Interlinguas & Semantic Roles

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Tutorial

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Overview

- What is an *interlingua*?
- Why we need interlinguas
- Parts of an interlingua
- Focus on Conceptual relations
  - Perspectives
  - Evaluation
  - YASRS?
- Mapping
  - Mapping into interlinguas
  - Mapping from interlinguas

What's an *interlingua*?

- An interlingua is an information or content markup language (*i*ML)
  - It's used for annotating *conceptual* information to facilitate natural language (and other) processing, for example machine translation.
  - It's like XML, but more detailed

What's an *interlingua*?

XML content-type markup

<step id=3497>Insert the disk into the drive.</step>

No information is stored about the content except for its type ("step")

How can we check (automatically) if the string really is of type "step"? (data validation)

Interlingual content markup

```
<step id=3497>
 <ppn pid=1>
    <head type=action>      #insert    </head>
    <agent>                 [#you]     </agent>
    <affected object>       #disk      </affected object>
    <goal>                  _pid=2     </goal>
</ppn>
<ppn pid=2>
    <head type=object>      #disk      </head>
    <location>              #in drive</location>
</_ppn>
</step>
```

The tags generally indicate semantic roles

Links in semantic networds are
head <role> role_filler triples

Many good questions to answer

Interlingual content markup

```
<step id=3497>
 <ppn pid=1>
    <head type=action>   #insert  </head>
    <agent>              [#you]   </agent>
    <affected object>    #disk    </affected object>
    <goal>               _pid=2   </goal>
</ppn>
<ppn pid=2>
    <head type=object>   #disk    </head>
    <location>           #in drive</location>
</_ppn>
</step>
```

Which tags are needed?
How to evaluate a system of tags?
How should the tags be interpreted?

How should the concepts be organized?

How do we know if and when these statements are well formed and make sense?

How much implicit information should be included?

Which syntax is best?

Why bother?

Why we need interlinguas

for Description

Consider these sentences:

- Something the *teacher* did with the *knife* punctured the *balloon*
- The *balloon* was *knifed* by the *teacher*
- The *knife* wielded by the *teacher* punctured the *balloon*
- The *teacher knifed* the *balloon*
- The *teacher* punctured the *balloon* by wielding a *knife*
- The *teacher* punctured the *balloon* through the use of a *knife*
- The *teacher* punctured the *balloon* using a *knife*
- The *teacher* punctured the *balloon* with a *knife*
- The *teacher* punctured the *balloon* with the *knife* method
- The *teacher* used a *knife* to puncture the *balloon*
- The *teacher* punctured the *balloon knifewise*
- The *teacher* punctured the *balloon knifely*
- *Etc.*

How can we describe paraphrases?

Why we need interlinguas

for Description

At least since Jeffrey Gruber's work on case in the 1960s (Gruber, 1976), many people have had the nagging intuitions that:

- these sentences are all equivalent in some very relevant sense;
- this kind of equivalence is pervasive in all languages and across all domains;
- a description of this kind of equivalence is related to a common "meaning" or common "information" expressed by these sentences;
- an operationalization of this kind of equivalence will be very useful for machine translation;
- an operationalization of this kind of equivalence will be very useful for knowledge engineering;

We need interlinguas to describe this kind of equivalence.

Why we need interlinguas

for Generality

A part-of-speech class *p* represents an equivalence class of words $(w_j, \ldots, w_k)$ in a given natural language

A parse tree *t* represents an equivalence class of sentences $(s_j, \ldots, s_k)$ in a natural language

- We get a more abstract, more general, more powerful, linguistic data processing strategy by processing *classes* rather than exemplars

Why we need interlinguas

for Generality

Similarly,

A statement i_n in interlingua represents an equivalence class of statements (s_j, …, s_k) in m natural languages

-The criteria for determining equivalence are simply different

"equivalence class" is weaker than synonymy. Equivalence is more like "approximate, partial synonymy"

Why we need interlinguas
for Precision

- Query 1: **"What causes lung cancer?"**
- Query 2: **"What is caused by lung cancer?"**
  - Search problem (=indexing problem) (see WebKB)
  - "Meaningless" stop words are removed: "cause & lung & cancer"
  - Question answering problem

- Consider these possible sources of information:
  - Substances, behaviors and ambient conditions that have been shown to increase the occurrence of dysplasias
  - Things that can cause cancer
  - Cancer-causing agents
  - Substances that can induce neoplastic transformation
  - Stuff that can give you the big C
  - Oncogenic factors
  - Oncogens
  - Carcinogens

***x* <CAUSE> #cancer**

Why we need interlinguas

for Scalability

- Scalability is a real-world issue
  - eBay, Oracle, World Bank
  - Endangered languages
- Reuse of NLP components
  - Components = k * 2 (for interlingua or pivot)
  - Components = $k^2 - k$ (for transfer, SMT, EBMT)
- Personnel
  - Bilingual computational linguists using the same theory
  - Bilingual QA workers

k Source Languages	Interlingua	Transfer SMT EBMT
8	16	56
16	32	240
32	64	992
153	306	23256
	Chinese <> IL <> French	Japanese <> Arabic

Why we need interlinguas

for Modularity

- To deal better with Divergences
  - Syntax or phrasing is often very different across languages
    - E.g. Bonnie Dorr's "translation divergences"
    - Interlinguas can isolate this kind of processing
- To partition Complexity
  - We are trying to map very complex, variable input to very complex, variable output (e.g., Japanese sentences to English sentences)
    - > Large rule bases of language-pair-specific rules in rule-based systems
    - > Large number of dimensions and sparse data problems in statistical systems
    - Mapping into and out of simpler interlinguas can reduce or modularize the complexity

Why we need interlinguas

for Integration

- For Integration with:
  - The Semantic Web
    - Did you go to the workshop this morning?
  - Agent communication languages
  - Knowledge management systems
  - Automated reasoning systems
  - Information extraction systems
  - Machine translation systems

Interest in interlinguas

- Semantic Role Mapping "bake-offs"
  - CoNLL 2004, SENSEVAL 2004, CoNLL 2005
- NSF-funded IAMTC project -- interlingual annotation (2004 - 2006)
  - http://aitc.aitcnet.org/nsf/iamtc/
- REFLEX (http://www.nbc.gov/reflex.htm)
  - 2004 – 2007
  - "The primary goal of this (sub)task is to produce **a structured language-neutral information representation from unstructured language data**, to be used by a range of possible analytic applications, eliminating the need for language-specific capabilities for those applications."
- DAML (http://www.daml.org/about.html) Since 2000
- ACE (Automatic Content Extraction - http://www.ldc.upenn.edu/Projects/ACE/)
  - TIDES (http://www.darpa.mil/ipto/Programs/tides/index.htm)
  - Since 1999
  - PropBank annotation of the Penn Tree Bank
- FrameNet (www.icsi.berkeley.edu/~framenet/ - since 1999)
- UNL (http://www.undl.org)
  - Since 1996 at United Nations University, Tokyo
- TREC (http://trec.nist.gov/)
  - Since 1992 (from Tipster)

Challenges of interlinguas

- Limited existing linguistic resources
  - FrameNet
  - Prop Bank
- No consensual interlingua
  - No standard set of semantic roles
  - No consensus on evaluation criteria
  - No discussion of design criteria
- Few descriptive studies of text-to-IL mapping are available
  - But see Jackendoff, 1990; Davis, 2001
- "Lost" literature from the last 30 years
- Compounding of errors in MT (?)
- Interlinguas "don't work for MT" (?)

"Anatomy" of an interlingua

- An interlingua is a metalanguage
  - Units / "vocabulary"
  - Relations / Roles / "functions"
  - Syntax / acceptable combinations
  - Semantics / interpretation
    - How expressions are linked to external entities

"Anatomy" of an interlingua

- Units
  - Units or "vocabulary" of an interlingua are nodes in some ontology
  - There's a large literature on ontologies, so we won't focus on that here
  - We assume the most general categories like object, event, attribute, time, quantity, etc.
    - "entity" is the name of the top node
    - Features, as well, like "+/- animate", etc.

"Anatomy" of an interlingua

- Syntax
  - There's also a large literature on formalisms such as
    - XML Schemas (www.w3.org/XML/Schema)
    - RDF (www.w3.org/rdf), RDF schemas
    - TRIPLE (triple.semanticweb.org) ("Notation 3")
  - We don't need to talk about this here
    - Home-grown formalisms need to be avoided

"Anatomy" of an interlingua

- The focus today will be on:
  - The system of *conceptual relations* between concepts (or *roles*) that are represented in an interlingua
    - YASRS? (yet another semantic role set?)
    - Design & Evaluation
    - Emphasize the *semantics* of these conceptual relations to avoid problems of past efforts
  - The mappings between surface linguistic phenomena and these conceptual relations
    - This is much more varied than many efforts seem to assume
- These are what differentiate interlinguas from other markup or metalanguages

Conceptual relations

Perspectives

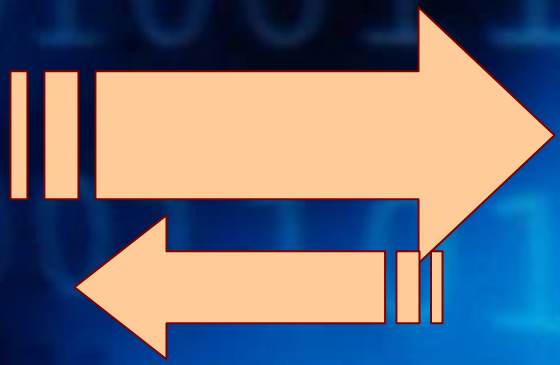
- Perspectives
  - Bottom-up, syntactic perspective: defining semantic roles from verb meanings
    - What are the verbs and sentence structures we want to cover?
  - Top-down, conceptual perspective: defining semantic roles from conceptual structures
    - What are the conceptual structures we want to cover?

Conceptual relations

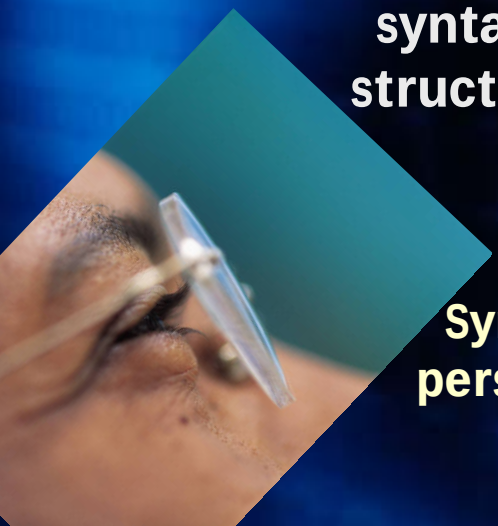
Perspectives

Conceptual perspective

Phrases, Sentences (lexical items, syntactic structures)



Concepts, Conceptual relations



Syntactic perspective

Conceptual relations

Kinds of Relations

Syntactic perspective* Delisle, et al, 1997: 275	Conceptual perspective* Frederiksen, 1975: 372
Case relations – between a main verb and its syntactic arguments	Event-defining relations – between event concepts and other concepts
Clause-level relations – between finite clauses connected by conjunctions	Logical and algebraic relations – between propositions or interlingua statements
Noun-modifier relations – between a head noun and its modifiers	State-defining relations – between an entity and its attributes
Roles described in terms of the kinds of *indicators* in the object language	Roles described in terms of the kinds of *elements* in the conceptual metalanguage

Conceptual relations

Perspectives

- Problems with a syntactic perspective
  - Syntactic bias
    - Different syntax => different semantics
      - "overanalysis"
      - Lead to multiple representations of paraphrases
    - Same syntax => same semantics
      - Direct Object => affected object
      - John laughed **at** the joke (as directional)
      - "underanalysis"
    - There's much more happening than that!
    - Sometimes syntactic relations are included in the IL
  - Biases the analysis toward a specific language
  - Focus on syntax
    - Analysis of sentences, not of meanings
    - Ignore morphological and lexical markers
  - Linguistic diversity becomes overwhelming

Conceptual relations

Perspectives

- Overlap:
  - Both define and label equivalence classes of phrases and sentence fragments
    - According to some notion of equivalent meaning
    - "agent" groups a range of linguistic phenomena together

Conceptual relations

Examples

- SIL Example < >
- UNL Example < >

Semantic Roles according to SIL

(based on Payne, T. 1997. *Describing morphosyntax: A guide for field linguists.* New York: Cambridge University Press. See: http://www.sil.org/linguistics/GlossaryOfLinguisticTerms/WhatIsASemanticRole.htm)

A **semantic role** is the underlying relationship that a participant has with the main verb in a clause. (…) Semantic role is the actual role a participant plays in some real or imagined situation, apart from the linguistic encoding of those situations.

- If it is "apart from the linguistic encoding", how can it be defined as "related to the main verb"?

Accompaniment is the semantic role of a thing that participates in close association with an agent, causer, or affected in an event.

- What does "in close association" mean? "In someone's pocket"?

Agent is the semantic role of a person or thing who is the doer of the event. (…) A prototypical agent is conscious, acts with volition (on purpose), and performs an action that has a physical, visible effect.

- What is a "doer"?
- What are other, non-prototypical agents like?

A **beneficiary** is the semantic role of a referent which is advantaged or disadvantaged by an event.

- In "John arrested the assailant", the assailant is the beneficiary?
- What's a referent? Does agent have to do with referents, as well?

Causer is the semantic role of the referent which instigates an event rather than actually doing it.

- What are the differences between a "doer" and an "instigator"?
- Doesn't an agent instigate an event? And an instrument?

A **counteragent** is the semantic role of a force or resistance against which an action is carried out.

- In "John pushed against the door", door is a counteragent?

Dative is the semantic role of a referent that is conscious of being affected by the state or action identified by the verb.

- No verb, no dative?
- No awareness, do dative?
- In "They gave the sleeping man $100", the man isn't the dative?
- Isn't "dative" a morphosyntactic case rather than a semantic role?

Experiencer is the semantic role of an entity (or referent) which receives, accepts, experiences or undergoes the effect of an action.

- Too many options. Beware of "or"s in definitions.
- Doesn't the beneficiary "receive the effect of an action"?
- Doesn't a patient "undergo the effect of an action"?

Factitive is the semantic role of a referent that results from the action of state identified by a verb.

- No verb, no factitive?
- Semantic roles are supposed to be "apart from the linguistic encoding".

Goal is the semantic role of the place to which something moves, or thing toward which an action is directed.

- Are these different?
- Can states, measures or attributes be goals? "John strove to be calm"

Instrument is the semantic role of an inanimate thing that an agent uses to implement an event. It is the stimulus or immediate physical cause of an event. (…) Instrument **words** are usually…

- Are "instrument" and "use" different?
- What does it mean to "implement" an event? Is that different from "doing" and "instigating" an event?

Locative is a semantic role which identifies the location or spatial orientation of a state or action. A locative semantic role does not imply motion to, from, or across the location.

- But it can imply motion over, under, around or through.
- "…danced across the room" is not locative?

Manner is a semantic role that notes how the action, experience, or process of an event is carried out.

- What are "action of an event", "experience of an event" and "process of an event"?
- How does one carry these out? Is this different from "doing", "instigating", and "implementing"?

Measure is a semantic role which notes the quantification of an event.

- Objects and attributes can't be quantified?
- "Notes" is different from "identifies"?

Path is the semantic role describing the locale(s) traversed in motion or propulsion predications.

- "Predications" rather than events?
- "Traversed" means it really happened. What about future or hypothetical events?

Patient is a semantic role that is usually the surface object of the verb in a sentence. (…) predicated with a state or location; undergoing a change of state or location; which is possessed, acquired or exchanged (…) thing that is affected by an event; person or thing that undergoes a process; person who experiences an event

- It's also "the kitchen sink" – almost anything at all.
- Semantic roles are supposed to be "apart from the linguistic encoding".

Range is the semantic role of the entity that completes, is a product of, or further specifies an event. (…) [some linguists] give it the same meaning as locative or location.

- This sounds like a complement that "completes the meaning of a verb". What does it mean?
- "A product of an event" seems to be the same as factitive, patient, and result.

A **result** is a semantic role that refers to that which is produced by an event.

- The even t produces it or it is produced during the event?

Source is the semantic role of the following referents: the place or origin; the entity from which a physical sensation emanates; the original owner in a transfer.

- Beware of "or"s.
- Are these different?

Time is the semantic role of the temporal placement of an event.

- This exemplifies the localizationist hypothesis: time is expressed with metaphors of place.
- What is a "temporal placement"?

What do we do with?

John read **while** Mary slept.
Suzy **looks like** Ilona.
During positron emission tomography, isotopes degrade emitting protons.
The car roared **down** the street.

Semantic Roles from UNL
(Universal Networking Language)

[http://www.undl.org/unlsys/unl/unl2005/Relation.htm]

agt	agent	indicates a thing in focus that initiates an action
and	conjunction	indicates a partner to have conjunctive relation to
aoj	thing with attribute	indicates a thing that is in s state or has an attribute
bas	basis	indicates a thing used as the basis (standard) of comparison
ben	beneficiary	indicates an indirectly related beneficiary or victim of an event or state
cag	co-agent	indicates a thing not in focus that initiates an implicit event that is done in parallel
cao	co-thing with attribute	indicates a thing not in focus that is in a parallel state
cnt	content	indicates the content of a concept
cob	affected co-thing	indicates a thing that is directly affected by an implicit event done in parallel or an implicit state in parallel
con	condition	indicates a non-focused event or state that conditions a focused event or state
coo	effected co-thing	indicates a co-occurrent event or state for a focused event or state
dur	duration	indicates a period of time during which an event occurs or a state exists
equ	effected co-thing	indicates an equivalent concept
fmt	range/from-to	indicates a range between two things
frm	origin	indicates an initial state of a thing or a thing initially associated with the focused thing
gol	goal/final state	indicates a final state of object or a thing finally associated with the object of an event
icl	included/a kind of	indicates an upper concept or a more general concept
ins	instrument	indicates an instrument to carry out an event
int	intersection	indicates all common instances to have with a partner concept
iof	an instance of	indicates a class concept that an instance belongs to
man	manner	indicates a way to carry out an event or the characteristics of a state
met	method/means	indicates a means to carry out an event
mod	modification	indicates a thing that restricts a focused thing
nam	name	indicates a name of a thing
obj	affected thing	indicates a thing in focus that is directly affected by an event or state
opl	affected place	indicates a place in focus affected by an event
or	disjunction	indicates a partner to have disjunctive relation to

per	proportion/rate/distribution	indicates a basis or unit of proportion, rate or distribution
plc	place	indicates a place where an event occurs, or a state that is true, or a thing that exists
plf	initial place	indicates a place where an event begins or a state that becomes true
plt	final place	indicates a place where an event ends or a state that becomes false
pof	part of	indicate a concept of which a focused thing is a part
pos	possessor	indicates the possessor of a thing
ptn	partner	indicates an indispensable non-focused initiator of an action
pur	purpose	indicates the purpose or objective of an agent of an event or the purpose of a thing that exists
qua	quantity	indicates the quantity of a thing or unit
rsn	reason	indicates a reason why an event or a state happens
scn	scene	indicates a scene where an event occurs, or state is true, or a thing exists
seq	sequence	indicates a prior event or state of a focused event or state
src	source/initial state	indicates the initial state of an object or thing initially associated with the object of an event
tim	time	indicates the time an event occurs or a state is true
tmf	initial time	indicates the time an event starts or a state becomes true
tmt	final time	indicates a time an event ends or a state becomes false
to	destination	indicates a final state of a thing or a final thing (destination) associated with the focused thing
via	an intermediate place or state	indicates an intermediate place or state of an event

Evaluation criteria

- Barker et al, 1997

- **Generality (~Granularity)**
  - "account for relationships between more than one distinct verb-argument pair"
  - The more general, the better – for easier inference
  - Measure of generality: number of surface markers per relation
- **Specificity**
  - "distinguish between the roles of each verb argument"
  - One role per argument; one argument per role
  - The more specific, the better – for easier mapping
  - This does ***not*** mean that different role labels are needed for each
- **Completeness**
  - "cover any possible relationship" observed
  - Empirical Measure: % of unlabelled surface elements
  - Theoretical Measure: % of known-to-be-useful relations
- **Uniqueness**
  - "no superfluous or redundant" relations
  - No "arbitrary" addition of relations: new relations must cover previously unaccounted for sentence elements
- **Independence** (Mora Gutierrez, 2001, based on Dowty, 1991)
  - "Each role is given a consistent semantic definition that applies to all verbs and all situations. Thus, role definitions do not depend on the meaning of the particular verb or on the other thematic roles it assigns."

Verbs only?
Non-arguments?

Evaluation Criteria

Granularity

How many roles should we use?

- Link roles to each verb (Cyc, PropBank): fine granularity (thousands of relations)
- Link roles to Conceptual Frames or groups of verbs (FrameNet): medium granularity (hundreds of relations)
- Link roles to events / states in general: coarse granularity (tens of relations)

An ontology of relations allows us to choose the granularity by application

Evaluation Criteria

Generality

Which roles should we use?

- Roles characterize the relations between concepts, NOT the concepts themselves
  - Recipient, Agent, Instrument are OK
  - Liquid or Food does not characterize the type of *relation* (cf. FrameNet)
- Relations that only differ by the kinds of fillers they take are redundant
  - Examples follow

Evaluation Criteria

Redundancy

- Do we need both instrument and method?
  - Both refer to parts of the main event
  - **John ate the sushi with chopsticks.**
    - [John ate sushi] >PRT> [chopsticks] (instrument)
    - [John ate sushi] >PRT> [using chopsticks] (method)
  - The "instrument" is shorthand for an event
  - The "method" makes the event explicit
- *The relation is the same;* the arguments are different

Evaluation Criteria

Redundancy

Do we need roles for both agent and cause?

- Of course, we need a way of representing the difference
- We have CAUSE
- We have <+/- volitional> in the ontology

- John broke the window.
  - John >AGT> [the window broke]
- John's arrival started an argument.
  - [John arrived] >CAU> [someone argued]
  - [John] >CAU> [the window broke]

- The "agent" is shorthand for an event
- "agent" is a configuration of more basic roles and attributes: agent is redundant
  - AGT is a notational convenience
  - See Jackendoff, 1990

Evaluation Criteria

Completeness

- How do we know the system of roles is complete?
  - Empirical measure: % of elements that are unlabeled
  - Theoretical measure: % of known-to-be useful relations that are used
  - See Table <here>

Coverage of Semantic Roles by different interlinguas

Classification of roles	**Frederiksen, C.** Representing logical and semantic structure of knowledge acquired from discourse. *Cognitive Psychology, 7* (3): 371-458. 1975	**UNL** *UNL Specification* (v. 1.6). 1999. Tokyo: UNL Center.	**Sowa** *Knowledge Representation*. 2000. Pacific Grove, CA: Brooks/Cole.	**Gildea & Jurafsky** *Automatic labelling of semantic roles*. ICSI Tech Report TR-01-005, 2001	**Gazelle** http://www.isi.edu/natural-language/mt/interlingua.html	**KANT/NMSU** http://crl.nmsu.edu/Research/Proj…case-roles.html
lexical	#	antonym	#	#	#	#
lexical	#	semantic field	#	#	#	#
lexicalized predicates	is_of_category?	#	child	#	#	#
lexicalized predicates	is_of_category	#	#	#	instance	#
lexicalized predicates	*poss*(pat:*)#	possessor	possession	#	generalized-possession	#
logical	if	con	#	#	#	#
logical	iff	#	#	#	#	#
logical	existential quantifier	#	#	#	#	#
logical	universal quantifier	#	#	#	#	#
logical	and	and	#	#	#	#
logical	or	or	#	#	#	#
truth value	neg	#	#	#	#	#
truth value	modal:qualified	#	#	#	possible; obligatory; likely; permitted	#
truth value	interrogative					
truth value	Truth Value	#	#	#	mood; polarity	#
meta	id#	id#	#	proposition	#	#
meta	#	#	has/role	#	#	#
meta	#	smd (arbitrary association)	#	#	concat	#
meta	#	#	argument (of function)	#	#	#
meta	[ ]#	[ ]#	#	null_role	#	#
meta	id#	id#	#	state	#	#
amount	null	#	#	#	#	#
amount	#	per	#	#	#	#

Coverage of Semantic Roles by different interlinguas

	Frederiksen, C.	UNL	Sowa	Gildea & Jurafsky	Gazelle	KANT/NMSU
amount	degree	#	amount	#	#	#
amount	degree#	#	measure	#	#	#
amount	identity	equal	#	#	#	#
amount	q.number	quantity	#	degree	#	degree
location	>analyzed#	logical_place	#	location#	#	location#
location	goal#	place_to	#	goal	#	#
location	Loc 0,,j	physical_place#	#	location#	spatial-locating	location#
location	Loc 0,0	physical_place#	#	location#	spatial-locating	location#
location	Loc I,,j	physical_place#	#	location#	spatial-locating	location#
location	loc:closed path	via	path	path	via	path
location	locative	physical_place	location	location	spatial-locating	location
location	result	goal#	destination	result	destination	destination
location	source#	place_from	#	source	#	#
location	source#	source#	origin		source#	
location	source, result#	from_to	#	source, result#	#	#
reference	r.definite	#	#	#	definiteness	#
reference	r.generic	#	#	#	#	#
reference	r.token	#	#	#	instance	#
case	cause?	#	effector	#	#	#
case	agent	agent	agent	agent	agent; agent-of	agent
case	agent#	co-agent	accompaniment	#	#	accompanier
case	agent#	partner	accompaniment	#	#	accompanier
case	ASPECT: INCIP	#	start	#	#	#
case	attribute	attribute	attribute; characteristic	#	domain; domain-of	co-theme?
case	cause#	reason	#	goal#	reason	purpose
case	goal	goal	#	goal	destination; recipient; dative; purpose; range	#
case	has_part	part_of	part	#	#	#
case	inanimate patient	#	#	#	#	#
case	instrument	instrument	instrument	instrument	instrument	#
case	instrument#	instrument#	medium	#	means	#
case	object	object	patient	patient	object	theme
case	object#	object#	patient	patient	patient	theme
case	ord:temp	sequence	successor	#	#	#
case	part of event#	method	#	#	manner	means
case	patient	experiencer	experiencer	experiencer	#	experiencer

Coverage of Semantic Roles by different interlinguas

	Frederiksen, C.	UNL	Sowa	Gildea & Jurafsky	Gazelle	KANT/NMSU
case	recipient	goal#	beneficiary	result#	#	beneficiary
case	recipient#	goal#	recipient		#	
case	result	goal#	completion	result	consequence	destination
case	result#	object#	result	patient#	#	theme#
case	rslt/goal#?	purpose	#	goal	#	#
case	source	source	matter	source	source	source
case	theme	object#	theme	topic	topic	#
case	theme#	object#	#	percept	#	#
attribute	attribute of event	manner	manner	manner	#	manner
attribute	attribute of attribute	modifier	#	#	#	#
attribute	attribute#	modifier	#	#	mod; mod-1	#
relation	cause	cau?	because	cause	#	#
relation	conditional	condition	#	cause	condition	#
relation	diff	#	#	#	diff-quant	#
relation	equiv#	name	#	#	#	#
relation	equiv:temp#	co-occurrence	#	#	#	#
relation	equivalence	equivalent	#	#	#	#
relation	order	#	#	#	#	#
relation	prox#	basis_of_comparison ?	#	#	role-of-agent ("as president")	#
relation	prox#	basis_of_comparison ?	base	#	role-of-patient ("used as garbage")	#
relation	prox:deg (*,)#	basis_of_comparison	base	#	anchor	co-theme?
relation	prox:deg (*,)#	basis_of_comparison	comparand	#	compared-to	co-theme?
time	act	coo#	#	#	#	#
time	state	coo#	#	#	#	#
time	temp/reslt	time_to	#	#	#	#
time	temp/source	time_from	#	#	#	#
time	temp:*dur*	duration	duration	#	#	#
time	temporal	time	pointintime	#	temporal-locating	time
Coverage:	**93%**	**74%**	**39%**	**38%**	**38%**	**29%**

Evaluation Criteria

Explanatory Adequacy

- Explanatory Adequacy
  - Why these roles? Where do they come from?
    - If we can't answer this, we're doomed
  - Define the division of labor between ontology and system of roles
  - Lists, groups, trees, models
  - Account for equivalence classes of Ss, not just individual Ss
  - What does each role mean?
    - The basis for inference and paraphrase / translation

Conceptual structures

- Here's one approach to identifying "semantic roles" for a conceptual interlingua
  - Lists > models
    - Relation + Typed argument(s) ~ (fewer) roles
  - Syntactic structures > conceptual structures
    - States, events, structures of events, propositions
  - Describe sentences > describe sets of equivalent sentences ("paraphrases")

Propositions

- Propositions (interlingua statements) in general
  - <_Ppn id=*x*> (proposition identifier)
  - <_Head>
  - *Filler* refers to a node in an ontology
    - Ex: <Location> *filler* </Location>
  - <Truth_value type=“”> *Qualifier* </Truth_value>
    - type $=_{df}$ Affirmative | Negative | Interrogative
    - Qualifier
      - Filler is of type Location **…at home**
      - Filler is of type Time **…in the morning**
      - Filler is of type Frequency **... every week**
      - Etc.

States

- States relate an entity with its attributes; provides "descriptive" or "stative" information
  - <_Head> (of any type)
  - <Attribute> *filler* </Attribute>
    - Filler is of type Attribute
      - John is intelligent
      - John has a high IQ
    - Filler is of type Amount
      - Three apples
      - Sixteen tons of bauxite
    - Filler is of type Object
      - John is a pig
      - John is a psychologist
    - (example later)
    - A picture of Mary
    - A story about courage
  - <Location>
  - <Components>
  - <Content> (symbolic content)
  - See also: <Truth_value>

Simple events

- Simple events relate an event and entity
  - <_Head> (of type event)
  - <Changing entity>
    - <Initial state> (of changing entity)
    - <Medial state > (of changing entity)
    - <Final state > (of changing entity)
  - See also
    - Stative information (of event)
    - <Truth_value>

  - **#fly**
  - **#John**
    - **from #DC**
    - **via #SFO**
    - **to #Osaka**

    - **by #beating his wings**

Components

- "instrument", "means", "method"
  - John cooked his lunch *with* a CAT scanner.
  - John cooked his lunch *by using* a CAT scanner.
- "instrument", "purpose"
  - John used a CAT scanner *to* cook his lunch.
  - *To* cook his lunch, John put it in a CAT scanner.
- "instrument", "agent", "cause"
  - The CAT scanner cooked John's lunch.
  - The CAT scanner *made* John's lunch cook.

Components

- John cooked his lunch... **<~goal or purpose>**
  - John took his lunch out of the box.
  - John took the wrapper off his lunch.
  - John put his lunch into the CAT scanner.
  - John turned on the CAT scanner. > **<~instrument>**
    - The CAT scanner made John's lunch hot. > **<~cause>**
      - John took his lunch out of the CAT scanner.
      - …
- … with a CAT scanner. **<~part of *cooking*>**
- Events have components, just like objects do
  - Do we need all of these different roles? <link>

Semantic Roles from UNL
(Universal Networking Language) -- grouped

[http://www.undl.org/unlsys/unl/unl2005/Relation.htm]

amount	fmt	range/from-to	indicates a range between two things
amount	per	proportion/rate/distribution	indicates a basis or unit of proportion, rate or distribution
amount	qua	quantity	indicates the quantity of a thing or unit
attribute	aoj	thing with attribute	indicates a thing that is in a state or has an attribute
attribute	cao	co-thing with attribute	indicates a thing not in focus that is in a parallel state
attribute	icl	included/a kind of	indicates an upper concept or a more general concept
attribute	iof	an instance of	indicates a class concept that an instance belongs to
attribute	man	manner	indicates a way to carry out an event or the characteristics of a state
attribute	mod	modification	indicates a thing that restricts a focused thing
attribute	nam	name	indicates a name of a thing
cause	agt	agent	indicates a thing in focus that initiates an action
cause	cag	co-agent	indicates a thing not in focus that initiates an implicit event that is done in parallel
cause	ptn	partner	indicates an indispensable non-focused initiator of an action
changing object	ben	beneficiary	indicates an indirectly related beneficiary or victim of an event or state
changing object	cob	affected co-thing	indicates a thing that is directly affected by an implicit event done in parallel or an implicit state in parallel
changing object	obj	affected thing	indicates a thing in focus that is directly affected by an event or state
changing object	opl	affected place	indicates a place in focus affected by an event
component	ins	instrument	indicates an instrument to carry out an event
component	met	method/means	indicates a means to carry out an event
component	pof	part of	indicates a concept of which a focused thing is a part
component	pur	purpose	indicates the purpose or objective of an agent of an event or the purpose of a thing that exists
component	rsn	reason	indicates a reason why an event or a state happens
content	cnt	content	indicates the content of a concept

final state	gol	goal/final state	indicates a final state of object or a thing finally associated with the object of an event
final state	to	destination	indicates a final state of a thing or a final thing (destination) associated with the focused thing
medial state	via	an intermediate place or state	indicates an intermediate place or state of an event
initial state	frm	origin	indicates an initial state of a thing or a thing initially associated with the focused thing
initial state	src	source/initial state	indicates the initial state of an object or thing initially associated with the object of an event
location	plc	place	indicates a place where an event occurs, or a state that is true, or a thing that exists
location	scn	scene	indicates a scene where an event occurs, or state is true, or a thing exists
relation	coo	effected co-thing	indicates a co-occurrent event or state for a focused event or state
relation	seq	sequence	indicates a prior event or state of a focused event or state
relation	pos	possessor	indicates the possessor of a thing
relation	and	conjunction	indicates a partner to have conjunctive relation to
relation	bas	basis	indicates a thing used as the basis (standard) of comparison
relation	con	condition	indicates a non-focused event or state that conditions a focused event or state
relation	equ	effected co-thing	indicates an equivalent concept
relation	int	intersection	indicates all common instances to have with a partner concept
relation	or	disjunction	indicates a partner to have disjunctive relation to
truth value	dur	duration	indicates a period of time during which an event occurs or a state exists
truth value	tim	time	indicates the time an event occurs or a state is true
truth value	plt	final place	indicates a place where an event ends or a state that becomes false
truth value	tmt	final time	indicates a time an event ends or a state becomes false
truth value	plf	initial place	indicates a place where an event begins or a state that becomes true
truth value	tmf	initial time	indicates the time an event starts or a state becomes true

Complex events

- Relational propositions
  - <_Head>*null*</Head>
    - <relation><_Arg1>*filler1*<_Arg2>*filler2*</relation>
  - Relations
    - <Cause>
    - <Condition>
    - <And>, <Or>
    - <Equivalence type="…"> (of time, location, amount)
    - <Order type="…"> (of time, location, amount)
    - <Similarity type="…"> (of time, location, amount)
    - <Difference type="…"> (of time, location, amount)
  - See also
    - Stative information (of head)
    - <Truth_value>

There's more to discuss…

- Today we're focusing on *sense*, not reference
  - Classes or predicates, not individuals
- Referential relations
  - <identity>
  - Definite, indefinite, generic reference
  - Scope of quantifiers
- Pragmatic information
  - "but", "however" ~ contrary to expectations
- Salience (relative importance of concepts)
  - Topicalization
- Etc.

Design criteria

- From verbs, out vs. from syntax, in
  - Verb-centric: agree-er, A0, etc. e.g., CYC, PropBank
  - Syntax-centric: agt, inst, etc.
  - Concept-centric: top-down
- Maximize language independence
  - Independent of tense, aspect, perspective, part of speech, topicalization
  - Independent of morphological, lexical, or syntactic realization
- Maximize abstractness to facilitate inference
  - maximize language-independence of relations
  - maximize number of surface realizations for each role
  - minimize number of roles
- Maximize coherence, explicitness, and transparency
  - Lists, groups, trees, models of relations
- Make rules for adding/deleting roles: when and how
- Balance systematicity of mapping from surface with regularity of processing IL statements

"Physiology" of interlinguas

- We talked about "anatomy"
  - Parts and how they're interrelated
- Now about "physiology"
  - How they work in practice
    - Mapping from natural language expressions into propositions
    - Processing sets of propositions (not today)
    - Mapping from propositions to natural language expressions

Mapping into interlinguas

- Mapping from surface linguistic structures or parse trees to conceptual roles is many-to-many
  - Very many (thousands) surface forms (of different types) for a single conceptual role
  - Many (tens) conceptual roles for a single surface form
- Many early researchers underestimated the scale of the problem

Mapping into interlinguas

(some) Conceptual roles of "with" in English

Bill ate the cake…	with NP		
	with a fork	**instrument**	Possible tool
	with Mary	**agent**	animate object
	with short, jerky movements	**component of event**	action
	with glee	**attribute**	attribute
	with the lights off	**simultaneous state**	state
	with blue icing	**component of object**	Possible part
	with the intent of pleasing the cook	**purpose**	

Mapping into interlinguas

- "with" in FrameNet
  - *With* by frequency <see data>
  - *With* by similarity <see data>

Distribution of Semantic roles for "with" in FrameNet 1.1 (by Freq)

Role	Freq	Raw %	Cum %
Theme	706	17.8%	18%
Instrument	297	7.5%	25%
Interlocutor 2	242	6.1%	31%
Item 2	231	5.8%	37%
Means	222	5.6%	43%
Manner	204	5.1%	48%
Stimulus	172	4.3%	**52%**
Internal cause	112	2.8%	55%
Duration	91	2.3%	57%
Arguer2	86	2.2%	**60%**
Depictive	82	2.1%	62%
Partner 2	79	2.0%	64%
Cause of shine	75	1.9%	66%
Descriptor	75	1.9%	67%
Part 2	62	1.6%	69%
Norm	54	1.4%	**70%**
Persistent characteristic	53	1.3%	72%
Cotheme	51	1.3%	73%
Liquid	42	1.1%	74%
Knowledge	42	1.1%	75%
Connector	41	1.0%	76%
Reason	38	1.0%	77%
Addressee	38	1.0%	78%
Co resident	33	0.8%	79%
Bodypart of agent	33	0.8%	**80%**
Impactee	32	0.8%	81%
Emotion	31	0.8%	81%
Subregion	30	0.8%	82%
Co travelers	27	0.7%	83%

Role	Freq	Raw %	Cum %
Affected party	24	0.6%	84%
Body part	21	0.5%	85%
Co Variable	20	0.5%	85%
Content	19	0.5%	86%
Charges	17	0.4%	86%
Contents	17	0.4%	86%
Message	17	0.4%	87%
Part	17	0.4%	87%
Impactor	16	0.4%	88%
Resource	16	0.4%	88%
Focal participant	15	0.4%	88%
Treatment	15	0.4%	89%
Employer	14	0.4%	89%
Response action	13	0.3%	89%
Frequency	13	0.3%	**90%**
Practice	13	0.3%	90%
Force	13	0.3%	90%
Medium	12	0.3%	91%
Goal	12	0.3%	91%
Change agent	11	0.3%	91%
Degree	11	0.3%	92%
Obstruction	11	0.3%	92%
Category	11	0.3%	92%
Cause	11	0.3%	92%
Controllee	10	0.3%	93%
Evaluee	10	0.3%	93%
Company	10	0.3%	93%
Circumstances	10	0.3%	93%
StandardItem	9	0.2%	94%

Role	Freq	Raw %	Cum %
Food2	9	0.2%	94%
Performer2	8	0.2%	94%
Weapon	8	0.2%	**95%**
Alterant	8	0.2%	95%
Concept 2	8	0.2%	95%
Style	8	0.2%	95%
Experiencer	7	0.2%	95%
Offender	7	0.2%	95%
Skill	7	0.2%	96%
Fastener	7	0.2%	96%
Specification	7	0.2%	96%
Ingredients	7	0.2%	96%
Topic	6	0.2%	96%
Sign 2	6	0.2%	96%
Entity	6	0.2%	97%
Activity	5	0.1%	97%
Medication	5	0.1%	97%
Result	5	0.1%	97%
Teacher	4	0.1%	97%
Purpose	4	0.1%	97%
Performer	4	0.1%	97%
Accuracy	4	0.1%	97%
Injuring entity	4	0.1%	98%
Punishment	4	0.1%	98%
Behavior	4	0.1%	98%
Characterization	4	0.1%	98%
Constant location	4	0.1%	98%
Issue	3	0.1%	98%
Side 1	3	0.1%	98%
Amends	2	0.1%	98%
Accessory	2	0.1%	98%

Distribution of Semantic roles for "with" in FrameNet 1.1 (by Freq)

Role	Freq	Raw %	Cum %
Constituent parts	2	0.1%	98%
Location	2	0.1%	98%
Characteristic	2	0.1%	98%
Part Prop	2	0.1%	98%
Entity 2	2	0.1%	98%
Substance	2	0.1%	98%
Attendee	2	0.1%	99%
Name	2	0.1%	99%
Co theme	2	0.1%	99%
Material	2	0.1%	99%
Interlocutors	2	0.1%	99%
Speed	2	0.1%	99%
Institution	2	0.1%	99%
Society	2	0.1%	99%
Road	2	0.1%	99%
Cognizer	1	0.0%	99%
Baggage	1	0.0%	99%
Self mover	1	0.0%	99%
Compensation	1	0.0%	99%
Landmark occasion	1	0.0%	99%
Use	1	0.0%	99%
Action	1	0.0%	99%
Hot Cold source	1	0.0%	99%
Focal occasion	1	0.0%	99%
Protagonist	1	0.0%	99%
Outcome	1	0.0%	99%
Dimension	1	0.0%	99%
Traveler	1	0.0%	99%
Prize	1	0.0%	99%
Standard attribute	1	0.0%	99%
Field	1	0.0%	99%
Event	1	0.0%	99%
Perceiver agentive	1	0.0%	99%
Host	1	0.0%	99%
Parts	1	0.0%	99%
External cause	1	0.0%	99%
Iteration	1	0.0%	99%
Owner	1	0.0%	100%
Circumstance	1	0.0%	100%
Healer	1	0.0%	100%
Configuration	1	0.0%	100%
Item	1	0.0%	100%
Abundant entities	1	0.0%	100%
Extent	1	0.0%	100%
Sides	1	0.0%	100%
Arguers	1	0.0%	100%
Conditions	1	0.0%	100%
Stuff	1	0.0%	100%
Area	1	0.0%	100%
Place	1	0.0%	100%
Empathy target	1	0.0%	100%
Combatants	1	0.0%	100%
Criteria	1	0.0%	100%
Evidence	1	0.0%	100%
Iterations	1	0.0%	100%
Intoxicant	1	0.0%	100%
Co abductee	1	0.0%	100%
	3966		

Distribution of Semantic roles for “with” in FrameNet 1.1 (by similarity)

Role name	Freq	Notes
Activity	5	ACTIVITY
Behavior	4	ACTIVITY
Action	1	ACTIVITY
Event	1	ACTIVITY
Impactor	16	AGT
Employer	14	AGT
Performer2	8	AGT
Experiencer	7	AGT
Fastener	7	AGT
Offender	7	AGT
Injuring_entity	4	AGT
Performer	4	AGT
Teacher	4	AGT
Cognizer	1	AGT
Healer	1	AGT
Intoxicant	1	AGT
Owner	1	AGT
Perceiver_agentive	1	AGT
Self_mover	1	AGT
Traveler	1	AGT
Stimulus	172	CAU
Internal_cause	112	CAU
Cause_of_shine	75	CAU
Reason	38	CAU
Change_agent	11	CAU
Cause	11	CAU
External_cause	1	CAU
Depictive	82	CHAR
Descriptor	75	CHAR
Persistent_characteristic	53	CHAR
Skill	7	CHAR
Characteristic	2	CHAR

Role name	Freq	Notes
Partner_2	79	CO
Co_resident	33	CO
Co_Variable	20	CO
Company	10	CO
Co_theme	2	CO
Co_abductee	1	CO
Combatants	1	CO
Knowledge	42	CONTENT
Content	19	CONTENT
Contents	17	CONTENT
Message	17	CONTENT
Concept_2	8	CONTENT
Impactee	32	GOAL
Goal	12	GOAL
Purpose	4	GOAL
Outcome	1	GOAL
Instrument	297	INST
Means	222	INST
Weapon	8	INST
Interlocutor_2	242	INTERLOC
Arguer2	86	INTERLOC
Addressee	38	INTERLOC
Interlocutors	2	INTERLOC
Arguers	1	INTERLOC
Item_2	231	ITEM
Item	1	ITEM
Iteration	1	ITER
Iterations	1	ITER
Focal_occasion	1	OCC
Landmark_occasion	1	OCC
Constant_location	4	PL
Location	2	PL

Role name	Freq	Notes
Part_2	62	PRT
Bodypart_of_agent	33	PRT
Body_part	21	PRT
Part	17	PRT
Ingredients	7	PRT
Accessory	2	PRT
Constituent_parts	2	PRT
Part_Prop	2	PRT
Substance	2	PRT
Parts	1	PRT
Response_action	13	RESULT
Result	5	RESULT
Theme	706	THEME
Cotheme	51	THEME
Co_travelers	27	THEME
Affected_party	24	THEME
Evaluee	10	THEME
Manner	204	
Duration	91	
Norm	54	
Liquid	42	
Connector	41	
Emotion	31	
Subregion	30	
Communication	26	
Charges	17	
Resource	16	
Focal_participant	15	
Treatment	15	
Force	13	
Frequency	13	
Practice	13	

Distribution of Semantic roles for “with” in FrameNet 1.1 (by similarity)

Role name	Freq	Notes
Category	11	
Degree	11	
Obstruction	11	
Circumstances	10	
Controllee	10	
Food2	9	
Money	9	
Standard_item	9	
Alterant	8	
Style	8	
Specification	7	
Entity	6	
Sign_2	6	
Topic	6	
Medication	5	
Accuracy	4	
Characterization	4	
Punishment	4	
Issue	3	
Side_1	3	
Amends	2	
Attendee	2	
Entity_2	2	
Institution	2	
Material	2	
Name	2	
Road	2	
Society	2	
Speed	2	
Abundant_entities	1	
Area	1	
Baggage	1	

Role name	Freq	Notes
Compensation	1	
Conditions	1	
Configuration	1	
Criteria	1	
Dimension	1	
Empathy_target	1	
Evidence	1	
Extent	1	
Field	1	
Host	1	
Hot_Cold_source	1	
Prize	1	
Protagonist	1	
Sides	1	
Stuff	1	
Use	1	

Mapping into interlinguas

- Issues
  - Consistency and reliability
  - Granularity
  - Focus on relations

Mapping into interlinguas
with rules

- The TANKA Project (Delisle et al., 1997)
  - "…to build a conceptual model of the domain described in a real text using as little a priori domain knowledge as possible…"
    - Romacker, Markert & Hahn (1999) "lean semantic interpretation"
  - "conceptual model" = array of interlingual statements
  - Lexical knowledge + domain-independent surface-syntactic features
  - Propose [interlingual] analyses to a user for approval; learns approved mappings

Mapping into interlinguas
with rules

- Information extraction approaches
  - Riloff's (1998) bootstrapping approach
  - Hearst's (1999) text mining
  - Both emphasize identifying sentence patterns for a limited set of specific semantic roles
  - Examples
    - <w> was killed
    - <x> was bombed by <y>

Mapping into interlinguas

with statistics

- Machine learning of mappings
  - Gildea & Jurafsky (2002)
    - Statistical classifiers for each semantic role
    - Trained on FrameNet data to find frame elements (semantic roles)
    - Features used:
      - Phrase type, governing category, parse tree path, position, voice, head word
      - 82% performance overall
    - System was retrained to identify abstract semantic roles
      - Syntactic relation, lexical head and frame were best predictors of role
      - 75% performance overall

Mapping into interlinguas

with statistics

- A wide variety of techniques have been explored to identify or learn semantic role mappings from surface features
  - Support Vector Machines (Hacioglu, 2004)
  - Maximum Entropy (Blunsom, 2004)
  - Generative classifiers (Thompson, Levy & Manning, 2003)
  - Boosting (Ngai et al, 2004)
  - Latent semantic analysis (Dennis, 2004)
  - See Carreras & Márquez (2004) for a good overview of techniques and features used at the CoNLL2004 competition.

Mapping into interlinguas

- Challenges
  - Approach
    - Syntactic indicators of semantic relations
      - Phrase type, governing category, parse tree path, position, voice
      - >Use of semantic constraints
        - » For Instrument must be inanimate object
        - » For Co-agent must be animate object
    - Lexical indicators of semantic entities
      - head word
      - >WordNet upper ontology
  - Data
    - Frame Net
    - PropBank (not yet)

Prepositional and positional markers of semantic roles

aboard	location at	*beside*	location at	*in*	location at	*outside*	location at	*unto*	recipient
about	content	*besides*	exclusion		location to	*outside of*	exclusion		measure
	location through	*between*	location at		time at	*over*	direction		purpose
	location at		accompaniment		time through		location at		accompaniment
above	location at		time at		content		cause		beneficiary
	direction		time through		material		location through	*up*	direction
across	location at	*beyond*	location at		measure		intrument		location through
	direction		measure		direction		*time through*		location at
after	order		order		frequency	*past*	time at	*upon*	time at
	time at		time through		manner		location at		location at
	location at	*but*	exclusion		purpose		measure		purpose
against	opposition	*by*	agent		effect		location through		cause
	direction		experiencer	*in front of*	location at		direction		intrument
	location at		cause	*in lieu of*	exclusion	*pending*	time through	*up to*	time at
	purpose		manner	*in spite of*	opposition	*respecting*	content	*versus*	opposition
ahead of	location at		measure	*inside*	location at	*round*	location at	*via*	intrument
	order		intrument		direction		location through		location through
along	location at		manner	*instead of*	exclusion	*save*	exclusion	*with*	material
	location through		location at	*into*	time to	*saving*	exclusion		accompaniment
alongside	location at		time at		location to	*since*	time from		time from
amid	location at		location through		direction	*through*	location through		manner
amidst	location at	*by means of*	manner	*in the midst of*	location at		direction		intrument
among	location at	*concerning*	content		time at		intrument		content
	accompaniment	*considering*	opposition	*lacking*	exclusion		*time through*		recipient
amongst	location at	*despite*	opposition	*like*	manner		cause		cause
	accompaniment	*down*	direction	*near*	location at		exclusion		effect
apart from	exclusion		location at		time at	*throughout*	location through	*with respect to*	content
around	location through	*during*	time at	*next to*	location at		*time through*	*within*	measure
as	manner		time through		exclusion	*till*	time to		location at
as of	time from	*except*	exclusion	*notwithstanding*	opposition	*to*	time to		direction
aside from	exclusion	*except for*	exclusion	*of*	material		location to	*without*	exclusion
at	direction	*excepting*	exclusion		cause		direction		location at
	location at	*for*	location to		object		recipient		
	time at		direction	*off*	location at		measure		
	manner		content		location from		purpose		
	content		time through	*on*	content		effect		
	measure		beneficiary		location at		accompaniment		
	cause		purpose		time at		beneficiary		
atop	location at		measure		purpose	*toward*	location at		
bar	exclusion		cause		cause	*under*	location at		
barring	exclusion		recipient		intrument		manner		

Prepositional and positional markers of semantic roles

before	order		time at		orientation		direction	**Positional markers**	
	time at		purpose	*onto*	direction		measure		
	location at	*from*	location from		location at		accompaniment	*indirect object*	recipient
behind	location at		time from	*opposite*	location at	*underneath*	location at		beneficiary
	accompaniment		material		time at		direction	*direct object*	object
below	location at		cause	*out of*	location from		order	*subject*	agent
	direction		location at		purpose	*unlike*	exclusion		experiencer
	measure		direction		direction	*until*	time to		intrument
	order		cause	*towards*	location at				cause
beneath	location at		material		purpose				object
	order		intrument		direction				
	time at								

From: Barker, K. 1996. The assessment of semantic cases using English positional, prepositional and adverbial case markers. Technical Report TR-96-08. Department of Computer Science, University of Ottawa.

Adverbial markers of semantic roles

above	location at	*continually*	frequency	*frequently*	frequency	*nowhere*	location to	*sideways*	orientation
abroad	location at	*continuously*	frequency	*globally*	location at	*obliquely*	orientation	*sidewise*	orientation
aerially	intrument	*currently*	time at	*halfhourly*	frequency	*occasionally*	frequency	*sometime*	time at
afterwards	time at	*daily*	frequency	*hence*	location from	*off*	time to	*sometimes*	frequency
again	frequency	*decadally*	frequency		time from		location at	*somewhere*	location at
ago	time at	*distantly*	location at	*henceforth*	time from	*often*	frequency		location to
ahead	direction	*diurnally*	time at	*henceforward*	time from	*on*	direction		location from
	time at	*domestically*	location at	*here*	location at		location at	*someplace*	location at
along	direction	*down*	measure		direction	*once*	frequency		location to
	accompaniment		direction	*hereafter*	time from	*out*	direction		location from
also	accompaniment	*downhill*	manner	*hereinafter*	location at		location at	*soon*	time at
already	time at		direction	*hereunder*	location at	*outdoors*	location at	*southeasterly*	direction
always	frequency		location at	*hitherto*	time to		direction	*southeastwardly*	direction
angularly	orientation	*downrange*	location at	*hourly*	frequency	*outside*	direction	*southerly*	direction
annually	frequency		direction	*how*	manner		location at	*southwesterly*	direction
anywhere	location at	*downstairs*	location at	*immediately*	time at	*outward*	direction	*southwestwardly*	direction
	location to		direction	*incessantly*	frequency		orientation	*temporarily*	time through
apart	location at	*downstream*	location at	*indoors*	location at	*outwards*	direction	*terrestrially*	location at
	measure		direction	*inside*	direction		orientation	*then*	time at
aperiodically	frequency	*downtown*	location at		location at	*overhead*	location at	*thence*	location from
around	direction	*downward*	direction	*intrumentantly*	time at		direction		time from
	location at		orientation	*intrumentead*	EXCL	*partly*	measure	*there*	direction
aside	direction	*downwards*	direction	*inward*	direction	*periodically*	frequency		location at
astray	location at		orientation	*inwards*	direction	*permanently*	frequency	*thereafter*	time from
away	direction	*early*	time at	*irregularly*	frequency		time through	*therein*	location at
axially	location at	*easterly*	direction	*just*	time at	*perpetually*	frequency	*today*	time at
backward	direction	*eastwardly*	direction	*last*	order		time through	*together*	accompaniment
	time to	*either*	EXCL	*lastly*	order	*presently*	time at	*tomorrow*	time at
backwards	direction	*elsewhere*	location at	*late*	time at	*previously*	time at	*tonight*	time at
	orientation	*entirely*	measure	*left*	direction	*primarily*	order	*too*	accompaniment
before	time at	*epochally*	frequency	*locally*	location at	*publicly*	location at	*triennially*	frequency
beforehand	time at	*equatorially*	location at	*long*	time through	*quadrennially*	frequency	*triweekly*	frequency
behind	location at		location through	*midweekly*	time at	*quarterly*	frequency	*up*	direction
belatedly	time at	*erectly*	orientation	*millennially*	frequency	*rarely*	frequency		orientation
below	location at	*eternally*	time through	*momentarily*	time at	*recently*	time at	*uphill*	manner
	direction	*eventually*	time at		time through	*regularly*	frequency		direction
bicentennially	frequency	*ever*	time at	*monthly*	frequency	*remotely*	location at		location at
biennially	frequency	*everywhere*	location at	*never*	frequency	*right*	manner	*upstairs*	location at
bimonthly	frequency	*externally*	location at	*nevertheless*	opposition		direction	*upward*	direction
biweekly	frequency	*far*	location at	*next*	order	*round*	direction		orientation
biyearly	frequency	*federally*	location at		time at		location at	*upwards*	direction

Adverbial markers of semantic roles

briefly	time through	*finally*	time at	*nightly*	frequency	*second*	order		orientation
	time at	*first*	order	*nocturnally*	time at	*secondly*	order	*usually*	frequency
by	location at		time at	*nonetheless*	opposition	*seldom*	frequency	*weekly*	frequency
centenially	frequency	*formerly*	time at	*northeasterly*	direction	*semiannually*	frequency	*westerly*	direction
centrally	location at	*forth*	location from	*northeastwardly*	direction	*semiweekly*	frequency	*westwardly*	direction
coastally	location at	*fortnightly*	frequency	*northerly*	direction	*septennialy*	frequency	*yearly*	frequency
	location through	*forward*	location at	*northwesterly*	direction	*sexennially*	frequency	*yesterday*	time at
collinearly	location at		direction	*northwestwardly*	direction	*short*	location at	*yet*	time at
constantly	frequency		time at	*now*	time at	*shortly*	time at	*yon*	direction
contiguously	location at	*forwards*	direction	*nowadays*	time at		manner	*yonder*	location at

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Conceptual role	Marker	Example text
amount	a lot of N	a lot of sugar
amount	all around	he showed me all around
amount	all over	he covered me all over with feathers
amount	awfully	I'm awfully tired
amount	enough	I'm fluent enough
amount	extremely	I'm extremely fluent
amount	fewer	I've fewer books than David
amount	greater	He makes a greater salary
amount	how	How big is it?
amount	however	However famous he may be, he can't pee on my rug
amount	kind_of	I'm kind of depressed
amount	less	I'm less shy than she is
amount	long	Long before her arrival, I was ready
amount	more	I want more money
amount	really	I'm really tired
amount	sufficient	My tiredness is sufficient
amount	sufficiently	I'm sufficiently well-trained
amount	thoroughly	I'm thoroughly trained
amount	very	I'm very well-trained
amount	enough	I'm tired enough
amount	nil	His comprehension was nil
amount	no	he showed no understanding
amount	none	She had biscuits, but I had none
amount	nothing	She had biscuits, but I had nothing
amount	null	His results were null
amount	a lot of Npl	He bought a lot of books
amount	few	She had few friends
amount	number of	the number of people present was incredible
amount	one, two, …	I've four sisters
amount	several	I've several brothers
amount	a, an	a stitch in time saves nine
amount	one	one course is too many
amount	that	that woman is listless
amount	the	the man left
amount	these	these are my favorite glasses
amount	this	this man is greek
amount	those	those are nice pants
amount	many	He had many enemies
amount	n>1	Seven sisters sat serenely
amount	these	these rings are from Paris
amount	those	those are nice earrings
amount of event	afresh	he began his study afresh
amount of event	again	he began his study again
amount of event	anew	he began his study anew
amount of event	back	he called back
amount of event	frequently	he frequently studied
amount of event	often	his head often aches
amount of event	once	I saw her only once.
amount of event	once more	his head ached once more
amount of event	over again	his head ached over again
amount of event	over and over	his head ached over and over
amount of event	re-V	re-translate
amount of event	repeatedly	his head ached repeatedly
amount of event	repetetively	his head ached repetetively
amount of event	time after time	his head ached time after time
amount of event	twice	his head ached twice
amount of event	V and V	he drank and drank
amount of event	X times	his head ached three times
and	and	Jack and Jill went up the hill.
and	instead of	he slept instead of working

Conceptual role	Marker	Example text
attribute of event	-ly	he left quickly
attribute of event	ADJ	a dirty murder
attribute of event	ADV	she left quietly
attribute of event	ADV	quickly he slipped out
attribute of event	amount	a large amount of dancing
attribute of event	copula1 + ADJ	the murder was grisly
attribute of event	copula1 + ADJ	he was happy
attribute of event	copula2 + ADJ	the investigation got difficult
attribute of event	feel + ADJ	I felt sick
attribute of event	in	it changed in color and brightness
attribute of object	ADJ	A good man
attribute of object	ADJ	make me sick
attribute of object	amount	a large amount of money
attribute of object	copula1 + ADJ	she looked sexy
attribute of object	copula2 + ADJ	he got sick
attribute of object	N	scanner room
attribute:object	1,2,… of	two of them left
attribute:object	ADJ N	a greek physicist
attribute:object	is a kind of N	A pita is a kind of bread.
attribute:object	is a N	Jack is a doctor.
attribute:object	is a type of	Penicillin is a type of mold.
attribute:object	member	Guy is a member of the team.
attribute:object	N N	staff doctor
attribute:object	of	a collection of articles
attribute:object	subset	X is a subset of Y
attribute:object	superset	Y is a superset of X
attribute:object	which	which of the guys did you see?
attribute:object	which	Which book do you want?
cause	-er -or	the maker of this pizza needs lessons
cause	and	Jack came and built it
cause	by	It was invented by Marconi.
cause	D.O.	he made me break it.
cause	POSS	Jack's arrival was fortuitous.
cause	SUBJ	Alice left the room.
cause	and	Jack came and I left
cause	because	Heat rises because the molecules are less densely packed
cause	because of	Objects stay on the earth because of gravity
cause	bring about	The Sandinistas' activities brought about Somoza's downfall
cause	by reason of	He killed the man by reason of insanity
cause	cause	Jack caused the vase to break
cause	create	The President's statement created chaos among the reporters
cause	engender	Her research engendered a whole new specialty
cause	force	he forced me to leave
cause	found	He founded the institute
cause	generate	His research generated interest in Zulu
cause	give rise to	His research gave rise to a great deal of interest in Zulu
cause	have	We had the tailor make me a suit
cause	impel	Hunger impelled me to finish quickly
cause	incite	His actions incited them to rise up against the government
cause	institute	He instituted the Friday morning meetings
cause	make	he made me leave
cause	occasion	His statements occasioned international consternation
cause	on account of	I left on account of Jack's insistence
cause	originate	Her research originated a new area of specialization
cause	produce	His actions produced violent reactions
cause	propel	The action of the wind propelled the small boat
cause	therefore	Sue was insistent, therefore I left
changing entity	D.O.	manipulate the color of the image
changing entity	D.O.	Joe broke his arm.
changing entity	N N	brain scanning center; brain scanner

Conceptual role	Marker	Example text
changing entity	of NP	an injection of a solution
changing entity	on	he was working on a program
changing entity	POSS N	The president's assassination was tragic
changing entity	PP	He was show in the foot
changing entity	refl pro	He shot himself in the foot
changing entity	subj	the image changed in color
changing entity	SUBJ	This is made by Gastarbeiter
changing entity	with	Let's play with the ball Joe gave us
changing entity	D.O. Vinf	he made me listen.
changing entity	of N	The attempt of the assassin was unsuccessful
changing entity	POSS N	The assassin's attempt was successful
changing entity	SUBJ	Emmy slept quietly.
changing entity	to N	sounds crazy to me.
component	area	an area of tissue
component	attach to	They attached the antenna to the hood
component	by	He opened it by using a pin.
component	by	He got in by using a skeleton key
component	by what means	By what means did you open that door
component	has N	Sally has big feet.
component	how	How did you do that
component	N's N	the hospital's emergency ward
component	part	This is the biggest part
component	POSS N	Jack's arm is muscular
component	through	He got in through the use of a skeleton key
component	with	the screen with an image
component of event	abort	I aborted his investigation
component of event	arrest	I arrested his investigation
component of event	bring X to an end	I brought his investigation to an end
component of event	call a halt to	I called a halt to his investigation
component of event	cease	he ceased his investigation
component of event	close	he closed his investigation
component of event	conclude	he concluded his investigation
component of event	curtail	he curtailed his investigation
component of event	cut short X / cut X shor	I cut short his investigation
component of event	desist	He desisted from? his investigation
component of event	end	I ended his investigation
component of event	finish Ving	He finished doing his investigation
component of event	give_up	he gave up his investigation
component of event	halt	I halted his investigation
component of event	impede	I impeded his investigation
component of event	put an end to	I put an end to his investigation
component of event	stop	He stopped to smoke
component of event	stop	He stopped smoking
component of event	suspend	He suspended his investigation
component of event	terminate	he terminated her investigation
component of event	-ing	He was singing.
component of event	ceaselessly	She sang ceaselessly
component of event	continuously	She sang continuously
component of event	incessantly	She sang incessantly
component of event	Ns	it made loud noises
component of event	begin N	She began a song
component of event	begin to V	she began to investigate
component of event	begin Ving	she began investigating
component of event	commence Ving	she commenced investigating
component of event	get X under way	she got the investigation under way
component of event	set to work	she set to work investigating
component of event	set_about	she set about investigating
component of event	set_out_on	He set out on a long voyage
component of event	start N	she started a composition
component of event	start to V	she started to investigate

Conceptual role	Marker	Example text
component of event	start Ving	she started investigating
component of event	start_out_on	she started out on a long investigation
component of event	take_up D.O.	He took up knitting
component of event	undertake	she undertook a new investigation
component of event	making use of	He broke in making use of a screwdriver
component of event	subj	wires connected them together; the key opened the door
component of event	using	he opened the door using a screwdriver
component of event	with	He opened it with a screwdriver
condition	-ing	Jack being a schmuck, I left him
condition	allow	His absence allowed us to study in peace
condition	because	Because he was gone, we could study in peace
condition	coerce into	The police coerced them into a confession
condition	conditional on	Their release was conditional on a full confession
condition	enough_for	A full confession was enough for their release
condition	enough_to	A full confession was enough to assure their release
condition	for	I'm ready for anything you have to suggest
condition	given	Given his indisposition, I think we should do something else
condition	goad into	they goaded him into jumping
condition	had	Had we seen him, we might have gotten a ride home.
condition	having V	Jack having come, I left
condition	hence	Jack came, hence I left
condition	if	If Jack comes, I'll leave
condition	permit	Jack's absence permitted us to study in peace
condition	prod into	The professor prodded his students into learning
condition	push into	The professor's actions pushed the students into studying
condition	since	Since Jack is coming, I won't stay
condition	so	He came, so I left.
condition	so X as to	It's so late as to make it impossible to get home by bus
condition	suffice	His arguments will suffice to persuade us
condition	sufficient for	His arguments are sufficient for persuading us
condition	taunt into	The boys taunted him into climbing the tower
condition	therefore	I think, therefore I am
condition	thus	I think, thus I am
condition	to	I'm ready to do anything you have to suggest
condition	if	If snow is white then it is cold
condition	if and only if	Jack is gone if and only if Jack has left
content	for	we thanked him for his explanation
content	to	he liked to sleep
content	about	we talked about everything
content	D.O.	he explained it to us
content	Ø	he said he would call
content	refer_to	this word refers to a subatomic particle
content	that	he said that he would call
content	to	He asked me to leave
content	of	an image of the region
content	to	he wanted to go.
equivalence	identical	identical twins
equivalence	is called	This man is called Yousef
equivalence	N N	his friend Yoshio
equivalence	named	I have a friend named Alex.
equivalence	represent	this squiggle represents spacetime!
equivalence	be	the scanner was a big ring
equivalence_amount	as … as	He's as crazy as I thought
equivalence_time	as	as I watched, they took away my furniture
equivalence_time	as soon as	She left as soon as I came
equivalence_time	it was time	it was time I left
equivalence_time	when	when Sylvie arrived, I was eating
equivalence_time	while	While we worked…
equivalence_time	with	she waited with her heart in her throat
final state	D.O.	he greeted **us**

Conceptual role	Marker	Example text
final state	to	he explained it to us
final state	become	He became ill
final state	come	Her dreams came true
final state	D.O.	he made a bomb; different diseases show different patterns
final state	end_up	She ended up sleepy
final state	get	she got drunk
final state	go	the milk went sour
final state	PP	put it on the table
final state	turn_out	it turned out (to be) fortunate
final state	wind_up	He wound up in Cleveland
final state	refl pro	he sent himself a letter
final state	SUBJ	he received it
final state	to	Let's go to the lab
final state	toward	she shuffled toward the door
initial state	D.O.	he left the house
initial state	from	came from Toronto
initial state	of	made of steel
initial state	out of	made out of wood
location	at	He went to the store at the corner
location	between	He went to the store between the Ferraris
location	here	He went to the store here
location	in	We sat in the room
location	off	He took the book off the table
location	on	She put the book on the table
location	out	They were out of town for a week
location	over	The plant hung over the table
location	to	The scanner was connected to a computer
location	under	The frog lived under the bridge
location	along	We strolled along the river
location	around	We strolled around the park
location	away	We ran away from the police
location	by (dir prep)	he walked by the bank.
location	down	We walked down the hill
location	in	We walked in the room
location	into	We walked into the room
location	onto	We walked onto the stage
location	over	We walked over the bridge
location	past (dir prep)	he walked past the bank
location	through	he walked through the forest
location	under	he walked under the scaffold
location	up	she walked up the hill
Ø	both	both of them left
Ø	all the same	She came. All the same, I didn't see her
Ø	although	Although she came, I didn't see her
Ø	but	She came, but I didn't see her
Ø	even so	Even so, I stayed on.
Ø	however	He came, however I didn't see him
Ø	it was	It was Jack who stole the cookie
Ø	moreover	Moreover, I'm sick of you too!
Ø	though	though she came, I didn't see her
Ø	yet	He came, yet I saw him not
Ø	with respect to	They are similar with respect to their nose size
Ø	D.O.	it made noises; perform a diagnosis
or	either	Either Jack or Jill will have to get some water
or	or	Jack or Jill will have to get some water
or	or	Jack or Jill will have to keep the money
order_amount	-er	he's yellower than her
order_amount	-er	He's older than I am
order_amount	less	He has less money than his friends
order_amount	more	They have more money than he does

Conceptual role	Marker	Example text
order_amount	only	You're only sixteen!? (=not more than)
order_amount	above	It's floating above the city
order_amount	above	It's thirteen degrees above zero
order_amount	ordinals	I'm the second person in line
order_location	before	The dog sat before the bowl of food drooling
order_location	behind	The safe was behind the picture
order_location	in back of	The safe was in back of the picture
order_location	in front of	the picture was in front of the safe
order_superlative	-est	His mother is yellowest
order_superlative	-est	That's the reddest rose I've ever seen
order_time	after	She arrived after I left
order_time	afterwards	Afterwards, I left too
order_time	already	I've already seen that film
order_time	before	She arrived before I left
order_time	finally	She finally kissed me
order_time	first	He first wrote the largest chapter, then the others
order_time	in time	We arrived in time for the show.
order_time	next	The next show is on Tuesday
order_time	on	On seeing my situation, he immediately took over
order_time	previous	His previous request was more polite
order_time	since	I've been working on this since I came
order_time	then	Jack came then I left
order_time	until	Jack worked until I arrived
order_time	when	When he arrived, she left.
order_time	with	With that, she turned on her heels and left.
similarity_attribute	feels like	This feels like terrycloth
similarity_attribute	like	it's like a video game
similarity_attribute	looks like	She looks like Rose
similarity_attribute	remind X of	She reminds me of Rose
similarity_attribute	shaped like	She's shaped like Rose
similarity_attribute	similar to	She similar to Rose
similarity_attribute	similarity	Their similarity is striking
similarity_attribute	sounds like	She looks like Rose
similarity_attribute	tastes like	She looks like Rose
similarity_location	by	over there by the sofa
similarity_location	close to	it's close to the bus station
similarity_location	near	near the ashtray
similarity_location	nearby	He's lurking nearby
similarity_location	next	the next room
similarity_location	next to	next to the door
time	for	for three days
time	at <time>	Dinner at six.
time	it was <time>	It was 6 o'clock
time	now	I'm leaving now
time	often	I often go
time	on time	Charlie never arrived on time.
time	for	they walked for three days
time	may	I may leave soon
time	might	I might leave soon
time	Pres Cont	I'm leaving in ten minutes
time	shall	I shall leave on Thursday
time	will	I will leave on Thursday
time	ago	he went three days ago
time	past adverbs	yesterday
time	past tense	I left
time	pres perf tense	I have been there and back
time	pres adverbs	now, today
time	pres cont	I'm thinking
time	would	I would leave on Thursday
truth value	can	I can play the piano

Conceptual role	Marker	Example text
truth value	could	I could play better, but I didn't keep it up
truth value	likely	It's likely that he's finished
truth value	may	He may be finished
truth value	might	He might be finished
truth value	probable	It's probable that he's finished
truth value	probably	He's probably finished
truth value	usually	It's usually easy
truth value	have to	I have to go now
truth value	must	I must be off
truth value	should	I should leave
truth value	Subj-Aux inversion	Is he here?
truth value	Wh- qs	You saw who?
truth value	whq w/inversion	Who did you see?
truth value	n't	I didn't see her
truth value	neither	Neither Jack nor Jill was here
truth value	never	I never drink
truth value	nor	Neither Jack nor Jill was here
truth value	not	I'm not sleeping
truth value	Ø	This is my brother
truth value	whether	he asked whether it was really so

Mapping from interlinguas

(some) Surface markers of <changing object> in English

-ed	The baptiz**ed** were taken to another room
direct object	Joe broke **his arm.**
N N	**brain** scanner
N Ning	**brain** scanning center
of NP	an injection **of a solution**
on NP	he was working **on a program**
poss N	The **president's** assassination was tragic
PP	He was bitten **in the foot**
reflexive pronoun	He shot **himself** in the foot
subject	**the image** changed in color
subject of passive	**This stereo** is made by Toshiba
lexical	The **victim** of the attack survived.
with NP	Let's play **with the ball** Joe gave us

Mapping from interlinguas

- UNDL Project
  - Modules for mapping from the Universal Networking Language (UNL) to 10+ languages
  - Patented interlingual MT approach (2004), belonging to the United Nations (www.undl.org)
- PILLS
  - Interactive environment to produce interlingual statements for automatic generation of technical text in 3 languages (Scott et al, 2001)
- Others
  - HPSG
  - Etc.

Next steps

- Move from lists of relations to interlinguas proper
- Standardize ontological resources
- Standardize to XML syntax
- Revitalize existing interlinguas
- Define more precise semantics for roles
- Collaborate: distribute mapping problems
- Identify what's doable and do it well
- Develop more reliable mappings and resources
- Accumulate and share mappings

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