Natural Language Understanding

Lecture 1: Introduction

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Introduction

- What is Natural Language Understanding?
- Course Content

Why Deep Learning?

- The Success of Deep Models
- Representation Learning
- Unsupervised Models

Course Mechanics

Reading: Goldberg (2015), Manning (2015)

Introduction

What is Natural Language Understanding?

Natural language understanding:

- often refers to full comprehension/semantic processing of language;
- here, natural language understanding is used to contrast with natural language generation.

Understanding:

Text $\Longrightarrow$ Analyses (parse trees, logical forms, discourse segmentation, etc.)

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Understanding:

Text $\Longrightarrow$ Analyses (parse trees, logical forms, discourse segmentation, etc.)

Generation:

Non-linguistic input (logical forms, database entries, etc.) or text $\Longrightarrow$ Text

Course Content

NLU covers advanced NLP methods, with a focus on *learning representations,* at all levels: words, syntax, semantics, discourse.

We will focus on *probabilistic models* that use *deep learning methods* covering:

- word embeddings;
- feed-forward neural networks;
- recurrent neural networks;
- (maybe) convolutional neural networks.

We will also touch on discriminative and unsupervised learning.

Course Content

Deep architectures and algorithms will be applied to NLP tasks:

- language modeling
- part-of-speech tagging
- syntactic parsing
- semantic parsing
- (probably) sentiment analysis
- (probably) discourse coherence
- (possibly) other things

The assignments will involve practical work with deep models.

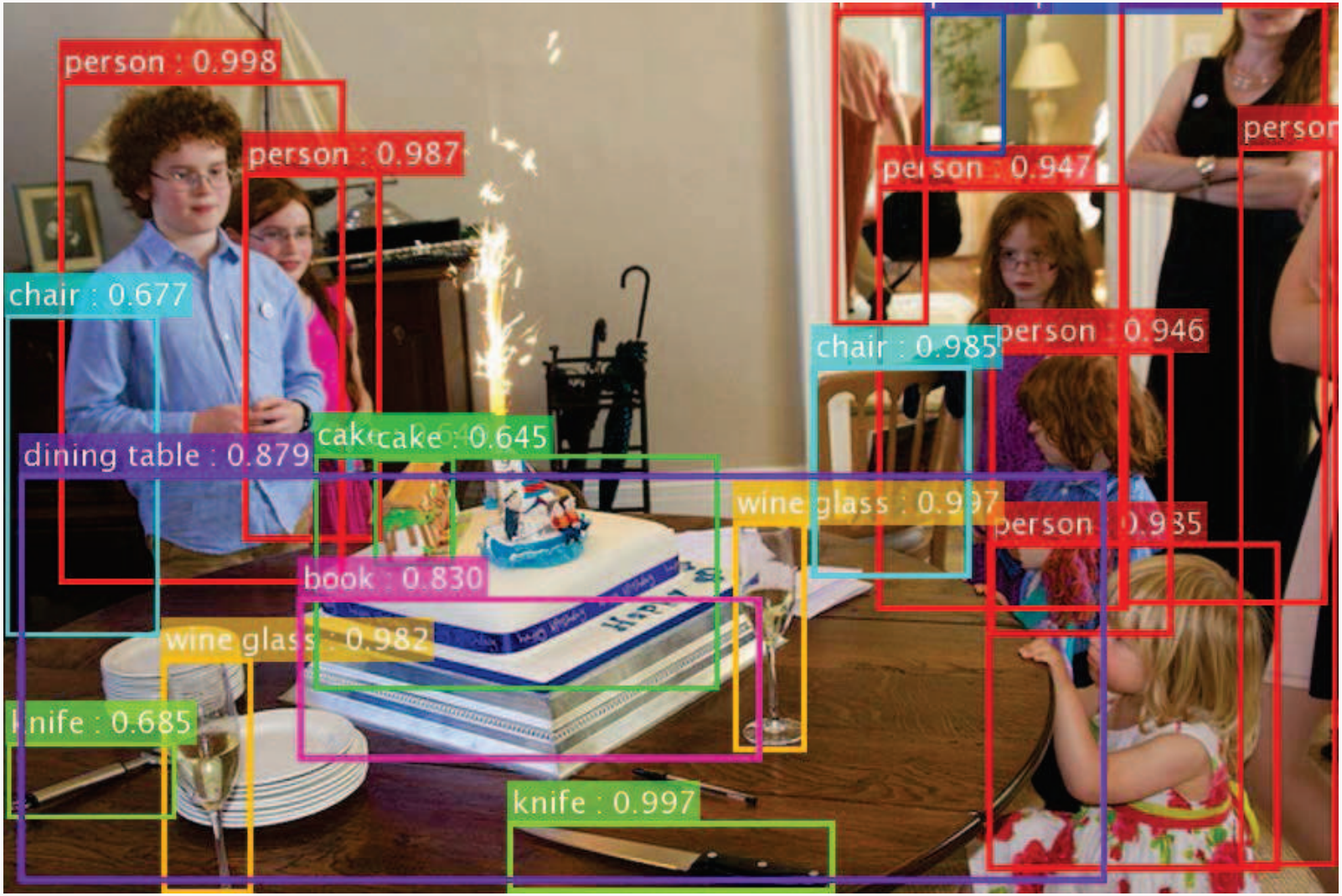
Why Deep Learning?

The Success of Deep Models: Speech Recognition

Deep belief networks (DBNs) achieve a 33% reduction in word error rate (WER) over an HMM with Gaussian mixture model (GMM) (**?**):

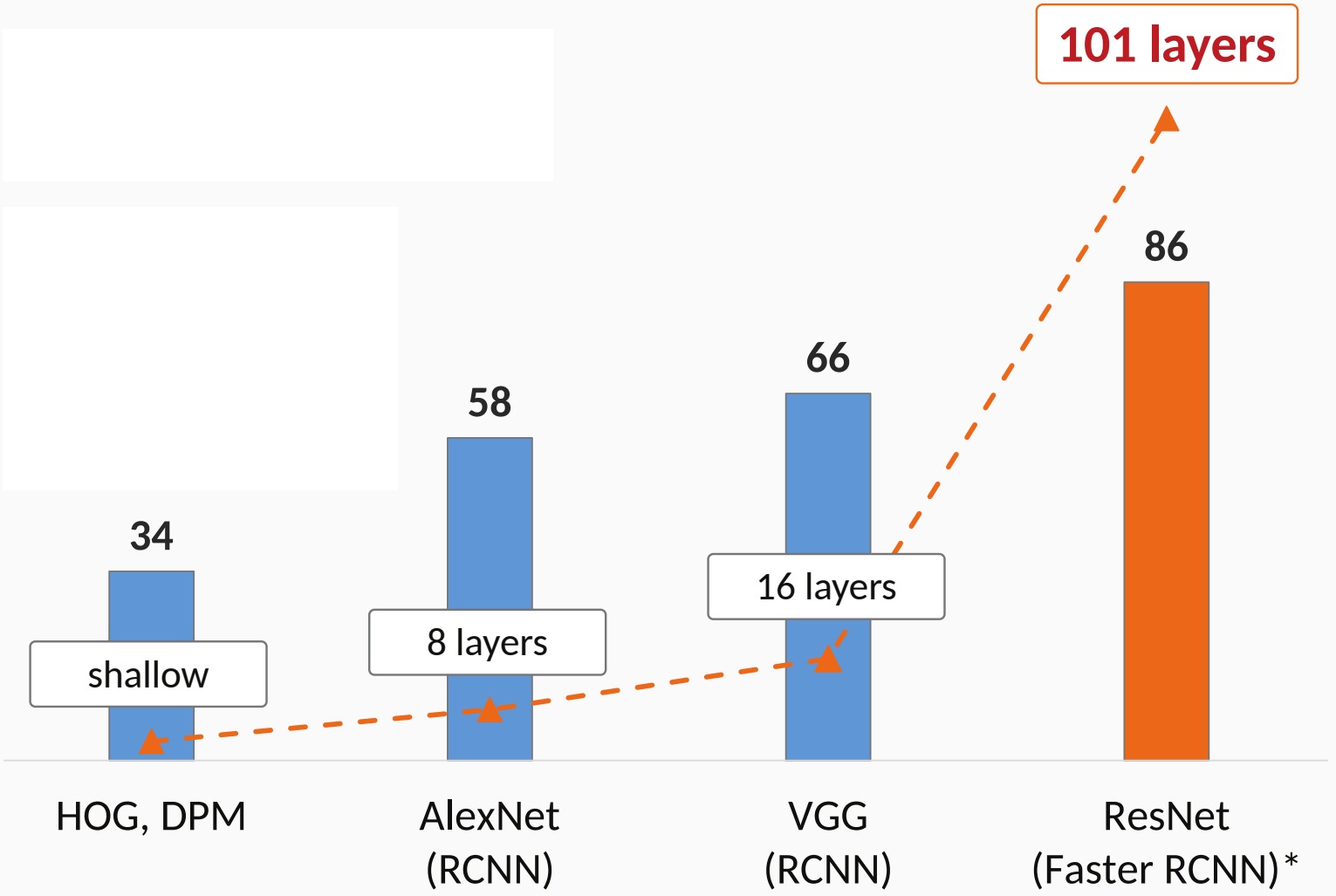
		WER	
MODELING TECHNIQUE	**#PARAMS [10^6]**	**HUB5'00-SWB**	**RT03S-FSH**
GMM, 40 MIX DT 309H SI	29.4	23.6	27.4
NN 1 HIDDEN-LAYER $\times$ 4,634 UNITS	43.6	26.0	29.4
+ 2 $\times$ 5 NEIGHBORING FRAMES	45.1	22.4	25.7
DBN-DNN 7 HIDDEN LAYERS $\times$ 2,048 UNITS	45.1	17.1	19.6
+ UPDATED STATE ALIGNMENT	45.1	16.4	18.6
+ SPARSIFICATION	15.2 NZ	16.1	18.5
GMM 72 MIX DT 2000H SA	102.4	17.1	18.6

The Success of Deep Models: Object Detection



Source: Kaiming He: Deep Residual Learning: MSRA @ ILSVRC & COCO 2015 competitions. Slides.

The Success of Deep Models: Object Detection



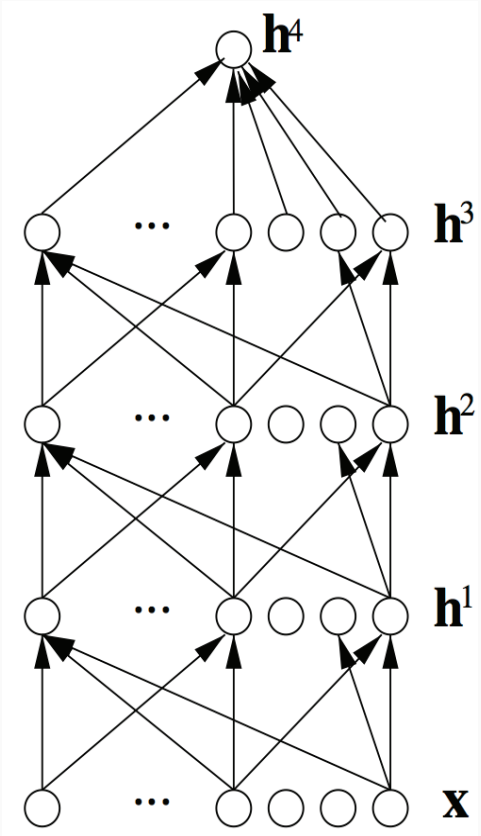
PASCAL VOC 2007 **Object Detection** mAP (%)

Source: Kaiming He: Deep Residual Learning: MSRA @ ILSVRC & COCO 2015 competitions. Slides.

Representation Learning

Why do deep models work so well (for speech and vision at least)?

Because they are good at *representation learning:*



Source: Richard Socher: Introduction to CS224d. Slides.

Neural nets learn multiple representations $\mathbf{h}^n$ from an input $\mathbf{x}$.

Representation Learning vs. Feature Engineering

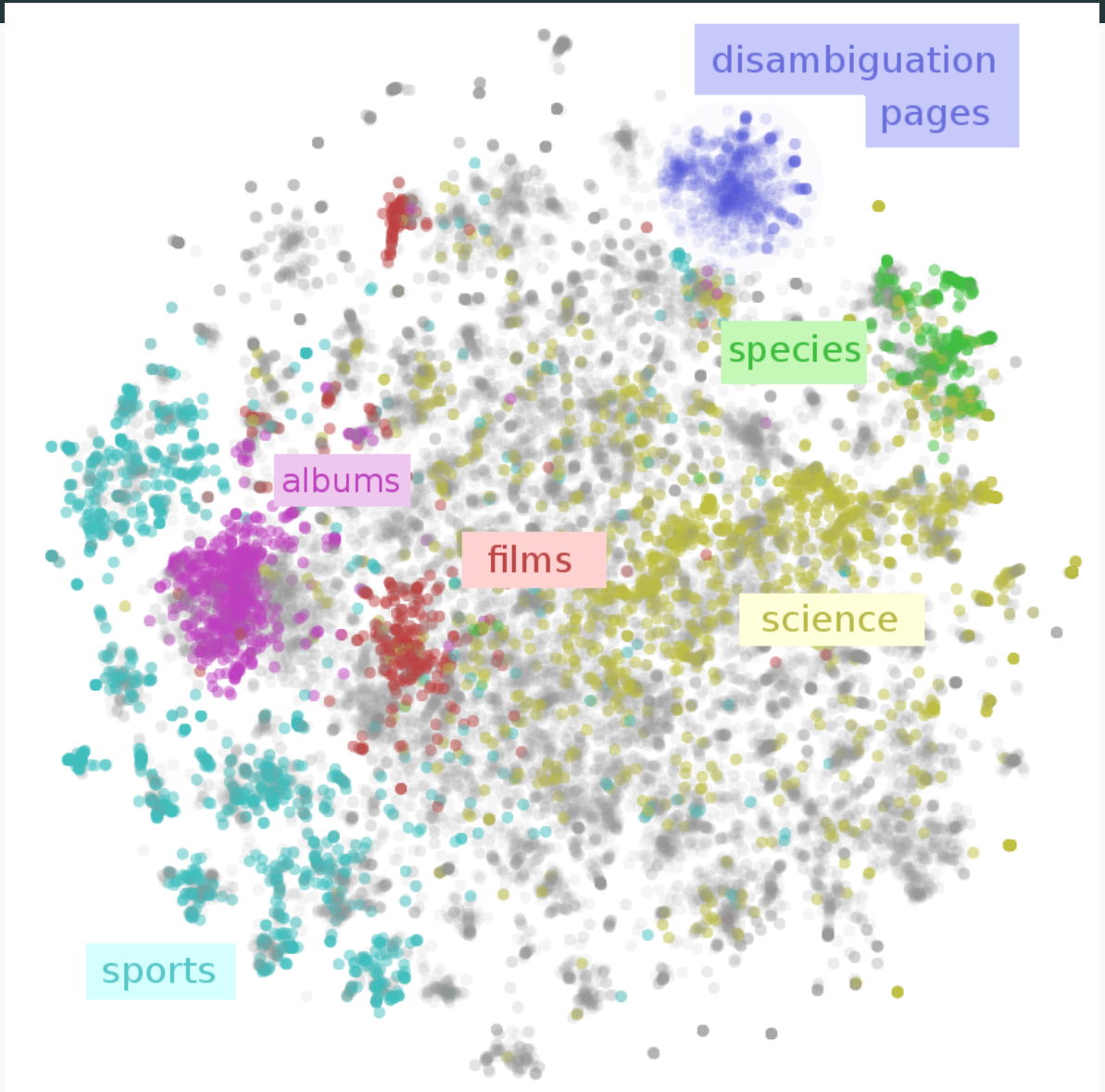
What's the appeal of representation learning?

- manually designed features are over-specified, incomplete and take a long time to design and validate;
- learned representations are easy to adapt, fast to obtain;
- deep learning provides a very flexible, trainable framework for representing world, visual, and linguistic information;
- in probabilistic models, deep learning frees us from having to make independence assumptions.

In short: deep learning solves many things that are difficult about machine learning... rather than NLP, which is still difficult!

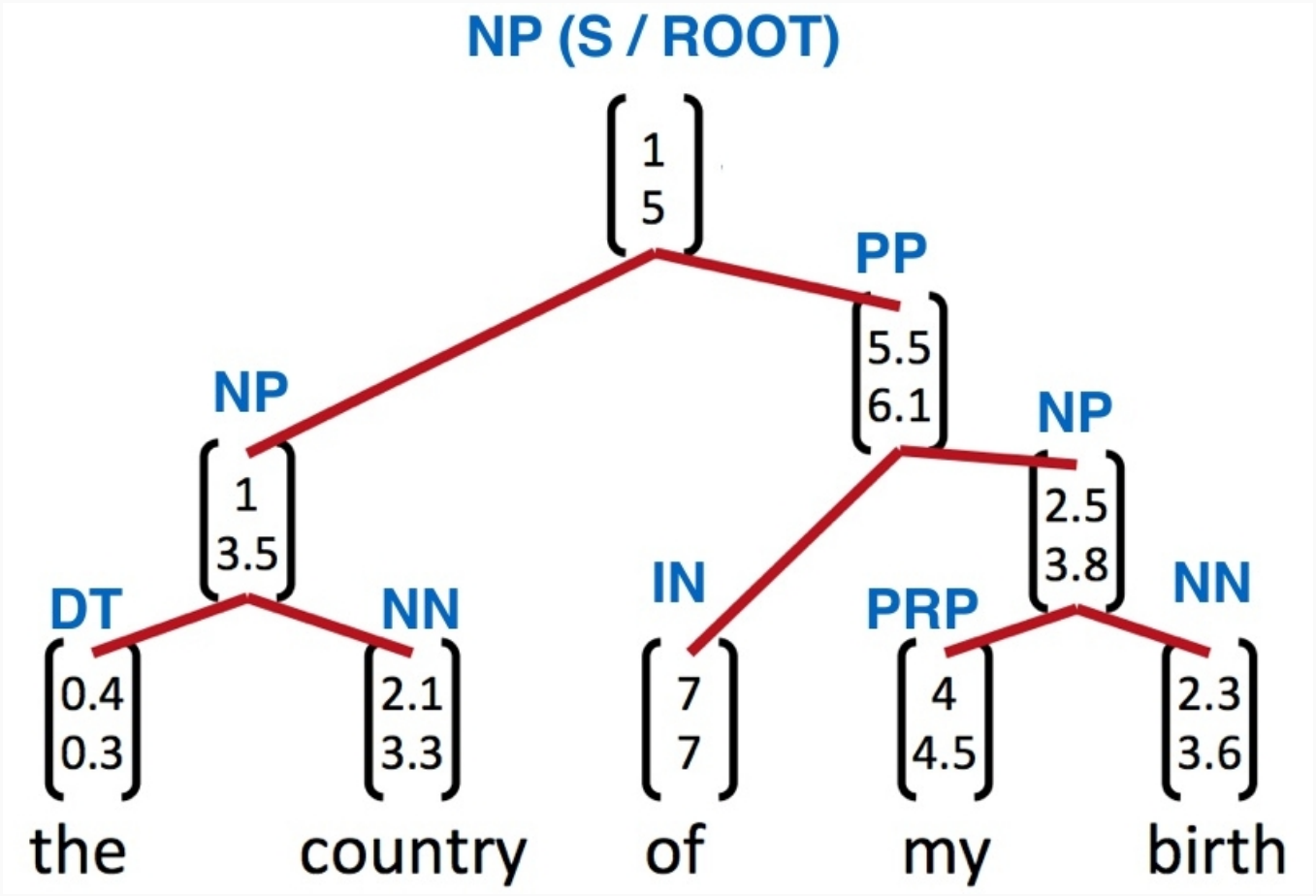
Adapted from Richard Socher: Introduction to CS224d. Slides.

Representation Learning: Words



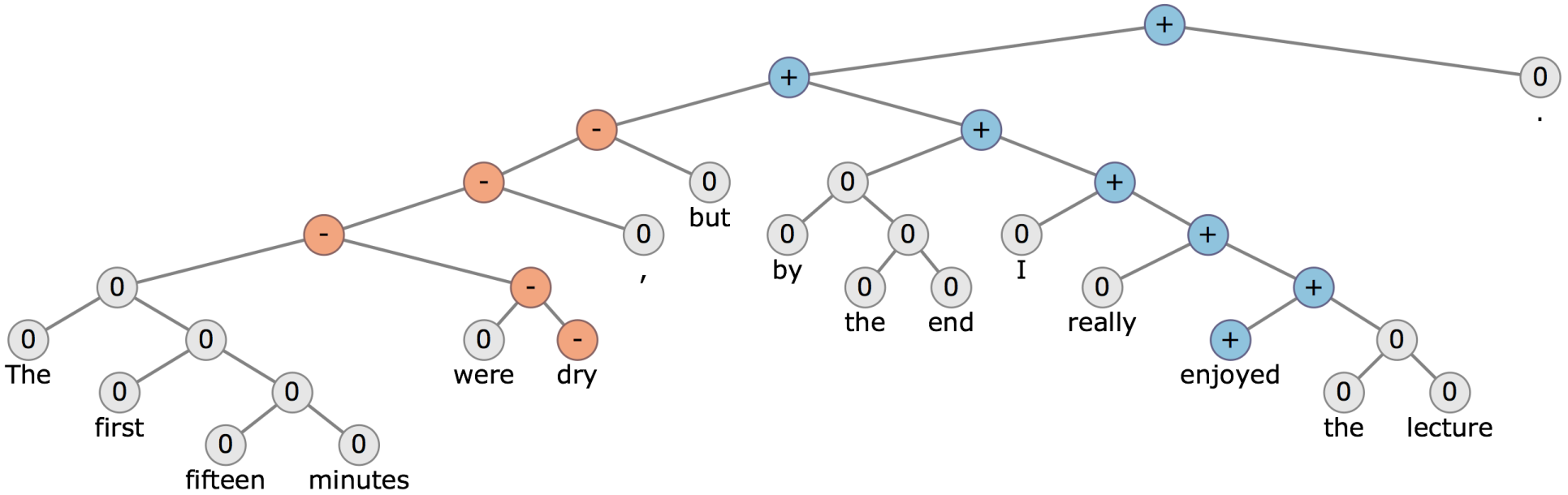
Source: http://colah.github.io/posts/2015-01-Visualizing-Represent

Representation Learning: Syntax



Source: Roelof Pieters: Deep Learning for NLP: An Introduction to Neural Word Embeddings. Slides.

Representation Learning: Sentiment



Source: Richard Socher: Introduction to CS224d. Slides.

Supervised vs. Unsupervised Methods

Standard NLP systems use a supervised paradigm:

Training:

Labeled training data $\Longrightarrow$ Features, representations $\Longrightarrow$ Prediction procedure (trained model)

Supervised vs. Unsupervised Methods

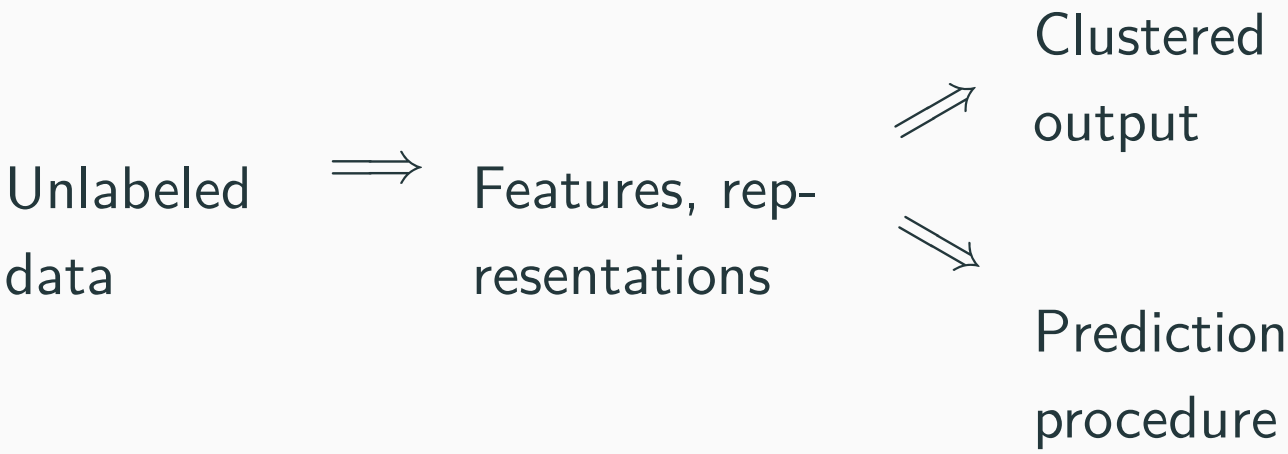
Standard NLP systems use a supervised paradigm:

Testing:

Unlabeled test data $\Longrightarrow$ Features, representations $\Longrightarrow$ Prediction procedure (from training) $\Longrightarrow$ Labeled output

Supervised vs. Unsupervised Methods

NLP has often focused on *unsupervised learning,* i.e., learning without labeled training data:



Deep models can be employed both in a supervised and an unsupervised way. Can also be used for *transfer learning*, where representations learned for one problem are reused in another.

Supervised vs. Unsupervised Methods

Example of unsupervised task we'll cover:

Part of speech induction:

walk	$\Longrightarrow$	walk.VVB
runners		runners.NNS
keyboard		keyboard.NN
desalinated		desalinate.VVD

Course Mechanics

Relationship to other Courses

Natural Language Understanding:

- requires: Accelerated Natural Language Processing OR Informatics 2A and Foundations of Natural Language Processing;
- complements: Machine Translation; Topics in Natural Language Processing.

Machine learning and programming:

- IAML, MLPR, or MLP (can be taken concurrently);
- CPSLP or equivalent programming experience.

A few topics may also be covered in MLP or MT.

Background

Background required for the course:

- You should be familiar with Jurafsky and Martin (2009)
- But this textbook serves as background only. Each lecture will rely on one or two papers as the main reading. The readings are assessible: read them and discuss.
- You will need solid maths: probability theory, linear algebra, some calculus.
- for a maths revision, see Goldwater (2015).

Course Mechanics

- NLU will have 15 lectures, 1 guest lecture, 2 feedforward sessions; no lectures in flexible learning week;
- `http://www.inf.ed.ac.uk/teaching/courses/nlu/`
- see course page for lecture slides, lecture recordings, and materials for assignments;
- course mailing list: `nlu-students@inf.ed.ac.uk`; you need to enroll for the course to be subscribed;
- the course has a Piazza forum; use it to discuss course materials, assignments, etc.;
- assignments will be submitted using TurnItIn (with plagiarism detection) on Learn;
- *You need a DICE account!* If you don't have one, apply for one through the ITO as soon as possible.

Assessment

Assessment will consist of:

- one assessed coursework, worth 30%. Pair work is strongly encouraged.
- a final exam (120 minutes), worth 70%.

Key dates:

- Assignment issued week 3.
- Assigment due March 8 at 3pm (week 7).
- Assignment will include intermediate milestones and a suggested timeline.

Assignment deadline will be preceded by *feedforward sessions* in which you can ask questions about the assignment.

Feedback

Feedback students will receive in this course:

- the course includes short, non-assessed quizzes;
- these consist of multiple choice questions and are marked automatically;
- each assignment is preceded by a feedforward session in which students can ask questions about the assignment;
- the discussion forum is another way to get help with the assignments; it will be monitored once a day by course staff;
- the assignment will be marked within two weeks;
- individual, written comments will be provided by the markers and sample solutions will be released.

How to get help

Ask questions. Asking questions is how you learn.

- In-person office hour (starting week 3). Details TBA.
- *Virtual* office hour (starting week 3). Details TBA.
- piazza forum: course staff will answer questions once a day, Monday through Friday. You can answer questions any time! Your questions can be private, and/ or anonymous to classmates.
- Don't ask me questions over email. I might not see your question for days. And when I do, I will just repost it to piazza.