Intelligent Narrative Generation: Creativity, Engagement, and Sense-Making

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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
  - Logical 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

- Think like an author
- Creative writing is a problem-solving activity
- Author goals vs. character goals
- 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?

• Conventional Planning
  – Single agent
  – Goal state is agent’s desired world state
  – Goal state is intended by the agent

• 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

  [Diagram: Coerce (Villain, Joe) → Rob-Bank (Joe, Bank) → Give (Joe, $$$, Villain) → Outcome]

  Joe intends has(Villain, $$$)

  Give (Joe, $$$, Villain) → has (Villain, $$$)

  Rob-Bank (Joe, Bank) → has (Joe, $$$)

• 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

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The “goodness” question

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

• How can a computational system generate a suspenseful story?

New author goal

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 narrative generator
Initial State

5: Red Greet Wolf
4: Red Tell Wolf Granny
6: Wolf Eat Red
3: Wolf Eat Granny
9: Player Kill Wolf
10: Red Escape Wolf
8: Granny Escape Wolf
7: Red Give Granny Cake

Intermediate State

11: Fairy Resurrect Wolf
6: Wolf Eat Red
3: Wolf Eat Granny
9: Player Kill Wolf
10: Red Escape Wolf
8: Granny Escape Wolf
7: Red Give Granny Cake

Outcome

Red not alive
Wolf not alive
Red not has cake

Real time execution

- Pre-compute branches
- Semi-autonomous virtual characters
  - Reactive planning decomposes plot events into primitive behaviors
  - Respond to player actions and dialogue

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Interactive Narrative | Story Generation | Computer Games

Military training | Role playing | Computer Games
Replayability

• Role playing games (and training scenarios) interleave challenges and narrative connectives.

• The replay value of a game diminishes as game affordances and story content are exhausted.

• Can we adapt an existing game plot so that the player never experiences the same plot progression twice?

• Can we personalize the game to an individual player?
Game adaptation problems

• Challenge tailoring
  – Choose and order the challenges the player should experience

• Challenge contextualization
  – Provide appropriate motivating story context between challenges
Game plot representation

- Partial-order plan of events
- Skill-based events

Witch-hunt episode

Rescue: Rescue-Task → Rescue-Reward
Treasure-Hunt: Treasure-Task → Treasure-Reward
Witch-Hunt-Task (1): Take → Pour
Witch-Hunt-Task (2): ...
Witch-Hunt-Reward (1): King-Trusts
Witch-Hunt-Reward (2): Tell-About-Treasure
Rescue-Task (1): Kill-Dragon → Free-Princess → Teleport
Rescue-Task (2): ...
...

Rescue episode

Rescue task
- Kill dragon
- Free princess
- Teleport princess to palace
- Move to lair
- King trusts you
- Witch-Hunt-Reward (1): King-Trusts
- Tell-About-Treasure
- Move to palace
- Marry princess
Challenge Contextualization

• Start with hand-authored narrative

• Given: which skill events and episodes should be present (or not)

• Plot adaptation
  – Search for a set of modifications to the plot structure until the required episodes are present and plan is free of flaws
  – Add, remove, re-order, and causal-rewire events
## Plot adaptation

<table>
<thead>
<tr>
<th>Flaw</th>
<th>Description</th>
<th>Repair Strategies</th>
</tr>
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</table>
| **Open condition**                 | Event $e$ has a precondition $p$ that is not satisfied by a causal link      | 1. Instantiate new event $e_{new}$ that has an effect that unifies with $p$. Extend a causal link from $e_{new}$ to $e$.  
2. Select an existing event $e_{old}$ that has an effect that unifies with $p$. Extend a causal link from $e_{old}$ to $e$.  
3. Delete $e$. |
| **Causal threat**                  | Event $e_k$ has an effect that negates a causal link between events $e_i$ and $e_j$ | 1. Promotion: temporally constrain $e_k$ before $e_i$.  
2. Demotion: temporally constrain $e_k$ after $e_j$.  
3. Delete $e_k$. |
| **Un-decomposed abstract event**   | Event $e$ is abstract but has no children                                   | 1. Select and apply a decomposition rule, instantiating new events or reusing existing events as children. |
| **Dead end**                       | Event $e$ is a dead end                                                     | 1. Select an existing event $e_{old}$ that has a precondition that is unsatisfied and that unifies with an effect of $e$. Extend a causal link from $e$ to $e_{old}$.  
2. Select an existing event $e_{old}$ that has a precondition that is satisfied by causal link $c$ and unifies with an effect of $e$. Transfer the starting point of $c$ to $e$.  
3. Delete the flaw.  
4. Ignore the flaw. |
| **Superfluous event**              | Event $e$ is superfluous                                                    | 1. Link effects of earlier steps to effects of $e$.  
2. Ignore the flaw |
Challenge contextualization

Witch-hunt episode

Witch-hunt task
- Take water bucket
- Pour water on witch
- Witch dies and drops shoes

Witch-hunt reward
- King trusts you
- Pick up shoes
- Show shoes to king
- Tell about lair
- Move to lair
- Tell about treasure

Escape episode

Escape Task
- Pickup gold
- Solve puzzle
- Respond 'princess to palace

Escape reward
- Gate opens
- Move to palace
- Gate closes
- Free princess
- Marry princess

Escape episode

Escape reward
- Gate opens
- Move to palace
- Marry princess
- Free princess
- Marry princess

Witch-hunt episode

Witch-hunt task
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Witch-hunt reward
- King trusts you
- Pick up shoes
- Show shoes to king
- Tell about lair
- Move to lair
- Tell about treasure
Challenge contextualization

Witch-hunt episode

- Witch-hunt task
  - Take water bucket
  - Pour water on witch
- Witch-hunt reward
  - Witch dies and drops shoes
  - Pick up shoes
  - Show shoes to king

Move to cave

Tell about treasure

Escape episode

- Escape Task
  - Pickup gold
  - Gate closes
  - Solve puzzle
- Escape reward
  - Gate opens

Gate opens

Tell about treasure

Georgia Tech
College of Computing
School of Interactive Computing
Challenge tailoring

• Which skill-based events and in what order?
• Player model predicts skill performance
Player modeling

- Collaborative filtering
  - Observe many players’ proficiency at various challenges
  - Exploit statistical correlations between players’ performances
  - Temporal matrix factorization
Game world generation
Open story generation

• Narrative intelligence is knowledge-intensive

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

• Can we eliminate the knowledge engineering bottleneck?

• Can an intelligent system learn to tell stories about any imaginable domain?

Artificial intelligence meets real world

- A crowd of humans on the web → a supercomputer
- Use a crowd to simulate a lifetime of experiences
- Crowdsourcing a highly specialized corpus of narrative examples
- Learn a generalized model of the situation

Automatically generate stories and interactive experiences **without** a priori domain knowledge
Crowdsourcing narrative intelligence

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

- Generate stories and interactive narratives:

```
Collect Stories ➔ Script Learning ➔ Memory ➔ Create Story
```

- **Examples of steps:**
  - *walk/go into restaurant*
  - *read menu*
  - *wait in line*
  - *choose menu item*
  - *take out wallet*
  - *place order*
  - *pay for food*

...
Learning to tell stories

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

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

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<td>d. John waits for his food.</td>
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Learning to tell stories

1. Query the crowd
2. **Identify the salient events**
3. Determine event ordering
4. Mutually exclusive events
5. Validate and fix

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

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* 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
5. Validate and fix

• Seek evidence for temporal relations
• Search for the most compact graph that explains the stories
Learning to tell stories

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

- Measure mutual information between events
- Mutual information is high and co-occurrences is low
- Generalization of “or” relations
Learning to tell stories

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

- Crowd can improve results at every stage of process
- Re-cluster
- Verify relations
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. wait for food
10. get food
11. find table
12. sit down
13. eat food
14. clear trash
15. leave restaurant
16. drive home
17. drive to window
18. drive to drive-thru
Going on a date to the movies

1. arrive at theatre
2. go to ticket booth
3. wait for ticket
4. buy tickets
5. choose movie
6. go to concession stand
7. order popcorn / soda
8. show tickets
9. buy popcorn
10. enter theatre
11. find seats
12. turn off cellphone
13. sit down
14. eat popcorn
15. watch movie
16. use bathroom
17. discard trash
18. talk about movie
19. hold hands
20. kiss
21. leave movie
22. drive home
Bank robbery

John covers face

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

Sally is scared

John hands Sally a note

Sally reads note

The note demands money

Sally gives Sally bag

John gives scared

John shows gun

Sally opens cash drawer

Sally collects money

John demands money

Sally puts money in bag

Sally gives John money

John collects money

Sally gives John bag

John takes bag

Sally presses alarm

John opens bank door

Sally gives John money

John collects money

Sally gives John bag

John takes bag

Sally presses alarm

John opens bank door

Police arrives

John drives away

Sally calls police

Police arrests John

John leaves bank

Sally collects money

Sally gives John money

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John takes bag

Sally presses alarm

John opens bank door

Police arrives

John drives away

Sally calls police

Police arrests John

John leaves bank
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:
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
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