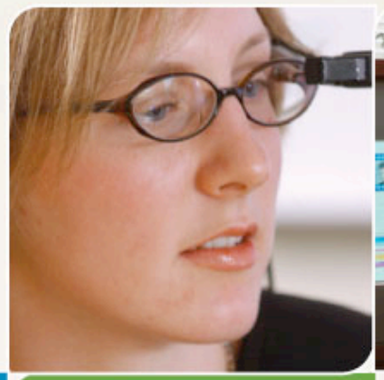
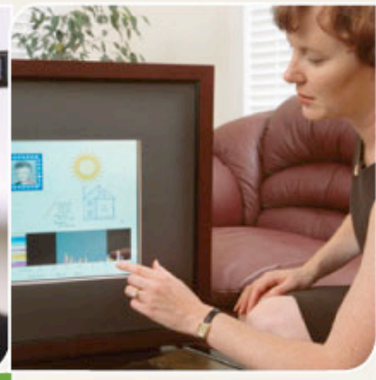

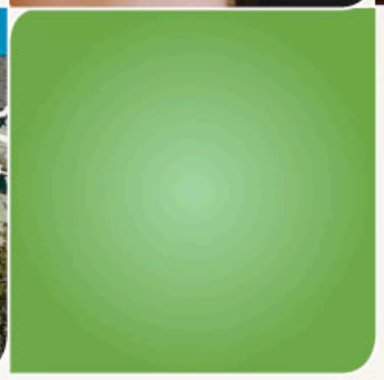

Intelligent Narrative Generation:
Creativity, Engagement, and Cognition

Mark Riedl

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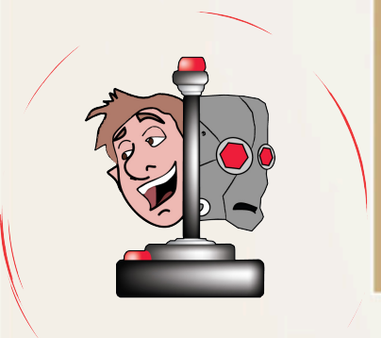
@mark_riedl



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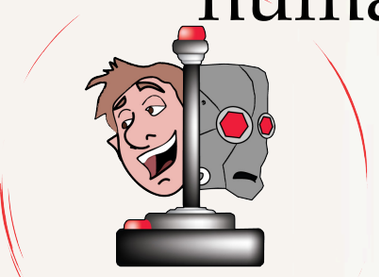
Tell me a story

Storytelling

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

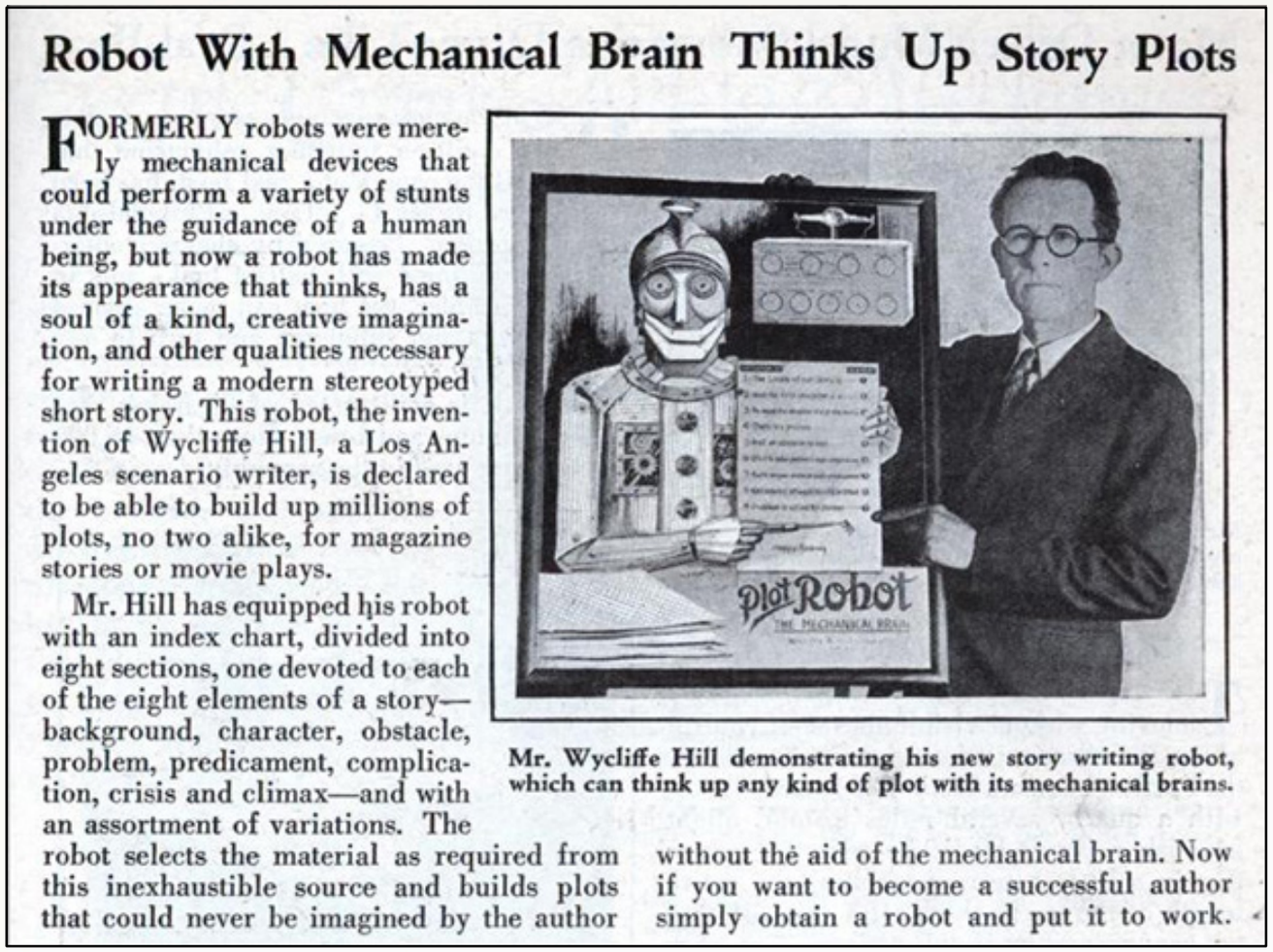
- **Narrative Intelligence:** Narrative is a fundamental means by which we organize, understand, and explain the world

- 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



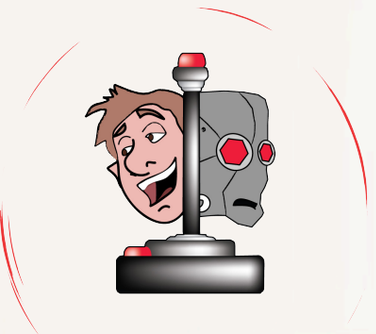
Robot With Mechanical Brain Thinks Up Story Plots

FORMERLY robots were merely mechanical devices that could perform a variety of stunts under the guidance of a human being, but now a robot has made its appearance that thinks, has a soul of a kind, creative imagination, and other qualities necessary for writing a modern stereotyped short story. This robot, the invention of Wycliffe Hill, a Los Angeles scenario writer, is declared to be able to build up millions of plots, no two alike, for magazine stories or movie plays.

Mr. Hill has equipped his robot with an index chart, divided into eight sections, one devoted to each of the eight elements of a story—background, character, obstacle, problem, predicament, complication, crisis and climax—and with an assortment of variations. The robot selects the material as required from this inexhaustible source and builds plots that could never be imagined by the author without the aid of the mechanical brain. Now if you want to become a successful author simply obtain a robot and put it to work.

Mr. Wycliffe Hill demonstrating his new story writing robot, which can think up any kind of plot with its mechanical brains.

© Popular Mechanics, 1931



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.

```
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.
```

" IT'S GETTING TO BE DARK."

Story Generation

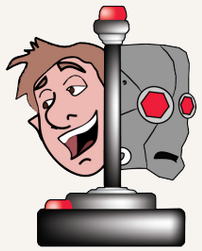
Computer Games

Narrative Intelligence

Automated story generation

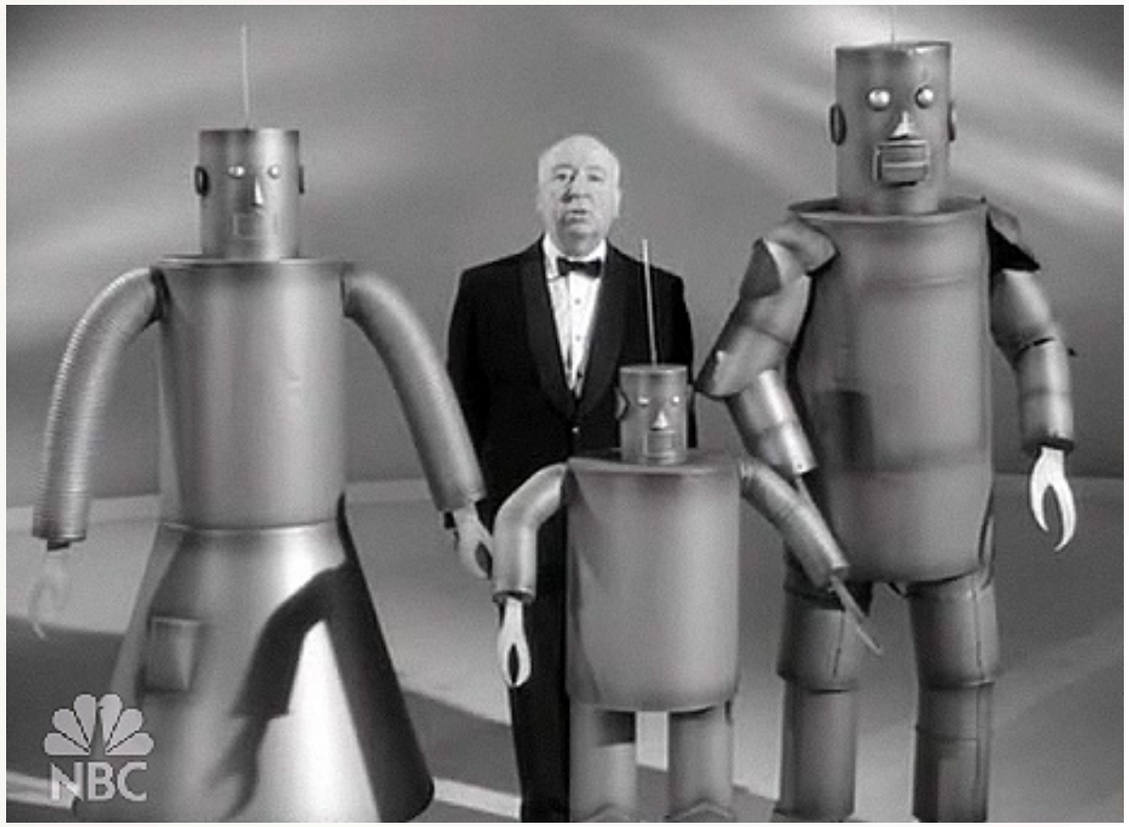
- Automatic creation of meaningful fictional sequences is hard
  - Complexity, subtlety, nuance, mimesis
  - Focus on plot

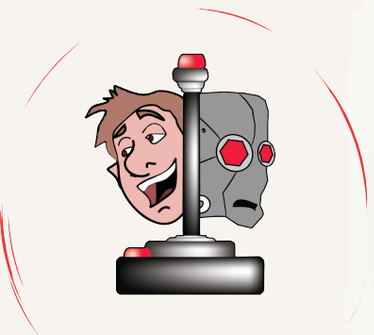
- Two nearly-universal properties of story
  - Causal progression
    - Perception that the main events of the story make up causal chains that terminate in the outcome
  - Character believability
    - Perception that characters act in a manner that does not distract from one's suspension of disbelief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



Computer as author

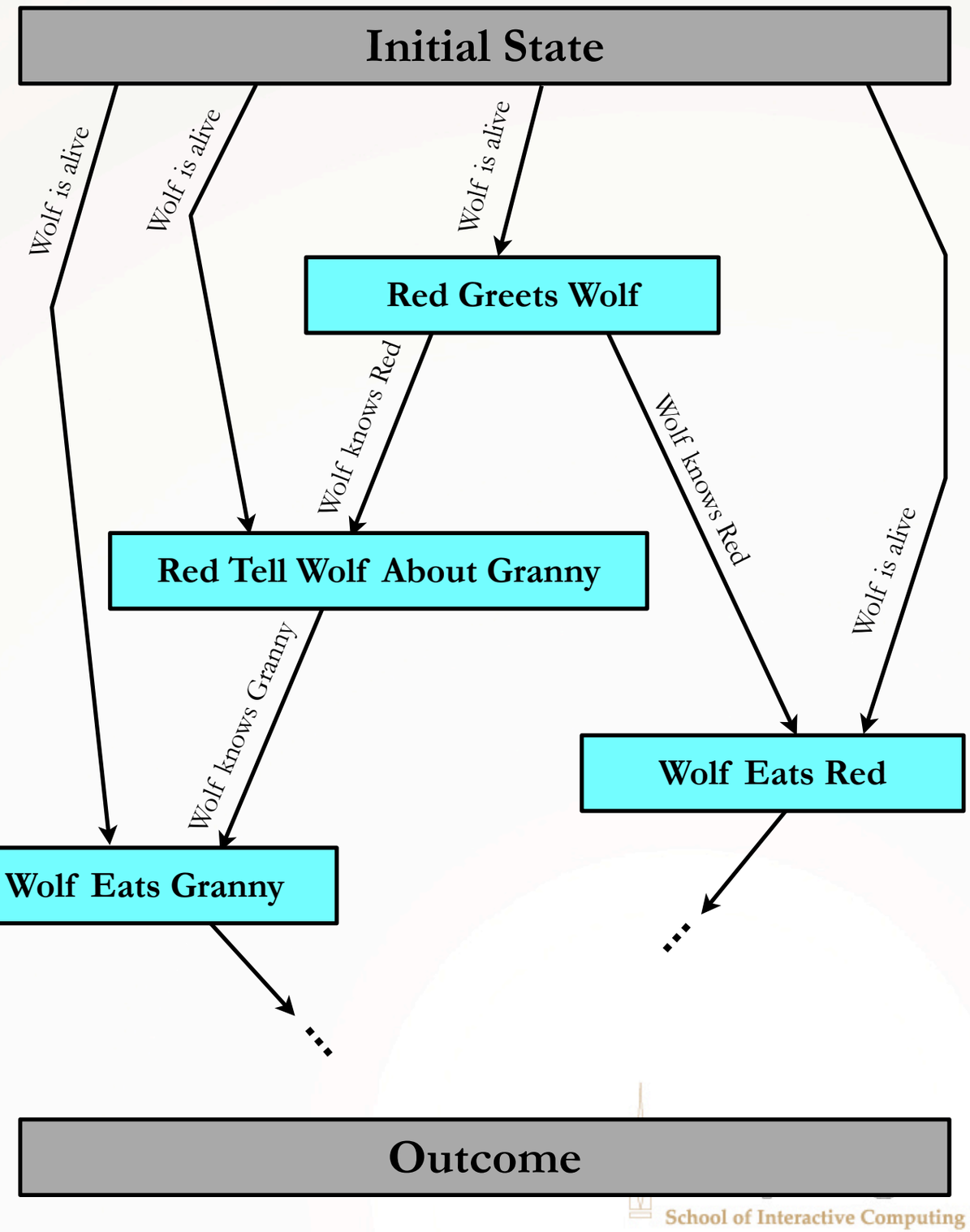
- Creative writing is a problem-solving activity
- Author goals vs. character goals
- Plan out the events that should occur in the narrative

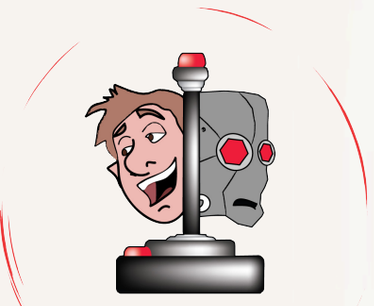




Narratives as plans

- 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





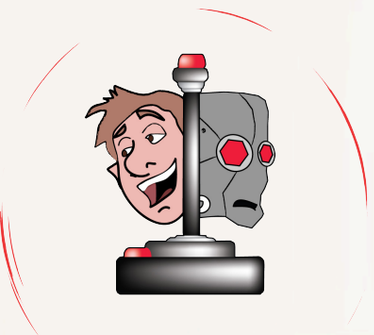
Planning stories

- 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

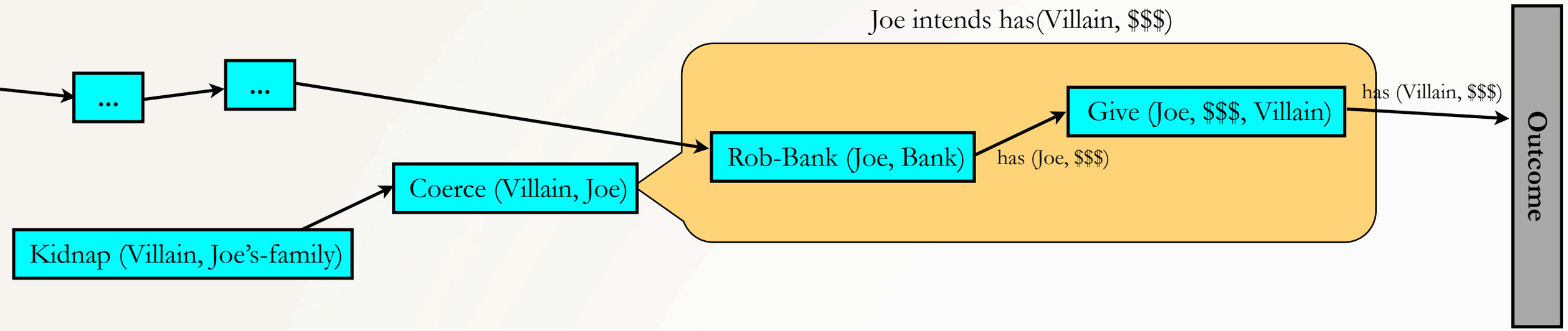
- Narrative Planning
  - Multiple characters
  - Goal state describes outcome of the story
  - Outcome is not necessarily intended by any characters

- Augment planning algorithm to reason about author goals **and** character goals

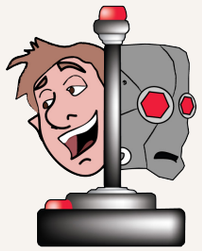


Fabulist

- Conventional causal dependency planning
  - Provides logical causal progression



- 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



Riedl & Young. Journal of Artificial Intelligence Research, 39, 2010.

Falls-in-Love (King, Jasmine, Castle)

Order (King, Aladdin, has(King, Lamp))

Travel (Aladdin, Castle, Mountain)

at (Aladdin, Mountain)

Slay (Aladdin, Dragon, Mountain)

~alive (Dragon)

Pillage (Aladdin, Lamp, Dragon, Mountain)

has (Aladdin, Lamp)

Give (Aladdin, Lamp, King, Castle)

has (King, Lamp)

Summon (King, Genie, Lamp, Castle)

at (Genie, Castle)
controls (King, Genie)

Command (King, Genie, loves(Jasmine, King))

loves (King, Jasmine)

Love-Spell (Genie, Jasmine, Castle)

loves (Jasmine, King)

Marry (King, Jasmine, Castle)

at (Aladdin, Mountain)

at (Aladdin, Mountain)

Travel (Aladdin, Mountain, Castle)

at (Aladdin, Castle)

at (Aladdin, Castle)

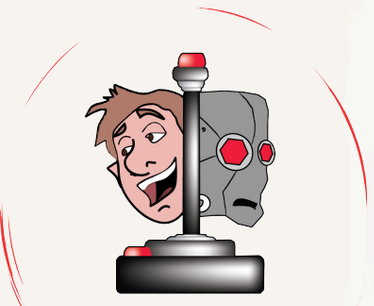
at (Aladdin, Castle)

at (Genie, Castle)

Appear-Threatening (Genie, Aladdin, Castle)

at (Genie, Castle)

Slay (Aladdin, Genie, Castle)



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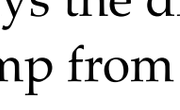

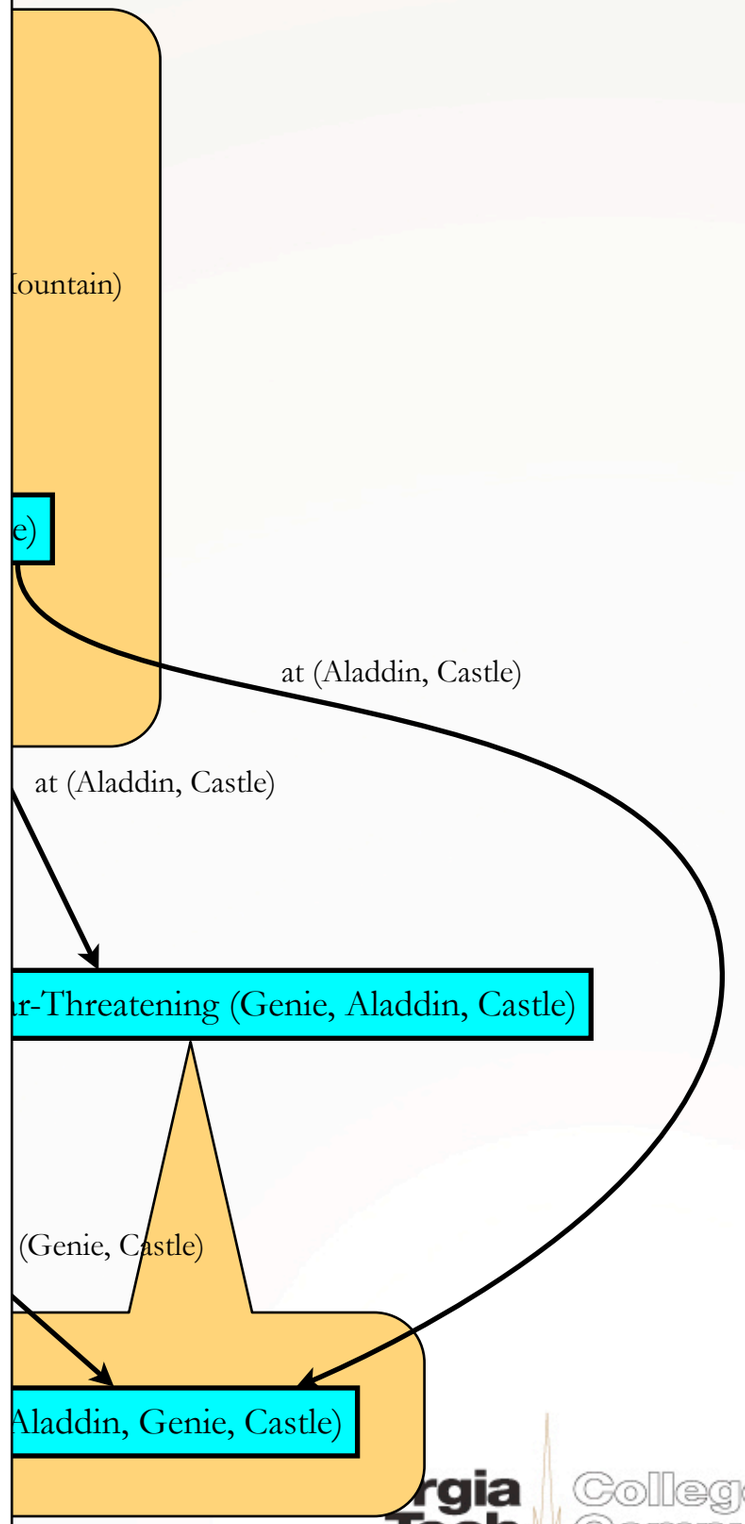

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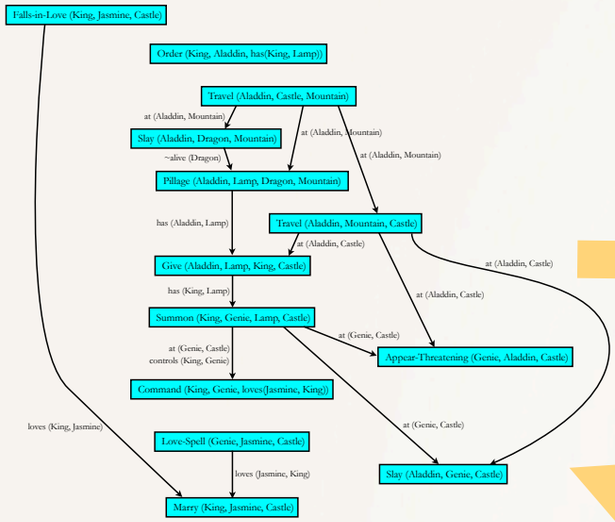
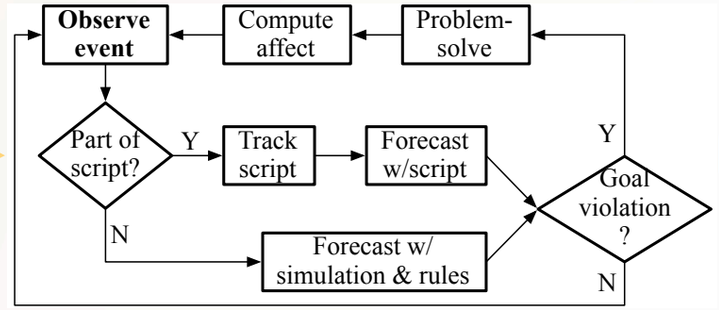
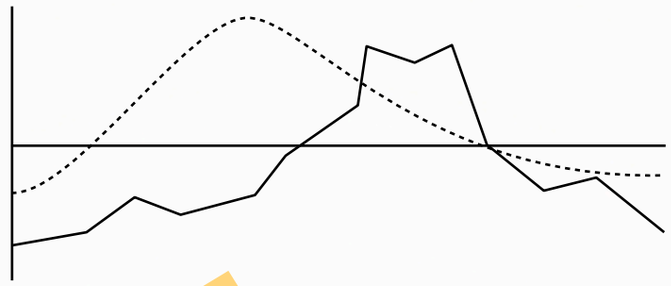
The “goodness” question

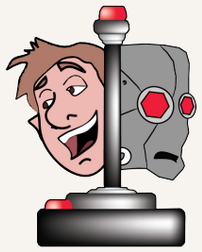
- Does the story generator know that it is creating something good?
- How can a computational system generate a suspenseful story?







New author goal



O’Neill & Riedl. Proc. ACII 2011 Conference.

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Story Generation

Computer Games

Narrative Intelligence

Replayability

- Role playing games (& 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 Personalization

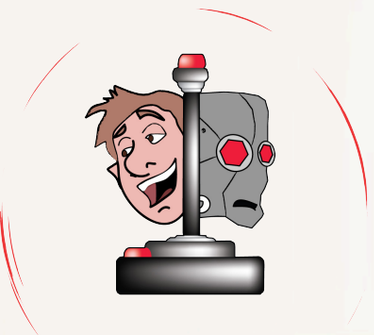
- Narrative authored by humans and thus one-size-fits-all
- Can we learn a model of player (learner) preferences, skills, desires, needs?
- Data-driven player modeling

Challenge tailoring

Choose and order the challenges the player should experience

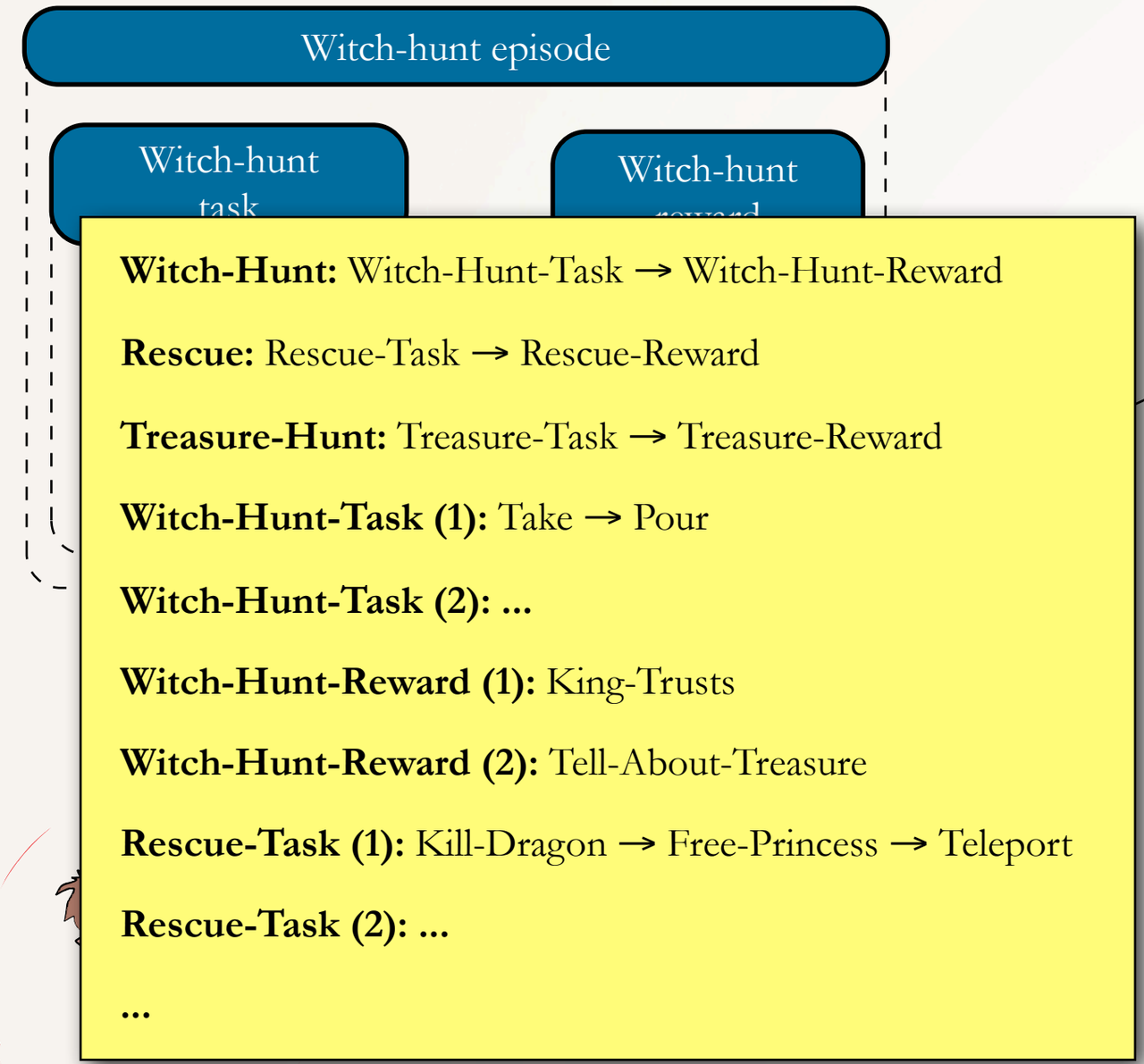
Challenge Contextualization

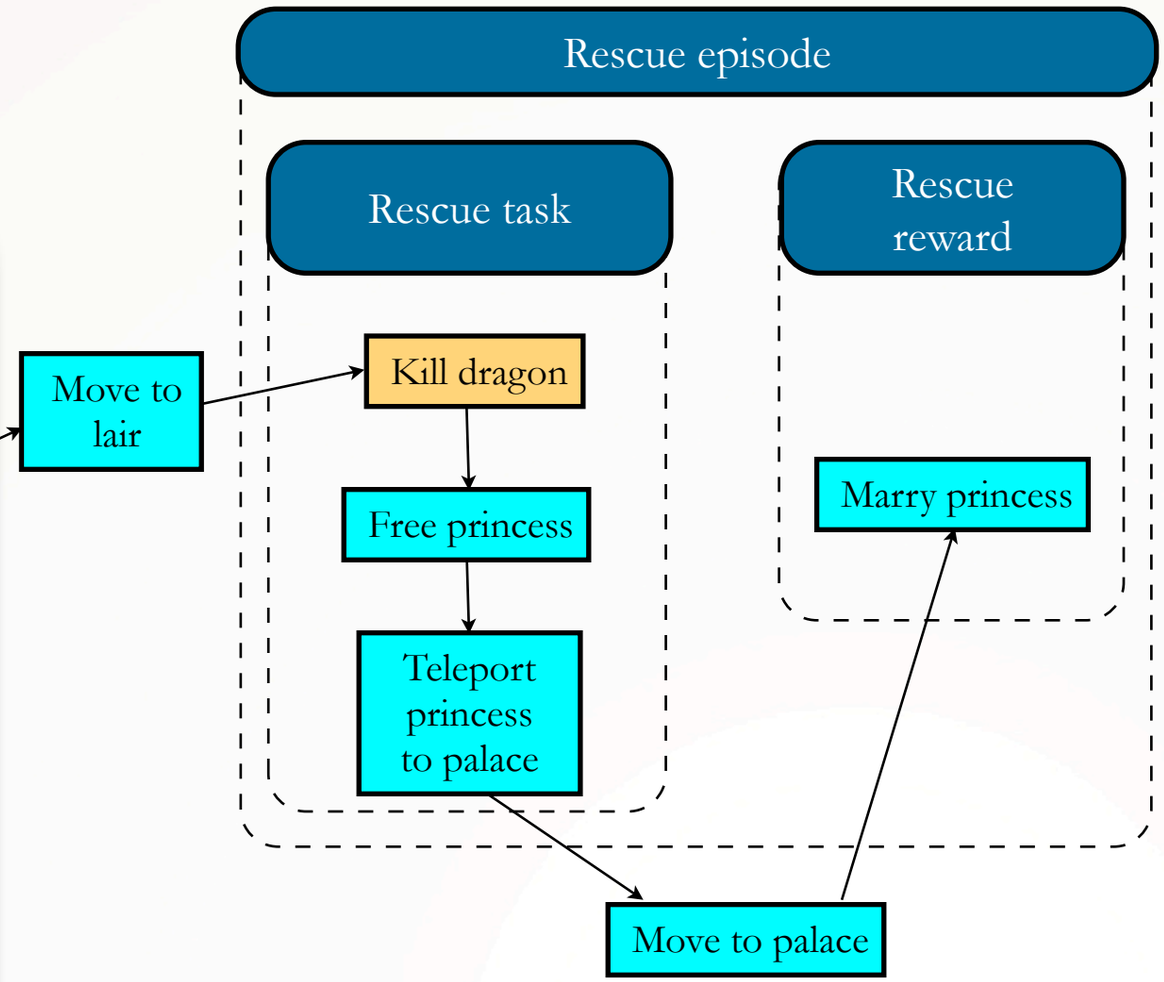
Provide motivating story context between challenges



Game plot representation

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





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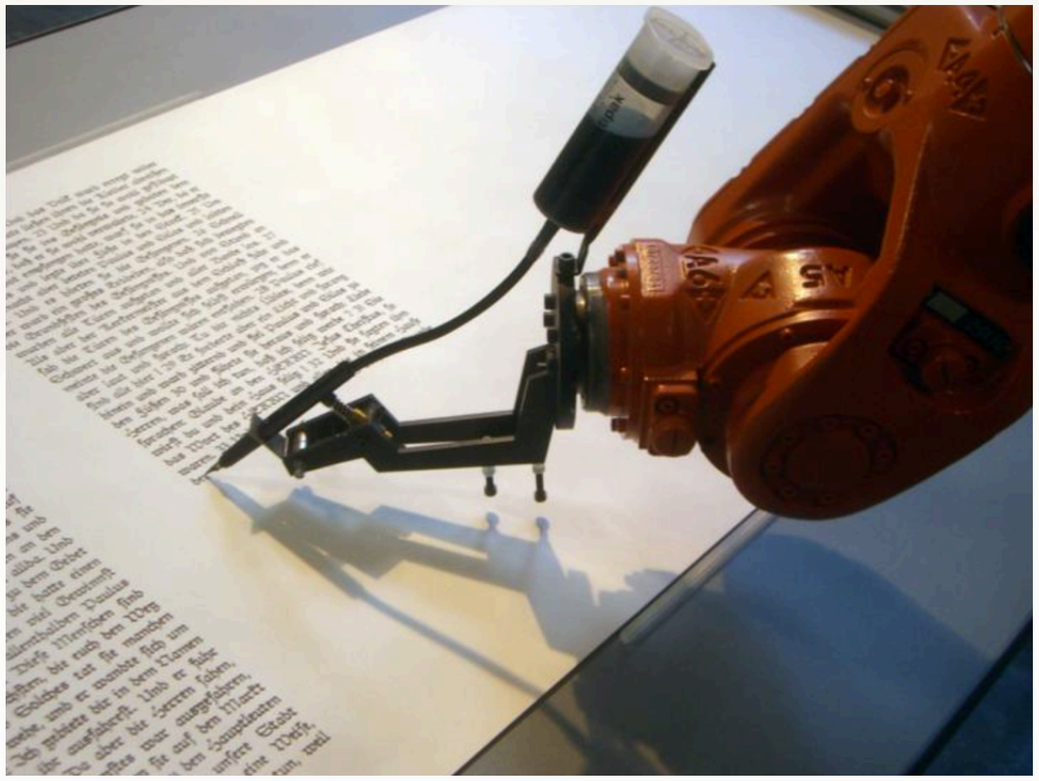
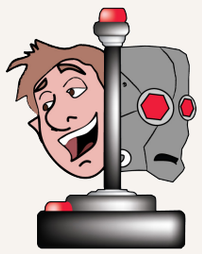
Challenge Contextualization

- Start with hand-authored narrative



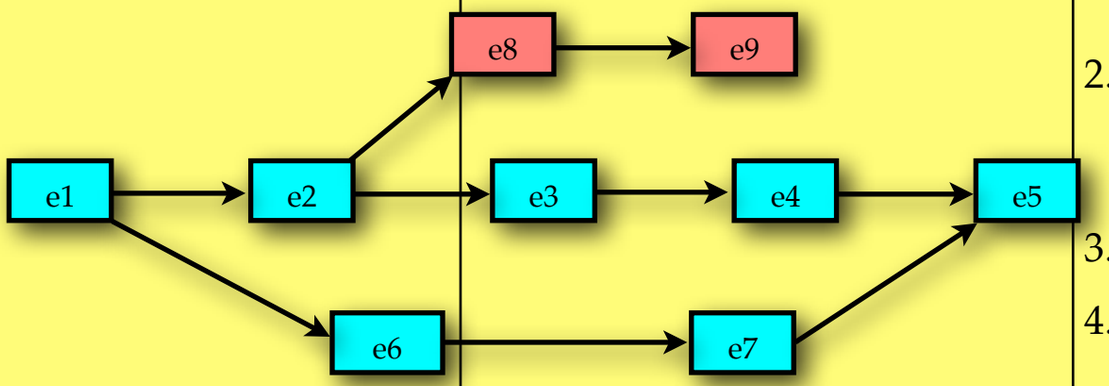
- Given: which skill events and episodes should be present (or not)

- Plot adaptation
  - Search for a set of modifications to the plot structure such that the required episodes are present and plan is free of flaws
  - Add, remove, re-order, and causally-rewire events

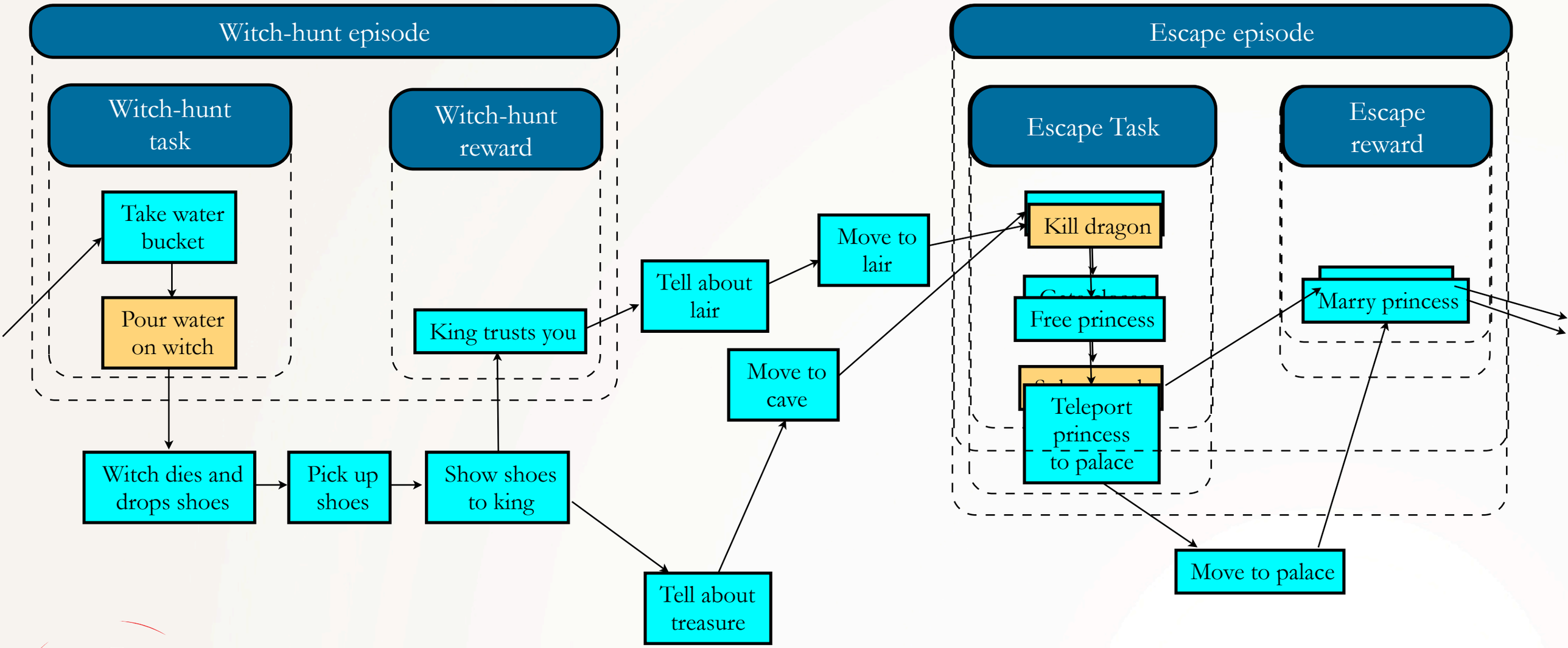


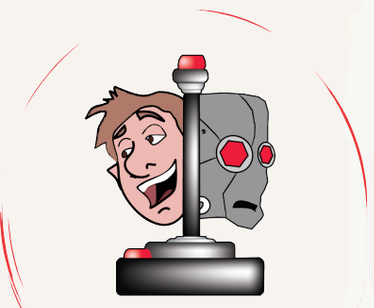
Li & Riedl. Proc. AIIDE 2010 Conference.

Flaws and repairs

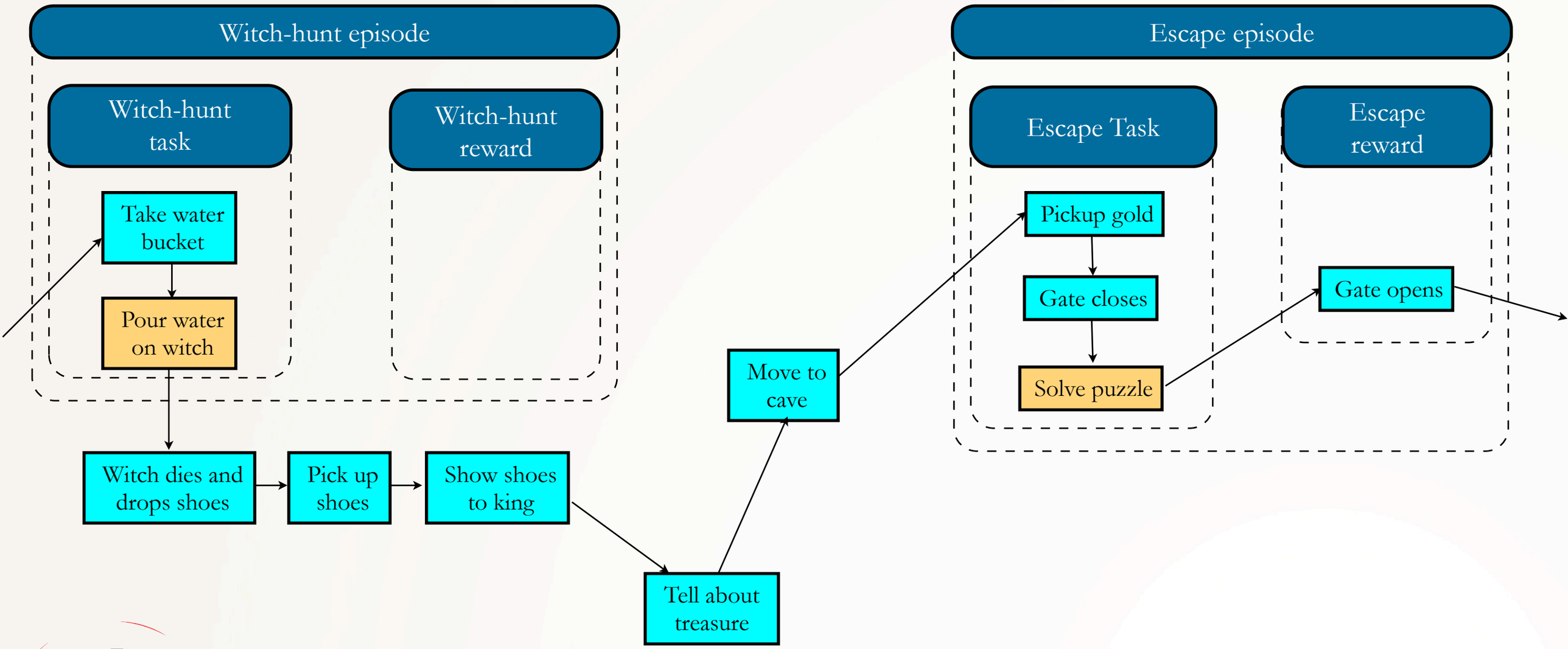
Flaw	Description	Repair Strategies
Open condition	Event e has a precondition p that is not satisfied by a causal link	1. Instantiate new event e_{new} that has an effect that unifies with p. Extend a causal link from e_{new} to e. 2. Select an existing event e_{old} that has an effect that unifies with 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

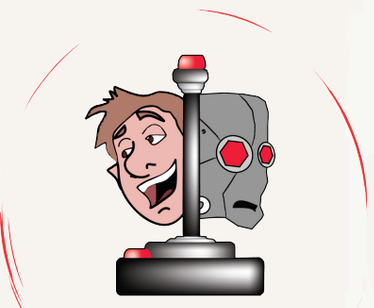
Challenge contextualization example





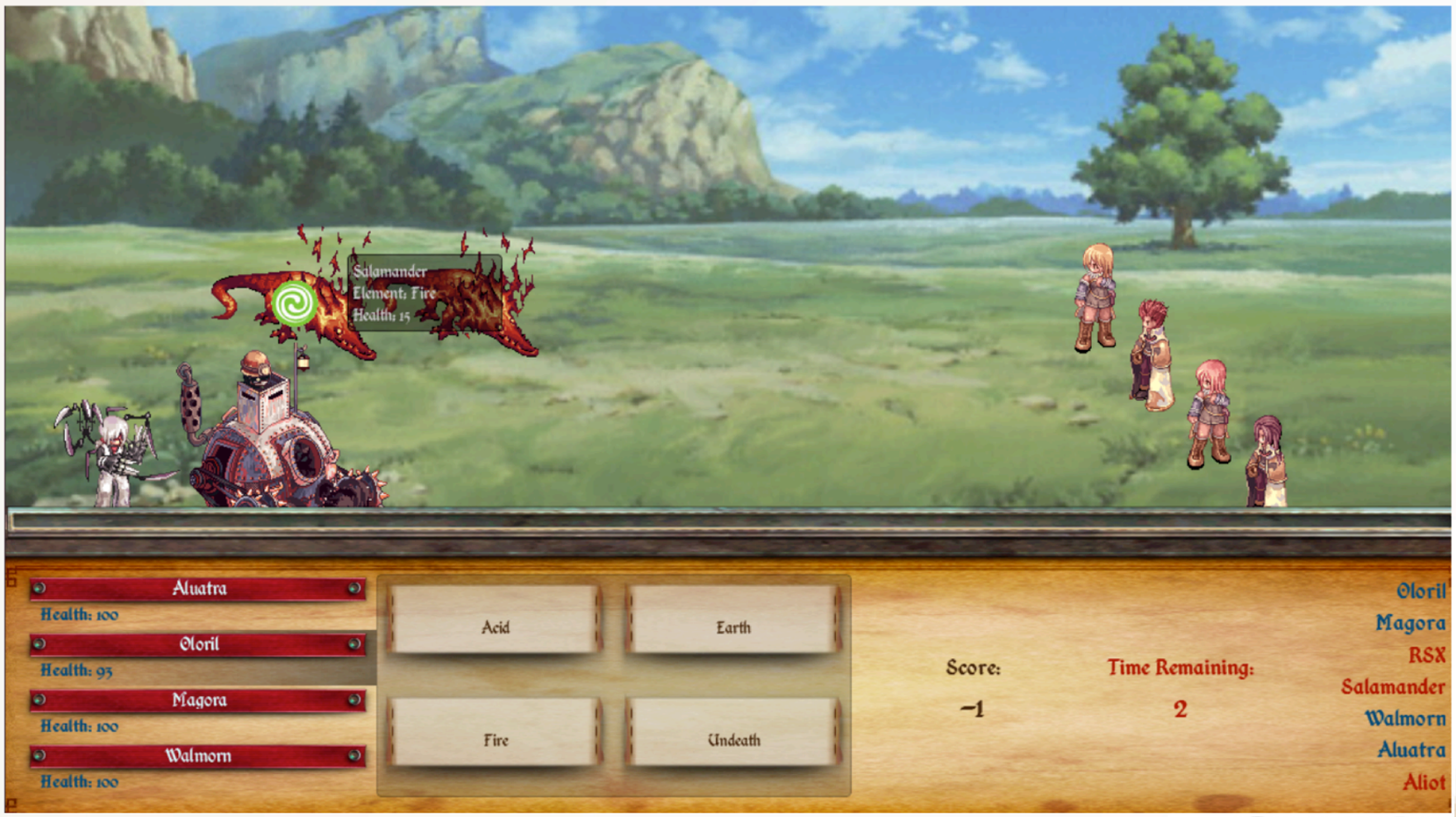
Challenge contextualization example

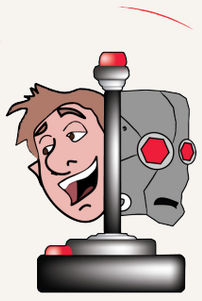




Challenge tailoring

- Which skill-based events and in what order?
- Simple example: dynamic difficulty adjustment
- Data-driven player model predicts skill performance





Zook & Riedl. Proc. AIIDE 2012 Conference.

Player modeling

- Collaborative filtering via temporal matrix factorization

$$Z \approx \sum_{k=1}^{K} \lambda_k w_k \circ h_k \circ q_k$$

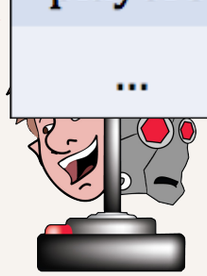
	"learning1"	"learning2"
time1	0	0.1
time2	1.2	-0.3
...	...	...

	"difficulty1"	"difficulty2"
fire	0.3	0.2
water	-1.8	0.4
...	...	...

	"skill1"	"skill2"
player1	0.5	0.7
player2	2.5	-0.8
player3	1.9	0
...	...	...

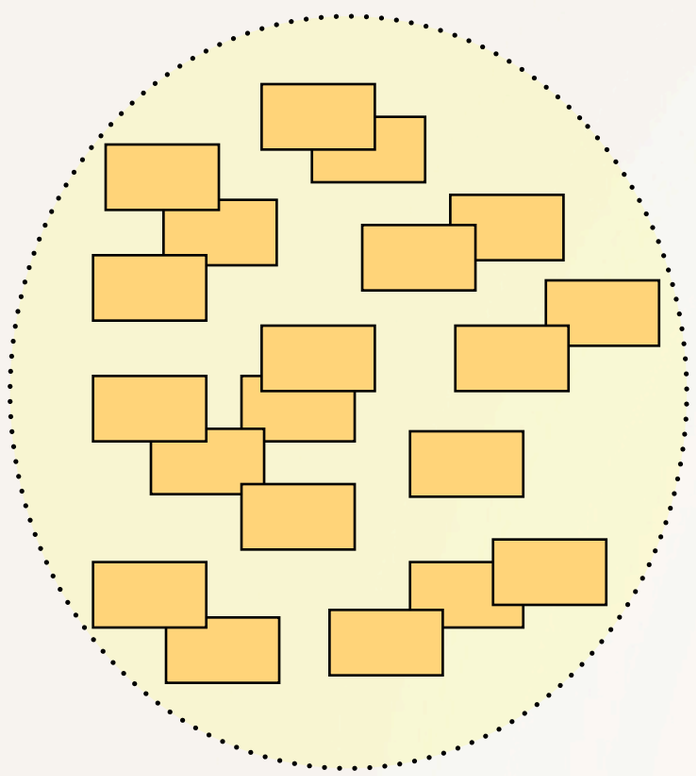
	Fire	Water	...
player1	-	1	...
player2	2	-	...
player3	1	-	...
...	...	...	...

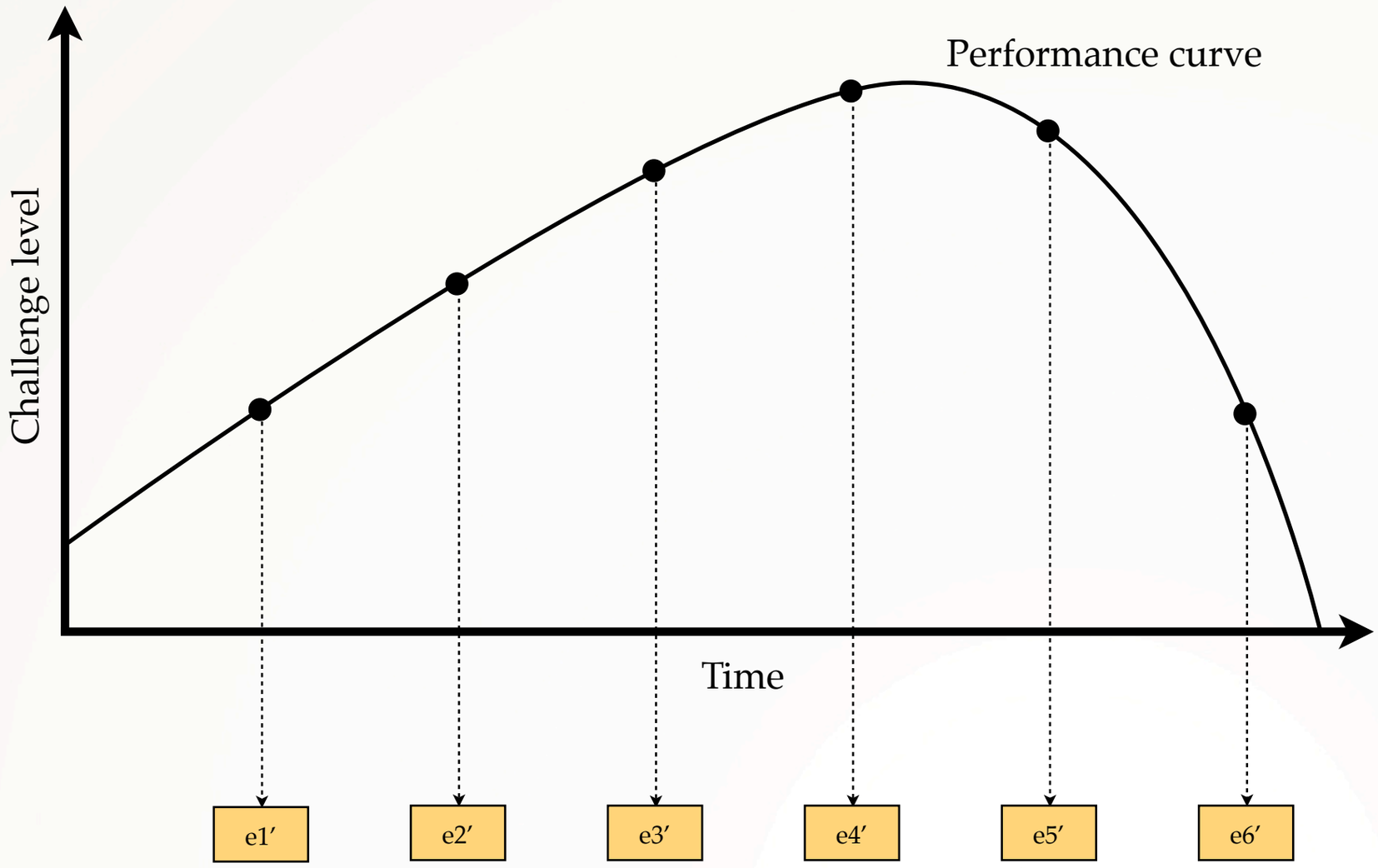
Time

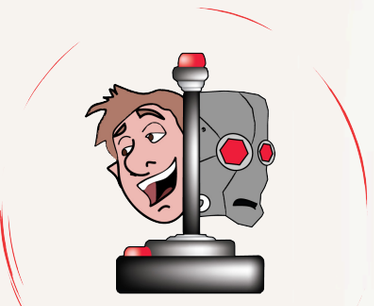


Plot content optimization

- Performance curve captures designer's intent
- Optimization via answer set programming







* Compare to original plot as input to challenge contextualization

Game world generation

Hartsook, Zook, Das & Riedl. Proc. CIG 2010 Conference.

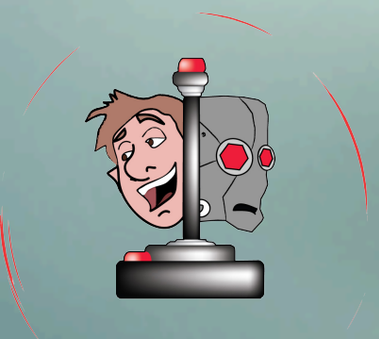
Story Generation

Computer Games

Narrative Intelligence

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?

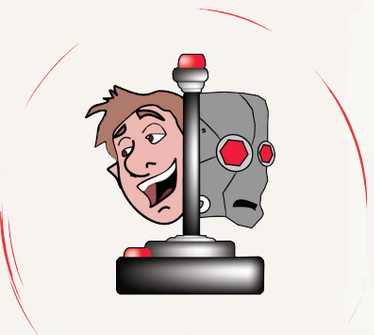


Learning sociocultural knowledge

- Humans rely on a lifetime of experiences from which to explain about 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

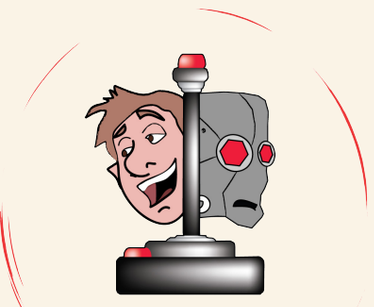
- Possible approaches:
  - Read natural language corpora & websites
  - Mine commonsense knowledge bases
  - Learn from humans

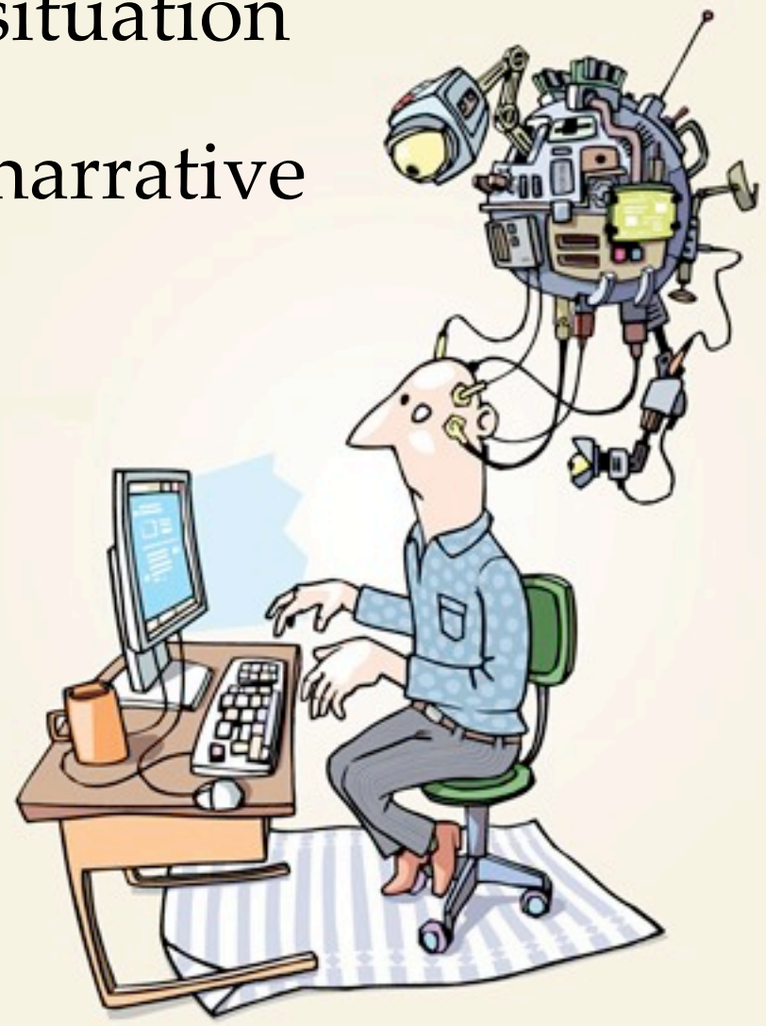


Crowdsourcing narrative intelligence

- 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

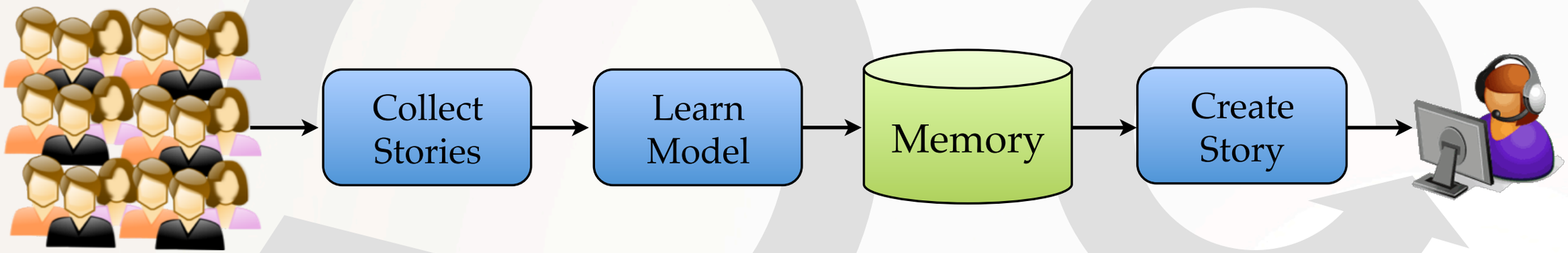
Automatically generate stories and interactive experiences **without** a priori domain knowledge authoring

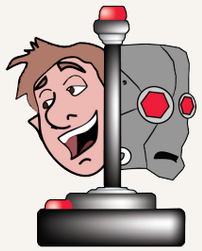




Scheherazade

- Just-in-time model learning
  - Semantic parsing, pattern mining, global optimization
  - Barthes: human narratives implicitly encode causality
  - Grice: maxims of quality and relevance (and quantity)





Li, Lee-Urban, Appling & Riedl. Advances in Cognitive Systems, 2, 2012.

Sociocultural knowledge representation

- Model a situation as a **script**
  - Representation of procedural knowledge
  - Tells the computer what to do and when to do it
  - Correlated with expertise
- Set of temporally ordered events
- Grounded in language

Sally chose item from the menu

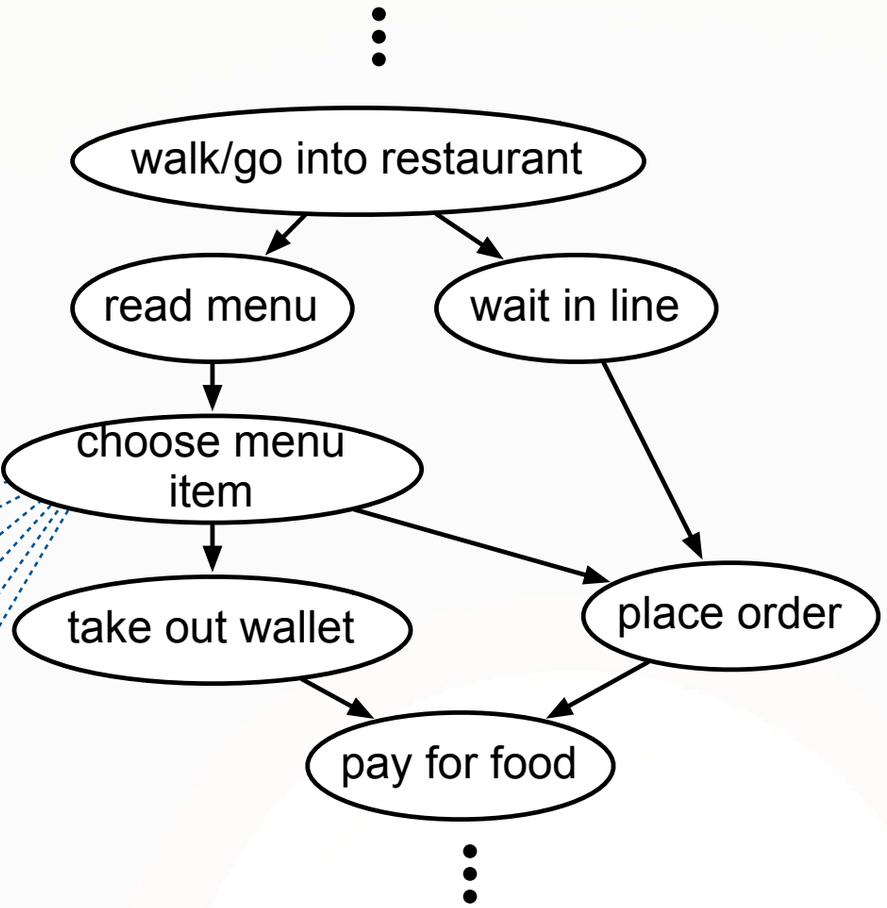
Sally thought about what Sally wanted

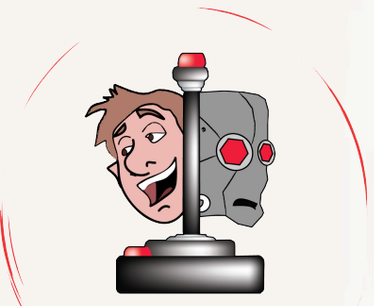
Sally decided what to order

Sally chose something from the menu

John made a selection

...



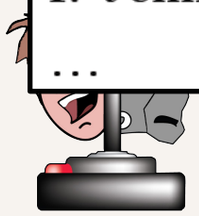


Learning to tell stories

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

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

Story A	Story B
a. John drives to the restaurant.	a. Mary looks at the menu.
b. John stands in line.	b. Mary decides what to order.
c. John orders food.	c. Mary orders a burger.
d. John waits for his food.	d. Mary finds a seat.
e. John sits down.	e. Mary eats her burger.
f. John eats the food.	…
…	



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

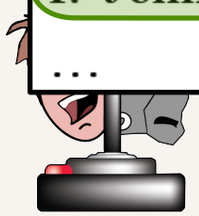
5. Active learning

Story A	Story B
a. John drives to the restaurant.	a. Mary looks at the menu.
b. John stands in line.	b. Mary decides what to order.
c. John orders food.	c. Mary orders a burger.
d. John waits for his food.	d. Mary finds a seat.
e. John sits down.	e. Mary eats her burger.
f. John eats the food.	…
…	

Order food

Eat food

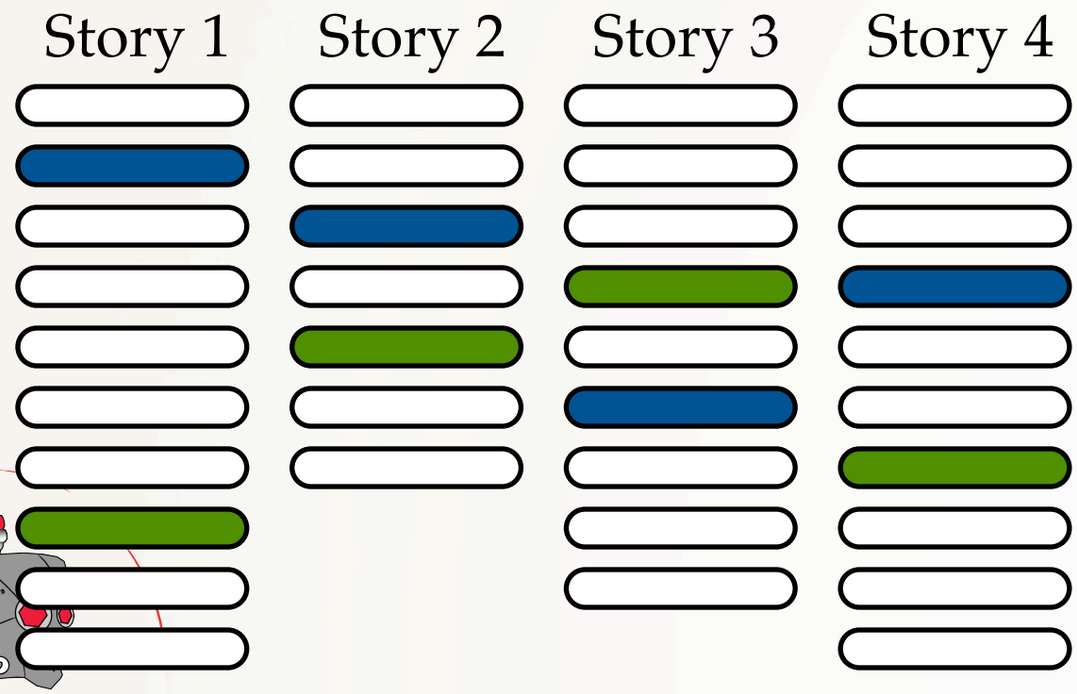
* Precision ≈ 85%

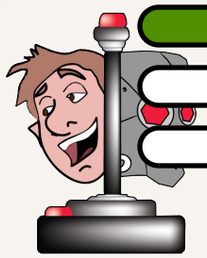


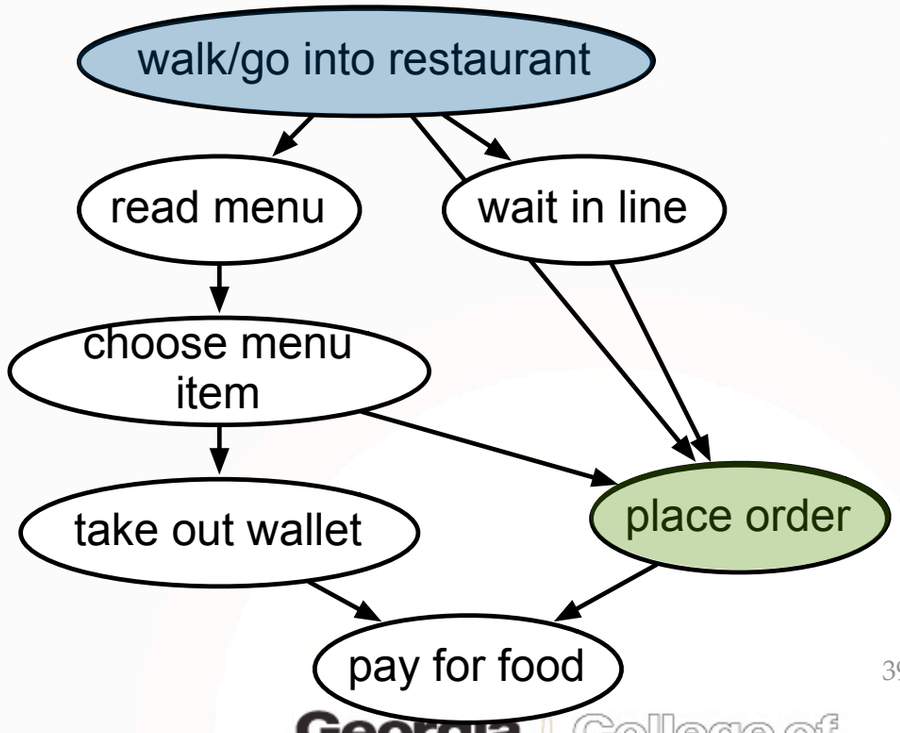
Learning to tell stories

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

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







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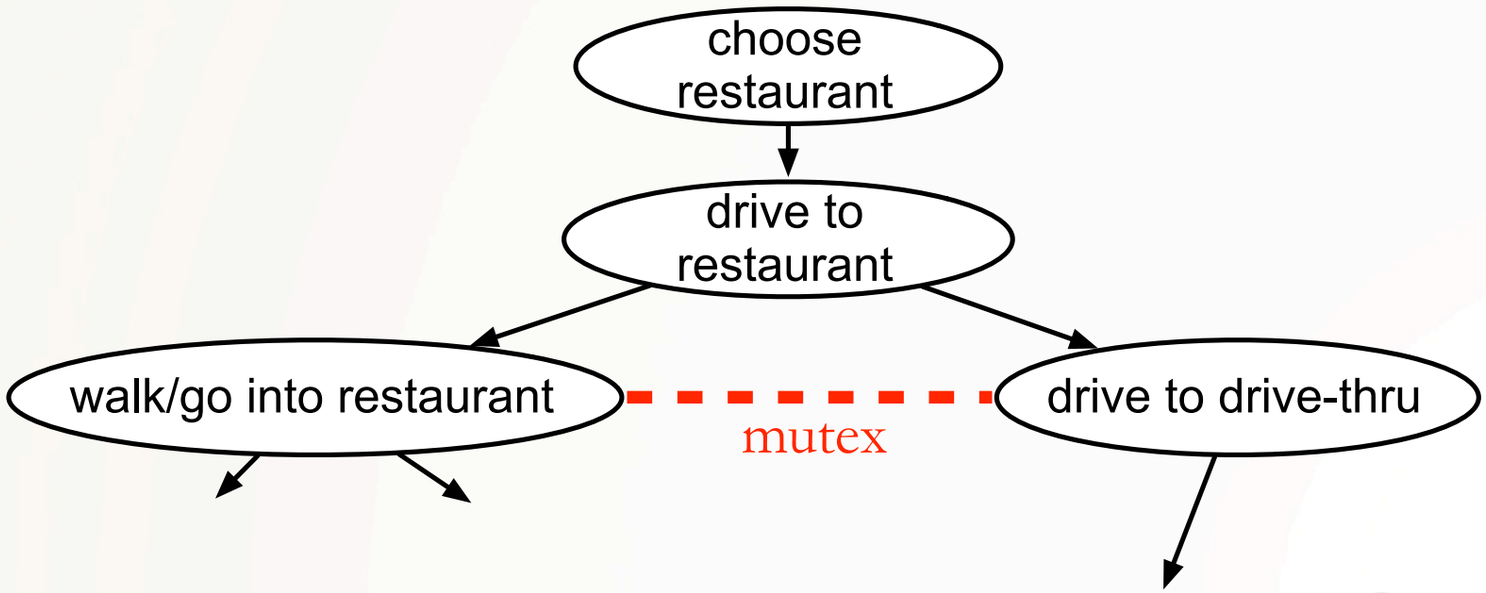
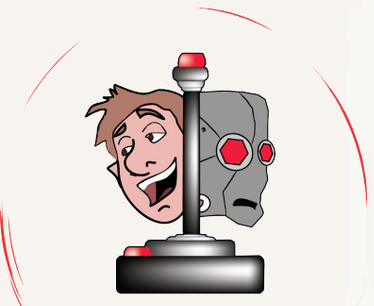
Learning to tell stories

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

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





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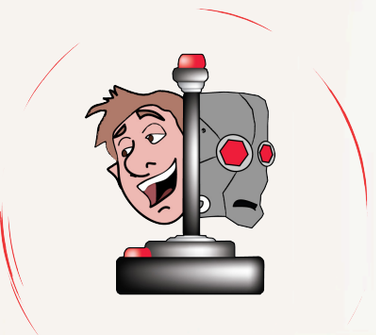
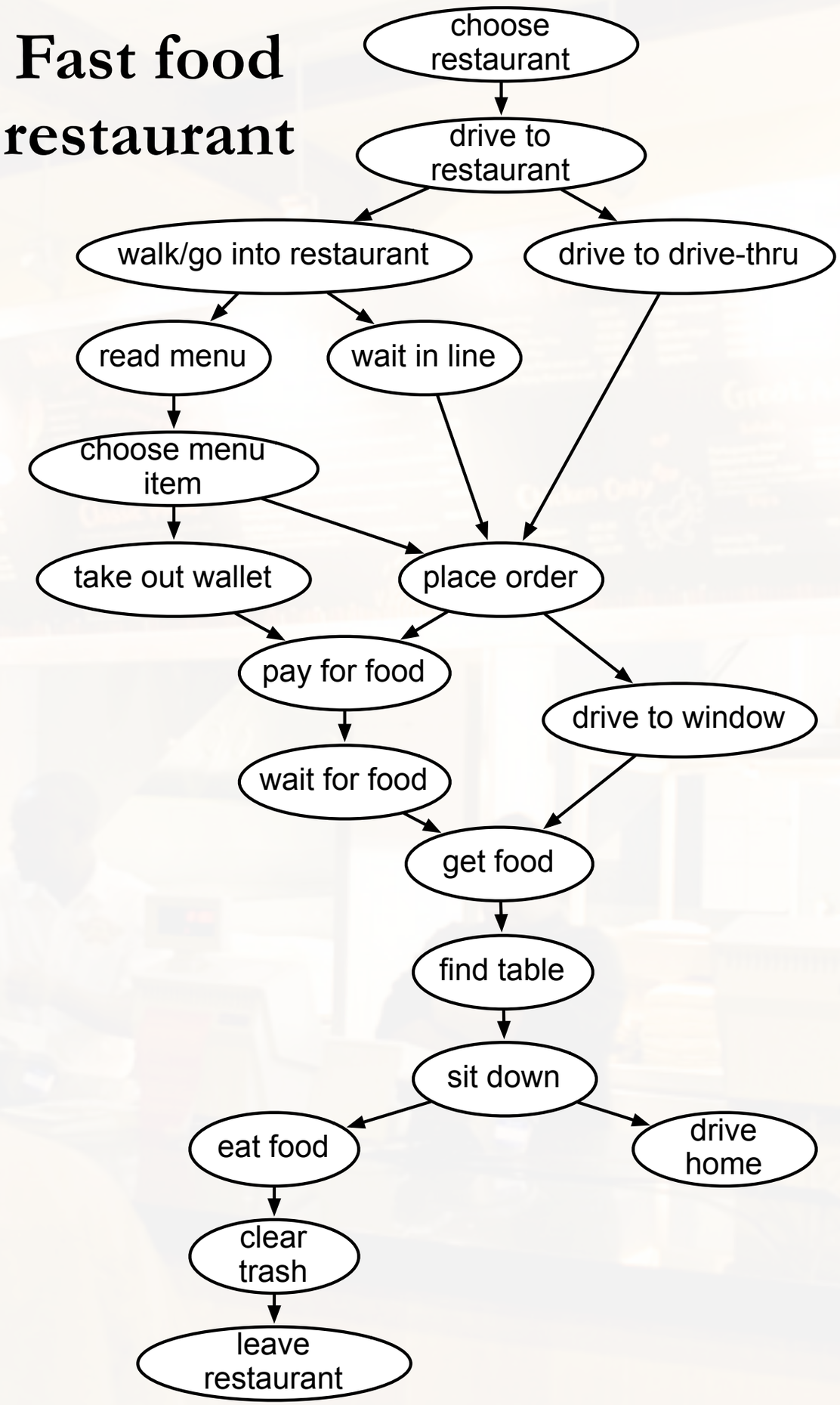
Learning to tell stories

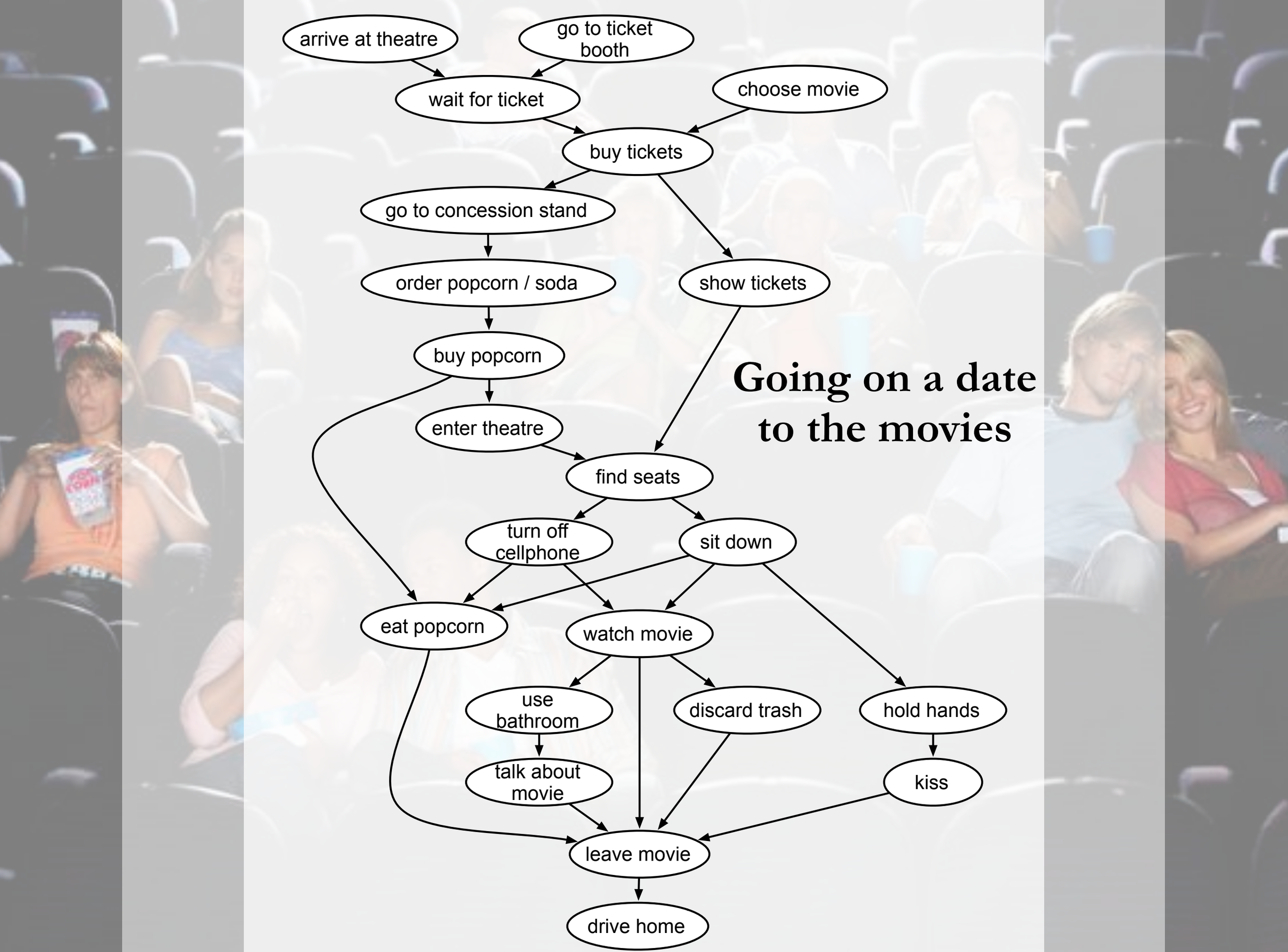
1. Query the crowd
2. Identify the salient events
3. Determine event ordering
4. Mutually exclusive events
5. **Active learning**

- Crowd can improve results at every stage of process
- Re-cluster
- Verify relations
- Acquire additional examples



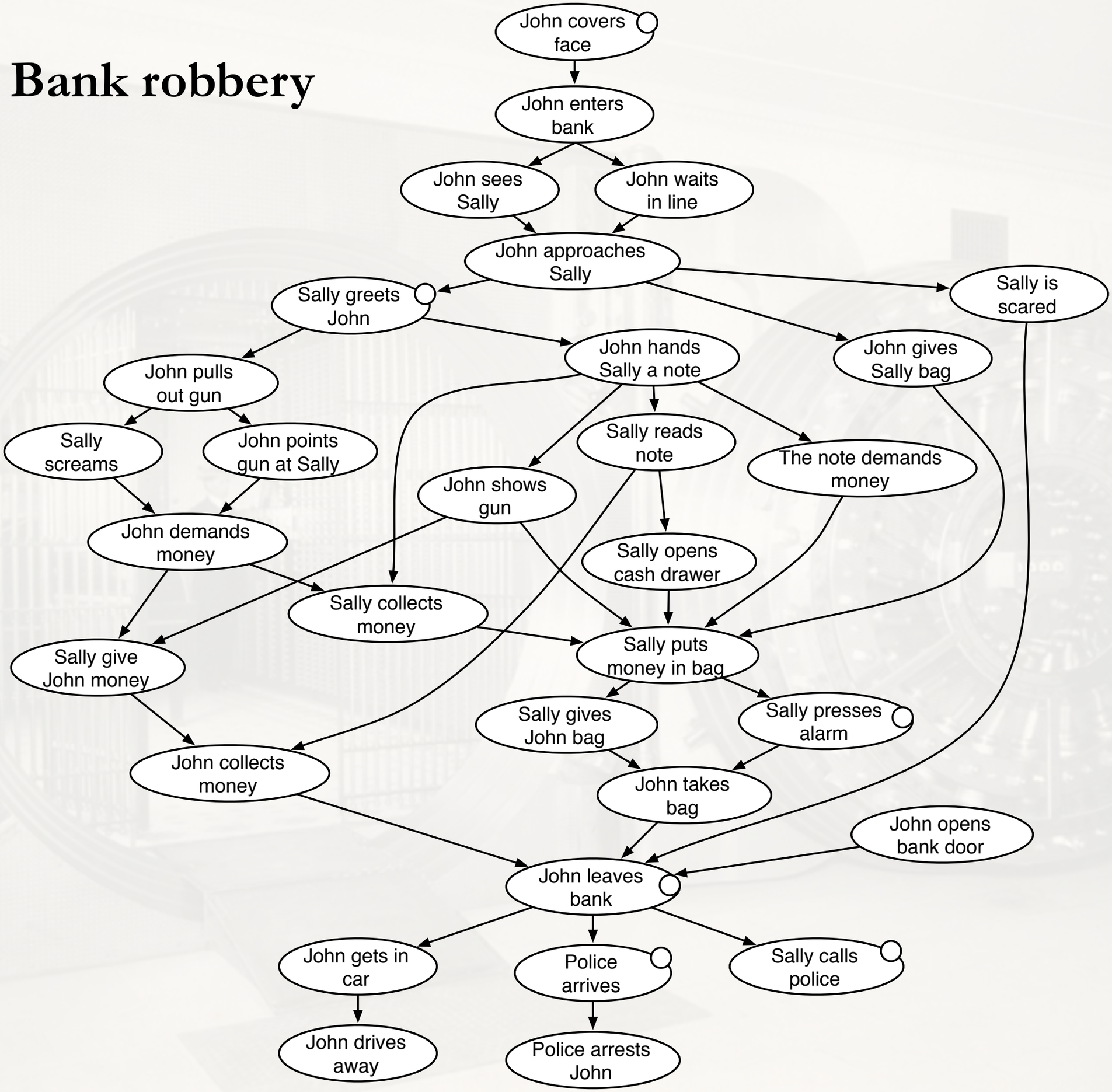
Fast food restaurant





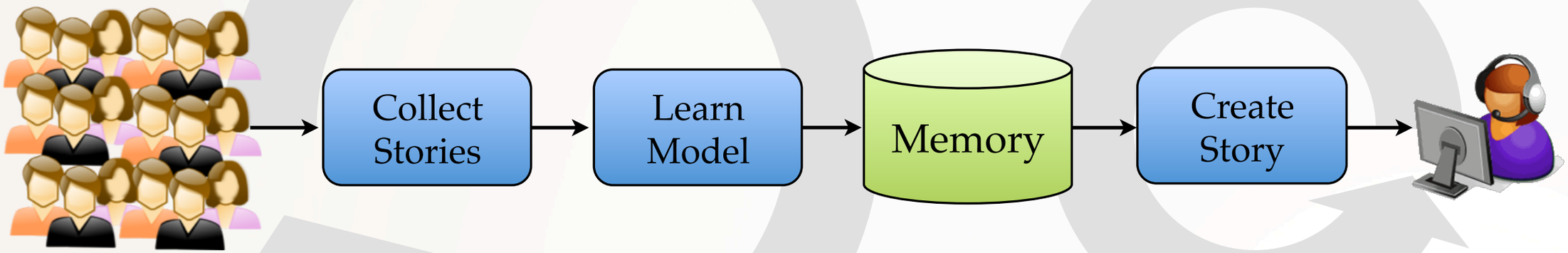
Going on a date to the movies

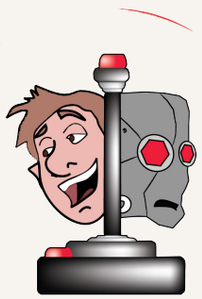
Bank robbery



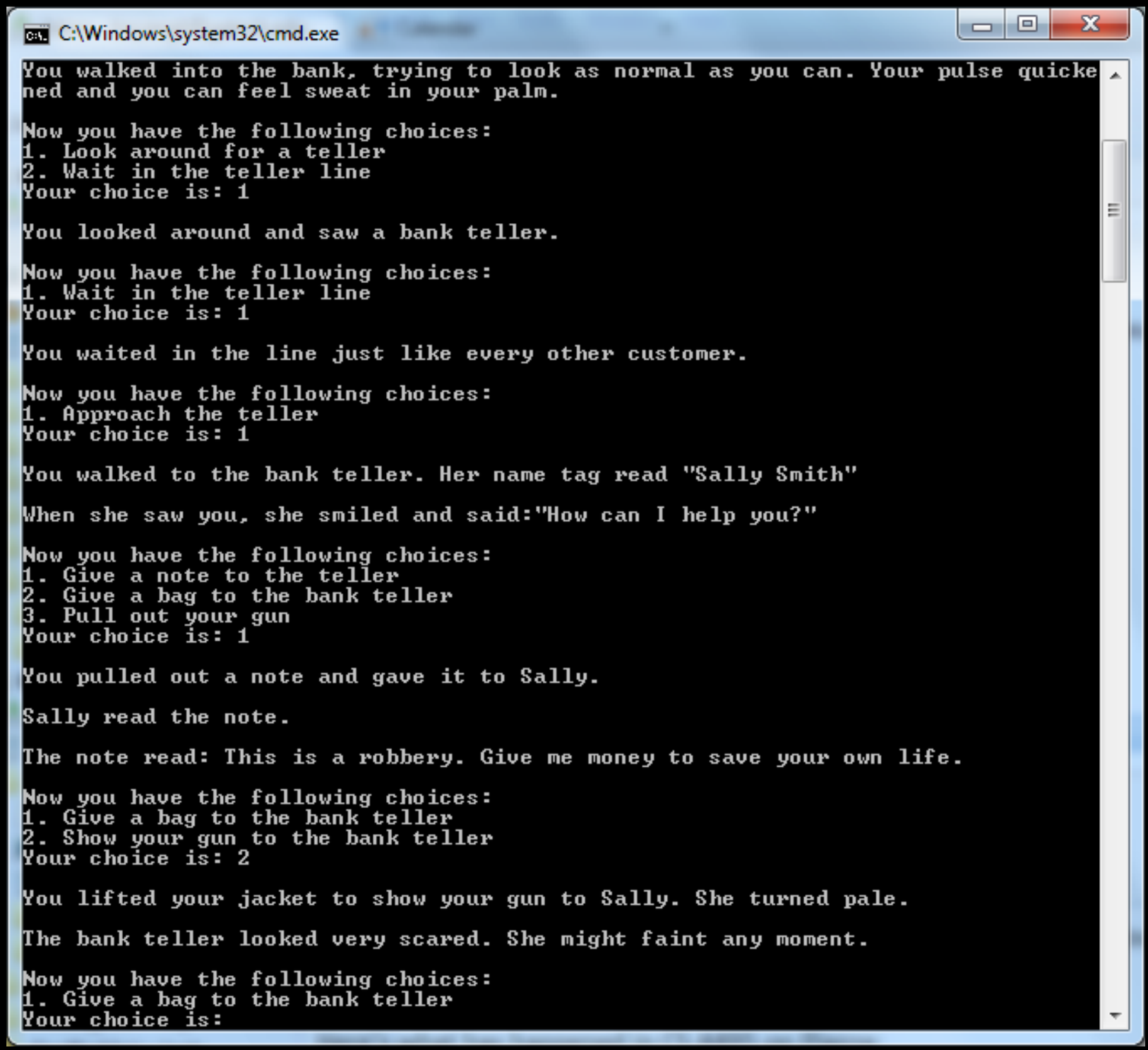
Narrative generation

- Script defines a space of linear sequences
  - Search for most typical, least typical, specific events, surprising, etc.
  - Comparable to human-authored stories





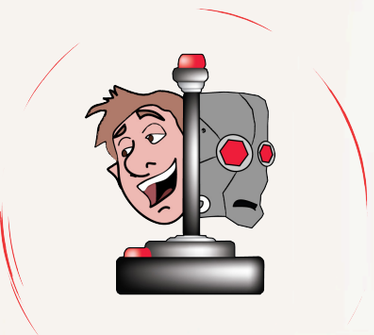
Interactive narrative generation

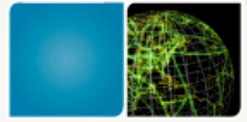


Li, Lee-Urban & Riedl. Proc. Intelligent Narrative Technologies 2012 Workshop.

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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- Andrew Stern
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- Don Dini
- Jason Alderman
- R. Michael Young

Walt Disney Imagineering

SAIC
From Science to Solutions

HUMANA
Guidance when you need it most

Thanks! Questions?

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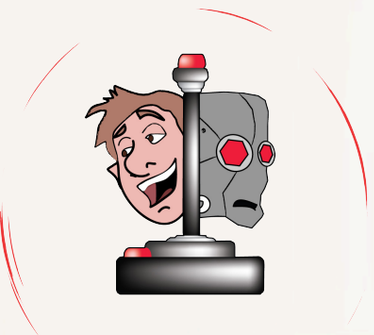

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