Situation Semantics

- Introduced in the early 80s by Jon Barwise & John Perry.
- Originally motivated as realistic approach to a semantics of propositional attitudes.
- Developed by Keith Devlin as a theory of information (units).
- Developed into a formal model of information flow by Jon Barwise & Jerry Seligman.

Bringing Ontology Back Into Information Theory

- The theories considered so far were syntactic, semantic or were concerned with epistemic properties of information.
- Situation semantic´s slogan was „bringing ontology back to semantics“: definitions and explanations are based on a plethora of ontological categories.
- This applies to a analysis of information in terms of situation semantics as well.

Basic Ontology

The basic ontology includes:

- individuals, denoted by a, b, c…
- relations, denoted by P, Q, R…
- spatial locations, denoted by l, l´, l´´…
- temporal locations, denoted by t, t´, t´´
- situations, denoted by s, s´, s´´…
- truth values: 1 (true) and 0 (false)

A Note on Situations

- Situations are of course central to situation semantics – but what is a situation?
- Are situations abstract or concrete entities?
- The most important feature of situations is: they are partial (not total as possible worlds)
- Situation semanticists speak of “situations”, “abstract situations”, “situation types”, “facts”, “propositions” and “infones”!

Situations Are Parts of Reality (the Universe)

- Here we take (following Devlin in some of his remarks) situations as concrete entities.

  Peter´s clock is white in Trento, 8/5/2002 at 8 a.m.

  is a situation.
- If you take a part of the universe you have a situation s (involving some individuals, relations and location), s being partial.
- “abstract situation” etc. are constructed then

Types

- To introduce more complex entities we need some more basic categories:

- types: for each object of the theory there is at least one type which it is an object of.

basic types are:

TIM: the type of temporal locations (resp. LOC)

IND: the type of an individual

SIT: the type of a situation

REL^n: the type of an n-place relation

Parameters

- parameters: for each basic type there is an infinte collection of basic parameters.

  a* is parameter for individuals

  s* is a parameter for situations

  t* is a parameter for a time region etc.

- We write “x:T” to say that x is of type T.

- Given parameters we can introduce more types by type abstraction:
  [x*| s |= I] , the type of those x for which situation s supports the infons in the set of infons I (in which infons contain a parameter x*).

Parameters Anchored

- Parameters work like variables: they can be anchored to objects of their type.
- An *anchor* for a set A of basic parameters is a function defined on A which assigns to each parameter T_n in A an object of Type T.
- If γ is a (compound) infon –to be defined next– and *f* an anchor for some parameter in γ, γ[*f*] denotes the infon resulting from replacing each parameter a* in dom(*f*) by *f*(a*). (Compare interpreting variables in a formula.) Given a condition φ, a*| φ is a *restricted parameter*, open only to be anchored to objects that fulfil the condition φ. (A *condition* being a conjunction of infons.)

Derived Ontology

- Taking our primitive categories we define:

\- infons: $<<R, a_1, \ldots, a_n, 1>>$
A simple infon says that some objects stand in some relation or don´t.

\- propositions: $s |= \phi$
An infon ϕ “is made factual” by s. s is a real situation which is like ϕ says. s supports ϕ.
So information is always about a situation.

Infon Logic

- Compound infons are defined by closing infons under conjunction, disjunction, and bounded quantification (over parameters):
  $\varphi \wedge \sigma$, for example, is a compound infon.
  For any s: $s \models \varphi \wedge \sigma$ iff $s \models \varphi$ and $s \models \sigma$
  For any s: $s \models \varphi \vee \sigma$ iff $s \models \varphi$ or $s \models \sigma$
  If φ is an infon that involves the parameter x* and A is some set of objects, then $(\exists x^* \in A)\ \varphi$ is a compound infon. So for a situation that contains the member of A: $s \models (\exists x^* \in A)\ \varphi$ iff there is an anchor *f* of x* to an element of A, such that $s \models \varphi[f]$. (accordingly for $(\forall x^* \in A)$)
- Note: infons are not closed under negation!

A Note on Infons

- Infons were introduced into situation semantics by Devlin. They correspond to what Barwise & Perry –most of the time– call “situations”.
- Note that infons are something like ordered tuples, which means that an infon really *contains* the entities which make it up.
- We like infons, since we`re after information and information flow.

Infons and Language

- Infons are no linguistic entities. Sometimes some expressions are *mentioned* in an infon, but only just like objects are parts of infons.
- The theory of information presented is therefore *independent* of language and a specific coding scheme! (Which is the op-posite in the syntactic and possible worlds approach, which is relative to some L_i.)

Infons, Situations and Facts

- We said situations are concrete entities, so situations can be contained in infons, e.g.

  <<see, David, s´, l´, t´, 1>>

  David sees situation s´ (say a football match) at time t´ in location l´.

  (Since situations support infons this embedding of situations in infons might lead to semantic paradoxes, but we don´t care here now.)

- We can say that infon σ is *a fact* iff the world is as σ says. For a real s, $s \models \sigma$

Fine Grained Information

- The ontological approach allows for more fine grained information content.
- The syntactic approach only very indirectly (by the definition of the coding scheme) talks about semantic content at all. The possible worlds approach gives the same information content to all contingent statements (in case of an *a priori* measure)!

Fine Grained Information (II)

- Given an approach that bases information on the structure of information bearing entities you can make finer distinctions: The infon i_1
  <<happy, peter, t´, ´l´, 1>>
  has another information content as i_2
  <<happy, helga, t´, l´, 1>>
  since the one involves Peter and the other involves Helga.

Derived Ontology (II)

- Abstract situations: $\{\sigma \mid s \models \sigma\}$

  An abstract situation is defined as the set of infons that are made real by a situation of that kind. Not all abstract situations are instantiated (e.g., might be inconsistent).

- Situation types: $[s^* \mid s^* \models \sigma]$
  having the same purpose.
  Example: $[s^* \mid s^* \models \langle\langle \text{running}, a^*, l', t', 1 \rangle\rangle$
  the type of situation where some individual in running in l´ at t´.

Abstract Situations

- The relation of support can be applied to abstract situations: Let s be an abstract situation, now we have: $s \models \sigma$ iff $\sigma \in s$.
- Relative to abstract situations we can now explain what it means that one real situation is *part* of another real situation:
  Let s_{1a}, s_{2a} be the abstract situations that contain all infons supported by the situations s_1 and s_2,
  s_1 is part of s_2 iff $s_{1a} \subseteq s_{2a}$.

Events

- Space (time) regions have basic relations

  l ° l´ , l overlaps l´ (in space)

  l ~ l´ , l precedes l´ (resp. t ~ t´)
  t @ t´ , t overlaps t´ (in time)

- A *course of events* is a partial function from the product of space and time regions into situation types with space and time parameters. It tells a partial history of the universe. (A minimal one changes one situation into another.)

Partiality

- Note: courses of events are not total (they aren`t negation complete world histories like in some modal logics).
- Situation semantics argues that it is sufficient and fruitful to start with partial descriptions or partial information.
- Note: $s \not\models \langle\langle cat,c,1 \rangle\rangle$ does not imply $s \models \langle\langle cat,c,0 \rangle\rangle$. Situations supporting infons (propositions) are not negation complete.

Getting Information

- To model information flow we need a *cognitive system*.
- That is an object that is able to know:
  - the system is able to extract digital information from analogue representations of its environment (cf. Dretske).
  - the system then can use its initial information to derive more information by some mechanisms (here called *constraints*).

Constraints

- Constraints link situations. Constraints are used in situation semantics to model (natural) laws, conventions, regularities.
- Constraints are relations between types of situations.
- Example: Smoke means fire.
  That is: If S_1 is the type of situations where smoke is present, and S_2 is the type of situations where there is fire, these situations are linked by a (natural) constraint. An agent can pick up information (that there is a situation of type S_2) by observing that there is a situation of type S_1 if the agent is aware of or attuned to the constraint.

Constraints (II)

- Constraints can be written: S´ ⇒ S´´ where S´ and S´´ are situation types.
- Constraints are involved in meaning relations; example: “fire” means fire
  This is a contraint linking an utterance situation type to a type of situation where fire is present. (Attuned agents understand “fire”.)
- The situation semantic´s account of meaning is based on constraints.

Constraints (Detailed Example)

- The constraints mentioned can be modelled:
  $S = [s^* | s^* |= \langle\langle smokey, t^*, 1 \rangle\rangle]$
  $S' = [s^* | s^* |= \langle\langle firey, t^*, 1 \rangle\rangle]$
  $S'' = [s^{*\prime} | s^{*\prime} |= \langle\langle speaking, a^*, t^*, 1 \rangle\rangle \wedge \langle\langle utters, a^*, \textit{fire}, t^*, 1 \rangle\rangle$
  with the two constraints
  (C1) $S \Rightarrow S'$ and (C2) $S'' \Rightarrow S'$

  The constraints give information what other *kind* of situation is involved here.
- Any instance where a constraint is utilised making an inference about an object x* involves *specific* situations by anchoring.

Meaning (Example)

We are not concerned with the analysis of meaning here, but to give an example of using the notion of constraint to explain *sentential meaning*:

Let σ be the sentence “I am eating now.”

The meaning of σ (||σ||) is the constraint linking the following situation types:

[s´* | s´*|={<<speak, a*, t*, 1>>, <<say, a*, σ, t*, 1>>}]

[s´´* | s´´*|=<<eat, a*, t*, 1>>]

(If individual a utters σ at time t *that* individual is eating at *that* time.)

Information Flow: The Idea

- Consider the contraints and situation types we just have given, say (C1) S $\Rightarrow$ S´
 (S = [s*| s*|= <<smokey,t*,1>>], S´= [s*| s*|=<<firey,t*,1>>])
 Suppose s_1:S (situation s_1 is of type S).
- Being aware of the constraint (C1) *we have the information* that there is a situation s_2 (maybe $s_2 = s_1$) with s_2:S´ so that s_1 and s_2 are co-temporal, i.e. t* has to be *anchored to the same time interval*.

Information Flow: The Role of Parameters

- We get information about some situation given that we know a given situation is of some type and that type is linked by a constraint to some other type (of situation).
- The actual linking of situations is done by parameters (where a parameter present in the two situation types is anchored to an object present in the two situations linked).

Knowledge and Information

- To see that some infons are supported by some situation s´ given what we know about some other situation s and being aware or attuned to constraints C, C´… is to acquire *knowledge* (an externalist epistemology).
- You can acquire knowledge without being aware of it or the acquiring process.
- Knowledge is independent of its mode of representation.

Information?

Then what is information after all?

- The information an agent a has about a situation s is the closure of a´s representation of s under infon logic given the constraints that a is aware of or attuned to.
- The information present in a situation is the closure of the set of infons supported by s under infon logic given all constraints.

Information *is present* in the world.

Why Use Situation Semantics?

- Mainly an *ontologically* new theory: lingu-istic phenomena are treated as well, e.g., in categorical grammar (Montague-Grammar).
- Shouldn`t be considered *psychologically real*. With respect to human cognitive mechanisms: naïve and uninformed (cf. Jackendoff).
- But: It might model one aspect of situati-onal information flow. Information flow can be represented at such an abstract level of *logical (conceptual) analysis*. There we are.

Sources & Bibliography

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