

Introduction

Text

Speech

Searching in a
Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches
with regular
expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

Language and Computers (Ling 384)

Topic 2: Searching

Arantxa Martin-Lozano*

Dept. of Linguistics, OSU

Autumn 2006

* The course was created by Chris Brew, Detmar Meurers and Markus Dickinson.

Introduction

Topic 2: Searching

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

Introduction

Searching in a Library Catalogue

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

Introduction

Searching in a Library Catalogue

Searching the web

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

Introduction

Searching in a Library Catalogue

Searching the web

Advanced searches with regular expressions

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

- ▶ A breathtaking number of information resources are available: books, databases, the web, newspapers, . . .
- ▶ To locate relevant information, we need to be able to search these resources, which often are **written texts**:
 - ▶ Searching in a library catalogue (e.g., using **OSCAR**)
 - ▶ Searching the web (e.g., using **Google**)
 - ▶ Advanced searching in text corpora (using regular expressions) (e.g., using **Opus**)

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

- ▶ One might also want to search for **speech**, e.g., to find a particular sentence spoken in an interview one only has a recording (audio file) of.
- ▶ With current technology, this is only possible if the interview is transcribed, using the IPA or another writing system.
- ▶ It is, however, already possible to
 - ▶ detect the language of a spoken conversation, e.g., when listening in to a telephone conversation
 - ▶ detect a new topic being started in a conversation
- ▶ In the following, we focus on searching in text.

Searching in a library catalogue

- ▶ To find articles, books, and other library holdings, a library generally provides a **database** containing information on its holdings.
- ▶ OSCAR is the **database frontend** providing access to the library database at OSU.
- ▶ OSCAR makes it possible to search for the occurrence of **literal strings** occurring in the author, title, keywords, call number, etc. associated with an item held by the library.

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

Basic searching in OSCAR

- ▶ Literal strings are composed of characters which naturally must be in the same character encoding system (e.g. ASCII, ISO8859-1, UTF-8) as the strings encoded in the database.
- ▶ For literal strings, OSCAR does not distinguish between upper and lower-case letters (i.e. they aren't so literal after all ;-)
- ▶ Adjacent words are searched as a phrase.
 - ▶ art therapy
 - ▶ vitamin c
- ▶ In addition to **querying** literal strings, the **query language** of OSCAR also supports the use of
 - ▶ **special characters** to abbreviate multiple options
 - ▶ special **operators** for combining two query strings (boolean operators) or modifying the meaning of a single string (unary operators)

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

OSCAR: Special characters

- ▶ Use * for 1–5 characters at end or within a word.
 - ▶ `art*` finds arts, artists, artistic
 - ▶ `gentle*n`
- ▶ Use ** for any number of characters at end of word.
`art**` finds artificial, artillery
- ▶ Use ? for a single character at end or within a word.
`gentlem?n`
- ▶ The special * and ? characters must have at least 2 characters to their left. (→ for efficiency reasons)

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

OSCAR: Literal Strings and Operators (I)

- ▶ Use and or or to specify multiple words in any field, any order.
 - ▶ art and therapy
 - ▶ art or therapy
 - ▶ c+ or c++
- ▶ Use and not to exclude words.
art and not therapy

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

OSCAR: Operators (II)

- ▶ Use parentheses to group words together when using more than one operator.
art therapy and not ((music or dance) therapy)
- ▶ Use near to specify words within 10 words of each other, in any order.
 - ▶ art near therapy
- ▶ Use within n to specify words within n words of each other. The value of n has no limit.
 - ▶ art within 12 therapy

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

A computer user

- ▶ wants to find something on “the web”, i.e., in files accessible via the **hypertext transfer protocol (http)** protocol on the internet
- ▶ goes to a **search engine** = program that matches documents to a user’s search requests
- ▶ enters a **query** = request for information
- ▶ gets a list of websites that might be relevant to the query
- ▶ **evaluates the results**: either picks a website with the information looked for or reformulates the query

The nature of the web

- ▶ Web pages are generally less structured than a record in a library database (with title, author, subject, and other fields).
- ▶ One generally searches for words found anywhere in the document.
- ▶ It is, however, possible to include **meta data** in a web page.
- ▶ Meta data is additional, structured information that is not shown in the web page itself: e.g., the language a web page is in, its character encoding, author, keywords, etc.
- ▶ Example for a **meta tag**: `<META name="keywords" lang="en-us" content="vacation, Greece">`

Introduction

Text
Speech

Searching in a Library Catalogue

Special characters
Operators

Searching the web

Operators
Improving searching
Ranking of results
Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions
Grep: An example for using
regular expressions
Text corpora and searching
them

- ▶ Search engines (e.g., Google)
 - ▶ store a copy of all web pages
 - ▶ create an **index** to provide efficient access to this large number of pages (e.g., Google currently searches over 4 billion pages)
 - ▶ compute a rank for each web page to be able to rank the query results
- ▶ Search engines differ in various ways:
 - ▶ **stemming**: treat *bird* and *birds* as the same or not
 - ▶ **capitalization**: treat *trip* and *Trip* the same or not
 - ▶ use of **operators**
 - ▶ special interface for advanced searching
 - ▶ how search results are **ranked**
 - ▶ **clustering**: group similar results or not

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

- ▶ +: Require a word to occur in the result
e.g., To find a restaurant that serves both tofu and BBQ
one could try +tofu +BBQ.
- ▶ -: Disallow a word from occurring in the result
e.g., As a *potatos* purist, I search for potatos
-potatoes
- ▶ ~: Include synonyms of the word
- ▶ Quotation Marks (phrases)
e.g., "What Cheer" when looking for sites on *What
Cheer, Iowa*

Google: Operators (II)

- ▶ `intitle:` Find words used in a title
 - ▶ e.g., `intitle:Buckeye` finds only web pages which has this word in the title
- ▶ `inurl:` Find words used in the url
 - ▶ e.g., `inurl:ling` returns more linguistics webpages than `ling` does
- ▶ `link:` Find pages that link to a certain page
 - ▶ e.g., `link:www.osu.edu` to show pages linking to the main osu web page
- ▶ `site:` Find pages that are part of a single domain
 - ▶ e.g., I want to find strange attractions involving fish. Knowing one site which has such stuff, one can try `fish site:www.roadsideamerica.com`.

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

More elaborate **web forms** are provided as alternative to using operators:

- ▶ match all: matches all terms in your query
- ▶ match any: matches as many terms in your query as it can find
e.g., I'm looking for a restaurant that has *bbq* or *bb-que* or *barbeque* in the title
⇒ most search engines return “match all” followed by “match any” results
- ▶ exclude: eliminate documents which contain certain words

Introduction

Text
Speech

Searching in a Library Catalogue

Special characters
Operators

Searching the web

Operators

Improving searching
Ranking of results
Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions
Grep: An example for using regular expressions
Text corpora and searching them

Improving searching (I)

Introduction

Text
Speech

Searching in a Library Catalogue

Special characters
Operators

Searching the web

Operators

Improving searching

Ranking of results
Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions
Grep: An example for using
regular expressions
Text corpora and searching
them

How can I make my searches better?

- ▶ Be on the watch for **ambiguity** = one word has multiple meanings
e.g., *bed*: flower bed, sleeping bed, truck bed
- ▶ Use **synonyms** and other related words
e.g., *plant*: building, complex, works, power (distinguish from flora)
- ▶ Be aware of **stop words** = words that search engines ignore because they are “uninformative,” such as *the*, *of*, and so on
e.g., *The Police* won't help you find the rock band any more than *Police* will

Improving searches (II)

- ▶ Exclude problematic words
e.g., “jefferson airplane -starship” (if you don’t want info on the Starship years)
- ▶ Be aware of **parts of speech** and what other guises they come in.
e.g., *plant*: planting, planter, planted (distinguish from *power plant*)
- ▶ Continually narrow your focus (using the feedback)
e.g., Want to find information on the game *Hearts*
 1. *hearts*: too vague, too many non-card game sites → add a related word
 2. *hearts cards*: better, but still greeting cards listed → I see *trick* listed on one site’s description and realize this makes for a good keyword
 3. *hearts cards trick*: good, but now we get card tricks → time for boolean expressions

Introduction

Text
Speech

Searching in a Library Catalogue

Special characters
Operators

Searching the web

Operators

Improving searching

Ranking of results
Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions
Grep: An example for using
regular expressions
Text corpora and searching
them

Ranking of results

- ▶ Ideally, the webpages matching a query are returned as an ordered list based on a page's **relevance**.
- ▶ How can a search engine, which does not understand language, determine the relevance of a particular page?

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

Information used to rank results

- ▶ Counting the number of links to and from a page, to determine how popular a page is. (As a result, unpopular or new pages require a more specific query to be found.)
- ▶ Keeping track of the nature of links to a page; linked pages might be thematically related.
e.g., Even if I never mention Sinclair Lewis on a page describing his book *Babbitt*, it can be identified if many Sinclair Lewis sites link to my page.
- ▶ bonuses/penalties for sites known to be of high/low quality
- ▶ looking for **keywords in metadata**
- ▶ counting how often a web result was clicked on by a user (**click-through measurement**)
- ▶ various secret ingredients

Introduction

Text
Speech

Searching in a Library Catalogue

Special characters
Operators

Searching the web

Operators
Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions
Grep: An example for using
regular expressions
Text corpora and searching
them

What measures can one use to evaluate how successful a query is?

- ▶ **precision:** How many of the pages returned are the ones we want?
e.g., Google gives me 400 hits for a query, 200 of which are related to the topic I want; precision = 50%.
- ▶ **recall:** How many pages on the topic we wanted were actually given? (hard to calculate for web searching)
e.g., Google gave me 200 pages I wanted, but there were actually 1000 pages on that topic out there somewhere on the internet; recall = 20%.

We saw earlier how to use our initial results to refine our query and improve precision

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

Introduction

Text

Speech

Searching in a
Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches
with regular
expressions

Syntax of regular expressions

Grep: An example for using
regular expressionsText corpora and searching
them

Motivating regular expressions

If one wants to be able to describe more complex patterns of words and text, sometimes boolean expressions aren't enough:

- ▶ In a large document I want to find addresses with a zip code starting with 911 (around Pasadena, CA); but clearly we would not want to report back all occurrences of emergency phone numbers in the document.
- ▶ I want to find all osu email addresses which occur in a long text.
- ▶ I'm writing an online fill-in-the-blank quiz, and I ask you to name the Jackson 5: for Jermaine, I want to accept *Germaine*, *Germane*, *Jermain*, and so on.
⇒ It would be nice to have a compact way of representing all of these options.
- ▶ Anything where you have to match a complex pattern so-called **regular expressions** are useful.

Regular expressions: What they are

- ▶ A regular expression is a compact description of a set of strings, i.e., a language (in **formal language** theory).
- ▶ They can be used to search for occurrences of these strings
- ▶ Regular expressions can only describe so-called **regular languages**.
- ▶ This means that some patterns cannot be specified using regular expressions, e.g., finding a string containing any number of **as** followed by exactly the same number of **bs**.
- ▶ Note that just like any other formalism, regular expressions as such have no linguistic contents, but they can be used to refer to strings encoding a **natural language** text.

Introduction

Text
Speech

Searching in a Library Catalogue

Special characters
Operators

Searching the web

Operators
Improving searching
Ranking of results
Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions
Grep: An example for using
regular expressions
Text corpora and searching
them

Regular expressions: Tools that use them

- ▶ A variety of unix tools (grep, sed, ...), editors (emacs, ...), and programming languages (perl, python, ...) incorporate regular expressions.
- ▶ Implementations are very efficient so that large text files can be searched quickly; but not efficient enough for web searching → no web search engine offers them (yet).
- ▶ The various tools and languages differ w.r.t. the exact syntax of the regular expressions they allow.

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

The syntax of regular expressions (I)

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

Regular expressions consist of

- ▶ strings of literal characters: `c`, `A100`, `natural language`, `30 years!`
- ▶ disjunction:
 - ▶ ordinary disjunction: `devoured|ate`, `famil(y|ies)`
 - ▶ character classes: `[Tt]he`, `bec[oa]me`
 - ▶ ranges: `[A-Z]` (any capital letter)
- ▶ negation:
 - `[^a]` (any symbol but a)
 - `[^A-Z0-9]` (not an uppercase letter or number)

The syntax of regular expressions (II)

- ▶ counters
 - ▶ optionality: ?
colou?r
 - ▶ any number of occurrences: * (Kleene star)
[0-9]* years
 - ▶ at least one occurrence: +
[0-9]+ dollars
- ▶ wildcard for any character: .
beg.n for any character in between beg and n

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

The syntax of regular expressions (III)

- ▶ Escaped characters: to specify a character with a special meaning (*, +, ?, (,), |, [,]) it is preceded by a backslash (\)
e.g., a period is expressed as _
- ▶ Operator precedence, from highest to lowest:
 - parentheses ()
 - counters * + ?
 - character sequences
 - disjunction |

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

- ▶ grep is a powerful and efficient program for searching in text files using regular expressions.
- ▶ It is standard on Unix, Linux, and Mac OSX, and there also are various ports to Windows (e.g., <http://gnuwin32.sourceforge.net/packages/grep.htm>, <http://www.interlog.com/~tcharron/grep.html> or <http://www.wingrep.com/>).
- ▶ The version of grep that supports the full set of operators mentioned above is generally called egrep (for extended grep).

Grep: Examples for using regular expressions

(I)

In the following, we assume a text file `f.txt` containing, among others, the strings that we mention as matching.

- ▶ Strings of literal characters:
`egrep 'and' f.txt` matches and, Ayn Rand, Candy and so on
- ▶ Character classes:
`egrep 'the year [0-9][0-9][0-9][0-9]' f.txt` matches the year 1776, the year 1812, the year 2001, and so on
- ▶ Escaped characters:
`egrep 'why\?'` `f.txt` matches `why?`, whereas
`egrep 'why?'` `f.txt` matches `why` and `wh`

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

Grep: Examples for using regular expressions (II)

- ▶ disjunction (|):
egrep 'G|g' f.txt matches G or g, so egrep 'G|gouda' f.txt matches gouda or Gouda. Note that (G|g)ouda has the same effect.
- ▶ grouping with parentheses:
egrep 'un(interest|excit)ing' f.txt matches uninteresting or unexciting.
- ▶ Any character (.):
egrep 'o.e' f.txt matches ore, one, ole

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

Grep: Examples for using regular expressions (III)

- ▶ Kleene star (*):
egrep 'a*rgh' f.txt matches argh, aargh, aaargh
egrep 'sha(la)*' f.txt matches sha, shala, shalala, or if you're Van Morrison shalalalalalalalala
- ▶ One or more (+):
egrep 'john+y' f.txt matches johny, johnny, ..., but not johy
- ▶ Optionality (?):
egrep 'joh?n' f.txt matches jon and john

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

- ▶ A **corpus** is a collection of text.
- ▶ Corpora with the works of various writers, newspaper texts, etc. have been collected and electronically encoded.
- ▶ Corpora can be quite large
- ▶ The **British National Corpus** is a 100 million word collection representing a wide cross-section of current written and spoken British English.
- ▶ Another example is the **European Parliament Proceedings Parallel Corpus 1996–2003**.

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them

How corpora can be searched

- ▶ Both the BNC and the European Parliament corpus can be searched using on-line web-forms.
- ▶ Both of the web forms allow **regular expressions** for advanced searching.
- ▶ To provide efficient searching in large corpora, in these search engines regular expressions over characters are limited to single tokens (i.e. generally words).
- ▶ BNC:
 - ▶ web form: <http://sara.natcorp.ox.ac.uk/lookup.html>
 - ▶ regular expressions are enclosed in { }
- ▶ European Parliament Corpus:
 - ▶ web form: <http://logos.uio.no/cgi-bin/opus/opuscqp.pl?corpus=EUROPARL;lang=en>
 - ▶ in the simplest case, regular expressions are enclosed in " "

Introduction

Text

Speech

Searching in a Library Catalogue

Special characters

Operators

Searching the web

Operators

Improving searching

Ranking of results

Evaluating search results

Advanced searches with regular expressions

Syntax of regular expressions

Grep: An example for using
regular expressions

Text corpora and searching
them