The Role of Abduction in Automatic Storytelling

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Abstract

Some researches state that discovering what to say is part of the writing process. We are interested in studying this aspect of writing within the scope of computer models. MEXICA is a computer model for plot generation which, inspired by the idea of the discovering aspect of writing, avoids the use of predefined story-structures and explicit characters' goal. This work claims that abduction is an important part of the process of discovering what to say and therefore computers models of abduction for automatic plot generation are an important topic to be studied. This paper describes some basic concepts about abduction and how they are implemented within the MEXICA program.

Introduction

MEXICA (Pérez y Pérez and Sharples, 2001) is a computer model of plot generation based on the engagement-reflection account of creative writing (Sharples 1999). One of the main goals of the MEXICA project is to create a system capable of producing interesting, novel and coherent plots that emerge as a result of a cycle between engagement and reflection operation modes rather than employing predefined story structures or explicit character's goals. We believe that, at least in part, writing is a discovering activity and we are interested in studying it within the scope of computer models. Different researches and authors supports the discovering view. For example, Torrance, Thomas and Robinson state that "The models of text production that currently dominate writing research (or, at least, currently are most cited in writing research articles) describe writing as the conscious and analytical application of specific cognitive strategies in pursuit of rhetorical goals" (Torrance, Thomas and Robinson 1996, p.189). However, Torrance and his colleagues disagree with this position and believe that discovering what to say is part of the writing process. Other authors have expressed similar ideas. For example, the philosopher Monroe C. Beardsley points out that "In other words, as the poet moves from stage to stage, it is not that he is looking to see whether he is saying what he already meant, but that he is looking to see whether he wants to mean what he is saying." (Beardsley 1965, cit. in Rothenberg and Hausman 1976, p.307). Carlos Fuentes affirms that "The novel is a verbal search of what is waiting for to be written" (Fuentes 1993, p.28). In an interview, Aldous Huxley expresses similar ideas:

> Interviewer: Do you block out chapters or plan the over-all structure when you start out on a novel?
> Huxley: No, I work away a chapter at a time, finding my way as I go. I know very dimly when I start what's going to happen. I just have a very general idea, and then the thing develops as I write... But I'm never entirely certain what's going to happen in the next

> chapter until I've worked it out. Things come to me in driblets, and when the driblets come I have to work hard to make them into something coherent. (Huxley, cited in Plimpton 1963, p.165)

Even when this aspect of the writing process has been highlighted, most AI models fail to incorporate it. This work claims that abduction is a relevant part of the process of discovering what to say and therefore computers models of abduction for automatic plot generation are an important topic to be studied. Or following Huxley, we state that abduction is a useful tool to transform driblets into something coherent. This paper describes how the abduction process is implemented within the MEXICA program. In particular we discuss (1) how anomalies arise within a story that is being generated by the program, (2) how anomalies are recognized by the program, and (3) how anomalies are explained by the program. As far as these authors know, abduction has not being explicitly stated in most automatic storytellers.

Abduction

Abduction is a reasoning process invoked to explain a puzzling observation. Following Peirce, abduction is triggered by a *surprising phenomenon* (Aliseda 2006, p. 69). According to our interpretation of Peirce's surprise, there are two kinds of them. A phenomenon may be a surprising because it is completely novel to us, but makes no conflicts with our known information. But a fact may also be surprising because it clashes with our known body of knowledge, in which case it is considered am anomaly. In both cases, a puzzling or surprising fact is one in need of an explanation. An abductive explanation is always an explanation with respect to some body of beliefs or theory, represented by the symbol Θ. The surprising observation is represented by the symbol φ. The two kind of abductions are formalized in classical logic as follows:

Abductive novelty: Θ ≠> φ, Θ ≠> ¬φ. In this case, φ is novel: it cannot be explained (Θ ≠> φ), but it is consistent with the theory (Θ ≠> ¬φ). In order to produce the abductive explanation the theory must be expanded by adding new formulas.
Abductive anomaly: Θ ≠> φ, Θ => ¬φ. In this case, φ is anomalous: the theory explains rather its negation (Θ => ¬φ). In order to produce the abductive explanation the theory must be revised, i.e. first contracted by deleting existing formulas and then expanded by adding new formulas.

During abduction changes occur only in the theory, since the situation or world to be modelled is supposed to be static; that is, only new information is coming in. Although in her book Aliseda is concerned with scientific discovery and explanation, it is possible to employ her ideas as starting point to develop a computer model of abduction in the automatic story-telling domain. What does an automatic storyteller require to employ abduction during plot generation? We have identify three aspects to this end:

1. The ability to build a puzzling or surprising situation in the story-world during plot generation that requires an explanation that can be produced through an abductive process.
2. The ability to recognise a puzzling or surprising situation that triggers an abductive process.
3. A set of heuristics that allow performing an abductive process.

The following sections analyses each of these aspects and describes how the engagement-reflection model of storytelling employed to build MEXICA provides an adequate framework for abduction in automatic storytelling.

MEXICA

MEXICA (Pérez y Pérez and Sharples 2001, 2004; Pérez y Pérez 2006) is a program that generates frameworks for short stories about the Mexicas (the old inhabitants of what today is México City). From now on, the program's outputs are referred to as stories or short-stories. Figure 1 shows a story generated by the system.

> Jaguar knight was an inhabitant of the great Tenochtitlan. Princess was an inhabitant of the great Tenochtitlan. Eagle knight was an inhabitant of the great Tenochtitlan. Jaguar knight felt a special affection for eagle knight. Eagle knight bumped into jaguar knight while two drunk hunters were fighting. Taking advantage of the confusion, eagle knight attempted to steal jaguar knight's goat-skin. Jaguar knight realised of this situation and got furious. Jaguar knight had ambivalent thoughts towards eagle knight. On the one hand, jaguar knight had strong feelings for eagle knight but on the other hand, jaguar knight abominated what eagle knight did. Jaguar knight tried to scare eagle knight by pretending that jaguar knight wanted to kill eagle knight with a lance. But instead, jaguar knight stumbled and wounded himself. Princess tried to cure jaguar knight, but princess did not know how to use the curative plants. The injuries that jaguar knight received were very serious. So, while praying to Huitzilopochtli jaguar knight died. Eagle knight got depress and committed suicide.

Figure 1. A story produced by MEXICA

During engagement MEXICA generates material driven by content and rhetorical constraints avoiding the use of

explicit character's goals or story-structure information. This characteristic contrasts with previous systems which employ explicit goals or story-structure information to generate their outputs (e.g. Turner 1993, Gervás et al. 2005). During reflection MEXICA breaks impasses, modifies the story in progress to satisfy coherence requirements, and evaluates the novelty and interestingness of the story in progress. As a result of this evaluation MEXICA may modify the constraints that drive the production of material during engagement. Thus, the stories produced by MEXICA are the result of the interaction between engagement and reflection. MEXICA is based on:

Operators or story-actions (used indistinctively throughout this paper). Operators are defined by the user of the system and have associated a set of preconditions and a set of consequences or post conditions that modifies the story-world. A story is defined as a sequence of story-actions.

Emotional links between characters. In MEXICA characters can establish emotional links between them; examples of emotional links are *character A is in love with character B*, *character A hates character B*, and so on. The system includes two predefined types of emotional links which are implemented in discrete terms with a value in the range of -3 to +3: type 1 represents a continuum between brotherly love and hate and it is represented as a solid arrow joining two characters; type 2 represents a continuum between amorous love and feeling hatred towards and it is represented as a dashed arrow joining two characters (see figure 2).

Dramatic tension. All short-stories require tension. In MEXICA the tension is triggered when the health of a character is at risk (represented by the mnemonic Hr), when two characters are in love with a third character (love competition, represented by the mnemonic Lc), when a character establishes opposite emotional links towards another character (clashing emotions, represented by the mnemonic Ce), etc. In this paper, tensions between personae are represented as sharp arrows joining two characters (see figure 2).

All operators' preconditions and consequences are formed by emotional links and tensions between characters. For example, the operator *princess hurt jaguar knight* includes as a precondition the fact that the princess hates the knight (en emotional link), and as a consequence or post condition the fact that the knight hates the princess (an emotional link) and that his life is at risk (a tension due to life at risk).

A hurt B

Preconditions

A hates B (emotional link of type 1 intensity -3)

Post conditions

B hates A (emotional link of type 1 intensity -3)

A puts the health of B at risk (Tension due to health at risk, Hr)

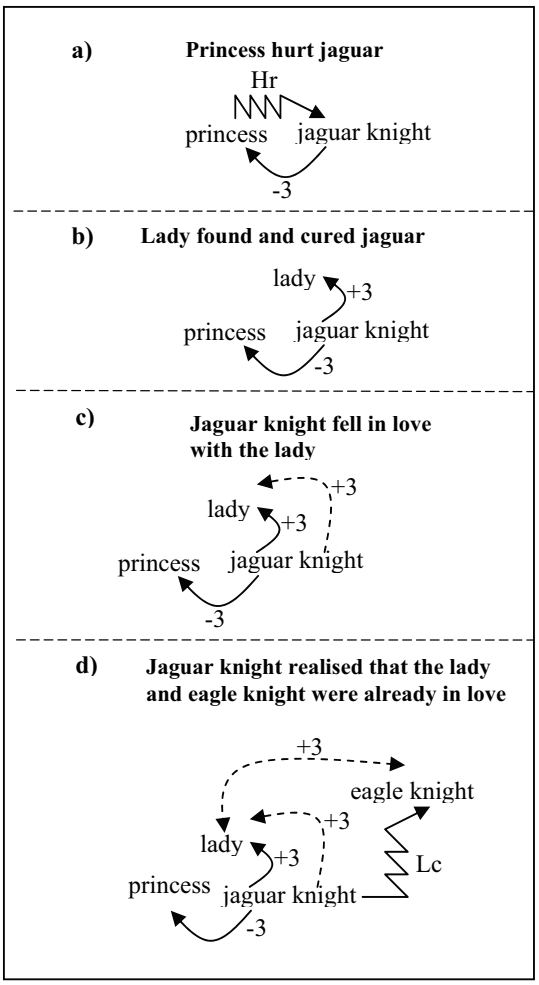

Figure 2. Examples of clusters of emotional links and tensions that progress over story-time.

When this operator is performed its post conditions are recorded into a structure known as the story-world context (see Fig. 2-a). For the sake of the explanation, let us assume that MEXICA progress this story with the operator *lady found and cured jaguar knight.* As a consequence, the tension due to health at risk is deactivated (the knight is not wounded any more) and the knight establishes a strong gratitude towards the lady (an emotional link of type 1 intensity +3). Figure 2-b shows the story-world context at this moment. If as a result of saving his life *jaguar knight fell in love with the lady*, the story-world context registers an emotional link of type 2 intensity +3 from the knight towards the lady (see figure 2-c). Finally, if jaguar knight realises that the lady and eagle knight are already in love, the system triggers an emotional link of type 2 intensity +3

between the lady and eagle knight, and a tension due to love competition between both knights (see figure 2-d). MEXICA can represent this story as evolving clusters of emotional links and tensions between characters as in figure 2, or as a sequence of operators as follows:

1. Princess hurt jaguar knight
2. Lady found and cured jaguar knight.
3. Jaguar knight fell in love with the lady.
4. But, jaguar knight realised that the lady and the handsome eagle knight were already in love

…

Notice that the cluster representation includes information about the core events of the whole story in progress. For example, the cluster in figure 2-d clearly shows that jaguar knight hates the princess, that he is very grateful with the lady, and that also he is in love with the lady; that the lady and eagle knight are in love and therefore, jaguar knight feels a tension due to love competition towards eagle knight. So, the story-world context represents the state of affairs of the story-world in the narrative produced so far. This characteristic is important because, in order to produce an adequate explanation of any given situation, it is necessary to have as much information as possible of the composition in progress.

MEXICA works as follows. First, it creates all its knowledge structures from the group of story-actions and a set of histories, known as the previous stories, provided by the user; in this way, the user can control all the knowledge in the system. MEXICA processes the previous stories action by action. Each time an action is performed the system updates the story-world context, copies the story-world context into a new structure known as atom, links the atom with the next action in the story, and finally substitutes all characters in the atom and in the associated next action for variables. Thus, MEXICA ties clusters of emotional links and tensions between characters (represented by the atoms) and possible actions to perform. These knowledge structures are employed during plot generation. For example, let us imagine that figure 2 represents a story provided by the user; MEXICA executes the first action *Princess hurt Jaguar Knight* generating the story-world context in figure 2-a. MEXICA employs such a story-context to create a new atom in memory, which is linked to the next action in the previous story (see figure 3-a). In this way, MEXICA creates a knowledge structure that indicates that when character A hurts character B and B hates A, a possible action to continue the story in progress is that a third character C cures B. Now, MEXICA performs the second action in the story *Lady found and cured jaguar knight*, updates the story-world context, creates a new atom and associates it to the next action (see figure 3-b). The process is repeated for all the actions in the previous stories (see figure 3). The number of atoms depends on the number of previous stories and their length.

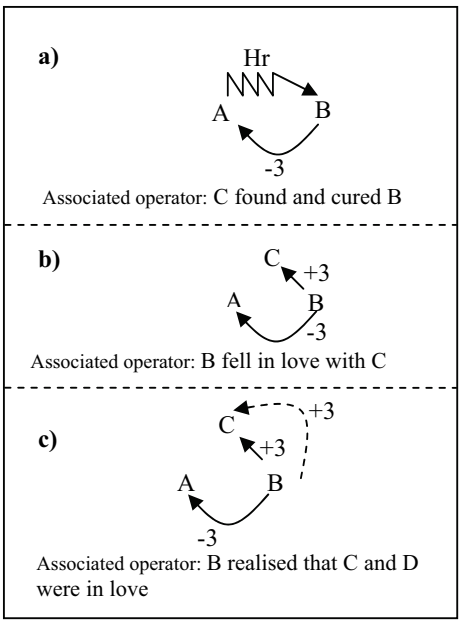

Figure 3. Examples of Atoms.

If the user provides enough previous stories, one atom might have associated several possible actions to perform, i.e. different options to continue the story in progress.

Once the knowledge structures are loaded in memory the system is ready to develop new stories. Plots are the result of engagement-reflection cycles. During engagement the system employs the story-world context as cue to probe memory; the purpose is to match atoms in memory which are equal or similar to the current story-world context and retrieve its associated operators. Then, the system chooses one operator to progress the story, updates the story-world context and looks for a new action. This cycle continues until an impasse is declared or a predefined number of actions are generated. At this point operators' preconditions are ignored and therefore situations that require explanation might be produced. During reflection MEXICA evaluates the coherence, interestingness and novelty of the material generated so far. This evaluation modifies the constraints that drive the retrieval of information during engagement. Coherence is evaluated by checking that all operators' preconditions in the story in progress are satisfied; if required, the system inserts new operators to satisfy preconditions. When the story is finished, MEXICA substitutes all operators with predefined texts to produced the final output. Figure 4 shows the pseudocode of the main functions in MEXICA.

Abduction in storytelling

The first step in order to implement an abductive process within an automatic storyteller is to establish Θ and φ. The set of beliefs or theory Θ is represented by the knowledge structures of the system. In the case of MEXICA it includes all operators, their preconditions and post conditions, and the set of previous stories provided by the user. The goal of a computerised storyteller is to develop plots; therefore, it is out of its scope to perform observations of the world. Rather, the attention must be concentrated in the material produced by the system.

```
GenerateStory():
 story-in-progress := <empty story-in-progress>
  swc := <empty story-world context>
  a := GetInitialActionFromUser;
  add a to end of story-in-progress;
  swc := update story-world context with the post conditions of a;
  while  (not end of story) do
     engagement (story-in-progress);
     reflection (story-in-progress);
   end while
  return story-in-progress

engagement (story-in-progress)
   repeat
      a := RetrieveActionFromAtoms (swc);
      add a to end of story-in-progress;
      swc:= update story-world context with the post conditions of a;
   until (an impasse is declared or N actions are generated);
return story-in-progress

reflection (story-in-progress)
   EvaluateNovelty (story-in-progress);
   EvaluateInterestingness (story-in-progress);
   EvaluateCoherence (story-in-progress);
return story-in-progress;

EvaluateCoherence (story-in-progress)
  currentA := FirstAction (story-in-progress);
  while (unchecked actions in story-in-progress)
       if UnsatisfiedPreconditions (currentA) then
          print 'puzzling situation'
          NewAction := GetActionToSatisfy( Precondition (currentA) )
          insert NewAction before currentA in story-in-progress;
          currentA := NewAction;
       else
          currentA := GetNextAction (story-in-progress);
  end while
return story-in-progress
```

Figure 4. MEXICA's pseudocode.

During plot generation an automatic storyteller introduces characters and setting and advances one or more key characters through activities within the setting to produce a plot. Each activity performed by a character produces a new story-world context —i.e. produces a new representation of the state of affairs of the story-world— which constrains the options available to the system for progressing the narrative. For example, if the current story-world context indicates that princess and jaguar knight are in love, it does make sense that they get married (the preconditions to get married are that both characters love each other). On the other hand, if we employ the same context, it does not make sense that they kill each other (the precondition to kill a character is to hate her); so, if MEXICA generates a scene where two lovers kill each other then the system must provide an explanation of why this situation occurs (if they are in love why are they killing each other?). Θ provides the common sense and the rhetorical knowledge necessary to decide if the pair *current story-world context/next action in the story* makes sense (i.e. if actions' preconditions are satisfied by the story-world context) or if it requires a justification. *Thus, a puzzling or surprising situation that requires an explanation arises when the current story-world context does not satisfy all preconditions needed to perform the next action in the story, given* Θ. Viewed this way, one can conclude that φ is constructed by the current story-world context and the next action in the tale. The following lines analyse three main aspects that an automatic storyteller requires in order to perform an abductive process.

1. The ability to build a puzzling or surprising situation. In contrast with the abductive process in the domain of scientific discovery described in (Aliseda 2006), an automatic storyteller must be able to build, and if required modify, φ. In this way, the abductive process within a computer model of plot generation consists in modifying the story in progress (and therefore modifying the story-world context) in order to explain a puzzling or surprising φ. This does not exclude the possibility of modifying Θ. Now, how is a storyteller able to build a puzzling, surprising context φ? That is, how can it build a context that does not satisfies the requirements of the next action performed in the story in progress? The engagement-reflection computer model provides an answer. Engagement begins with an initial action that produces a story-world context that cues the retrieval of a new action. This action results in a new story-world context, which cues the retrieval of another action, and so on. Since there is no overall plan to the plot produced by the engaged state and the retrieval-heuristics are only loosely constraining, then the process may leave unexplained events that need to be solved. This resolution is carried out in the Reflective Mode. In this way, MEXICA might produce a sequence of actions like the following one:

> The farmer was an inhabitant of the great Tenochtitlan City.
> Jaguar knight attacked the farmer.
> The farmer ran away to save his life
> …

In this case, it is necessary to explain why jaguar knight attacked the farmer (see a possible explanation some lines below). We claim that the capability of creating surprising

contexts provides the system with a great flexibility and therefore it is an important characteristic of storytellers.

2. The ability to recognise a surprising situation. Surprising contexts arise when the system detects unsatisfied preconditions. In MEXICA there are two kinds of preconditions that require to be fulfilled:

a) Operators' preconditions. All operators or story actions are defined by the user. Each operator includes a name, a set of preconditions and a set of post conditions. During reflection MEXICA verifies that all actions' preconditions in the story in progress are satisfied. If necessary, the system inserts new actions to satisfy them. Notice that any action inserted by the system might also have unfulfilled preconditions that require to be meet. So, during this process MEXICA can insert a whole new episode. In the hypothetical example above, MEXICA inserts the following actions to explain why the knight attacked the farmer:

> The farmer was an inhabitant of the great Tenochtitlan City.
> The farmer saw a young girl in the market and try to mug her.
> Jaguar knight observed the whole scene and hated the farmer.
> So, Jaguar knight attacked farmer.
> The farmer ran away to saved his life
> …

Figure 1 is an example of a story generated exclusively as a result of abductive processes that satisfies operators' preconditions. This is a raw version of the story:

*** NEW STORY:
T=1 Jaguar knight was an inhabitant of Tenochtitlan.
T= 2 Princes was an inhabitant of Tenochtitlan.
T=4 Eagle knight was an inhabitant of Tenochtitlan.
T=6 Jaguar knight was fond of eagle knight
T=5 Eagle knight attempted to steal jaguar knight
T=3 Jaguar knight try to scare eagle knight but instead hurt himself
T = 0 Princess did not know how to cure jaguar knight
T=7 Jaguar knight died because by his injuries.
T=8 Eagle knight committed suicide

The number on the left indicates the moment when MEXICA introduces the action in the story. For reasons of clarity the text of each operator has been modified in this example and therefore it is not the same as the one in figure 1. It is necessary to mention that MEXICA requires to create the structure of all characters participating in a tale. For that reason, all characters must be introduce at the beginning of the story with the action *was an inhabitant of*. MEXICA creates this story as follows. The first action given by the user is *Princess tried to cure jaguar knight but she did not know how to cure jaguar knight*. The system starts in engagement but it cannot retrieve any action from memory and declares an impasse. The system switches to reflection and detects that it is necessary to introduce the characters involved in the action and then explain why the knight requires to be cured, i.e. to satisfy the preconditions of the action where the princes tries to cure the knight. So, at t=1 jaguar knight is introduced in the story and at t=2 the princess is introduced. Now, MEXICA looks in its knowledge-base for an action that satisfies the preconditions of the action *did not know how to cure* (the precondition of this action specifies that the knight must be injured before the princess tries to cure him), and finds the following action: jaguar knight tried to scare eagle knight whit his lance but instead he wounded himself (action at t=3). Because there is a new character MEXICA introduces eagle knight in the action at t=4. Immediately the program finds out that it is necessary to satisfy the preconditions of the action where jaguar knight tried to scare eagle knight; the system searches for a possible options and finds in its knowledge base the action where eagle knight tried to steal jaguar knight's goat-skin and as consequence jaguar knight gets very angry (at t=5). In order to add some dramatic flavour to the story in progress, the action where eagle knight attempts to steal jaguar knight's goat-skin has as a precondition the fact the jaguar knight must be fond of eagle knight. So, the system inserts this action at t=6. Finally, the system tries to break the impasse inserting actions at t=7 and t=8; however, the impasse cannot be broken and the story ends.

Although most stories created by MEXICA are the result of the interaction between engagement and reflection, this example illustrates how the system is capable of developing tales exclusively employing abductive processes.

b) The law of smooth progress. The law of smooth progress states that if character A has only positive emotional links towards character B, character A cannot perform any action that produces negative consequences to character B (e.g. put the life of B at risk, kill B, and so on). In the same way, if character A has only negative emotional links towards character B, character A cannot perform any action that produces positive consequences to character B (e.g. character A cannot fall in love with B). If during plot generation MEXICA brakes this rule, a surprising φ that requires an explanation emerges. The following lines summarise a story generated by MEXICA that exemplifies this case. *Jaguar knight had an accident and the princess saved his life. So, he was very grateful towards her. One day the enemy kidnapped the princess in order to assassinate her. The knight looked for them and killed the enemy. The princess was very grateful towards the knight and fall in love with him. When they were kissing the princess discovered in his arm the tattoo of the*

clan that had killed her father some months ago. She was really furious and killed the knight. Then, she killed herself. During the creation of this plot a peculiar situation arises: the system generates the action where the knight rescues the princess; then, generates the action where the princess falls in love with the knight; then, out of the blue, the system generates an action where the princess kills the knight!

> *** NEW STORY:
> …
> Time = 10: In this way jaguar knight rescued the princess.
> Time = 11: As a consequence the princess fell in love with jaguar knight.
> Time = 12: Princess decided to kill jaguar knight.

(A detailed explanation of how this story is created can be found in Pérez y Pérez 2006). This odd situation breaks the law of smooth continuation and requires to be explained. The example is important because MEXICA's knowledge-based does not include any story where a character kills her lover. So, the system is capable of creating a novel situation. However, without an adequate explanation the story is useless. The current version of MEXICA justifies the scene employing a set of actions provided by the user to deal with this kind of cases: the princess realised that the knight participated in the murder of her father; now, she has a reason to kill him. We are already looking for more intelligence ways of justifying this kind of contexts, as well as looking for more sophisticated scenarios that might trigger an abductive process.

3. A set of heuristics that allow performing an abductive process. MEXICA performs the abductive process by inserting actions in the story in progress. Some of these actions satisfy the operators' preconditions defined by the user, others satisfy the preconditions established by the law of smooth progress. The current version of MEXICA satisfies the law of smooth progress by inserting actions previously specified by the user. As mentioned above, currently we are looking for more interesting ways of producing such explanations. This search also includes finding mechanisms to build accounts that satisfy rhetoric requirements. This is a major point in plot generation because a justification must suit the whole narrative. Otherwise, it can make a story worthless. For example, for the case where the princess kills her lover, we have an unexpected event (the explanation of the tattoo) that immediately leads to the tragic situation that gives the story a particular flavour. An alternative option is to prolong the justification, i.e., to build a long sequences of actions that finally explains why the princess abominates the knight. In both cases, the requirement that the princess hates the knight in order to kill him is satisfied. However, the consequences for the narrative of selecting a short or a long explanation might be quit different.

Conclusions

The MEXICA project studies the discovery aspects of the writing process employing computer models of plot generation. This paper describes the role of abduction in this enterprise. The ability to create situations which are unexpected even for the program itself, as well as the ability to justify them, are two essential characteristics of computer models of creative storytelling which help to create more interesting —and perhaps some day more beautiful— tales. Therefore, we suggest to consider abductive processes in the design of automatic storytellers. MEXICA provides an adequate framework to start exploring the possibilities of abduction within plot generation. Abduction comes into play when some precondition is not met for an action to be coherent. For example if the princess cures the knight, he must have been ill beforehand. If he has not being so, in any previous part of the plot, then abduction must invent some situation in which he is ill or unhealthy, at least. Abduction comes into play when the law of smooth process is violated, and thus the program needs to construct an explanation in order to save the plot. An example of this case is given above, when MEXICA needs to make coherent that princess is both in love with jaguar knight and decides to kill him. An ingenious explanation is then performed "… *when they were kissing, the princess discovered on his arm the tattoo of the clan that killed her father some months ago*…" . And this is how the program solves the abductive anomaly. This paper describes our first steps in the direction of using abduction as the underlying mechanism for plot-generation. More research is needed in order to produce more results.

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