Corpus Linguistics (L615)
Linguistic Annotation

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Corpus mark-up

 Corpus mark-up is information about the corpus included in the corpus itself
  ▸ some of it governs formatting, printing, other processing

Mark-up is important to:
  ▸ help recover the original context
  ▸ allow for a wider range of questions to be explored (e.g., sociolinguistic variables)
  ▸ encode extralinguistic details (e.g., laughs, formulas)

Annotation

We will often use the term annotation to refer specifically to linguistic information encoded in the text
  ▸ Generally speaking, annotation is a form of markup
  ▸ Non-linguistic information also encoded in markup (meta-data)
    ▸ i.e. information about the text: author, version, date, information about author, encoding

Meta-data systematically needs to be kept separate from the corpus data

A general idea is to use attributes and corresponding values
  ▸ e.g., attribute author has a value William Shakespeare
  ▸ We’ll see this encoded in XML in ways such as:
    ▸ <... author="William Shakespeare" ...>
    ▸ <author name="William Shakespeare">

Text Encoding Standards

▶ TEI: Text Encoding Initiative
▶ CES: Corpus Encoding Standard
▶ XCES: XML version of CES

Text Encoding Initiative (TEI)

TEI-compliant documents are broken into 2 parts:
  1. Header = information about the document
    ▸ File description (<fileDesc>): bibliographic information
    ▸ Encoding description (<encodingDesc>): relationship to the source
    ▸ Text profile (<profileDesc>): non-bibliographic information (setting of the text, languages used, etc.)
    ▸ Revision history (<revisionDesc>): changes made
  2. Body = the original text itself

TEI documents can be encoded in different mark-up languages, e.g., SGML and XML
Mark-up languages

Mark-up languages generally have the following aspects
- Tags, which come in both start (e.g., `<s>`) and end (e.g., `</s>`) forms
- Attributes and values, encoded within the start tag (e.g., `<s num="1"/>`)

<s POS="AT0">the</s>

XML

XML stands for: eXtensible Markup Language
- In contrast to HTML, XML does not have built-in “meaning” for labels: you must define your own tags
An XML document consists of two parts: XML Schema and the real document
- XML Schema define structure of document
  - DTD (Document Type Definition) does the same thing, but in a different format
- XML documents can be validated, i.e., checked against rules in Schema
More thorough discussion of XML for the end of this unit

Character encodings

Corpus should specify character encoding of the text (ASCII, ISO-8859-1, etc.)
Unicode has a single representation for every possible character
- Version 6.0 has codes for over 109,000 characters from alphabets, syllabaries and logographic systems
- Unicode has three versions
  - UTF-32 (32 bits): direct representation
  - UTF-16 (16 bits): $2^{16}$
  - UTF-8 (8 bits): $2^8$ - more frequent characters stored with shorter codes
UTF-8 is mostly the standard these days

Motivating Annotation

Why would we want annotation?
- for training NLP tools
- for finding examples
  - what is the plural form of fish?
  - which nouns can occur as bare nouns, without a determiner?
  - are there subjectless sentences in German? – Yes, e.g., *Mir ist kalt.* (‘To me is cold.’)
  - is it possible in English to have something between a noun and its modifying relative clause?

Annotation makes it possible to find phenomena that would otherwise disappear in masses of data
Potential benefits of annotation

- Corpus annotation adds much value to a corpus
  - Extracting information is easier:
    - Can easily isolate left in its adjective uses
    - Can find information on a language you don’t speak
  - Corpus is more reusable
    - Insights are more accessible to others
    - Corpus is more multifunctional
  - Annotation provides a clear record of analysis, open to future scrutiny
    - Decisions are more reproducible

Potential criticisms of annotation

- Annotation is cluttered
  - But: it can be easily ignored
- Annotation imposes one particular linguistic analysis
  - But: users can reject the analysis, and annotation at least makes the analysis process clearer
- Annotation makes a corpus less accessible & expandable
  - But: corpora can be extended without annotation, if need be
- Annotation cannot be done completely consistently
  - But: humans are fallible, and there are ways to ensure better consistency

Leech’s Seven Maxims (2)

1. It should be possible to remove the annotation from an annotated corpus in order to revert to the raw corpus.
2. It should be possible to extract the annotations by themselves from the text. (flip side of maxim 1)
   - Taking points 1 & 2, the annotated corpus should allow the maximum flexibility for manipulation by the user
3. The annotation scheme should be based on guidelines which are available to the end user.
4. It should be made clear how and by whom the annotation was carried out.
5. The end user should be made aware that the corpus annotation is not infallible, but simply a potentially useful tool.
6. Annotation schemes should be based as far as possible on widely agreed and theory-neutral principles.
7. No annotation scheme has the a priori right to be considered as a standard. Standards emerge through practical consensus.

How corpus annotation is achieved

Some options:
- Fully manually
  - Pro: has the potential to be of highest quality
  - Con: time-consuming + humans are prone to errors
- Fully automatically (assuming appropriate technology)
  - Pro: quick and consistent
  - Con: will often be consistently wrong
- Semi-automatically, e.g., automatic analysis + manual post-editing
  - Pro: Can combine the best of both worlds
  - Con: Have to avoid the pitfalls of each

In a week or so, we’ll look at some annotation tools

Levels of linguistic annotation

- morphological annotation (e.g. inflection, derivation, compounding)
- morpho-syntactic annotation: part-of-speech (POS) tagging
- syntactic annotation (e.g. named entities, phrasal chunking, full syntactic analysis)
- semantic annotation (e.g. word-sense disambiguation, anaphora & coreference resolution, information structure)
- discourse annotation (e.g. dialog turns, speech acts)
Step by Step Annotation

- tokenization
- lemmatization / morphological analysis
- part-of-speech tagging
- named-entity recognition
- partial parsing
- full syntactic parsing
- semantic and discourse processing

See section A4.4 of the book for a more thorough analysis of each of these

Preprocessing the Text: Tokenization

Tokenization refers to the annotation step of dividing the input text into units called tokens.

Each token consists of one of the following:
- a morpho-syntactic word
- a punctuation mark or a special character (e.g. &, @, %)
- a number

Why is Tokenization Non-Trivial?

- Disambiguation of punctuation
e.g. period can occur inside cardinal numbers, after ordinals, after abbreviations, at end of sentences
- Recognition of complex words
  - compounds, e.g. bank transfer fee, US-company
  - mergers, e.g. don’t, England’s, French: t’aime
  - multiwords, e.g. complex prepositions provided that, in spite of

Languages such as Chinese present more challenging segmentation issues

Annotation uses

- POS annotation: compare occurrences of word classes
- Lemmatization: study distribution of lexemes for lexicography
- Parsing: study clauses types in a language or teach grammatical analysis
- Semantic annotation: analyze content

Other types of annotation can cover specific purposes:
- stylistic annotation, error tagging, problem-oriented annotation, ...

We’ll examine POS and syntactic annotation in greater detail later in the semester

Tokenization – Example

before tokenization:
Milton wrote "Paradise Lost." Then his wife dies and he wrote "Paradise Regained."

after tokenization:
Milton wrote "Paradise Lost." Then his wife dies and he wrote "Paradise Regained."
(taken from a "student blooper" list, http://www.snopes.com/humor/lists/student.asp)

Lemmatization

- Process of relating individual word forms to their citation form (lemma) by means of morphological analysis
  - e.g., stopped ⇒ stop
- Distinguishes between the total number of word tokens and distinct lemmata that occur in a corpus
  - e.g., helps to find all occurrences of buy
- Indispensable for highly inflectional languages which have a large number of distinct word forms for a given lemma
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### Lemmatization – German Example

<table>
<thead>
<tr>
<th>wie</th>
<th>wie +Adv+Wh+≤COWIE</th>
</tr>
</thead>
<tbody>
<tr>
<td>wie</td>
<td>+Conj+Coord+≤COWIE</td>
</tr>
<tr>
<td>wie</td>
<td>+Conj+Subord+≤COWIE</td>
</tr>
<tr>
<td>sie</td>
<td>+Pr ON+Pers+3P+PI+Fem+Nom+≤PERS SPRO</td>
</tr>
<tr>
<td>sie</td>
<td>+Pr ON+Pers+3P+SG+Fem+Nom+≤PERS SPRO</td>
</tr>
<tr>
<td>offenbar</td>
<td>offenbar +Verb+Imp+2P+SG+≤VVF IN</td>
</tr>
<tr>
<td>gedacht</td>
<td>gedachten +Verb+PPast+≤V VPP</td>
</tr>
<tr>
<td>gedacht</td>
<td>danken +Verb+PPast+≤V VPP</td>
</tr>
<tr>
<td>haben</td>
<td>hat +Verb+Indc+3P+Sg+Pres+≤VAF IN</td>
</tr>
</tbody>
</table>

### Example Tools for Lemmatization

- **XEROX Morphological Analyzer**: comprehensive morphological analyzers for many languages including English, French, German, Hungarian, Italian, Czech, Polish, Russian, Turkish.
- **Lingsoft**: morphological analyzers for English, Danish, German, Swedish, and Finnish

Search online for lemmatizers to find more (e.g., [http://nlp.stanford.edu/software/corenlp.shtml](http://nlp.stanford.edu/software/corenlp.shtml)).

### Morphological Analysis

**Xerox:**
- half half+Adj
- half half+Adv
- half half+Noun+Sg

**Lingsoft:**
- "<half>"
- "half" <Quant> DET PRE SG/PL @QN>
- "half" <NonMod> <Quant> PRON SG/PL
- "half" N NOM SG
- "half" ADV

### Standoff annotation

Instead of embedding annotation in the base document, one can use standalone, or standoff, annotation:

- The annotation is linked to particular points in the original document.

**Advantages:**
- Allows base documents to be treated as read-only & can be distributed separately
- Allows for overlapping & alternative annotations
- Allows for new annotation levels to be easily added

**Disadvantages:**
- Potentially difficult to allow for annotation to point to other annotation
- Less pre-built tools for standoff annotation

### XML tags

In the previous example, there are several things to note about the tags, i.e., the things in angled brackets (<...>):

- There has to be one root tag—in this case, `<note>` is the root tag
- Every (opening) tag needs a closing tag: `<heading>Reminder</heading>` is legitimate; `<heading>Reminder` is not
- Along with that, tags must be properly nested: `<b><i>word</i></b>` is legitimate; `<b><i>word</i></b>` is not

So, you'll wind up with a structure like:

```
<root>
  <child>
    <subchild>....</subchild>
  </child>
</root>
```
Attributes

Each tag (or element) can have a variety of attributes (provided such attributes have been declared; see below)

- Attributes are noted within an element tag; there can be multiple attributes
- Attribute values are put in quotes after the attribute
- Some examples:
  - `<note date="2/23/2006" author="joe shmoe">`
- This last one is equivalent to:
  - `<note author="joe shmoe" date="2/23/2006">`

Attributes vs. Elements (1)

There is often a question of where to store information: in element text, in attributes, as children elements, ... Here are three different ways to say the "same" thing

- `<note date="12/11/2002">`
- `<to>Tove</to>`
- `<from>Jani</from>`
- `<heading>Reminder</heading>`
- `<body>Don’t forget me this weekend!</body>`
- `<note>`
  - `<date>12/11/2002</date>`
  - `<to>Tove</to>`
  - `<from>Jani</from>`
  - `<heading>Reminder</heading>`
  - `<body>Don’t forget me this weekend!</body>`

Attributes vs. Elements (2)

Putting data in attributes needs to be done with care:

- attributes cannot contain multiple values (child elements can)
- attributes are not easily expandable (for future changes)
- attributes cannot describe structures (child elements can)
- attributes are more difficult to manipulate by programs

**But:** converting all attributes to elements can result in an inflated structure

Attributes vs. Elements (3)

If you want to do something with the day, month, or year, the last example is the most effective (i.e., most structured)

Comments and whitespace

Comments are added in between <!-- and -->

When whitespace matters ...

- Within tags, each whitespace character is treated as significant (unlike, e.g., HTML)
- But it doesn’t matter how much whitespace you put between different tags, or if you indent a child tag
  - The data is structured in and of itself, regardless of whitespace.

Attributes

Putting data in attributes needs to be done with care:

- attributes cannot contain multiple values (child elements can)
- attributes are not easily expandable (for future changes)
- attributes cannot describe structures (child elements can)
- attributes are more difficult to manipulate by programs
The complexity of the XML used depends on exactly what the task is.

Using XML and a corresponding XSD or DTD also allows corpus designers or software designers to specify how the annotation information should be formatted.

We want to know what makes up a valid XML file, i.e., make sure a corpus is annotated in a consistent fashion.

Some validations you may encounter:

- XML Schema (XSD)  
  - XSDs show what structures are valid
  - XSDs use XML syntax, so you don’t have to relearn a new syntax
- Document Type Definition (DTD) in a separate file or at the top of the XML file
  - DTDs tell what the valid elements are; what children those elements can have; what attributes; etc.

More on XML

Validation

Document Type Definition (DTD) example

```xml
<!DOCTYPE note [
  <!ELEMENT note (to, from, heading, body)>
  <!ATTLIST note to (xs:string) #REQUIRED>
  <!ATTLIST note from (xs:string)*>
  <!ATTLIST note heading (xs:string)*>
  <!ATTLIST note body (xs:string)*>
]
```

- Document is of type note (i.e. that’s the root element
- The element note has four different children
- The other four elements simply have parsed character data (#PCDATA) as their content

XML for “raw” text

**New York Times data from the English Gigaword corpus:**

```xml
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<story>
  <headline>
    "In Los Angeles, O.J. Simpson Bought Knife Wees Before Slayings"
  </headline>
  <birthdate>1947-07-21</birthdate>
  <location>Los Angeles</location>
  <ex-wife>DeBello</ex-wife>
  <friend>friend</friend>
  <knife>15-inch</knife>
  <event>slayings</event>
  <ex-wife:>She frequented the restaurant quite often,” DeBello said.
  <friend:>
  </story>
```

More on XML

XML for linguistic purposes

- XML allows us to add structured information to a text
  - By adding XML annotation, we are able to preserve the original document—i.e., we only add to it
  - The complexity of the XML used depends on exactly what the task is.
- Using XML and a corresponding XSD or DTD also allows corpus designers or software designers to specify how the annotation information should be formatted

Some possibilities for linguistic data:

```xml
<terminal tag="NN">dog</terminal>
<terminal word="dog" tag="NN"></terminal>
<terminal word="dog" tag="NN"/> -->
<terminal>
<word>dog</word>
<tag>NN</tag>
</terminal>
```

Linguistic example

```xml
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<note>
  <to>from</to>
  <from>to</from>
  <heading>body</heading>
  <body>from</body>
</note>
```

XSD example

```xml
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema">
  <xs:element name="note">
    <xs:complexType>
      <xs:sequence>
        <xs:element name="to" type="xs:string"/>
        <xs:element name="from" type="xs:string"/>
        <xs:element name="heading" type="xs:string"/>
        <xs:element name="body" type="xs:string"/>
      </xs:sequence>
    </xs:complexType>
  </xs:element>
</xs:schema>
```
Adding POS information: BNC

```xml
<DOC...
</DOC>
```

XML for syntactic trees: TigerXML (WSJ)

```xml
<graph root="s1_500">
  ...
</graph>
```

WSJ in TigerXML (cont.)

```xml
<nonterminals>
...
</nonterminals>
```