich cast of characters, with appropriate actions and an emotional behaviour. To achieve this emotional behaviour we are using an OCC based architecture (FAtiMA)[15] developed at GAIPS, for the minds of the characters and director (Agents).

Each agent in the world (the character) perceives the environment through a set of sensors (allowing the perception of events, objects, etc. in the world) and acts within the environment through its effectors.

In order to achieve believable and expressive agents, their behaviour is influenced by their emotional state and personality. FAtiMA models emotions based on the OCC cognitive appraisal theory of emotions, where emotions are

defined as valanced (good or bad) reactions to events. Whenever the agent receives a perception, the agent appraises its significance and triggers the appropriate emotions. Additionally, if a goal becomes active, it will add a new intention to achieve the active goal in the agent's mind.

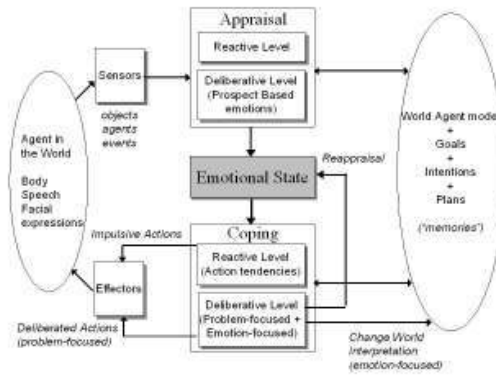


Figure 6 - Goals Implementation

The agent's mind architecture is shown in Figure 6 (taken from [15]). Given the several components that constitute such minds, for each agent built (thus, for each autonomous actor in our cast), the author needs to define a set of elements that includes among other things their goals and action tendencies that can be triggered by a particular emotional state of the agent. These action tendencies represent the character's impulsive and hardwired actions which he performs without thinking (reactive actions), and are implemented according to each character's personality. Using this architecture we were able to create different types of characters for each "physical shadow". The FAtiMA architecture provides a framework to start authoring these characters using emotional behaviours, because it guarantees its consistency with the character's emotional state and personality. Furthermore, the relations between characters can develop dynamically along the story development and influence their behaviour. Using FAtiMA, the implementation of reactive behaviours and emotionally influenced behaviour is quite straightforward. The authoring process of these characters consists in four steps: Identifying the Characters and their Domain Actions, Defining their initial Relations, Defining their Action Tendencies (emotionally triggered actions) and Defining "Personality". This last step includes defining each character's goals and emotional reactions to external

events. In addition to this, in order to allow for an even more emergent behaviour we created two new concepts at the implementation level, Meta Goals and Activation Actions.

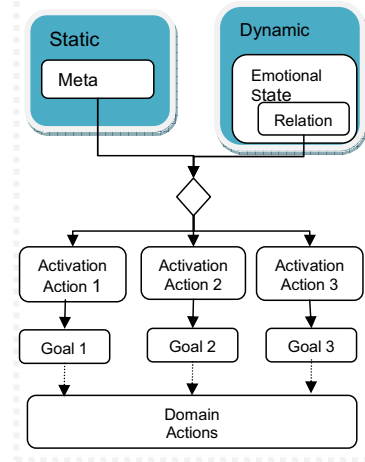


Figure 7 - Goals Implementation

This implementation allowed us to separate two kinds of goals for our cast: the "meta goals" that represent intentions at a high level such as "Show Love" or "Show Hate", and the dynamic ones, which, combined with the emotional state of the character (including interpersonal relations), use Activation Actions to activate the respective Goal using the common domain Actions.

The relations between the characters are established according to their roles in the story. The following example shows the initial relations of a Princess with the other characters. Each relation can be quantified dynamically in a $[-10, 10]$ range, where "-10" represents a very negative dislike relation, and 10 represents a strong like relation.

For example, let's consider that Mary (a girl shadow) is a princess and victim. The example below shows that the princess starts acting with a small love relation towards the Hero, but as this relation is not static, it will evolve according to her emotional reactions to the actions of the Hero.

To sum up, we considered that, although our agents should act autonomously, to achieve different personalities and guarantee a rich cast of actors for the same role we needed to manage the emotional "parameters" (and thus the personality) of each character. By manipulating the values of activation and decay of emotions, it was possible to build for example, a hero that easily falls in love, or a hero that likes to be a lone ranger.


```

<Relation target="Donor" like="-2"/>
<Relation target="Hero" like="2"/>
<Relation target="Helper" like="-2"/>
<Relation target="Villain" like="-0.5"/>
<Relation target="Candy" like="2"/>

```

Figure 8 - Princess Relation

Director

As said before, the emergence of a story with several autonomous entities, our cast and our users should result if the process of acting and reacting is collaborative in essence. For example, an agent waits for another agent to perform its actions before it says its own line. This is guaranteed by the agent's minds. However, there are other elements in this collaborative process that are beyond the autonomous behaviours of the actors: for example, when a character from the cast is brought into scene. To control such type of emergence we have developed a "director agent" that controls the whole interactive process to keep the tension values proposed previously. Although it is still being implemented, this component is responsible for collecting all the affective information produced by the characters, specially focusing on the emotions of the hero and the victim. Based on this information and on its knowledge about the characters' relations, it chooses between: sending a message to a character in the cast telling it to enter; sending a message to a character on the scene to leave; or not performing any action for the moment. The entrance and exit of characters will have an emotional impact on the characters' relations, thus influencing the drama development. With studies performed with children collaborating in this story construction, this type of action (managing the appearance and disappearance of the characters) was very regularly used. In the future we expect to augment the repertoire of narrative actions done by the Director.

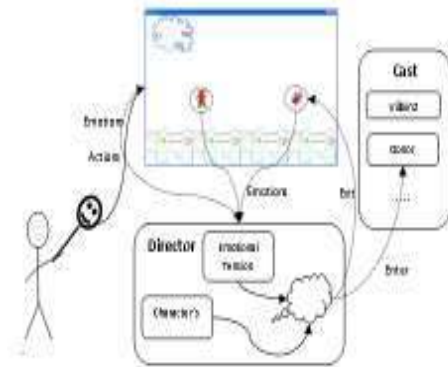


Figure 9- The director influencing the cast

Preliminary Results

So far, we have shown how we approached the construction of a narrative drama application, where stories emerge as a collaboration process between the users and the agents. To achieve that, we gave the agents a rich set of behaviours supported by an agent architecture that allows for affective and social behaviour.

The authoring process of I-Shadows combined elements of acting and fairy tales (by creating heroes, victims, or villains) and of acting itself. As the system was designed as a close collaboration between children and teachers, some good results in terms of expression detection and emotion expression were achieved.

The following example illustrates some elements of this process, with an interaction between a Princess and a Hero. Consider that the Princess loves the Hero with an intensity corresponding to the initial value shown above. When she sees the Hero, a Show Love intention is activated by the Show Love meta goal (built into its mind).

According to her emotional state, the Princess decides that the way of Showing Love for the hero is to offer him a Candy. This action generates a Joy emotion in the Hero that triggers a Smile.



Figure 10 – Princess feels Hope of Showing Love

The Hero's smile is appraised by the Princess as a positive action. This appraisal has a positive impact on the relation with the Hero. As a consequence, the next time the princess intends to show love she will consider a more intense relation with the Hero that will activate a kiss intention.



Figure 12 shows the actual hero's emotional state after failing to defend a Victim. The hero was in a very positive mood because of the joy he felt when the victim expressed her love for him. Suddenly the villain hits the victim. The hero appraised this event as a very negative action, and felt disappointed, this appraisal generated resentment and reproach towards the action and towards his subject (Villain). As a consequence of these events, his "Like" relation will decrease towards the villain and will increase towards the victim. And because of this he will try to protect the victim the next time. Figure 12 shows the hero's emotional state after defending the victim. This time the hero succeeded in defending the victim and had a positive feeling of satisfaction.

Conclusions

This paper argues that, to achieve interactivity in interactive narrative systems, we can regard the story construction as a collaborative process between users and characters. However, for that to be possible, the characters need to have a role and be autonomous enough to decide what to do at a certain instant. In the paper, we have described the construction of such type of autonomous agents using an emotional architecture based on FATiMa. This development was done in the context of the I-Shadows system, an interactive drama where the user is free to act in the physical world by manipulating shadow puppets.

The stories created are a result of the actions of the user and the actions of autonomous characters. Furthermore, supported by theoretical groundings in interactive drama and the role that the proposed emotional model has in achieving interactivity, we have built a Director agent that somehow coordinates parts of this process (based on that emotional model).

Authoring characters using FATiMa is not easy due to the lack of a real methodical authoring approach for building agents for interactive narrative. A character-centred approach needs to be followed, and that is often difficult to do. Characters are acting according to their roles and have dynamic relations, and it is these roles and relations that need to be captured in the agents' minds. Although the results are so far positive, we believe however that, to really obtain a good play, the characters need to be further improved. Moreover, we expect to start evaluating the system with children very soon and evaluate the degree of collaboration achieved between the children and the system.

Acknowledgements

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Appendix B

AAMAS ABSHLE 2007

From Chinese Shadows to Interactive Shadows: Building an storytelling application with *autonomous* shadows

ABSHLE: Agent-Based Systems for Human Learning and Entertainment

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Abstract: Creating Interactive Drama applications, where users can freely act out their roles in stories and, at the same time, be perceived by the application which adapts the story to these actions, is a challenge that many researchers are dealing with. Perhaps the main problem lies in the balance that must be reached between the author's need for control and the user's need for freedom. One of the approaches for addressing this problem is to adopt a multi-agent system as the base underlying simulation model for the Interactive Drama application. However, this approach is not only quite complex to develop but also extremely difficult to author. In this paper we describe the authoring process that took place for building autonomous characters in a storytelling application called I-shadows. I-Shadows is a Chinese shadows theatre with interactive characters that can be either autonomous or controlled by children. Drama in I-Shadows emerges from the collaboration between the children and the system. Children choose their shadows and act them out on the screen. The system collaborates with the children by controlling other characters that were created using an Emotional Agents Architecture (FAtiMA), allowing for the generation of believable behavior as the stories develop. In the paper we describe the creation of such characters, focusing on how they can embed in their behavior both elements of the story domain and at the same time, acting knowledge thus allowing them to really engage the user into the interactive experience.

Keywords: Interactive Drama, Autonomous Characters, Affective Characters

1. Introduction

Until recently, most of the interactive drama systems were developed using script-based or plot-based approaches. These plots were defined by manipulating each character's goals as in RobotImprov[1], or by limiting its planning decisions[2][3]. These approaches did not allow an effective creative intervention in the stories development beyond the pre-defined plot.

An approach to allow this intervention was made by the Interactive-Theatre project[4][5], where agents were free to improvise their actions under the influence of the user. However this influence was only achieved at a very high level, not directly, and depended on pre-defined actions of the controlled character.

The use of autonomous characters, brought in by research such as the one developed by M. Cavazza [6], and Aylett et.al. [7], allowed new models of flexibility on both, and a new model of interactivity in the latter thus giving users eventually more freedom. Users in interactive drama may interact with characters and stories emerge from the characters and those interactions. It is the maturity achieved recently in the area of autonomous characters that allows them to be used to generate believable behavior to respond to users' expectations in interactive stories.

However, for the construction of these characters is not only quite complex to develop but also extremely difficult to author. In this paper we describe the authoring process that took place for building autonomous characters in a storytelling application called I-Shadows. I-Shadows is a Chinese shadows theatre with interactive characters that can be either autonomous or controlled by children..

The paper is organised as follows. First we will present the main foundations that led to the approach taken in I-Shadows. Then, a brief description of the project, exploring some details of implementation, in particular the integration of the main ideas into the characters created using FAtiMA framework. Finally, we will report of some preliminary results and provide some concluding remarks concerning I-shadows..

2. Foundations for Interactive Drama and Autonomous Agents

In order to provide a fundamental mechanism to study interactivity and the role of users in an interactive drama, we

have adopted the well known model from Murray [8], who defined three aesthetic categories for evaluating the users experience in a interactive drama. These are: *Immersion*, *Agency* and *Transformation*. *Immersion* is achieved when the user totally accepts the logic of the environment. Furthermore, and according to Mateas this acceptance can be noticed when a player assumes the role of a first-person character in a dramatic story. Differently, *Agency* is defined as the influence that the user's actions might have in the unfolding of the story. *Transformation* is achieved when the combination of *Immersion* and *Agency* provide a unique users' experience each time he or she uses the system. [8][9]

One should note that there is a conflict between *Agency* and the other two categories. This conflict can be related to the conflict between the author's need to guarantee a safe story development, thus following a drama structure, and the Characters and users' need to act autonomously.

Several approaches have been made in order to try to combine these three categories, either reinforcing the author's influence, or reinforcing the characters' autonomy (see for example *Façade* or *Agent Stories*).[10] [11]

In our approach (as already addressed by other researchers such as Aylett[7]) the way to think about the combination of these two approaches would be to try to pass some of the structural knowledge of the play from the Author to the Characters. This approach is to some extent similar to what is followed by improv companies of theatre where the actors try to develop plays from an initial scene based only on pre-defined relations and their own creativity. The first major reference to his theatrical method goes back to Europe's Renaissance period when Comedia Dell'Arte tropes travelled through all Europe presenting plays based upon open narratives with well defined characters, and narrative structure. More recently theatre teachers such as Viola Spolin and Keith Johnston created new techniques that launched the growth of several Improvisational Theatre companies, such as Compass. Most Improv directors agree on the following basic principles for an improve actor's actions on stage:

- Always accept information given from others.
 - Otherwise we say the actor is "Blocking" the scene
- Always add history to the scene
- Scene Beginnings should be short and objective
- Enter, stay and exit scene with purpose
- Maintain character's point of view

According to Spolin "Improvisational theatre requires very close group relationships because it is from group agreement and group playing that material evolves from scenes to plays". This suggests that in order to achieve a successful interactive drama, the user must take part in this group relation.[12] [13]

Our research on interactive drama has taken this direction of integrating the user in an affective environment, where he or she can interact with emotional characters that act like real actors adapting the play to what is happening. Relations are established between the user and the characters according to their roles in the story and a consistent emotional behaviour. It is from the richness of these interactions, where the user is immersed, that we expect to bring to life real interactive drama, with surprising but structured story developments.

2.1-Shadows

2.1 Description

The I-Shadows' installation was inspired by one of the oldest forms of theatre: Chinese Shadows Theatre. There are however some important differences: (1) in I-shadows a user is a puppeteer in the play (thus manipulating physically his/her shadow puppets), and (2) some of the characters in the play are automatically controlled by a computer system. The play emerges as a collaborative process between the user (puppeteer) and the system (I-shadows). The system monitors the action on the screen using a vision component, and participates in it by projecting characters onto the screen. The drama emerges from the interaction between the projected characters and users that physically manipulate other characters, puppets.

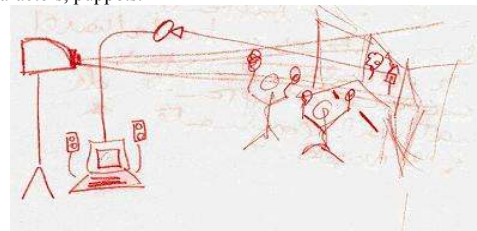


Figure 1 – I-Shadows installation

One of the goals of I-shadows is to provide an environment where children learn how to create stories and act them out in character in front of an audience. So, we expect that the audience will be able to watch a play improvised by a child (or group of children) in cooperation with autonomous characters.

To contextualize I-Shadows in children's imagination, we found inspiration in the most common enfant stories: Fairy Tales. The set of characters developed were based on typical fairy tales stories, thus including fairies, goodies, a boy, a girl, a witch, a dragon (among other characters).

The challenges imposed by this project are numerous. Going back to the fundamentals of interactive drama, and in terms of Agency there are no severe restrictions over the actions of the user (a children actions have a direct impact over the action) as long as he or she uses his/her puppet. Immersion will depend on the level of cooperation achieved between the user and the system. Transformation is achieved if the user feels that this cooperation does not monopolize his own decisions.

2.2 Designing Interactivity in I-Shadows

In general, and from the past few years, the theory of drama has been a good source of knowledge for interactive drama researchers. The challenge of placing the user in the process of creating and acting in a play, has taken researchers to try to adapt the theories of the classic theatre into new theories. A good example of this is the Neo-Aristotelian Theory of Interactive Drama, proposed by Mateas[9] or the effort to implement Improv theories as in Interactive Theatre[4].

In 1863, Freytag defined the Freytag Pyramid and stated that drama (based on what he had studied) in general followed the same pattern of development along a variable that he called tension.[14]

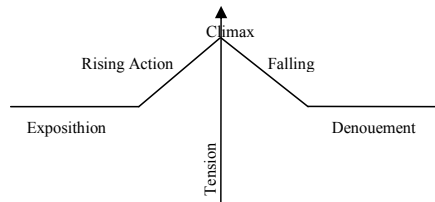


Figure 2 - Freytag's Pyramid

Following the storyline from left to right, there are 5 acts. In *Exposition* provides the information about the environment, the characters and their relations. *Rising action* is the reaction to some negative events that are preventing the protagonist from reaching his or her goals. *Climax* is a turning point, usually into a positive solution. *Falling Action* brings everything back to normal. Finally, *Denouement* is the conclusion of the story. From an emotional point of view we can somehow associate the story start with a positive mood, which then suffered a negative impact and, reacted back with a positive conclusion. We call this process a *Valence Loop*. It is this valence loop that we will try to create in the I-shadow episodes.

Note that tension is a direct consequence of the emotional mood of the play. Emotions with a high arousal such as anger or surprise, will contribute positively to the increase of the tension. Using arousal and valence, we propose an emotional reaction model as a form to monitor an Interactive Drama emotional state, which will somehow be the application of Freytag's storyline onto an emotional Valence vs. Arousal system (see Figure 3).

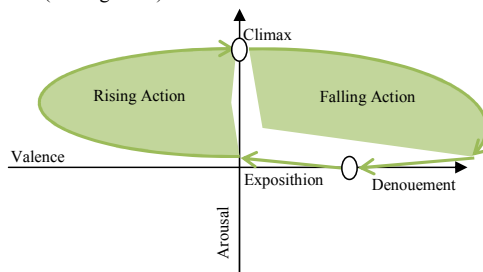


Figure 3 - Emotional Model for Interactive Drama

As such, the storyline would start with a positive mood when all the characters live peacefully, in neutral arousal. As the story develops someone or something, is subtly unbalancing the peace (similar to the villainy function of Propp[15]). Once the good and evil are identified, the villain will express his or her evil again but this time with enough impact to change the mood of the action into negative values. The hero's response, here we are assuming a hero is made known to the audience rising the arousal until the decisive moment of climax, when the valence of the story changes definitively and the villainy's defeat seems inevitable. Then we will achieve the falling action, and there will be a return to normality, ending with the denouement.

Using this model and trying to capture the emotional state of the scene, our system should be able to identify at which moment of a storyline the interactive drama is, and decide how to intervene in order to guarantee a story development

around the proposed storyline. Since our goal is to let the story emerge from the relations between characters, the intervention in the action will include the ordering characters to enter or leave the scene (as well as sounds, and indications to the actors). To sum up, the proposed model adapts to the user's actions, not only by the interpretation of some patterns of behavior but also by adjusting the storyline as the emotional state of the story progresses.

2.3 The I-Shadows' Installation

The I-Shadows' installation merges the real world with the virtual world in the sense that the user, the real shadows and the screen exist in the real world, but what is projected is a result of a virtual world, where the characters' shadows are controlled by agents minds and decide upon the events of the Drama. In this paper we will mainly focus on the aspects of mind in the virtual world although some aspects of the user interaction in the real world are essential for the whole mechanism.

The virtual world is modeled symbolically and has two main components. The *Virtual Set* which is a virtual representation of the real set that compounds all the active characters (all the characters in the scene, including an image of the real characters), and the *Cast* which aggregates all the inactive characters (characters that are ready to be used but are not on scene). In the Virtual Set, the user (controlling one or more characters) decides on the actions to do, and those actions are captured and symbolically represented. All the other agents acting in that virtual set perceive the actions of the others and act accordingly. Managing the transfers of characters between these two components is a Director Agent, that perceives the emotional parameters of the scene and decides which characters should enter the scene, moving from the cast to the virtual set, or letting the scene, moving from the virtual set to the cast.

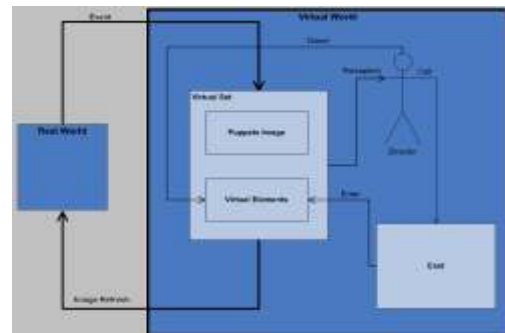


Figure 4 - High level architecture for I-Shadows

2.3.2 The agents in I-shadows

Based on the proposed model, I-Shadows implements a very rich cast of characters, with appropriate actions and a rich emotional behavior. The characters are based on Fairy tales and were designed with the help of children. To achieve this rich emotional behavior we are using an OCC based architecture (FAiMA) developed at GAIPS, for the minds of the characters and director (Agents).



Figure 5 – Shadow of a Physical puppet

2.3.2 Agent's Minds: FATiMA

FATiMA is an agent architecture designed to allow the generation of an emergent and unscripted narrative through believable agents. The plot is built by the interaction between the several characters, which autonomously decide upon their own actions according to their beliefs and goals.

Each agent in the world (the character) perceives the environment through a set of sensors (allowing the perception of events, objects, etc. in the world) and acts on the environment through its effectors.

In order to achieve believable and expressive agents, their behavior is influenced by their emotional state and personality. FATiMA models emotions based on the OCC cognitive theory of emotions, where emotions are defined as valenced (good or bad) reactions to events. The assessment of this relationship between events is called the appraisal process.

Whenever the agent receives a perception, the agent appraises its significance and triggers the appropriate emotions. Additionally, if a goal has become active, it will add a new intention to achieve the active goal.

FATiMA provides two distinct levels in both appraisal and coping. The reactive level provides a fast mechanism to appraise and react to a given event, while the deliberative level takes longer to react but allows a more complex goal-driven behavior.

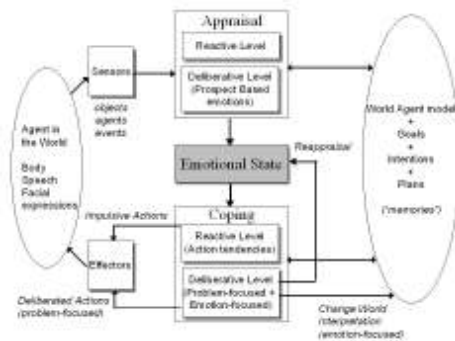


Figure 6 FATiMA architecture

In order to build agents in FATiMA one has to define the actions available for the domain (they will be used by the planner in the deliberative layer), and then to individually define each of the characters. The character's personality is strongly based in OCC and is defined by: a set of goals; a set of emotional reaction rules; the character's action tendencies; emotional thresholds and decay rates for each of the 22 emotion types defined in OCC.

The emotional reaction rules assess how generic events are appraised and represent the character's standards and attitudes. Since the appraisal process is clearly subjective, these rules must be very dependent on personality. The emotional rules are also important because they are used to influence interpersonal relations that are also modeled in FATiMA. For instance, if an agent performs an action that triggers negative emotions in another agent, the relation of the latter with the former will deteriorate. These relations are stored explicitly in the agent's model of the world and can be used to activate goals and other type of behavior.

Action tendencies represent the character's impulsive and hardwired actions which he performs without thinking (reactive actions). Action tendencies correspond to simple action rules triggered by particular emotions. For example, we may have a character crying when very distressed. Specifying action tendencies for characters is very important to convey the viewer a well defined personality. Loyall pointed out that in order to achieve believability, characters must have very particular details of movements, mannerisms and reactions. [16]

OCC specifies for each emotion type an emotional threshold and decay rate. An emotional threshold specifies a character's resistance towards an emotion type, and the decay rate assess how fast does the emotion decay over time. When an event is appraised, the created emotions are not necessarily "felt" by the character. The appraisal process determines the potential of emotions. However such emotions are added to the character's emotional state only if their potential surpasses the defined threshold

So, in addition to goals, standards and attitudes, these emotional thresholds and decay rates are used to complement a character's personality. For example, a peaceful character will have a high threshold and a strong decay for the emotion type of Anger, thus its anger emotions will be short and low. Thus, it is possible to have two characters with the same goals, standards and behaviors that react with different emotions to the same event (by having different thresholds).

Further information about FATiMA can be found in [17].

2.3.3 Authoring Process: Defining Domain, Actions and Expressions

As explained earlier in the text, before jumping into the authoring of each character it was necessary to define their scope. Thus, we needed to know which emotions could be used in the context of I-Shadows. Although FATiMA allows for a good range of emotions to be used in its appraisal system there was a gap in the communication with the user that had to be analyzed. Which emotion expressions could be used and identified, in the cooperation with children in this kind of interactive drama?

To answer these questions we have developed a non-functional prototype and tested it in a local school, using a fast prototyping user's centered approach. In the tests users were invited to several games that included, telling stories from scratch, from a suggested beginning, or simply playing mime games of emotions. These tests gave us some clear clues about the potential of the project, and most importantly the actions and the expressions that the characters should implement. At the end of the tests we have built and tested a prototype that generated and detected expressive movements.

A detailed description of the methodology used and its results can be found in [18].



Figure 7 – First Prototype with Virtual Character with expressions

2.3.4 Characters

After deciding the domain of actions and expression of the characters, the authoring process had four main steps: Identify Characters and Goals, Define Relations, Define Action Tendencies, Define Multiple Emotional “Personality”.



Figure 8 –Authoring Process with FATiMA

The first step was to identify the characters and their goals. Assuming the children’s preference for Fairy Tales the choice of adapting Propp’s work that identified 9 roles and 31 functions in classical Fairy Tale literature seemed inevitable. Hero, Villain, Victim, Relative, Friend, Dispatcher, Donor, Helper and False Hero are all being implemented with the respective goals of performing “villainies” against an enemy or protecting his friends, inspired on the concept of Spheres of Action of the same author.[15]

The relations between the characters are established according to the roles. The following example shows the initial relations of a Hero with the other characters. Each relation can be quantified dynamically in a [-10, 10] range, where “-10” represents a very negative dislike relation, and 10 represents a strong like relation.

```

<Relation target="Villain" like="0"/>
<Relation target="Victim" like="3"/>
<Relation target="Donor" like="3"/>
<Relation target="Helper" like="3"/>
  
```

Figure 7 – Hero’s interpersonal relations

For example, let’s consider that we have John (a boy shadow) and he is a hero. As you can see in the example above the hero starts acting with a neutral relation towards the villain. However this relation is not static, and will evolve according to the emotional reactions of John to the actions of the Villain.

To do that, the character’s minds include a set of action tendencies are the actions that are executed as an immediate reaction to a change in the environment. An author may give the John (the hero) an action tendency of running to his friends whenever he feels sad, or attacking a Villain

whenever a Villain attacks him. By modelling these actions, it is possible to author different kinds of characters in the same role, which means that it is possible to define a more or less aggressive Hero.

Another way of authoring different personalities for the same role is by managing the emotional “personality” of each character. By manipulating the values of activation and decay of emotions, it is possible to build a hero that easily falls in love, or a Hero that likes to be a lone ranger.

2.3.5 Director

The Director agent controls the whole interactive process to keep the tension values are proposed in section 2.2. Although still being implemented this component is responsible for collecting all the affective information produced by the characters, specially focusing on the emotions of the hero and the victim. Based on this information and on its knowledge about characters relations it chooses between: sending a message to a character in the cast telling it to enter; sending a message to character on the scene to leave; or not to take any action for the moment. For the moment we are expecting that the entrance and exit of characters, that have an emotional impact in the characters relations, will be enough to influence the drama development. In the future these actions do not show enough results, we will study the implementations of new actions, although these should not reduce the users direct control of the puppets.

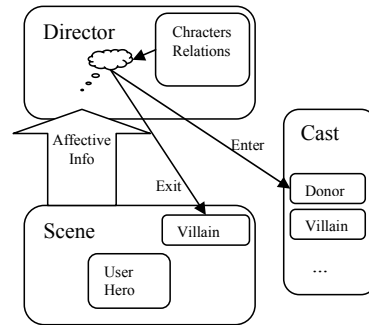


Figure 9. General Architecture

3. Preliminary Results

The authoring process of I-shadows has combined elements of acting and fairy tales (by creating heroes, victims, or villains) and on acting itself. As the system was designed as a close collaboration with children and teachers, some good results in terms of expression detection and emotion expression were achieved.

In terms of authoring the characters are interacting in small pieces of actions according to their roles, and more importantly, according to their relations with the other characters (taking into account their acting role).



Figure 10 - Hero Disappointed

Figure 10 shows the actual hero emotional state after failing to defend a Victim. The hero was in a very positive mood, because of the joy felt when the victim expressed her love for him. Suddenly the villain hits the victim. The hero appraised this event as a very negative action, and felt disappointed, this appraisal generated resentment and reproach towards the action and towards his subject (Villain). As a consequence of these events his "Like" relation will decrease towards the villain and will increase toward the towards the victim. And because of this he will try to protect the victim the next time. The next figure shows the hero's emotional state after defending the victim.



Figure 2 - Hero Satisfied

This time the hero succeeded defending the victim and has a positive satisfaction feeling.

4. Conclusions

This paper presented gives a brief description on the development of I-shadows, an interactive drama where the user is free to act in the physical world by manipulating shadow puppets. The stories created are a result of the actions of the user and the actions of autonomous characters, controlled by an emotional architecture based on FATiMa. In the paper we tried to show the theoretical groundings that

supported the approach to interactive drama, and the role that the emotional model proposed has on achieving interactivity.

As with the authoring of FearNot! (also using FATiMa agents) the process is difficult due to the lack of a real methodic authoring approaches for building agents. A character centered approach needs to be followed, and that is often difficult to do. Characters are acting according to their roles and have dynamic relations, and it is these roles and relations that need to be captured in the agents minds. Although the results are so far positive, we believe however that, to really obtain a good play, the characters need to be further improved. Moreover, we expect to start evaluating the system with children very soon, thus providing us with enough feedback to improve our approach.

6. Acknowledgements

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Appendix C

HUMAINE WP9 2006

Children as Affective Designers

I-Shadows Development Process

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Abstract

The following text describes a user-centred prototyping development process that is being used in GAIPS INESC-ID, to produce an affective system for children, named I-Shadows. This system uses Chinese Shadows as an interaction metaphor to help children build a logical narrative for an audience.

Introduction

Imagine a dark room full of children where suddenly a new world gains form with a light beam. Imagine that this new world is filled with coloured intelligent and interactive shadows, in which you can participate with your own shadow. Other intelligent shadows participate and help children to build the virtual and real worlds of Interactive Shadows.



Figure 1 - I-Shadows installation

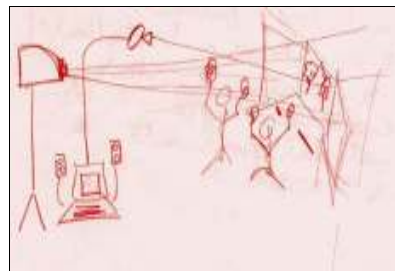


Figure 2 I-Shadows components

The previous paragraph describes the conceptual model of I-Shadows. Our main goal in this project is to help children achieve logical narrative on-the-fly, by reacting to the emotions and intentions that children express through shadows' manipulation in an intelligible way. These emotions and intentions are detected by a system that integrates a computer, a projector, a video camera and a shadow screen. The computer uses a camera, a projector and a vision algorithm to interpret real actions and project virtual elements, such as characters and sounds onto reality at the same time.

The following text describes the method that is being used in this project to test and involve users in the design process.

Method

Developing an affective loop where users' expressions have a special role raises two difficulties:

- How to understand and compute users' expressions with I-Shadows
- How to express emotions in an intelligible way

Our approach to these questions consisted in considering them as the need for coherence between users' expectations and shadows' emotional expressions. To achieve this coherence we propose that computer generated expressions should be as similar as possible to the user's expressions. Before

generating emotional impact we have to learn from the users how they express it. This is how we concluded that users should be involved in the design process as soon as possible as in Sentoy[1].

The involvement of users in the design process raises some known difficulties: it's a time consuming task; it's hard to find appropriate users; users are often not committed to the project, etc. In addition, we must consider that, because our users are children, they need some special attention to keep focused on the objectives of each experiment.

Our main concern when involving children was to assure that they wouldn't feel tested and observed but rather authors and participants in the design of a new and different kind of game. We wanted them to be as natural as possible to achieve more accurate results. To overcome these difficulties we defined four rules:

- Children are members of the development team as users.
- All team members' opinions are important.
- Children collaborate, and are not developers.
- Children and adults have fun, but only adults take notes.

To implement these rules, and concerns, we adopted a fast prototyping method, which allowed children to participate in several experiments from the beginning of the project until the present day.

Development Process and Tests

The I-Shadows' development process consists in managing the interaction between two main activities: Implementation and Tests. This interaction management can be seen as a loop that begins with the users' requisites that guide the implementation of a solution, and closes with the users' evaluation of that implementation which raises new requisites to be considered in the next implementation.

Five different kinds of tests were already made until the present day: Acceptance Tests, Observation Tests, Design Workshop, Expression Tests and Expression Recognition. All tests are being held at a local school, and are included as a free activity in which they can choose to participate.

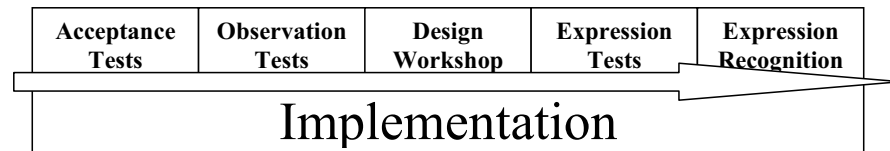


Figure 3 – Development Process

Acceptance and Observation Tests

It wouldn't make any sense to build such a complex installation as I-Shadows if children didn't like it. Consequently we had to test children's acceptance of the idea. For that, we built a non-functional prototype of I-Shadows that embedded a simple Chinese Shadows Theatre.

This Prototype was also used with success to see how children expressed, and how they created narratives using it. The results of these tests included a non-quantitative definition of four different patterns of expressions, which corresponded to four emotions, Happiness, Sadness, Anger and Fear. These results can be seen in *Designing Affect in a Chinese Shadows Theatre*[2].

Other conclusions reached with these tests were that children like the I-Shadows concept, accept suggestions for starting a narrative, as well as they need it to keep their narrative logical enough to be seen by an audience.

Design Workshop

While implementing a first functional prototype with the requisites and patterns taken from the first experiments, we had to support the users' continuous integration in the development process and make them feel like developers. Due to this, we prepared a Design Workshop, where children were invited to create characters, and sets for their stories.



Figure 4 and 5 - Design Workshop (Left: Boy drawing; Right: Dragon's home)

The goal of this workshop was simple; we wanted I-Shadows to be as similar as possible to the users' expectations. We wanted I-Shadows to present characters and sets according to children's perspectives.

Expression Tests

This test was taken in July, with eight children (4 boys and 4 girls) aged 8. The goal of this test was to see the accuracy of the proposed expression patterns this time in a quantitative way, with a functional prototype simulated in a computer, controlled by a mouse.

The experiments were preceded by a small introduction where children were invited to play a mime game within the group. "*This mime game has some special words. These words are emotions like Happiness, Sadness, Fury and Fear*". Once the game started to slow down, we started the experiment that consisted of two tests.

1st test – After choosing two virtual puppets, from the functional prototype, a character to manipulate and a friend to play with, the test worked like the previous mime game, but it was up to their "friend" to recognize their emotion and repeat it. This test was taken in two rounds for each set of emotions (Happy, Sad, Angry and Sad). The results are shown in table 1, the 'Success' percentage means the percentage of expressions correctly detected by the prototype.

	Success (1 st Round)	Success (2 nd Round)
Happy	63%	100%
Sad	88%	100%
Scared	75%	88%
Angry	13%	13%

Table 1 - Tests Results

The children responded enthusiastically to the 1st experiment. Sometimes less expressive kids showed some difficulty at the beginning. However, they adapted to the game very fast by watching how the others did it.

The results were in line with the expected. All patterns except for Angry showed a significant value above the random value. Most of the children showed great difficulty when trying to produce the Anger pattern, because of its high speed, which made them lose control over the mouse.

2nd test – Everyone should try to show their "friend" how he should move when he is angry. The movements' quantified data was collected and a new Anger pattern was implemented.

Fifth Experiment – Expression Recognition

In November 2005, we were ready to test the generated expressions of the animated shadows. The experiment involved 10 children (7 boys and 3 girls).

In this test children were invited to guess which spell (emotion) a computer generated shadow was experiencing. The Anger pattern used was the improved version due to the previous test. The results are shown in table 2.

	Success
Happy	70%
Sad	30%
Scared	40%
Angry	50%

Table 2 - Expressions' recognition

Three expressions showed a significant value above a random distribution, which makes us believe in the success of this test. The Sadness expression presented a low success percentage. We interpret this result as an alert that points out the incoherence between the sad expression animation patterns defined by the children.

Afterwards in an informal chat, children mentioned that the lack of facial expressions and sounds of the character made their task more difficult. We also considered by observation that the lack of context in which the expressions occurred might have led to the low results of some expressions.

Conclusions and Future Work

At this point of the project we feel that the obtained results are very satisfying. We are able to detect three users' expressions with success, and to express other three in an intelligible way. We will continue testing these first patterns and we expect to improve our success margins with the Anger detection and the Sad Expression.

Children's excitement when we visit them in order to test the prototype (plays), convinces us that their expectations are being met, and that, consequently, our development method is succeeding.

The next step, after resolving the expression's recognition, is to achieve the context concept by creating high level actions, based on these primitive expressions. These high level actions must accurately correspond to the characters' behaviors so they can act in a believable way and create an effective affective loop.

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