

Computational Modeling of Narrative Texts, Films and Games

Course 3 - Time and space

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Time and space

- Genette's typology of narrative space and time
- Burch's taxonomy of filmic space and time
- Reasoning about time and change
- Discrete Event Calculus
- The snowman
- Paris, I love you
- Back to the future
- New disorders : Pulp fiction, Inception, Memento, Eternal sunshine of the spotless mind

Genette's typology

ANALYTICAL CATEGORIES	ELEMENTS ANALYZED	COMPONENTS			
NARRATIVE MOOD	DISTANCE	Narratized speech	Transposed speech, indirect style	Transposed speech, free indirect style	Reported speech
	FUNCTIONS OF THE NARRATOR	Narrative function	Directing function	Communication function	Testimonial function
NARRATIVE INSTANCE	NARRATIVE VOICE	Homodiegetic narrator	Heterodiegetic narrator		Autodiegetic narrator
	TIME OF NARRATION	Subsequent narration	Prior narration	Simultaneous narration	Interpolated narration
NARRATIVE LEVELS	NARRATIVE PERSPECTIVE	Zero focalization	Internal focalization		External focalization
	EMBEDDED NARRATIVES	Extra-diegetic	Intra-diegetic	Meta-diegetic	Meta-meta-diegetic, etc.
NARRATIVE TIME	METALEPSIS	Breaching of narrative levels			
	ORDER	Analepsis	Prolepsis	Reach	Extent
	NARRATIVE SPEED	Pause	Scene	Summary	Ellipsis
	FREQUENCY OF EVENTS	Singulative	Repeating		Iterative

Frequency

- An event can occur once and be narrated once (singular).
 - 'Today I went to the shop.'
- An event can occur n times and be narrated once (iterative).
 - 'I used to go to the shop.'
- An event can occur once and be narrated n times (repetitive).
 - 'Today I went to the shop' + 'Today he went to the shop' etc.
- An event can occur n times and be narrated n times (multiple).
 - 'I used to go to the shop' + 'He used to go to the shop' + 'I went to the shop yesterday' etc.

Order

- Say a story is narrated as follows: the clues of a murder are discovered by a detective (event A); the circumstances of the murder are finally revealed (event B); and lastly the murderer is caught (event C).
- Add corresponding numbers to the lettered events that represent their order chronologically: 1, 2, and 3.
- If these events were described chronologically, they would run B1, A2, C3. Arranged in the text, however, they run A2 (discovery), B1 (flashback), C3 (resolution).
- This accounts for the 'obvious' effects the reader will recognise, such as flashback. It also deals with the structure of narratives on a more systematic basis, accounting for flash-forward, simultaneity, as well as possible, if rarely used effects. These disarrangements on the level of order are termed 'anachrony'.

Duration

- The separation between an event and its narration means that there is discourse time and narrative time. These are the two main elements of duration.
- "Five years passed", has a lengthy narrative time, five years, but a short discourse time (it only took a second to read).
- James Joyce's novel *Ulysses* has a relatively short narrative time, twenty-four hours. Not many people, however, could read *Ulysses* in twenty-four hours. Thus it is safe to say it has a lengthy discourse time.

Time in films

- Discourse time = movie time (two hours)
 - Movie time never stops
- Narrative time = story time
 - Bullet time (story time stops)
 - Descriptions
 - Real-time (Hitchcock's *Rope*, Varda's *Cleo*)
 - Ellipses (twenty years later)

Space and time in films

- Movie shots are continuous in time and in space
- Cuts between shots introduce discontinuities
 - Keep or change viewpoint and location
 - Keep or change time - shorter or longer ellipsis, flashback
- Noel Burch : At least $2^3 - 1 = 7$ possible space-time cuts (pure viewpoint, pure location, pure ellipsis, pure flashback, ellipsis and viewpoint, ellipsis and location, flashback and viewpoint, flashback and location)

Time in games

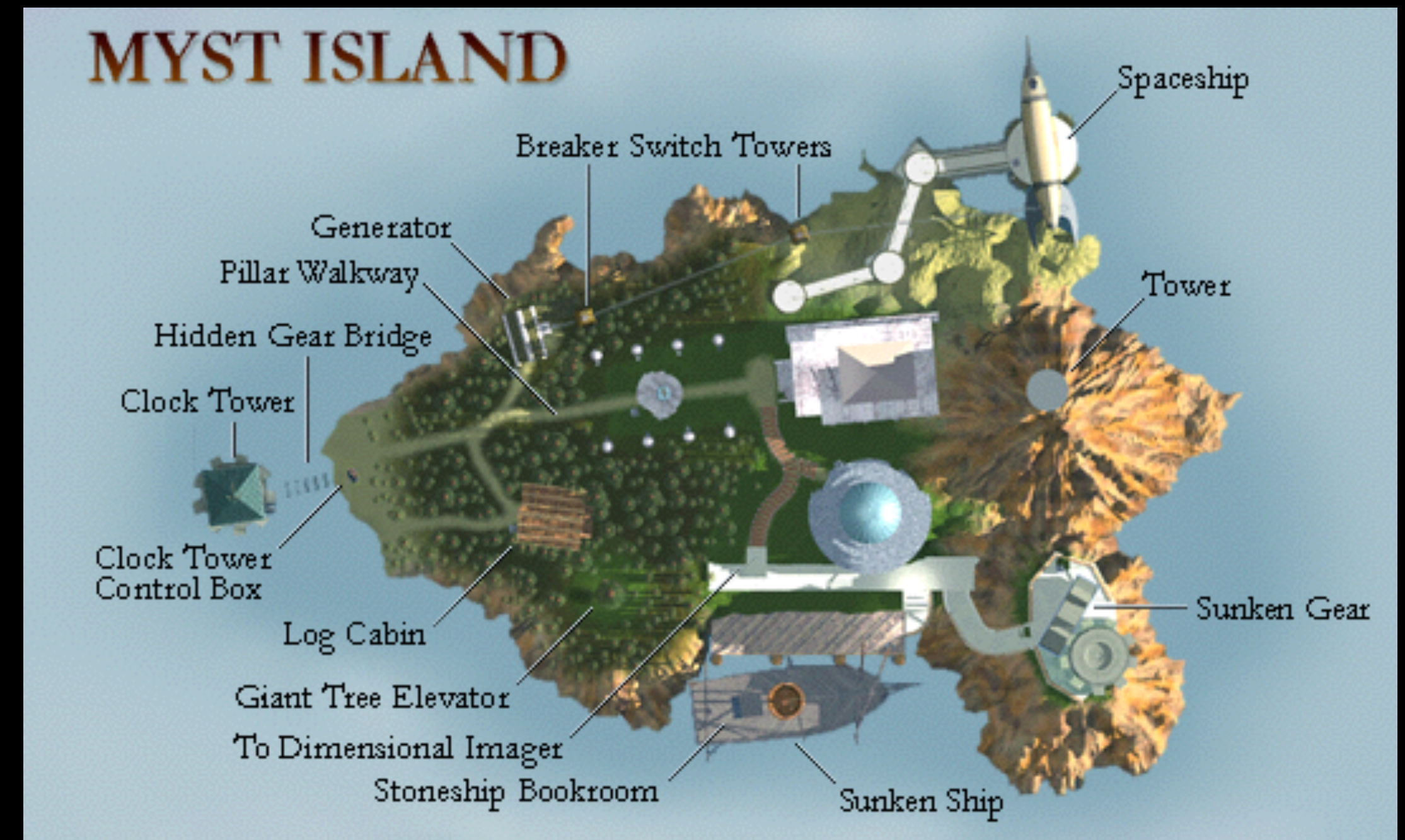
- Games can be re-played until player succeeds
- Multiple outcomes are possible
- This does not usually happen in film (Groundhog Day)
- Games can be reset and re-started
- Player can die and be born again multiple times

Space in films

- Audience is « directed » by cinematography, lightng, editing, etc.
- Actions take place onscreen and offscreen

Space in games

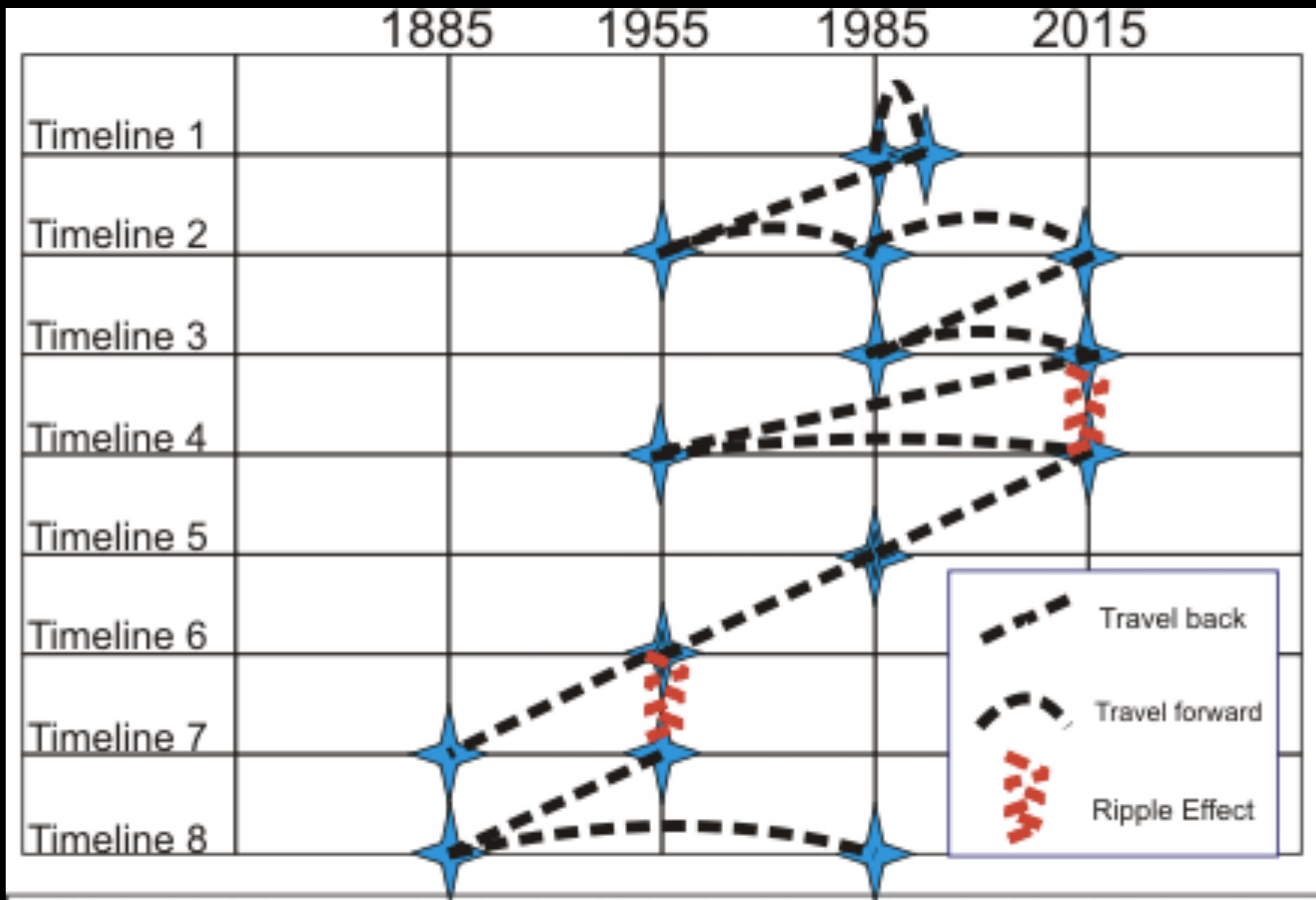
- Game levels introduce new spaces
- The player can move around levels
- Player actions are voluntary (unlike camera movements in film)
- Player is not « directed » and can change viewpoint and location freely



Story time vs movie time

- My dinner with André
- Le jour se lève
- Cléo de 5 à 7
- Memento
- Inception
- Twelve angry men
- Eternal sunshine of the spotless mind

Back to the future



TL1: 1985: Einstein moves 1 minute into the future. Marty then travels to 1955 creating timeline 2.
 TL2: 1955: Marty changes elements of his parent's history then moves forward to 1985. The Doc then travels to 2015.
 TL3: 2015: Doc arrives in 1985 and takes Marty and Jennifer to 2015 to solve a problem with Marty Jr. Whilst there, Old Biff steals the De Lorean and travels to 1955 creating timeline 4.
 TL4: 1955 Old Biff gives Young Biff the Almanac and changes history so drastically that he is no longer alive (he would have died in the 1990s). The ripple effect removes him from the Timeline. Doc and Marty head back to 1985 as the ripple effect is transforming TL3 into TL4.
 TL5: The Doc and Marty arrive in 1985A and realise what has happened. They go to 1955 to solve it.
 TL6: Whilst in 1955 the De Lorean is struck by lightning and sends the Doc back to 1885. The ripple effect cleanses the TL6 into TL7.
 TL7: A delivery man hands Marty instructions the Doc wrote in 1885 and Marty travels to 1885 to save him.
 TL8: Marty helps Doc and travels back to 1985.



Movie time in Pulp Fiction

- The movie starts on day 1 with Pumpkin and Honey Bunny preparing for a holdup
- Then flashback to Vincent and Jules earlier the same day
- Then flashforward to Vincent's evening with Mia
- Then flashback again to that same morning
- Flashback 20 years then flash forward to day 2 and 3 with Butch's story where Vincent dies
- Flashback to day 1 with the hold up (and Vincent alive)

Characters in Pulp Fiction

- Jules
 - plan
 - attributes
 - actions
 - goals
 - evaluations



- Vincent
 - plan
 - attributes
 - actions
 - goals
 - evaluations



Characters in Pulp Fiction

- Fabienne
 - plan
 - attributes
 - actions
 - goals
 - evaluations



- Butch
 - plan
 - attributes
 - actions
 - goals
 - evaluations



Characters in Pulp Fiction

- Honey Bunny
 - plan
 - attributes
 - actions
 - goals
 - evaluations



- Pumpkin
 - plan
 - attributes
 - actions
 - goals
 - evaluations



Characters in Pulp Fiction

- Mia
 - plan
 - attributes
 - actions
 - goals
 - evaluations



- Marcellus
 - plan
 - attributes
 - actions
 - goals
 - evaluations



Chronology of Pulp Fiction

- Twenty years ago : the story of Butch and his father's watch and its travels as told by Butch's father's friend Captain Koons.
- Day 1: Vincent and Jules are driving to an apartment to retrieve Marcellus' attache case and the property within, and to kill the occupants. It is a hit. There is a third man hiding in the bathroom. He bursts out shooting and miraculously misses hitting Jules and Vincent. Jules experiences an epiphany.
- Vincent and Jules take Marvin into their car but Vincent accidentally blows off Marvin's head, causing a very large bloody mess in the car. Jules calls his old pal Jimmie, and they drive there to find a way to get out of this mess.
- Jimmie calls Marcellus who summons Wolf (the fixer), and he is dispatched to Jimmie's house. Jules and Vincent clean up the car, change into those ridiculous shorts and t-shirts provided by Jimmy after they have cleaned off the blood and brain pulp from their bodies. They follow The Wolf to Monster Joe's Truck & Tow and the car and the body are safely disposed of.

Chronology of Pulp Fiction

- Day 1 (later that morning)
- Jules and Vincent go to a diner to eat before going to Marcellus' bar to drop off the attache case. Jules continues his discussion of the miracle he felt he witnessed, and that he is going to be leaving "the life". Vincent interrupts to go to the bathroom.
- Pumpkin and Honey Bunny decide to stage a robbery at the diner where they feel they can score big, and hold everyone at bay with guns and threats of murder. They collect wallets, and are confronted by Jules when he refuses to give up the briefcase. Through intimidation, Jules gets back his wallet, but gives the robbers his money. He does not kill them, he explains, because of this recent miracle he experienced.

Chronology of Pulp Fiction

- Day 1 (later that morning continued)
- Vincent and Jules go to Marcellus' bar (still dressed in shorts and t-shirts) to deliver their cache. They have to wait because Marcellus is talking to a washed-up palooka boxer named Butch. Butch is being paid off to throw a fight the next night. As Butch leaves, he and Vincent verbally tee off, but Butch backs down and leaves.
- Jules and the bartender are exchanging amusing looks with reference to Vincent's evening assignment. He is to escort Marcellus' wife, Mia, out for the evening. Vincent and Jules have talked about this before, while they were waiting to burst into the apartment on their hit.

Chronology of Pulp Fiction

- Day 1 (early evening): Vincent goes to his drug dealer's house and buys heroin. The dealer puts it in a baggie. Vincent shoots up, and then leaves for his evening with Mia. They go to a bizarre retro 50's club. They eat, talk, and enter a dance contest, which they win.
- Back at Mia's house, Vincent goes to the bathroom to try and figure out how he can leave without getting into trouble. While he is in the bathroom, Mia sings and dances around the room. She finds the heroin in Vincent's pocket, and has an overdose.
- Vincent rushes her to his drug dealer Lance's house in hopes of getting help. With a giant hypodermic needle full of adrenaline, Mia is revived. Vincent takes her home, and they both agree that Marcellus never need know of the events of the evening.

Chronology of Pulp Fiction

- Day 2 (early evening): Butch has a dream then jumps up, ready for his fight.. However, instead of throwing the fight, he KO's his opponent, and kills him. He jumps into a cab and goes to the motel where his girlfriend is waiting. They make love and go to sleep. Marcellus is furious, and orders Butch found and killed.

Chronology of Pulp Fiction

- Day 3 (early in the morning): Butch realizes that his girlfriend forgot his watch back in his apartment. He goes back to his apartment for his watch. Marcellus has put out a hit, and dispatched Vincent to wait for Butch should he return to his apartment. Butch does return, but as Vincent is once again in the bathroom, and is able not only to retrieve his watch, but to kill Vincent as well. Vincent's story is done.
- Butch feels lucky. He drives away and literally bangs into Marcellus on the street carrying burgers and cokes. There is a bloody confrontation, and Marcellus chases Butch into a sleazy gun shop.

Chronology of Pulp Fiction

- The owner brings them both down to the basement, which is an S/M playground. Marcellus is chosen to be the victim first, and Butch is able to untie himself and flee.
- On the way out, Butch decides to go back and save Marcellus with a Samurai sword. Marcellus is being raped by one of the men, and Butch saves him by shooting the other guy. Marcellus is appropriately thankful. Butch is free to go, providing he never mention this to anyone, or come back to L.A. again.
- Butch rides off on "Grace", Zed's chopper, and returns to the waiting arms of his girlfriend Fabienne back at the motel. They both ride off happily into the sunset, heading to Knoxville. Butch is the winner in a story of losers.

Space and Time in Eternal Sunshine of the Spotless Mind

- Wednesday 19th November 2003: Joel Barish is bored at the prospect of being a boring couple with Clem Kruczynski, as they have dinner at Kang's again.
- Wednesday 11th February 2004: Joel Barish asks for Clem Kruczynski to be erased from his mind.
- Friday 13th February 2004: Stan and Patrick erase Clem from Joel's mind as he sleeps.
- Saturday 14th February 2004: Joel takes a train to Montauk instead of going to work, and meets Clem (again); Mary the receptionist quits her job at the clinic.
- Sunday 15th February 2004: Clem and Joel visit the frozen Charles River.
- Monday 16th February 2004: Mary the ex-receptionist sends out tapes to all former patients; Clem and Joel realise they erased each other.



Space and Time in Eternal Sunshine of the the Spotless Mind

Starts on day 2

Then flashback to day 1
with parallel actions in reality (forward)
and in Joel's memory (backward)

Then flashforward to day 2 and day 3



Eternal Sunshine of the Spotless Mind Timeline

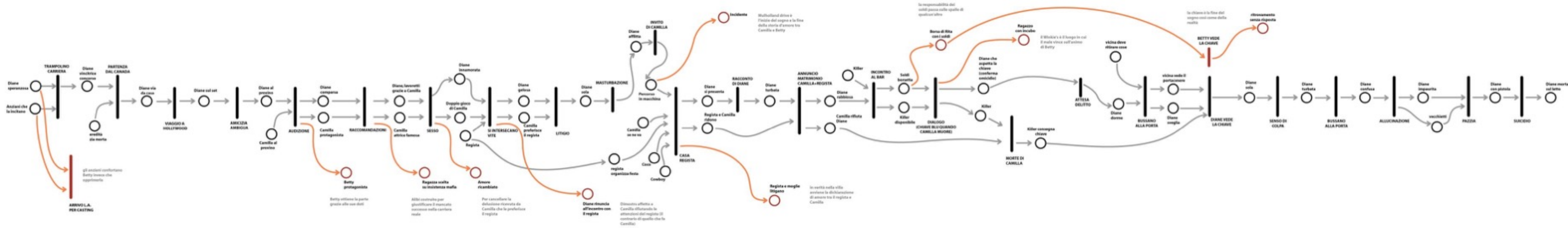
John Sadauskas
<http://johnsadauskas.com>

Boris Vian in *Eternal Sunshine of the Spotless Mind*

- L'Herbe rouge narre les aventures d'un ingénieur nommé Wolf, créateur d'une machine pouvant lui faire revivre son passé et ses angoisses pour les oublier.
- L'Arrache-cœur narre le parcours de Jacquemort, psychiatre qui est en fait une capacité vide et cherche à se remplir en psychanalysant les gens, en assimilant leurs pensées et dont deux des personnages se prénomment Clémentine et Joël.
- La maison au bord de l'océan est également une reprise de celle de L'Arrache-cœur, qui était déjà inspirée de la maison d'enfance de Boris Vian, à Landemer.

Space and Time in Mulholland Drive

- Two versions of the same story
 - First as a dream
 - Then as reality
- Petri net representation of story / discourse



Reasoning about time and change

- Things change over time
 - In the living room, Lisa picked up a newspaper and walked into the kitchen.
 - Kate set a book on the coffee table and left the living room. When she returned, the book was gone. Someone must have take it.
- Commonsense law of inertia = things stay the same unless affected by some event.
 - Jamie goes to the kitchen sink, puts the stopper in the drain, turns on the faucets and leaves.

Reasoning about time and change

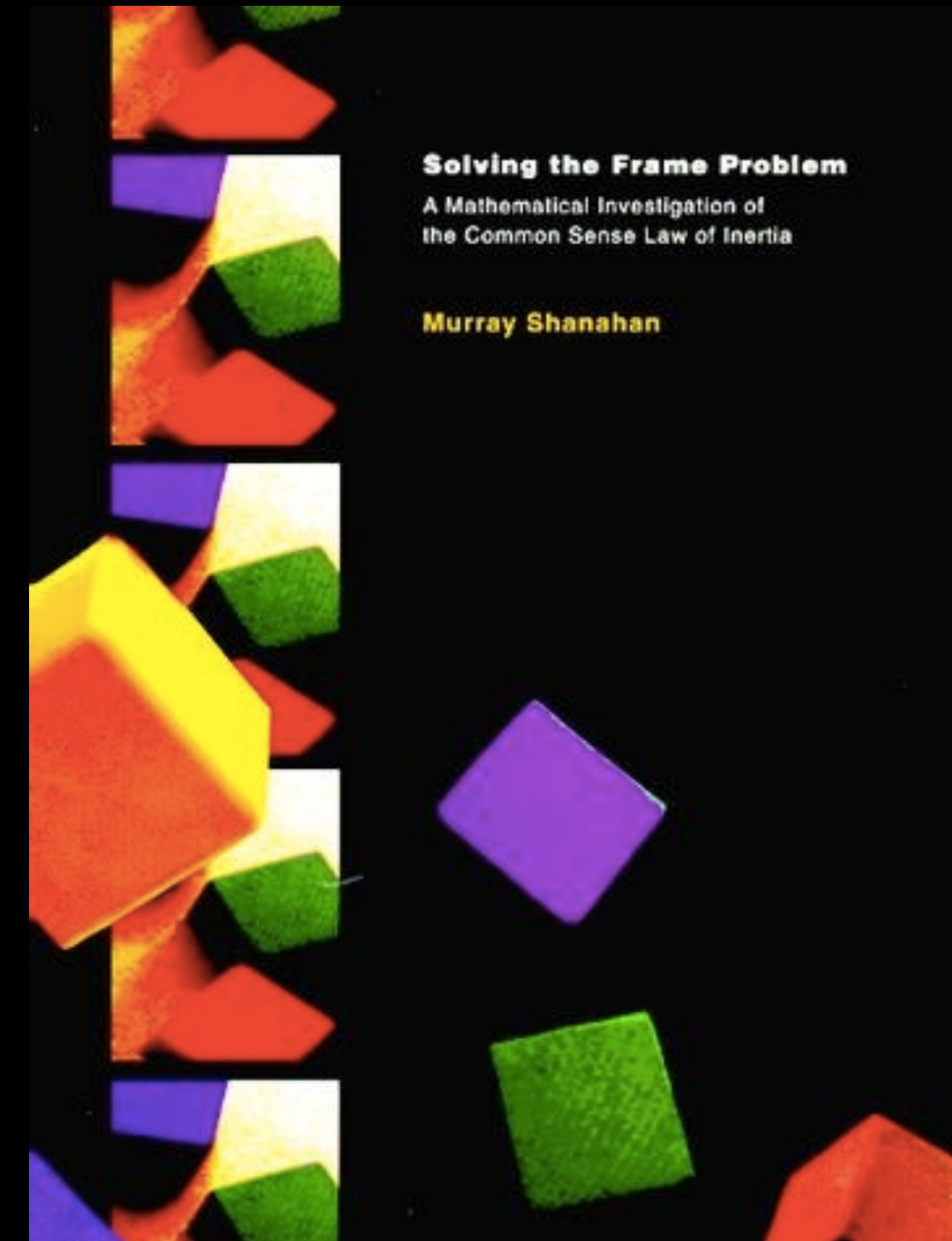
- Default reasoning
 - Kimberley turns on the fan. It starts turning ... or not (maybe it was not plugged in)
- Mental events
 - A hungry cat saw some food on a table. The cat jumped onto a chair.

Reasoning about time and change

- Prediction (temporal projection) from initial state and events to final state.
- Abduction (explanation) from initial and final states to events.
- Postdiction from events and final state to initial state.

The Frame Problem

- Solving the Frame Problem
- A Mathematical Investigation of the Common Sense Law of Inertia
- By Murray Shanahan



Non-Monotonic Logic

- In monotonic logic
 - $A \Rightarrow C$ implies A and $B \Rightarrow C$
- Not so in temporal logic
 - event $A \Rightarrow$ fluent C is true
 - event A then event $B \Rightarrow$ fluent C not true
 - example : switch on the light then switch off the light

Solving the frame problem

- Situation calculus : successor state actions
 - Give consequences of all events/actions
 - Assume everything else remains the same
- Event calculus : circumscription
- In both cases, requires a « domain theory »
 - How the real world changes as a result of events
 - How the fiction world changes as a result of events

Circumscription

- $\text{CIRC}(\text{Initiates}(\text{SwitchOn}, \text{LightOn}, t))$ is
 - $\text{Initiates}(e, f, t)$ IFF $e = \text{SwitchOn}$ and $f = \text{LightOn}$
- $\text{CIRC}(\text{Terminates}(\text{SwitchOff}, \text{LightOn}, t))$ is
 - $\text{Terminates}(e, f, t)$ IFF $e = \text{SwitchOn}$ and $f = \text{LightOn}$

Discrete Event Calculus

- First-order logic representation of a story
- Fluents are time-varying properties of the world
 - $\text{HoldsAt}(f,t)$
- Events - everything that happens in the world
 - $\text{Happens}(e,t)$
 - $\text{Initiates}(e,f,t)$ or $\text{Terminates}(e,f,t)$

Discrete Event Calculus

- $\text{ReleasedAt}(f,t)$: fluent is no longer subject to the commonsense law of inertia
 - the water level increases, the newspaper changes location, etc.
- $\text{Trajectory}(f_1,t_1,f_2,t_2)$: if f_1 is initiated at t_1 then f_2 is true at $t_1 + t_2$
- $\text{Anti-trajectory}(f_1,t_1,f_2,t_2)$: if f_1 is terminated at t_1 then f_2 will be true at $t_1 + t_2$

Discrete Event Calculus Axioms

- Axiom DEC1
 - StoppedIn(t_1, f, t_2) iff Happens(e, t) and $t_1 < t < t_2$ and Terminates(e, f, t)
- Axiom DEC2
 - StartedIn(t_1, f, t_2) iff Happens(e, t) and $t_1 < t < t_2$ and Initiates(e, f, t)

Discrete Event Calculus Axioms

Axiom DEC3

$$\begin{aligned} & \text{Happens}(e, t_1) \wedge \text{Initiates}(e, f_1, t_1) \wedge 0 < t_2 \wedge \\ & \text{Trajectory}(f_1, t_1, f_2, t_2) \wedge \neg \text{StoppedIn}(t_1, f_1, t_1 + t_2) \Rightarrow \\ & \text{HoldsAt}(f_2, t_1 + t_2) \end{aligned}$$

Discrete Event Calculus Axioms

Axiom DEC4

$$\begin{aligned} & \text{Happens}(e, t_1) \wedge \text{Terminates}(e, f_1, t_1) \wedge 0 < t_2 \wedge \\ & \text{AntiTrajectory}(f_1, t_1, f_2, t_2) \wedge \neg \text{StartedIn}(t_1, f_1, t_1 + t_2) \Rightarrow \\ & \text{HoldsAt}(f_2, t_1 + t_2) \end{aligned}$$

Discrete Event Calculus Axioms

- Axiom DEC5

$$\begin{aligned} & \textit{HoldsAt}(f, t) \wedge \neg \textit{ReleasedAt}(f, t + 1) \wedge \\ & \neg \exists e (\textit{Happens}(e, t) \wedge \textit{Terminates}(e, f, t)) \Rightarrow \\ & \textit{HoldeAt}(f, t + 1) \end{aligned}$$

Discrete Event Calculus Axioms

- Axiom DEC6

$$\begin{aligned} & \neg \text{HoldsAt}(f, t) \wedge \neg \text{ReleasedAt}(f, t + 1) \wedge \\ & \neg \exists e (\text{Happens}(e, t) \wedge \text{Initiates}(e, f, t)) \Rightarrow \\ & \quad \neg \text{HoldsAt}(f, t + 1) \end{aligned}$$

Discrete Event Calculus Axioms

- Axiom DEC7

$$\begin{aligned} & \text{ReleasedAt}(f, t) \wedge \\ \neg \exists e & \left(\text{Happens}(e, t) \wedge \left(\text{Initiates}(e, f, t) \vee \text{Terminates}(e, f, t) \right) \right) \Rightarrow \\ & \text{ReleasedAt}(f, t + 1) \end{aligned}$$

Discrete Event Calculus Axioms

- DEC8

$$\neg \text{ReleasedAt}(f, t) \wedge \neg \exists e (\text{Happens}(e, t) \wedge \text{Releases}(e, f, t)) \Rightarrow \neg \text{ReleasedAt}(f, t + 1)$$

Discrete Event Calculus Axioms

Axiom DEC9

If a fluent is initiated by some event that occurs at timepoint t , then the fluent is true at $t + 1$.

$$\textit{Happens}(e,t) \wedge \textit{Initiates}(e,f,t) \Rightarrow \textit{HoldsAt}(f,t+1)$$

Discrete Event Calculus Axioms

Axiom DEC10

If a fluent is terminated by some event that occurs at timepoint t , then the fluent is false at $t + 1$.

$$\textit{Happens}(e,t) \wedge \textit{Terminates}(e,f,t) \Rightarrow \neg \textit{HoldsAt}(f,t+1)$$

Discrete Event Calculus Axioms

Axiom DEC11

If a fluent is released by some event that occurs at timepoint t , then the fluent is released from the commonsense law of inertia at $t + 1$.

$$\textit{Happens}(e,t) \wedge \textit{Releases}(e,f,t) \Rightarrow \textit{ReleasedAt}(f,t+1)$$

Discrete Event Calculus

- Axiom DEC 12

$$\begin{aligned} \textit{Happens}(e,t) \wedge \textit{Initiates}(e,f,t) \vee \textit{Terminates}(e,f,t) \Rightarrow \\ \neg \textit{ReleasedAt}(f,t+1) \end{aligned}$$

Domain Descriptions

An event calculus *domain description* is given by

$$\begin{aligned} &CIRC[\Sigma; \textit{Initiates}, \textit{Terminates}, \textit{Releases}] \wedge \\ &\quad CIRC[\Delta_1 \wedge \Delta_2; \textit{Happens}] \wedge \\ &CIRC[\Theta; Ab_1, \dots, Ab_n] \wedge \Omega \wedge \Psi \wedge \Pi \wedge \Gamma \wedge E \wedge CC \end{aligned}$$

Domain Descriptions

- Effect axioms
 - $\text{Condition} \Rightarrow \text{Initiates}(e,f,t) \text{ or } \text{Terminates}(e,f,t)$
- Fluent pre-conditions
 - $\text{HoldsAt}(f,t) \Rightarrow \text{Condition}$
 - $\text{NOT Condition} \Rightarrow \text{NOT HoldsAt}(f,t)$
- Action pre-conditions
 - $\text{Happens}(e,t) \Rightarrow \text{condition}$
 - $\text{NOT condition} \Rightarrow \text{NOT Happens}(e,t)$

Example : The snowman by Raymond Briggs

- The Snowman is the tale of a boy who builds a snowman one winter's day. That night, at the stroke of twelve, the snowman comes to life.
- The first part of the story deals with the snowman's attempts to understand the appliances, toys and other bric-a-brac in the boy's house, all while keeping quiet enough not to wake the boy's parents. The two then venture back outside and go for a ride on a motorbike, disturbing many animals: pheasants, rabbits, a barn owl, a fox and a brown horse.
- In the second part of the story, the boy and the snowman take flight.
- The morning after the return journey the sun has come out and the boy wakes up to find the snowman has melted. As the credits play, the boy mourns the loss of his new friend.

Domain theories in The snowman

- CTime: clock time.
- ECTime: the event calculus model of time.
- Feeling: simple positive, neutral, and negative emotions, and positive, neutral, and negative attitudes toward objects.
- OMSpace: object-scale metric space, with falling and collisions.
- OTSpace: object-scale topological space.
- PlayNeed: the need to play, with a simple model of needs and intentions.
- RTSpace: room-scale topological space.
- Sleep: sleeping and body posture.
- Snow: snow and snow falling from the sky.
- SpeechAct: some simple speech acts.
- Vision: some simple aspects of vision.

Room Scale Topology axioms

Formula	English
<i>Adjacent(location1, location2)</i>	<i>location1</i> is adjacent to <i>location2</i> .
<i>At(object, location)</i>	<i>object</i> is at <i>location</i> .
<i>BuildingOf(room) = building</i>	The building of <i>room</i> is <i>building</i> .
<i>DoorClose(actor, door)</i>	<i>actor</i> closes <i>door</i> .
<i>DoorIsOpen(door)</i>	<i>door</i> is open.
<i>DoorLock(actor, door)</i>	<i>actor</i> locks <i>door</i> .
<i>DoorOpen(actor, door)</i>	<i>actor</i> opens <i>door</i> .
<i>DoorUnlocked(door)</i>	<i>door</i> is unlocked.
<i>DoorUnlock(actor, door)</i>	<i>actor</i> unlocks <i>door</i> .
<i>Floor(room) = integer</i>	The floor of <i>room</i> is <i>integer</i> .
<i>GroundOf(outside) = ground</i>	The ground of <i>outside</i> is <i>ground</i> .
<i>LookOutOnto(room) = outside</i>	<i>room</i> looks out onto <i>outside</i> .
<i>NearPortal(object, portal)</i>	<i>object</i> is at a location that has <i>portal</i> .
<i>Side1(portal) = location</i>	Side one of <i>portal</i> is <i>location</i> .
<i>Side2(portal) = location</i>	Side two of <i>portal</i> is <i>location</i> .
<i>SkyOf(outside) = sky</i>	The sky of <i>outside</i> is <i>sky</i> .
<i>WalkDownStaircase(actor, staircase)</i>	<i>actor</i> walks down <i>staircase</i> .
<i>WalkThroughDoor12(actor, door)</i>	<i>actor</i> walks through side one of <i>door</i> .
<i>WalkThroughDoor21(actor, door)</i>	<i>actor</i> walks through side two of <i>door</i> .
<i>WalkUpStaircase(actor, staircase)</i>	<i>actor</i> walks up <i>staircase</i> .

Domain axioms for the snowman story

Axiom 1.

$HoldsWithAt(At(object, location1), time) \wedge$
 $HoldsWithAt(At(object, location2), time) \Rightarrow$
 $location1 = location2$

Axiom 2.

$HoldsWithAt(NearPortal(object, portal), time) \Leftrightarrow$
 $\exists location (Side1(portal) = location \vee$
 $Side2(portal) = location) \wedge$
 $HoldsWithAt(At(object, location), time)$

Axiom 3.

$Happens(DoorUnlock(actor, door), time) \Rightarrow$
 $HoldsWithAt(Awake(actor), time) \wedge$
 $\neg HoldsWithAt(DoorUnlocked(door), time) \wedge$
 $HoldsWithAt(NearPortal(actor, door), time)$

Axiom 4.

$Initiates(DoorUnlock(actor, door),$
 $DoorUnlocked(door), time)$

Domain axioms for the snowman story

Axiom 5.

*HoldsAt(DoorIsOpen(door), time) \Rightarrow
HoldsAt(DoorUnlocked(door), time)*

Axiom 7.

Initiates(DoorOpen(actor, door), DoorIsOpen(door), time)

Axiom 6.

*Happens(DoorOpen(actor, door), time) \Rightarrow
HoldsAt(Awake(actor), time) \wedge
 \neg HoldsAt(DoorIsOpen(door), time) \wedge
HoldsAt(DoorUnlocked(door), time) \wedge
HoldsAt(NearPortal(actor, door), time)*

Axiom 8.

*Happens(WalkThroughDoor12(actor, door), time) \Rightarrow
HoldsAt(Awake(actor), time) \wedge
HoldsAt(Standing(actor), time) \wedge
HoldsAt(DoorIsOpen(door), time) \wedge
HoldsAt(At(actor, Side1(door)), time)*

Domain axioms for the snowman story

Axiom 9.

$Happens(WalkThroughDoor21(actor, door), time) \Rightarrow$
 $HoldsWithAt(Awake(actor), time) \wedge$
 $HoldsWithAt(Standing(actor), time) \wedge$
 $HoldsWithAt(DoorIsOpen(door), time) \wedge$
 $HoldsWithAt(At(actor, Side2(door)), time)$

Axiom 10.

$Side2(door) = location \Rightarrow$
 $Initiates(WalkThroughDoor12(actor, door),$
 $At(actor, location), time)$

Axiom 11.

$Side1(door) = location \Rightarrow$
 $Initiates(WalkThroughDoor21(actor, door),$
 $At(actor, location), time)$

Axiom 12.

$Side1(door) = location \Rightarrow$
 $Terminates(WalkThroughDoor12(actor, door),$
 $At(actor, location), time)$

Domain axioms for the snowman story

Axiom 13.

$Side2(door) = location \Rightarrow$
 $Terminates(WalkThroughDoor21(actor, door),$
 $At(actor, location), time)$

Axiom 14.

$HoldsAt(At(actor, outside), time) \Rightarrow$
 $HoldsAt(Dressed(actor), time)$

Axiom 15.

$Adjacent(location1, location2) \Leftrightarrow$
 $\exists portal (Side1(portal) = location1 \wedge$
 $Side2(portal) = location2) \vee$
 $(Side2(portal) = location1 \wedge$
 $Side1(portal) = location2)$

Axiom 16.

$GroundOf(outside) = ground \Rightarrow$
 $HoldsAt(At(ground, outside), time)$

Axiom 17.

$SkyOf(outside) = sky \Rightarrow$
 $HoldsAt(At(sky, outside), time)$

Next week : plot/story grammars

