Linguistic Knowledge (cont.)

11-731 Machine Translation
February 26, 2007

Teruko Mitamura
Language Technologies Institute
Carnegie Mellon University

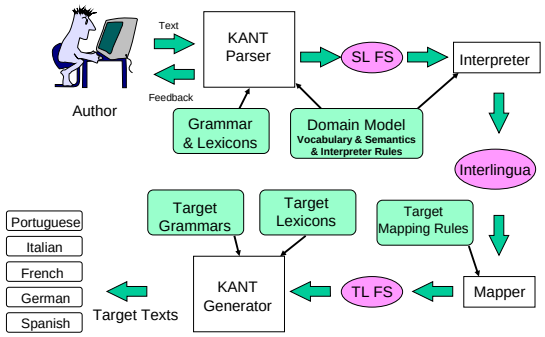
Analysis Knowledge Sources

- In general, 'state of the art' MT systems are not based on one single linguistic theory.
- MT requires coverage of all the peculiarities of actual usage in a domain.
- Contrastive analysis of languages is required for MT.
- MT researchers have been obliged to take much more pragmatic attitudes than theoretical researchers.

Analysis/Generation Modules

1. Lexicon
2. Morphology
3. Grammar
4. Interpretation rules/Mapping rules
5. Interlingua
6. Domain Model

KANTOO MT Modules



Design Decisions in Lexicon Development (1)

- What is a unit of lexicon entry?
  - Root form vs. Full form
  - Inflectional morphology (e.g -ing, -ed)
  - Derivational morphology (e.g. -ly, -ment)
  - Single word entry vs. Phrasal entry (e.g. factory installed hose)
  - POS (e.g. verb, adjective, adverb)
  - Subcategory (e.g. intransitive, transitive)
  - Morphological class
    (e.g. Japanese: 5-dan, 1-dan verbs)

Lexical Variation Issues

- Spelling
  - Nonstandard spelling: nite vs. night
  - British spelling: colour vs. color
- Acronyms
  - PM (permanent magnet)
  - PM (phase modulation)
- Abbreviations
  - p.m. (post meridiem)
  - no. (number)
  - N.O. (normally open)
- Capitalization
  - all-caps: MIL (military specification)
  - nonstandard: BrakeSaver
- Hyphenation (e.g. de-energized, make-up valve)
- Use of Slash (e.g. check/relief valve)

Design Decisions in Lexicon Development (2)

- What kind of morphological and/or syntactic information is stored in the lexicon?
- Meaning definition included with lexical items?
- Any link(s) to semantic concept(s) for lexical items?
- Translation(s) for target language(s)?
- Usage examples for lexical items?
- Any other information for developers? (e.g. comments, frequency, update info)

Design Decisions in Morphology Development

- What level of morphological processing is needed?
  - Depends on the lexicon design
  - Inflectional processes
  - Derivational processes
  - Compounding
  - Also, depends on the grammar design

Japanese Morphology Example

Japanese morphological rules can be written in the same formalism as syntactic rules

input string: tabe-sase-rare-ta

eat-caus-pass-past

Japanese Examples (2)

tabeta eat-PAST
tabesaseta eat-CAUS-PAST
taberareta eat-PASS-PAST
tabesaserareta eat-CAUS-PASS-PAST

*taberaresaseta eat-PASS-CAUS-PAST
*tabetasaserare eat-PAST-CAUS-PASS
*tabetararesase eat-PAST-PASS-CAUS
*taberaretasase eat-PASS-PAST-CAUS
*tabesasetarare eat-CAUS-PAST-PASS
*taberaresase eat-PASS-CAUS
*tabetarare eat-PAST-PASS
*tabetasase eat-PAST-CAUS

Design Decisions in Grammar Development

- Specify set of structures to be covered. (e.g. corpus analysis)
- For each type of structure, specify:
  - the appropriate phrase structure rules
  - the set of grammatical features (e.g., person/number/gender agreement, verb class features, etc.)
  - the grammatical functions (e.g., SUBJ, OBJ, PP, etc.)
  - the feature structure (cat n) (number sg) (form pastpart)

Grammar Development

- Organize the types of rules (e.g. start rules, NP rules, VP rules, PP rules, etc.)
- Write phrase structure rules.
- Add equations to phrase structure rules.
  - Unification statement
  - Constraint equations
- Test the grammar on a test suite

Design Decisions in Interlingua Development

- Structure of the Interlingua
  - Concept head: Open class vs. Closed class
    (e.g. *A-LIFT)
  - Semantic roles
    (e.g. agent, theme)
  - Feature value pairs
    e.g.
    (TENSE PRESENT)
    (PERFECTIVE +)

Semantic Roles

- Verb argument semantic roles (e.g. agent, theme)
- Prepositional phrase semantic roles
  (e.g. instrument_with, instrument_of)
- Adjective semantic roles
  (e.g. attribute)
- Adverb semantic roles
  (e.g. manner)
- Subclause semantic roles
  (e.g. event)
- Numeric semantic roles
  (e.g. identifier "cylinder 1")

Interlingua Features

- Tense (past, present, future)
- Modality:
  Ability (+,-) Possibility (+,-) Necessity (+,-), etc.
- Mood (declarative, imperative)
- Determiner
  Reference (Definite, Indefinite)
  Number (Singular, Plural, Mass)
  Distance (Near, Far)
- Pronoun
  Person (First, Second, Third)
  Number (Singular, Plural)
  Gender (Feminine, Masculine, Neuter)
- Acronym (+,-)
- Abbreviation (+,-)

KANT: Interlingua Example

```
((*A-LIFT
        (PUNCTUATION PERIOD)
        (TENSE PRESENT)
        (MOOD IMPERATIVE)
        (ARGUMENT-CLASS AGENT+THEME)
        (Q-MODIFIER
          (*Q-MEANS_WITH
            (ROLE MEANS)
            (CASE (*K-WITH))
            (OBJECT
              (*O-ADJUSTABLE-LIFTING-BEAM
                (REFERENCE INDEFINITE)
                (NUMBER
                  (:OR SINGULAR MASS))))))
        (THEME
          (*O-ENGINE
            (NUMBER SINGULAR)
            (REFERENCE DEFINITE)))))
```

Interpretation Rules

- Mapping from F-structure to Interlingua:
  (change, add, or delete information)
- Types of mapping:
  - **Head Mapping** (SEM *A-LIFT) -> *A-LIFT
  - **Feature promotion** (PUNCTUATION PERIOD) -> (PUNCTUATION PERIOD)
  - **Feature-to-feature mappings**
    (MOOD IMP) -> (MOOD IMPERATIVE)
    (SEM *DET-AN) -> (REFERENCE INDEFINITE)
  - **Feature Assignment**
    (TENSE PRESENT)
    (ARGUMENT-CLASS AGENT+THEME)
  - **Structural mapping**
    OBJ -> THEME
    PP -> Q-MODIFIER
  - **Feature-to-concept mapping**
    (SEMSLOT MEANS_WITH) -> *Q-MEANS_WITH

Interpretive Mapping

Relationship between predicate conceptual structures and syntactic structures.

- Argument Mapping: Mapping between grammatical functions and semantic roles
  (e.g. subject <-> agent)
- Lexical Mapping: Mapping between words and domain concepts
  (e.g. naguru <-> *HIT)

Alternations

Systematic semantic-syntactic correspondences

Mapping regularities within the same class of verbs

Change of state verbs

1. subject <-> agent
   object <-> theme
   a. John broke the vase.
   b. John cracked the vase.
   c. John melted the ice.
2. subject <-> theme
   a. The vase broke.
   b. The vase cracked.
   c. The ice melted.

Alternations (cont.)

Verbs of cutting:

1 a. John cut the meat.
b. John cut at the meat.
c. *The meat cut.

2 a. John slashed the wood.
b. John slashed at the wood.
c. *The wood slashed.

Change of state verbs:

3 a. *John broke at the vase.
b. *John cracked at the vase.

Japanese Case Alternations

1. wo/de alternation: **Motion-path-verbs**
   a. Taro ga kawa wo oyoida
   `Taro swam down the river'
   b. Taro ga kawa de oyoida
   `Taro swam in the river'
2. kara/wo alternation: **Departure-verbs**
   a. Kinou uchi kara/wo denakatta.
   `(I) didn't leave the house yesterday.'
   b. Basu kara/wo oritekudasai.
   `Please get off the bus.'

Design Decisions in Domain Model Development

- Represent semantic information about objects/actions/relations in the domain
- How much domain modeling is needed for an MT system?
- How much domain modeling is feasible?
- How much domain knowledge can be extracted from existing corpora, on-line dictionaries, thesauri, etc.?
- KANT: DM is used to disambiguate sentences.
- Meaning representations (interlinguas) are instantiations of (generic) domain model concepts.

Examples

- What Domain Model frames do you need a priori?
- What do the instantiated frames look like for each example?
  Example: English to German
  – Drain the tank. "abpumpen"
    Drain the cylinder.
  – Drain the oil. "ablassen"
    Drain the fuel.

Examples (Cont.)

```
(*A-DRAIN-CONTAINER
      (is-a *ACTION)
      (theme *O-CONTAINER))
(*A-DRAIN-LIQUID
      (is-a *ACTION)
      (theme *O-LIQUID-SUBSTANCE))
(*O-CONTAINER
      (is-a *OBJECT))
(*O-TANK
      (is-a *O-CONTAINER))
(*O-CYLINDER
      (is-a *O-CONTAINER))
```

```
(*O-LIQUID-SUBSTANCE
      (is-a *OBJECT))
(*O-OIL
      (is-a *O-LIQUID-SUBSTANCE))
(*O-FUEL
      (is-a *O-LIQUID-SUBSTANCE))
```

Interlingua

Drain the tank.

(*A-DRAIN-CONTAINER
(MOOD IMPERATIVE)
(theme *O-TANK))

Drain the oil.

(*A-DRAIN-LIQUID
(MOOD IMPERATIVE)
(theme *O-OIL))

Conflation: Talmy (1985)

Manner or cause is incorporated into motion verbs

– motion + manner
The pencil rolled off the table =
(The pencil moved off the table, rolling)

– motion + cause
The pencil blew off the table =
(The pencil moved off the table, from [the wind] blowing on it.)

How do we represent conflation in Domain Model?

- motion + manner concepts separately?
  - move rolling
  - roll as one concept?
- motion + cause concepts separately?
  - move blowing
  - blow as one concept?

Japanese Examples

Mitamura (1989)

action + manner:

English ->	Japanese
(conflation)	(compound verb)
rip ->	hiki-saku
	pull-tear
chop ->	kiri-kizamu
	cut mince

Japanese Examples (2)

action + manner:

English ->	Japanese
(conflation)	(no conflation)
tap ->	karuku tataku (adv + v)
	lightly hit
slash ->	satto kiru (adv + v)
	quickly cut

Japanese Examples (3)

action + instrument:

English ->	Japanese
(conflation)	(no conflation)
punch ->	genkotsu de tataku
	fist with hit
tape ->	teepu de tomeru
	tape with fix

Chinese Examples (1)

Frank Lin

- Verb-Resultant Construction in Chinese Example:

Chinese: 我 絆倒 了 他
Gloss: I trip-fall (past) him
Translation: I tripped him

Chinese Examples (2)

- Example:

Chinese: 我 打死 他
Gloss: I beat-death him
Translation: I beat him to death

Chinese Examples (3)

- Example:

Chinese: 我 喝完 了 牛奶
Gloss: I drink-finish (past) milk
Translation: I finished drinking milk

Chinese Examples (4)

- Example:

Chinese: 我 喝光 了 牛奶
Gloss: I drink-empty (past) milk
Translation: I drank all the milk

Sinhala Examples

Sanjika Hewavitharana

1. We walked across the road.
   api avidagena paara harahaa *giyaa*.
   (We *went* across the road by walking)
2. He drove to the town.
   ohu motar riyen nagarayata *giyaa*.
   (He *went* to the town by a car)
3. They flew to New York.
   owun guwan yaanayen New York vetha *giyaa*.
   (They *went* to New York by plane)

One to Many Lexical Translations

- *rice* in Korean, Cantonese, Tamil, Sinhala, Japanese
- Family relationships in Chinese, Farsi, Telugu, Kannada
- How do we represent in the Domain Model?
  - *cooked-rice, *uncooked-rice, *rice-plant,
  - *uncooked-rice-(un)processed (Shinhala)
- What are the problems with *rice concept?

Questions?