

# Language and Computers (Ling 384)

## Topic 2: Searching

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Syntax of regular expressions
Grep: An example for using regular expressions
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## Outline

### Introduction

### Searching in a Library Catalogue

### Searching the web

### Advanced searches with regular expressions

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## Searching

- ▶ 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)

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

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## Searching in speech

- ▶ 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.

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## 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.

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## 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)

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## 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)

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## 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

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## 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

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## Searching the web

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### 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">`

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## Search engines

- ▶ 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

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## Google: Operators (I)

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- ▶ +: 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 *potatoes -potatoes*
- ▶ ~: Include synonyms of the word
- ▶ Quotation Marks (phrases)  
e.g., "What Cheer" when looking for sites on *What Cheer, Iowa*

## Google: Operators (II)

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- ▶ **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`.

## Google: Advanced searching

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

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## Improving searching (I)

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### 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)

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- ▶ 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

## 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?

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## 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

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## Evaluating search results

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

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## 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.

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## 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.

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## 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.

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## The syntax of regular expressions (I)

Regular expressions consist of

- ▶ strings of literal characters: `c`, `A100`, `natura1` 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)

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## 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`

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## 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 `|`

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## Grep

- ▶ `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`).

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# Grep: Examples for using regular expressions (I)

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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`

# Grep: Examples for using regular expressions (II)

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- ▶ 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`

# Grep: Examples for using regular expressions (III)

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- ▶ Kleene star (`*`):  
`egrep 'a*rg' f.txt` matches `argh`, `aargh`, `aaargh`  
`egrep 'sha(1a)*' 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`

# Corpora

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- ▶ 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.

# How corpora can be searched

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- ▶ 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/opuscp.pl?corpus=EUROPARL;lang=en>
  - ▶ in the simplest case, regular expressions are enclosed in `" "`