Intelligent Narrative Generation: Creativity, Engagement, and Cognition

Mark Riedl
riedl@cc.gatech.edu
@mark_riedl
Tell me a story
Storytelling

• Storytelling is pervasive part of the human experience
  – Books, movies, computer games, training scenarios, education, every-day communication, etc.

• Narrative Intelligence: narrative is a fundamental means by which we organize, understand, and explain the world

• Instill computational systems with the ability to craft and tell stories in order to be better entertainers, educators, trainers, communicators, and generally more capable of relating to humans
Why study story generation?

• Stories are everywhere

• Humans make up stories all the time, but computers do not

• Cognitive science

• Computational creativity

• Practical creativity
There is a woman named Jasmine. There is a king named Jafar. This is a story about how King Jafar becomes married to Jasmine. There is a magic genie. This is also a story about how the genie dies.

There is a magic lamp. There is a dragon. The dragon has the magic lamp. The genie is confined within the magic lamp. King Jafar is not married. Jasmine is very beautiful. King Jafar sees Jasmine and instantly falls in love with her. King Jafar wants to marry Jasmine. There is a brave knight named Aladdin. Aladdin is loyal to the death to King Jafar. King Jafar orders Aladdin to get the magic lamp for him. Aladdin wants King Jafar to have the magic lamp. Aladdin travels from the castle to the mountains. Aladdin slays the dragon. The dragon is dead. Aladdin takes the magic lamp from the dead body of the dragon. Aladdin travels from the mountains to the castle. Aladdin hands the magic lamp to King Jafar. The genie is in the magic lamp. King Jafar rubs the magic lamp and summons the genie out of it. The genie is not confined within the magic lamp. King Jafar controls the genie with the magic lamp. King Jafar uses the magic lamp to command the genie to make Jasmine love him. The genie wants Jasmine to be in love with King Jafar. The genie casts a spell on Jasmine making her fall in love with King Jafar. Jasmine is madly in love with King Jafar. Jasmine wants to marry King Jafar. The genie has a frightening appearance. The genie appears threatening to Aladdin. Aladdin wants the genie to die. Aladdin slays the genie. King Jafar and Jasmine wed in an extravagant ceremony. The genie is dead. King Jafar and Jasmine are married. The end.
Automated story generation

- Automatic creation of meaningful fictional sequences is hard
  - Complexity, subtlety, nuance, mimesis
  - Focus on plot

- Two nearly-universal properties of story
  - Causal progression
    - Perception that the main events of the story make up causal chains that terminate in the outcome
  - Character believability
    - Perception that characters act in a manner that does not distract from one’s suspension of disbelief
    - Characters are perceived to be intentional agents
Computer as author

• Creative writing is a problem-solving activity

• Author goals vs. character goals

• Model: plan out the events that should occur in the narrative
Narratives as plans

- Partial-order plan is a good representation of plot
  - Action, temporality, causality

- Planning: find a sound and coherent sequence of actions that transforms the initial state into one in which the goal situation holds
Planning stories

• But, is planning a good model of story creation?

• Narrative Planning:
  – Multiple characters
  – Goal state describes outcome of the story
  – Outcome is not necessarily intended by any characters

• Augment planning algorithm to reason about author goals and character goals
Fabulist

• Conventional causal dependency planning
  – Provides logical causal progression

• Reasoning about character intentions
  – Use a cognitive model to determine whether characters appear intentional and revise the plan otherwise
  – Insert actions that explain character goals

There is a woman named Jasmine. There is a king named Jafar. This is a story about how King Jafar becomes married to Jasmine. There is a magic genie. This is also a story about how the genie dies.

There is a magic lamp. There is a dragon. The dragon has the magic lamp. The genie is confined within the magic lamp.

King Jafar is not married. Jasmine is very beautiful. King Jafar sees Jasmine and instantly falls in love with her. King Jafar wants to marry Jasmine. There is a brave knight named Aladdin. Aladdin is loyal to the death to King Jafar. King Jafar orders Aladdin to get the magic lamp for him. Aladdin wants King Jafar to have the magic lamp. Aladdin travels from the castle to the mountains. Aladdin slays the dragon. The dragon is dead. Aladdin takes the magic lamp from the dead body of the dragon. Aladdin travels from the mountains to the castle. Aladdin hands the magic lamp to King Jafar. The genie is in the magic lamp. King Jafar rubs the magic lamp and summons the genie out of it. The genie is not confined within the magic lamp. King Jafar controls the genie with the magic lamp. King Jafar uses the magic lamp to command the genie to make Jasmine love him. The genie wants Jasmine to be in love with King Jafar. The genie casts a spell on Jasmine making her fall in love with King Jafar. Jasmine is madly in love with King Jafar. Jasmine wants to marry King Jafar. The genie has a frightening appearance. The genie appears threatening to Aladdin. Aladdin wants the genie to die. Aladdin slays the genie. King Jafar and Jasmine wed in an extravagant ceremony.

The genie is dead. King Jafar and Jasmine are married. The end.
Effect on reader comprehension?

- Fabulist vs. conventional planner
- Question-answering protocol to elicit readers’ mental models
  - Enablement (how questions)
  - Intention (why questions)
- Compared readers’ answers to the computer’s answers

**Q:** Why did Aladdin travel from the mountains to the castle?

**A:** Because the genie wanted to cast a spell on Jasmine.

<table>
<thead>
<tr>
<th></th>
<th>Questions computer thinks are “good” (closer to 4)</th>
<th>Questions computer thinks are “bad” (closer to 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fabulist</td>
<td>3.20</td>
<td>1.19</td>
</tr>
<tr>
<td>Control</td>
<td>2.99</td>
<td>1.30</td>
</tr>
</tbody>
</table>
The “goodness” question

• Does the story generator know that it is creating something good?

• How can a computational system generate a suspenseful story?
Interactive narrative

A form of digital entertainment in which the player influences a dramatic storyline through actions
Interactive narrative

- Narrative branches in response to player actions
- Combinatorics of authoring
- Leverage story generator
Automated story director

• Use a story generator to construct alternative branches
• Start with an exemplar narrative (generated or hand-authored)
• Exceptions: player actions that derail the narrative plan
• How to detect exceptions?
• How to respond to exceptions?
Automated story director

- Pre-compute tree of contingency narratives
- Semi-autonomous virtual characters

Wolf sits and waits.
Wolf walks in a circle and sits back down.
Wolf walks in a circle and sits back down.
Red has arrived.
Wolf eyes Little Red hungrily.
Red looks closely at Wolf.
Red says, "My what big teeth you have!"
Wolf says, "The better to eat you with, my dear!"
Red screams.
Wolf swallows Little Red in one big gulp.
Red disappears suddenly for parts unknown.
Wolf is feeling very drowsy.
Wolf falls asleep.
:kills wolf
Fred kills wolf
Granny arrives.
Granny claws her way out of the wolf.
Personalized drama management

- Need to account for individual preferences for how story should unfold

- Can we learn a model of player story preferences?

- Can we guide a player through his or her most preferred story trajectory?
Player modeling

- Collaborative filtering: observe many players and find statistical similarities with which to recommend next plot point

- **Sequential recommendation**: recommendation of plot point is dependent on history of plot points experienced so far

- Convert branching story graph into a prefix tree and recommend the next partial trajectory
**INTERACTIVE STORYTELLING EXPERIMENT**

Start!

---

**Story 1**

Carlos and you make a good climbing team. You two decided to find Yeti, sometimes called the Abominable Snowman, in the Himalayas which forms a great natural wall between India and China, with Nepal tucked in amid the peaks. Your goal is to find positive proof that Yeti exists. That is what brings you to Kathmandu, the capital of Nepal. Two days ago Carlos left by helicopter to look over the terrain near Mt. Everest, one of the best-known mountains in the Himalayas. The helicopter returned without him since Carlos decided to stay up at the Everest base camp to check out a report that a Yeti had been seen. He had a radio transmitter but the weather turned bad and radio communication was interrupted.

Mr. Runal, the Director of Expeditions and Mountain Research and an authority on the Yeti, knows of your plans. You telephone him at the Foreign Ministry. He kindly offers to help you. Two hours later, you land at the Everest base camp where Carlos was last seen. His red nylon mountain tent is still there, but the storm has erased all footprints. "Most reports of the Yeti have them well below base camp. But it is possible that they are up this high," Runal says as the two of you stand by the tent looking at the glacier and the high peaks.

**Please rate the story so far:** 8 (Best) 4 3 2 1 (Worst)

**Please rate the following option(s) and select one of them to continue:**

- You and Runal want to search below the base camp in the valley. 8 (Best) 4 3 2 1 (Worst)
- You and Runal want to search above the base camp. 8 (Best) 4 3 2 1 (Worst)
Prefix-based collaborative filtering

- Non-negative matrix factorization over story prefixes
Experimental results

- Non-sequential recommendation indistinguishable from random
- PBCF improves human-rated story experiences

<table>
<thead>
<tr>
<th></th>
<th>Random</th>
<th>Personalized</th>
<th>Accuracy</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>2.9449</td>
<td>3.8899</td>
<td>0.828</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Returning</td>
<td>3.032</td>
<td>4.035</td>
<td>0.863</td>
<td>&lt; 0.0224</td>
</tr>
<tr>
<td>New</td>
<td>2.8993</td>
<td>3.8138</td>
<td>0.809</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>
Player agency

• Can we manipulate the player into picking the branches that lead to personalized optimal trajectory?

• Modify story graph: more than one option/action between plot points

• Collaborative filtering to also predict rank order of options

• Guides player by selecting which options to present to the player
Computer game adaptation

Challenge tailoring
Choose and order the challenges the player should experience

Challenge Contextualization
Provide motivating story context between challenges
Challenge tailoring
Challenge contextualization

Take water bucket
- Pour water on witch
  - Witch drops shoes
    - Pick up shoes
      - Show shoes to king
        - King trusts you
          - Tell about princess
            - Move to lair
              - Kill dragon
                - Free princess
                  - Teleport princess to palace
                    - Marry princess

Li & Riedl. Proc. AIIDE 2010 Conference.
Story Generation

Interactive Narrative
Open story generation

- Narrative intelligence is knowledge-intensive, resulting in micro-worlds
- Can we overcome the knowledge engineering bottleneck?
- Can an intelligent system learn to tell stories about any imaginable domain?
Sociocultural storytelling

• Humans rely on a lifetime of experiences from which to explain stories, tell stories, or act in the real-world

• Computational systems can now live in a rich information ecosphere, including the Web, other agents, and humans

• Possible approaches:
  – Read natural language corpora & websites
  – Mine commonsense knowledge bases
  – Learn from humans
Crowdsourcing narrative intelligence

- A crowd of humans on the web → a supercomputer

- **Insight:** humans learn from stories

- Use a crowd to simulate a lifetime of experiences by asking people to tell stories about a specific type of situation

- Crowdsource a highly specialized corpus of narrative examples and learn a generalized model of sociocultural situations

Automatically generate stories and interactive experiences **without** a priori domain knowledge authoring
Scheherazade

• Just-in-time model learning
  – Collect written stories via Amazon Mechanical Turk
  – Learn model via semantic parsing, pattern mining, global optimization
  – Barthes: human narratives implicitly encode causality
  – Grice: maxims of quality and relevance (and quantity)
Sociocultural knowledge representation

- Model a situation as a **script**
  - Representation of procedural knowledge
  - Tells one what to do and when to do it
  - Correlated with expertise

- Set of temporally ordered events
Learning to tell stories

1. Query the crowd
2. Identify the salient events
3. Determine event ordering
4. Mutually exclusive events

• Crowd control:
  – Segment narrative
  – Use one verb per sentence
  – Avoid conditionals and compound structures
  – Avoid using pronouns

<table>
<thead>
<tr>
<th>Story A</th>
<th>Story B</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. John drives to the restaurant.</td>
<td>a. Mary looks at the menu.</td>
</tr>
<tr>
<td>b. John stands in line.</td>
<td>b. Mary decides what to order.</td>
</tr>
<tr>
<td>c. John orders food.</td>
<td>c. Mary orders a burger.</td>
</tr>
<tr>
<td>d. John waits for his food.</td>
<td>d. Mary finds a seat.</td>
</tr>
<tr>
<td>e. John sits down.</td>
<td>e. Mary eats her burger.</td>
</tr>
<tr>
<td>f. John eats the food.</td>
<td>...</td>
</tr>
</tbody>
</table>
Learning to tell stories

1. Query the crowd
2. Identify the salient events
3. Determine event ordering
4. Mutually exclusive events

- Crowd control simplifies NLP
- Compute semantic similarity between sentences
- Cluster sentences into events

<table>
<thead>
<tr>
<th>Story A</th>
<th>Story B</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. John drives to the restaurant.</td>
<td>a. Mary looks at the menu.</td>
</tr>
<tr>
<td>b. John stands in line.</td>
<td>b. Mary decides what to order.</td>
</tr>
<tr>
<td>c. John orders food. (highlighted)</td>
<td>c. Mary orders a burger.</td>
</tr>
<tr>
<td>d. John waits for his food.</td>
<td>d. Mary finds a seat.</td>
</tr>
<tr>
<td>e. John sits down.</td>
<td>e. Mary eats her burger.</td>
</tr>
<tr>
<td>f. John eats the food.</td>
<td>...</td>
</tr>
</tbody>
</table>

Order food
Eat food

* Precision ≈ 85%
Learning to tell stories

1. Query the crowd
2. Identify the salient events
3. Determine event ordering
4. Mutually exclusive events

- Seek evidence for temporal relations
- Binomial confidence testing
- Search for the most compact graph that explains the stories

Story 1
- walk/go into restaurant
- read menu
- choose menu item
- take out wallet
- pay for food
- place order
- wait in line

Story 2
- place order
- take out wallet
- pay for food
- place order

Story 3
- read menu
- choose menu item
- take out wallet
- pay for food
- place order
- wait in line

Story 4
Learning to tell stories

1. Query the crowd
2. Identify the salient events
3. Determine event ordering
4. Mutually exclusive events

- Measure mutual information between events
- Mutual information is high and co-occurrence is low
- Generalization of “or” relations

Choose restaurant

Drive to restaurant

Walk/go into restaurant

Drive to drive-thru

Mutex
Fast food restaurant

1. Choose restaurant
2. Drive to restaurant
3. Walk/go into restaurant
4. Read menu
5. Choose menu item
6. Take out wallet
7. Place order
8. Pay for food
9. Drive to window
10. Wait for food
11. Get food
12. Find table
13. Sit down
14. Eat food
15. Clear trash
16. Leave restaurant
17. Drive home
arrive at theatre
go to ticket booth
wait for ticket
buy tickets
choose movie
go to concession stand
order popcorn / soda
show tickets
buy popcorn
turn off cellphone
find seats
sit down
eat popcorn
watch movie
use bathroom
talk about movie
discard trash
hold hands
leave movie
kiss
drive home
Going on a date to the movies
Bank robbery

John enters bank
- John sees Sally
- John waits in line
- John approaches Sally
  - Sally greets John
  - John pulls out gun
  - Sally screams
  - John points gun at Sally
  - John demands money
  - Sally collects money
  - Sally gives John money
  - John collects money
  - Sally gives John a note
    - John hands Sally a note
      - Sally reads note
        - The note demands money
          - Sally opens cash drawer
            - Sally puts money in bag
              - Sally presses alarm
                - Sally calls police
                - Police arrives
                  - Police arrests John
                    - Police
                    - Sally calls police
                      - Sally
                      - John
                        - John drives away
                          - John
                            - John gets in car
                              - John
                                - John leaves bank
                                  - John
Narrative generation

- Script defines a space of linear sequences
- Random walk, preserving temporal order and mutual exclusion
- Evaluation shows generated stories statistically indistinguishable from human-authored stories

Interactive narrative generation

You walked into the bank, trying to look as normal as you can. Your pulse quickened and you can feel sweat in your palm.

Now you have the following choices:
1. Look around for a teller
2. Wait in the teller line
Your choice is: 1

You looked around and saw a bank teller.

Now you have the following choices:
1. Wait in the teller line
Your choice is: 1

You waited in the line just like every other customer.

Now you have the following choices:
1. Approach the teller
Your choice is: 1

You walked to the bank teller. Her name tag read "Sally Smith"

When she saw you, she smiled and said: "How can I help you?"

Now you have the following choices:
1. Give a note to the teller
2. Give a bag to the bank teller
3. Pull out your gun
Your choice is: 1

You pulled out a note and gave it to Sally.

Sally read the note.

The note read: This is a robbery. Give me money to save your own life.

Now you have the following choices:
1. Give a bag to the bank teller
2. Show your gun to the bank teller
Your choice is: 2

You lifted your jacket to show your gun to Sally. She turned pale.

The bank teller looked very scared. She might faint any moment.

Now you have the following choices:
1. Give a bag to the bank teller
Your choice is:
The road ahead

• Starting with basics of plot causality and character believability

• Progressively layering complexity

• Computational aesthetics

• Data-driven tailoring

• Story generation in the real world
Conclusions

• Story generation is a key capability that unlocks many practical, real-world applications
  – Create and manage user experiences in virtual worlds
  – Games, interactive narratives, training simulations, narrative learning environments, virtual characters

• Narrative intelligence is a step toward human-level intelligent systems

• Creative, expressive computational systems
Acknowledgements

• Boyang Li
• Brian O’Neill
• Alexander Zook
• Hong Yu
• Ken Hartsook
• Michael Drinkwater
• Steve Lee-Urban
• Sauvik Das
• Rania Hodhod
• Mohini Thakkar
• Sanjeet Hajarnis
• George Johnston
• Charles Isbell
• R. Michael Young

Thanks! Questions?

riedl@cc.gatech.edu
@mark_riedl