Computational Models of Events

Lecture 1: The Role of Events in Language and Computation

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Course Goals

- Look at event structure from a unifying perspective, enabled by a new synthesis from different disciplines;
- Examine the structure of events at every level impacted by communication;
- Survey formal semantic models of events;
- Examine AI approaches to defining and manipulating events;
- Review CL techniques for finding events and reasoning with them;
- Answer: When is a model of events computational?

The Big Picture Goal

- A General Computational Theory of Event Structure: A common vocabulary and model for events at all levels
- Atomic Event Structures: Compositional at the level of the sentence
- Graphical Event Structures: Modal Model of Change at the subatomic level
- Linking sub-atomic and atomic events: temporal ordering of events
- Linking atomic events: discourse structuring of events
- Linking events with actors: Narrative structures

Course Outline

- Monday: The Role of Events in Language and Computation
- Tuesday: Atomic Theories of Events
- Wednesday: Sub-atomic and Dynamic Models of Events
- Thursday: Situational Grounding of Events
- Friday: Event Structure above the Sentence

Monday Lecture Outline

- Definitions of event from different fields:
  linguistics, logic, AI, robotics, computational linguistics
- Constituents of events:
  frame structure, participants, inter-particpant relations
- Temporal Characterization of Events
  measurement, quantity, order
- Event Localization and Situating Events
  spatial anchoring, locus, aspect
- Events in Discourse and Narrative
- Objects and Latent Event Structure
  qualia structure, affordances, habitats

What makes a Model Computational

- "Computational modeling is the use of computers to simulate and study the behavior of complex systems using mathematics, physics and computer science. A computational model contains numerous variables that characterize the system being studied."
- "Computational models are mathematical models that are simulated using computation to study complex systems. ... The parameters of the mathematical model are adjusted using computer simulation to study different possible outcomes."
- "A computational model takes the form of an algorithm, that is, a precise description of the steps that are carried out."

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Events in Different Disciplines

- Philosophy: kinds of occurrences:
- Linguistics: grammatically and compositionally relevant object types
- Artificial Intelligence: states for goals, and events for moving through plans
- Computational Linguistics: Reasoning and explanation

Events in Philosophy

- Events vs.:
  - objects, facts, propositions, properties
- Types of Events
  - states, activities, achievements, accomplishments
- Negative Events
  - non-events, prevented events

Events in Philosophy - Distinctions

- Mode of being (Hacker 1982a; Cresswell 1986):
  - material objects such as stones and chairs are said to exist;
  - events are said to occur or happen or take place
- Relation to space and time.
  - objects are supposed to have relatively crisp spatial boundaries and vague temporal boundaries;
  - events have relatively vague spatial boundaries and crisp temporal boundaries.
  - objects are said to be located in space
  - events can be co-located (Quinton 1979)
  - objects can move;
  - events cannot (Dretske 1967)
- Type
  - objects are construed as continuants: they are in time and persist through time by being wholly present at every time at which they exist;
  - events are occurrents: they take up time and persist by having different parts (or stages) at different times (Mellor 1980; Simons 2000)

Events in Linguistics

- Aspectual Properties
  - durativity, boundedness, dynamicity, telicity, iteration
- Aktionsarten
  - states, activities, achievements, accomplishments
- Quantification
  - cumulativity, distributivity

Aktionsarten – conceptual categories of event types

- Stative vs. Non-stative

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(10) . a. The statue stands in the square.
b. The statue is standing in the square.

Structural vs. Phenomenal distinction – Goldsmith and Woisetschlager (1979)

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As seen with the English progressive marking before, states are not always permanent. Other languages also mark these differences (but not always for the same concepts).

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- Spanish – *ser* vs. *estar*

(12) a. Soy enfermo (I am a sickly person)
b. Estoy enfermo (if I have a cold)

Processes

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Processes

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(18) a. John ran for twenty minutes.
b. Sheila ate apples for two days straight.
c. !John ran in twenty minutes.
d. !Sheila ate apples in two days.

Distinguishing Processes from Transitions

- Activities: Atelic i.e. have no natural endpoint or goal (e.g. *I'm running in the park*) Compatible with a durative adverbial (e.g. *for*) that profiles the amount of time the activity takes.

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- Accomplishments: Telic i.e. have a natural endpoint of goal (e.g. *I'm running a mile*) Compatible with a container adverbial (e.g. *in*) that profiles the amount of time taken to reach the desired goal.

Typological Effects

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(21) Jeg reser till Frankrike *på* två månader.
I('m) going to France for two months.

(22) Jeg reste i Frankrike *i* två månader.
I traveled in France for two months.

Achievements and points

Achievements: Events that are conceived of as instantaneous. Often, however, there is an underlying activity that causes a change of state. Their point-like nature tends to require them to be described in the past tense or narrative present.

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(24) a. John shattered the window.
b. ! John shatters/is shattering the window.
c. The canals froze.
d. Mary found her keys.
e. *Mary is finding her keys.
f. John reached the top.

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(26) a. Bill coughed.
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(27) a. Bill coughed.
b. The light flashed.
c. Bill is coughing.
d. The light is flashing.

(c) and (d) have an iterative interpretation. Compare with the gradual achievements *John is reaching the top* or *The canals are freezing*.

Events in AI

- events as states for goals in planning
- actions that move from one state to the next state
- models of agent beliefs and intentions

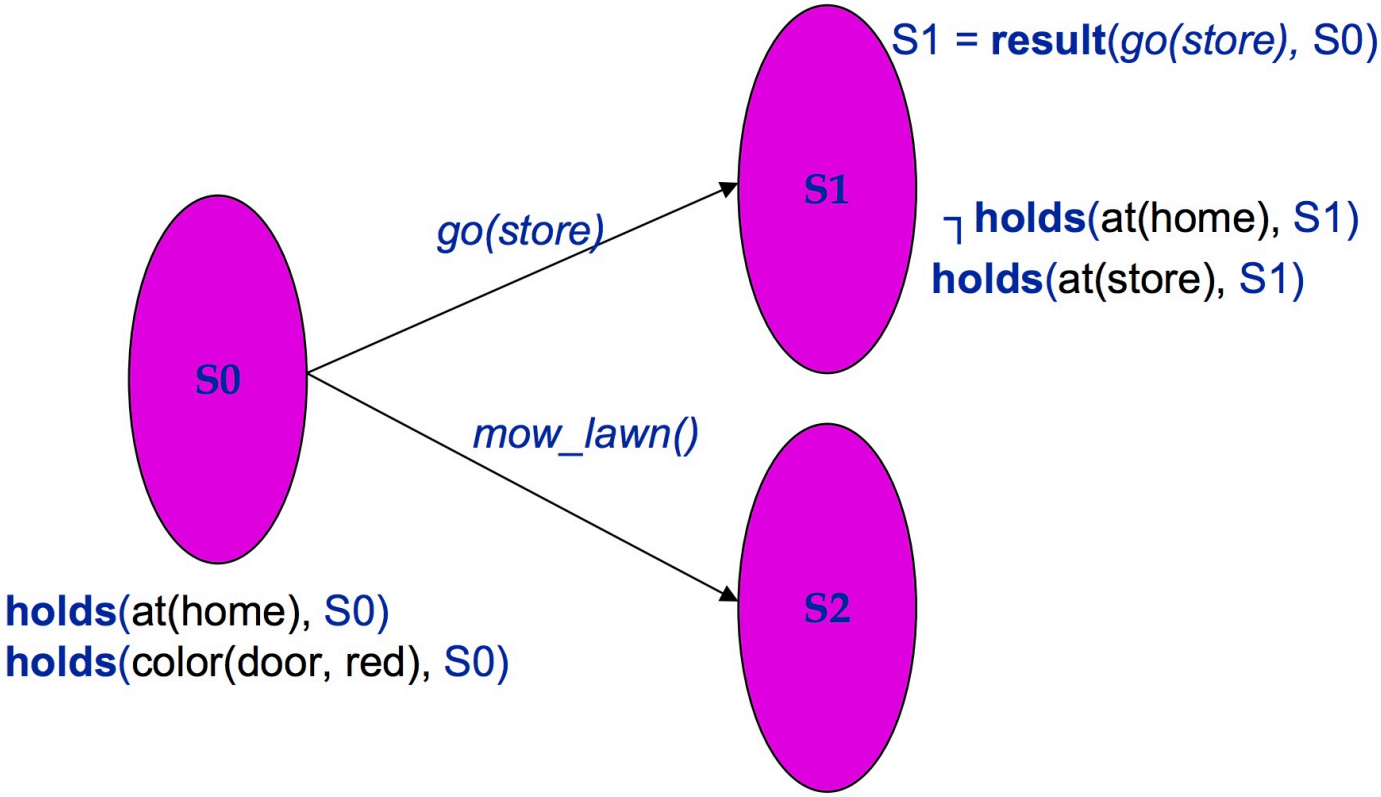
Events in AI - Data

- Causation/enablement

Bill flicked the switch.
The room was flooded with light.
Bill moved the switch to the "on" position, which caused a light to come on, which lit up the room Bill was in.

Betty opened the blinds.
The courtyard was flooded with light.
Betty adjusted the blinds so that she could see through the window they were in front of, after which she could see that the courtyard on the other side of the window was bright.

Events in AI - Planning



Events in AI - Frame Problem

- I go from home to the store, creating a new situation S'. In S':
  - My friend is still at home
  - The store still sells chips
  - My age is still the same
  - Los Angeles is still the largest city in California…
- How can we efficiently represent everything that hasn't changed?

Events in Computational Linguistics

- Textual and semantic named entities in text
- Units that need to be normalized, anchored, and ordered relative to a fixed time
- Task is to identify, reference, and co-reference recurring mentions of events

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Identifying and Reasoning with Events

- The bridge collapsed during the storm but after traffic was rerouted to the Bay Bridge.
- President Roosevelt died in April 1945 before
  - the war ended. (*event happened*)
  - he dropped the bomb. (*event did not happen*)
- The CEO plans to retire next month.
- Last week Bill was running the marathon when he twisted his ankle. Someone had tripped him. He fell and didn't finish the race.

Influences on Modeling Events

- Model-Theoretic Semantics:
  Montague (1968), Davidson (1967), Kamp (1969), Partee (1975), Dowty (1979), Verkuyl (1972), Kim (1973), Kratzer (1994), Piñon (1997)
- Decompositional Semantics:
  Lakoff (1965), Fillmore (1968), Jackendoff (1972), Talmy (1975), Langacker (1987), Fillmore (1985), Jackendoff (1983)
- Lexical-semantic approaches:
  Higginbotham (1986), Tenny (1987), Pustejovsky (1991, 1995), Krifka (1998), Levin and Hovav-Rappaport (1995)
- Modern Syntheses:
  Steedman (2002), Fernando (2001), Naumann (2001), Pustejovsky (2013), Hybrid Modal Logic

Cognitive and Computational Models of Events

- Simulation Semantics
  Feldman (2010), Bergen (2012), Evans (2013)
- Simulation Theory
  Gordon, (1986), Goldman (1989), Heal (1986), Goldman (2006)
- Computational Modal Logic
  Blackburn et al (2002), Blackburn and Bos (2005), van Eijck (2013)

The Role of Events

- Planning as Temporal Reasoning:
  Allen (1983), Allen and Hayes (1985)
- Textual Entailment:
  Dagan, Glickman and Magnini (2006)
- Syntactically-governed entailments:
  Davidson (1967)
- Event-class based entailments:
  Dowty (1979), Bach (1986)

Levels of Analysis for Events

- *Atomic* event structure: the clausal (sentential) event
- *Molecular* event structure: events connected by discourse relations
- *Sub-atomic* event structure: internal structure of atomic event
- *Macro-event* structure: event sequencing and grouping beyond linguistic provenance.

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Constituents of Events

- Aspectual Type:
  state, process, achievement, accomplishment
- Semantic Type:
  action, motion, contact, change_of_state ...
- Participants :
  Agent, Patient, Theme, Goal, Source, Location, ...
- Temporal Anchoring or Ordering:
  before, equal, after, overlap, ...
- Modality and Evidentiality:
  future, necessary, possible, heard-of, seen, ...
- Embedding Space (medium)

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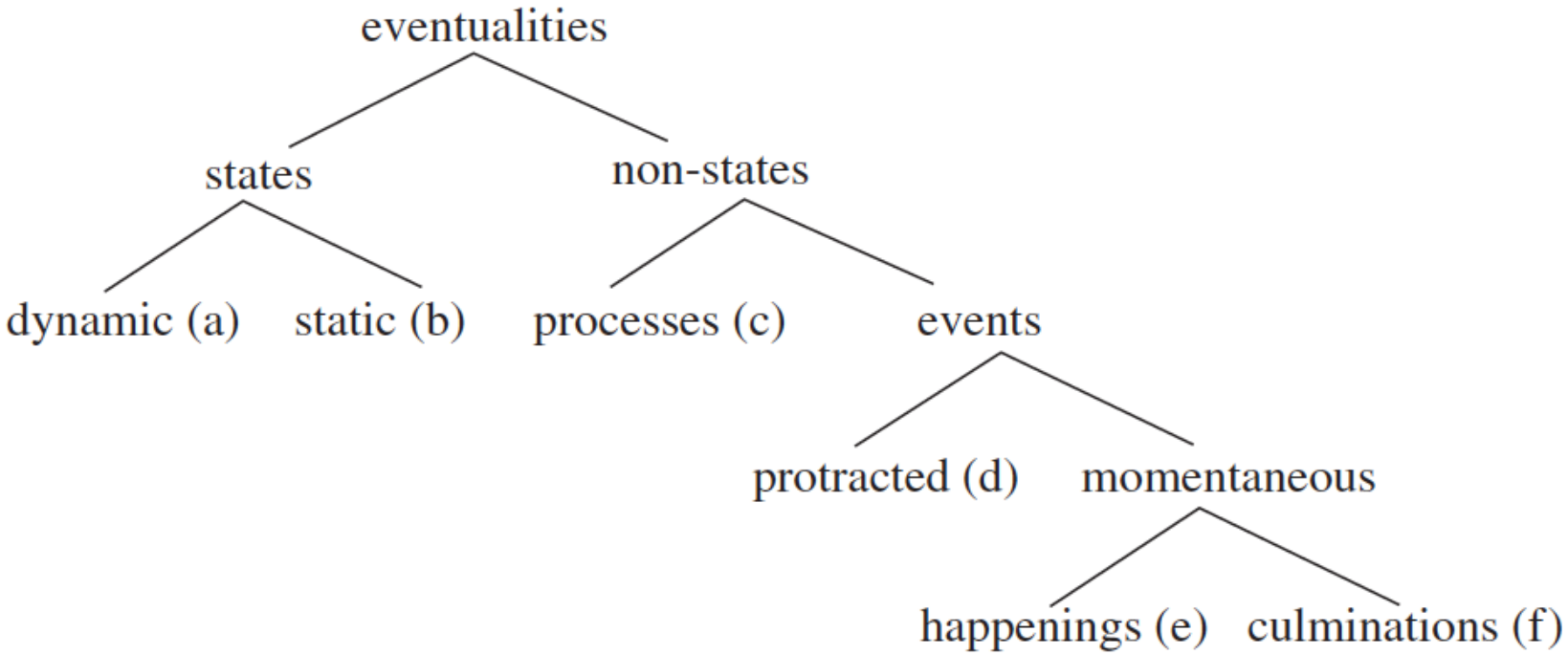
- ACHIEVEMENT: John found a Euro on the floor.
- POINT: John knocked on the door (for 2 minutes).

Bach Eventuality Typology (Bach, 1986)



Event Transition Graph (Moens and Steedman 1988)