Chapter 3

Analyzing Features of Grammatical Categories

3.1 Lecture notes

Chapter Three, Lecture One

Review

- Last time we saw that CFG looked promising as basic architecture of grammar.
- However, CFG as we presented it has some weaknesses:
  1. No notion of head.
  2. Gets quite cumbersome and redundant as one tries to extend the grammar to account for agreement, subcategorization, etc.
- Chapter 3 concerns an extension to CFG which addresses these problems: the replacement of atomic node labels with typed feature structures.

I. **Features & types**

- What are typed feature structures? Let's first consider the example from the textbook (pp.50–54).
- In that example, there are three types of entities: *university*, *department*, and *individual*.

- If we were to use this theory to model a particular university, we would model each department with an instance of *department* etc.
- The benefit of having three different types, instead of one type *entity*, is that not all features (or properties) are relevant for all of the types. In particular, the features TEL and NAME are appropriate for all three, but CHAIR is only appropriate for *department*.
- In order to capture the generalization that these types have something in common, we can arrange them into a hierarchy. [**Slides:1**]
- The supertype *entity* declares that the features TEL and NAME are appropriate for all of its subtypes. Each subtype can add other features.
- Sometimes types may have the same feature but have a different range of values that are appropriate for that feature.
- Lets add two subtypes of *department*: *humanities* and *engineering*, and a feature DEGREES (degrees offered). This feature is appropriate for both of the new subtypes (we declare it on the supertype *department*), but the range of appropriate values is different. [**Slides:2**]

II. **A richer conception of feature structures**

- So far, all of the values assigned to features have been atomic.
- Consider the feature structure model of the linguistics department: [**Slides:3**]
- The value of the feature CHAIR is the name 'Stanley Peters' (think of this as an atom, for now), but in fact we have a better model of Stanley Peters than that, namely: [**Slides:4**]
- So, we would like to make that feature structure the value of the feature CHAIR in the model of the linguistics department: [**Slides:5**].
- In general, we allow the value of features to be either atomic symbols or typed feature structures.
- We can add a constraint to the type *department* that the value of the feature CHAIR must be of type *individual*. This will mean that feature structures like the following are ill-formed. [**Slides:6–7**].

(1) $$\begin{bmatrix} \textit{department} & \\ \text{NAME} & \text{Stanford Linguistics} \\ \text{CHAIR} & \begin{bmatrix} \textit{university} & \\ \text{NAME} & \text{Stanford University} \\ \text{PRESIDENT} & \text{Gerhard Casper} \\ \text{TEL} & \text{650-723-2300} \end{bmatrix} \\ \text{TEL} & \text{650-723-2212} \end{bmatrix}$$

- Another kind of constraint we might want to add is that the telephone number of a department must be the same as that of its chair.
- We write that constraint with boxed numbers: [**Slides:8**]

(2) $$\begin{bmatrix} \textit{department} & \\ \text{CHAIR} & \begin{bmatrix} \textit{individual} & \\ \text{TEL} & \boxed{1} \end{bmatrix} \\ \text{TEL} & \boxed{1} \end{bmatrix}$$

- [For the technically oriented: The boxed numbers indicate token identity. That is, the feature structures of which the avm (2) is a partial description are reentrant; the edges from both TEL features lead to the same point.]

III. **Unification**

- In using feature structures in a grammar, we will often have information from different sources combining. The operation of *unification* allows us to combine information from multiple feature structures, so long as it is consistent.
- The unification of two consistent feature structures is the feature structure that contains all of the information from each and nothing else. The unification of two feature structures that are not consistent is not defined.

? Illustrate unification with the examples in [**Slides:9-16**].

IV. Modeling Things

- Note that when we model things like unversities, there are three distinct things:
  1. the actual university, department, department chair, etc., i.e. things in the real world,
  2. the things in our models that correspond to these real world entities, and
  3. our descriptions of these modeling entitites.
- Now a model is something that only contains certain information – relevant for whatever the model purports to provide a theory of. The lack of irrelevant information is precisely what makes something a model. So a social model of Stanford might have very different stuff in it than a geographic model, a DNA model, or an architectural one. Stanford, in any case, remains Stanford.
- These models would leave different things out. So the model we have been considering would leave out lots of irrelevant information, e.g. the hair color of particular faculty members, whether they liked Indian food, on what day of the week the department held its colloquia in 1954, and so forth...
- Obviously, if we set up our models with certain goals in mind, we will choose our entities accordingly, but once we've chosen them, each entity in our model has all the properties that we have chosen to model. Every department or individual has a name, for example. We'll assume that each individual has a Social Security Number and a telephone, too (perhaps leaving none as a possible value; after all we want to distinguish not knowing a telephone number from knowing that someone doesn't have one).
- Likewise, we choose the description language so that we can talk about these modeling entities in various ways. And, as we've already seen, the descriptions can be partial, they can unify or not, etc. In this way, the descriptions differ systematically from the modeling entities we have set up. The latter may be incomplete with respect to irrelevant information, but we will assume that each modeling is complete with respect to the properties we are studying.

- In terms of feature structures, this means that each feature structure (that's a modeling entity) has a determinate fully resolved value for every feature appropriate for entities of the relevant type. Our descriptions of these feature structures, however, may be partial.
- We carry over this same way of thinking about universities to our linguistic models. That's why the textbook tries to be careful in distinguishing the word structures and phrase structures (modeling entities) from our descriptions of them. It may seem pedantic if this stuff doesn't really grab you, but precision is the soul of science.

Chapter Three, Lecture Two

Preliminary Remark:

Some of the constructs we saw last time, e.g. types and constraint inheritance hierarchies, may be familiar to you (say, from object-oriented programming). That is because they come from work in Artificial Intelligence and other branches of Computer Science that wrestle with problems of representing knowledge. It's not surprising that some of the techniques developed for general purpose knowledge representation (a crucial area in AI) should prove useful in representing the particular domain of linguistic knowledge as well.

I. Categories as feature structures

- One immediate benefit of moving to feature structures instead of atomic symbols for categories is that it allows us to express the similarities between different categories.

? On the feature structure theory, what do these categories have in common?: N, NP, V, VP

1. NP and VP are [*phrase*]
2. N and V are [*word*]
3. NP and N are [HEAD noun]
4. VP and V are [HEAD verb]

? Why do we want a theory of categories that makes certain categories related?

1. To express generalizations. For example, Problem 5 of Chapter 2 of the textbook (p.42) asked you to think of properties that IVs, TVs, and DTVs all have in common. [If there's time and the students have done this problem, ask for examples.] Feature structure descriptions of these categories will allow us to capture those generalizations. These generalizations include:
    - morphology
    - agreement with the subject
    - general distribution (appearing first in the VP, never right after a determiner, etc.)

2. To eliminate redundancy in the rules. For example, feature structure categories will allow us to formulate a head feature principle and to collapse some of the PS rules into fewer, more general rules.

II. The Head Feature Principle

? What is the HFP? Why do we have it?

1. To extract the common properties of diverse kinds of phrases.
2. To express this as a general constraint.
3. To collapse rules, hence simplifying the grammar. **[Slides:17]**

? What kind of value does the feature HEAD take? (a feature structure)

? Why is it useful for HEAD to take a feature structure as its value?

1. It allows us to type HEAD values and declare that certain features are appropriate only for certain types. (E.g. AUX is only appropriate for HEAD values type *verb*.)
2. It allows us to simplify the HFP: We only have to state one identity (the HEAD values) instead of several separate ones (POS, NUM are the only ones so far, but later there will be more). **[Slides:18–19]**

III. Valence

? Which of the old rules do each of the new rules collapse? **[Slides:17]**

? What are the VAL values for *Sandy* and *into*? (itr and tr)

- If nouns and verbs and prepositions are not assigned appropriate values for VAL, the collapsing of the rules won't work.

? Do all prepositions have the same value for VAL? (no, examples:)

1. *Afterwards* is VAL itr. Evidence that it's a P includes the fact that it freely coordinates with bona fide PPs, e.g. in *We'll visit them [[on Tuesday] and [afterwards]]*. (This evidence isn't conclusive because adverbs can coordinate with PPs, but it's a start.) Another example might be *there*, which is selected by verbs like *put*, which normally only select PPs: *They put it on the table/there.*

2. Some prepositions can be itr or tr:

(3) a. Kim threw it out (the window).
    b. Sandy is inside (the house).

IV. Descriptions and Models, Underspecification

? What should the NUM value be for *fish*?

(4) a. Fish swim.
    b. That fish is swimming.

- We want to say that the entry for *fish* in the lexicon is underspecified — it doesn't provide a value for NUM.
- That entry for *fish* is a description or set of constraints that can be satisfied by two models — one with NUM sg and one with NUM pl.
- Note that this problem is pervasive in lexical representation. Just in the domain of fish, we can observe that any noun naming a kind of fish has this property, e.g. *perch*, *trout*, *salmon* etc.
- The definition of a well-formed structure is also in terms of constraint satisfaction. **[Slides:20]**
- Consider the structural description for *Fish swim.* **[Slides:21]**

? For each subtree, which part of the well-formed structure definition is involved?

? Where does the NUM value on fish come from?

- Remember: in any given utterance, a word like *fish* is resolved to be either singular or plural.

V. Why Learn 'Wrong' Grammars?

At this point in the course, some of our students ask why they had to learn CFG, if we were just going to discard it. We tell them that the purpose of this course is not just to teach them English grammar, but rather to learn how to argue for why our grammars and lexicons are the way they are — to learn how to do scientific linguistics.