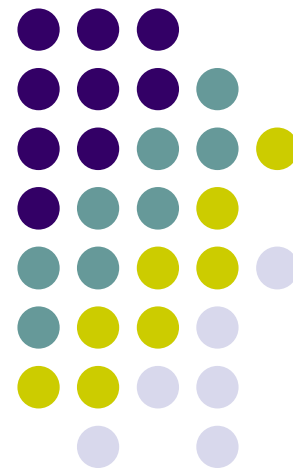


Natural Language Processing

Lê Thanh Hương
School of Information and Communication Technology
Email: huonglt@soict.hust.edu.vn



Course Goals



- Learn the basic principles and theoretical approaches underlying natural language processing
- Learn techniques and tools which can be used to develop practical, robust systems that can (partly) understand text or communicate with users in one or more languages
- Gain insight into many of the open research problems in natural language

References

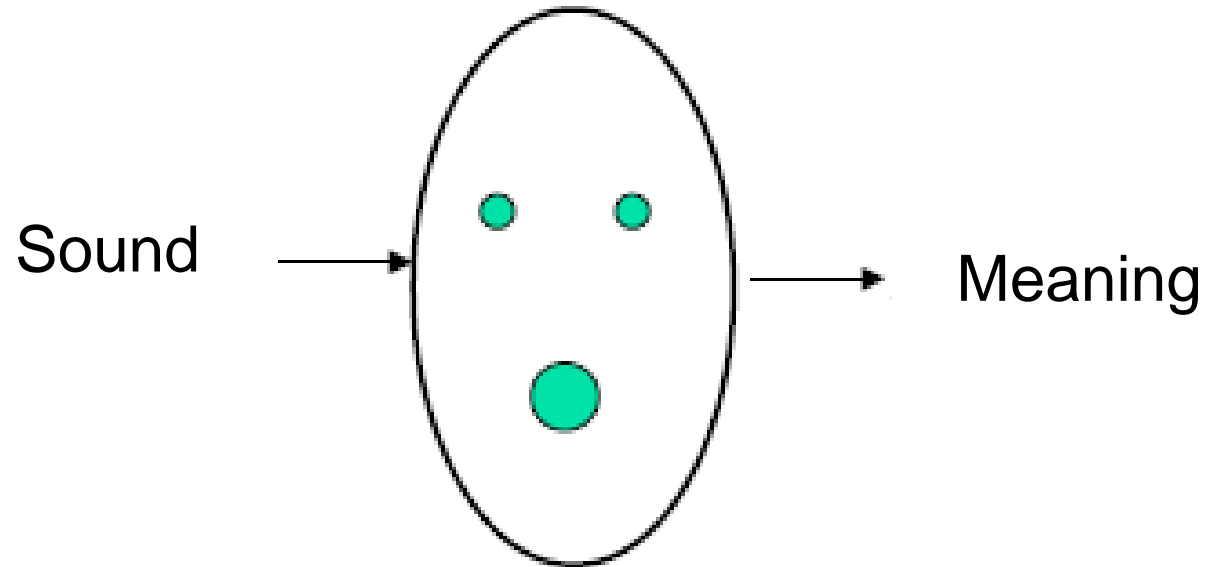
- Christopher Manning and Hinrich Schütze. 1999. *Foundations of Statistical Natural Language Processing*. The MIT Press.
- Dan Jurafsky and James Martin. 2000. *Speech and Language Processing*. PrenticeHall.
- James Allen. 1994. *Natural Language Understanding*. The Benjamins/Cummings Publishing Company Inc.

General information



- **Evaluate**
 - Midterm: 30%
 - Continuous assessments: 15%
 - Group project: 15%
 - Final Exam: 70%
 - Group project :
 - Research papers or implement a NLP tool (≤ 4 students)
 - Defend the project in the 15th week of the semester
- **Website:** <https://users.soict.hust.edu.vn/huonglt/UNLP>

What is NLP?



What is NLP?



- Target: understand multi languages
- Not simple as text matching or keyword matching



Applications of NLP




Language Tools

[About G](#)

Search across languages

Type a search phrase in your own language to easily find pages in another language. We'll translate the results for you to read.

Search for:

My language:  English

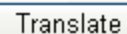
Search pages written in:  Spanish

Tip: Use [advanced s](#)

Search by language and country without translating your search phrase.

Translate text


 French »

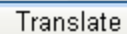


Translate a web page

http://

 French »

 English



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Bulgarian
Chinese (Simplified)
Chinese (Traditional)
Croatian
Czech
Danish
Dutch
English
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Inside the USA » Blog Archive » April Fools - Microsoft Internet ...

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Address <http://insidetheusa.net/2008/04/02/april-fools/> Go Links

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Krankenversicherung USA
Unkomplizierter, hoher Kostenschutz vom US-Spezialisten! Div. Lösungen.

Annonces Google

April Fools

par Jerome ITU ~ 02/04/2008, 09:22 . Classé dans : Humour, Politique US .

La journée de mardi a été riche en poissons de tout genre.

Dans la catégorie écolo, on nous a présenté le tout nouveau [Air Force One](#), un modèle hybride, "15 à 20% plus économique".

Dans la catégorie politique, Hillary fend l'armure et propose, au vu des récentes [performances](#) du sénateur, un défi [au bowling](#) à Obama pour décider du nominé démocrate. Ainsi "les américains sauront que si le téléphone sonne à 3 heures du matin, ils auront un président prêt à jouer au bowling dès le premier jour".

Dans la catégorie sport, c'est Chabal qui a fait les frais de l'humour du jour. Les sites spécialisés ont relayé son [départ dans la NFL](#) américaine, aux New England Patriots, pour un contrat de 15 millions de dollars pour 3 ans. On attend toujours la confirmation de l'homme qui soulève les foules en Nouvelle-Zélande.

Et, enfin, dans la catégorie blog, Superfrenchie a révélé un pan de sa [généalogie](#). Il serait apparenté à un certain... Bill O'Reilly. "My cousin Billy". Là, c'est gros quand même !

Merci pour cette imagination débordante, en tout cas.

De la part d'un internaute bloqué devant son écran toute la journée, la faute à de maudits troubles digestifs...

Internet

Translated version of <http://insidetheusa.net/2008/04/02/april...>

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Ads by Google

April Fools

by Jerome ITU ~ 02/04/2008, 09:22. Filed under: Funny, U.S. policy.

The day Tuesday was rich in fish of all kinds.

In the green category, we introduced the brand new [Air Force One](#), a hybrid "15 to 20% more economical."

In the political category, Hillary fend armor and offers, given the recent [performances](#) of the senator, a challenge [bowling](#) to Obama to decide the Democratic nominee. Thus "the Americans know that if the phone rings at 3 o'clock in the morning, they will have a president ready to play bowling from the first day."

In the sport category is Chabal who has borne the brunt of humour of the day. The specialized sites have relayed his [departure in the NFL](#) American, the New England Patriots, for a contract of 15 million dollars for 3 years. It is still awaiting confirmation from the man who raised the crowds in New Zealand.

And, finally, in the category blog, Superfrenchie revealed a pan of its [genealogy](#). It would be akin to a certain... Bill O'Reilly. "My cousin Billy." There is still big news.

Thank you for your imagination, anyway.

On the part of a visitor blocked in front of his screen all day, the fault of cursed digestive disorders...

Some anecdotes crispy, you who you are delivered to your workplace on Tuesday.

8

Internet

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TH ̣ GI ̣I



Mỹ tiết lộ danh sách quà tặng của Obama

(Dân trí) - Theo Bộ Ngoại giao Mỹ, Tổng thống Obama và gia đình đã nhận hàng trăm ngàn đô la quà tặng từ các nhà lãnh đạo thế giới trong năm 2009, năm đầu tiên ông tại vị.

Xem tiếp

- Mỹ phát hiện balô chứa bom trên đường diễu hành
- Bò chết la liệt tại một trang trại ở Mỹ
- Nhật mua chiến đấu cơ tiềm kích tối tân của Mỹ

TH ̣ THAO



Hàn Quốc, Australia thắng tiến vào tứ kết

(Dân trí) - Hàn Quốc chứng tỏ tham vọng lên ngôi ở Asian Cup năm nay khi đè bẹp Ấn Độ 4-1. Tuy nhiên, Australia mới là đội giành ngôi đầu bảng C sau khi hạ Bahrain 1-0 nhờ hơn hiệu số so với Hàn Quốc (cùng được 7 điểm)...

Xem tiếp

- Denilson chỉ trích Fabregas, nội bộ Arsenal dậy sóng
- Cự lại "vua sân cỏ", sao MU có nguy cơ bị FA phạt nặng
- 11 ngôi sao sáng nhất vòng 23 Premier League

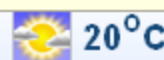
GI ̄O D ̄C - KHUY ̄N HỌC



Khâm phục nghị lực của cô giáo khuyết tật

(Dân trí) - Dù bị khuyết tật, Nguyễn Thị Hải Ly (28 tuổi, trú tại phường Trường An, TP Huế) vẫn vượt qua mặc cảm, học rất giỏi. Tốt nghiệp 2 trường đại học với tấm bằng loại ưu, Ly quyết định mang "ánh sáng tri thức" đến với trung tâm trẻ em khuyết tật Thủy Biều (TP Huế).

Xem tiếp



20°C

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natural language processing



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Các trang từ Việt Nam
Trang nước ngoài được dịch

Mọi lúc

2 tuần qua

Kết quả chuẩn

Trang web có hình ảnh

[Natural language processing - Wikipedia, the free encyclopedia](#) - [[Dịch trang này](#)]

Natural language processing (NLP) is a field of computer science and linguistics concerned with the interactions between computers and human (natural) ...

History - NLP using machine learning - Major tasks in NLP - Statistical NLP

[en.wikipedia.org/.../Natural_language_processing](#) - Đã lưu trong bộ nhớ cache - [Tương tự](#)

[PDF] [NLP - Natural Language Processing INTRODUCTION Natural Language](#) ... - [[Dịch trang này](#)]

Định dạng tệp: PDF/Adobe Acrobat - [Xem Nhanh](#)

Natural Language Processing (NLP) is the computerized approach to ... Definition: **Natural Language Processing** is a theoretically motivated range of ...

[www.cnlp.org/publications/03nlp.lis.encyclopedia.pdf](#) - [Tương tự](#)

[The Stanford NLP \(Natural Language Processing\) Group](#) - [[Dịch trang này](#)]

Stanford **Natural Language Processing** and Computational Linguistics Group.

[nlp.stanford.edu/](#) - Đã lưu trong bộ nhớ cache - [Tương tự](#)

[Course Home - Stanford School of Engineering - Stanford ...](#) - [[Dịch trang này](#)]

This course is designed to introduce students to the fundamental concepts ...

[see.stanford.edu/.../courseinfo.aspx?...](#) - Đã lưu trong bộ nhớ cache - [Tương tự](#)

[+](#) [Hiển thị kết quả khác từ stanford.edu](#)

[Natural Language Processing - Microsoft Research](#) - [[Dịch trang này](#)]

Building a computer system that will analyze, understand, and generate **natural** languages.

[research.microsoft.com/.../nlp/](#) - Đã lưu trong bộ nhớ cache

[Natural Language Processing - AAAI](#) - [[Dịch trang này](#)]

What is **NLP**. From the **Natural Language Processing** Research Group at the University of Sheffield Department of Computer Science. ...

[www.aai.org/aitopics/html/natlang.html](#) - [Tương tự](#)



"công nghệ thông tin"



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Articles

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Case law

Tội Phạm Trong Lĩnh Vực Công Nghệ Thông Tin

PV Lợi - Tội Phạm Trong Lĩnh Vực Công Nghệ Thông Tin, 2008 - lib.hpu.edu.vn

My library

Khái niệm, đặc điểm của tội phạm trong lĩnh vực **công nghệ thông tin**. Tình hình tội phạm và các quy định pháp luật về phòng chống tội phạm. Quan điểm và giải pháp đấu tranh phòng chống tội phạm trong lĩnh vực **công nghệ thông tin** ở nước ta. Công ước của hội

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... Năm xuất bản: 2007. Nhà xuất bản: **Công nghệ thông tin**. Trích dẫn: Thông tin KHKT & Kinh tế Bưu điện. Tóm tắt: UPS (United Parcel Services) là một công ty chuyển phát bưu gửi đường bộ và đường không lớn nhất thế giới. Công ty này được thành lập vào năm 1907. ...

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[CITATION] Wireless power transfer: Principles and engineering explorations

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www.FlipDog.com Fetch your next **job** at FlipDog.com!

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... Re: **JOB OPENING** Philip Herring - 2000/04/28 22:35 ... RE: omf to timeline Martin **Baker** - 2000/04/26 17:33; Re: omf to timeline adam - 2000/04/26 18:11 ...
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Martin Baker, a person

Genomics job

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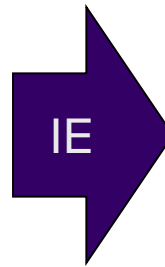
October 14, 2002, 4:00 a.m. PT

For years, [Microsoft Corporation](#) [CEO Bill Gates](#) railed against the economic philosophy of open-source software with Orwellian fervor, denouncing its communal licensing as a "cancer" that stifled technological innovation.

Today, Microsoft claims to "love" the open-source concept, by which software code is made public to encourage improvement and development by outside programmers. Gates himself says Microsoft will gladly disclose its crown jewels--the coveted code behind the Windows operating system--to select customers.

"We can be open source. We love the concept of shared source," said [Bill Veghte](#), a [Microsoft VP](#). "That's a super-important shift for us in terms of code access."

[Richard Stallman](#), [founder](#) of the [Free Software Foundation](#), countered saying...



NAME	TITLE	ORGANIZATION
Bill Gates	CEO	Microsoft
Bill Veghte	VP	Microsoft
Richard Stallman	founder	Free Soft..



Information Extraction & Sentiment Analysis



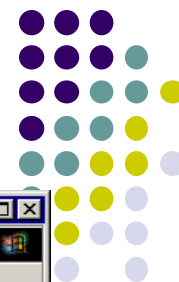
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Size and weight

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4 Killed In Florida Fireworks Blast July 2, 2003 19:10:48

4 Killed In Florida Fireworks Blast July 2, 2003 19:10:48. BONITA SPRINGS, Fla., July 2, 2003 Investigators and firefighters gather at the scene of a tractor-trailer that exploded as workers were unloading fireworks in Bonita Springs, Fla., Wednesday, July 2, 2003. Kevin McKenzie was mowing a strip of grass at Lover's Key about 300 feet from the tractor trailer when the explosion happened at 2:10 p.m., shooting flames and fireworks from the truck.

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- 'Israel pulls out of Bethlehem'**
[5 articles, 4 summaries:](#) 07/01, 11:25 AM

Recent CIDR Clusters (more)

- 'Bush challenge to Iraq attackers: Bring them on'**
[25 articles, 4 summaries:](#) 07/02, 7:40 PM
- 'Bill sparks massive Hong Kong protest'**
[14 articles, 4 summaries:](#) 07/02, 7:40 PM
- 'Edinburgh Evening News - Top Stories - Palestinian police back in Bethlehem'**
[13 articles, 4 summaries:](#) 07/02, 7:40 PM

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- 'Israel pulls out of Bethlehem'**
[5 articles, 4 summaries:](#) 07/01, 11:25 AM
- 'India cool on Pakistan offer'**
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produced on 07/02, 7:40 PM

2% Summary

4 Killed In Florida Fireworks Blast July 2, 2003 19:10:48 (4:1) BONITA SPRINGS, Fla., July 2, 2003 Investigators and firefighters gather at the scene of a tractor-trailer that exploded as workers were unloading fireworks in Bonita Springs, Fla., Wednesday, July 2, 2003. (4:2)

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Birmingham, England, according to police in Vaesteraas, 60 miles northwest of the capital, Stockholm. (7:6) Security officers at Vaesteraas airport found the weapon in a toiletries bag when they scanned the man's hand luggage on Thursday, police spokesman Ulf Palm said. (7:7)

Summaries of all documents: [\[10%\]](#) [\[20%\]](#)

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Included	Index	Title	Source	Publication Date
<input checked="" type="checkbox"/>	1	Hijack suspect 'denies having gun' [Use As Seed] http://news.bbc.co.uk/1/hi/world/europe/2224395.stm	news.bbc.co.uk	08/30, 5:23 PM
<input checked="" type="checkbox"/>	2	Swedish airport security praised [Use As Seed] http://news.bbc.co.uk/1/hi/world/europe/2225741.stm	news.bbc.co.uk	08/30, 12:34 PM
<input checked="" type="checkbox"/>	3	'It can't get more scary than this' [Use As Seed] http://news.bbc.co.uk/1/hi/world/europe/2225342.stm	news.bbc.co.uk	08/30, 11:10 AM
<input checked="" type="checkbox"/>	4	Hijack suspect 'not attending conference' [Use As Seed] http://news.bbc.co.uk/1/hi/england/2225318.stm	news.bbc.co.uk	08/30, 8:54 AM
<input checked="" type="checkbox"/>	5	Terror experts quiz hijack suspect [Use As Seed] http://www.cnn.com/2002/WORLD/europe/08/30/stockholm.gun/index.html	www.cnn.com	08/30, 5:57 AM
<input checked="" type="checkbox"/>	6	Swede charged with plans to hijack plane [Use As Seed] http://www.msnbc.com/news/801304.asp?cp1=1	www.msnbc.com	08/30, 12:00 AM
<input checked="" type="checkbox"/>	7	Swede faces attempt hijack charge [Use As Seed] http://www.msnbc.com/news/801297.asp	www.msnbc.com	08/29, 12:00 AM



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Palestinians Resume Control of Bethlehem
Washington Post - 40 minutes ago
BETHLEHEM, West Bank, July 2 -- Israeli troops pulled out of this biblical West Bank town today and turned over control to Palestinian security forces, who raised flags and patrolled the city's historic Manger Square. The hand-over was the latest step ...
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Pentagon readies plans for peace mission in Liberia
Minneapolis Star Tribune - 1 hour ago
WASHINGTON, DC -- The Pentagon has ordered military planners to prepare detailed options for US troops to join an international peacekeeping force in Liberia, two senior military officials said Wednesday.
[Bush May Send Troops To Liberia](#) WCCO
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Kenyan Women Accuse British Troops of Rape
New York Times - 3 hours ago
LONDON, July 2 -- A group of 650 Kenyan women who say they

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Low-Profile Suburb Braces for Onslaught
Washington Post - 40 minutes ago
CHESAPEAKE, Va., July 2 -- At first a Fairfax County judge's

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Wednesda

in what year did John Lennon die?

Answer: 1980

[[The Beatles Anthology](#) 02/28/2006 [wiki](#)]

ELIZA



- <http://en.wikipedia.org/wiki/ELIZA>
- <http://www.cs.bham.ac.uk/research/projects/cogaff/eliza/>



Talk with Eliza

- E: how are you today?
- H: not so good
- E: why do you say not so good?
- H: i suffer from allergies?
- E: that's interesting
- H: i come out in spots
- E: i'm not sure i know what you're talking about
- H: spots on my face
- E: your face
- H: that's right
- E: is it really that right?

Talk with Eliza



- H: you're a program, aren't you?
- E: does it please you to believe i am a program, am not i?
- H: it sure does
- E: i see
- H: yup
- E: a while back you talk about your face
- H: what about your face?
- E: what is it you really want to know?
- H: are you my kind of girl?
- E: perhaps in your fantasies i am your kind of girl
- H: in my fantasies you are blonde



Talk with Eliza

- E: what makes you think i am blonde?
- H: i don't know
- E: don't you really know?
- H: no
- E: are you saying no just to be negative?
- H: no
- E: you are being a bit negative
- H: no i'm not
- E: how long have you been not?

Current achievements of NLP



Dan Jurafsky

Language Technology



mostly solved

Spam detection

Let's go to Agra!



Buy V1AGRA ...



Part-of-speech (POS) tagging

ADJ ADJ NOUN VERB ADV

Colorless green ideas sleep furiously.

Named entity recognition (NER)

PERSON ORG LOC

Einstein met with UN officials in Princeton

making good progress

Sentiment analysis

Best roast chicken in San Francisco!



The waiter ignored us for 20 minutes.



Coreference resolution

Carter told Mubarak he shouldn't run again.

Word sense disambiguation (WSD)

I need new batteries for my *mouse*.



Parsing

I can see Alcatraz from the window!

Machine translation (MT)

第13届上海国际电影节开幕...



The 13th Shanghai International Film Festival...

Information extraction (IE)

You're invited to our dinner party, Friday May 27 at 8:30



Party
May 27
add

still really hard

Question answering (QA)

Q. How effective is ibuprofen in reducing fever in patients with acute febrile illness?

Paraphrase

XYZ acquired ABC yesterday

ABC has been taken over by XYZ

Summarization

The Dow Jones is up

The S&P500 jumped

Housing prices rose



Economy is good

Dialog

Where is Citizen Kane playing in SF?



Castro Theatre at 7:30. Do you want a ticket?



Some interested applications

- Analyze user intend in ecommerce
- Analyze user opinion
- Event detection
- Single/multi-document summarization
- Information extraction
- Current techniques:
 - Deep learning
 - Word embedding



Levels of Analysis

- Morphology: how words are constructed; prefixes & suffixes
- Syntax: structural relationships between words
- Semantics: meanings of words, phrases, and expressions
- Discourse: relationships across different sentences or thoughts; contextual effects
- Pragmatic: the purpose of a statement; how we use language to communicate
- World Knowledge: facts about the world at large; common sense



Morphology

English: metamorphic, polysyllabic language

- kick, kicks, kicked, kicking
- sit, sits, sat, sitting
- murder, murders

v: nhồi nhét; n: những cái đã ăn, hẻm núi

But it's not just as **rực rỡ** s adding and deleting endings..

- gorge, gorgeous
- arm, army

Cánh tay

Quân đội

Vietnamese: untransforming, monosyllabic language → need word segmentation



Word segmentation

- A sentence can have n possibilities of word segmentation, but only one of them is correct.
- Simple solution: get the longest syllable chain from the current position. The chain is in the dictionary.
- Problem: overlapping
 - Học sinh | học sinh | học.
 - Học sinh | học | sinh học.
- ☞ List all possibilities and propose a method to select the best possibility.



Past of Speech Tagging

The boy threw a ball to the brown dog.

- The/**DT** boy/**NN** threw/**VBD** a/**DT** ball/**NN** to/**IN** the/**DT** brown/**JJ** dog/**NN**./.

DT – determiner

từ chỉ định

NN – noun,

danh từ, số ít hoặc số nhiều

VBD – verb, past tense

động từ, quá khứ

IN – preposition

giới từ

JJ – adjective

tính từ

. – dấu chấm câu



Past of Speech Tagging

Con ngựa đá con ngựa đá.

- Con ngựa/DT đá/ĐgT con ngựa/DT đá/DT.
- Ông/ĐaT già/TT đi/Phó_từ nhanh/TT quá/trạng_từ.
- Ông già/DT đi/ĐgT nhanh/TT quá/trạng_từ.

Syntax: structural ambiguity (part of speech)



Time flies like an arrow.

Time // flies like an arrow.
 VBZ IN (giới từ so sánh)

Time flies // like an arrow.
 NNS VBP

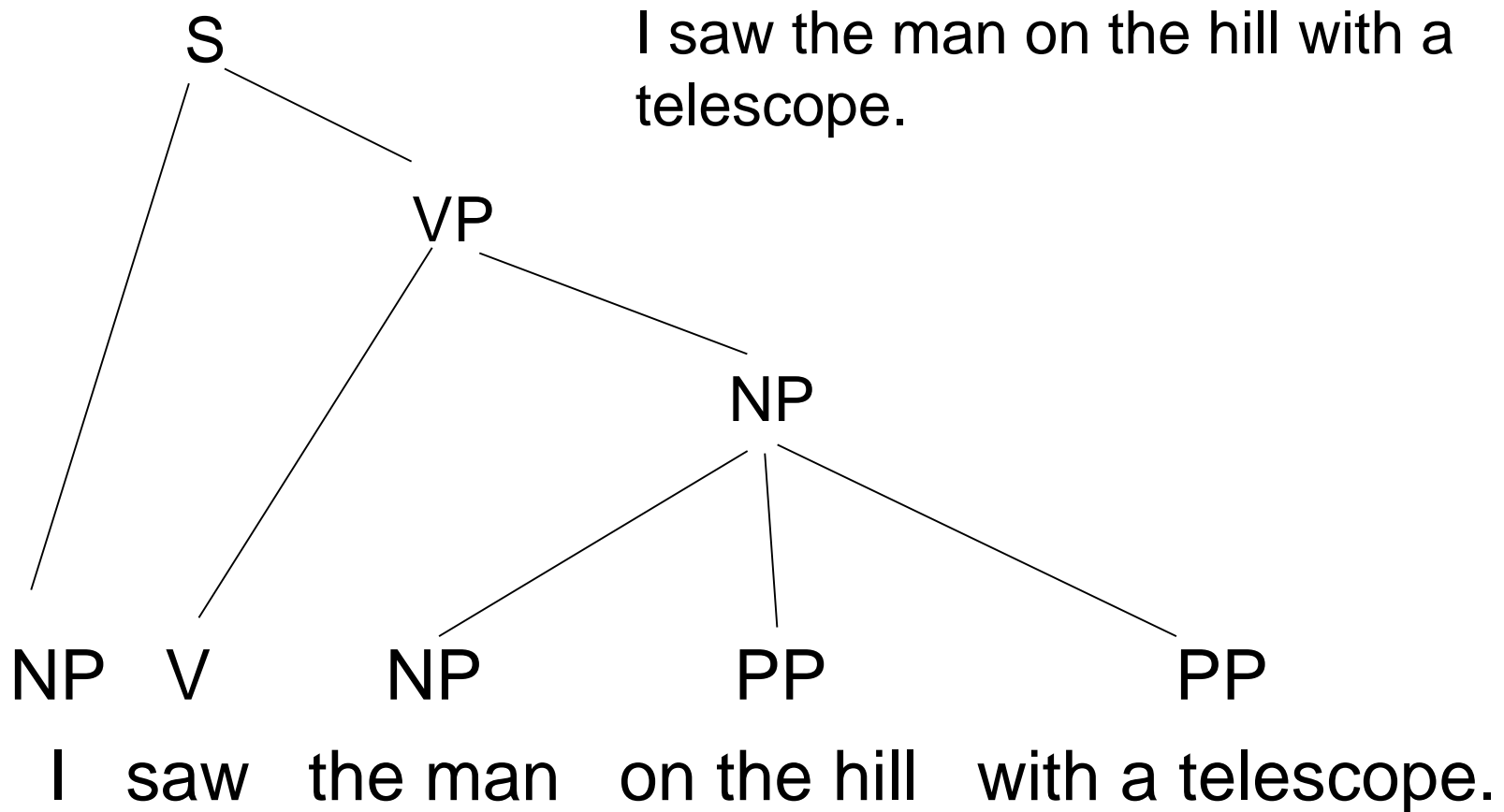
Syntax: structural ambiguity (part of speech)



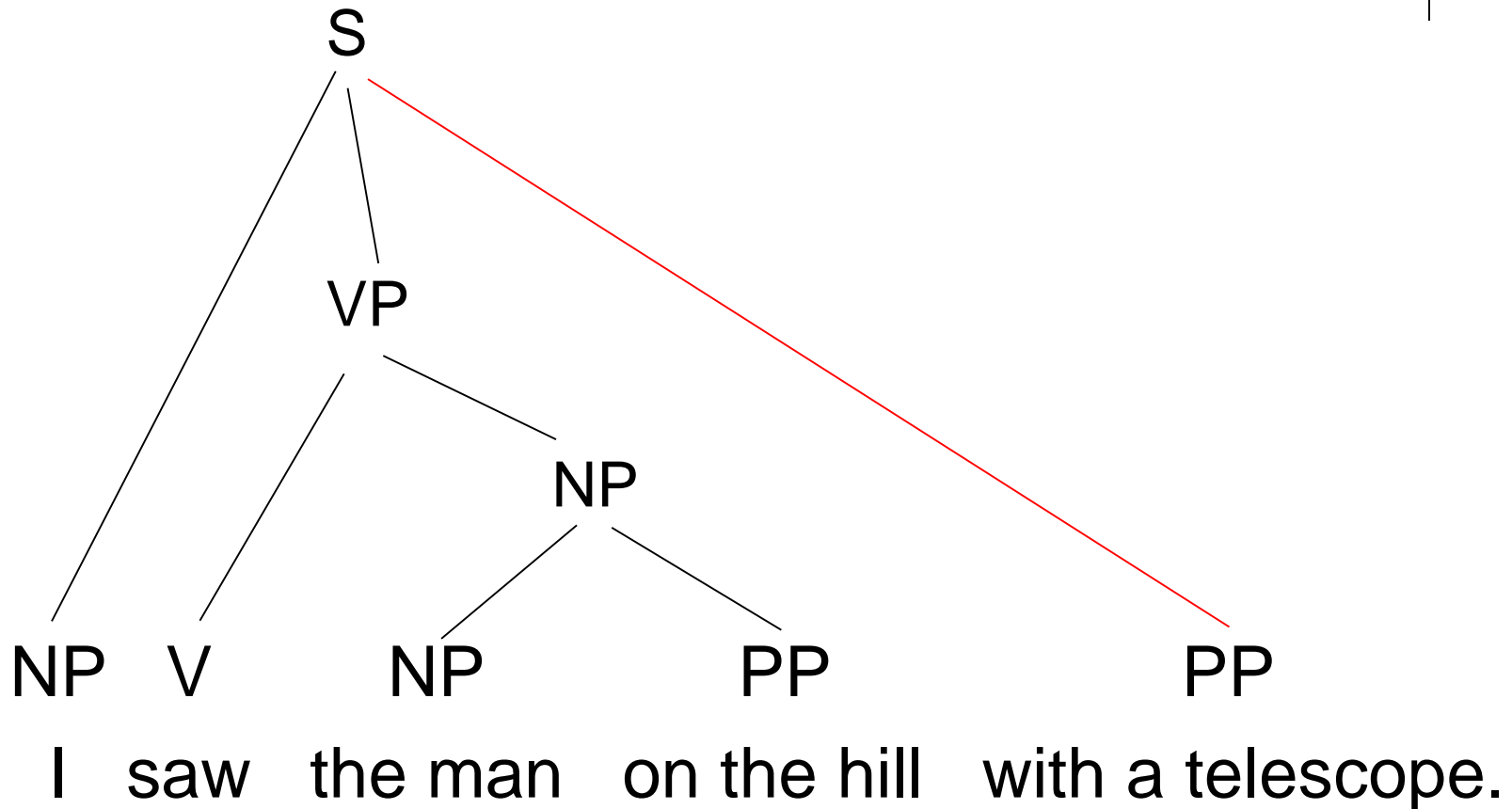
Ông già // đi nhanh quá.

Ông // già đi nhanh quá.

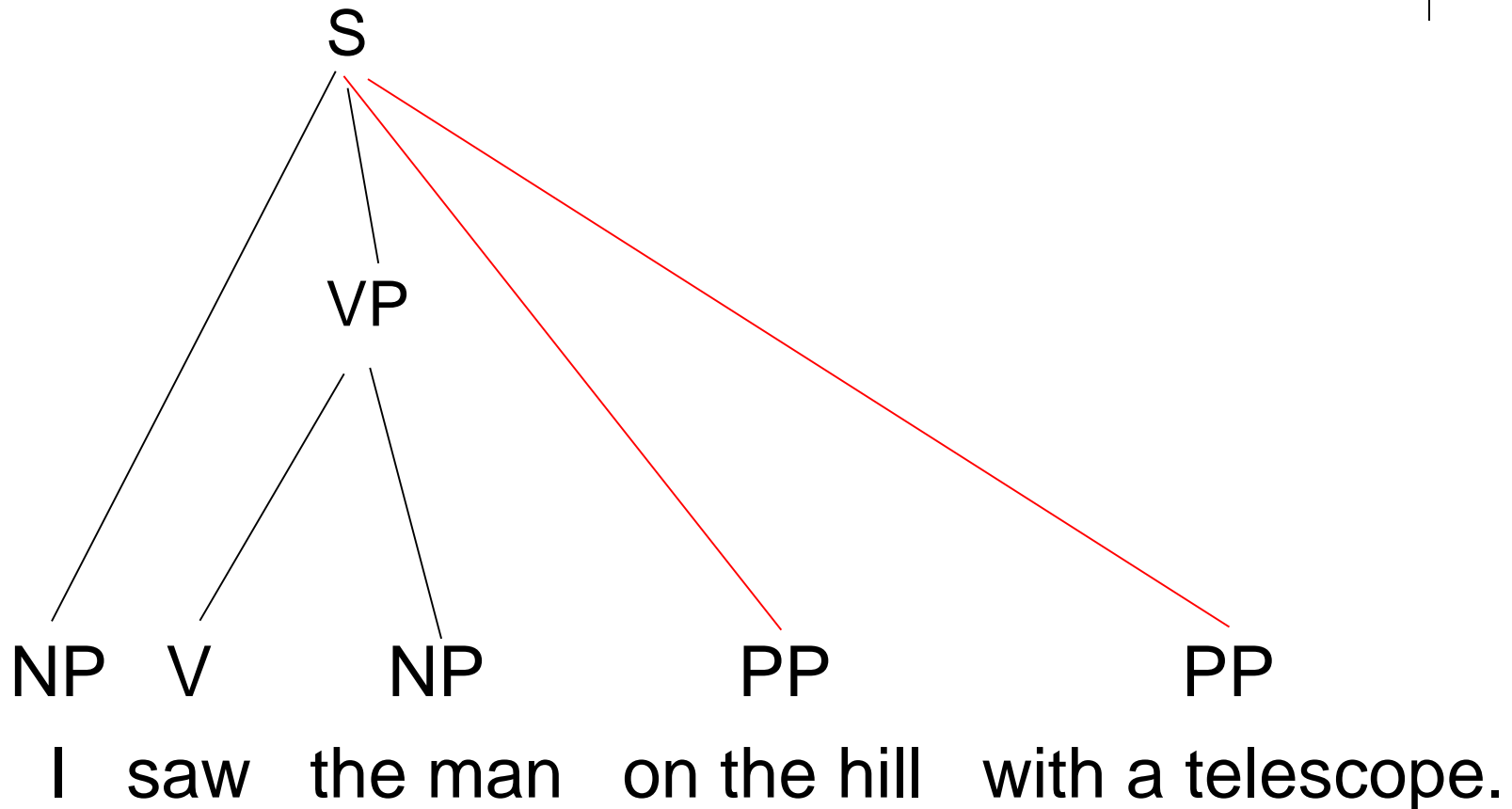
Syntax: structural ambiguity (attachment)



Syntax: structural ambiguity (attachment)



Syntax: structural ambiguity (attachment)



But syntax doesn't tell us much about meaning



- Colorless green ideas sleep furiously.
[Chomsky]
- fire match arson hotel
- plastic cat food can cover



Semantics: lexical ambiguity

- I walked to the bank ...
of the river.
to get money.
- The bug in the room ...
was planted by spies.
flew out the window.
- I work for John Hancock ...
and he is a good boss.
which is a good company.



Discourse: coreference

President John F. Kennedy was assassinated.

The president was shot yesterday.

Relatives said that John was a good father.

JFK was the youngest president in history.

His family will bury him tomorrow.

Friends of the Massachusetts native will hold a candlelight service in Mr. Kennedy's home town.



Pragmatics

How do you react from what I said?

Rules of Conversation

- Can you tell me what time it is?
- Could I please have the salt?

Speech Acts

I bet you \$50 that the Jazz will win.



World Knowledge

Mai went to the diner. She ordered a steak.
She left a tip and went home.

- What did Mai eat for dinner?
- Who brought Mai her food?
- Who cooked the steak?
- Did Mai pay her bill?

Knowledge about language: What do we know about this sentence?



- Words must be appeared at a specific order:
 - a. Chó kem ăn. b. Chó ăn kem
- Các bộ phận cấu thành câu:
chó = chủ ngữ (subject); ăn kem = vị ngữ (predicate)
- Who did what to whom?
chủ thể(chó), hành động(ăn), đối tượng(kem)



Hidden knowledge

1. I want to solve the problem
 - I wanna solve the problem

2. I understand these students
 - These students I understand
 - I want these students to solve the problem
 - These students I want [x] to solve the problem
 - [x]=these students

LSAT / (former) GRE

Analytic Section Questions



- Six sculptures – C, D, E, F, G, H – are to be exhibited in rooms 1, 2, and 3 of an art gallery.
 - Sculptures C and E may not be exhibited in the same room.
 - Sculptures D and G must be exhibited in the same room.
 - If sculptures E and F are exhibited in the same room, no other sculpture may be exhibited in that room.
 - At least one sculpture must be exhibited in each room, and no more than three sculptures may be exhibited in any room.
- If sculpture D is exhibited in room 3 and sculptures E and F are exhibited in room 1, which of the following may be true?
 - A. Sculpture C is exhibited in room 1
 - B. Sculpture H is exhibited in room 1
 - C. Sculpture G is exhibited in room 2
 - D. Sculptures C and H are exhibited in the same room
 - E. Sculptures G and F are exhibited in the same room

Reference Resolution



U: Where is A Bug's Life playing in Mountain View?

S: A Bug's Life is playing at the Summit theater.

U: When is it playing there?

S: It's playing at 2pm, 5pm, and 8pm.

U: I'd like 1 adult and 2 children for the first show.
How much would that cost?

- Knowledge sources:
 - Domain knowledge
 - Discourse knowledge
 - World knowledge

What is the character of this knowledge?



- Some of it must be memorized :
 - Singing → Sing+ing; Bringing → bring+ing
- *Duckling* → ?? *Duckl +ing*
- So, must know duckl is not a word
- But it can't all be memorized

Besides memory, what else do we need?



English plural:

- Toy+s -> toyz ; add z
- Book+s -> books ; add s
- Box+s-> boxes ; add es

➤ ***Need a rule system to generate/analyze such cases***



Characteristics of NLP

- Ambiguous at all levels
- Involve reasoning about the world



Solutions?

- What do we need?
 - Linguistic knowledge
 - World knowledge
 - Combining all types of knowledge
- Potential solution:
 - Probabilistic models constructing from text corpus:
 - $P(\text{"maison"} \rightarrow \text{"house"})$ high
 - $P(\text{"L'avocat general"} \rightarrow \text{"the general avocado"})$ low



Remind fundamental tasks in NLP



Morphology (word ‘shape’)

- Input: sequence of phonemes (~ (lexical) letters)
- Output: sequence of pairs (lemma, (morphological) tag)
- Deals with:
 - composition of phonemes into word forms and their underlying lemmas (lexical units) + morphological categories (inflection, derivation, compounding)
 - e.g. quotations ~ quote/V + -ation(der.V->N) + NNS



Word segmentation

- Input: a text
- Output: possible cases of segmenting words from the input text.
- Deals with:
 - Special formats (e.g., datetime, number,...)
 - Word ambiguity

Syntactic parsing



- Input: sequence of pairs (lemma, (morphological) tag)
- Output: sentence structure (tree) with annotated nodes (all lemmas, (morphosyntactic) tags, functions), of various forms
- Deals with:
 - the relation between lemmas & morph. categories and sentence structure
 - uses syntactic categories such as Subject, Verb, Object,...
 - E.g.:

Tôi/ĐaT nhìn thấy/ĐgT Mai/DT
→ ((Tôi/ĐaT)CN ((nhìn thấy/ĐgT) (Mai/DT)OBJ)VN)C



Semantics

- Input: sentence structure (tree) with annotated nodes (lemmas, (morphosyntactic) tags, surface functions)
- Output: sentence structure (tree) with annotated nodes (semantic lemmas, (morphosyntactic) tags, functions)
- Deals with:
 - relation between categories such as “Subject”, “Object” and categories such as “Agent”, “Effect”; adds other cat’s
 - E.g.
((Học sinh/DT)CN ((học/ĐgT sinh học/DT)ĐgN)VN)C
(Học sinh/DT)Sbj (học/ĐgT)action (sinh học/DT)Obj