MEXICA-Impro: a Computational Model for Narrative Improvisation

Rafael Pérez y Pérez, Santiago Negrete, Eduardo Peñalosa, Rafael Ávila, Vicente Castellanos, Christian Lemaitre

División de Ciencias de la Comunicación y Diseño
Universidad Autónoma Metropolitana - Unidad Cuajimalpa
México
{ rperez, snegrete, eduardop, ravila, vcastellanos,
clemaitre}@correo.cua.uam.mx

Abstract.
This paper describes a system that dynamically generate narratives through improvisation. MEXICA-impro is based on a cognitive account of the creative process called *engagement-reflection*. Its architecture defines a framework where two agents participate in a simulated improvisation session to generate the plot of a story in which each one draws knowledge from two different databases representing cultural backgrounds. A worked example is explained in detail to show how this approach produces novel stories that could not be generated before.

1   Introduction

Storytelling has a relatively long history in computational creativity research. Some well known models of storytelling include: TALESPIN (Meehan 1981), MINSTREL (Turner 1994), FABULIST (Riedl 2004). Improvisation is a means by which creativity can be exercised in storytelling. Two or more participants (agents) intervene in a session where each contributes pieces of stories that are combined with those of the others as time passes, until a whole story is constructed. The intervention of each individual agent in the process, with a certain degree of unexpectedness and a personal point of view, makes the whole process interesting and different from a creative process where only one agent participates.

Once several agents participate in a process where their beliefs (rules) are tested by exposure to those of other agents, we enter the realm of social interaction. Here, the notion of creativity acquires a new meaning, namely the creative process is seen as a social process where a cultural clash might result in something new for both originators. The interaction among computational agents represents a metaphor of the processes of communication in a socio-cultural context, given that, when under controlled observation and with clear parameters, we can shed light on the understanding that characterizes the starting up of human systems of meaning.

Social cognition processes have an especially important role in a model such as MEXICA-Impro. We identify some important components of this kind influencing the collaborative improvisation of narratives. We consider three important elements of social cognition in our model: 1) communication resources, including the understanding of symbolic systems such as languages and key meanings facilitating mutual comprehension (Clark & Brennan, 1991); 2) availability of pieces of knowledge shared by agents, such as concepts, principles, procedures or strategies, conforming a convergent (shared) knowledge base in the agents' minds (Jeong & Chi, 2007), and 3) multiple perspectives, including an amount of divergent knowledge pieces (not shared by agents), leading to flexible ways of analyzing the same phenomena.

In a creative collaborative goal such as constructing narratives, the agents: first, interact and generate a common ground, or mutual understanding space, while directing their efforts to achieve a common goal; second, in order to construct new stories, they rely on their common knowledge base, which should contain the minimal knowledge schemas or mental models to allow discussing the topics under analysis; and finally, according to cognitive flexibility theory (Scott, 1962), they make associations from multiple representations of the same information, such as their own representations compared to other agent's ideas of the same phenomenon, a process allowing the mental scaffolding necessary to consider novel applications of knowledge, or the emergence of new ideas.

There needs to be a balance between what both agents know (common knowledge) and what they know individually (unique knowledge) to construct creative stories: when both agents' knowledge bases share an important amount of knowledge pieces, the plots generated by both agents are very similar; otherwise, when agents have an important amount of divergent pieces of knowledge, plots generated by both agents would be completely different (Jeong & Chi, 2007).

2   MEXICA-impro: a computer model of narrative improvisation

Mexica (Pérez y Pérez & Sharples 2001, 2004) is a computational model of plot generation on top of which our system is built. It was inspired by the engagement-re ection (E-R) cognitive account of writing as creative design (Sharples 1999). So, MEXICA-impro is a computer model of narrative improvisation. It is formed by two mexica agents working together to develop as a team a story plot. Agent 1 is also called the leader, and agent 2 is also called the follower. The leader starts the improvisation and decides when it finishes (although in future versions both should be able to decide when to finish). The leader generates material through one complete E-R cycle and then cues the follower to continue the narrative. Then the follower takes the material generated so far and progress the story through one complete E-R cycle and then cues the leader to continue the narrative, and so on.

Each agent in MEXICA-impro is formed by two main modules: the construction of knowledge structures (the K-S module) and the generation of plots through engagement-reflection cycles (the E-R module). The K-S module takes as input two text les de ned by the user: a dictionary of valid story-actions and a set of

stories known as Previous Stories. The dictionary of story-actions includes the names of all actions that can be performed by a character within a narrative along with a list of preconditions and post conditions for each. The Previous Stories are sequences of story actions that represent well-formed narratives. With this information the system builds its knowledge base with structures known as atoms. Atoms represent (in terms of emotional links and tensions between characters) potential situations that can happen in the story-world and have associated a set of possible actions to be performed when that situation occurs. For example, an atom might represent the situation where a knight is in love with the princess, and it might have associated the action "the knight buys flowers to the princess" as a possible action to be performed by the lover. In MEXICA-impro each agent has different story-actions and/or different set of previous stories. Thus, the same situation might lead each agent to perform different actions.

The E-R module takes two main inputs: the knowledge-base and an initial story-action provided by the user of the system (e. g., the princess heals jaguar knight) that sets in motion the E-R cycle. During engagement, an agent generates sequences of actions guided by rhetorical and content constraints; during reflection, the agent breaks impasses, evaluates, and, if necessary, modifies the material generated so far. It works as follows: the system starts in engagement; the post conditions of the initial action are triggered, generating a story-world context; the story-world context is employed as cue to probe memory and match an atom; then, the system retrieves the actions associated to the atom, selects one at random and updates the story-world context; After that, the engagement cycle starts again; the system attempts to match an atom that is equal to the current story-world context; if it fails the agent looks for an atom that is similar to the current story-world context; after generating three actions (this number can be modified by the user), the system switches to reflection. During reflection the system verifies that all actions' preconditions are satisfied; if it is necessary, the agent inserts actions to satisfy them; then, it evaluates the material generated so far. At this point, a E-R cycle ends.

3   Generating narratives via improvisation

The MEXICA-impro project has an important goal: the stories generated by the collaborative agents cannot be developed by any one of them alone. If, furthermore, the story produced by the collaborative agents cannot be found within their knowledge bases, we refer to it as a *collectively-creative story*. Collectively-creative narratives are produced by providing each of our agents with different computational representations of culture, experience (knowledge-base) and personality. Let us elaborate this idea. For example, when one talks about knowledge bases in the context of the MEXICA-impro project, it is possible to describe at least three possible situations. The first one has to do with providing both agents with the same knowledge base. In this case the stories generated by them cannot be classified as collectively-creative because each agent can develop the same story alone. The second one consists of providing both agents with completely different knowledge bases. In this case we might be able to produce collectively-creative stories; however,

there is a high risk that our agents cannot progress the story as a team due to the lack of shared experiences. The third possibility involves providing both agents with partially different knowledge bases. In this case, we expect to produce collectively-creative stories through a fluid collaboration between agents. This is the case we are interested in. In this paper we report some tests that we have performed employing partially different knowledge-bases. There are several issues related to dissimilar knowledge bases that should be discussed: how the dissimilarity between two knowledge bases can be measured? What is the best ratio similarity/dissimilarity between two knowledge bases to generate the best collectively-creative stories? And so on. However, due to space limitations, in this document we focus exclusively on explaining the core characteristics of our examples.

As explained earlier, the knowledge base is built from the dictionary of story-actions and the set of previous stories. For this example, both agents employ the same actions; only the previous stories are different. From now onwards, the file of previous stories of agent 1 will be referred to as PH1 and the file of previous stories of agent 2 will be referred to as PH2. PH1 includes seven previous stories; PH2 includes six previous stories. Each story in PH1 shares a similar plot with at least one story in PH2. Sometimes they are very similar and sometimes they only share few elements.

Tensions between characters

	0	1	2	3	4	5	6	7	8
0		1-0							
1	1-1-(2)	1-0	1-0-(1)						
2	2-2-(1)	1-2	1-1	1-0	1-1				
3	1-2-(1)	3-1	2-1	0-1	0-1		1-0	1-0	
4	1-0	2-2	3-4	2-0	0-1	1-1	0-1	0-1	0-1
5	0-1	0-2(1)	0-2	2-3	1-0	1-0	0-1		
6	0-1	0-3			1-0	0-1-(1)	1-2		
7		1-1	1-0	1-0			0-1	0-1	0-1
8	1-0		0-1	(1)	(1)	1-0	1-0		1-0

(row label at left, rotated: **Emotional Links**)

Figure 1. Partial map of atoms. The first digit in each cell indicates the numbers of atoms in the knowledge base of agent 1; the second digit indicates the numbers of atoms in the knowledge base of agent 2; numbers in parentheses indicate the shared atoms.

For example, story four in PH1 and story three in PH2 only differ in their first action; the rest of the actions and the characters participating in the story are alike. However, story one in PH1 only shares few actions with story 1 in PH2. The knowledge bases built from PH1 and PH2 are partially represented in figure 1(for reasons of space we only show half of the map). This map allows comparing each

agent's atoms in terms of the number of components it has. All atoms are comprised by emotional links and tensions between characters (see Pérez y Pérez 2007 for details on how atoms are built). The horizontal axis indicates the number of tensions and the vertical axis indicates the number of emotional links that each atom contains. Each entrance in the map has figures that indicate the number of atoms in that position. The first digit in each cell indicates the number of atoms that belong to the knowledge base of agent 1; the second digit in each cell indicates the number of atoms that belongs to the knowledge base of agent 2; numbers in parentheses indicate those atoms that are equal in both knowledge bases. For example, the position (0 tensions, 2 emotions) shows that both agents share one identical atom, and that each agent has 2 unique atoms. As the reader can observe, agent 1 and agent 2 only share nine identical atoms. Those atoms located in the same position or located close to each other in the map share some characteristics; therefore, they are similar but no identical. Finally, we have few atoms that are very different to the rest. In this way, we are able to have two knowledge bases that are similar but not identical.

4   A story generated by MEXICA-impro

MEXICA-impro is set to produce three actions during engagement and then switch to reflection. From now on agent 1 is referred to as the leader and agent 2 is referred to as the follower. The user provides the following first action:

(0) princess cured jaguar knight

The number on the left indicates that this action was produced at Time = 0. The leader starts an E-R cycle; during engagement the following actions are retrieved from memory:

(0) princess cured jaguar knight
(1) enemy kidnapped princess
(2) enemy attacked princess
(3) jaguar knight looked for and found enemy

At time = 1 the enemy kidnaps the princes, at time = 2 the enemy attacks her and at time = 3 the knight decides to look for the enemy. Now, the leader switches to reflection.

(4) jaguar knight is introduced in the story
(5) princess is introduced in the story
(7) hunter is introduced in the story
(9) hunter tried to hug and kiss jaguar knight
(8) jaguar knight decided to exile hunter
(10) hunter went back to Texcoco Lake
(6) hunter wounded jaguar knight
(0) princess cured jaguar knight
(1) enemy kidnapped princess
(11) enemy got intensely jealous of princess

```
(2) enemy attacked princess
(3) jaguar knight looked for and found enemy
```

The system introduces the princess and the jaguar knight into the story. Then, the system requires to justify why the princess healed the knight and inserts the action where the hunter injured the knight at time = 6. Since there is a new actor, the system introduces the hunter into the story (time = 7). The leader now requires to justify why the hunter wounded the knight; so, it inserts the action where the knight exiled the hunter (time = 8). Why did the knight do that? Because the hunter attempted an excessive demonstration of love on the knight (time = 9). However, because the hunter was exiled, it changed his position inside the story-world. Therefore, in order to wound the knight, first it had to move back to the lake (where the knight is located). The system detects this situation and moves back the hunter to the Texcoco Lake (Time = 10). Finally, MEXICA-impro requires justifying why the enemy decided to attack the princess. So, it inserts action at time = 11. At this point, all preconditions are satisfied and the leader ends its first E-R cycle and cues the follower to continue the story.

The follower starts its E-R cycle and during engagement generates two actions:

```
(12) jaguar knight had an accident
(13) enemy decided to sacrifice jaguar knight
```

So, after the knight finds the enemy the follower continues the story inserting an action where the knight suffered an accident (time = 12) and the enemy decides to kill him (time = 13). The follower cannot match an atom in memory to continue the story and an impasse is declared. Thus, the system switches o reflection.

```
Jaguar knight is introduced in the story
princess is introduced in the story
hunter is introduced in the story
hunter tried to hug and kiss jaguar knight
jaguar knight decided to exile hunter
hunter went back to Texcoco Lake
hunter wounded jaguar knight
princess cured jaguar knight
enemy kidnapped princess
enemy got intensely jealous of princess
enemy attacked princess
jaguar knight looked for and found enemy
(12) jaguar knight had an accident
(13) enemy decided to sacrifice jaguar knight
(14) hunter found by accident jaguar knight (breaking
impasse)
```

All preconditions are satisfied, so the system inserts at the end of the story in progress the action where the hunter found accidentally the knight (time = 14) to try to break the impasse. The E-R cycle ends and the follower cues the leader to continue the story.

The leader attempts to match an atom in memory; however, it fails and an impasse is declared. This is not surprising because none of the leader's previous histories includes a scene where a hero goes to rescue a victim and instead suffers an accident. Now the leader switches to reflection. All preconditions are fulfilled and the system inserts the action where the hunter killed the knight to try to break the impasse.

```
(15) hunter killed jaguar knight (breaking impasse)
```

This produces an interesting situation. One would expect that the enemy killed the knight; however, the hunter, who hated the knight, is reintroduced in the story and performs the murder. There is not a similar precedent in the previous stories of both agents. The leader cues the follower to continue the story.

The follower tries to match an atom but again an impasse is declared during engagement; the system switches to reflection to try to break the impasse and inserts the action where the hunter killed himself.

```
(16) hunter committed suicide (breaking impasse)
```

The follower evaluates the story in progress and decides that the story is completed. So, the follower cues the leader to continue the story and informs the leader about its decision of finishing the story.
The leader receives the information and nevertheless tries to advance the story. During engagement it cannot match an atom in memory and an impasse is declared. During reflection it cannot break the impasse. So, the leader decides to finish the story. This is the plot that both agents built together:

```
*** Final Story
(4) jaguar knight is introduced in the story (l)
(5) princess is introduced in the story (l)
(7) hunter is introduced in the story (l)
(9) hunter tried to hug and kiss jaguar knight (l)
(8) jaguar knight decided to exile hunter (l)
(10) hunter went back to Texcoco Lake (l)
(6) hunter wounded jaguar knight (l)
(0) princess cured jaguar knight
(1) enemy kidnapped princess (l)
(11) enemy got intensely jealous of princess (l)
(2) enemy attacked princess (l)
(3) jaguar knight looked for and found enemy (l)
(12) jaguar knight had an accident (f)
(13) enemy decided to sacrifice jaguar knight (f)
(14) hunter found by accident jaguar knight (f)
(15) hunter killed jaguar knight (l)
(16) hunter committed suicide (f)
```

What makes this story original is its conclusion: a hero goes to rescue a victim but instead suffers an accident that leads to his murder, not by the enemy, but by an old

resented rival that suddenly is reintroduced in the plot. There is no similar story in either PH1 or PH2.

The letter on the right side indicates if the action was generated by the leader (l) or by the follower (f). Actions in italics were generated during reflection. In this example the leader performed three E-R cycles while the follower performed two. The leader contributed with 12 actions while the follower contributed with 4. This difference arouse because the initial action provided by the user required that the leader inserted several actions during reflection to satisfy preconditions. During its first E-R cycle the leader produced 11 actions; so, almost its whole contribution to the narrative was generated during its first participation (i.e. during its first E-R cycle). During its second participation the leader inserted one action to try to break an impasse and during its final participation the leader was not able to contribute to the story. The follower contributed with three actions during its first participation and with one during its final participation. Both agents were able to generate more actions during its first E-R cycle because as the narrative unravelled the story-context became more complex and novel and it was more difficult to match an atom. The sequence of actions generated by the leader during its first participation (actions time = 1 to 11) produced a context that was novel to both the leader and the follower. That is, neither the leader's knowledge-base nor the follower's knowledge-base contained an atom that was equal to the current story-world context. This novelty arouse as a result of the heuristics employed to satisfy preconditions. The production of novel contexts is a normal and necessary situation when MEXICA generates stories: novel contexts arise and MEXICA looks for atoms similar to the current story-world context and then retrieves its associated actions to unravel the narrative in progress. In this way MEXICA is able to create novel narratives. However, in MEXICA-impro the follower receives unknown material (in this case produced by the leader) that must be progressed coherently: the actions chosen to continue the story must connect with the previous ones, the relation between characters must be kept, and so on. This is a difficult task. The E-R model provides the necessary elements to achieve this goal.

We hypothesized that if the knowledge bases of the two agents were similar enough, the agents would interact without problems. However, in this case, the sequence of actions generated at times 1 to 11 produces a novel context for both agents. This characteristic is positive because the system is generating original situations to push the story forward instead of just copying the content of its knowledge base. However, if the context is "too novel", the system is not capable of matching an atom in memory and an impasse is declared. In this case, the follower was able to retrieve an action during engagement to continue the narrative. Due to lack of space, it is not possible to explain the details of how the follower matched the atom and retrieved the action at time 12. But it is important to mention that the atom matched only satisfied the minimum requirements to be considered similar to the current story context. That is, because the context was pretty novel the follower was close to declaring an impasse. Nevertheless, agent 2 was able to continue the story. Would the leader be able to match an atom employing the same story-context? This question leads to a more important question: would the leader be able to generate the same story alone? In order to answer these questions we ran a second test. We forced agent 1 to generate exactly the same initial first 11 actions and see if it could continue

the story alone. The result was that, after generating again the first eleven actions, agent 1 was not capable of matching any atom in memory. Thus, an impasse was declared and the system switched to reflection to try to break the impasse. Employing the heuristics designed for this purpose, the system inserted an action where Jaguar Knight made the enemy a prisoner. Then, the system considered that the story was completed and decided to finish it. In this way, the story generated alone by agent 1 is shorter and its conclusion is not as original as the conclusion in the story generated by both agents (one could easily expect that the knight would make the enemy a prisoner). Because its knowledge base does not include the necessary knowledge, the leader could never produce alone the same tale produced by MEXICA-impro.

Would agent 2 be capable of generating alone the first same 11 actions and then continue the story? To answer this question we attempted to forced agent 2 to produce the same initial sequence of actions. However, the content of its knowledge base made it impossible. Agent 2 could not come out with the proposal that, after the princess cured the knight, something logical to happen was that the enemy kidnapped her. Thus, this agent could not generate the desired sequence of actions.

As mentioned earlier, collectively-creative narratives are produced by providing each of our agents with different computational representations of culture, experience and personality. In our current version of MEXICA-impro, these characteristics are represented in the system's knowledge base. This way, because the story produced by MEXICA-impro is novel and could not be produced by any of the agents alone, we consider it as a collectively-creative narrative. This is a nice example of how the cooperation between both agents allowed producing a novel story.

5   Conclusions

MEXICA and other systems have explored in the past how narratives can be created automatically according to different cognitive models and ideas. MEXICA has been successful in representing in computer terms the engagement-reflection account of the human creative process, especially through its capability to 'reflect' about partial stories and adjust generation cycles thereafter. One of the main characteristics of creativity, however, one accounted for by many authors (e.g. Boden, 1990), is that products of the process need to be novel to a community, either in a particular group, or in society at large. This particular constraint for some product to be deemed 'creative', takes the problem of building models and systems of creative processes into the realm of the social: not only the outcomes need to be sound and interesting but also new to the community. Creative agents then, need to take into account the community's knowledge when trying to come up with something new.

Our project explores an approach to creativity, namely the use of improvisation in story generation as a metaphor of social reproduction. We believe that creativity is achieved by confronting established local (or global) lore with new, different knowledge and practice. Improvisation is a well known creative experimental medium where two or more different worlds collide in an organised environment to establish the ground for innovative, amusing and relevant knowledge, art work or otherwise. MEXICA-impro has provided a good starting point for our endeavour since it allows

us to redefine the creative process as a dialog between two improvising agents that draw their information from different databases considered as cultural contexts for different cultures. From the methodological point of view, our project establishes right from the onset a multidisciplinary approach to a multidisciplinary subject. What creativity is and how it can be modelled and studied can only be investigated by involving all the relevant disciplines. Our system possesses an architecture that provides all members of the group with a clear knowledge of all the relevant mechanisms and parameters at stake, in such a way that everyone can participate almost right from the start in discussions about future design and experiments.

MEXICA-impro simulates the interaction between two agents with separate cultural backgrounds. The resulting system has become an experimental zone at the crossroad of several disciplines. The members of the group developing it come from backgrounds as diverse as A.I., Film Studies, Sociology and Psychology. We believe that we, ourselves, have set out in an engagement-reflection journey to explore in a multidisciplinary way the possibilities of creativity.

6   References

Boden, Margaret. The Creative Mind. Abacus. London, U.K. 1990, p32.

Clark, H. H., & Brennan, S. A. (1991). Grounding in communication. In: Resnick, L.B., J.M. Levine, and S.D. Teasley (Eds.). *Perspectives on socially shared cognition*. Washington: APA Books.

Jeong, H., & Chi, M. T. H. (2007). Knowledge convergence and collaborative learning. *Instructional Science*, 35, 287-315.

Meehan, J. (1981). Tale-spin. In R. C. Shank & C. K. Riesbeck (Eds.), Inside computer understanding: Five programs plus miniatures. Hillsdale, NJ: Erlbaum Press

Pérez y Pérez, R. (2007). Employing Emotions to Drive Plot Generation in a Computer-Based Storyteller. Cognitive Systems Research. Vol. 8, number 2, pp. 89-109. DOI information: 10.1016/j.cogsys.2006.10.001

Pérez y Pérez, R. & Sharples, M. (2004) Three Computer-Based Models of Storytelling: BRUTUS, MINSTREL and MEXICA. Knowledge Based Systems Journal. Vol. 17, number 1, pp. 15-29.

Pérez y Pérez, R. & Sharples, M. (2001) MEXICA: a computer model of a cognitive account of creative writing. Journal of Experimental and Theoretical Artificial Intelligence. Volume 13, number 2, pp. 119-139.

Riedl, M. (2004). Narrative planning: balancing plot and character. Ph.D. dissertation, Department of Computer Science, North Carolina State University, Raleigh, NC

Scott, W. (1962). Cognitive Complexity and Cognitive Flexibility. *Sociometry*, 25 (4), 405-414

Sharples, M. (1999). How we write? Writing as creative design. London: Routledge.

Turner, S. R. (1994). The creative process: A computer model of storytelling. Hillsdale, NJ: Lawrence Erlbaum Associates.