COMP 472: Artificial Intelligence
Natural Language Processing Introduction

part 5

video 1

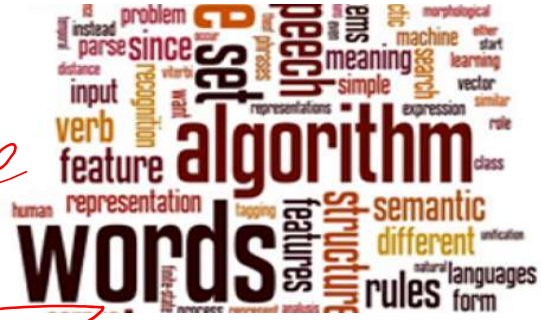
- Russell & Norvig: Sections 23.5, 23.6

Today

1. Introduction
2. Bag of word model
3. n-gram models
4. Deep Learning for NLP
   1. Word Embeddings
   2. Recurrent Neural Networks

NLP vs Speech Processing

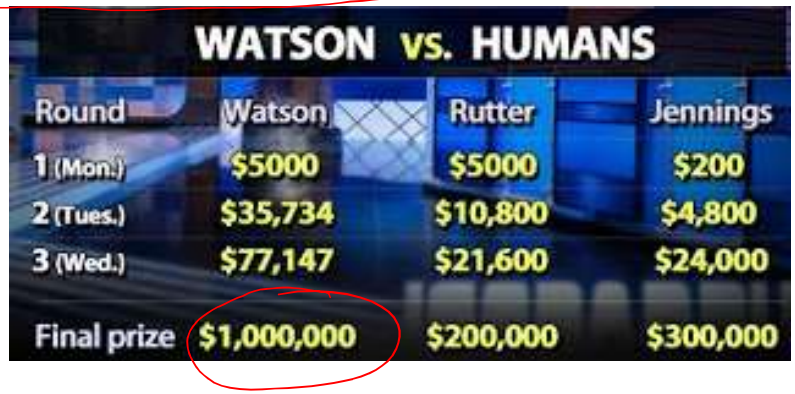
- Natural Language Processing
  = automatic processing of written texts
  处理写出来的东西
  1. Natural Language Understanding
     - Input = text
     理解自然语言并作出回应
  2. Natural Language Generation
     - Output = text
     生成自然羽然



- Speech Processing
  = automatic processing of speech
  1. Speech Recognition
     - Input = acoustic signal
  2. Speech Synthesis
     - Output = acoustic signal

GPS Voice. icanbarelydraw.com

Question Answering: IBM's Watson



WATSON VS. HUMANS

Round	Watson	Rutter	Jennings
1 (Mon.)	$5000	$5000	$200
2 (Tues.)	$35,734	$10,800	$4,800
3 (Wed.)	$77,147	$21,600	$24,000
Final prize	$1,000,000	$200,000	$300,000

- Won Jeopardy on February 16, 2011!

WILLIAM WILKINSON'S
"AN ACCOUNT OF THE PRINCIPALITIES OF WALLACHIA AND MOLDOVIA"
INSPIRED THIS AUTHOR'S
MOST FAMOUS NOVEL

Who is Bram Stoker?
(Dracula)

Information Extraction

Subject: **curriculum meeting**

Date: January 15, 2012 date

To: Dan Jurafsky person

Hi Dan, we've now scheduled the curriculum meeting.

It will be in Gates 159 tomorrow from 10:00-11:30.

location

-Chris

可以提取信息，这里date是15，但是还有个tomorrow，他成功提取到16

Create new Calendar entry

Event: Curriculum mtg

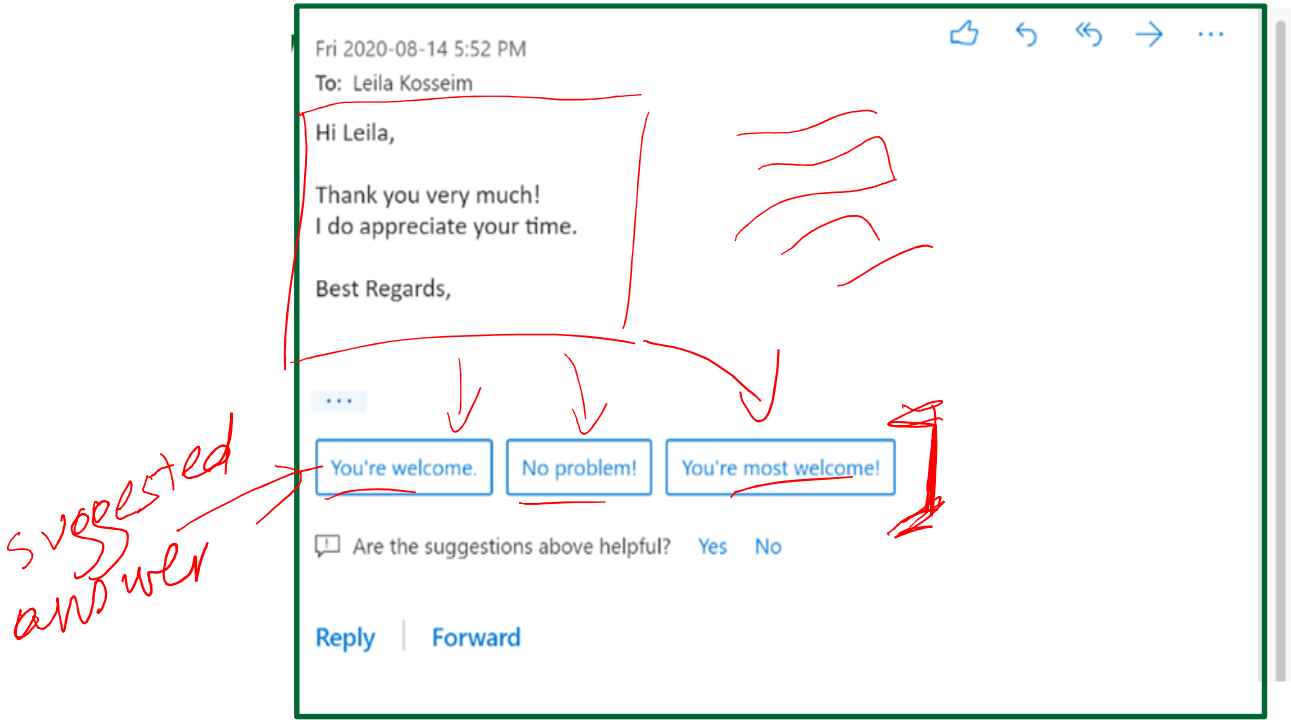
Date: Jan-16-2012

Start: 10:00am

End: 11:30am

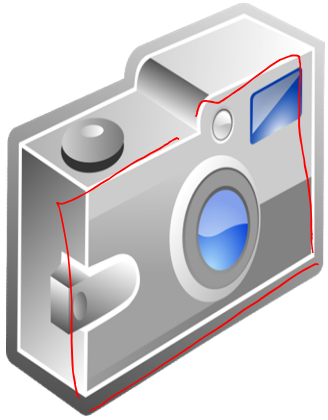
Where: Gates 159

Email Answering



情感分析

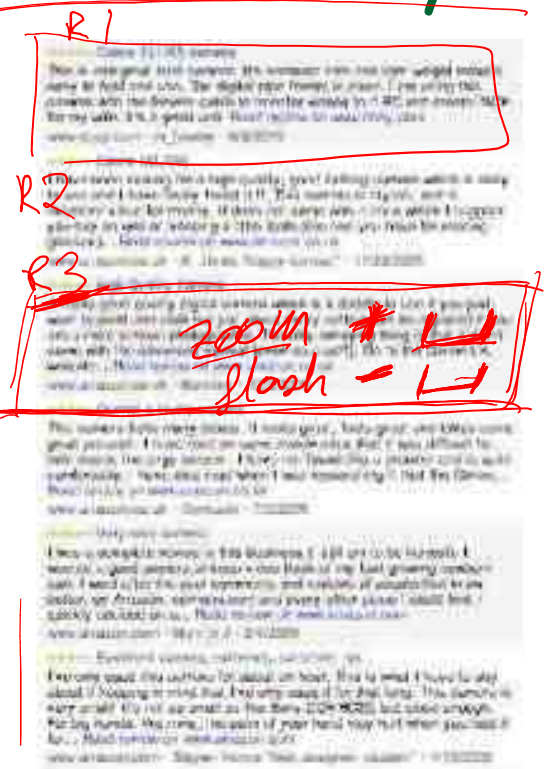
Information Extraction & Sentiment Analysis



Attributes:

- zoom
- affordability
- size and weight
- flash
- ease of use

Reviews



可以分出是posi,negative,natural

posi neutral neg

Size and weight

✓ nice and compact to carry!

✓ since the camera is small and light, I won't need to carry around those heavy, bulky professional cameras either!

✗ the camera feels flimsy, is plastic and very light in weight you have to be very delicate in the handling of this camera

slide from Olga Veksler (U. Western Ontario)

Machine Translation

google翻译从stastical machine translation转换到neural machine translation ,质量提高一大截

Fully automatic

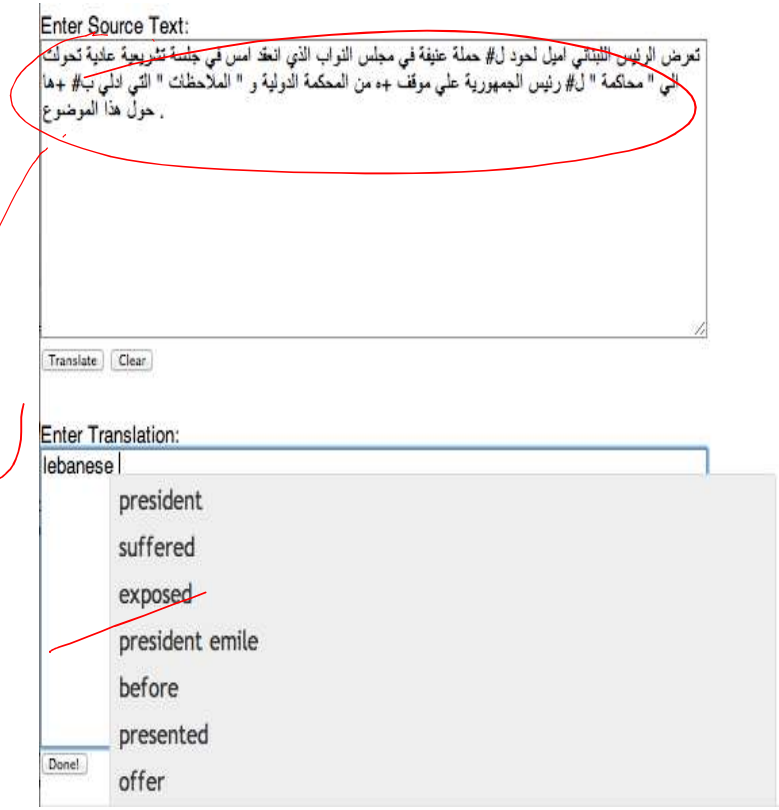
Enter Source Text:

这 不过 是 一 个 时间 的 问题 .

Translation from Stanford's *Phrasal*:

This is only a matter of time.

Helping human translators



slide from Olga Veksler (U. Western Ontario)

Why is NLP hard?

- Languages
  - Artificial eg. Python, C++, Java
    - Smaller vocabulary
    - Simple syntactic structures for (–;–;–) ← if if else
    - Non-ambiguous semantic / meaning
    - Not tolerant to errors (ex. Syntax error) for (–, –, –) ×
  - Natural eg. English, Spanish
    - Large and open vocabulary (new words everyday)
    - Complex syntactic structures
    - Very ambiguous several possible meanings
    - Robust (ex. forgot a comma, a word… still OK)

有限的词汇量，
固定的结构
不含混
不容忍错误

强健的

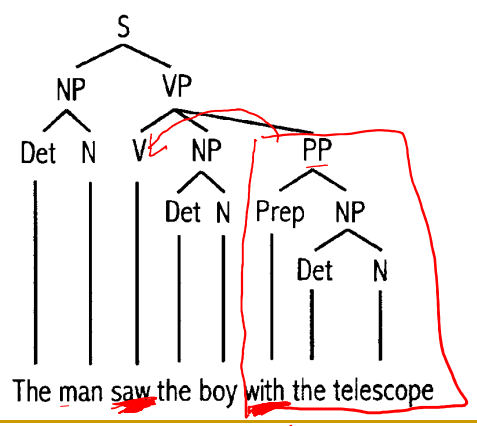
the leg of the chair is broken

Ambiguity

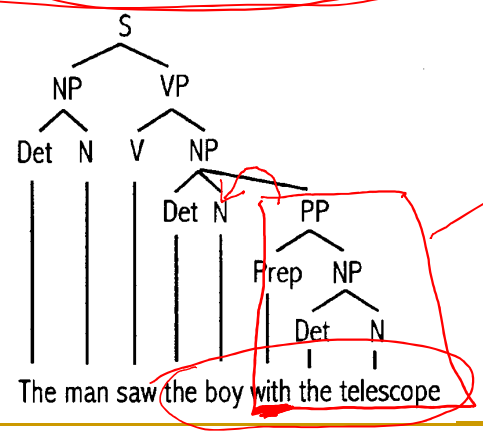
- Even simple sentences can be highly ambiguous at different levels
- sources of ambiguity:
  1. lexical level ≈ individual words ? 单个词语
     - Can I offer you a glass of *airag* ?
  2. syntactic level 顺序符合语言规则
     - *The man saw the boy with the telescope.*

50% 50% 8P NP

meaning #1



parse 1



parse 2

meaning #2

Ambiguity

- sources of ambiguity (con't):
  3. semantic level 语义
     - *Kids Make Nutritious Snacks*
     - *Iraqi Head Seeks Arms*

prepare

can be used as

body part

gun

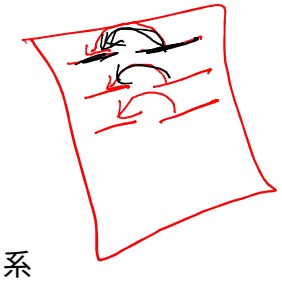
body part

government

  4. world knowledge level 现实知识
     - *Local High School Dropouts Cut in Half* 高中辍学率减少一半

~~多~~ % 多 rate

  5. discourse/rhetorical level 修辞
     - *Alex broke a window. He is grounded.* 接地的



CAUSALITY

He is tall.

He is shy.

前后没关系

Remember these slides?

History of AI

- Another big "hype" … Expert Systems (70s - mid 80s)
  - people realized that general-purpose problem solving (weak methods) do not work for practical applications
  - systems need specific domain-dependent knowledge (strong methods)
  - development of knowledge-intensive, rule-based techniques
  - major expert systems
    - MYCIN (1972): expert system to diagnose blood diseases
  - In the industry (1980s): First expert system shells and commercial applications.

☹ HUMANS need to write the rules by hand…

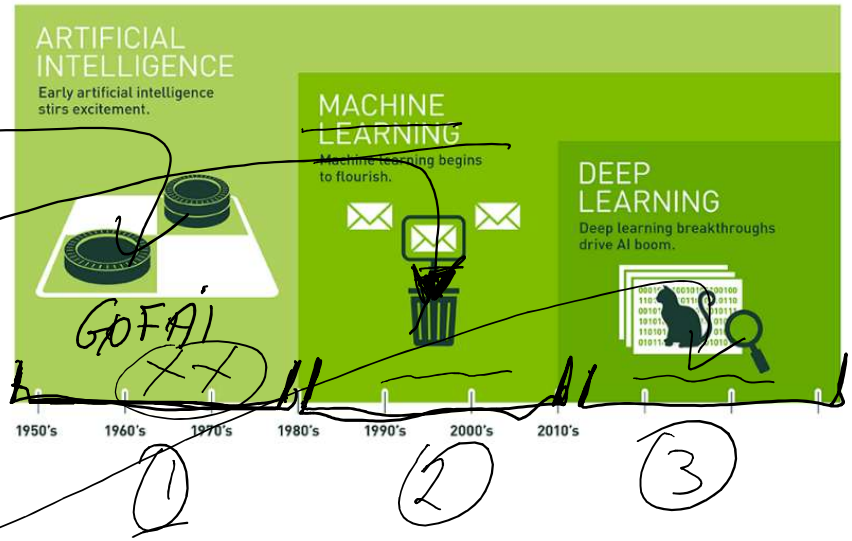
GOFAI

History of AI

- The rise of Machine Learning (1980s – 2010)
  - More powerful CPUs-> usable implementation of neural networks
  - Big data -> Huge data sets are available to learn from
    - document repositories in NLP, datasets in ML, billions on images for image retrieval, billions of genomic sequences, …
  - ☺ Rules are now learned automatically !
  - AI adopts the Scientific Method

History of AI

- The era of Deep Learning (2010-today)
  - Development of "deep neural networks"
  - Trained on massive data sets
  - Use of GPU for computations
  - Use of "generic networks" for many applications

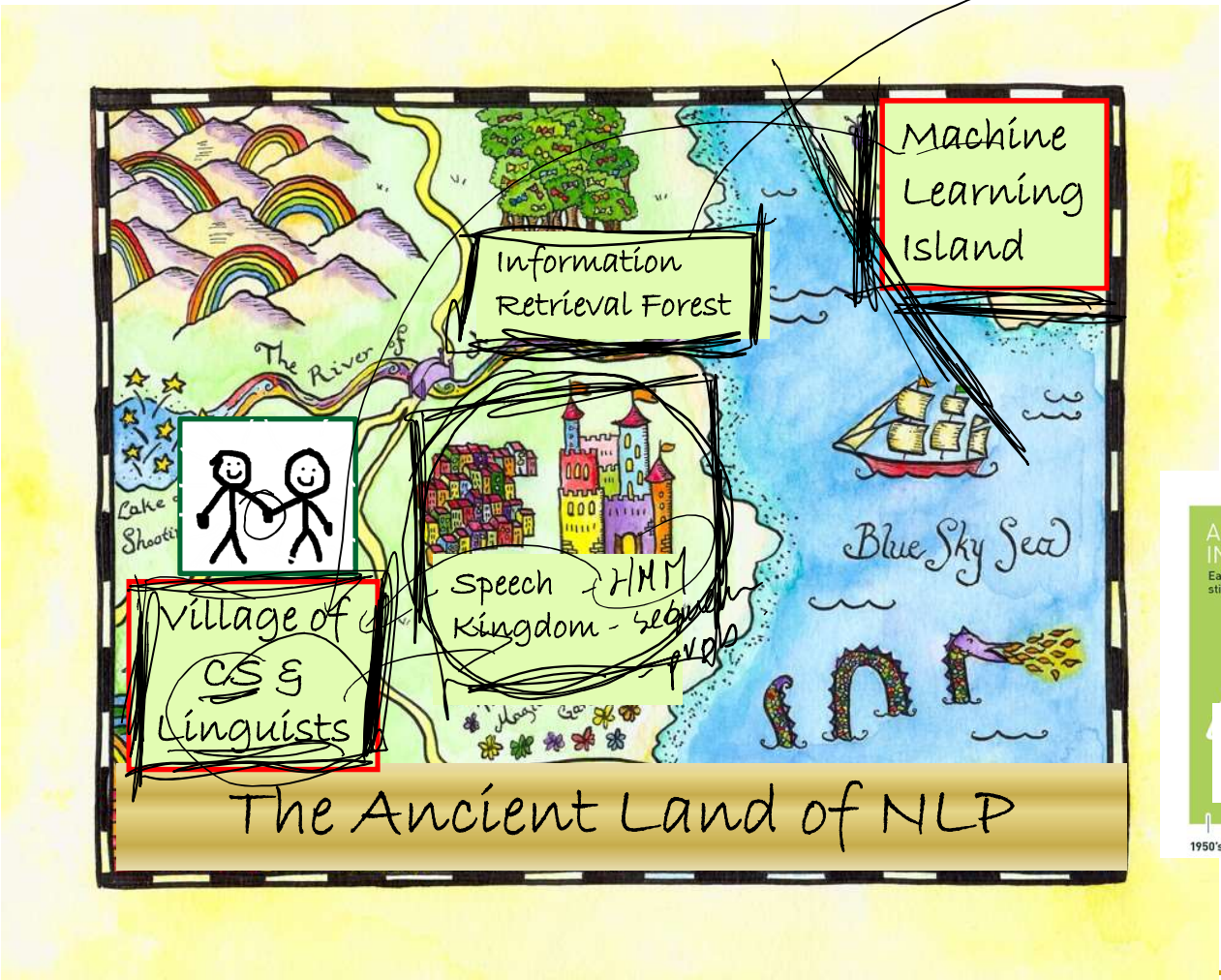


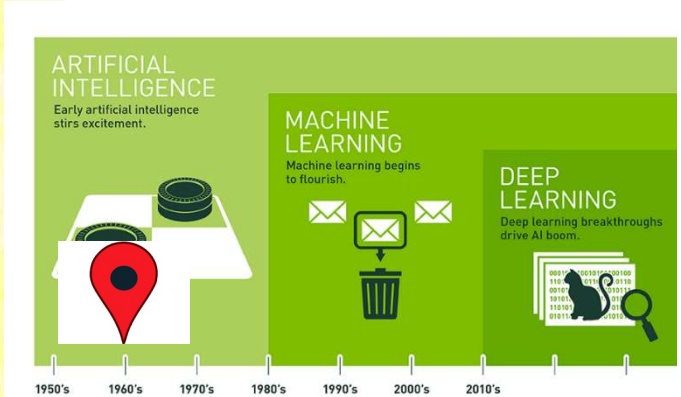
The Ancient Land of NLP (aka GOFAI)

(circa A.D. 1950…mid 1980)

Web search

CS + domain experts
linguists





Rule-based NLP
(circa A.D. 1950...mid 1980)

①

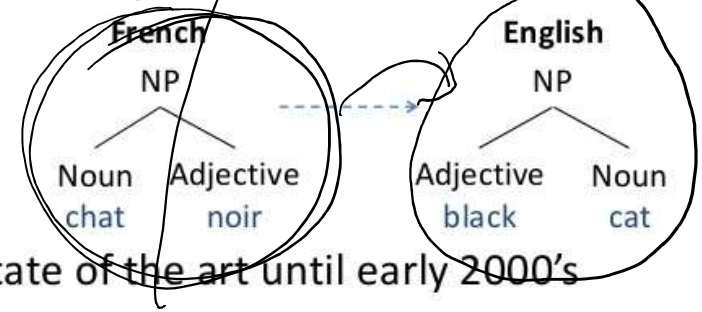
best Machine Translation system based on hand-written rules

Prolog (or Lisp)

```
s      --> np, vp.
vp     --> v, np.
vp     --> v.
np     --> n.
n      --> [john].     n      --> [lisa].
n      --> [house].
v      --> [died].     v      --> [kissed].

?- s([john, kissed, lisa], []).
   yes
?- s([lisa, died], []).
   yes
?- s([kissed, john, lisa], []).
   no
```

- Rules hand-written by linguists

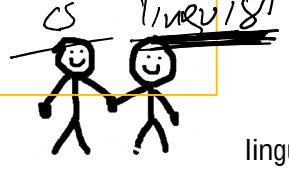


- State of the art until early 2000's
  - e.g. Systran
- Expensive to create maintain and adapt

需要knowloedge expert的协助

Symbolic methods / Linguistic approach / Knowledge-rich approach

- Cognitive approach
- Rules are developed by hand in collaboration with linguists

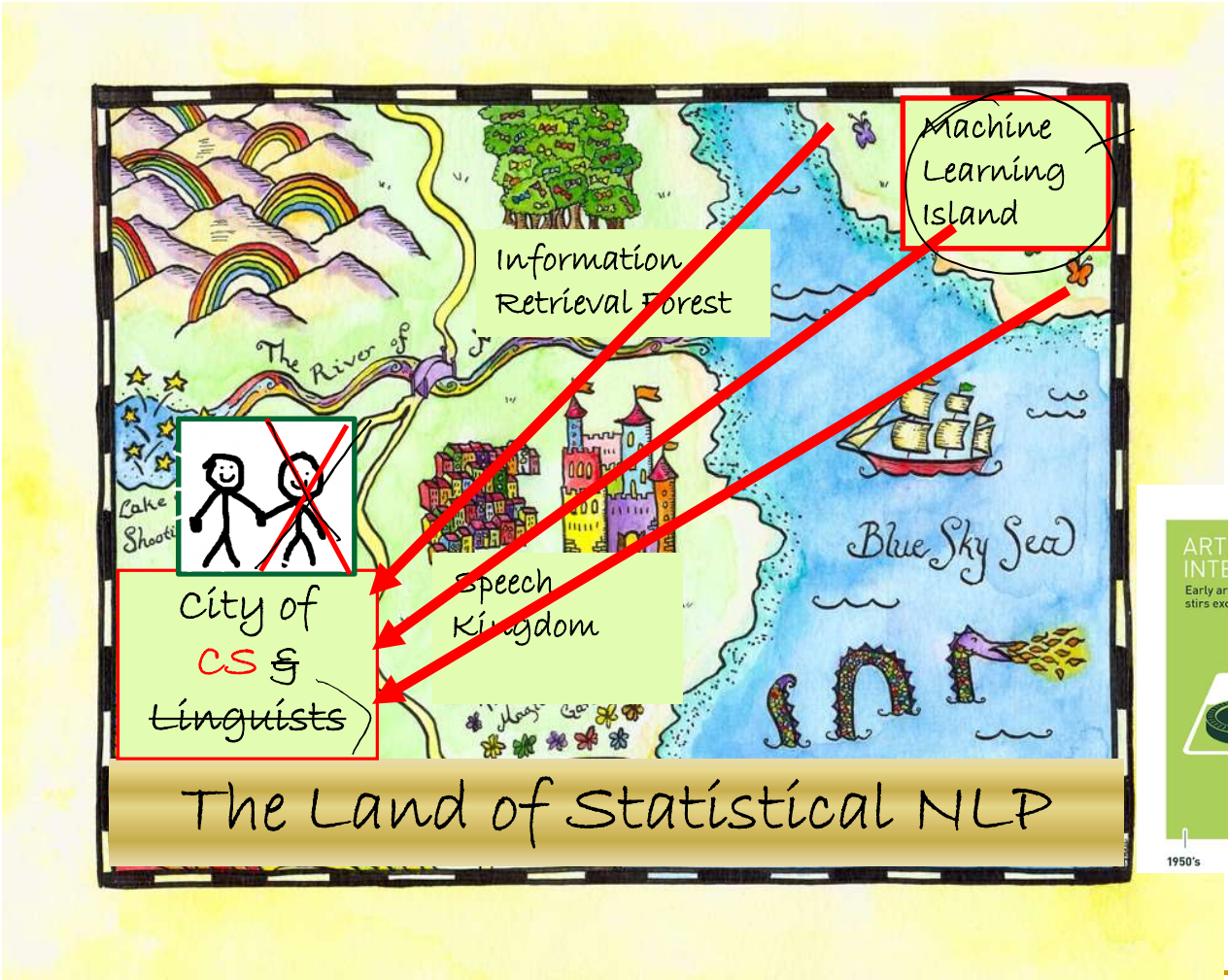


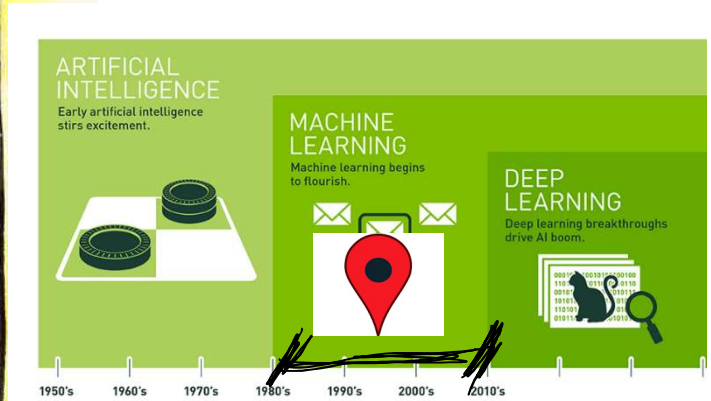
不是sustainable可持续性发展的

linguistic写出条件，翻译成计算机语言

https://image.slidesharecdn.com/maryamsaihbani-161004094341/95/lefttoright-hierarchical-phrasebased-translation-and-its-application-in-simultaneous-speech-translation-maryam-siahbani-4-638.jpg?cb=1477004310

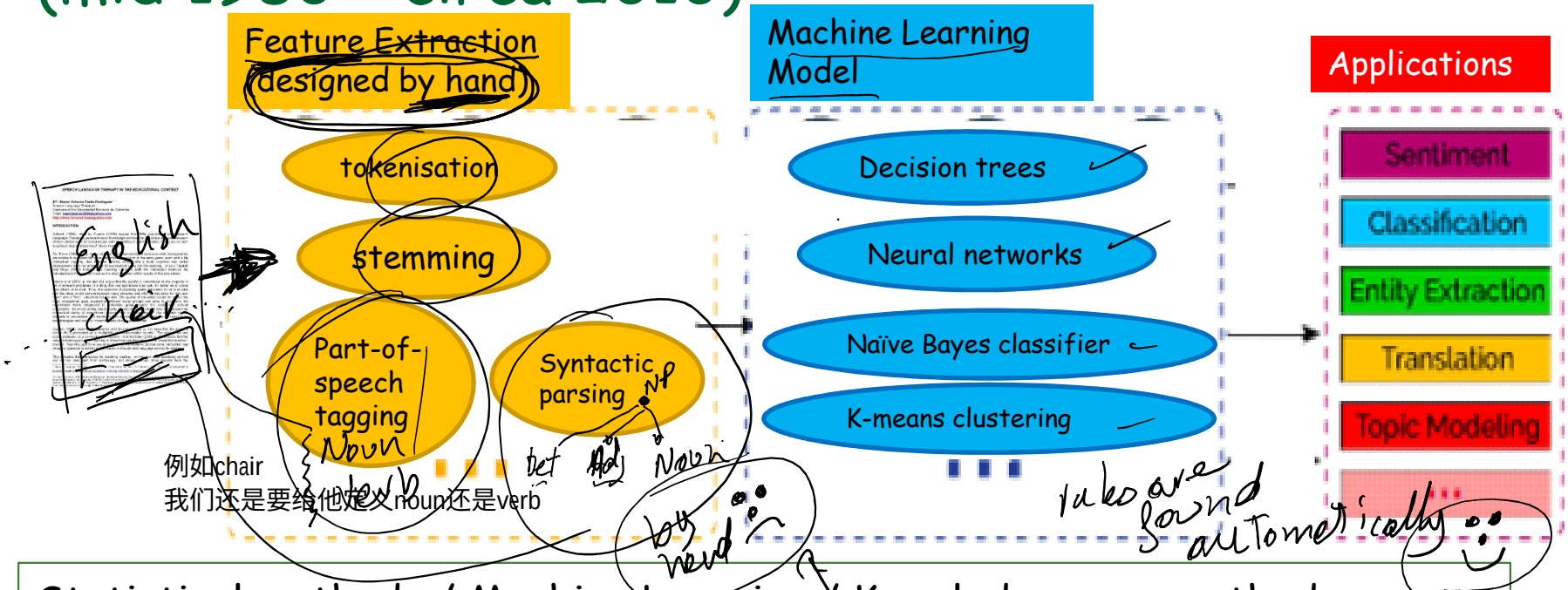
1st Invasion of NLP, from ML
(mid 1980 - circa 2010)





Statistical NLP
(mid 1980 – circa 2010)

multinomial NB classifier for spam filtering.



Statistical methods / Machine Learning / Knowledge-poor method

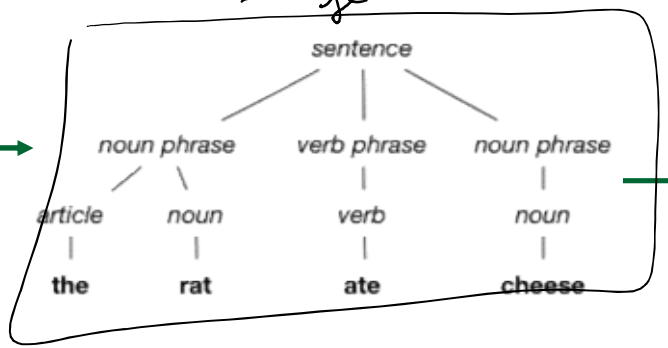
- Engineering Approach
- Rules are developed automatically (using machine learning)
- But the linguistic features are hand-engineered and fed to the ML model
- Applications: Information Retrieval, Predictive Text / Word Completion, Language Identification, Text Classification, Authorship Attribution...

Statistical NLP (mid 1980 - circa 2010)

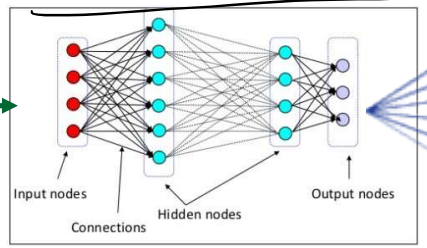
(2)

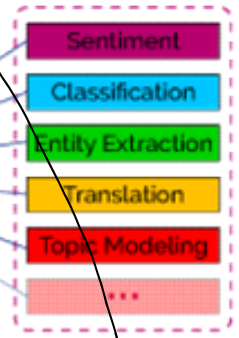
Google translate based on statistical Machine Translation

linguistic features



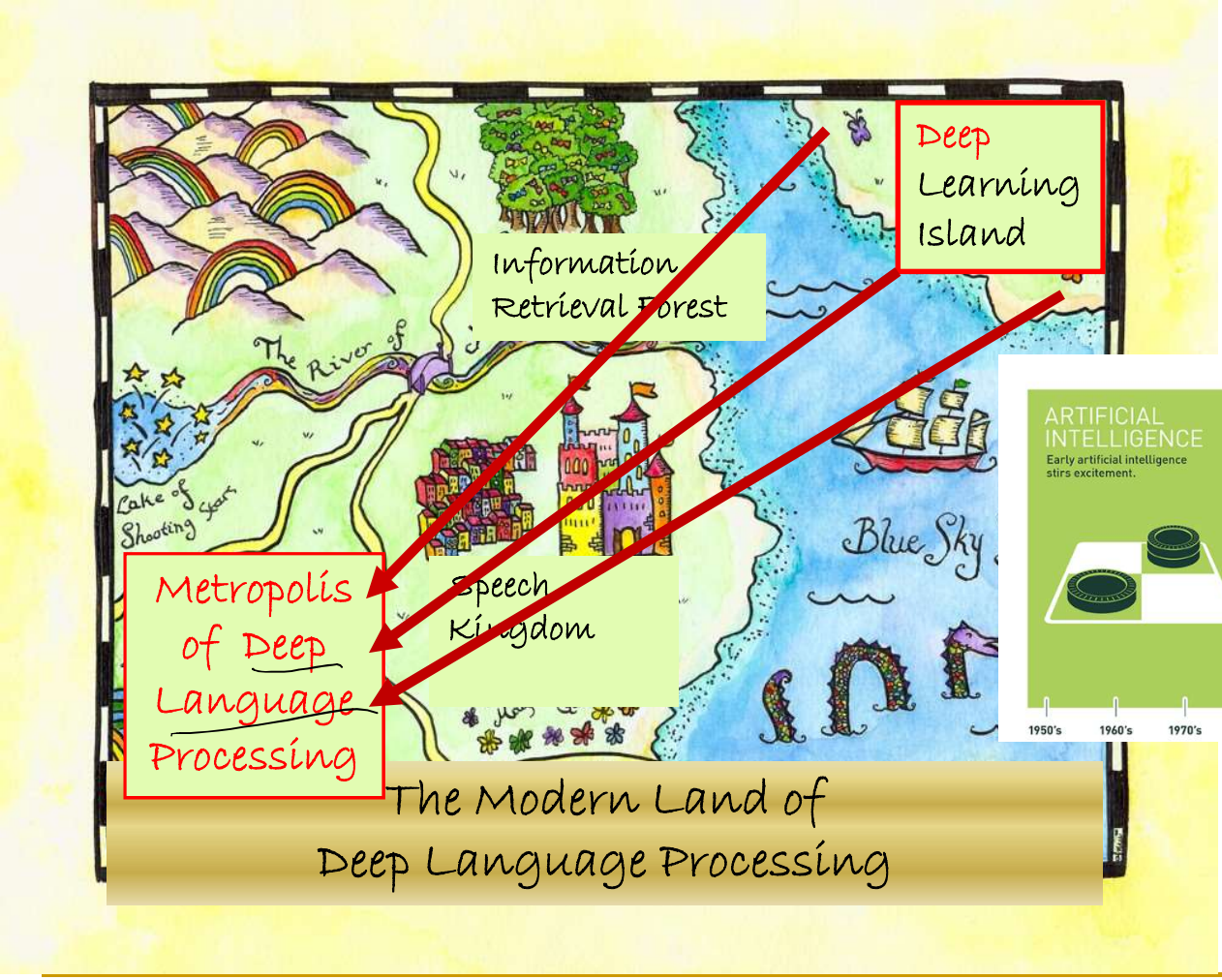
other ML model

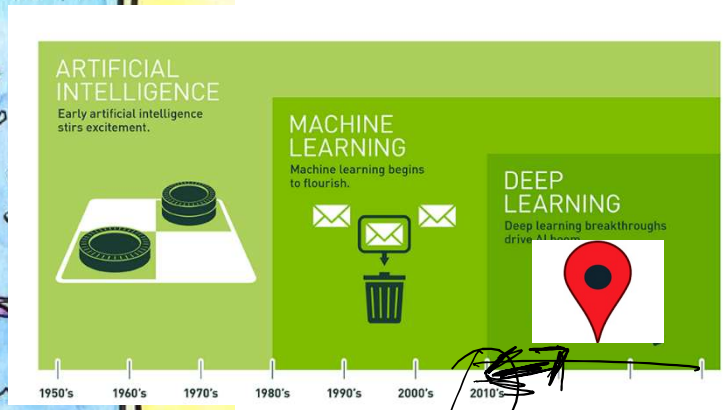




linguistic features are hand-engineered and fed to the ML model

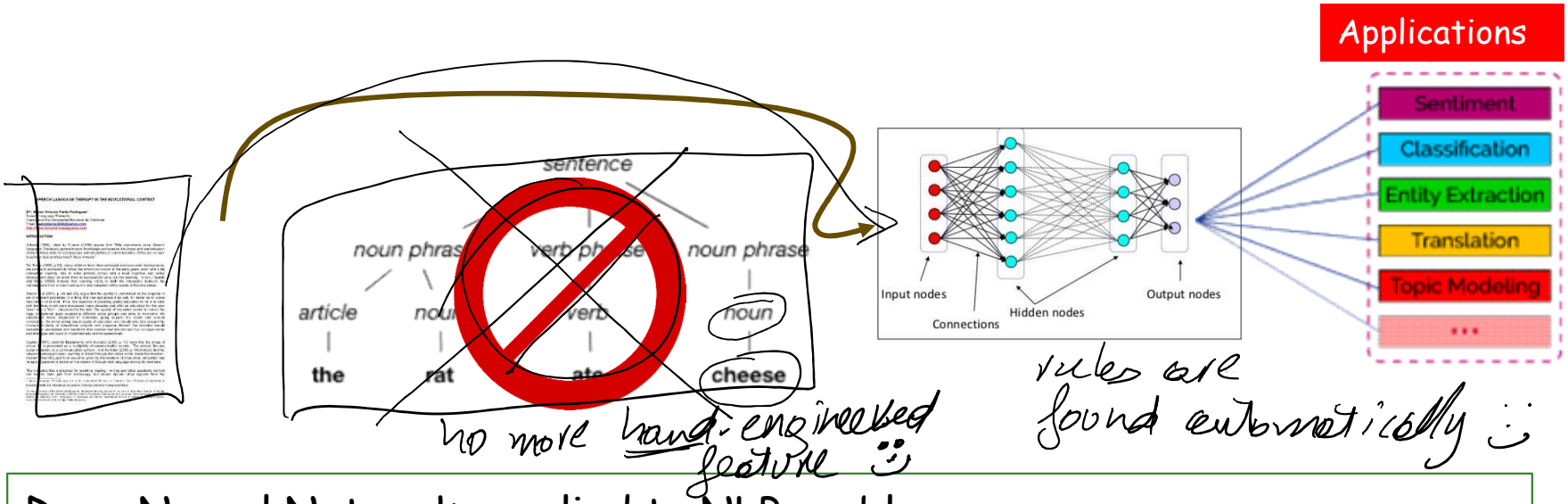
2nd Invasion of NLP, by Deep Learning (circa 2010-today)





2015

Deep Language Processing (circa 2010-today)



Deep Neural Networks applied to NLP problems

- Rules are developed automatically (using machine learning)
- And the linguistic features are found automatically!

Today

1. Introduction ✓
2. Bag of word model
3. n-gram models
4. Deep Learning for NLP
   1. Word Embeddings
   2. Recurrent Neural Networks

Up Next

1. Introduction
2. Bag of word model 2
3. n-gram models 2
4. Deep Learning for NLP 3
   1. Word Embeddings
   2. Recurrent Neural Networks