What is NLP?

- Fundamental goal: analyze and process human language, broadly, robustly, accurately...
- End systems that we want to build:
  - Ambitious: speech recognition, machine translation, information extraction, dialog interfaces, question answering...
  - Modest: spelling correction, text categorization...

Speech Systems

- Automatic Speech Recognition (ASR)
  - Audio in, text out
  - SOTA: 0.3% error for digit strings, 5% dictation, 50%+ TV

- Text to Speech (TTS)
  - Text in, audio out
  - SOTA: totally intelligible (if sometimes unnatural)

Question Answering

- Question Answering:
  - More than search
  - Ask general comprehension questions of a document collection
  - Can be really easy: “What’s the capital of Wyoming?”
  - Can be harder: “How many US states have capitals as their largest cities?”
  - Can be open ended: “What are the main issues in the global warming debate?”

- SOTA: Can do facts, even when text isn’t a perfect match

Information Extraction

- Unstructured text to database entries

<table>
<thead>
<tr>
<th>Name</th>
<th>Company</th>
<th>Year</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russell R. Lewis</td>
<td>New York Times</td>
<td>1999</td>
<td>NY</td>
</tr>
<tr>
<td>Russell R. Lewis</td>
<td>New York Times</td>
<td>1999</td>
<td>NY</td>
</tr>
<tr>
<td>Lance R. Primo</td>
<td>New York Times Co.</td>
<td>1999</td>
<td>NY</td>
</tr>
</tbody>
</table>

- SOTA: perhaps 70% accuracy for multi-sentence temples, 90%+ for single easy fields

HMMs for Information Extraction
Syntactic Analysis

Hurricane Emily howled toward Mexico’s Caribbean coast on Sunday, packing 135 mph winds and torrential rain and causing panic in Cancun, where frightened tourists squeezed into musty shelters.

PCFGs

- Natural language grammars are very ambiguous!
- PCFGs are a formal probabilistic model of trees
  - Each “rule” has a conditional probability (like an HMM)
  - Tree’s probability is the product of all rules used
- Parsing: Given a sentence, find the best tree

Coreference Modeling

The Weir Group, whose headquarters is in the U.S., is a large specialized corporation. This power plant, which, will be situated in Jiangsu, has a large generation capacity.

Machine Translation

Original Text

The Weir Group, whose headquarters is in the U.S., is a large specialized corporation. This power plant, which, will be situated in Jiangsu, has a large generation capacity.

Translated Text

The Weir Group, whose headquarters is in the U.S., is a large specialized corporation. This power plant, which, will be situated on the shores of Jiangsu, has a large generation capacity.

Machine Translation

Input: example translations (bitext)

Gracias, yo haré de muy buen grado.
Thank you, I shall do so gladly.

Output: a system which can translate new sentences

Gracias
Thank you

do so

you,
MT Overview

A Phrase-Based Model

A Phrase-Based Decoder

Probabilities at each step include LM and TM

MT from Monotext

Translation without parallel text?

Output

Language Evolution
Robotics

Motion as Search

- Motion planning as path-finding problem
- Problem: configuration space is continuous
- Problem: under-constrained motion
- Problem: configuration space can be complex

Probabilistic Roadmaps

- Idea: just pick random points as nodes in a visibility graph
- This gives probabilistic roadmaps
  - Very successful in practice
  - Lets you add points where you need them
  - If insufficient points, incomplete, or weird paths

Policy Search

- Problem: often the feature-based policies that work well aren't the ones that approximate $V$ / $Q$ best
  - E.g. your value functions from project 2 were probably horrible estimates of future rewards, but they still produced good decisions
  - We'll see this distinction between modeling and prediction again later in the course

- Solution: learn the policy that maximizes rewards rather than the value that predicts rewards
- This is the idea behind policy search, such as what controlled the upside-down helicopter

Policy Search*

- Advanced policy search:
  - Write a stochastic (soft) policy:
    \[
    \pi_w(s) \propto e^{\sum_i w_i f_i(s,a)}
    \]
  - Turns out you can efficiently approximate the derivative of the returns with respect to the parameters $w$ (details in the book, but you don’t have to know them)
  - Take uphill steps, recalculate derivatives, etc.
Object Recognition

Comparing Local Regions

Shape Context

Compact representation of distribution of points relative to each point

Similar Regions

Match for Image Similarity

Color indicates similarity using Geometric Blur Descriptor

Not Quite...