Course Review

Kevin Duh
Intro to NLP, Fall 2019

Congrats!

- We’re at the end of the course. You’ve learned a lot. Pat yourself on the back for your achievement!

Final Exam Logistics

- Time: Thursday, December 19, 9:15AM - 10:30AM (1hr 15min)
- Place: Shaffer 301
- Cheatsheet allowed: 1 page front/back A4/Letter-size
- Exam is comprehensive:
  - Covers all 11 modules of the course
  - Does not cover guest lectures

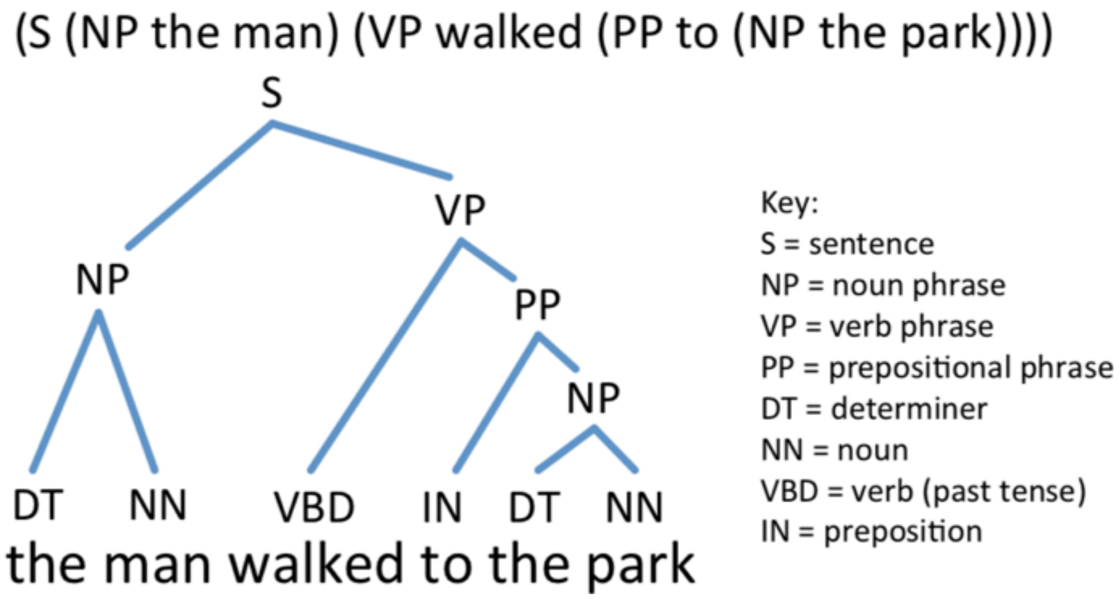
Study Tips

- Review the slides and lecture notes
- Make sure you have mastered the assignments
    - e.g. can you now do the assignments all by yourself (without collaborators) if necessary?
- Make sure you have mastered the midterm exam
- Attend TA review session: **12:15 to 1:45 on Tuesday, December 17 (Hackerman 320)**

Check your understanding…

1. Grammar Writing

- Context Free Grammar rules for English
  - What are the common rules? Can you derive some reasonable CFG rules based on sentence observations?
  - How do PCFG rules make things more flexible?
- Understand basic part-of-speech tags. Be able to tag yourself



(S (NP the man) (VP walked (PP to (NP the park))))

Key:
S = sentence
NP = noun phrase
VP = verb phrase
PP = prepositional phrase
DT = determiner
NN = noun
VBD = verb (past tense)
IN = preposition

2. Language Modeling

- Probability basics:
  - Explain joint probability, conditional probability, Bayes Rule, & entropy in mathematical terms
- Perplexity — be able to implement LM evaluation
- N-grams

$$\begin{aligned} p(\vec{w}) &= p(w_n \mid w_{n-1}, w_{n-2}, \ldots, w_1) \times p(w_{n-1} \mid w_{n-2}, \ldots, w_1) \\ &\times \; p(w_{n-2} \mid w_{n-3}, \ldots, w_1) \times p(w_{n-3} \mid w_{n-4}, \ldots, w_1) \\ &\times \; p(w_{n-4} \mid w_{n-5}, \ldots, w_1) \times \ldots \times p(w_2 \mid w_1) \times p(w_1) \end{aligned}$$

  - What assumptions are made?
  - How to estimate probabilities & do smoothing

3. Text Classification

- Log-linear model

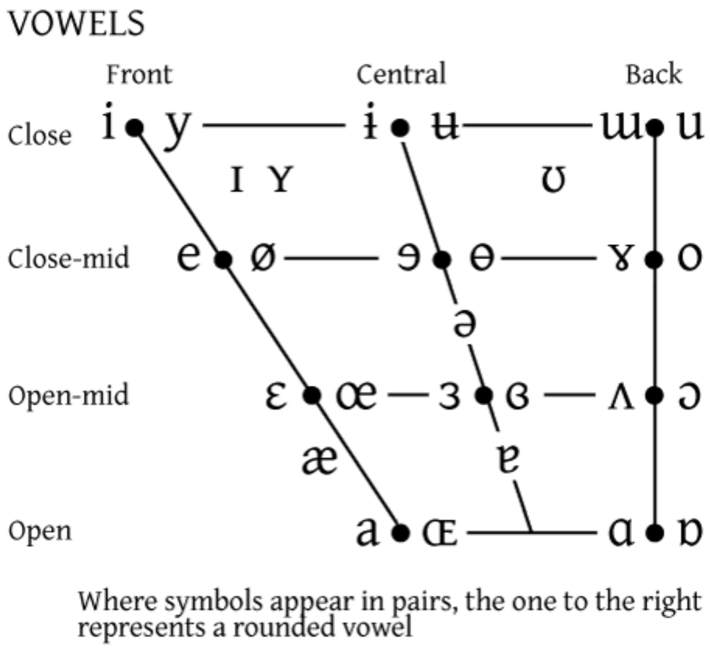
$$p(y \mid x) = \frac{1}{Z(x)} \exp(score(x, y)) = \frac{1}{Z(x)} \exp(\sum_{k=1}^{K} \theta_k f(x, y))$$

  - Explain how it's defined, i.e. the math
  - Explain why it's a powerful model

- Machine learning concepts: generalization, overfitting, underfitting, model expressiveness, bias-variance

- How to setup experiments (train/dev/test split & procedures) when asked to deploy a classifier somewhere

4. Linguistics 101



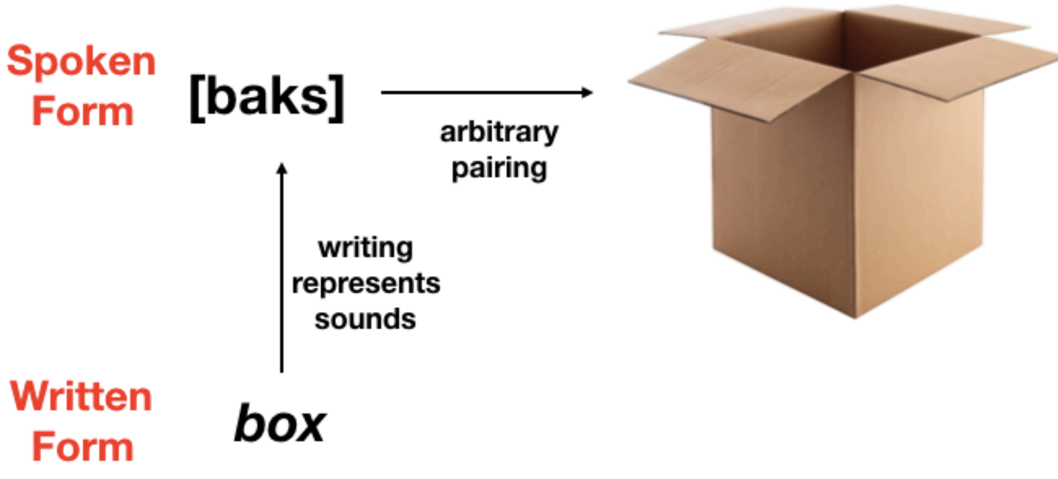
Where symbols appear in pairs, the one to the right represents a rounded vowel

- Recognize that language is a spoken phonemon. i.e. Language != written text

- Phonetics: how to classify vowels & consonants?

- Writing systems: logographic, syllabary, alphabet, abugida, abjad

Linguistic Sign
= Form + Meaning



Spoken Form

[baks]

arbitrary pairing

writing represents sounds

Written Form

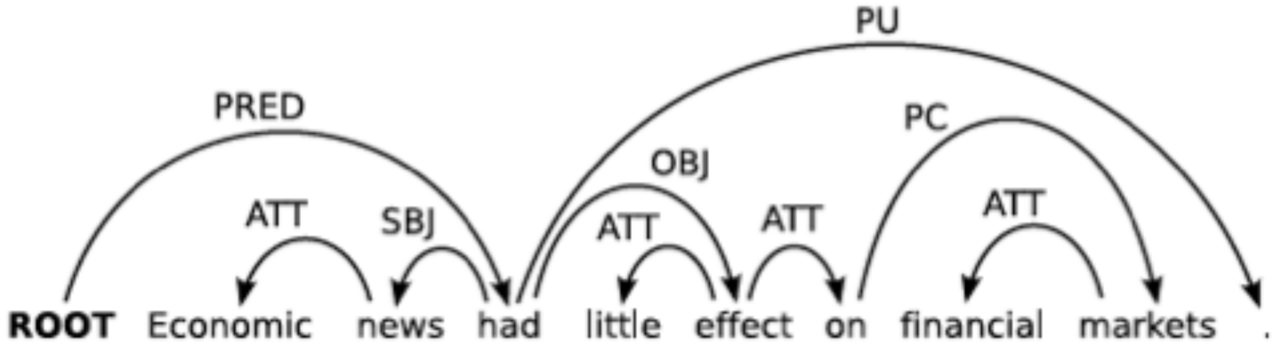
box

4. Linguistics 101

- Morphology
  - Identify morphemes, derivations, and inflections
  - Classify: analytic, agglutinative, fusional
- Syntax:
  - Know that languages may be SVO, SOV, etc. or free-word order. Recognize the diversity in expression: some things expressed in syntax in English might be expressed in morphology in another.
- Semantics vs. Pragmatics — what’s the difference?

5. Parsing

- What is dynamic programming?
- Be able to implement CKY for constituency parsing
  - i.e. I give you a grammar and a sentence, you give me all the valid parse trees
- Be able to read and understand a dependency parse



6. Neural Networks

- Understand how to derive backpropagation equations (don’t need to do it for real, but understand it’s chain rule)
- Basic familiarlity with Word2Vec & Neural LM models
- Be able to figure out how to set parameters to a simple neuron, e.g. midterm question on fitting AND/OR operators

7. HMM

- What’s it good for? Sequence labeling problems
- Mathematical form $P(O,Q) = P(O|Q)P(Q) = \prod_{t=1}^{T} P(o_t|q_t) \times \prod_{t=1}^{T} P(q_t|q_{t-1})$
- What are the 3 problems for an HMM
    - Be able to compute likelihood and decode by hand, if given model parameters and observation
    - Understand the basic mechanics of Baum-Welch
- Basically, master the homework assignment

8. Topic Models

- High level differences (advantage/disadvantages) between Latent Semantic Analysis (LSA), Probabilistic Latent Semantic Analysis (PLSA) and Latent Dirichlet Allocation (LDA)
- Generative story of LDA and how it maps to graphical model. Be clear about what’s ‘latent’, ‘observed’, ‘hyperparameter’ variables in the model

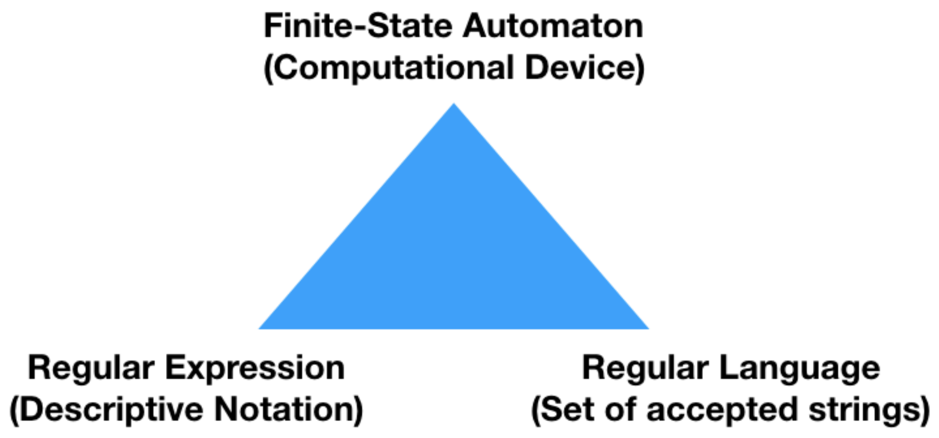
9. FST

- Understand relationship between FSA, RegEX, set of strings

- If given a weighted FST, be able to explain what it's doing; be able to generate output based on some input.

- Be able to do the above under different semirings.

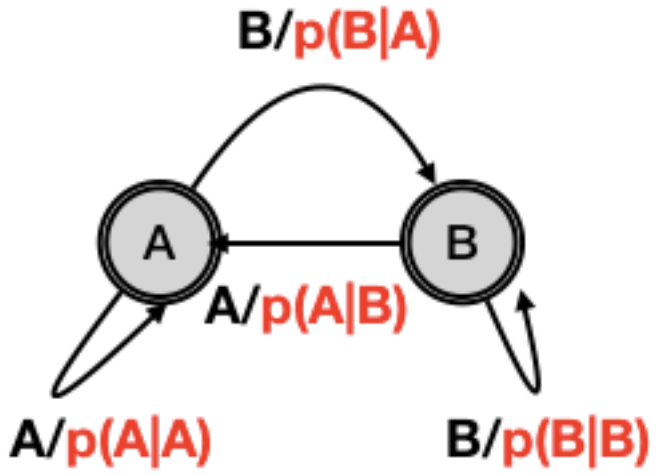
- Understand the purpose of various FST operations, e.g. composition



Finite-State Automaton (Computational Device)

Regular Expression (Descriptive Notation)

Regular Language (Set of accepted strings)

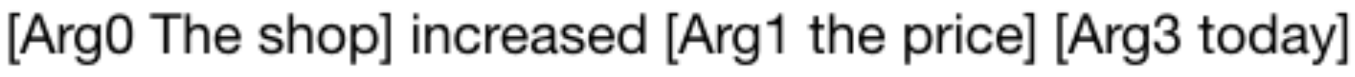


10. Semantics

- Recognize that semantics is hard, that different “kinds” of semantics work for different purposes.
- Distributional Semantics: what is it? some examples?
- Word sense:
    - Be able to think of multiple senses when given a word
    - Describe relations between senses, e.g. hypernym
    - What’s a synset? How is WordNet organized?

10. Semantics

- Semantic Role Labeling: what is the task and how does this relate to semantics?
    - Identify different thematic roles in a sentence
- PropBank and FrameNet:
    - How do these approaches differ?
    - If given an annotation, explain in words what it means



[Arg0 The shop] increased [Arg1 the price] [Arg3 today]

11. Structured Prediction

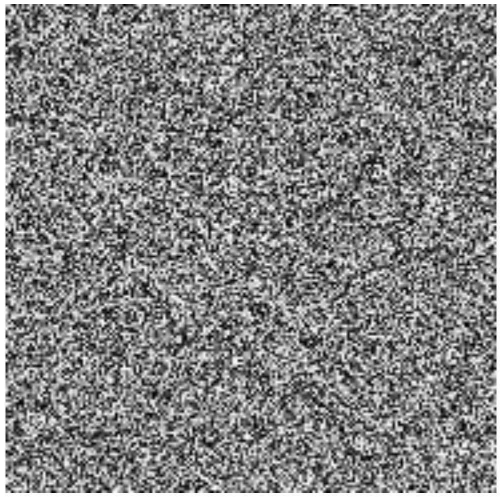
- What problems can be called structured prediction?
- Generative vs. Discriminative.
  - Explain the difference in terms of math. Explain the benefits of each. Understand how bad features affect generative models.
- Local vs. Global. Explain the difference. Explain the label bias problem.
- CRF - how does it relate to log-linear models?
- Structured Perceptron - understand the pseudocode
- When to use CRF, Structured Perceptron, or Structured SVM?

Final Remarks

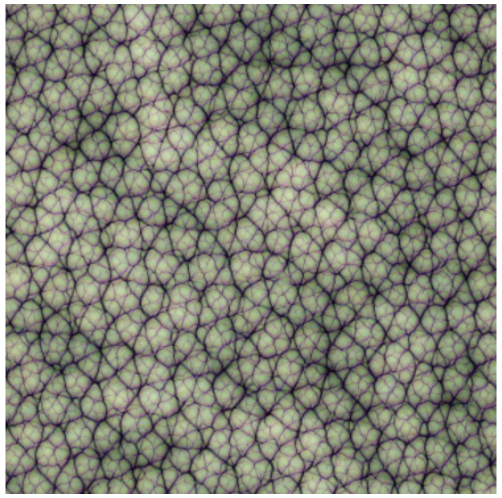
Two Major Themes

- Language has structure
  - There are patterns in what we say; this can be exploited this for more efficient learning and inference
- Language processing involves ambiguity resolution
  - There is ambiguity in what we say; this has to be resolved, e.g. by probabilistic models

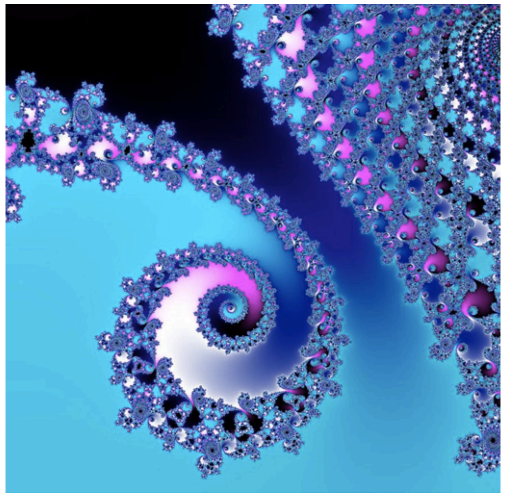
What is structure?



No apparent structure



Some structure



Some structure

Structure = there is some pattern, not just randomness

What is structure?

sdfpfkgpowkpork
opvsdkofaewpewmd
fdfadffpkbwkr

No apparent structure

abc abc abc
efg efg efg
xyz xyz xyz

Some structure

How do you describe this image?

There are infinite set of sentences:

a cute dog
a very cute dog
super cute puppy
adorable puppy looking at me
....

But not all are likely:
dog cute a
dog cut a very
puppy cute super
me at puppy looking adorable at
....

Language is full of ambiguity

- “I made her duck”

From: Jurafsky and Martin, Speech and Language Processing, 2nd ed.

To resolve ambiguity, we'll be exploring different probabilistic models

- Counting statistics
    - e.g. how many times "duck" means

- Linear (or log-linear) models
    - e.g. extract features: "I", "made", "her", "duck" and combine with weights
- Neural network models
    - can be viewed as a logical extension of linear models

Questions? Comments?
Thanks for a good semester!