

Machine Translation Case Studies

Francis Bond

NTT Communication Science Laboratories

`www.kecl.ntt.co.jp`

`bond@cslab.kecl.ntt.co.jp`

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Course Outline

(1) Introduction

- Why do Machine Translation?
- Approaches to Machine Translation
 - * Rule-based (Knowledge-based): Transfer, Interlingual
 - * Example-based: Statistical, Case-based, Translation Memories
 - * Combinations: Hybrid, Multi-engine

(2) Case Studies

- An in depth-look at some MT Systems
 - * Analysis and Generation
 - * Transfer
 - * Tuning and Adaptation
- Conclusion and References

Outline for Lecture 2

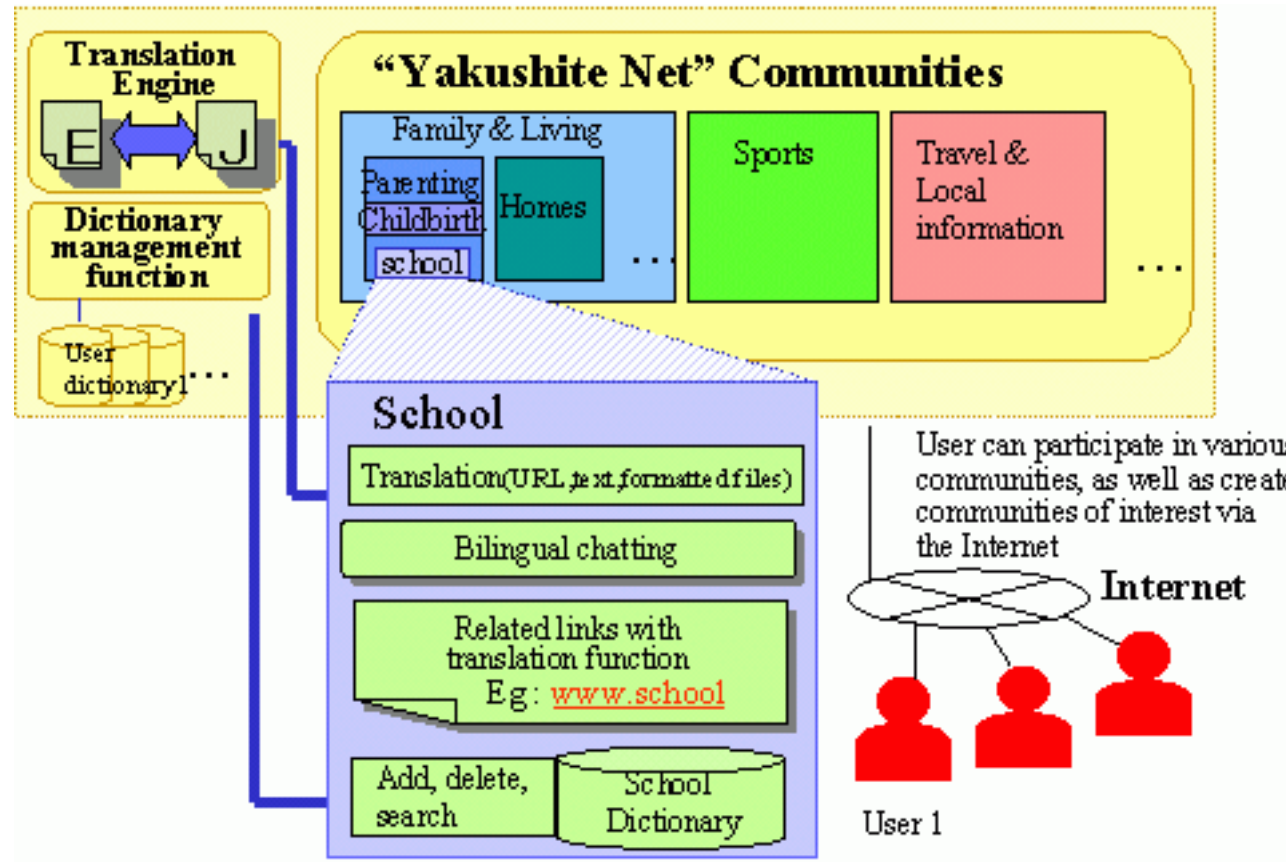
- Outline
- A deeper look at some systems
 - Commercial Systems
 - Research Systems
 - * ALT-J/E (NTT RBMT System)
 - * Ntrans (NTT SMT System)
 - * Open Systems: Jaen Demo (DELPH-IN Transfer system)
- Summary and References

Some slides adapted from John Hutchins
<http://ourworld.compuserve.com/homepages/wjhutchins/>

State of the Art (in Japan)

- Shrink-wrapped or pre-installed direct-transfer systems
- Three price levels
 - 50,000 yen: Best systems, e.g. ATLAS (Fujitsu)
 - 10,000 yen: Most large companies
 - 2–3,000 yen: Many awful systems
- Competition by bullet point:
 - Lexicon size + number of domain lexicons
 - MS Word integration
 - Web integration
 - Translation Memory (**TM**) integration

Innovation in Social Engineering



Oki Denki's shared translation environment/Community Web Site

Yakushite Net

- This has a hierarchical collection of domains
Travel / Foreign countries / Europe / Norway
- Each domain lists the number of users, the number of lexical entries (EJ and JE), and the number of FAQs

matpakker	N	お弁当	<i>obentō</i>	EJ	Bond
pølser	N	ホットドッグ	<i>hotto doggu</i>	EJ	Bond
- Users can then upload the dictionary to their machine or translate on-line (file or web page)
 - **Selecting one or more user dictionaries**
- Endless vigorous debate about translation entries
- Can edit translations on-line, results are stored

Hand-held speech systems: Enavi



- Produced by NEC
 - Speech input and output
 - Text feedback
 - Narrow domain
Information about the Airport
 - < 5,000 word vocabulary
-
- Distributed at Tokyo New International Airport

Template-based Translation: ALTFLASH

- Useful when there are many domain-specific phrases that rarely appear elsewhere.
E.G., stock market news reports, disaster reports
- Hard to translate
 - the syntax is often convoluted
 - words are used with special meanings
- Prepare template-rules for frequently occurring expressions in the domain
- Translate them using these template-rules.

An Example Template

- (1) (売買高|商い) (は|が|の) (概算|概算で|約)
(*baibaidaka|akinai*) (*wa|ga|no*) (*gaisan|gaisande|yaku*)
(trade up|trade) (TOP|NOM|ACC) (estimate|estimated|about)
<X> 株 [だった].
<X> *kabu* [*datta*] .
<X> share [was] .

Trading volume was estimated at <X> shares.

This template rule will match any combination of the alternatives (in brackets) combined with an unknown numerical value, the verb *datta* “was” may be omitted. All the possible matches are translated into the same English sentence.

➤ Used to replace two translators and an editor with just an editor.

Summary of commercial activities

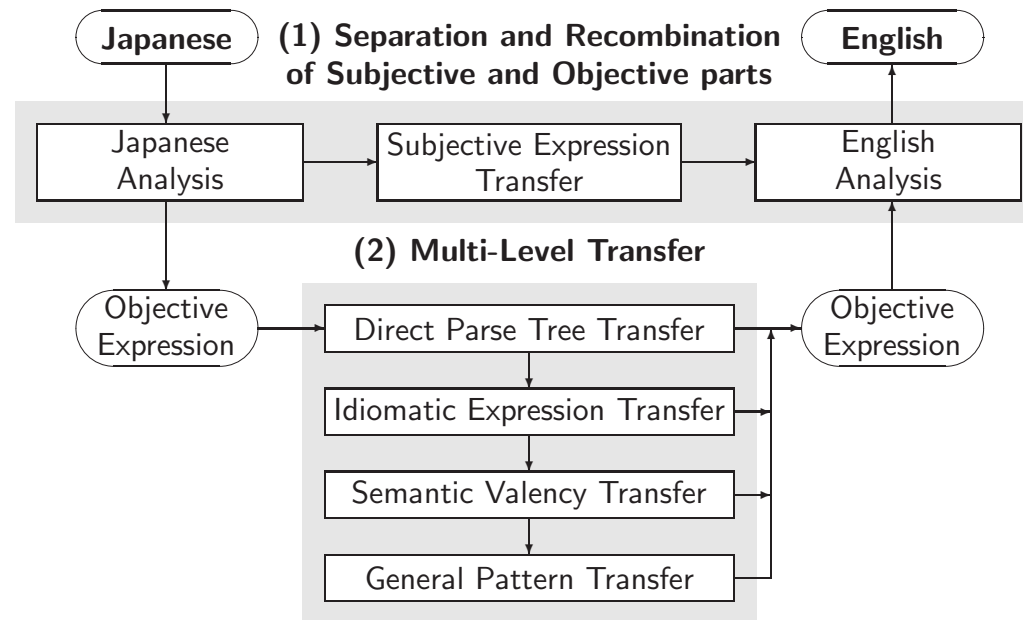
- Almost no research on machine translation itself since 1999
- Some research on lexicon expansion
- Much development of better interfaces
- Many small niche companies

A deeper look at some Research Systems

- ALT-J/E (NTT RBMT System)
- Ntrans (NTT SMT System)
- Open Systems: Jaen Demo (DELPH-IN Transfer system)

NTT's RBMT ALT-J/E

ALT-J/X: Automatic Language Translator — Japanese to X —
NTT's research system from 1985 to 2003



The Multi-Level Translation Method

The translation process

The process of translation can be divided into seven parts.

1. **ALT-J/E** splits the Japanese text into morphemes.
2. Analyses the sentence syntactically, often giving multiple possible interpretations.
3. Rewrites complicated Japanese expressions.
4. Evaluates the various interpretations using syntactic and semantic criteria.
5. Selects the best interpretation and does discourse processing.
6. This interpretation is used as input to generate English or Malay (Chinese, French, Vietnamese).
7. The translated sentence is adjusted to give the correct word order and inflectional forms.

ALT-J/E's distinguishing features

- Precise Semantic Dictionaries
 - Semantic attribute system: 3,000 categories (**is-a** and **has-a**)
 - 400,000 word semantic lexicon
- Appropriate Selection of Translations
- Principled English Generation
- Automatic Transliteration
- Automatic Rewriting; Direct Parse Tree Transfer
- Context Processing
- Extensibility

The Top Four Levels of ALT-J/E's Semantic Hierarchy



Japanese Noun Lexical Entries (ホテル *hoteru* “hotel”)

Index Form	ホテル
Pronunciation	/hoteru/
Canonical Form	ホテル
Part of Speech	noun
Semantic Classes	[common noun lodging, enterprise]

Japanese-English Noun Lexical Entries (鼻 *hana* “nose”)

Index	鼻 <i>hana</i>	
sense 1	English Translation	<i>nose</i>
	Part of Speech	noun
	Noun Countability Pref.	fully countable
	Default Number	singular
	Default Article	—
	Inherently Possessed	t
	Semantic Classes	[common noun nose, nose-main]
sense 2	English Translation	<i>trunk</i>
	Part of Speech	noun
	Noun Countability Pref.	fully countable
	Default Number	singular
	Default Article	—
	Inherently Possessed	t
	Semantic Classes	[common noun nose, nose-main]
	Selectional Restriction	[modified-by zō “elephant”]

Japanese-English Verb Lexical Entries (取る *toru* ↔ *take*)

Pattern-ID	-0001-00-																
Semantic Class	(action, transfer)																
Japanese	pred 取る <i>toru</i>																
	pos verb																
	N1	<table border="1"> <tr> <td>case-role</td> <td>Agent</td> </tr> <tr> <td>case-marker</td> <td><i>ga</i> "NOM"</td> </tr> <tr> <td>restriction</td> <td>agent</td> </tr> </table>	case-role	Agent	case-marker	<i>ga</i> "NOM"	restriction	agent									
	case-role	Agent															
	case-marker	<i>ga</i> "NOM"															
restriction	agent																
N2	<table border="1"> <tr> <td>case-role</td> <td>Patient</td> </tr> <tr> <td>case-marker</td> <td><i>o</i> "ACC"</td> </tr> <tr> <td>restriction</td> <td>*</td> </tr> </table>	case-role	Patient	case-marker	<i>o</i> "ACC"	restriction	*										
case-role	Patient																
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restriction	*																
English	<table border="1"> <tr> <td>pred</td> <td><i>take</i></td> </tr> <tr> <td>pos</td> <td>verb</td> </tr> <tr> <td>N1</td> <td> <table border="1"> <tr> <td>function</td> <td>subject</td> </tr> <tr> <td>case</td> <td>nominative</td> </tr> </table> </td> </tr> <tr> <td>N2</td> <td> <table border="1"> <tr> <td>function</td> <td>direct-object</td> </tr> <tr> <td>case</td> <td>accusative</td> </tr> </table> </td> </tr> </table>	pred	<i>take</i>	pos	verb	N1	<table border="1"> <tr> <td>function</td> <td>subject</td> </tr> <tr> <td>case</td> <td>nominative</td> </tr> </table>	function	subject	case	nominative	N2	<table border="1"> <tr> <td>function</td> <td>direct-object</td> </tr> <tr> <td>case</td> <td>accusative</td> </tr> </table>	function	direct-object	case	accusative
pred	<i>take</i>																
pos	verb																
N1	<table border="1"> <tr> <td>function</td> <td>subject</td> </tr> <tr> <td>case</td> <td>nominative</td> </tr> </table>	function	subject	case	nominative												
function	subject																
case	nominative																
N2	<table border="1"> <tr> <td>function</td> <td>direct-object</td> </tr> <tr> <td>case</td> <td>accusative</td> </tr> </table>	function	direct-object	case	accusative												
function	direct-object																
case	accusative																

Japanese-English Verb Lexical Entries (取る *toru* ↔ *reserve*)

Pattern-ID	-0002-00-		
Sem. Class	(action)		
Japanese	pred	取る <i>toru</i>	
	pos	verb	
	N1	case-role	Agent
		case-marker	<i>ga</i> "NOM"
		restriction	agent
N2	case-role	Patient	
	case-marker	<i>o</i> "ACC"	
	restriction	lodging, room, vehicle, ...	
English	pred	<i>reserve</i>	
	pos	verb	
	N1	function	subject
		case	nominative
	N2	function	direct-object
case		accusative	

Correct translation of Verbs and Nouns

「私は休暇を取る許可を取り、妻はホテルを取った。」

私は 休暇を 取る 許可を 取り、妻は ホテルを 取った。
watashi-wa kyūka-o toru kyōka-o tori, tuma-wa hoteru-o totta.
I vacation take permission take, wife hotel took.

‘I **got** permission to **take** a vacation and my wife **reserved** a hotel.’

「象は鼻が長い、豚は鼻が短い。」

象は 鼻が 長い が、豚は 鼻が 短い。
zou-wa hana-ga nagai ga, buta-wa hana-ga mijikai.
elephant nose long but, pig nose short.

‘Elephants have long **trunks** but pigs have short **snouts**.’

Translation of the particle 「と」 to “and”

「私は大阪と京都に行き、彼は社長と京都に行った。」

私は 大阪と 京都に 行き、彼は 社長と 京都に
watashi-wa oosaka-to kyouto-ni iki, kare-wa shachou-to kyouto-ni
I Osaka Kyoto go, he president Kyoto
行った。
itta.
went.

‘I went to Osaka **and** Kyoto and he went to Kyoto **with** the president.’

When is an idiomatic expression idiomatic?

「私は彼のしっぽをつかみ、彼は猫のしっぽをつかんだ。」

私は 彼の しっぽをつかみ、彼は 猫の しっぽを
watashi-wa kare-no shippo-o tsukami, kare-wa neko-no shippo-o
I he tail grasp, he cat tail

つかんだ。

tsukanda.

grasped.

‘I found his weak point and he grasped the cat’s tail.’

Context processing: Supplementation

「NTTは新型交換機を導入する。」

NTTは 新型交換機を 導入する。
NTT-wa shingatakoukanki-o dounyuu-suru.
NTT new model switching system introduce.

‘NTT will introduce a new model switching system.’

「自己診断機能を搭載、20システムを設置する予定だ。」

自己診断機能を 搭載、20システムを 設置する 予定だ。
jikoshindankinou-o tousai, 20-shisutemu-o secchi-suru yotei-da.
self checking function equip, 20 system install plan

‘The new model switching system is equipped with a self checking function and NTT is planning to install 20 systems.’

Automatic rewriting within the source language

「私は電車に乗って学校へ行き、彼は川に沿って歩いて学校へ行った。」

私は 電車に 乗って学校へ 行き、彼は 川に 沿って 歩いて
watashi-wa densha-ni notte gakkou-e iki, kare-wa kawa-ni sotte aruite
I train ride school go, he river go along walking
学校へ 行った。
gakkou-e itta.
school went.

‘I ride to a train and go to school and it went along a river and he walked and went to school.’

私は 電車で 学校へ 行き、彼は 川に沿って 学校へ 歩いた。
watashi-wa densha-de gakkou-e iki, kare-wa kawa-nisotte gakkou-e aruita.
I by train school go, he river along school walked.

‘I went to school by train and he walked to school along a river.’

Translation of the particle 「の」 *no* “of”

「京都の銀閣寺の塔の上の一片の雲。」

京都の 銀閣寺の 塔の 上の 一片の 雲。
kyouto-no ginkakuji-no tou-no ue-no hitohira-no kumo.
Kyoto Ginkakuji Temple tower top one wisp cloud.

‘One wisp of cloud **on** the tower **of** Ginkakuji Temple **in** Kyoto.’

Translation of the particle 「で」 de “by”

「私はコンピュータで作成した映画で有名になるまで、このスタジオでちよくちよく過労で熱を出した。」

私は コンピュータで作成した 映画で 有名に なるまで、
watashi-wa konpyūta-de sakusei-shita eiga-de yuumei-ni naru-made,
I computer made movie famous become until,
この スタジオでちよくちよく過労で 熱を 出した。
kono sutajio-de chokuchoku karou-de netsu-o dashita.
this studio often overwork fever put out.

‘Until I became famous **for** the movie made **with** a computer, I often developed a fever **from** overwork **in** this studio.’

Automatic Transliteration

マーズグローバルサーベイヤーに続いて打ち上げられたマーズパスファインダーの探査車ソジャーナーは地表の走行に成功した。

マーズグローバルサーベイヤーに続いて 打ち上げられた
māzugurōbarusābeiyā-ni tудuite uchi-agerareta

Mars global surveyor following was launched

マーズパスファインダーの探査車ソジャーナーは 地表の 走行に
māzupasufaindā-no tansasasha-sojānā-wa jihyō-no sōkō-ni

mars pathfinder inquiry vehicle sojourner earth surface travel

成功した。

seikō-shita.

succeeded

‘ ‘Sojourner’, an inquiry car of ‘Mars pathfinder’ launched following ‘Mars global surveyor’, succeeded in the traveling of the surface of the earth.’

Translation into very different structures

「川崎市は全国に先駆けてオンブズマン制度を導入した。」

川崎市は 全国に 先駆けて オンブズマン制度を
kawasakishi-wa zenkoku-ni sakigakete onbuzuman seido-o
Kawasaki-city whole country leads ombudsman system
導入した。
dōnyū-shita
introduced.

‘Kawasaki-shi was **the first to introduce** an ombudsman system in the whole country.’

Translation of idiomatic expressions

「私はテニスに興味があるが、ウィンブルドンに行く余裕がない。」

私は テニスに 興味が ある が、ウィンブルドンに行く余裕が
watashi-wa tennis-ni kyoumi-ga aru ga, winburudon-ni iku yoyuu-ga
I tennis interest have but, Wimbledon go margin
ない。
nai.
have not.

‘I am interested in tennis but can not afford to go to Wimbledon.’

Automatic rewriting within the source language

「NTTは二階にショールーム，三階に商談室，会議室，セミナー室を開設する。」

NTTは 二階に ショールームを 開設し、 三階に
NTT-wa nikai-ni shōrūmu -o kaisetsu-shi, sangai-ni
NTT second floor showroom setup, third floor
商談室, 会議室, セミナー室を 開設する。
shoudan-shitsu, kaigi-shitsu, seminā-shitsu-o kaisetsu-suru.
meeting room, conference room, seminar room set up.

‘NTT will set up a showroom in the second floor and will set up meeting, conference and seminar rooms in the third floor.’

Generating Number and Countability

「牛の群れを追っていた狼の群れを狩人の群れが追った。」

牛の 群れを 追っていた 狼の 群れを 狩人の 群れが 追った。
ushi-no mure-o otte-ita ookami-no mure-o karyuudo-no mure-ga otta.
cow group were chasing wolf group hunter group chased.

‘A group of hunters chased a pack of wolves that were chasing a herd of cattle.’

「その大学は全国の高校から学生を集める。」

その 大学は 全国の 高校から 学生を 集める。
sono daigaku-wa zenkoku-no koukou-kara gakusei-o atsumeru.
that university whole country high school from student gather.

‘That university recruits students from high schools throughout the country.’

Countability

「私が各々のコンピュータを調べている間に、息子は各々のソフトウェアを調べた。」

私が 各々の コンピュータを調べている 間に、 息子は
watashi-ga onoono-no konpyūta-o shirabete-iru aida-ni, musuko-wa
I each computer be checking while, son
各々の ソフトウェアを調べた。
onoono-no sofutouea-o shirabeta.
each software checked.

‘While I was checking each computer, my son checked each piece of software.’

Use of possessive pronouns as determiners

「彼は息子をエンジニアにし，娘を医者にした。」

彼は 息子を エンジニアにし，娘を 医者に した。
kare-wa musuko-o enjinia-ni shi, musume-o isha-ni shita.
he son engineer do, daughter doctor did.

‘He made his son an engineer and made his daughter a doctor.’

NTRANS Statistical MT (NTT)

- Demo System trained on computer-related web-text
- 12 Languages (Ja → Ar, De, En, Es, Fr, It, Ko, Ne, Pt, Ru, Th, Zh)
- Data from 10-20 million words (aligned bitext)
- Bleu Score from 0.36 (Ja-De) to 0.52 (Ja-Zh).

NTRANS Example

ホーム | ブックマーク | Red Hat Network | Support | Shop | Products | Training

機械翻訳は便利です

NTRANS 送信

 machine translation is useful	 la traducción automática es útil
 기계 번역 는 편리합니다	 la traduction est utile
 maschinelle ist hilfreich	 la traduzione automatica utile
 машинного перевода полезно для	 de vertaling handig
 机器翻译 是 有用	 a tradução automática é útil
 إن ترجمة آلية مفيداً	 การ แปล ภาษา ด้วย สดวก

Some Open Systems

- Open Source Software provides
 - sharing of components
 - a chance to compare systems
 - a chance to combine the best parts
- Improvements in parts improve the whole
- We can grow MT through cooperative use

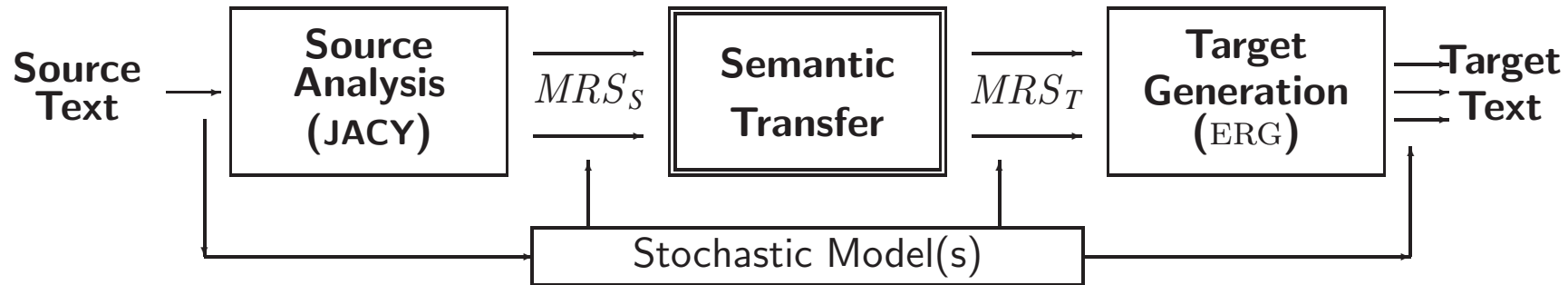
OpenTrad

- OpenTrad is a Spanish Open Source Translation Initiative
<http://www.opentrad.org/index.php?=&lang=en>
- A general MT framework and two Engines
 - Shallow Transfer (Apertium)
 - * Castilian Spanish ↔ Catalan
 - * Castilian Spanish ↔ Galician
 - * Castilian Spanish ↔ Portuguese
 - Structural Transfer
 - * Castilian Spanish ↔ Basque
- Shared components for all systems (deformatter, . . .)

OpenLogos Machine Translation

- OpenLogos is a 30 year-old Commercial Transfer System
<http://logos-os.dfki.de/>
- Mature System
- German/English → French/Italian/Spanish/Portuguese/. . .
- New Documentation already appearing
- Dual License (Commercial/GPL)

The DELPH-IN Open Source MT System



- HPSG-based bi-directional grammars
 - other grammars possible (e.g., LFG, used in LOGON)
- Semantic transfer using Minimal Recursion Semantics
- Controlled by the LOGON system architecture
- LGPL and BSD licensed components

Open Resources : DELPH-IN

➤ **Deep Linguistic Processing with HPSG Initiative**

Grammars Japanese, English, Korean, Norwegian, . . .

Development Environment LKB (Parser/Generator)

Runtime Environment PET (Parser)

Test Environment [incr tsdb()]

Treebanking and Stochastic Modeling Redwoods

Machine Translation LOGON (in [incr tsdb()])

Deep and Shallow Hybrids Heart of Gold

Example: Source

(2) ビールを 三つ もってきて ください
biiru-wo mittsu motte kite kudasai
beer-ACC three-CL hold come please
Please bring three beers.

(3) $\langle h_1, \{h_1: \text{imp_m}(h_3),$
 $h_4: \text{biiru_n}(x_1), h_6: \text{udef_q}(x_1, h_7, h_8), h_9: \text{card}(u_1, x_1, "3"),$
 $h_{11}: \text{motsu_v}(e_1, u_2, x_1), h_{11}: \text{kuru_v}(e_2, u_3),$
 $h_{15}: \text{kudasaru_v}(e_3, u_4, u_5, h_{17}),$
 $h_{17}: \text{proposition_m}(h_{18}) \},$
 $\{h_3 =_q h_{15}, h_7 =_q h_4, h_{18} =_q h_{11}\} \rangle$

Example: Transfer

Transfer:

- $biiru_n(x_i) \rightarrow beer_n(x_i)$
- $h_j: motsu_v(e_1, u_2, x_1), \text{ “hold” } h_j: kuru_v(e_2, u_3) \text{ “come” } \rightarrow$
 $h_j: bring_v(e_1, u_2, x_1)$
- $h_i: kudasaru_v(e_j, h_k) \rightarrow h_i: please_a(e_j, h_k)$

Generation:

- $h_1: imp_m(h_3) \Rightarrow h_2: pronoun_q(x_0, h_7, h_8), h_4: pron(x_0\{2nd\})$

Example: Target

- (4) $\langle h_0, \{ h_0: \text{please_a}(e_3, h_1),$
 $h_1: \text{imp_m}(h_3),$
 $h_2: \text{pronoun_q}(x_0, h_7, h_8), h_4: \text{pron}(x_0\{2nd\}),$
 $h_5: \text{bring_v}(e_2, x_0, x_1),$
 $h_4: \text{beer_n}(x_1), h_6: \text{undef_q}(x_1, h_{10}, h_8), h_{11}: \text{card}(u_1, x_1, "3") \},$
 $\{ h_3 =_q h_5, h_7 =_q h_4, h_{10} =_q h_{11}, \} \rangle$
- (5) Please bring three beers.

Comments

- Source and Target grammars do much of the work
- Language specific details hidden by the Semantic Interface (**SEM-I**)
- The EPs are an unordered bag
- Scope information is in the handles
- Easy to apply rules to the bag of EPs

Remaining Problems

- Sense Disambiguation
is 鳩 *hato* a *dove* or a *pigeon*
- Language Differences
 - number
 - honorification
- Multi-Word Expressions

Over-generate and choose with a stochastic model

Current Status

- Bi-Directional (Ja→En and En→Ja)
- Japanese Lexicon: 48,000 words (37,000 at MT Summit)
- English Lexicon: 33,000 words (21,000 at MT Summit)
- Transfer Lexicon: 50,000 word pairs (15,000 at MT Summit)
 - Automatic construction from Edict
Nouns, (In)Transitive Verbs, Adjectives, Adverbs
- Little systematic testing

Machine Translation: Summary

Machine translation (MT) is the application of computers to the task of translating texts from one natural language to another. One of the very earliest pursuits in computer science, MT has proved to be an elusive goal, but today a number of systems are available which produce output which, if not perfect, is of sufficient quality to be useful in a number of specific domains.

European Association for Machine Translation
— What is Machine Translation? (1997)

Has MT improved?

- In what respect?
 - translation quality: general-purpose vs. domain-specific
 - usability (ease of use)
 - adaptability (integration with other software)
- Since when?
 - quality perhaps not in last ten years, but since 1980 it has
- Why not?
 - inherent problems of language
 - inherent problems of 'cultural' differences

MT: when it works and when it doesn't

- Cannot be both fully automatic and general-purpose
 - Too difficult at present:
 - * literature, philosophy, sociology, law
- For large corporations, cost-effective if:
 - controlled input, standardised terminology, multilingual output, repetitive documentation, restricted domain
- Occasional (information-only)
 - Rough, not for publication; immediate (fast) production
- Small-scale MT
 - 'formulaic' documents (business correspondence), restricted domain
 - interactive assistance

MT and HT in complementation

➤ Dissemination

- HT: single item, context/culture-sensitive,
- HT with TM: repetitive (e.g. localization, web localization)
- MT only: restricted language, repetitive (e.g. Meteo); document drafting
- MT with post-editing/controlled language: large scale, technical, localization

➤ Assimilation

- MT with (rapid) post-editing: scientific, technical
- MT only (PC or online): single item (non-literary), general purpose; information monitoring/filtering
- MT domain-specific (online)

➤ Interchange

- HT: business correspondence; interpreting
- MT: email, personal correspondence; database searching; TV captions
- MT domain-specific: business correspondence
- MT (speech) domain-specific: telephone enquiries

General Comments

- MT is not translation as usually understood, it is merely a computer-based tool
 - for translators
 - for cross-language communication
 - for access to information resources

- Perfectionism is not necessary or essential
 - publishable quality will always require human editing/revision
 - assimilation/interchange can always tolerate imperfect communication

Conclusions

- MT should be used only as required to save costs/effort in appropriate circumstances

- Judgment should be based
 - not on whether system produces 'real' translations
 - and particularly not whether it produces 'good' translations
 - but: whether the output can be used
 - and: whether its use will save time or money

New directions and challenges (1)

- Spoken language translation
 - general-purpose?

- 'Minor' languages
 - languages of India, Africa, Asia
 - non-national ('official') languages (e.g. Welsh, Basque, Catalan)
 - languages of minorities (e.g. non-indigenous languages in Britain)

- Systems for monolinguals
 - from unknown source language
 - to unknown target language

New directions and challenges (2)

- Improvement expectations
 - particularly PC commercial and Internet systems
- Reusability of resources (particularly dictionaries and translation memories)
- Integration
 - MT as option in word processing packages, on Web pages
 - MT as option with summarization, information extraction, information retrieval, data retrieval, question-answering, Internet search tools

References (1)

- Websites and Mailing Lists
 - Machine Translation Archive <<http://www.mt-archive.info>>
 - linguist-list <<http://www.linguistlist.org>>
 - Association for Computational Linguistics (Anthology)
<<http://www.aclweb.org/>> (<<http://acl.ldc.upenn.edu/>>)
 - European Association for MT <<http://www.eamt.org/>>
 - Statistical Machine Translation Web site
<<http://www.statmt.org/>>
 - LISA website <<http://www.lisa.org>>
 - Deep Linguist Processing with HPSG (DELPH-IN)
<<http://www.delph-in.net/>>
 - Papillon Multilingual Lexical Database
<<http://www.papillon-dictionary.org/Home.po>>

References (2)

➤ Journals

- Machine Translation
- Computational Linguistics
- Multilingual Computing and Technology
- Journal of Natural Language Processing (English and Japanese)

➤ Conferences

- Theoretical and Methodological Issues in Machine Translation (TMI)
- Machine Translation Summit
- COLING, ACL, ANLP, IJCNLP . . .