Readings Summary

Today's assigned "reading" was to watch Peter Norvig's September 23, 2010, talk, "The unreasonable effectiveness of data," UBC Computer Science Distinguished Lecture Series. (video)

- Peter Norvig introduces us to the statistical machine learning approach to artificial intelligence
- Example problems discussed in the talk:
  - scene completion (in image processing)
  - scene carving (in image processing)
  - speech recognition
  - orbital mechanics
  - flu trends
  - word sense disambiguation
  - word segmentation
  - spelling correction
  - *language translation*

Today's Learning Goals

1. To explore additional examples of challenges in language translation, for both human and machine
2. To understand that computer science is about language design
   - programming languages are precise about both syntax and semantics
   - syntax determines whether a sequence of statements is valid in a language
   - given a valid sequence of statements in a language, semantics determines what the statements do (i.e., determine what is computed)
   - implementation of a programming language typically involves multiple language translations
3. To explore one approach to machine translation of natural language that resolves semantic ambiguity by appeal to large corpora of empirical data

Example 1: Back Translation

The following is a classic, but apocryphal, translation from English into Russian and back into English:

The spirit is willing but the flesh is weak

came back as

The vodka is fine but the meat is rotten

Example 2: Bill Gates and Steve Jobs

Scene: Bill Gates and Steve Jobs are having lunch together. The conversation is a bit strained

Bill Gates (glancing at his watch): "I have to leave now. I have an appointment at the bank to talk about a loan"

Steve Jobs (incredulous): "Why do you need a loan?"

Bill Gates (smiling): "I don't. The bank does"

Example 3: Spoken versus Written English

Fill in the blank:

There are three _____ in the English language: to, too and two

Example 4: Crown and Anchor Sign

I like the sign. But, please leave more space between crown and and and and and anchor

Example 5: Simple Arithmetic

Calculate

$$3 + 5 \times 2 = 13$$

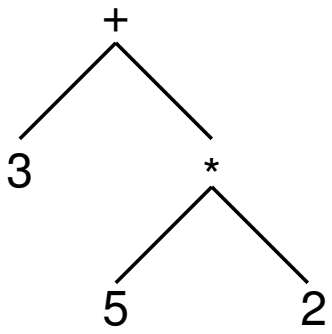
This result depends, in part, on the shared convention that multiplication has precedence over addition

That is, convention dictates that we interpret the left hand side of the equation as $3 + (5 \times 2)$, not as $(3 + 5) \times 2$

For those contemplating or taking CPSC 110, in Scheme the expression would be written as $(+\ 3\ (*\ 5\ 2))$

Example 5 (cont'd): "Abstract" Syntax Tree

The intended "meaning" of the arithmetic expression can be made explicit as a tree



regardless of the syntax (and associated conventions) used to represent the original expression

Example 6: GCC – the GNU Compiler Collection

Source Language "Front Ends"	*Abstract Syntax Tree (AST)*	Target Machine "Back Ends"
C C++ Objective C Objective C++ Fortran Java Ada Go ⋮	*common internal representation*	45 processor families (in standard release) 25 additional processors (from 3rd parties) ⋮

http://en.wikipedia.org/wiki/GNU_Compiler_Collection

In the GNU Compiler Collection, each source language supported requires its own "front end" parser to translate the source code in that language into its abstract syntax tree (AST) representation. This common, abstracted internal representation is further processed (and, where appropriate,

optimized). Each target machine requires its own "back end" to translate the results of this common internal processing into actual instruction sequences from that processor's instruction set.

As shown above, there are 8 source languages and 45 target machine processor families supported in the current GCC release. Using the AST as a common internal representation, a total of 8+45=53 language translators are required. Alternatively, if one imagined developing a separate compiler for each source language to each target machine, a total of 8×45=360 language translators would be required.

Example 7: Translation Fail – An Arm Gesture

. . . the interpreter translated their [Liberals Bill Graham and Marlene Jennings] description for the gesture – *"bras d'honneur"* – into *"Italian salute"*

"I want an apology on behalf of all Canadians of Italian heritage and I want it withdrawn," said Tory House Leader Bob Nicholson. "That is an insult"

Graham and Jennings demanded an apology for the mistaken suggestion they had made a racist slur

No apology was forthcoming

"I have a right to listen to it in translation. . . " Nicholson retorted

Speaker of the House Peter Milliken could do only one thing – throw up his arms and move onto to other business

House of Commons, June 14, 2006

Soviet premier Nikita Khrushchev spoke to western ambassadors at a reception at the Polish embassy in Moscow, November 18, 1956, and (was interpreted in English to have) said, "Whether you like it or not, history is on our side. We will bury you."

Example 8: (A More Serious) Translation Fail

http://en.wikipedia.org/wiki/We_will_bury_you

Example 8 (cont'd):

Original Russian:

Мы вас похороним

(transliterated as *Mi vas pokhoronim*)

Alternate English Translations:

We will be present when you are buried

We will be present at your funeral

We will outlast you

We will outlive you

The interpreter of Khrushchev's "We will bury you" phrase was Victor Sukhodrev, who died May 16, 2014, at age 81. Sukhodrev is quoted as having said, "I worked with Khrushchev for many years, he was an uneducated person and he also didn't like to read pre-edited texts. He liked to improvise, spoke plainly, and was fond of discussions and arguments." Sukhodrev noted that Khrushchev used scandalous statements, cheesy jokes, and liked to spice up his speech with proverbs (usually Ukrainian ones) that he [Sukhodrev] had never heard before. Throughout his life, Sukhodrev maintained that his translation, "We will bury you" was "an exact interpretation."

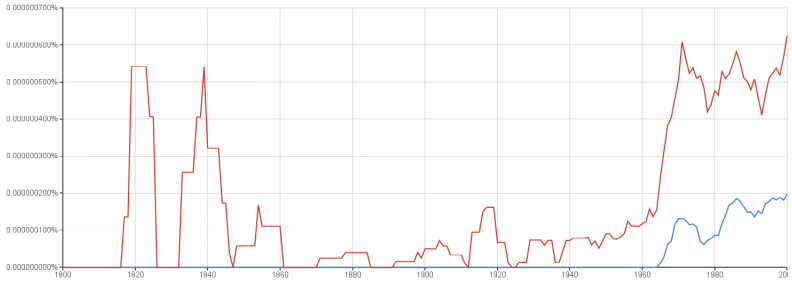
Example 9:

Time flies like an arrow

But,

Fruit flies like a banana

Example 9: Google Books Ngram



time flies like an arrow
fruit flies like a banana

Example 10: "THE CAT"

This example is constructed so that the "H" in "THE" and the "A" in "CAT" are identical. In the one case, we see the character as an "H" since it doesn't make sense, in English, as an "A." Similarly, in the other case, we see the character as an "A" since it doesn't make sense, in English, as an "H."

Example 10 (cont'd): "THE CAT"

An *on-line dictionary of American English* (file /usr/share/dict/american in OpenSuSE 12.3) contains a total of 305,089 "distinct" entries

Sequence	Count	Proportion
ca	16,152	5.29×10^{-2}
ch	15,311	5.02×10^{-2}
at	30,039	9.85×10^{-2}
ht	1,992	6.53×10^{-3}
ta	15,389	5.04×10^{-2}
th	11,342	3.72×10^{-2}
ae	2,394	7.85×10^{-3}
he	14,890	4.88×10^{-2}
cat	2,724	8.91×10^{-3}
cht	238	7.80×10^{-4}
tae	79	2.59×10^{-4}
the	3,424	1.12×10^{-2}

In terms of words in the dictionary, there are roughly 11 times as many words with the 3 letter sequence "cat" compared to the sequence "cht" (2,724 vs 238). Similarly, there are roughly 43 times as many words with the 3 letter sequence "the" compared to the sequence "tae" (3,424 vs 79).

Given that a dictionary entry contains the 2 letter sequence "th," there is roughly a 30% chance that it will be followed by the letter "e" (3,424 out of 11,342).

Example 10 (cont'd): "THE CAT"

Here are the 79 *"tae"* words...

Actaeon, antae, Antaean, Antaeus, aortae, arborvitae, arborvitae's, Archegoniatae, Archegoniatae's, Aristaeus, arytaenoid's, aspiratae, ballistae, chaetae, Clytaemnestra, Clytaemnestra's, Compositae's, Conjugatae, Conjugatae's, Crataegus, Crataegus's, cristae, crustae, emeritae, etaerio, etaerios, glutaeal, hetaera, hetaerae, hetaerai, hetaeras, hetaerismic, hetaerisms, hetaerist, hetaerists, Heterocontae, Heterocontae's, Isokontae, Isokontae's, Labiatae, Labiatae's, locustae, lyttae, metaethical, metaethics, Nabataea, Nabataean, Nabataea's, notaeum, notaeums, placentae, Plataea, Plataean, Plataeans, Plataea's, Ratitae, Ratitae's, setae, spirochaetaemia, Stael, Stael's, taedium, Taegu, Taegu's, Taejon, tael, tael's, taeniate, Therapeutae, Therapeutae's, Tsvetaeva, Tsvetaeva's, Tyrtaean, Tyrtaean's, vistaed, vitae, vittae, voltaelectric, voltaelectricity

Example 10 (cont'd): "THE CAT"

A decade (2000–2009) of *Bob's (spam filtered) email* contained a total of 51,106,155 "words"

Sequence	Count	Proportion
ca	1,722,653	3.37×10^{-2}
ch	1,237,612	2.42×10^{-2}
at	2,592,333	5.07×10^{-2}
ht	552,908	1.08×10^{-2}
ta	997,182	1.95×10^{-2}
th	4,104,575	8.03×10^{-2}
ae	73,151	1.43×10^{-3}
he	3,088,885	6.04×10^{-2}
cat	192,728	3.77×10^{-3}
cht	4,373	8.56×10^{-5}
tae	1,372	2.69×10^{-5}
the	2,307,626	4.52×10^{-2}

In terms of (email) usage, there are roughly 44 times as many words with the 3 letter sequence "cat" compared to the sequence "cht" (192,728 vs 4,373). Similarly, there are roughly 1680 times as many words with the 3 letter sequence "the" compared to the sequence "tae" (2,307,626 vs 1,372).

Given that a word in an email contains the 2 letter sequence "th," there is roughly a 56% chance that it will be followed by the letter "e" (2,307,626 out of 4,104,575).

Example 10 (cont'd): "THE CAT"

Comparison between actual *(Bob's email)* usage and *dictionary*

Sequence	Proportion Email	Proportion Dictionary	Ratio Email–to–Dictionary
ca	3.37×10^{-2}	5.29×10^{-2}	0.637
ch	2.42×10^{-2}	5.02×10^{-2}	0.482
at	5.07×10^{-2}	9.85×10^{-2}	0.515
ht	1.08×10^{-2}	6.53×10^{-3}	1.654
ta	1.95×10^{-2}	5.04×10^{-2}	0.387
th	8.03×10^{-2}	3.72×10^{-2}	2.159
ae	1.43×10^{-3}	7.85×10^{-3}	0.182
he	6.04×10^{-2}	4.88×10^{-2}	1.238
cat	3.77×10^{-3}	8.91×10^{-3}	0.423
cht	8.56×10^{-5}	7.80×10^{-4}	0.110
tae	2.69×10^{-5}	2.59×10^{-4}	0.104
the	4.52×10^{-2}	1.12×10^{-2}	4.036

Google Research uses word n-gram models in a variety R&D projects. Using Google's own data resources and processing infrastructure, a corpus of one trillion words has been generated from public Web pages.

The dataset is available here via the Linguistics Data Consortium (LDC). A total of 1,024,908,267,229 words of running text were processed. Counts are published for all 1,176,470,663 five-word sequences that appear at least 40 times. There are 13,588,391 unique words, after discarding words that appear less than 200 times.

Google: All Our N-gram are Belong to You

File sizes: approximately 24GB compressed (gzip'ed) text files

Number of tokens:	1,024,908,267,229
Number of sentences:	95,119,665,584
Number of unigrams:	13,588,391
Number of bigrams:	314,843,401
Number of trigrams:	977,069,902
Number of fourgrams:	1,313,818,354
Number of fivegrams:	1,176,470,663

Credit: Alex Franz and Thorsten Brants, Google Machine Translation Team

Peter Norvig wrote a chapter, Natural Language Corpus Data, that appears in the 2009 book Beautiful Data (by Toby Segaran and Jeff Hammerbacher). The chapter considers several text-based applications, in addition to those presented in his 2010 UBC Computer Science Distinguished Lecture Series talk. Norvig also has a web page containing Python code and data to accompany the chapter. It's easy to try things out for yourself.

Norvig: Natural Language Corpus Data

Applications considered:

- Word Segmentation
- Secret Codes
- Spelling Correction

Other tasks (briefly described):

- Language Identification
- Spam Detection and Other Classification Tasks
- Author Identification (Stylometry)
- Document Unshredding and DNA Sequencing
- Machine Translation

Example 10 (one last time): "THE CAT"

Data for this table derived from the *Google Web Trillion Word Corpus*

There are $26 \times 26 = 676$ distinct two letter combinations and $26 \times 26 \times 26 = 17,576$ distinct three letter combinations of the characters A–Z

Sequence	Count	Rank
ca	35,964,886,206	51
ch	34,170,408,619	54
at	80,609,883,139	11
ht	10,529,516,272	172
ta	42,344,542,093	42
th	133,210,262,170	2
ae	12,677,383,584	384
he	106,498,528,786	5
cat	6,716,493,366	133
cht	875,755,609	1,571
tae	55,488,859	5,242
the	82,103,550,112	1

In the Google Web Trillion Word Corpus, there are roughly 7.7 times as many words with the 3 letter sequence "cat" compared to the sequence "cht" (6,716,493,366 vs 875,755,609). Similarly, there are roughly 1480 times as many words with the 3 letter sequence "the" compared to the sequence "tae" (82,103,550,112 vs 55,488,859).

Given that a word in an email contains the 2 letter sequence "th," there is roughly a 62% chance that it will be followed by the letter "e" (82,103,550,112 out of 133,210,262,170).

In the Google Web Trillion Word Corpus, "the" is the most frequently occurring 3 letter sequence and "th" is the second most frequently occurring 2 letter sequence. Aside: The most frequently occurring 2 letter sequence is "in" with a total count of 134,812,613,554.

Finally, Norvig includes the complete works of Shakespeare as an additional word corpus at his book chapter web page. The 3 letter sequence "tae" does not occur in Shakespeare and the 3 letter sequence "cht" occurs exactly once, in the phrase "to your manor of Picht-hatch" (from "The Merry Wives of Windsor").

Chris' Example Revisited

The monkeys ate the bananas because they were ripe

The monkeys ate the bananas because they were hungry

Here's how a Google style analysis might proceed. Structural analysis of each sentence determines two possible antecedents for "they," either "monkeys" or "bananas." Comparing the relative co-occurence of "monkeys ripe" with "bananas ripe," in some corpus of text, would determine the antecedent for "they" in the first sentence. Comparing the relative co-occurence of "monkeys hungry" with "bananas hungry," in some corpus of text, would determine the antecedent for "they" in the second sentence.

Google Translate API

> *Important:* Google Translate API v2 is now available as a paid service. The courtesy limit for existing Translate API v2 projects created prior to August 24, 2011, will be reduced to zero on December 1, 2011. In addition, the number of requests your application can make per day will be limited. Google Translate API v1 will be shut off completely on the same date (December 1, 2011); it was officially deprecated on May 26, 2011. These changes are being made due to the substantial economic burden caused by extensive abuse. For website translations, we encourage you to use the Google Website Translator gadget
>
> http://code.google.com/apis/language/translate/overview.html

Google Translate API

Google is dropping an automatic-translation tool, because overuse by spam-bloggers is flooding the internet with sloppily translated text, which in turn is making computerized translation even sloppier

. . . I think it is very interesting in its implications – about language, "big data," Google's strategies, and the never-ending recalibration of goods vs bads, "signal to noise," on the internet

"An 'Economic Burden' Google Can No Longer Bear?"
James Fallows, The Atlantic, June 12, 2011
http://www.theatlantic.com/technology/archive/2011/06/an-economic-burden-google-can-no-longer-bear/240283/