

# Information Extraction

CIS, LMU München  
Winter Semester 2019-2020

Prof. Dr. Alexander Fraser, CIS

# Information Extraction – Administravia - I

- Vorlesung
  - Learn the basics of Information Extraction (IE)
- Seminar
  - Each student will present a Referat on IE (Powerpoint, LaTeX, Mac)
    - The group will discuss it
  - Also: three or so practical sessions in the computer lab (hopefully we have time)
  - There are two seminars! **You come to just one of the two sessions**, either Mondays 16:00 (Group 01) or Thursdays 10:00 (Group 02)

# Information Extraction – Administravia - II

- Registration:
  - If you are a CIS Student: check whether you are registered for *\*both\** the Vorlesung and the Seminar (these are **two things** in LSF!)
    - Please **ignore the Modulteilprüfung** entries, make sure you are registered for the Seminar and the Vorlesung
  - There are a good number of people only in the Vorlesung
  - There are just a couple of people only in the Seminar

# Information Extraction – Administravia - III

- Vorlesung and Seminar are two separate courses (in same module for CIS people)
  - However, there may be some shifting around of slots depending on time constraints
- Vorlesung (Grade):
  - Klausur on Feb 12th entirely determines the Vorlesung grade
- Seminar (Grade):
  - Referat
  - Hausarbeit (write-up of the Referat) (6 pages, due **3 weeks** after you hold your Referat)
  - The Hausarbeit can also include the practical exercises (optional, **extra points**)
- CIS-ler: No Notenverbesserung

# Information Extraction – Administravia - IV

- Syllabus: updated dynamically on my web page (see also WS last year, but there will be some differences)
  - Brief idea at end of this slide deck (if we finish, then today)
- List of Referatsthemen
  - This will be presented soon in the Seminar, next week
- Literature:
  - Required: **Sunita Sarawagi. Information Extraction.** Foundations and Trends in Databases, 1(3):261–377, 2008. (good survey paper, somewhat brief)
    - **Please read the introduction for next week (it is available on the web page!)**
  - Optional: Christopher D. Manning, Prabhakar Raghavan and Hinrich Schuetze, *Introduction to Information Retrieval*, Cambridge University Press. 2008. (good information retrieval textbook, preview copies available from the book website: <http://nlp.stanford.edu/IR-book/>)

# Information Extraction - Administravia - V

- There will also be guest lectures from Viktor Hangya, Dr. Matthias Huck, Dario Stojanovski
- Our tutor, Tobias Eder, will help with the exercises and be available to help you with any questions

- Questions?

# Information Extraction

- An introduction to the course
  - The topic "Information Extraction" means different things to different people
  - In this course we will look at several different perspectives
  - There is unfortunately no comprehensive textbook that includes all of these perspectives



# My Biases

- As you may have noticed by now: I am from the US (PhD in Computer Science from USC/ISI, Artificial Intelligence division)
- I am a professor here at CIS
- I do research in the broad area of **statistical NLP**
  - I mostly work on **machine translation**, and related structured prediction problems (e.g., treebank-based syntactic parsing, generation using sequence (tagging) models)
  - I also work on other multilingual problems such as cross-language information retrieval
- With respect to **rule-based NLP** (with manually written rules), I'll try to be as fair as humanly possible
  - I do use these techniques sometimes too

# Outline for today

- Motivation
  - Problems requiring information extraction
  - Basic idea of the output
- Abstract idea of the core of an information extraction pipeline
- Course topics

# A problem



**Mt. Baker, the school district**

**Baker Hostetler, the company**


**Baker, a job opening**

### [Bakery Jobs on CareerBuilder.com](#)

[www.careerbuilder.com/jobs/keyword/bakery](http://www.careerbuilder.com/jobs/keyword/bakery) 


Jobs 1 - 25 of 579 – Looking for **Bakery Jobs**? See currently available job **openings** on CareerBuilder.com. Browse the current listings and fill out job applications.

### [Baker Jobs, Employment | Indeed.com](#)

[www.indeed.com/q-Baker-jobs.html](http://www.indeed.com/q-Baker-jobs.html) 

Jobs 1 - 10 of 16047 – 16047 **Baker Jobs** available on Indeed.com. one search. all jobs.

### [Job Openings - Baker University](#)

[www.bakeru.edu](http://www.bakeru.edu) > Jobs 

If you are seeking employment in any of these areas, contact **Baker** University.

### [Baker, LA Jobs on CareerBuilder.com](#)

[www.careerbuilder.com/Jobs/Baker/](http://www.careerbuilder.com/Jobs/Baker/) 

Jobs 1 - 25 of 948 – Looking for **Baker, LA Jobs**? See currently available **job openings** on CareerBuilder.com. Browse the current listings and fill out **job ...**

### [Down Under Bakery Pies: Job Openings at DUB Pies](#)

[www.dubpies.com/jobs.php](http://www.dubpies.com/jobs.php) 

Listing of **job openings** at DUB Pies. Down Under **Bakery** (DUB) Pies is looking for more staff - check out our list of vacancies.

### [Field Engineers | Geoscience | Jobs and Careers at Baker Hughes](#)

[jobs.bakerhughes.com/](http://jobs.bakerhughes.com/) 


... Oil and Natural Gas? **Baker Hughes** has career information for you on these, more. ... Search **Jobs**. **Baker Hughes Jobs** ... Recent **Job Openings**. Completion ...

### [Corner Bakery Job Openings | Glassdoor](#)

[www.glassdoor.com/Job/Corner-Bakery-Job-Openings-E297310\\_P2...](http://www.glassdoor.com/Job/Corner-Bakery-Job-Openings-E297310_P2...) 

45 Corner **Bakery job openings**. Search job openings, see if they fit - company salaries, reviews, and more posted by Corner Bakery employees.

### [Jobs - Baker University](#)

[www.bakeru.edu/jobs](http://www.bakeru.edu/jobs) 

See links at left for a complete list of **Baker** University **job openings**. It is the policy of **Baker** University to afford equal opportunity for all persons without distinction ...

# A solution

job search find employment careers @ FlipDog.com free! - Microsoft Internet Explorer  
Address http://www.flipdog.com/home.html

**FlipDog.com**  
Home Find Jobs Your Account Resource Center Support Employers  
Job Search at FlipDog.com: Employment & Career Management

  
**647,514**  
Job Opportunities  
from **53,641** Employers  
[Find a Job!](#)  
[Post Your Resume](#)  
**Employers**  
click here for  
Products & Services

**Job Seekers: Find your dream job!**

- ▶ Check our 'Best Places to Find a Job' [January report](#).
- ▶ Open your [FREE account](#) and put your [resume online](#).
- ▶ Search 24x7 with our FREE automatic [JobHunters](#)™.
- ▶ Research our database of over [50,000 employers](#).
- ▶ Get [expert advice](#) at our new [Resource Center](#).
- ▶ Access [salary surveys/calculators](#), [relocation tools](#), [networking opportunities](#), & [training/testing](#) tools.
- ▶ Use FlipDog.com to search jobs right from your desktop! Download [Snippets](#) today!

**Pigskin Places**

- Health Care in NY [2,770](#)
- Health Care in MD [1,262](#)
- Sales in NY [3,751](#)
- Sales in MD [958](#)
- Computing in NY [8,050](#)
- Computing in MD [4,114](#)

**Jobs for Sports Fans**

- [Head Football Coach](#)
- [Football Coach](#)
- [Asst. Football Coach](#)
- [High School Football Coach](#)
- [Univ. Asst. Football Coach](#)

**Job Seeker Newsletter**

Enter your e-mail address:  
  
[Sign Me Up!](#)

**Showcase Jobs**


**MRI**  
Management Recruiters  
of Charlotte North


We provide total staffing solutions in the areas of Human Resources, Compensation, Web-based HR, self-service, and Customer Management Systems.  
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Looking for a Vice President of Academic Affairs to oversee planning, operation and evaluation of the college's academic programs.  
[Learn More](#)

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**WhizBang!**

 "Top 100 Web Sites"  
PC Magazine, Nov. 2000

 "Top 10 Career Web Site"  
Media Matrix, Sept. 2000

 "Top 10 Job Site"

Internet



FlipDog.com

Fetch Your Next Job Here™

Employers Support

Home

Find Jobs

Your Account

Resource Center

Return to Results | Modify Search | New Search



Learn While You Earn  
MBA, BA, AA Degrees  
Online & Project Mgt.

Click here to e-mail your resume to 1000's  
of Head Hunters with  
ResumeZapper.com



Breakthrough ebook  
shows why most people  
are WRONG about how  
to apply for jobs.

1 - 25 of 47 jobs shown below

1 2 Next >

Search these results for:



Search tips

Show Jobs Posted:

For all time periods

View: Brief | Detailed

Web Jobs: FlipDog technology has found these jobs on thousands of employer Web sites.

<a href="#">Food Pantry Workers</a> at <a href="#">Lutheran Social Services</a>	October 11, 2002	<a href="#">Archbold, OH</a>
<a href="#">Cooks</a> at <a href="#">Lutheran Social Services</a>	October 11, 2002	<a href="#">Archbold, OH</a>
<a href="#">Bakers Assistants</a> at <a href="#">Fine Catering by Russell Morin</a>	October 11, 2002	<a href="#">Attleboro, MA</a>
<a href="#">Baker's Helper</a> at <a href="#">Bird-in-Hand</a>	October 11, 2002	United States
<a href="#">Assistant Baker</a> at <a href="#">Gourmet To Go</a>	October 11, 2002	<a href="#">Maryland Heights, MO</a>
	October 10, 2002	<a href="#">Beaverton, OR</a>
	October 10, 2002	<a href="#">Alta, UT</a>
	October 10, 2002	<a href="#">Huntsville, UT</a>
<a href="#">School District</a>	October 10, 2002	<a href="#">Garden Grove, CA</a>
	October 10, 2002	<a href="#">Houma, LA</a>
	October 10, 2002	<a href="#">Nisswa, MN</a>
	October 10, 2002	<a href="#">Big Sky, MT</a>
	October 08, 2002	<a href="#">Willowbrook, IL</a>
<a href="#">Cake Decorator/Baker</a> at <a href="#">Mandalay Bay Hotel and Casino</a>	October 08, 2002	<a href="#">Las Vegas, NV</a>
<a href="#">Shift Supervisors</a> at <a href="#">Brueggers Bagels</a>	October 08, 2002	<a href="#">Minneapolis, MN</a>

**Job Openings:**  
**Category = Food Services**  
**Keyword = Baker**  
**Location = Continental U.S.**

# Extracting Job Openings from the Web

OPUS International, Inc., an executive search firm focusing on the Food Science industry. - Microsoft Internet Explorer

File Edit View Favorites

Back Forward Stop

Address [http://www.foodscier.com/jobs\\_midwest.html#top](http://www.foodscier.com/jobs_midwest.html#top)

Links AMEX Rewards Time DogHouse My Yahoo!

Welcome

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Executive Staff

**Job Listings**

Résumé Form

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OPUS INTERNATIONAL INC.

About | Staff | Job

OPUS: Job Listings - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Refresh Home Search Favorites

Address [http://www.foodscience.com/jobs\\_midwest.html#top](http://www.foodscience.com/jobs_midwest.html#top)

Links AMEX Rewards Time DogHouse My Yahoo!

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Test Kitchen - Consumer Food Relations

Major food manufacturer in Chicago area seeks a consumer food professional to write and test recipes. Will make presentations and marketing; will be a key player in a cross-functional team. Requires a BS in human ecology, nutrition, Food Science, or related field, plus a minimum three years applicable experience.

Contact: Moira: e-mail: 1-800-488-2611

**Ice Cream Guru**

If you dream of cold creamy chocolate or gooey cookie, there's a great opportunity for you to maintain and expand this major corporation's high-end ice cream brand. Will be based in the Upper Midwest for about a year. After that, California here I come! Requires a BS in Food Science or dairy, plus ice cream formulation experience. Will consider entry level with an MS and an internship.

Contact: Susan: e-mail: 1-800-488-2611

**Title:** Ice Cream Guru

**Description:** If you dream of cold creamy...

**Contact:** [susan@foodscience.com](mailto:susan@foodscience.com)

**Category:** Travel/Hospitality

**Function:** Food Services



# Another Problem

The screenshot shows an eBay Express search results page for 'Necklaces & Pendants'. The browser window title is 'eBay Express: Necklaces & Pendants in Pendants & Lockets, Solid Gold items for sale - Mozilla Firefox'. The address bar shows the search URL. The page features a navigation bar with categories like 'Apparel & Accessories', 'Books', 'Computers & Networking', 'Consumer Electronics', 'Home & Garden', 'Jewelry & Watches', 'Sporting Goods', 'Fall Fashion', and 'More Categories'. A search bar is present with the text 'Necklaces & Pendants' and a 'Search' button. Below the search bar, the page indicates '2,239 matches found' and 'New items only'. There are three filter buttons: 'Style: Pendants & Lockets', 'Metal & Material: Solid Gold', and 'Gemstone & Stone: Diamond'. A table of filter options is displayed:

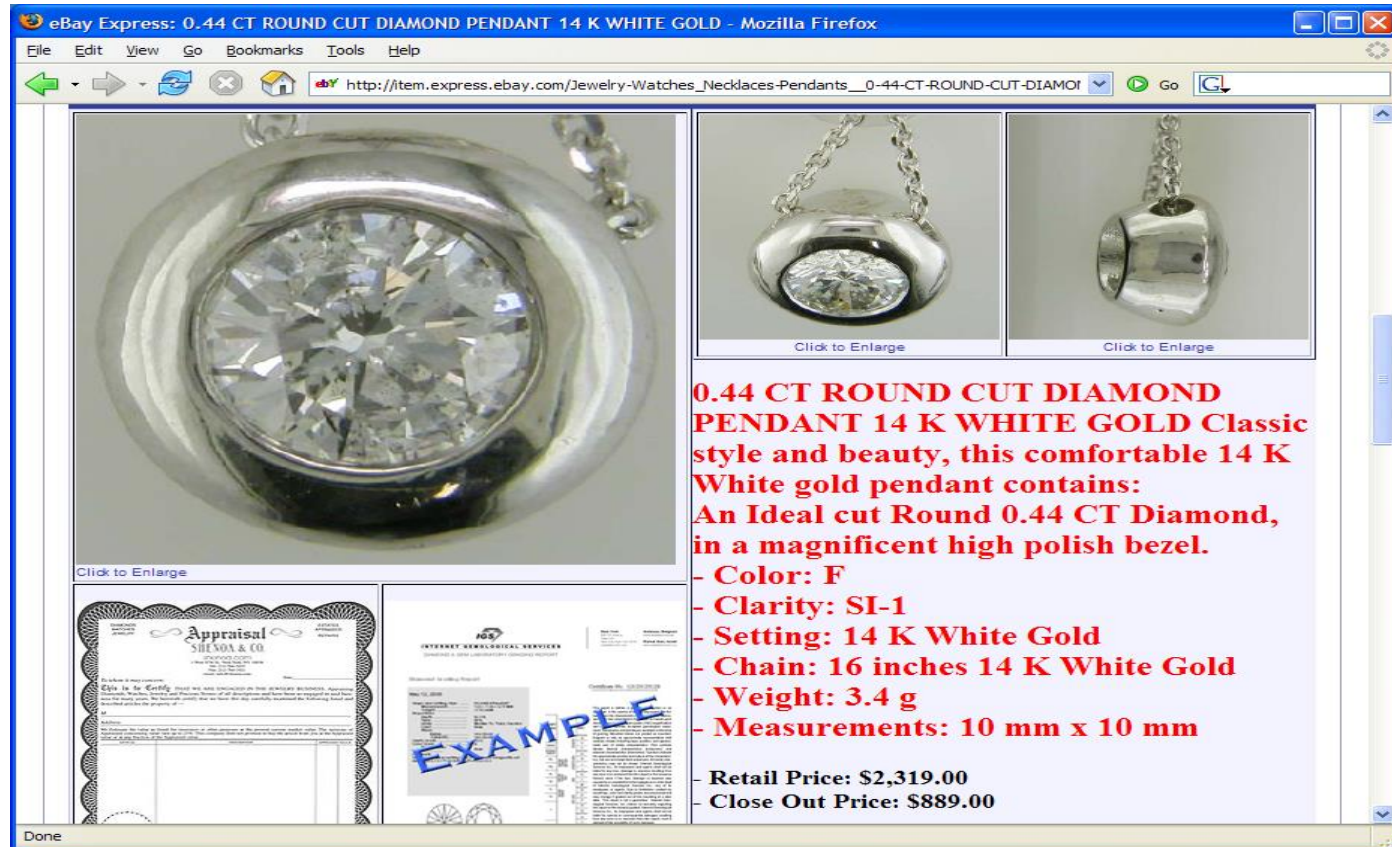
Pendant Shape, Theme	Gold Type	Main Shape	Total Carat Weight
Hearts & Love (893)	White Gold (1,222)	Heart (649)	0.29 to 0.45 carats (105)
Solitaires (499)	Yellow Gold (616)	Round (364)	0.46 to 0.69 carats (183)
Cross (479)	Rose Gold (13)	Square, Princess (88)	0.70 to 0.99 carats (115)
Flowers (121)	Not Specified (388)	Emerald (18)	1.00 to 1.49 carats (299)
<a href="#">More choices...</a>	<a href="#">More choices...</a>	<a href="#">More choices...</a>	<a href="#">More choices...</a>

Below the table, there are links for 'More options to browse' including Price, Brand, Gender, and Condition. A pop-up window titled 'Options to Browse' is open, showing a list of pendant shapes and themes with checkboxes and counts:

Pendant Shape, Theme	Count
<input type="checkbox"/> Angel	(2)
<input type="checkbox"/> Cluster	(26)
<input type="checkbox"/> Cross	(467)
<input type="checkbox"/> Flowers	(122)
<input type="checkbox"/> Hearts & Love	(878)
<input type="checkbox"/> Letters, Initials	(4)
<input type="checkbox"/> Lockets	(50)
<input type="checkbox"/> Solitaires	(494)
<input type="checkbox"/> Stars	(13)
<input type="checkbox"/> Not Specified	(147)



# Often structured information in text



eBay Express: 0.44 CT ROUND CUT DIAMOND PENDANT 14 K WHITE GOLD - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

http://item.express.ebay.com/Jewelry-Watches\_Necklaces-Pendants\_\_0-44-CT-ROUND-CUT-DIAMOND

**0.44 CT ROUND CUT DIAMOND PENDANT 14 K WHITE GOLD** Classic style and beauty, this comfortable 14 K White gold pendant contains:  
An Ideal cut Round 0.44 CT Diamond, in a magnificent high polish bezel.

- Color: F
- Clarity: SI-1
- Setting: 14 K White Gold
- Chain: 16 inches 14 K White Gold
- Weight: 3.4 g
- Measurements: 10 mm x 10 mm

- Retail Price: \$2,319.00  
- Close Out Price: \$889.00

Appraisal SHESSON & CO

INTERNET NEUROLOGICAL SERVICES

EXAMPLE

# Another Problem

The screenshot shows a Microsoft Internet Explorer browser window. The title bar reads "A Critical Evaluation of Commensurable Abduction Models for Semantic Interpretation - Peter, Wi - Microsoft Internet Explorer p". The address bar shows the URL "http://citeseer.nj.nec.com/peter90critical.html". The main content area features a yellow header with the title "A Critical Evaluation of Commensurable Abduction Models for Semantic Interpretation (1990) (Correct) (5 citations)" and the authors "Peter Norvig Robert Wilensky University of California, Berkeley Computer... Thirteenth International Conference on Computational Linguistics, Volume 3". To the right of the header are download links for "PS.gz", "PS", "PDF", "DjVu", "Image", "Update", and "Help", along with "From: norvig.com/resume (more)" and "Home: R.Wilensky HPSearch (Correct)". Below the header is a "NEC ResearchIndex" logo and links for "Bookmark", "Context", and "Related". A rating box on the right says "Rate this article: 1 2 3 4 5 (best)" with a link to "Comment on this article". The main text starts with an abstract: "Abstract: this paper we critically evaluate three recent abductive interpretation models, those of Charniak and Goldman (1989); Hobbs, Stickel, Martin and Edwards (1988); and Ng and Mooney (1990). These three models add the important property of commensurability: all types of evidence are represented in a common currency that can be compared and combined. While commensurability is a desirable property, and there is a clear need for a way to compare alternate explanations, it appears that a single scalar measure is not enough to account for all types of processing. We present other problems for the abductive approach, and some tentative solutions. (Update)". Below the abstract is a "Context of citations to this paper: More" link. The text continues with ".... (break slight modification of the one given in [Ng and Mooney, 1990] The new definition remedies the anomaly reported in [Norvig and Wilensky, 1990] of occasionally preferring spurious interpretations of greater depths. Table 1: Empirical Results Comparing Coherence and..." and ".... costs as probabilities, specifically within the context of using abduction for text interpretation, are discussed in Norvig and Wilensky (1990). The use of abduction in disambiguation is discussed in Kay et al. 1990) We will assume the following: 13) a. Only literals...". The "Cited by:" section lists "More" and three entries: "Translation Mismatch in a Hybrid MT System - Gawron (1999) (Correct)", "Abduction and Mismatch in Machine Translation - Gawron (1999) (Correct)", and "Interpretation as Abduction - Hobbs, Stickel, Appelt, Martin (1990) (Correct)". The "Active bibliography (related documents):" section lists "More All" and three entries: "0.1: Critiquing Effective Decision Support in Time-Critical Domains - Gertner (1995) (Correct)", "0.1: Decision Analytic Networks in Artificial Intelligence - Matzkevich, Abramson (1995) (Correct)", and "0.1: A Probabilistic Network of Predicates - DeRose, Liu (1992) (Correct)". The browser's status bar at the bottom shows "Internet".

# Definition of IE

**Information Extraction** (IE) is the process of extracting structured information (e.g., database tables) from unstructured machine-readable documents (e.g., Web documents).

Elvis Presley was a famous rock singer.

...

Mary once remarked that the only attractive thing about the painter Elvis Hunter was his first name.

**Information  
Extraction**



GName	FName	Occupation
Elvis	Presley	singer
Elvis	Hunter	painter
...	...	

*“Seeing the Web as a table”*

# Defining an IE problem

- In what I will refer to as "classic" IE, we are converting documents to one or more table entries
  - There are other kinds of IE, we will talk about those later
- The **design** of these tables is usually determined by some business need
- Let's look at the table entries for a similar set of examples to the ones we just saw

# Motivating Examples

**579 Jobs in Northern California**

Refine your search

Keyword(s)

**Search Results**

Job Title / Description ( show titles only )	Company
<p><b>RN-Registered Nurse/LVN-Licensed Vocational Nurse - View similar jobs</b></p> <p>Job type: Full-Time/Part-Time                      Maxim's office in Sherman Oaks is seeking compassionate Registered <b>Nurses</b> (RN) and Licensed ... Maxim's office in Sherman Oaks is seeking...</p> <p><a href="#">View full job description</a>   <a href="#">Save to MyCareerBuilder</a>   <a href="#">Email to a friend</a></p>	<p>Maxim Healthcare Services, Inc</p>
<p><b>Nurse Practitioner - Acute Care Nurse Practitioner - View similar jobs</b></p> <p>Job type: Full-Time                      Vanderbilt University Medical Center is currently hiring <b>Nurse Practitioners</b> to join our team ... Vanderbilt University Medical Center is...</p> <p><a href="#">View full job description</a>   <a href="#">Save to MyCareerBuilder</a>   <a href="#">Email to a friend</a></p>	<p>Vanderbilt University Medical Center (VUMC)</p>

QA Engineer - Release Engineer - Quality Assurance      \$50k - \$50k

Senior Flash Memory Technologist - Storage Architect - SSD      \$160k - \$200k

Title	Type	Location
Business strategy Associate	Part time	Palo Alto, CA
Registered Nurse	Full time	Los Angeles
...	...	

# Motivating Examples

Biography for

**Elvis Presley** [More at IMDb](#)

**Date of Birth**

[8 January 1935](#), [Tupelo, Mississippi, USA](#)

**Date of Death**

[16 August 1977](#), [Memphis, Tennessee, USA](#) (cardiac arrhythmia)

**Birth Name**

Elvis Aron Presley

**Nickname**

The Pelvis  
The King  
The King Of Rock 'n'

**Height**

6' (1.83 m)

**Mini Biography**

Elvis Aaron Presley

Name	Birthplace	Birthdate
Elvis Presley	Tupelo, MI	1935-01-08
...	...	



**Biography**

[Overview](#) / [1935-1957](#) / [1958-1965](#) / [1966-1969](#) / [1970-1977](#)

**Overview**

**Elvis Aaron Presley**, in the humblest of circumstances, was born to Vernon and Gladys Presley in a [two-room house in Tupelo, Mississippi](#) on January 8, 1935. His twin brother, Jessie Garon, was stillborn, leaving Elvis to grow up as an only child. He and his parents moved to [Memphis, Tennessee](#) in 1948, and Elvis graduated from Humes High School there in 1953.

# Motivating Examples

## Information Extraction: Techniques and Challenges

Ralph Grishman

### Information Integration Papers

[Answering Queries Using Templates With Binding Patterns](#). In PODS 1995, specify binding patterns.

[The TSIMMIS Approach to Mediation: Data Models and Languages](#). A survey appears in *J. Intelligent Information Systems* 8:2, pp. 117-132, March, 1997.

Author	Publication	Year
Grishman	Information Extraction...	2006
...	...	...

# Motivating Examples



Ballroom Dance Shoe  
[1 new from \\$49.95](#)  
 (5)  
[Show only So Danca items](#)

X-Strap Ballroom Dance Shoe  
[1 new from \\$49.95](#)  
 (5)  
[Show only So Danca items](#)



Compare

**Dynex™ - 32" Class / 720p / 60Hz / LCD HDTV**  
 Model: DX-32L150A11 | SKU: 9558089  
 3.8 of 5 (180 reviews)  
[Check Shipping & Availability >](#)

---



Compare

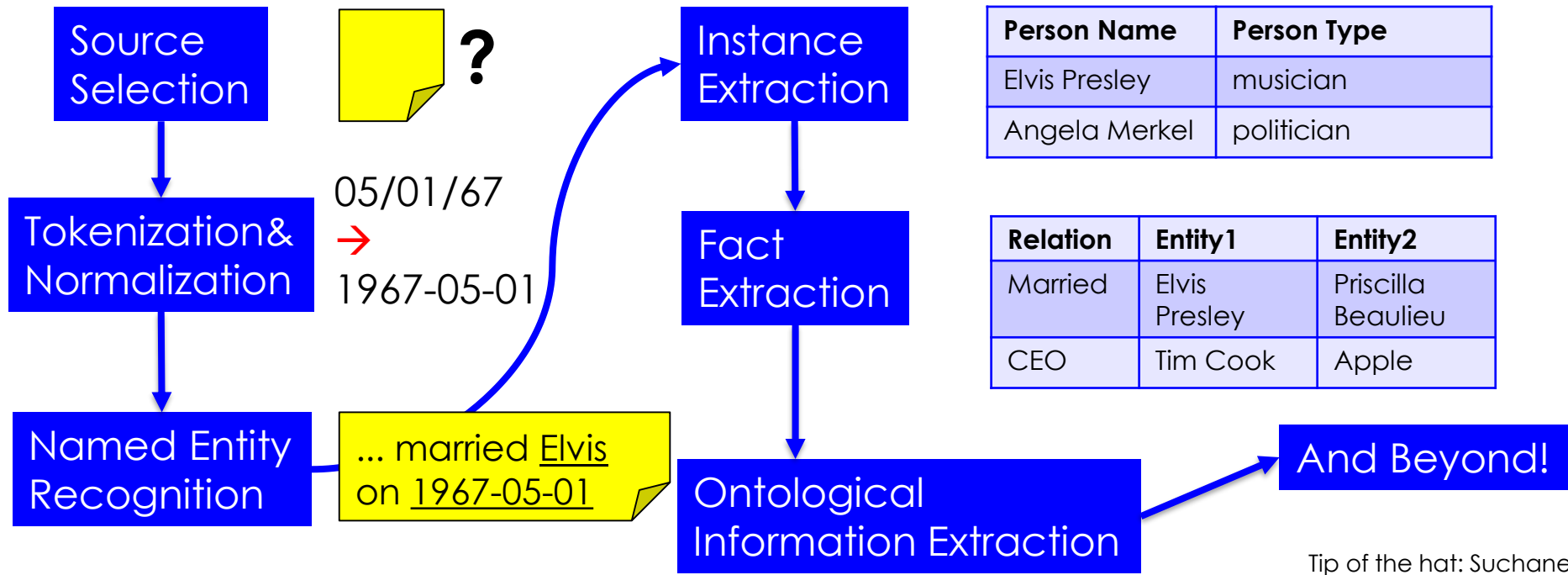
**Dynex™ - 24" Class / 1080p / 60Hz / LCD HDTV**  
 Model: DX-24L150A11 | SKU: 9848048  
 4.3 of 5 (54 reviews)  
[Check Shipping & Availability >](#)

Product	Type	Price
Dynex 32"	LCD TV	\$1000
...	...	



# Information Extraction

**Information Extraction (IE)** is the process of extracting **structured information** from unstructured machine-readable documents



# Information Extraction

**Traditional definition:** Recovering structured data from text

**What are some of the sub-problems/challenges?**

Management Team
<b>Board of Directors</b>
Our Firm & WOMMA
FAQs
Contact Us
Careers

## Board Members

- **Itzhak Fisher**  
Chairman of Nielsen BuzzMetrics
- **Thom Mastrelli**  
Executive Vice President/Corporate Development, VNU
- **Jonathan Carson**  
CEO of Nielsen BuzzMetrics
- **Mahendra Vora**  
CEO and Owner, Vora Technology Park
- **Ori Levy**  
President of Nielsen BuzzMetrics Israel
- **Ron Schneier**  
Senior Vice President and General Manager, Nielsen Ventures
- **James O'Hara**  
Senior Vice President and Chief Financial Officer, VNU's Media Measurement and Information Group

# Information Extraction?

- Recovering structured data from text
  - Identifying fields (e.g. named entity recognition)

Management Team
<b>Board of Directors</b>
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Careers

## Board Members

◦ <b>Itzhak Fisher</b> Chairman of Nielsen BuzzMetrics	◦ <b>Ori Levy</b> President of Nielsen BuzzMetrics Israel
◦ <b>Thom Mastrelli</b> Executive Vice President/Corporate Development, VNU	◦ <b>Ron Schneier</b> Senior Vice President and General Manager, Nielsen Ventures
◦ <b>Jonathan Carson</b> CEO of Nielsen BuzzMetrics	◦ <b>James O'Hara</b> Senior Vice President and Chief Financial Officer, VNU's Media Measurement and Information Group
◦ <b>Mahendra Vora</b> CEO and Owner, Vora Technology Park	

# Information Extraction?

- Recovering structured data from text
  - Identifying fields (e.g. named entity recognition)
  - Understanding relations between fields (e.g. record association)

Management Team
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◦ <b>Itzhak Fisher</b> Chairman of Nielsen BuzzMetrics
◦ <b>Thom Mastrelli</b> Executive Vice President/Corporate Development, VNU
◦ <b>Jonathan Carson</b> CEO of Nielsen BuzzMetrics
◦ <b>Mahendra Vora</b> CEO and Owner, Vora Technology Park

◦ <b>Ori Levy</b> President of Nielsen BuzzMetrics Israel
◦ <b>Ron Schneier</b> Senior Vice President and General Manager, Nielsen Ventures
◦ <b>James O'Hara</b> Senior Vice President and Chief Financial Officer, VNU's Media Measurement and Information Group

# Information Extraction?

- Recovering structured data from text
  - Identifying fields (e.g. named entity recognition)
  - Understanding relations between fields (e.g. record association)
  - Normalization and deduplication

**James O'Hara (I)**



Date of birth (location)  
[11 September 1927](#)  
[Dublin, Ireland](#)

Date of death (details)  
[3 December 1992](#)  
Glendale, California, USA.

Trivia  
Brother of [Maureen O'Hara](#)

Sometimes Credited As:  
James Lilburn / Jim O'Hara

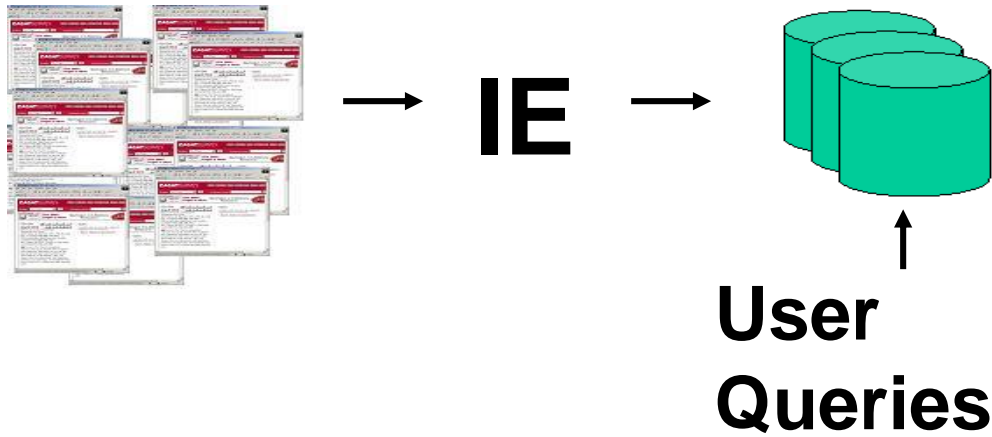
 [IMDbPro Details](#)  [Add IMDb Resume](#)

- **James O'Hara**  
Senior Vice President and Chief Financial Officer, VNU's Media Measurement and Information Group

Herkovic	Jane is a member of the Nielsen senior leadership team and a senior member of the VNU MMI Finance team. She is based in New York and reports to both Susan Whiting, president and CEO of Nielsen Media Research, and <a href="#">Jim O'Hara</a> , senior vice president and chief financial officer for VNU Media Measurement and Information.
Susan D. Whiting	
Douglas Darfield	
Paul J. Donato	
Sara Erichson	
Dave Harkness	
Jack Loftus	

# Information extraction

- Input: Text Document
  - Various sources: web, e-mail, journals, ...
- Output: Relevant fragments of text and relations possibly to be processed later in some automated way



# Not all documents are created equal...



- Varying regularity in document collections
- Natural or unstructured
  - Little obvious structural information
- Partially structured
  - Contain some canonical formatting
- Highly structured
  - Often, automatically generated

# Natural Text: MEDLINE

## Journal Abstracts

Extract number of subjects, type of study, conditions, etc.

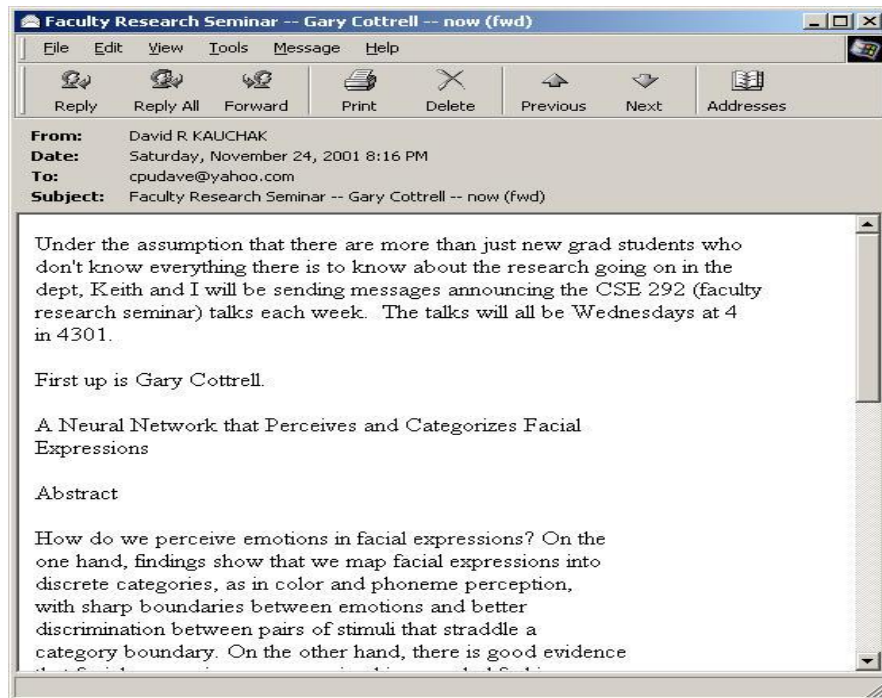
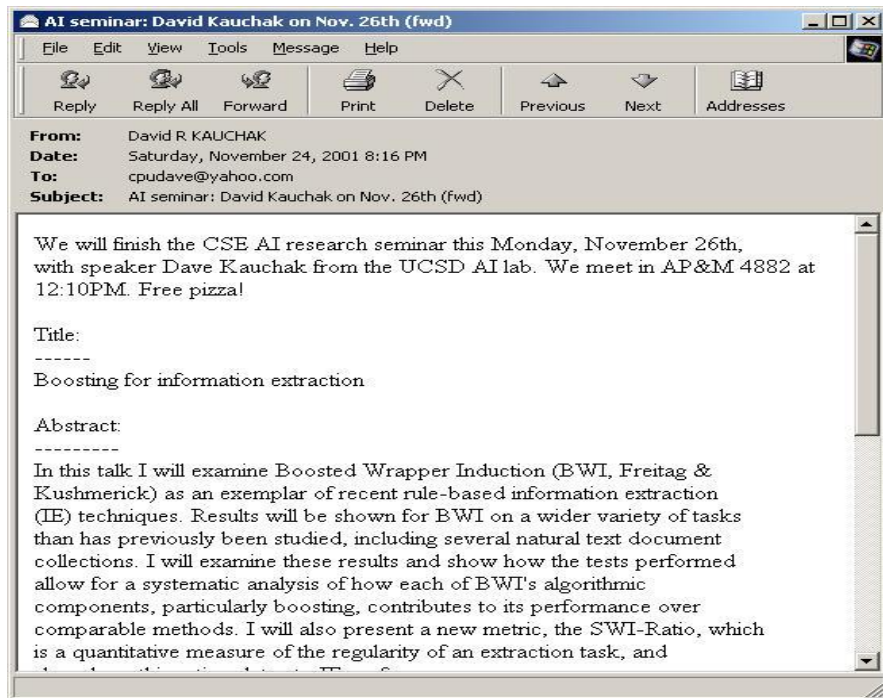
**BACKGROUND:** The most challenging aspect of revision hip surgery is the management of bone loss. A reliable and valid measure of bone loss is important since it will aid in future studies of hip revisions and in preoperative planning. We developed a measure of femoral and acetabular bone loss associated with failed total hip arthroplasty. The purpose of the present study was to **measure the reliability and the intraoperative validity of this measure** and to determine how it may be useful in preoperative planning. **METHODS:** From July 1997 to December 1998, **forty-five consecutive patients** with a failed hip prosthesis in need of revision surgery were prospectively followed. Three general orthopaedic surgeons were taught the radiographic classification system, and two of them classified standardized preoperative anteroposterior and lateral hip radiographs with use of the system. Interobserver testing was carried out in a **blinded fashion**. These results were then compared with the intraoperative findings of the third surgeon, who was blinded to the preoperative ratings. Kappa statistics (unweighted and weighted) were used to assess correlation. Interobserver reliability was assessed by examining the agreement between the two preoperative raters. Prognostic validity was assessed by examining the agreement between the assessment by either Rater 1 or Rater 2 and the intraoperative assessment (reference standard). **RESULTS:** With regard to the assessments of both the femur and the acetabulum, there was significant agreement ( $p < 0.0001$ ) between the preoperative raters (reliability), with weighted kappa values of  $>0.75$ .

There was also significant agreement ( $p < 0.0001$ ) between each rater's assessment and the intraoperative assessment. Slide from Kauchak



# Partially Structured: Seminar Announcements

Extract time, location, speaker, etc.



# Highly Structured: Zagat's Reviews

Extract restaurant, location, cost, etc.

**ZAGAT SURVEY: BY POPULAR VOTE** - Microsoft Internet Explorer

Address: <http://www.zagat.com/Search/Details.asp?VID=1&PID=1&LID=21&LID=21&LID=12268&BRW=21&NDPH=in+La+Jolla%>

**ZAGAT SURVEY.** HOME BROWSE LISTS NEWCOMERS VOTE SHOP

location: San Diego go restaurant search: go

**ZAGAT To Go Restaurants & Nightlife** [Click Here](#)

**The 2002 Zagat Is Here** Washington, D.C./Baltimore Restaurants [Click Here](#)

**REVIEW**

	Food	Decor	Service	Cost
<b>Bully's</b>	20	13	20	\$25

Beaches/Coastal, La Jolla/Golden Triangle, Mission Valley  
1404 Camino del Mar (bet. 13th & 15th Sts.) Del Mar, CA, 92014-2599 (858) 755-1660  
5755 La Jolla Blvd. (Bird Rock Ave.) La Jolla, CA, 92037-7302 (858) 459-2768  
2401 Camino del Rio S. (Texas St.) San Diego, CA, 92108-3701 (619) 291-2665

■ So much "fun" that it's sometimes "raucous", this "local" chainlet with "a blessed lack of pretense" specializes in some of "the best prime rib in town" insist carnivores who arrive eager for "a red-meat fix"; they "can always count on a good meal", with "generous portions" at "a great value", but vegetarians note there's "little for us" at these late-night American pubs.

**VOTE**

In order to vote, you must be a signed-in, registered user or subscriber.  
▶ [Sign in, register or subscribe here](#)

**ZAGAT SURVEY: BY POPULAR VOTE** - Microsoft Internet Explorer

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**REVIEW**

	Food	Decor	Service	Cost
<b>Aesop's Tables</b>	.	.	.	M
<b>Greek Cafe</b>	.	.	.	M

La Jolla/Golden Triangle  
8650 Genesee Ave. (La Jolla Village Dr.) San Diego, CA, 92122-1134 (858) 455-1535

Wafting "warm, inviting smells", this "great neighborhood" cafe in the Golden Triangle's bustling Costa Verde mall tantalizes with the "best Greek food in the area", "excelling" with "standards" such as skewers and pizzas while also "departing" from the usual with Mediterranean specialties like b'steeya; enjoy it all in a "pleasant" space that feels like "a cross between a tavern and a comfy B&B" -- "opal"

**VOTE**

In order to vote, you must be a signed-in, registered user or subscriber.  
▶ [Sign in, register or subscribe here](#)

# Landscape of IE Tasks:

## Document Formatting

Text paragraphs  
without formatting









Astro Teller is the CEO and co-founder of BodyMedia. Astro holds a Ph.D. in Artificial Intelligence from Carnegie Mellon University, where he was inducted as a national Hertz fellow. His M.S. in symbolic and heuristic computation and B.S. in computer science are from Stanford University.

Grammatical sentences  
and some formatting & links

**Dr. Steven Minton** - Founder/CTO  
Dr. Minton is a fellow of the American Association of Artificial Intelligence and was the founder of the Journal of Artificial Intelligence Research. Prior to founding Fetch, Minton was a faculty member at USC and a project leader at USC's Information Sciences Institute. A graduate of Yale University and Carnegie Mellon University, Minton has been a Principal Investigator at NASA Ames and taught at Stanford, UC Berkeley and USC.

- Press
- **Contact**
- General information
- Directions maps

Non-grammatical snippets,  
rich formatting & links

<b>Barto, Andrew G.</b> Professor. Computational neuroscience, reinforcement learning, adaptive motor control, artificial neural networks, adaptive and learning control, motor development.	(413) 545-2109	<a href="mailto:barto@cs.umass.edu">barto@cs.umass.edu</a>	CS276	 
<b>Berger, Emery D.</b> Assistant Professor.	(413) 577-4211	<a href="mailto:emery@cs.umass.edu">emery@cs.umass.edu</a>	CS344	 
<b>Brock, Oliver</b> Assistant Professor.	(413) 577-0334	<a href="mailto:oli@cs.umass.edu">oli@cs.umass.edu</a>	CS246	 
<b>Clarke, Lori A.</b> Professor. Software verification, testing, and analysis; software architecture and design.	(413) 545-1328	<a href="mailto:clarke@cs.umass.edu">clarke@cs.umass.edu</a>	CS304	 

## Tables

8:30 - 9:30 AM	Invited Talk: Plausibility Measures: A General Approach for Representing Uncertainty <i>Joseph Y. Halpern, Cornell University</i>				
9:30 - 10:00 AM	Coffee Break				
10:00 - 11:30 AM	Technical Paper Sessions:				
Cognitive Robotics	Logic Programming	Natural Language Generation	Complexity Analysis	Neural Networks	Games
739: A Logical Account of Causal and Topological Maps <i>Emilio Remolina and Benjamin Kuipers</i>	116: A-System: Problem Solving through Abduction <i>Marc Denecker, Antonis Kakas, and Bert Van Nuffelen</i>	758: Title Generation for Machine-Translated Documents <i>Rong Jin and Alexander G. Hauptmann</i>	417: Let's go Nats: Complexity of Nested Circumscription and Abnormality Theories <i>Marco Cadoli, Thomas Eiter, and Georg Gottlob</i>	179: Knowledge Extraction and Comparison from Local Function Networks <i>Kenneth McGarry, Stefan Wermter, and John MacIntyre</i>	71: Iterative Widening <i>Tristan Cazenave</i>
549: Online-Execution of ccGolog Plans <i>Henrik Grosskreutz and Gerhard Lakemeyer</i>	131: A Comparative Study of Logic Programs with Preference <i>Torsten Schaub and Kewen</i>	246: Dealing with Dependencies between Content Planning and Surface Realisation in a Pipeline Generation	470: A Perspective on Knowledge Compilation <i>Adnan Darwiche and Pierre Marquis</i>	258: Violation-Guided Learning for Constrained Formulations in Neural-Network Time-Series	353: Temporal Difference Learning Applied to a High Performance Game-Playing

# Landscape of IE Tasks

## Intended Breadth of Coverage

### Web site specific

#### Formatting

Amazon.com Book Pages

amazon.com. VIEW CART

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### Genre specific

#### Layout

Resumes

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Research Interests

My research interests lie in the automated analysis of data for the purposes of classification.

L. Douglas Baker

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Objective

A position in a dynamic, highly-skilled applied research and development team using statistical machine learning to solve large-scale, real-world tasks such as Information Retrieval and Text Classification.

Education

Carnegie Mellon University Pittsburgh, PA  
Ph.D., Computer Science, in progress  
M.S., Computer Science, 1999  
Technical University of Berlin Berlin, Germany  
Exchange Fellow, 1992-1993  
University of Michigan Ann Arbor, MI  
M.S.E., Computer Science and Engineering, 1994 B.S.E.,  
Computer Engineering, Summa Cum Laude, 1992

Research Experience

Carnegie Mellon University 1994-present

I am currently pursuing my dissertation research: a hierarchical probabilistic model for novelty detection in text. This work is being done as part of the Topic Detection and Tracking project at CMU, under the direction of Yoram Yona. The

### Wide, non-specific

#### Language

University Names

8:30 - 9:30 AM	Invited Talk: <b>Plausibility Measures: A General Approach</b> <i>Joseph Y. Halpern, Cornell University</i>		
9:30 - 10:00 AM	Coffee Break		
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**Dr. Steven Minton - Founder/CTO**  
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**Frank Huybrechts - COO**  
Mr. Huybrechts has over 20 years of

- Press Contact
- General information
- Directions maps

# Landscape of IE Tasks :

## Complexity of entities/relations

### Closed set

#### U.S. states

He was born in Alabama...

The big Wyoming sky...

### Regular set

#### U.S. phone numbers

Phone: (413) 545-1323

The CALD main office is 412-268-1299

### Complex pattern

#### U.S. postal addresses

University of Arkansas

P.O. Box 140

Hope, Al

Headquarters:

1128 Main Street, 4th Floor

Cincinnati, Ohio 45210

### Ambiguous patterns, needing context and many sources of evidence

#### Person names

...was among the six houses  
sold by Hope Feldman that year.

Pawel Opalinski, Software  
Engineer at WhizBang Labs.

# Landscape of IE Tasks:

## Arity of relation

Jack Welch will retire as CEO of General Electric tomorrow. The top role at the Connecticut company will be filled by Jeffrey Immelt.

### Single entity

*Person:* Jack Welch

*Person:* Jeffrey Immelt

*Location:* Connecticut

### Binary relationship

*Relation:* Person-Title

*Person:* Jack Welch

*Title:* CEO

*Relation:* Company-Location

*Company:* General Electric

*Location:* Connecticut

### N-ary record

*Relation:* Succession

*Company:* General Electric

*Title:* CEO

*Out:* Jack Welch

*In:* Jeffrey Immelt

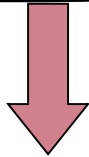
*"Named entity" extraction*

# Association task = Relation Extraction

- Checking if groupings of entities are instances of a relation
  1. Manually engineered rules
    - Rules defined over words/entities: “<company> located in <location>”
    - Rules defined over parsed text:
      - “((Subj<company>) (Verb located) (\*) (Obj <location>))”
  2. Machine Learning-based
    - Supervised: Learn relation classifier from examples
    - Partially-supervised: bootstrap rules/patterns from “seed” examples

# Relation Extraction: Disease Outbreaks

May 19 1995, Atlanta -- The Centers for Disease Control and Prevention, which is in the front line of the world's response to the deadly Ebola epidemic in Zaire, is finding itself hard pressed to cope with the crisis...



**Information  
Extraction System**



<i>Date</i>	<i>Disease Name</i>	<i>Location</i>
Jan. 1995	Malaria	Ethiopia
July 1995	Mad Cow Disease	U.K.
Feb. 1995	Pneumonia	U.S.



# Relation Extraction: Protein Interactions

“We show that CBF-A and CBF-C interact with each other to form a CBF-A-CBF-C complex and that CBF-B does not interact with CBF-A or CBF-C individually but that it associates with the CBF-A-CBF-C complex.”

CBF-A  $\xleftrightarrow[\text{complex}]{\text{interact}}$  CBF-C

CBF-B  $\xrightarrow{\text{associates}}$  CBF-A-CBF-C complex

# Resolving coreference (both within and across documents)

John Fitzgerald Kennedy was born at 83 Beals Street in Brookline, Massachusetts on Tue 29, 1917, at 3:00 pm,[7] the second son of Joseph P. Kennedy, Sr. and Rose Fitzgerald; R turn, was the eldest child of John "Honey Fitz" Fitzgerald, a prominent Boston political fi was the city's mayor and a three-term member of Congress. Kennedy lived in Brookline years and attended Edward Devotion School, Noble and Greenough Lower School, and the School, through 4th grade. In 1927, the family moved to 5040 Independence Avenue in l Bronx, New York City: two years later, they moved to 294 Pondfield Road in Bronxville, N where Kennedy was a member of Scout Troop 2 (and was the first Boy Scout to become President).[8] Kennedy spent summers with his family at their home in Hyannisport, Massachusetts, and Christmas and Easter holidays with his family at their winter home in Beach, Florida. For the 5th through 7th grade, Kennedy attended Riverdale Country School, a private school for boys. For 8th grade in September 1930, the 13-year old Kennedy attended Canterbury School in New Milford, Connecticut.



# Rough Accuracy of Information Extraction

Information type	Accuracy
Entities	90-98%
Attributes	80%
Relations	60-70%
Events	50-60%

- Errors cascade (error in entity tag → error in relation extraction)
- These are very rough, actually optimistic, numbers
  - Hold for well-established tasks, but lower for many specific/novel IE tasks

# What we will cover in this class (briefly)

- PART I: basic information extraction (through Named Entity Recognition)
  - History of IE, Related Fields
  - Source Selection
  - Tokenization and Normalization
  - Named Entity Recognition (NER)

# What we will cover in this class (briefly)

- PART II: machine learning in depth (mostly tagging models used for named entities)
  - Decision Trees and Overfitting
  - Linear Models
  - Feature Engineering
  - Word Embeddings
  - Deep Learning (Non-Linear Models)
  - In the seminar: the practical exercises will be on practical classification (you are also invited to these even if you are not in the seminar!)

# What we will cover in this class (briefly)

- PART III: advanced information extraction
  - Instance Extraction
  - Fact/Event Extraction
  - Ontological IE/Open IE
  - Sentiment Analysis

# Last words

- The seminar tomorrow is cancelled, but I will be there in case you need to discuss something
  - Topics will be presented next week (twice, once in each group)
- Also, don't forget the reading for next week!
- **Sarawagi: Information Extraction** (available from web page)  
Read the introduction!
- These slides will be uploaded as well

- Thank you for your attention!