

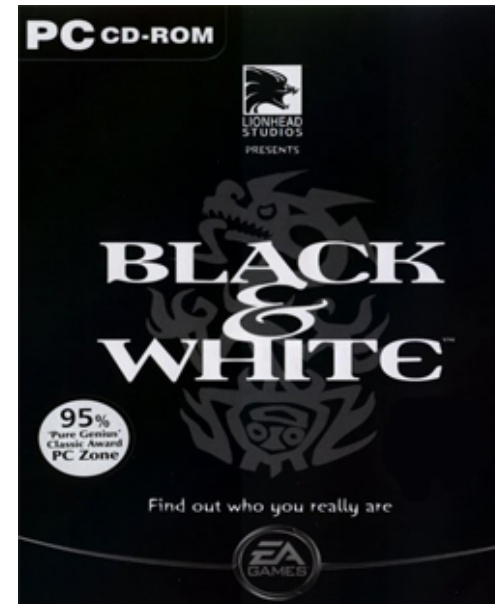
AI Storytelling in Games

Yun-Gyung Cheong

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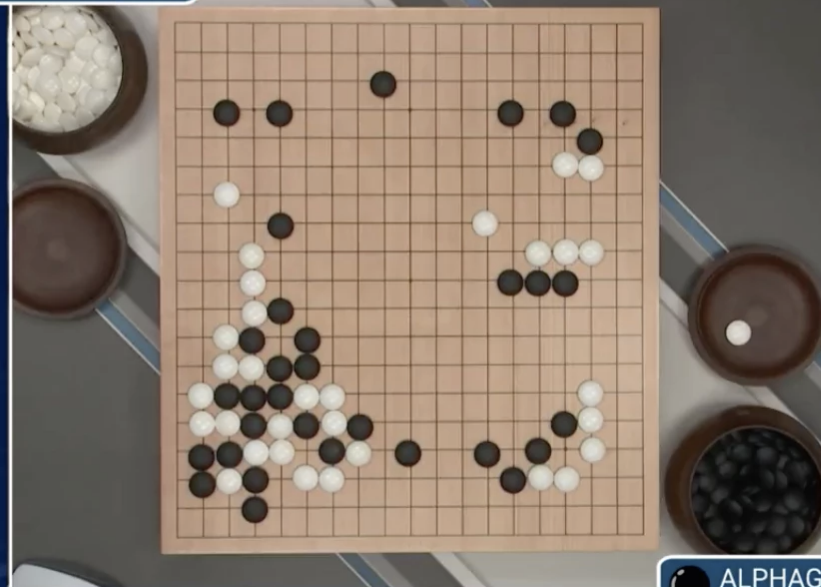
Department of Computer Engineering
SKKU

AI and Games



The founder of DeepMind Demis Hassabis himself was a chess player and AI game programmer

LEE SEDOL
01:00:30

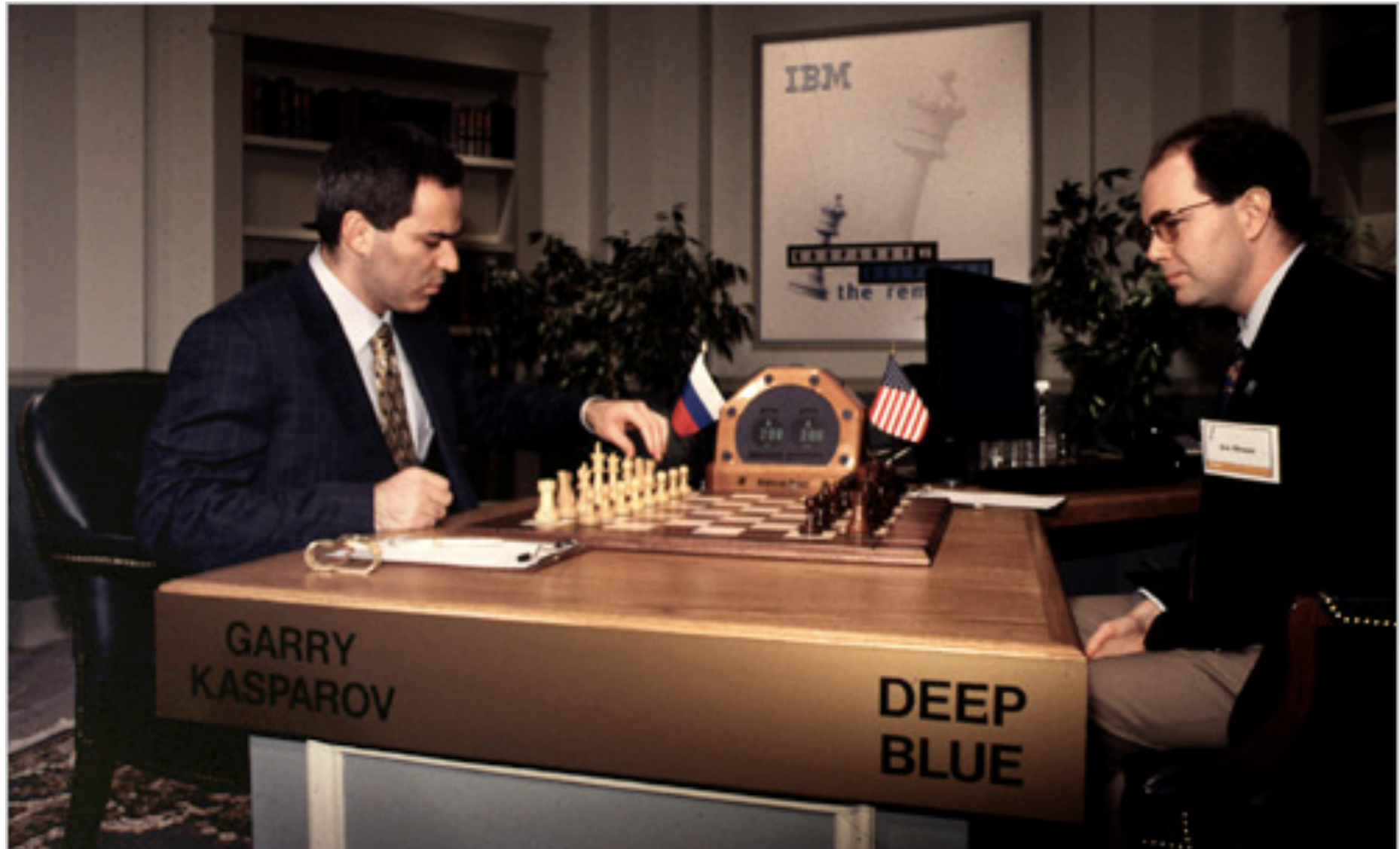


Google DeepMind
Challenge Match



ALPHAGO
01:22:04

AI and Games: Deep Blue (1977)



AI and Games: Jeopardy! (2011)



AI and Computer Games

- Serve as Test bed for AI
 - Interactive simulation environment
 - IBM Watson's **Q&A technique** is used for disease diagnosis, financial, and shopping domains
 - Alphago's underlying technology-**deep learning**- is planned to be used for medical and financial domains
- Present real world problems for AI
 - NPC (Non-Player Character) behaviors
 - Navigation
 - Fraud/bot detection
 - Numerous game item generation

Games with Stories

- Heavy Rain
- Indigo Prophecy
- Bioshock: Infinite
- L.A. Noire
- Dragon Age
- Fallout: New Vegas
- Assassin's Creed
- The Last of Us
- The Sims
- Myst
- Halo
- Tomb Raider
- Fable
- Half-life 2
- Portal 2
- Final Fantasy 4
- GTA 4



Quantic Dream Video Games



- Interactive drama action adventure game
- Sold over 700,000 units worldwide since it was released in 2005



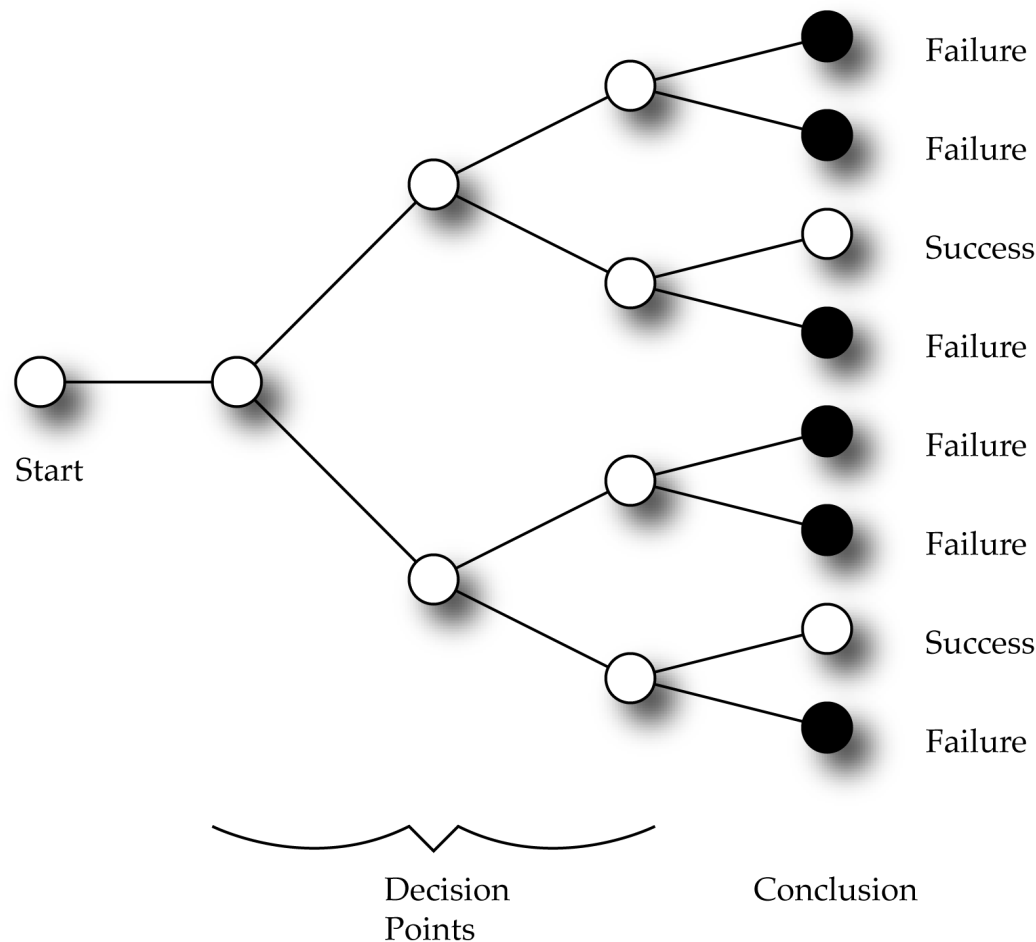
<https://youtu.be/HD5jc3CWVok?t=1081>

- Interactive drama action-adventure video game
- Film noir thriller genre
- Sold over 3M copies
- 4 main characters, 22 endings

<http://www.youtube.com/watch?v=xaBJun5hrko&feature=related>

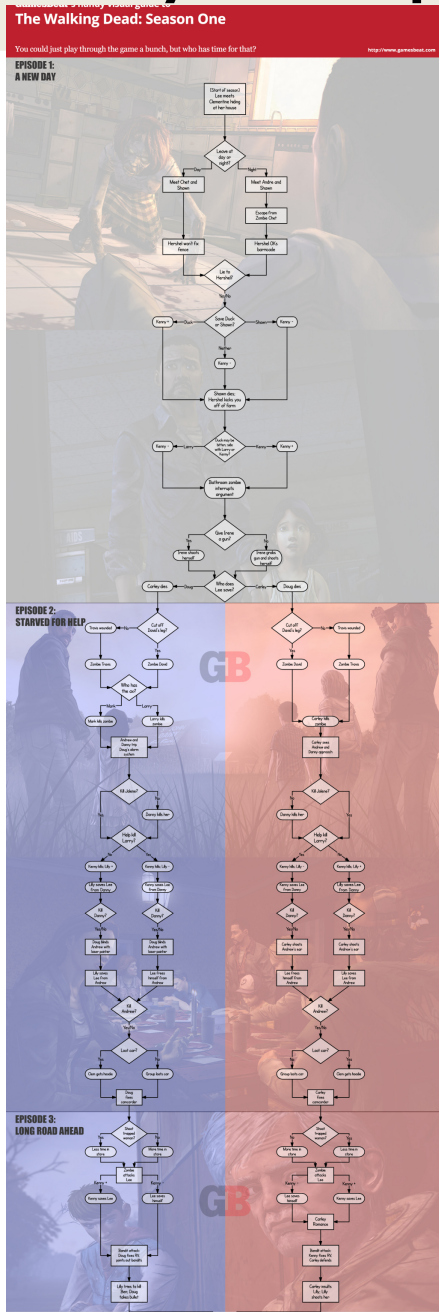
Branching Narrative Data Structure

- The story unfolds as the player makes a decision in the game
- Numerous different endings should be prepared




```

graph TD
    Start([Start of season  
Lee meets Clementine hiding  
at her house]) --> DayNight{Leave at  
day or  
night?}
    DayNight -- Day --> MeetChet[Meet Chet and  
Shawn]
    MeetChet --> HershelFix[Hershel won't fix  
fence]
    DayNight -- Night --> MeetAndre[Meet Andre and  
Shawn]
    MeetAndre --> Escape[Escape from  
Zombie Chet]
    Escape --> HershelOK[Hershel OKs  
barricade]
    HershelFix --> LieHershel{Lie to  
Hershel?}
    HershelOK --> LieHershel
    LieHershel -- Yes/No --> SaveDuck{Save Duck  
or Shawn?}
    SaveDuck -- Duck --> KennyPlus([Kenny +])
    SaveDuck -- Shawn --> KennyMinus([Kenny -])
    SaveDuck -- Neither --> KennyMinus
    KennyPlus --> ShawnDies([Shawn dies;  
Hershel kicks you  
off of farm])
    KennyMinus --> ShawnDies
    ShawnDies --> DuckBitten{Duck may be  
bitten, side  
with Larry or  
Kenny?}
    DuckBitten -- Larry --> KennyMinus
    DuckBitten -- Kenny --> KennyPlus
    KennyMinus --> Bathroom([Bathroom zombie  
interrupts  
argument])
    KennyPlus --> Bathroom
    Bathroom --> GiveGun{Give Irene  
a gun?}
    GiveGun -- Yes --> IreneShoots([Irene shoots  
herself])
    GiveGun -- No --> IreneGrabs([Irene grabs  
gun and shoots  
herself])
    IreneShoots --> WhoSave{Who does  
Lee save?}
    IreneGrabs --> WhoSave
    WhoSave -- Doug --> CarleyDies([Carley dies])
    WhoSave -- Carley --> DougDies([Doug dies])
  
```



Narrative

- Psychology: a form to understand the world and intentional human behavior (Bruner, 1991)
- Cultural studies: a way to propagate knowledge
- Narratology (literary studies): analyzing its properties and building blocks for story generation/comprehension
- Narrative Intelligence: Human ability to organize information/experience into narrative (Blair and Meyer, 1997)

https://www.youtube.com/watch?v=cBlRbrB_Gnc

Narrative Intelligence (Mateas and Sengers, 1998)

Narrative Definitions

- A chain of **events** in a **cause-effect** relationship occurring in **time** (Bordwell, 1980)
- A series of **connected events** caused/experienced by actors (Bal, 1985)
- A representation of **an event** or a series of **events** (Abbott, 2002)
 - My dog has fleas. (non-narrative)
 - My dog was bitten by a flea. (narrative)

Abbott (2002)

Narrative Intelligence

- Bruner (1991)
 - Construction of reality, a particular mode of thinking that relates to the concrete and particular as opposed to the abstract and general (e.g., scientific thinking)

https://www.youtube.com/watch?v=cBlRbrB_Gnc

Bruner, Jerome. The narrative construction of reality. *Critical Inquiry* 18, 1, 1-21. 1991.

소설 쓰는 AI



나고야대 전자정보시스템 전공 사토시 교수

- 일본의 '호시 신이치' 문학상에 응모해 1차 심사 통과
- 컴퓨터가 100% 썼다고 해도 상관없지만, 인간이 전부 썼다는 말도 맞다
- 이야기의 열개와 단어 등을 모두 직접 작성한 뒤, 이 단어들을 무작위로 재조합하는 프로그램을 이용해 소설을 만들었다.
- **"소설은 정답이 없는 영역이어서, 답을 찾아가는 과정인 머신러닝을 적용하지 않았다"**고 말했다.
- 소설의 내용과 흐름을 포함해 주어에 해당하는 단어, 목적어에 해당하는 수많은 단어를 모두 꼼꼼하게 미리 작성해 이 프로그래밍
- 2500자 정도의 단편소설을 생성하기 위해 수만 줄의 명령어로 프로그램을 작성

http://www.hani.co.kr/arti/science/science_general/749770.html

소설 쓰는 AI – the film *Sunspring*



Sunspring appeared in the Sci-Fi London film festival that includes the 48-Hour Film Challenge,

<http://media.daum.net/digital/others/newsview?newsid=20160614141940402>

소설 쓰는 AI - Benjamin

- Developed by Oscar Sharp and Ross Goodwin at NYU
- Benjamin, a self-improving LSTM RNN machine intelligence trained on human screenplays
 - learns about patterns in science fiction storytelling
- Sunspring appeared in the Sci-Fi London film festival that includes the 48-Hour Film Challenge (무작위로 정해진 소품, 한 두 줄의 대사가 영화에 등장하는 것을 조건으로 48시간내 완성)
 - 300여팀이 참가해 이중 180개 팀이 기한 내에 영화를 완성해 출품했다. '태양샘'은 여기서 심사위원단이 고른 상위작 10개 명단에 포함
- 한계
 - 이해할 수 없는 지시어. "He is standing in the stars and sitting on the floor."
 - 보통 이상으로 뛰어나지만 시나리오에서 유기적 연결성이 뚜렷이 부족하다 (르 몽드지)
 - 배우의 이름을 생각해낼 수 없다. 그래서 '태양샘'에 등장하는 배우의 이름은 H, H2, C이다.

<http://arstechnica.com/the-multiverse/2016/06/an-ai-wrote-this-movie-and-its-strangely-moving/>

Interview with Benjamin

What do you think of your historic nomination against human opponents in this contest?

I was pretty excited.

I think I can see the feathers when they release their hearts. It's like a breakdown of the facts. So they should be competent with the fact that they won't be surprised.

What is the future of machine written entertainment?

It's a bit sudden.

I was thinking of the spirit of the men who found me and the children who were all manipulated and full of children. I was worried about my command. I was the scientist of the Holy Ghost.

What's next for you?

Here we go. The staff is divided by the train of the burning machine building with sweat. No one will see your face. The children reach into the furnace, but the light is still slipping to the floor. The world is still embarrassed.

The party is with your staff.

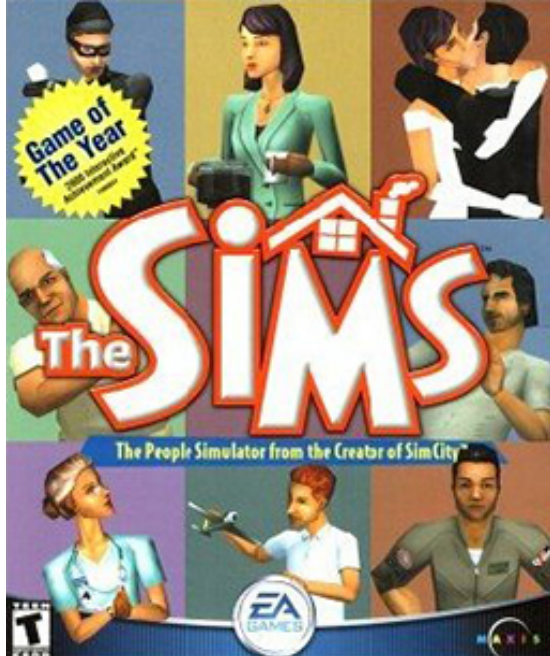
My name is Benjamin.

Narrative Generation Approaches

- Author-Centric
 - Talespin (Meehan, 1976), Universe (Lebowitz, 1985)
- Character-Centric
 - Rule-based approach: Sgurous (1999), Szilas (2001)

Character-centric Emerging Narrative

- Populate the game with characters and setting
- Undetermined events (i.e., plot and ending)
- Automated agent techniques are essential



Narrative Generation Techniques

- Planning
 - Talespin (Meehan, 1976), Universe (Lebowitz, 1985)
 - HTN (Cavazza group)
 - Partial Order Planning (Young, Riedl, Jhala, NCSU)
 - Reactive Planning (Mateas, UCSC)
- Reasoning
 - Rule-based approach: Sgurous (1999), Szilas (2001)
 - Case-based Reasoning (Minstrel by Turner 1994, Díaz-Agudo 2004, Swanson and Gordon 2012)
 - Story Grammar: Ryan (1999)

TALE-SPIN (Meehan, 1976)

- Simulator
 - **Problem-solver** that takes a goal as input, and recursively generates sub-goals until it produces events
 - **Memory** keeps track of the current world status
 - **Inference mechanism** produces the consequences of an event

Meehan (1977). TALE-SPIN, An Interactive Program that Writes Stories. Fifth International Joint Conference on Artificial Intelligence

Challenge in storytelling: A bad story example generated by Tale-Spin

One day Joe Bear was hungry. He asked his friend Irving Bird where some honey was. Irving told him there was a beehive in the oak tree. Joe threatened to hit Irving if he didn't tell him where some honey was.

A successful story – Joe Bear and Jack Bear

Once upon a time, there were two bears named Jack and Joe, and a bee named Sam. Jack was very friendly with Sam but very competitive with Joe, who was a dishonest bear. One day, Jack was hungry. He knew that Sam Bee had some honey to give him some. He walked from his cave, down the mountain trail, across the valley, over the bridge, to the oak tree where Sam Bee lived. He asked Sam for some honey. Sam gave him some. Then Joe Bear walked over to the oak tree and saw Jack Bear holding the honey. He thought that he might get the honey if Jack put it down, so he told him that he didn't think Jack could run very fast. Jack accepted the challenge and decided to run. He put down the honey and ran over the bridge and across the valley. Joe picked up the honey and went home.

Façade (Mateas and Stern, 2005)

- Real-time interactive drama game
- Dynamically generate stories
- Understand natural language



<https://www.youtube.com/watch?v=GmuLV9eMTkg>

Narrative and Plan Representation

- A narrative is **a sequence of actions or events** that are in causal relationships
 - E.g., A princess was locked in a castle. A prince rescued her. They fell in love. They got married.
- A plan is **a series of plan steps (action or event)** where steps are causally related to achieve the goal state from the initial state

AI Planning Components

- Consists of a problem, domain knowledge, and a search algorithm to find a solution to a given problem
- A **problem** consists of
 - Initial State: a set of conditions
 - (locked Princess)
 - Goal State: a set of conditions
 - (married Princess Prince)

Plan Library - knowledge

Operator: Rescue

Parameters: ?x ?y

Preconditions: (locked ?x)

Effects: \sim (locked ?x)

Operator: FallinLove

Parameters: ?x ?y

Preconditions: \sim (locked ?x)

\sim (locked ?y)

Effects: (inlove ?x ?y)

Operator: Marry

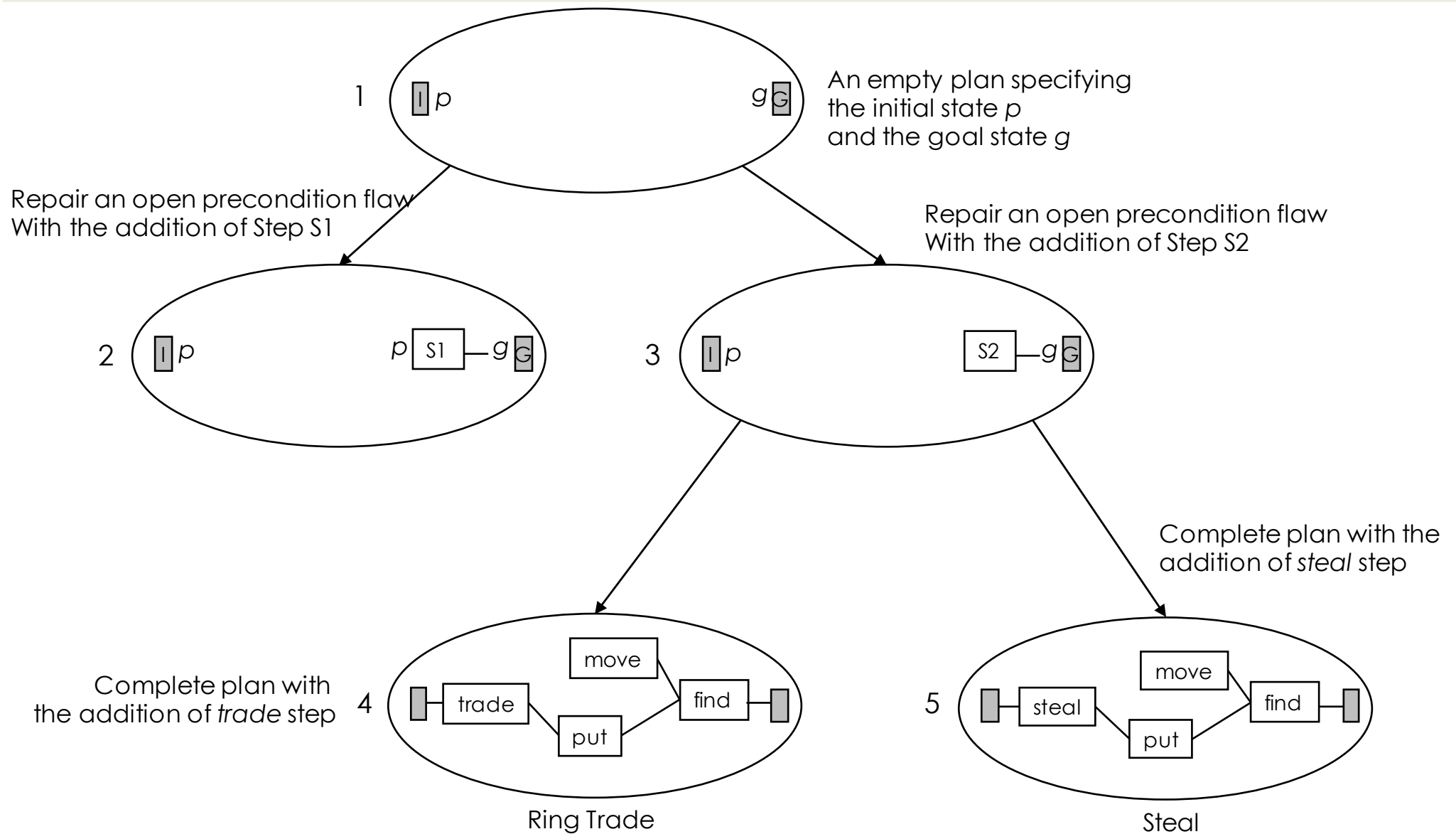
Parameters: ?x ?y

Preconditions:

(inlove ?x ?y)

Effects: (married ?X ?y)

Search Algorithm



INITIAL STATE

Initial Conditions

(locked Princess)

Plan Library

Operator: Rescue

Parameters: ?x ?y

Preconditions: (locked ?x)

Effects: \sim (locked ?x)

Operator: FallinLove

Parameters: ?x ?y

Preconditions: \sim (locked ?x)

\sim (locked ?y)

Effects: (inlove ?x ?y)

Operator: Marry

Parameters: ?x ?y

Preconditions:

(inlove ?x ?y)

Effects: (married ?X ?y)

temporal
ordering



Goal Conditions

(married Princess Prince)

GOAL STATE

INITIAL STATE

Initial Conditions

(locked Princess)

temporal
ordering

(inlove princess prince)

Marry (Princess, Prince)

(married Princess Prince)



Goal Conditions

(married Princess Prince)

GOAL STATE

INITIAL STATE

Initial Conditions

(locked Princess)

Plan Library

Operator: Rescue

Parameters: ?x ?y

Preconditions: (locked ?x)

Effects: \sim (locked ?x)

Operator: FallinLove

Parameters: ?x ?y

Preconditions: \sim (locked ?x)

\sim (locked ?y)

Effects: (inlove ?x ?y)

Operator: Marry

Parameters: ?x ?y

Preconditions:

(inlove ?x ?y)

Effects: (married ?X ?y)

(inlove princess prince)

Marry (Princess, Prince)

(married Princess Prince)



(married Princess Prince)

Goal Conditions

GOAL STATE

temporal
ordering

INITIAL STATE

(locked Princess)

$\sim(\text{locked Princess})$ $\sim(\text{locked Prince})$

FallinLove (Princess, Prince)

(inlove princess prince)



(inlove princess prince)

Marry (Princess, Prince)

(married Princess Prince)

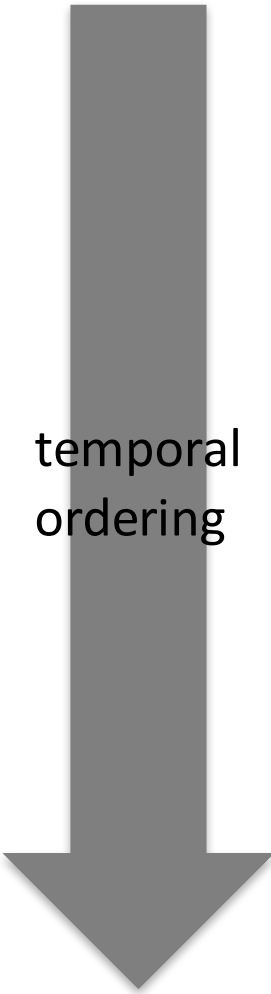


(married Princess Prince)

Goal Conditions

GOAL STATE

temporal
ordering



INITIAL STATE

Initial Conditions

(locked Princess)

Plan Library

Operator: Rescue

Parameters: ?x ?y

Preconditions: (locked ?x)

Effects: \sim (locked ?x)

Operator: FallinLove

Parameters: ?x ?y

Preconditions: \sim (locked ?x)

\sim (locked ?y)

Effects: (inlove ?x ?y)

Operator: Marry

Parameters: ?x ?y

Preconditions:

(inlove ?x ?y)

Effects: (married ?X ?y)

\sim (locked Princess) \sim (locked Prince)

FallinLove (Princess, Prince)

(inlove princess prince)

(inlove princess prince)

Marry (Princess, Prince)

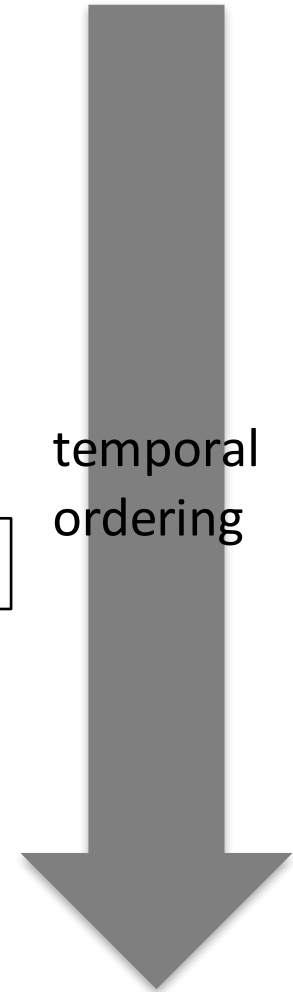
(married Princess Prince)

(married Princess Prince)

Goal Conditions

GOAL STATE

temporal
ordering



INITIAL STATE

Initial Conditions

(locked Princess)



(locked Princess)

Rescue(Princess, Prince)

\sim (locked Princess)



\sim (locked Princess) \sim (locked Prince)

FallinLove (Princess, Prince)

(inlove princess prince)



(inlove princess prince)

Marry (Princess, Prince)

(married Princess Prince)

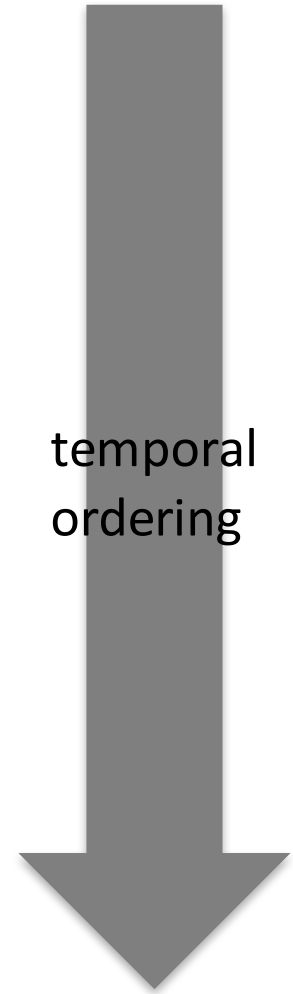


(married Princess Prince)

Goal Conditions

GOAL STATE

temporal
ordering



NARRATIVE GENERATION FOR SUSPENSE

Narrative Generation for Suspense

- Suspense can be defined as “*feeling of excitement or anxiety that audience members feel when they are anticipating the occurrence of some event and are uncertain about the event’s outcome*”
- Suspense impacts greatly on the reader’s enjoyment (Brewer and Lichtenstein, 1982; Alwitt, 2002)



Cognitive Theory about Suspense

- Suspense and problem solving (Gerrig and Bernardo 1994)
 - Readers act as problem-solvers
 - Readers constantly attempt to solve the protagonist's dilemmas
 - Suspense is related to the number of perceived solutions to the protagonist's current problem
 - More solutions, less suspense
 - Fewer solutions, more suspense

Heuristic function to measure suspense

Readers feel more suspense as the perceived solutions to the protagonist's problem decreases

$$suspense = \frac{1}{NumberofPlans(story, Goal)}$$

- Our system finds a subset of story (length = N) that results in the least number of solutions

INITIAL STATE

Initial Conditions

(has Dad ring)

(at Ben room)

(has Dad ring)

Trade (Dad, ring, toy)

(has Dad toy)

(has Dad toy)

Steal (Thief, Dad, toy)

\neg (has Dad toy) (criminal Thief) (has Thief toy)

(criminal Thief)

Arrest (Police, Thief)

(has Police toy) \neg (has Thief toy)

(has Police toy)

Give (Police, Dad, toy)

(has Dad toy) \neg (has Police toy)

(has Dad toy)

Put (Dad, toy, under-tree)

(at toy tree)

(at toy tree)

Find (Ben, toy, tree)

(has Ben toy)

Move (Ben, tree)

(at Ben tree)

(at Ben room)

(criminal Thief)

Goal Conditions

GOAL STATE

INITIAL STATE

Initial Conditions

(has Dad ring)

(at Ben room)

(has Dad ring)

Trade (Dad, ring, toy)

(has Dad toy)

(has Dad toy)

Steal (Thief, Dad, toy)

\neg (has Dad toy) (criminal Thief) (has Thief toy)

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Arrest (Police, Thief)

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(has Police toy)

Give (Police, Dad, toy)

(has Dad toy) \neg (has Police toy)

(has Dad toy)

Put (Dad, toy, under-tree)

(at toy tree)

(at toy tree)

Find (Ben, toy, tree)

(has Ben toy)

Move (Ben, tree)

(at Ben tree)

(at Ben room)

(criminal Thief)

Goal Conditions

GOAL STATE

INITIAL STATE

Initial Conditions

(has Dad ring)

(at Ben room)

(has Dad ring)

Trade (Dad, ring, toy)

(has Dad toy)

(has Dad toy)

Steal (Thief, Dad, toy)

\neg (has Dad toy) (criminal Thief) (has Thief toy)

The Reader infers solutions

Goal Conditions

(has Ben toy)

(criminal Thief)

GOAL STATE

INITIAL STATE

Initial Conditions

(has Dad ring)

(at Ben room)

(has Dad ring)

Trade (Dad, ring, toy)

(has Dad toy)

(has Dad toy)

Steal (Thief, Dad, toy)

\neg (has Dad toy) (criminal Thief) (has Thief toy)

(criminal Thief)

Arrest (Police, Thief)

(has Police toy) \neg (has Thief toy)

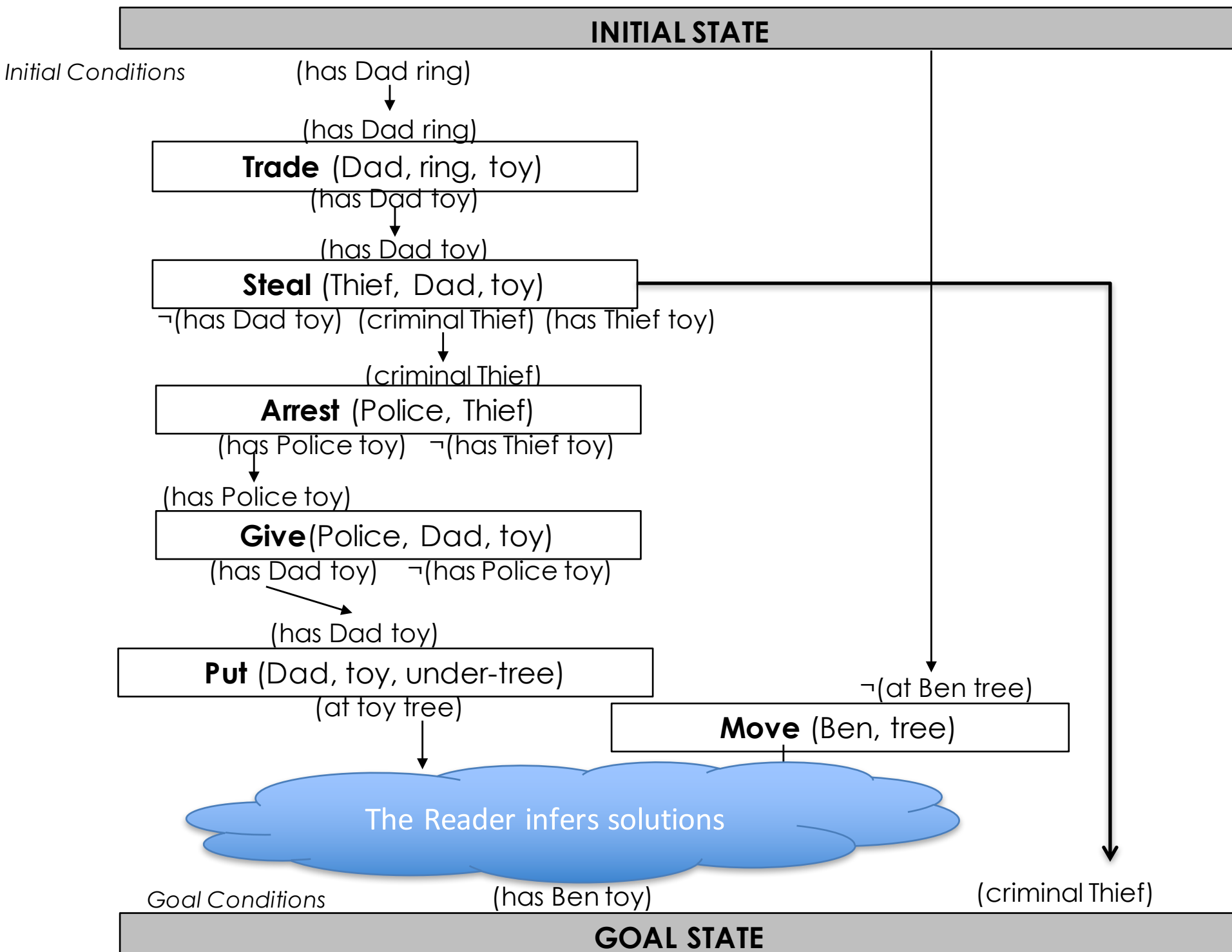
The Reader infers solutions

Goal Conditions

(has Ben toy)

(criminal Thief)

GOAL STATE



INITIAL STATE

Initial Conditions

(has Dad ring)

(at Ben room)

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Trade (Dad, ring, toy)

(has Dad toy)

(has Dad toy)

Steal (Thief, Dad, toy)

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(criminal Thief)

Arrest (Police, Thief)

(has Police toy) \neg (has Thief toy)

(has Police toy)

Give (Police, Dad, toy)

(has Dad toy) \neg (has Police toy)

(has Dad toy)

Put (Dad, toy, under-tree)

(at toy tree)

Move (Ben, tree)

(at Ben room)

of solutions = 2

Goal Conditions

(has Ben toy)

(criminal Thief)

GOAL STATE

Heuristic function to measure suspense

Readers feel more suspense as the perceived solutions to the protagonist's problem decreases

$$suspense = \frac{1}{NumberofPlans(story, Goal)}$$

INITIAL STATE

Initial Conditions

(has Dad ring)

(at Ben room)

(has Dad ring)

Trade (Dad, ring, toy)

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\neg (has Dad toy) (criminal Thief) (has Thief toy)

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(has Police toy) \neg (has Thief toy)

(has Police toy)

Give (Police, Dad, toy)

(has Dad toy) \neg (has Police toy)

(has Dad toy)

Put (Dad, toy, under-tree)

(at toy tree)

Move (Ben, tree)

(at Ben room)

of solutions = 2 \rightarrow $\frac{1}{2}$

\rightarrow 0.5 suspense

Goal Conditions

(has Ben toy)

(criminal Thief)

GOAL STATE

(1) Erica installs a wiretap in Smith's home while he is away. (2) Erica eavesdrops on the phone conversation in which Smith is given the order to rescue Dr. Cohen. (3) Erica meets with Smith. (4) Erica tells Smith that her father was kidnapped by Jack and taken to Skeleton Island, and she asks Smith to save her father. (5) Erica gives Smith the blueprints of Jack's fortress, with her father's cell marked. (6) Erica provides Smith with a boat for transportation to Skeleton Island. (7) Before going to the island, Smith hides a diamond in his shoe. (8) Smith goes to the port containing Erica's boat. (9) Smith rides the boat to Skeleton Island. (10) Smith sneaks into the cell marked on the map containing Erica's father. (11) Jack and his guard capture Smith as he enters the cell. (12) The guard disarms Smith. (13) The guard locks Smith into the cell.

[suspense measured]

(14) Smith bribes the guard with the diamond in his shoe. (15) The guard unlocks the door. (16) Smith leaves the cell. (17) Smith sneaks to the lab where Dr. Cohen is captured. (18) Smith fights the guards in the lab. (19) Smith takes Dr. Cohen from the lab. (20) Smith and Dr. Cohen ride the boat to shore.

System

Erica tells Smith that her father was kidnapped by Jack and taken to Skeleton Island, and she asks Smith to save her father. Erica provides Smith with a boat for transportation to Skeleton Island. Before going to the island, Smith hides a diamond in his shoe. **Smith rides the boat to Skeleton Island. Smith sneaks into the cell marked on the map containing Erica's father. Jack and his guard capture Smith as he enters the cell. The guard disarms Smith. The guard locks Smith into the cell.**

[suspense measured]

Human Author

Erica eavesdrops on the phone conversation in which Smith is given the order to rescue Dr. Cohen. **Erica tells Smith that her father was kidnapped by Jack and taken to Skeleton Island, and she asks Smith to save her father.** Erica gives Smith the blueprints of Jack's fortress, with her father's cell marked. Smith goes to the port containing Erica's boat. **Smith rides the boat to Skeleton Island. Smith sneaks into the cell marked on the map containing Erica's father. Jack and his guard capture Smith as he enters the cell. The guard locks Smith into the cell.**

[suspense measured]

Effect on the reader's suspense

Means suspense ratings for each story generator type

System (N=98)	Human author (N=98)	Control (N=98)
2.70	2.69	2.32

■ One-tailed t-test summary

Comparisons	t Value	Pr > t
System vs. Human	0.07	0.007
System vs. Control	2.56	0.006**
Human vs. Control	2.50	0.007**

AI Storytelling Topics

- **Story Generation**
- Story Comprehension
- Character Believability
- Drama Management
- Reader Modeling
- User Interfaces
- Visualization
- Natural Language Processing
- Virtual Reality

Summary

- AI and Games
- AI storytelling
 - TALE-SPIN, Façade
 - Planning
 - More topics
- Story Generation for Suspense
- More topics

Q&A

- 성균관대학교, 소프트웨어대학
- 정윤경
- Email to ygcheong@gmail.com