Minuano: a Fuzzy-Logic-Based Drama Manager

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Abstract

This paper describes Minuano - a fuzzy-logic-based drama management architecture model for interactive storytelling. Minuano uses Freytag's dramatic analysis, Tobias' master plots and Vogler's archetypes as rule source for beat generation. This architecture maintains story consistency using Fuzzy Logic for character selection, act transition and tension level. This model was implemented in a Java prototype, using XML for story world specification, JSON for scenario description and FuzzyF as rule base and inference engine for the drama manager. A case study was created with a Brazilian southern legend called *Negrinho do Pastoreio*, adapted for Minuano story world model, and rules extracted from Tobias' Underdog plot. Three tests are performed to evaluate drama manager influence over beat generation. In first test, with significant player actions, the drama manager creates beats with tension levels oscillating similarly to Freytag's dramatic arc, taking story forward. In second test, story stagnates because the drama manager try to advance story through conflict - selecting antagonistic characters – but player select only minor actions and tension level never rises. The final test is a combination of the first two tests: drama manager advances story thanks to significant player actions, but from Crisis to end, player takes only minor actions and drama manager can't advance the story: tension level ceases to growing up and story stagnates. We expect that this architecture can integrate stories and games consistently creating emergent stories from a limited set of beats and rules.

Keywords: Fuzzy Logic, Drama Manager, Interactive Storytelling

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1. Introduction

Story is a sequence of interrelated events, often presented through conflict between a protagonist – who wants to achieve a goal – and antagonistic forces - a growing set of obstacles and characters who wants to frustrate protagonist's intentions [Laurel 1993; McKee 2006]. Stories can be used to convey ideas or values [Tobias 1993] or offer emotional experience [Schuytema 2008]. In games, Fullerton et al. [2004] says that stories are considered dramatic elements because they involve emotionally the audience into game experience, motivating them to play and finish it.

Field [1995] says that all stories have three common elements: beginning, middle and end. These elements form the basic structure that supports characters, actions and scenarios, and are unified for a dynamic process called *plot*. For Tobias [1993], a plot maintains the story elements together in a coherent way, as a skeleton. Laurel [1993] says that what keep the plot structure are the cause and effect relationships between these elements. The plot forces the characters to make choices and reveal their real personalities through their actions [Miller 2004].

Although Tobias compares plot to a skeleton metaphor, he says that it is not static, but diffusive. In other words, it is difficult to define exactly when beginning, middle and end start or finish. And for Field [1995] and McKee [2006], this order may be followed or not: a beginning can start later or an end can be presented first, for example.

Not only story structure can be imprecise. Vogler [1997] says that a character can play several roles over a story, thanks to *archetypes* – a set of common personality traits found in almost all stories around the world. An archetype is not a character rigid role, but temporary functions or facets that arise when they are necessary to obtain dramatic effects or advance story. Interesting characters tend to be ambiguous and multifaceted, as are people in real life.

Ambiguity and vagueness are concepts found in another research area called Fuzzy Logic. This is an Artificial and Computational Intelligence research area that represents and manipulates uncertainty and inaccurate information like human reasoning, using linguistic terms and rules. It was proposed by Lotfi Zadeh in the sixties as an extension of traditional logic and set theory. [Ebehart et al. 1996]. Fuzzy logic uses fuzzy sets - intervals between true and false that represent non-statistical uncertainty - and approximate reasoning - operations to perform inferences on these sets - [Ebehart et al. 1996].

The main purpose of this paper is to demonstrate stories as potential fuzzy domains. This paper proposes Fuzzy Logic for interactive multilinear story generation in a drama management architecture called Minuano. This technique it will be used to ensure consistency between story events and player actions, creating emergent stories from a limited set of rules and beats.

Minuano architecture applies dramatic concepts to build structure and story constraints. One of these concepts is called *story world* [Crawford 2005]. A story world is a space where a player can make choices and determine the course of world's events. In Minuano, a story world is an object database composed by characters, scenarios, and actions, structured in the

form of *context beats*. Context beats contains all story world elements necessary to create a beat - an action-reaction behavior change – for a particular moment in story. A story world in Minuano architecture have seven context beats, corresponding to seven-act model proposed by Laurel and based on Freytag's analysis [1898 apud Laurel 1993]. The seven context beats are: Exposition, Inciting Incident, Rising Action, Crisis, Climax, Falling Action and Dénouement, and are presented in figure 1.

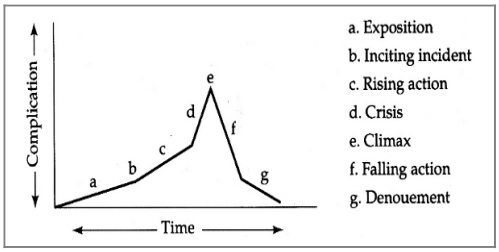

Figure 1: Freytag's Dramatic Arc

This structure was applied in Minuano architecture to offer more beat variation to drama manager during beat creation than three-act structure and preservers cause-and-effect relations, even in a multi or non-linear narrative. Also, Freytag' analysis offers a way to measure progression: complication or tension level.

In Minuano, characters can be different from story to story, but they can play the same role or execute similar actions thanks to *archetypes*. The main archetypes identified in the case study of this paper are: Protagonist (the player), Antagonist, Mentor and Neutral Character. As related previously, archetypes are vague and ambiguous, so they can be modeled as fuzzy variables. In other words, a character can be all of these archetypes, but in differents degrees of membership.

To create an interactive story it is necessary to identify and integrate story elements with player actions, creating a satisfying experience to the user. Miller [2004] presents three story structures, based on beat user navigation. The most traditional is linear structure, where the content is organized sequentially. [Miller 2004]. It is a established form in storytelling and familiar to authors. But it is limited in terms of interaction: each block provides only one choice. Player can follow only a single path in the story and can't return to other story block [Sheldon 2004].

Branching tree structures offers a wider variety of options to the user, including different endings. Some blocks have bifurcations containing multiple choices. Each of these choices leaves to another block, which may also contain other bifurcations. The tree structure is shown in figure 2.

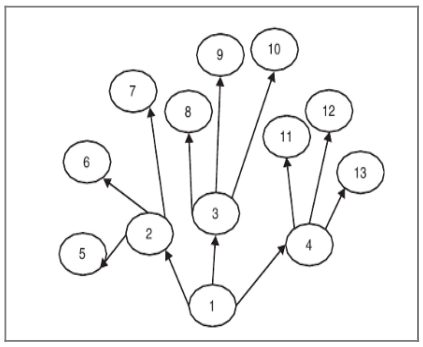

Figure 2: Branching tree structure

Modular structures acts like a map and are common in computer Role-Playing games and multi-user dungeon games. They offer full freedom of navigation, independent of the order in which the beats are arranged. But they offer very little support for dramatic arc because there is not a apparent initial organization of beats.

Branched structures offers balance between linearity - important to maintain authorial control - and variety of choices. It is a simple, intuitive and common in interactive storytelling projects. Minuano combines Freytag's seven-act linearity with branched structure's multiple player choices.

Minuano architecture model uses a drama manager to ensure consistency and reveal story. In role-playing games, there is a similar concept called Game Master, a player that controls non-playable characters, assign missions, establish rules and reveal story as players fulfill their missions [Pedroso 2007; Scaletscky 2009].

The purpose of Minuano is a flexible architectural model that allows procedural authorship and variety of stories. An author only defines story elements at the story world while a drama specialist defines rules. The Minuano drama manager uses these rules and elements to create dynamically a story, while player make choices and experiments multiple perspectives. With Minuano, we expect that the authorial process will be facilitated, due to separation between story elements and rules, description of these rules - closer to natural language in Fuzzy Logic - and a generic story world structure.

For fuzzy logic implementation, Minuano uses FuzzyF, a free solution developed in Java under GNU GPL [Bittencourt, 2002]. FuzzyF implements concepts like membership functions (triangular, Gaussian, trapezoidal, constant trapezoidal left and right trapezoidal), defuzzification methods (average of maximum or MOM, center of gravity or centroid, and center point of the area or MaxAv), grammar for fuzzy domain definition (input, intermediate and output variables and terms), definition of IF-THEN rules and an inference engine that can be used at runtime [Bittencourt 2002]. FuzzyF is simple to integrate with Java applications and was used in previows works, like Pedroso [2007] and Scaletscky [2009].

For model evaluation, a Brazilian southern legend called *Negrinho do Pastoreio* was adapted to a multilinear version and validated in a Java prototype. The rules come from Tobias' Underdog plot.

This paper is organized into seven chapters. Chapter 1 presents Minuano and main objectives of this research. Chapter 2 presents related works in interactive storytelling and fuzzy logic. Chapter 3 presents Minuano model. Chapter 4 presents prototype implementation. Chapter 5 presents a case study with an adapted folk story. Chapter 6 presents three experiments and results, and finally, Chapter 7 presents the conclusions.

2. Related Work

The most known related work about interactive storytelling is Façade, an interactive drama proposed by Mateas and Stern [2003] that uses dramatic structure concepts to control beat sequencing and evaluate story progression. Beats are built in a proprietary specific-purpose programming language called A Behavior Language (ABL) that supports pre and post conditions, weights, tension level and others. Minuano architecture uses open standards like *eXtensible Markup Language* (XML) for story world definition and FuzzyF rule notation to define rules and variables. Façade's beat sequencer selects the beat with satisfied pre conditions and closest tension level corresponding to dramatic arc. Minuano drama manager infers context beat elements like archetype, and dynamically creates beats according to tension level, player action, time and other variables.

Recent works about fuzzy logic in interactive storytelling includes Pedroso [2007] who created VDM - Virtual Dungeon Master, an agent that simulates a role-playing game dungeon master. This architecture uses XML ontologies to represent a fictional world, like Minuano's story world. But while VDM's fictional world is defined in *Sistema de Aventuras Instantâneas* or *SAI* - a RPG quest system [2002 apud Pedroso 2007] and composed of quest definitions, Minuano story world is based on Freytag' seven-act structure [1898 apud Laurel 1993] and composed of context beats. A FuzzyF knowledge base is used to manage processes like quest giving, world status and character actions. Rules are also based on SAI, while Minuano rules comes from Tobias' master plots. A story in VDM architecture is represented by the list of quests executed by the player. In Minuano, a complete story is composed of all beats generated by the drama manager.

Scaletscky proposed an architecture called C.H.R.I.A - *Criação de Histórias de RPG entre a Interação de Agentes* [2009] In this architecture, a specialized agent acts like a virtual dungeon master, perceiving a society of autonomous agents and creating quests using fuzzy rules. Like VDM architecture, stories in C.H.R.I.A. are composed by all the quests executed by the player, and these quests are structured in SAI. The agents use FuzzyF rules to infer about society status and modify features. The Game Master agent creates a new quest depending on these modifications. Minuano architecture doesn't have agents, but the drama manager acts like one, perceiving and modifying story status, creating beats and activating character's reactions.

Müller [2010] proposes a fuzzy Belief-Desire-Intention model to represent knowledge and influence character actions in a multi-agent architecture. This architecture uses the dramatic arc in story structure and tension level monitoring. A story consists of at most seven beats, defined by ontologies written in Web Ontology Language (OWL). Drama management and rules are written in Jason, a Java platform for developing multi-agent systems. The drama manager is BeatChooser, a specialist agent that selects beats and influences the beliefs of other agents. This agent receives messages in form of discourse acts, like in Façade, and it decides how the NPCs should react, based on player interaction. Player actions or *behaviors* have a significance level that represents the quantity of tension that a behavior adds or subtracts from beat. In Minuano architecture, drama manager infers next tension level input fuzzy variables.

Next chapters present Minuano architecture model and prototype implementation details, case study and experiment results.

3. Minuano Drama Management Architecture

As reported earlier, this paper proposes a drama manager that uses dramatic concepts and Fuzzy Logic to build and maintain the consistency of interactive stories, player's agency and authorial control. The architecture is called Minuano and is presented in Figure 3.

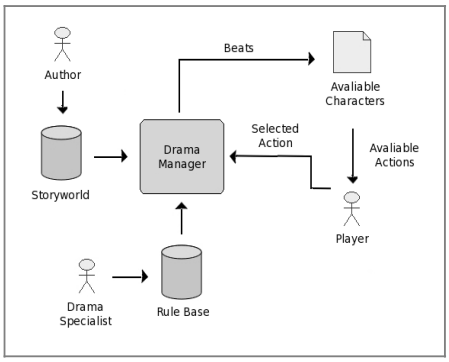

Figure 3: Minuano architecture model

The architecture consists of a drama manager, an object database or *story world*, defined by a human author, a rule base created by a drama specialist and a scenario description configuration file. The drama manager monitors story status and generate beats using story world contents and fuzzy rules. The player selects a character and his actions in current beat and the drama manager evaluates the impact of this action over story and modifies it, creating a new beat and updating indicators such as time and tension level. Figure 4 shows Minuano conceptual model and main classes.

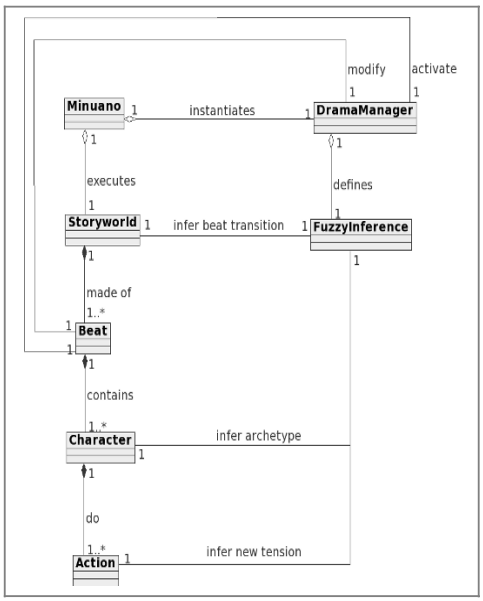

Figure 4: Minuano Class Diagram

Story world is based on modern Freytag's seven-act analysis suggested by Laurel [1993] and has seven generic beats called *context beats* representing those seven acts. Each beat consists of non-player characters classified by archetypes and a set of player's available actions and character's reactions. These actions and reactions are classified by significance value – greater value, greater significance and vice-versa. Minor actions offer other perspectives and give more interaction possibilities to the player. The author has to establish balance between the narrative flow and variety of choices, defining what action results are close to the values of the dramatic arc, and which only serve for interaction. The player is the protagonist, and must select a character and choose one of available actions.

Each context beat is associated with a list of scenario descriptions, stored in a separate configuration file. The author can set multiple descriptions for each context beat in order to vary the generated beats. The description is randomly selected during beat creation process.

The rule base is used by drama manager to infer character archetypes, act transition time and tension level. The rules are extracted from Tobias' master plots and Freytag's dramatic analysis. Who defines and establishes the rules should be a dramatic structure specialist, which may or may not be the author of story world. Currently, rule base is ready-only and provided with the architecture.

Master plots provide common events to all people. Freytag's dramatic analysis provides a framework for player progression measurement. And archetypes provide character profiles. Plot rules and archetypes give flexibility to the model, while tension measurement offers consistency.

The role of drama manager is emulate a role-playing-game master, creating new beats from story world context beats, and adapting story according player choices and fuzzy rules. Figure 5 shows Minuano Drama Manager main processes.

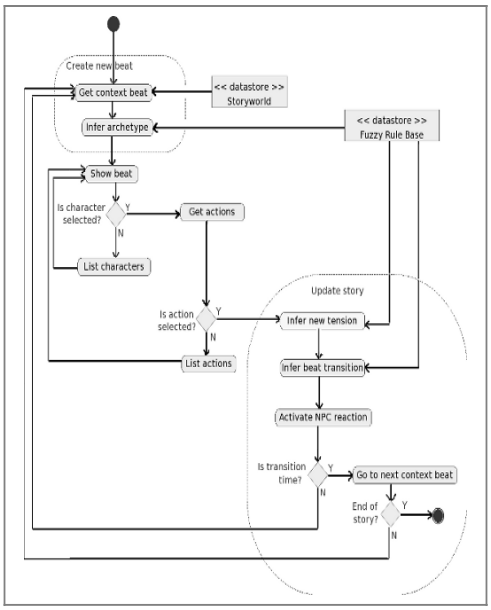

Figure 5: Minuano Drama Manager processes

The drama manager is activated immediately after story world loading. It builds the next beat inferring an archetype, selecting corresponding characters and combining them with a scenario description. This beat is presented to player, who must select one of the character and action. After player choice, the drama manager selects character reaction and updates time, tension and act transition. The drama manager activates end of story if the last context beat was presented and a act transition is inferred. Otherwise, it create and shows next beat, repeating cycle.

4. Prototype Implementation

Minuano architecture model was implemented in a Java prototype application. The main class is called *Minuano*. It activates drama manager and contains the prototype user interface. Story world loading is made by *XMLAnalizer* component. *Storyworld* class stores the beats coming from story world file. *Configurator* class extract scenario descriptions from a text file structured in JavaScript Object Notation – JSON, a simpler information exchange language than XML. [Crockford 2011].

Character class represents the characters. During story world loading, each character is stored in a pool and it is available during story play. *Action* class has three attributes: a *type* (action or reaction), a *verb* and the *significance value* depending on values defined in the fuzzy rules. *DramaManager* class is the drama manager implementation and uses FuzzyF as inference engine. And *FuzzyInference* class loads the rules from FuzzyF domain files.

In Minuano architecture, a story world is described in *eXtensible Markup Language* (XML). XML is a simple text-based format for representing structured information and is one of the most widely-used formats

for sharing structured information between systems, peoples and computers [Quin 2011]. Table 1 shows the Minuano XML story world structure.

Element	Description	Atributes
Storyworld	Root element	- Title
Beat	Context beat used by drama manager to generate new beats dinamically. Corresponding to Freytag's Acts.	- Description: keyword to scenario description in JSON configuration file - Act: {Exposition, IncitingIncident, Complication, Crisis, Climax, Resolution, Dénouement}
Character	character	- Name - Type: Only NPC (Non-Player Character) in this version - Archetype: {Antagonist, Mentor, Neutral}
Action	Player actions and character reactions	- Type: {action, reaction} - Verb: verb that represents action - Sig: significance value

Table 1: XML story world structure

Figure 6 presents a partial description of a context beat of Negrinho do Pastoreio's story world.

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<storyworld title="Negrinho do Pastoreio">
 <beat description="Cancha da carreira" act="Exposition">
  <character name="Cavalo" type="NPC" archetype="Neutral">
    <action type="action"   verb="Cavalga"   sig="10"/>
    <action type="action"   verb="Monta"     sig="5"/>
    <action type="action"   verb="Chicoteia" sig="0"/>
    <action type="reaction" verb="Corre"     sig="10"/>
    <action type="reaction" verb="Trota"     sig="5"/>
    <action type="reaction" verb="Para"      sig="0"/>
  </character>
```

Figure 6: Minuano XML story world

Scenario descriptions could compromise readability of story world file, so we decided to store them in a configuration file, structured in a simpler format than XML. This format is called *JavaScript Object Notation* or *JSON*. This is a text format for the serialization of structured data designed to be minimal, portable, textual, and a subset of JavaScript [Crockford 2011]. The prototype was adapted to support one or more descriptions of a same scenario and randomly select one of these descriptions when a beat is created. Figure 7 presents partially the configuration file, with story title and two scenarios: *Cancha da carreira* and *Corrida*.

```
{
 "title":
  {
   "Negrinho do Pastoreio" = "NAQUELE TEMPO os campos ainda eram abertos, não h
  },

 "scenarios":
  {
   "Cancha da carreira" =  [
      "Na cancha da carreira há gente como em festa de santo grande...\n",
      "Na cancha da carreira as parcerias já apostavam aperos contra rebanhos..
      "Na cancha da carreira, a gauchada não sabia se decidir, tão perfeito era
   ],
   "Corrida" =
   [
      "Empate! Empate! - grita a gauchada ao longo da cancha...\n",
      "Mau Jogo! - A gauchada estava dividida no julgamento da carreira...\n"
   ],
```

Figure 7: Minuano JSON scenario configuration file

Minuano drama manager uses three FuzzyF domain files as rule base and FuzzyF inference engine to process these rules. First domain contains rules for archetype inference and is used by the drama manager to select next character. It uses three input variables: *Time*, *Act* and *Tension*. Time refers to the number of player action executions during an act. Drama manager resets this variable to zero when advancing story to a next act. Figure 8 presents the fuzzy sets of *Time* variable.

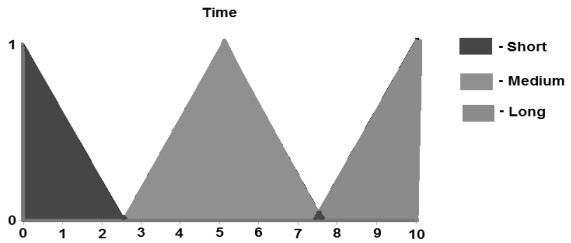

Figure 8: Time variable fuzzy sets

Drama manager needs to know, for example, if an antagonist can be selected at end of story, so it uses *Act* variable, whose fuzzy sets are presented in Figure 9.

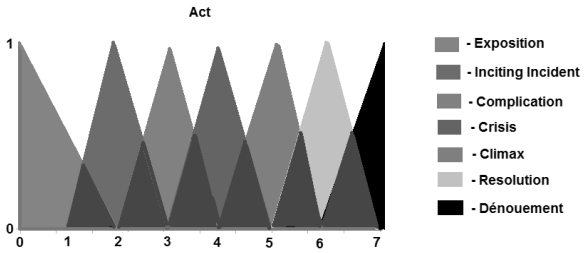

Figure 9: Act variable fuzzy sets

Figure 10 shows the fuzzy sets of *Tension* variable. If tension is very low, drama manager can select an antagonist to create conflict and advance story, for example.

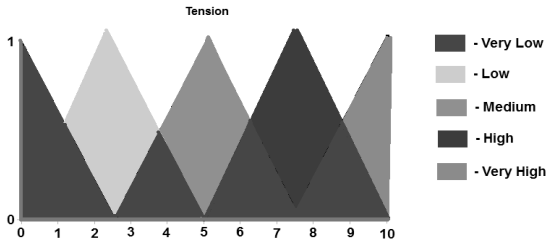

Figure 10: Tension variable fuzzy sets

Archetype is the output variable of this domain. It uses *centroid* defuzzification technique. Fuzzy sets are represented in figure 11.

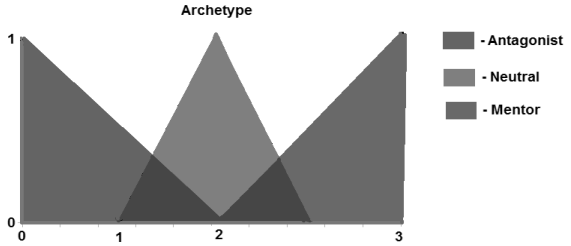

Figure 11: Archetype variable fuzzy sets

The second domain file contains rules for new tension inference. It uses three input variables:

Archetype, *Tension* and *Significance*. Output variable is *NewTension* and have the same fuzzy sets and defuzzification method of previous domain. The first input variables also have the same fuzzy sets of the previous domain. *Significance* represents the protagonist's desire to achieve the story goal and impact of player choices over tension. Figure 12 presents Significance's fuzzy sets.

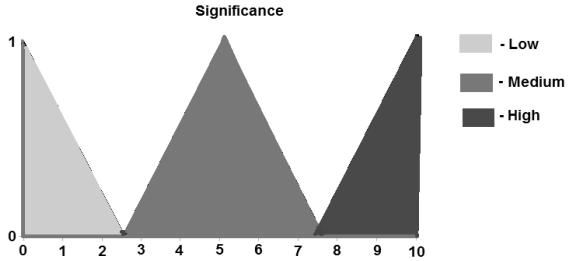

Figure 12: Significance variable fuzzy sets

The last domain file control act transition. It uses Time, Act and Tension as input variables, with same fuzzy sets of the previous domains. Output variable is *ChangeAct* and is represented in figure 13.

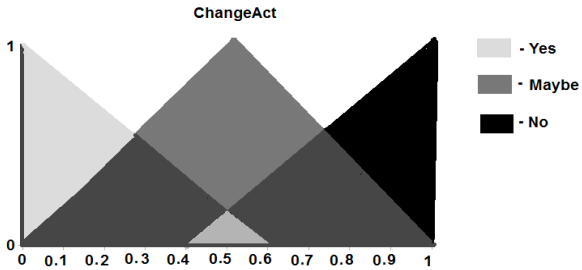

Figure 13: ChangeAct variable fuzzy sets

In this research work, only triangular functions and Mamdani model are used, because they are simpler to implement. We expect that other functions and models can be tested in future research works.

If Minuano can't infer a value in any of these domains, he uses a similarity formula given by $s = (v1, v2)^2$, where $v1$ is the current value, $v2$ is the infered value and s represents similarity value. The drama manager selects the inferred value with greatest similarity. Such cases occur if the author does not write a story sufficiently balanced, with lack or excess of beats or characters.

Minuano prototype's interface was developed in Java Swing and presents a graphical window containing a text box and two control groups. Text box presents story as a text with vertical scroll and stores introduction, beats and end message. The first control group is composed by a combo box containing the current beat's character list and a button with the label *Interact with*. The second control group is only activated after that the player choices a character for interaction. It is composed by character action's list combo box and a button with exclamation label, representing an order metaphor like "Do It!". After selecting a character, it's not possible to unselect it. The player needs to execute an action to release again the character controls. At end of story, both control groups are disabled and a "The End" message is presented.

The order of characters and actions in the combo boxes is random to previne influence over the player. But this randomness occurs only in interface, not in other parts of prototype.

Figure 14 presents Minuano prototype's interface with story text box and controls.

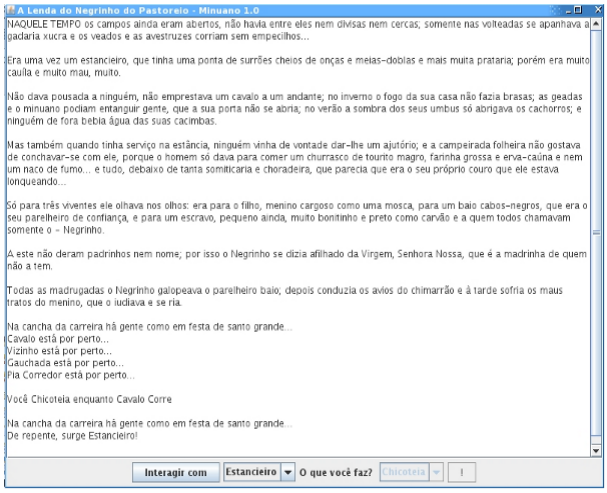

Figure 14: Minuano prototype's interface

5. Case Study

After prototype implementation and based on Propp's Russian tale works, we tested Minuano model adapting a south-American folklore legend called *Negrinho do Pastoreio* to a multilinear interactive version. This legend was chosen because its events are similar to events found in Tobias' Underdog master plot. It is well-known in South Region of Brazil, Uruguay and Argentina and has many literary versions.

Underdog is a plot where a protagonist suffers some kind of injustice or oppression but overcomes it. Tobias [1993] says that this plot is a sort of rivalry, where the only goal is to win. However, in Rivalry plot, opponents start on equal terms – equal forces, different weaknesses. In Underdog plot, one of the character gains power and goes immediately to oppress the other, that don't have forces and just resists. But at a certain time, this character gets a chance to reverse his condition and starts to gain strength. At the climax, both characters are able to confront each other.

The main archetypes in an Underdog plot are: *Protagonist*, who suffers oppression and try to reverse it, *Antagonist*, who keeps the protagonist oppressed, and *Mentor*, who helps the Protagonist. Other characters are considered *neutral* because it lacks the strength to help the protagonist or are unrelated to oppression.

Tobias uses the three-act structure in Underdog plot. At first, the protagonist is in his ordinary world when some event or crisis reverses its fortune. The antagonist acquires power and immediately overwhelms the protagonist who only resists.

In the second act some phenomenon or event reverses the condition of the protagonist and gives him chance to fight against oppression. This phenomenon usually occurs through meeting with a mentor, who offers a gift or advice. From there, the protagonist is living a double life: on one hand, oppression, another victory. He faces the obstacles, fails at first two attempts and overcomes them in third. The third act is where the protagonist confronts the antagonist on equal forces and usually wins through strength, honor and courage. The protagonist lives a new life.

Underdog examples are: movies Rocky and One Flew Over the Cuckoo's Nest, Joan of Arc' story and Grimm Brothers' version for fairy tale Cinderela, called Aschenputtel [Tobias 1993].

Negrinho do Pastoreio is a folklore tale of southern Brazil, written in 1906 by João Simões Lopes Neto in his work called *Lendas do Sul*. This legend tells the story of a black and slave boy named *Negrinho* that serves a very wicked rancher. The boy take care of horses, household chores and other ranch labors, and supports the daily humiliations of the rancher's son. He resists thanks to their faith in Our Lady. In a horse racing, the rancher's horse, ridden by *Negrinho,* stopped suddenly. The Rancher loses the bet and, furious, punish the boy with violence and order him to pastor a horse troop for 30 days, unable to return home. During this period, owls and foxes make the horses run away. The Rancher's son denounces the troop escape and *Negrinho* is punished again. But he prays and claims to Our Lady, who brings the horses back, providing magical items – for example, a candle that illuminates the ranch - and relieves his suffering. Then, the horse troop is released again, now by Rancher's son and the Rancher punishes *Negrinho* for the last time until near death, and throws his body in an anthill. After three days, the Rancher back to the anthill and see *Negrinho* standing, alive and unharmed, next to Our Lady and the horses. The Rancher trembles and falls to his knees, while *Negrinho* rides Rancher's horse, followed by the troop. The end of legend says that any person who lost anything, ask to *Negrinho* and Our Lady, lighting a candle, and says that if he can't find, no one can do it [Netto 2002].

This legend is an underdog plot because have an oppressed protagonist who win at final – *Negrinho*. It have antagonists who oppress the boy, like the Rancher. And it has Our Lady as a mentor and several neutral characters.

Tobias structured the Underdog plot into three acts. For Minuano, this plot was structured like the Freytag structure: Act I is Exposition, Act II consists of Inciting Incident, Complication and Crisis, and Act III consists of Climax, Resolution and Denouèment.

The following rules were identified for character selection domain:

I. If tension level is low or player remains long time in same moment, drama manager activates antagonist for tension rising. But only until Resolution, because tension must fall in Dénouement
II. Mentor character is activated to reduce tension level, when it is high
III. Neutral characters don't affect tension level

The following rules were identified for new tension level domain:

I. Significant actions raise tension level when the player interacts with an antagonist. Tension level remains the same when player select minor actions;
II. Significant actions fall tension when player interacts with a mentor. Tension level remains the same when player select minor actions;
III. Interaction with neutral characters doesn't affect new tension.

And finally, the following rule was identified for act transition domain:

I. Long interactions caused by minor actions make the drama manager to change the moment.

Importantly point that the rule base don't need to be changed if the author want to write other underdog stories. He needs only to write the new story in the XML story world and JSON description file, and use the same rule base for this plot. Other plots need their own rule base.

Figure 15 presents an example of FuzzyF rule domain for Underdog plot. It shows variable declaration and rule syntax of character selection domain.

```
INPUT_VAR = Tension
TERM = VeryLow    LeftTriangleFunction    0 2.5
TERM = Low        TriangularFunction    0 2.5 5
TERM = Medium     TriangularFunction    2.5 5 7.5
TERM = High       TriangularFunction    5 7.5 10
TERM = VeryHigh   RigthTriangleFunction  7.5 10
END_VAR

OUTPUT_VAR = Archetype
DEFUZZ = CenterOfGravity
TERM = Antagonist   LeftTriangleFunction   0 2
TERM = Neutral      TriangularFunction    1 2 3
TERM = Mentor       RigthTriangleFunction  2 3
END_VAR

BLOCK_RULES
RL = IF Time IS Short AND Act IS Exposition AND Tension IS VeryLow   THEN Archetype IS Neutral
RL = IF Time IS Short AND Act IS Exposition AND Tension IS Low       THEN Archetype IS Neutral
RL = IF Time IS Short AND Act IS Exposition AND Tension IS Medium    THEN Archetype IS Neutral
RL = IF Time IS Short AND Act IS Exposition AND Tension IS High      THEN Archetype IS Neutral
RL = IF Time IS Short AND Act IS Exposition AND Tension IS VeryHigh  THEN Archetype IS Neutral
```

Figure 15: FuzzyF character selection domain example

6. Experiment Results

After adapting Negrinho do Pastoreio story, we evaluated Minuano model with three experiments. In best case, player selected only significant actions. In worst case, player selected only minor actions. In average case, player started with significant actions and, from Crisis to end, used only minor actions. We compared tension generated during play with Freytag's dramatic arc, identifying how the drama manager selects archetypes and changes acts.

In first experiment, Figure 16 presents tension influence over archetype inference. The dotted line is the tension arc and the bars represent the archetype inferred values, corresponding to the fuzzy sets

presented in Chapter 4. At beat 3, drama manager try to raise tension, activating the antagonist. Tension stabilized until beat 8, because the player interacts with neutral characters, and because the underdog rules don't allow a mentor in Exposition. At beat 10, in Inciting Incident moment, another antagonist is activated to raise tension again. But the drama manager identified that the tension was high and activated the mentor. The Inciting Incident ended at beat 16, when Complication begins.

From beat 19 to the beginning of Crisis at beat 27, tension level stabilizes due player interactions with neutral characters. At beat 30, tension grew up to the maximum value and stabilized until beat 43, when the drama manager identified the end of Climax and beginning of Resolution act. Then, drama manager activates mentors frequently to reduce tension and antagonists for a final conflict. From Dénouement, at beat 50, the drama manager inferred only mentors and neutral characters to reduce tension, and story ended at beat 57.

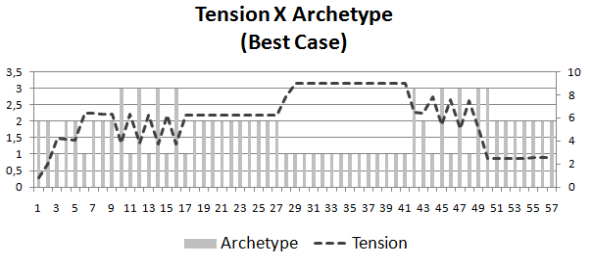

Figure 16: Tension influence over Archetype– best case

Figure 17 shows the tension influence over Act Transition moments. In this experiment, tension did not influence Act Transition, that occurred at beats 8, 16, 24, 32, 40, 48 and 57 (the end).

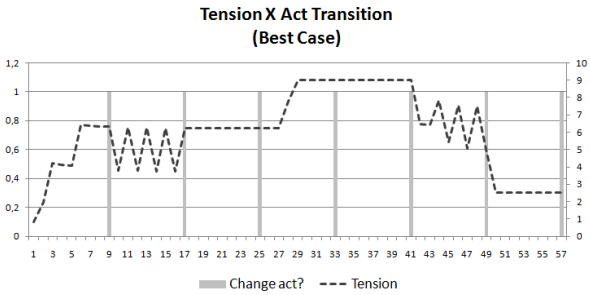

Figure 17: Tension influence over Act Transition – best case

Figure 18 shows Minuano prototype interface with last two beats of generated story. The first line of each beat presents the scenario description. Below are the characters of inferred archetype. When player executes some action, Minuano presents player selected action and character reaction in a phrase. In this experiment, player interacted two times with a neutral character called *Tropeiro*, because he was the only available character at Dénouement with inferred archetype, and executed the action *LightCandle*. When story ended, all interface controls, except story scrollbar, were disabled.

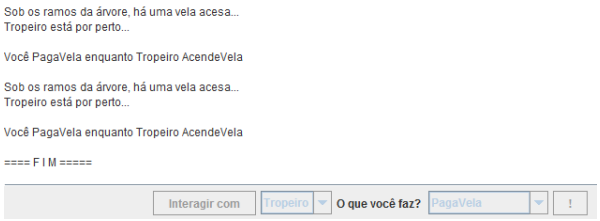

Figure 18: Negrinho do Pastoreio's ending with significant actions

In second experiment, the player selected only minor actions and the story stagnated. Figure 19 shows that, from beat 3 to 49 drama manager tried to create conflict inferring antagonists, because tension was low. As the player did not select meaningful actions, the drama manager had to advance story with a low tension value. Neutral characters was selected in the very beginning of story - when tension was low - and in the end, because Underdog plot rules don't present an antagonist at Dénouement and tension was very low to select a mentor.

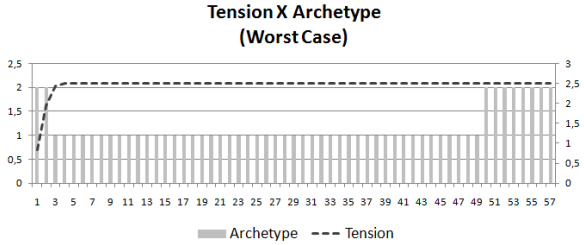

Figure 19: Tension influence over Archetype – worst case

Figure 20 shows that drama manager changed acts at beats 8, 16, 24, 32, 40 e 48, even with low tension.

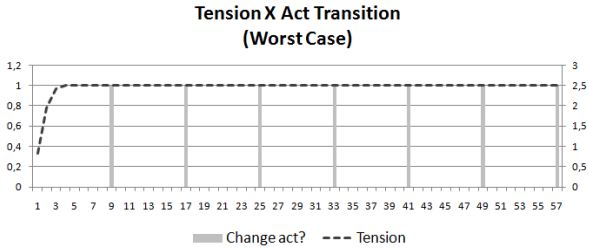

Figure 20: Tension influence over Act Transition – worst case

Figure 21 shows the two last beats created by the drama manager. The character *Tropeiro* now executes a different action from first experiment - to observe.

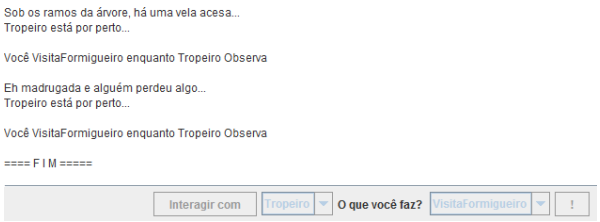

Figure 21: Negrinho do Pastoreio's ending with minor actions

The last experiment is almost a combination of the two first experiments. Significant actions was selected

from beginning to beat 26. From beat 27 – Crisis act - to the end of story, player selected only minor actions. As expected, the story progressed until Crisis and then stagnated.

Figure 22 show that drama manager activated only antagonists from beat 27 to beat 51, because tension level was not sufficiently high to select other archetypes. But it was high for Dénouement - from beat 52 to the end - so drama manager inferred mentors to reduce tension. However, player action's significance was low and drama manager couldn't reduce tension until the end of story.

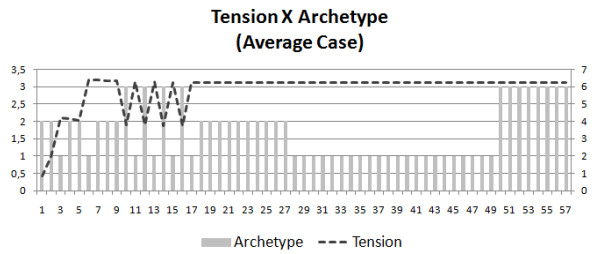

Figure 22: Tension influence over Archetype – average case

Figure 23 show that drama manager changed acts at same beats of previous experiments.

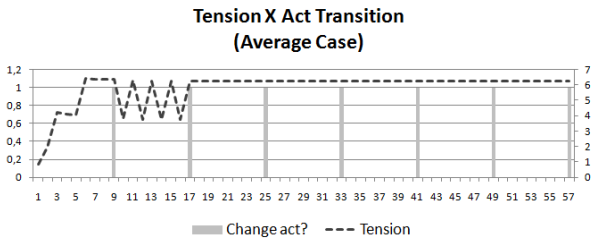

Figure 23: Tension influence over Act Transition inference – average case

Figure 24 presents the mentor character Our Lady at last two beats of the story version created in this case.

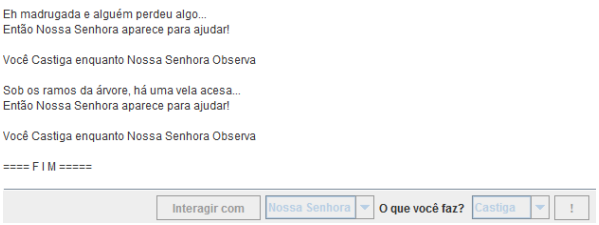

Figure 24: Negrinho do Pastoreio's ending with significant and minor actions

The experiments presented that, in best case, a Freytag-like dramatic arc emerged from drama manager fuzzy inferences about archetype, tension and player action significance. In other cases, story stagnated in some moment. These experiments also demonstrated that Archetype variable is strongly affected by tension level, while Act Transition is not, because the rules presented in Chapter 5.

Three different stories were created using fuzzy logic and dramatic principles. In first story ending, Tropeiro offers a candle to Negrinho (the player), and this offers that candle to Our Lady. In second story ending, Negrinho goes to the anthill, while Tropeiro only observes. And in last story ending, Our Lady try to help Negrinho, but he refuses.

7. Conclusion

This paper presented a fuzzy-logic-based drama management architecture model for interactive storytelling called Minuano. The main premise of this research work is that it is possible create interactive narratives using fuzzy logic. To investigate this hypothesis, we created a drama manager model that could generate several stories from a limited set of rules and contents. We suggested a story template structure and rules, using interactive storytelling concepts found in references presented in this paper. Then, we implemented Minuano model in a prototype and a folklore story was adapted for evaluation.

The results confirmed the initial hypothesis. It is possible to create an emerging story from a set of fuzzy rules. The narrative varied consistently according to player actions. When significant actions are executed, the drama manager acts to create conflict and progress story. Tension level values varied similarly to Freytag's dramatic arc. In opposition, when the player refused to take significant actions, story stagnated.

Knowledge specification through rules is simple in Fuzzy Logic. However the definition of rule base, the model that describes the implicit knowledge in the creation of stories is quite complex, requiring specialized knowledge. The complexity is due more to the subjective nature of the problem than the technique itself.

The main contribution of this work is to propose a generic architecture that supports narrative models - as the underdog plot - and can be applied to several stories. This adds a great reuse of the knowledge base. The greatest difficulty lies in validating the model due to the subjectivity of the domain. Questions like - "What is a good story?", "What an ideal time to change an act?", "What is a high tension level?" are examples of how difficult it is to extract metrics to analyze this domain.

The common aspect between Minuano research and related works is the search for a generic story structure model that uses open standards and artificial intelligent systems for Interactive Storytelling.

Refinement of Minuano's rule base is a suggestion for future work. It is important to verify if input and output variables are representing the knowledge model and membership functions adopted in the fuzzy sets are suitable. Certainly it requires definitions of a more robust model validation.

It is also suggested that future versions of the model includes the creation of sub-plots and the use of other characters in the narrative as a playable character. Thus, player can try out other perspectives about the same story.

Finally, it is interesting to think about ways to integrate Minuano to other technologies, such as game

engines, increasing user immersion and adding multimedia options - graphics, sounds and animations.

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