Natural Language Processing
CSCI 4152/6509 — Lecture 5
Basic NLP in Perl

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Location: Carleton Tupper Building Theatre C

Previous Lecture

- NFA-to-DFA translation (continued)
- Review of Regular Expressions
- Introduction to text processing with Perl

Perl Regular Expressions: ‘proc...ing’ Example

(*repeated slide*)

- Similar functionality as grep:

```
#!/usr/bin/perl
# run as: ./re-proc-ing.pl linux.words

while ($r = <>) {
  if ($r =~ /proc...ing/) {
    print $r;
  }
}
```

Shorter ‘proc...ing’ Code

- There are several ways how this program can made shorter: first, let us use the default variable ‘$_’:

```
while ($_ = <>) {
  if ($_ =~ /proc...ing/) {
    print $_;
  }
}
```

- Shorter version:

```
while (<>) {
  if (/proc...ing/) {
    print;
  }
}
```

Even Shorter ‘proc...ing’ Code

- and shorter:

```
while (<>) {
  print if (/proc...ing/);
}
```

- and shorter:

```
#!/usr/bin/perl -n
print if (/proc...ing/);
```

- or as a one-line command:

```
perl -ne ’print if /proc...ing/’
```

More Special Character Classes

`\d` — any digit

`\D` — any non-digit

`\w` — any word character

`\W` — any non-word character

`\s` — any space character

`\S` — any non-space character

A More Complete List of Iterators

`*`	example:	`\s*`
`+`	example:	`\d+`
`?`	example:	`\d?\d`
`{n}`	example:	`B\d{8}`
`{n,m}`	example:	`\w{3,5}`
`{n,}`	example:	`-{5,72}`
`{,m}`	example:	`.{,20}`

A More Complete List of Iterators

`*` — zero or more occurrence

`+` — one or more occurrences

`?` — zero or one occurrence

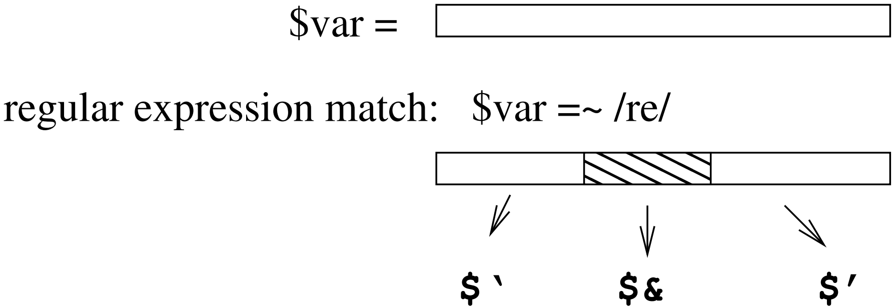
`{n}` — exactly n occurrences

`{n,m}` — between n and m occurrences

`{n,}` — at least n occurrences

`{,m}` — at most m occurrences

Some Special Variables Assigned After a Match in Perl



`$var =`

regular expression match: `$var =~ /re/`

``$` ``   `$&`   `$'`

Example: Counting Simple Words

```
#!/usr/bin/perl

my $wc = 0;
while (<>) {
    while (/\w+/) { ++$wc; $_ = $'; }
}
print "$wc\n";
```

Example: Counting Simple Words (2)

- Consider the following variation:

```
#!/usr/bin/perl

my $wc = 0;
while (<>) {
    while (/\w+/g) { ++$wc }
}
print "$wc\n";
```

Counting Words and Sentences

```
#!/usr/bin/perl
# simplified sentence end detection

my ($wc, $sc) = (0, 0);
while (<>) {
  while (/\w+|[.!?]+/) {
    my $w = $&; $_ = $’;
    if ($w =~ /^[.!?]+$/) { ++$sc }
    else { ++$wc }
  }
}
print "Words: $wc Sentences: $sc\n";
```

More on Perl RegEx'es

`\G`	anchor, end of the previous match
`(?=re)`	look-ahead
`(?!re)`	negative look-ahead
`(?<=re)`	look-behind
`(?<!re)`	negative look-behind

- Some examples:

`/foo(?!.*foo)/` — finding last occurrence of 'foo'
`s/(?<=\be)(?=mail)/-/g` — inserting hyphen
`/\b\w+(?<!s)\b/` — a word not ending with 's'

An Example with \G

```
while (<>) {
  while (1) {
    if    (/\G\w+/gc) { print "WORD: $&\n" }
    elsif (/\G\s+/gc) { print "SPACE\n" }
    elsif (/\G[.,;?!]/gc)
                      { print "PUNC: $&\n" }
    else { last }
  }
}
```

- Option g must be used with \G for global matching
- Option c prevents position reset after mismatch

Back References

- \1 \2 \3 . . . match parenthesized sub-expressions
- for example: /(a*)b\1/ matches $a^n b a^n$; such as b, aba, aabaa, . . .
- Sub-expressions are captured in (...)
- Aside, in grep: \(...\)
- (?:...) is grouping without capturing

Back Reference Examples

Consider examples:

`/(a+(b+))(c+(d+))\4/` and `/(a+(b+))(c+(d+))\3/`

Shortest Match

- default matching: left-most, longest match
- e.g., consider `/\d+/`
- Shortest match is sometimes preferred
  - e.g., consider: `/<div>.*<\/div>/` or `/<[^>]*>/` vs. `/<.*>/`
  - and: `/<div>.*?<\/div>/ and /<.*?>/`
- Shortest match iterators:
  `*? +? ?? {n}? {n,m}?`

Regular Expression Substitutions

- syntax: `s`/*re*/*sub*/*options*
- Some substitution options

  `c` – do not reset search position after /g fail

  `e` – evaluate replacement as expression

  `g` – replace globally (all occurrences)

  `i` – case-insensitive pattern matching

  `m` – treat string as multiple lines

  `o` – compile pattern only once

  `s` – treat string as a single line

  `x` – use extended regular expressions

Text Processing Example

- Perl is particularly well suited for text processing
- Easy use of Regular Expressions
- Convenient string manipulation
- Associative arrays
- Example: Counting Letters

Experiments on “Tom Sawyer”

- File: `TomSawyer.txt`:

```
The Adventures of Tom Sawyer

                                  by

                Mark Twain (Samuel Langhorne Clemens)

Preface
MOST of the adventures recorded in this book really occurred;
one or two were experiences of my own, the rest those of boys
who were schoolmates of mine. Huck Finn is drawn from life;
Tom Sawyer also, but not from an individual -- he is a
combination of the characteristics of three boys whom I knew,
and therefore belongs to the composite order of architecture.
```

Letter Count Total

```
#!/usr/bin/perl
# Letter count total

my $lc = 0;

while (<>) {
  while (/[a-zA-Z]/) { ++$lc; $_ = $’; }
}
print "$lc\n";

# ./letter-count-total.pl TomSawyer.txt
# 296605
```

Letter Frequencies

```
#!/usr/bin/perl
# Letter frequencies

while (<>) {
  while (/[a-zA-Z]/) {
    my $l = $&; $_ = $';
    $f{$l} += 1;
  }
}

for (keys %f) { print "$_ $f{$_}\n" }
```

Letter Frequencies Output

```
./letter-frequency.pl TomSawyer.txt
S 606
a 22969
T 1899
N 324
K 24
d 14670
Y 214
E 158
j 381
y 6531
u 8901
...
```

Letter Frequencies Modification

```
#!/usr/bin/perl
# Letter frequencies (2)

while (<>) {
  while (/[a-zA-Z]/) {
    my $l = $&; $_ = $’;
    $f{lc $l} += 1;
  }
}

for (sort keys %f) { print "$_ $f{$_}\n" }
```

New Output

```
./letter-frequency2.pl TomSawyer.txt
a 23528
b 4969
c 6517
d 14879
e 35697
f 6027
g 6615
h 19608
i 18849
j 639
k 3030
...
```

Letter Frequencies Modification (3)

```
#!/usr/bin/perl
# Letter frequencies (3)

while (<>) {
  while (/[a-zA-Z]/) {
    my $l = $&; $_ = $’;
    $f{lc $l} += 1; $tot ++;
  }
}

for (sort { $f{$b} <=> $f{$a} } keys %f) {
  print sprintf("%6d %.4lf %s\n",
              $f{$_}, $f{$_}/$tot, $_); }
```

Output 3

```
  35697 0.1204 e
  28897 0.0974 t
  23528 0.0793 a
  23264 0.0784 o
  20200 0.0681 n
  19608 0.0661 h
  18849 0.0635 i
  17760 0.0599 s
  15297 0.0516 r
  14879 0.0502 d
  12163 0.0410 l
   8959 0.0302 u
...
```

Elements of Morphology

- Reading: Section 3.1 in the textbook, “Survey of (Mostly) English Morphology”
- *morphemes* — smallest meaning-bearing units
- *stems* and *affixes*; stems provide the “main” meaning, while affixes act as modifiers
- affixes: prefix, suffix, infix, or circumfix
- cliticization — clitics appear as parts of a word, but syntactically they act as words (e.g., ’m, ’re, ’s)
- tokenization, stemming (Porter stemmer), lemmatization

Tokenization

- Text processing in which plain text is broken into words or *tokens*
- Tokens include non-word units, such as numbers and punctuation
- Tokenization may normalize words by making them lower-case or similar
- Usually simple, but prone to ambiguities, as most of the other NLP tasks

Stemming

- Mapping words to their *stems*
- Example: *foxes* → *fox*
- Use in Information Retrieval and Text Mining to normalize text and reduce high dimensionality
- Typically works by removing some suffixes according to a set of rules
- Best known stemmer: Porter stemmer