Information Extraction

Information Extraction (IE)

- Identify specific pieces of information (data) in a unstructured or semi-structured textual document.
- Transform unstructured information in a corpus of documents or web pages into a structured database.
- Applied to different types of text:
  - Newspaper articles
  - Web pages
  - Scientific articles
  - Newsgroup messages
  - Classified ads
  - Medical notes

MUC

- DARPA funded significant efforts in IE in the early to mid 1990's.
- Message Understanding Conference (MUC) was an annual event/competition where results were presented.
- Focused on extracting information from news articles:
  - Terrorist events
  - Industrial joint ventures
  - Company management changes
- Information extraction of particular interest to the intelligence community (CIA, NSA).

Other Applications

- Job postings
- Job resumes
- Seminar announcements
- Company information from the web
- Apartment rental ads
- Molecular biology information from MEDLINE

Sample Job Posting

Subject: US-TN-SOFTWARE PROGRAMMER
Date: 17 Nov 1996 17:37:29 GMT
Organization: Reference.Com Posting Service
Message-ID: <56nigp$mrs@bilbo.reference.com>

SOFTWARE PROGRAMMER

Position available for Software Programmer experienced in generating software for PC-Based Voice Mail systems. Experienced in C Programming. Must be familiar with communicating with and controlling voice cards; preferable Dialogic, however, experience with others such as Rhetorix and Natural Microsystems is okay. Prefer 5 years or more experience with PC Based Voice Mail, but will consider as little as 2 years. Need to find a Senior level person who can come on board and pick up code with very little training. Present Operating System is DOS. May go to OS-2 or UNIX in future.

Please reply to:
Kim Anderson
AdNET
(901) 458-2888 fax
kimander@memphisonline.com

Extracted Job Template

computer_science_job
id: 56nigp$mrs@bilbo.reference.com
title: SOFTWARE PROGRAMMER
salary:
company:
recruiter:
state: TN
city:
country: US
language: C
platform: PC \ DOS \ OS-2 \ UNIX
application:
area: Voice Mail
req_years_experience: 2
desired_years_experience: 5
req_degree:
desired_degree:
post_date: 17 Nov 1996

Amazon Book Description

```
….
</td></tr>
</table>
<b class="sans">The Age of Spiritual Machines : When Computers Exceed Human Intelligence</b><br>
<font face=verdana,arial,helvetica size=-1>
by <a href="/exec/obidos/search-handle-url/index=books&field-author=
            Kurzweil%2C%20Ray/002-6235079-4593641">
Ray Kurzweil</a><br>
</font>
<br>
<a href="http://images.amazon.com/images/P/0140282025.01.LZZZZZZZ.jpg">
<img src="http://images.amazon.com/images/P/0140282025.01.MZZZZZZZ.gif" width=90
   height=140 align=left border=0></a>
<font face=verdana,arial,helvetica size=-1>
<span class="small">
<span class="small">
<b>List Price:</b> <span class=listprice>$14.95</span><br>
<b>Our Price: <font color=#990000>$11.96</font></b><br>
<b>You Save:</b> <font color=#990000><b>$2.99 </b>
(20%)</font><br>
</span>
<p> <br>…
```

Extracted Book Template

Title: The Age of Spiritual Machines :
When Computers Exceed Human Intelligence
Author: Ray Kurzweil
List-Price: $14.95
Price: $11.96
:
:

Web Extraction

- Many web pages are generated automatically from an underlying database.
- Therefore, the HTML structure of pages is fairly specific and regular (*semi-structured*).
- However, output is intended for human consumption, not machine interpretation.
- An IE system for such generated pages allows the web site to be viewed as a structured database.
- An extractor for a semi-structured web site is sometimes referred to as a *wrapper*.
- Process of extracting from such pages is sometimes referred to as *screen scraping*.

Template Types

- Slots in template typically filled by a substring from the document.
- Some slots may have a fixed set of pre-specified possible fillers that may not occur in the text itself.
  - Terrorist act: threatened, attempted, accomplished.
  - Job type: clerical, service, custodial, etc.
  - Company type: SEC code
- Some slots may allow multiple fillers.
  - Programming language
- Some domains may allow multiple extracted templates per document.
  - Multiple apartment listings in one ad

Simple Extraction Patterns

- Specify an item to extract for a slot using a regular expression pattern.
  - Price pattern: "\b\$\d+(\.\d{2})?\b"
- May require preceding (pre-filler) pattern to identify proper context.
  - Amazon list price:
    - Pre-filler pattern: "List Price: "
    - Filler pattern: "\$\d+(\.\d{2})?\b"
- May require succeeding (post-filler) pattern to identify the end of the filler.
  - Amazon list price:
    - Pre-filler pattern: "List Price: "
    - Filler pattern: ".+"
    - Post-filler pattern: ""

Pre-Specified Filler Extraction

- If a slot has a fixed set of pre-specified possible fillers, text categorization can be used to fill the slot.
  - Job category
  - Company type
- Treat each of the possible values of the slot as a category, and classify the entire document to determine the correct filler.

Natural Language Processing

- If extracting from automatically generated web pages, simple regex patterns usually work.
- If extracting from more natural, unstructured, human-written text, some NLP may help.
  - Part-of-speech (POS) tagging
    - Mark each word as a noun, verb, preposition, etc.
  - Syntactic parsing
    - Identify phrases: NP, VP, PP
  - Semantic word categories (e.g. from WordNet)
    - KILL: kill, murder, assassinate, strangle, suffocate
- Extraction patterns can use POS or phrase tags.
  - Crime victim:
    - Prefiller: [POS: V, Hypernym: KILL]
    - Filler: [Phrase: NP]

Learning for IE

- Writing accurate patterns for each slot for each domain (e.g. each web site) requires laborious software engineering.
- Alternative is to use machine learning:
  - Build a training set of documents paired with human-produced filled extraction templates.
  - Learn extraction patterns for each slot using an appropriate machine learning algorithm.
- Rapier system learns three regex-style patterns for each slot:
  - Pre-filler pattern
  - Filler pattern
  - Post-filler pattern

Evaluating IE Accuracy

- Always evaluate performance on independent, manually-annotated test data not used during system development.
- Measure for each test document:
  - Total number of correct extractions in the solution template: *N*
  - Total number of slot/value pairs extracted by the system: *E*
  - Number of extracted slot/value pairs that are correct (i.e. in the solution template): *C*
- Compute average value of metrics adapted from IR:
  - Recall = *C*/*N*
  - Precision = *C*/*E*
  - F-Measure = Harmonic mean of recall and precision

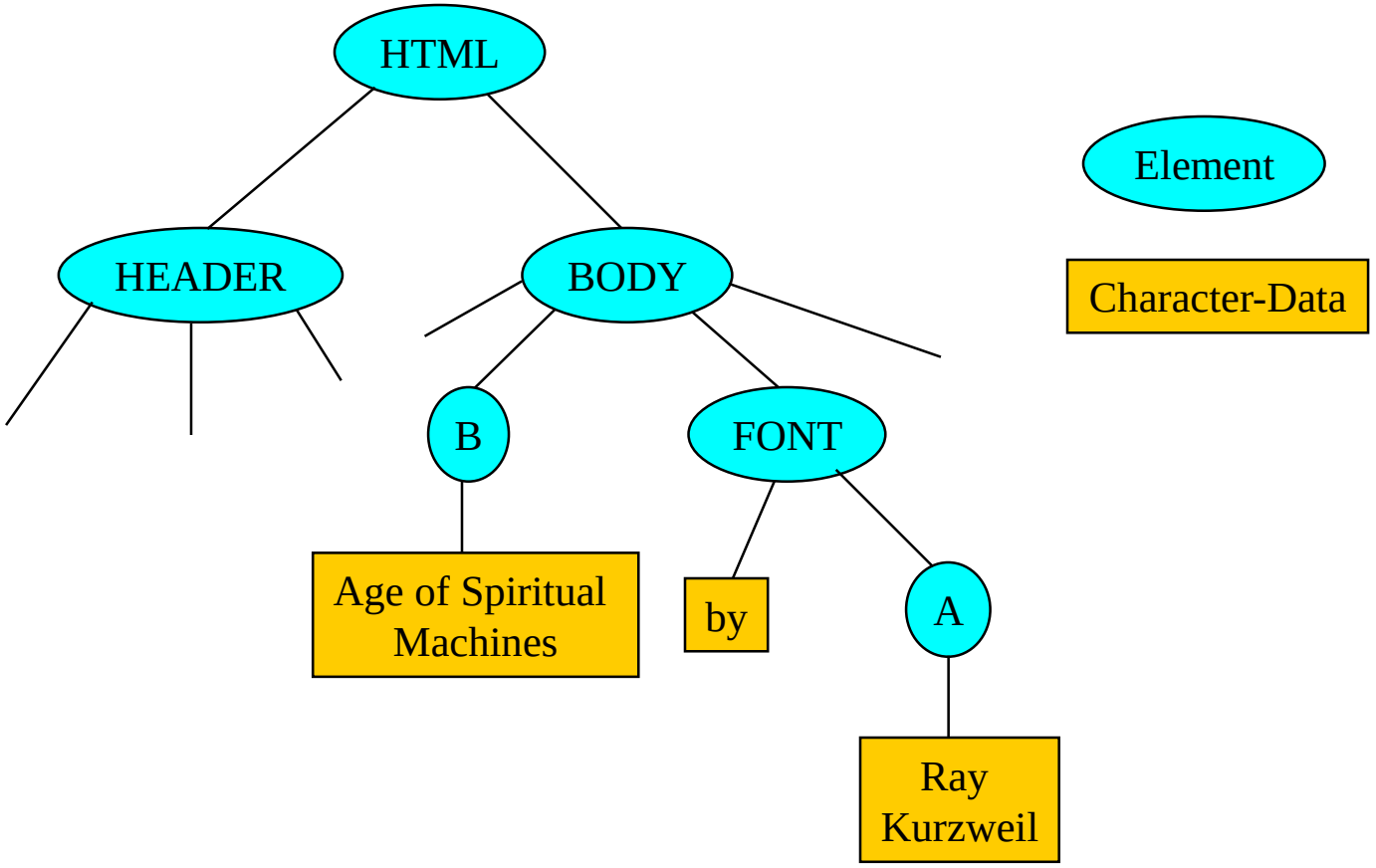
XML and IE

- If relevant documents were all available in standardized XML format, IE would be unnecessary.
- But…
  - Difficult to develop a universally adopted DTD format for the relevant domain.
  - Difficult to manually annotate documents with appropriate XML tags.
  - Commercial industry may be reluctant to provide data in easily accessible XML format.
- IE provides a way of automatically transforming semi-structured or unstructured data into an XML compatible format.

Web Extraction using DOM Trees

- Web extraction may be aided by first parsing web pages into DOM trees.
- Extraction patterns can then be specified as paths from the root of the DOM tree to the node containing the text to extract.
- May still need regex patterns to identify proper portion of the final CharacterData node.

Sample DOM Tree Extraction



Title: HTML→BODY→B→CharacterData

Author: HTML→ BODY→FONT→A→ CharacterData

Shop Bots

- One application of web extraction is automated comparison shopping systems.
- System must be able to extract information on items (product specs and prices) from multiple web stores.
- User queries a single site, which integrates information extracted from multiple web stores and presents overall results to user in a uniform format, e.g. ordered by price.

Information Integration

- Answering certain questions using the web requires integrating information from multiple web sites.
- Information integration concerns methods for automating this integration.
- Requires wrappers to accurately extract specific information from web pages from specific sites.
- Treat each wrapped site as a database table and answer complex queries using a database query language (e.g. SQL).

Information Integration Example

- Question: What is the closest theater to my home where I can see both “Doctor Strange” and “Jason Bourne”?
  - From movie listing site, extract theaters and their addresses where. are playing.
  - Intersect the two to find the theaters playing both.
  - Query map site for driving directions from your home address to the address of each of these theaters.
  - Extract distance and driving instructions for each.
  - Sort results by driving distance.
  - Present driving instructions for closest theater.