Andrei Zmievski, Yahoo! Inc.
andrei@gravitonic.com

php|tek 2006
Thursday 15:30-16:30

Andrei’s Regex Clinic

Andrei Zmievski, Yahoo! Inc.
andrei@gravitonic.com

php|tek 2006
Thursday 15:30-16:30

Andrei's Regex Clinic

Download this presentation from http://www.gravitonic.com/talks/

Andrei Zmievski, Yahoo! Inc.
andrei@gravitonic.com

php|tek 2006
Thursday 15:30-16:30

Andrei's Regex Clinic

Download this presentation from http://www.gravitonic.com/talks/

Andrei Zmievski, Yahoo! Inc.
andrei@gravitonic.com

php|tek 2006
Thursday 15:30-16:30

Andrei’s Regex Clinic

Download this presentation from http://www.gravitonic.com/talks/

about me

- PHP core developer since 1999
- Author of PHP-GTK, Smarty
- Core software engineer at Yahoo! Inc.
- Email: andrei@gravitonic.com

what's the plan?

- Introduction
- Syntax
- API
- Regex Toolkit
- Q & A

Excited

regular... expressions

Puzzled

regular... expressions

Angry

regular... expressions

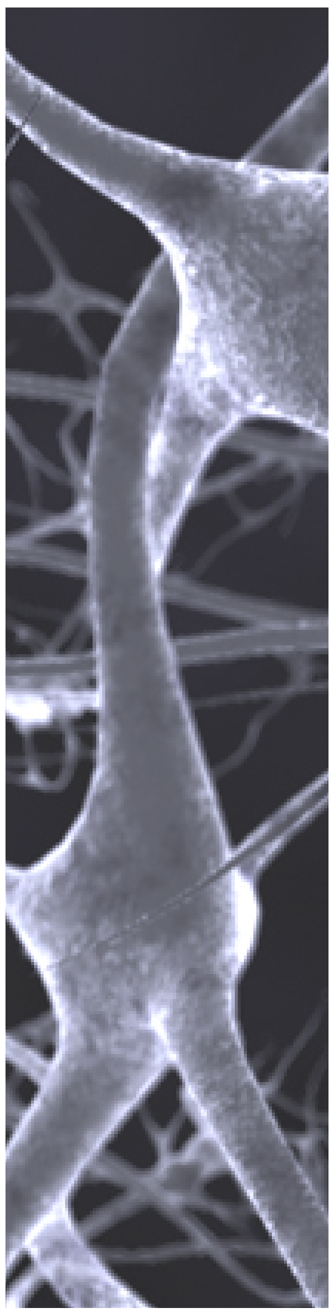
Scared

regular... expressions

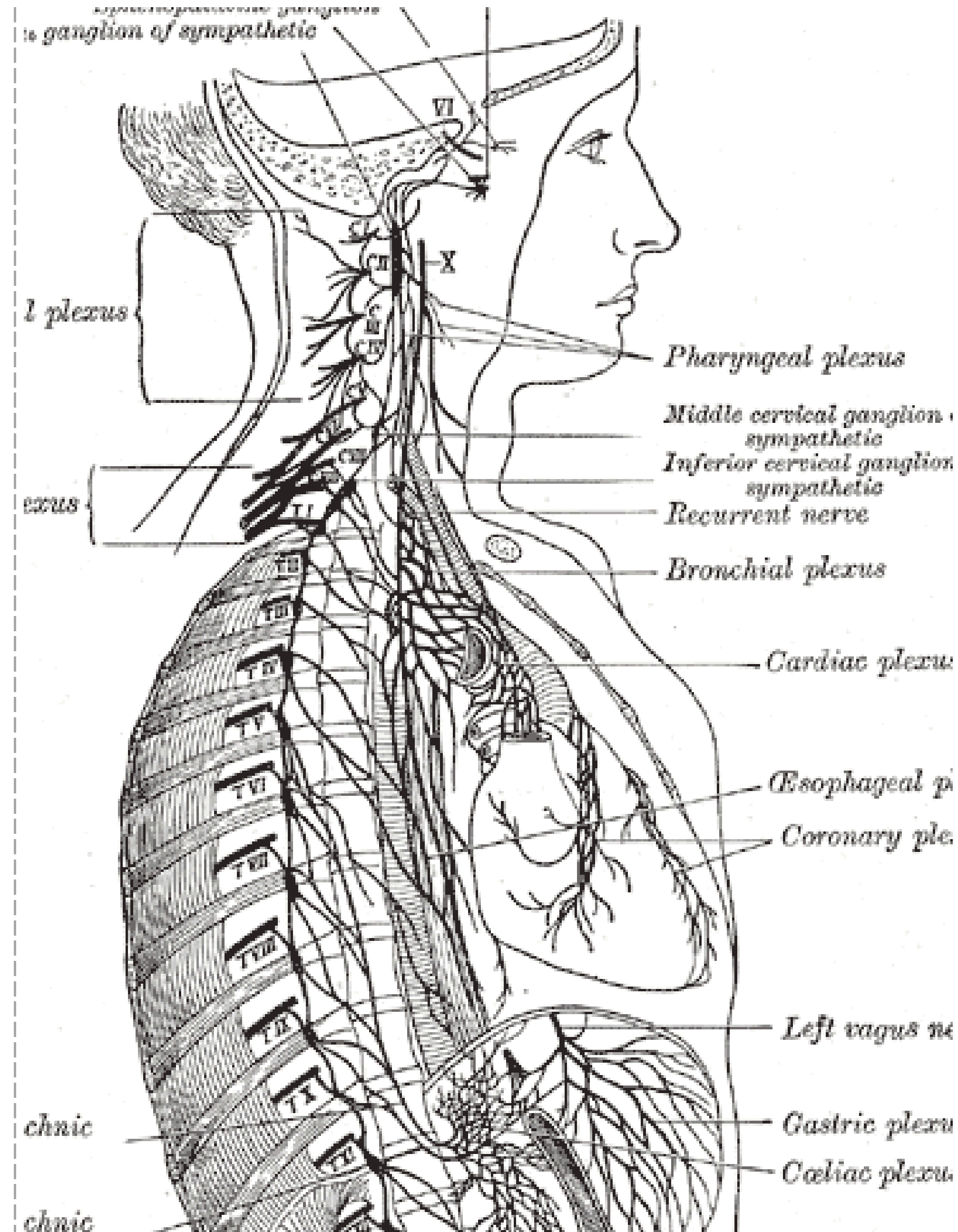
Confident

regular... expressions

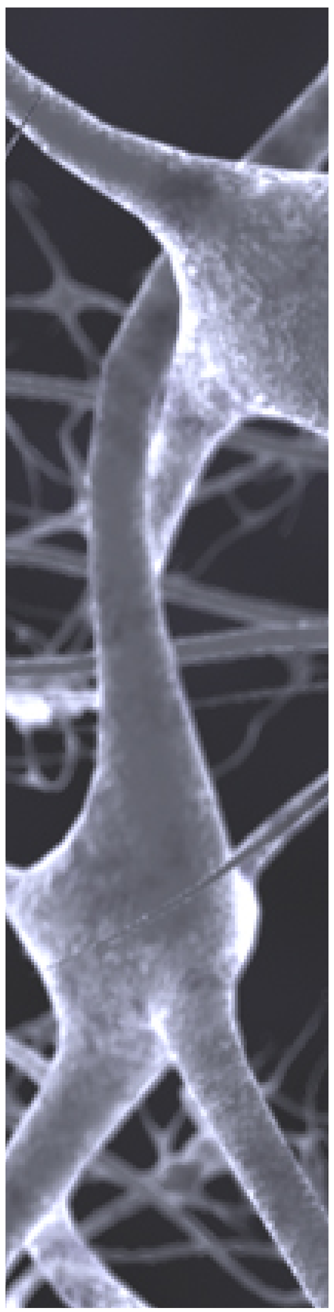
a bit of history



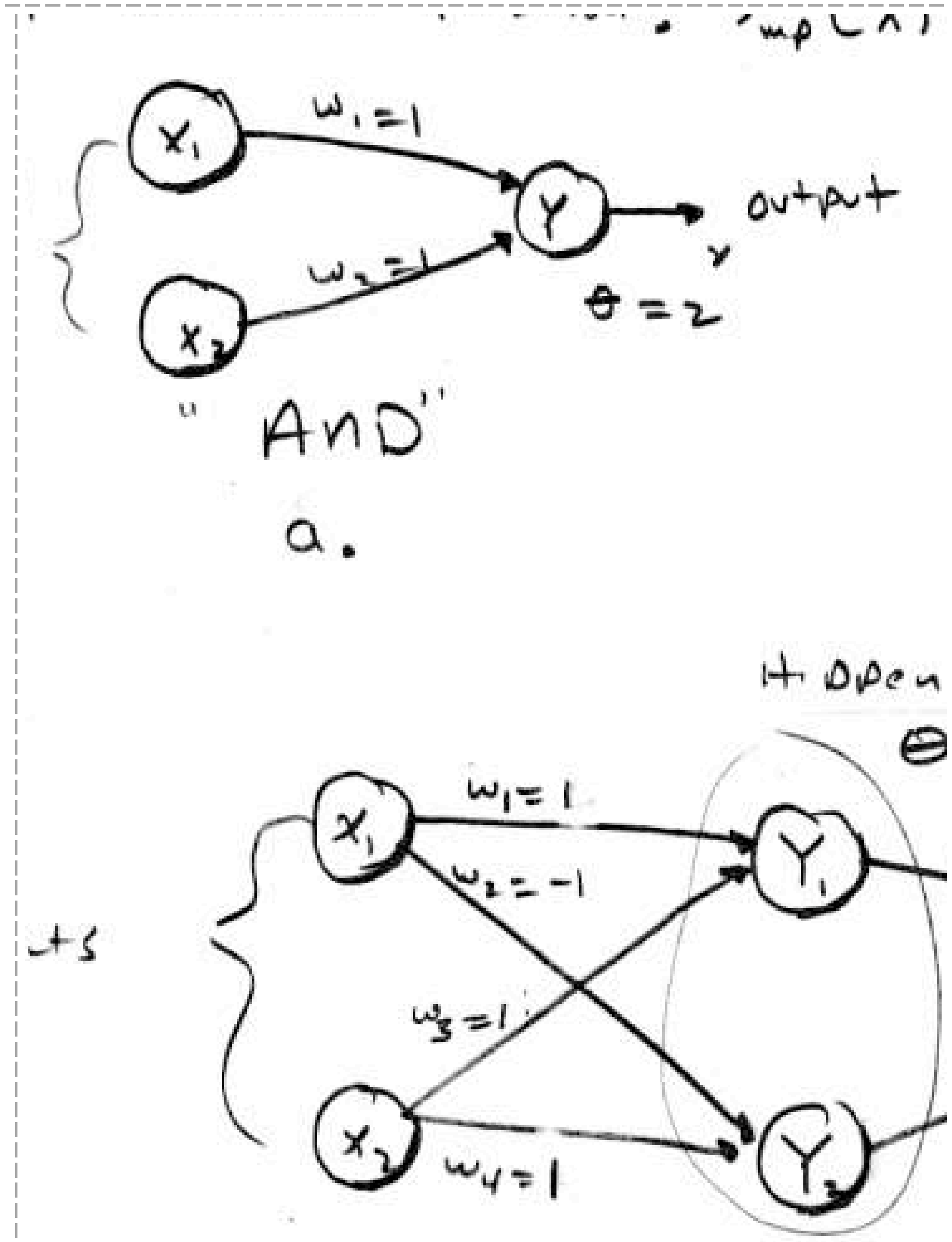
Regular expressions can be traced back to early research on the human nervous system



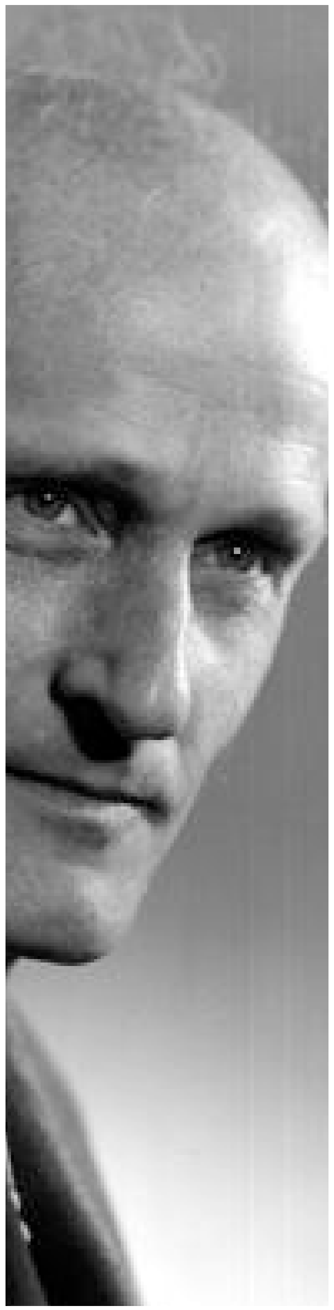
a bit of history



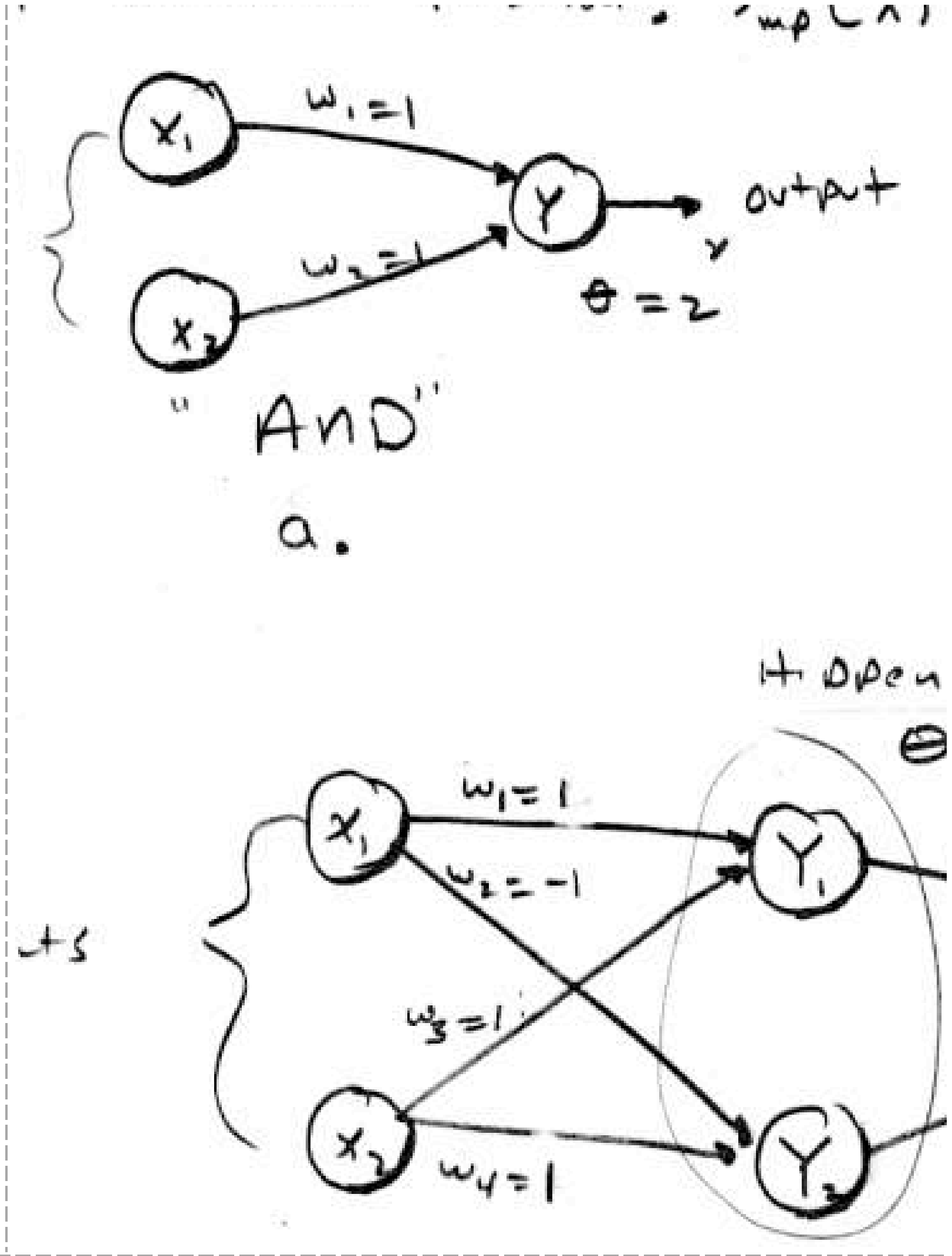
Neurophysiologists Warren McCulloch and Walter Pitts developed a mathematical way of describing the neural networks



a bit of history



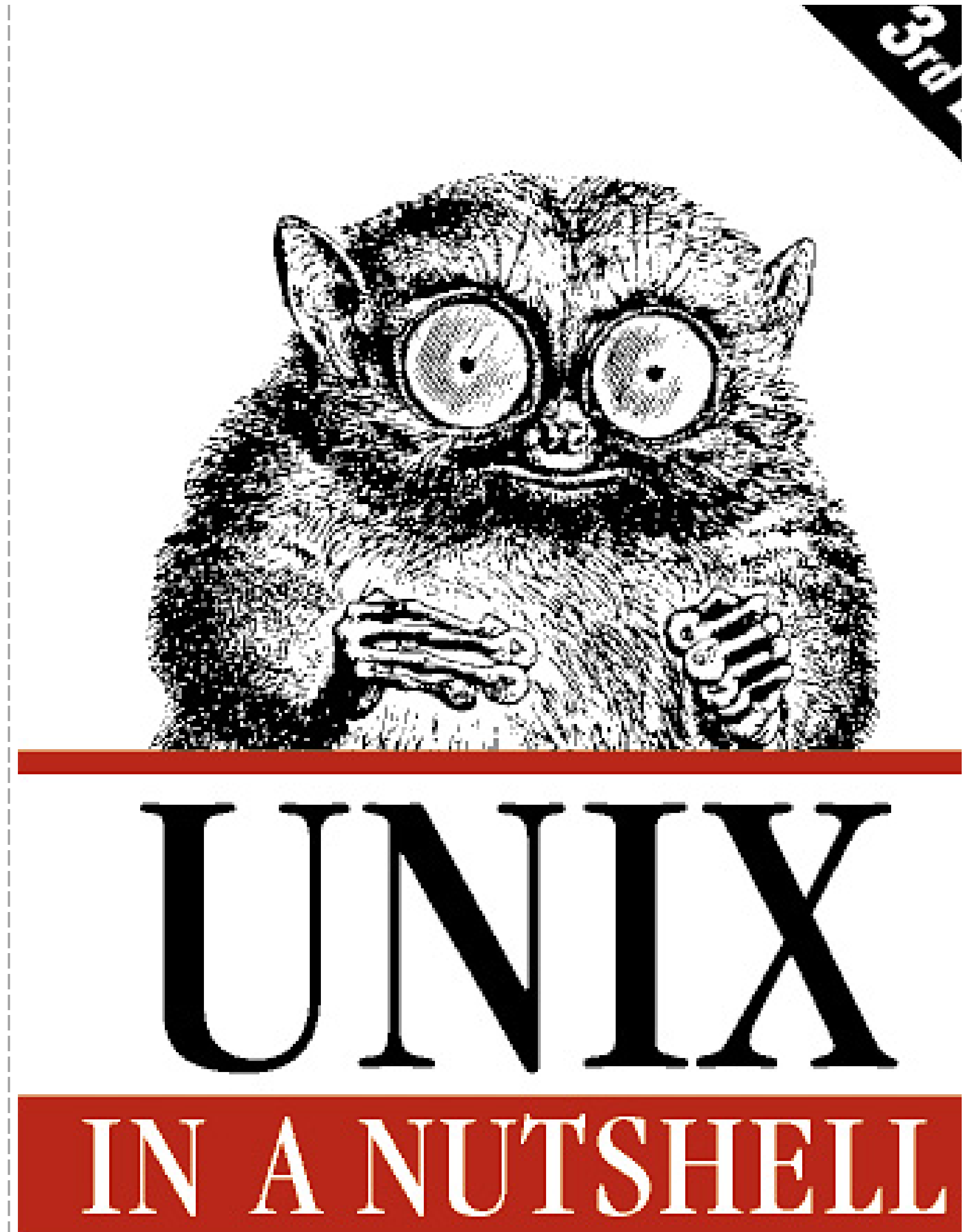
Later, mathematician Stephen Kleene published a paper that introduced the concept of regular expressions that were used to describe "the algebra of regular sets"



a bit of history

grep “^[A-Z]” *.txt

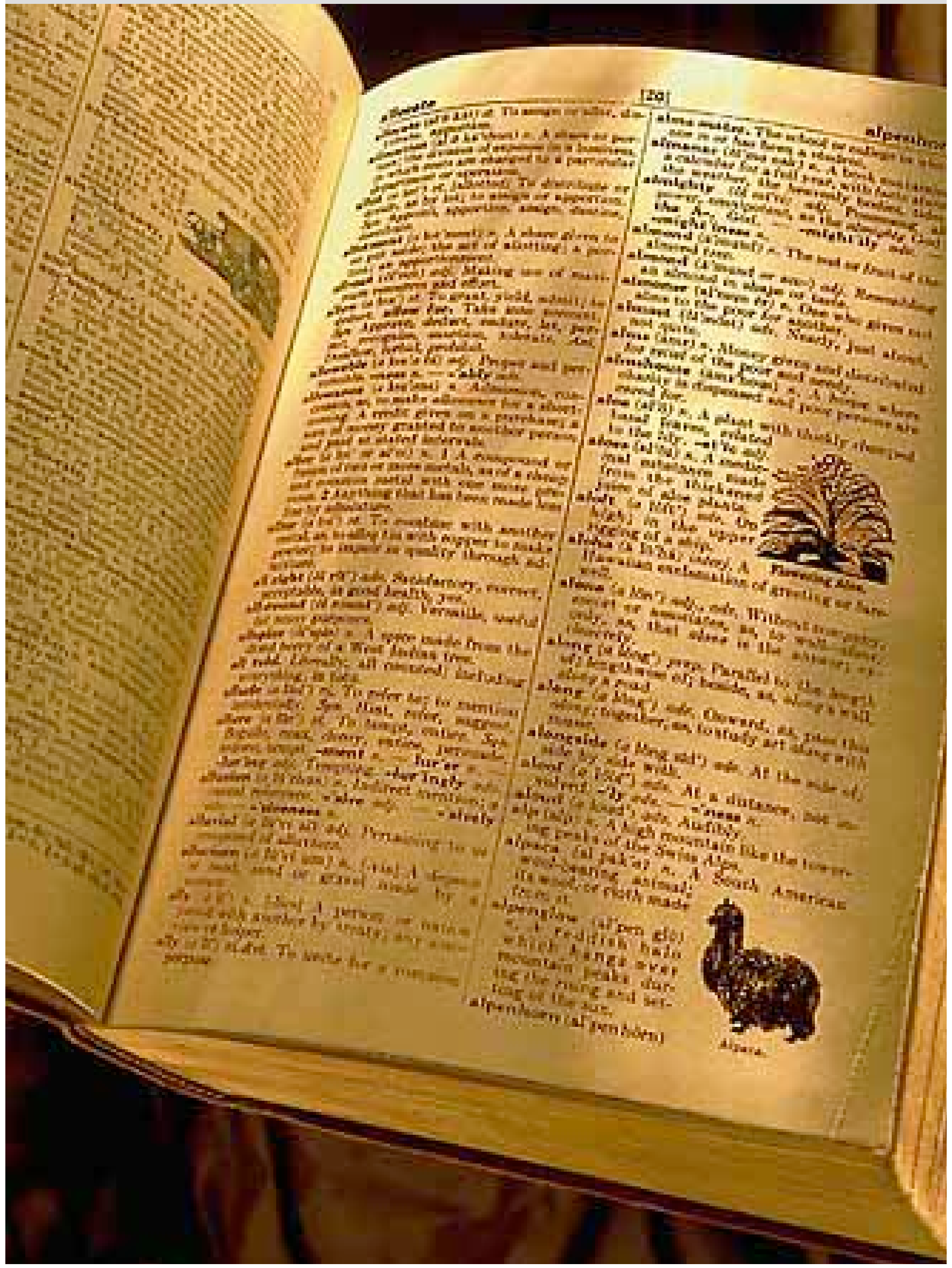
Ken Thompson, one of the fathers of Unix, found a practical application for them in the various tools of the early OS



what's it good for?

- Literal string searches are fast but inflexible
- With regular expressions you can:
  - Find out whether a certain pattern occurs in the text
  - Locate strings matching a pattern and remove them or replace them with something else
  - Extract the strings matching the pattern

terminology

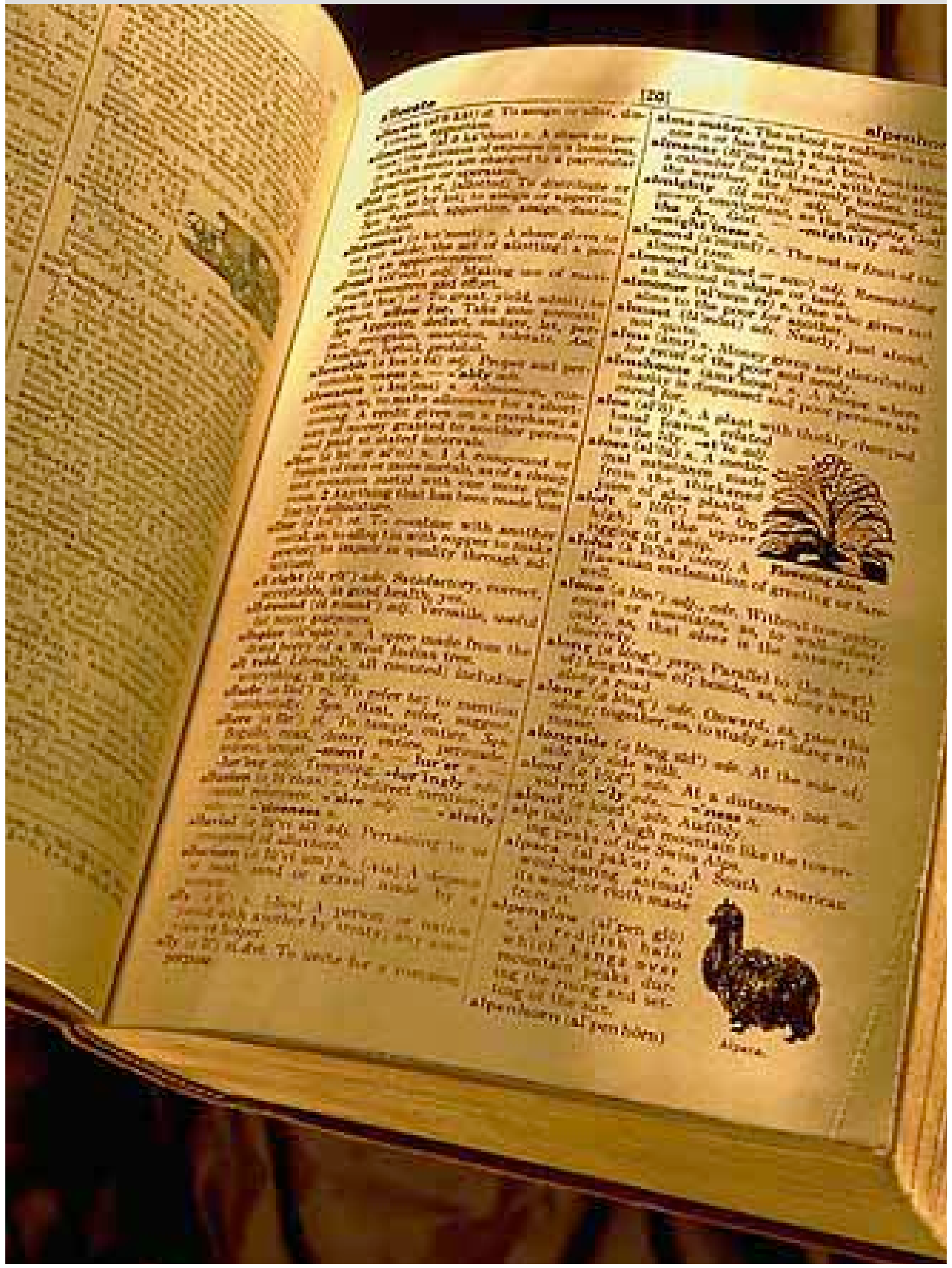


Regex

a pattern describing a set of strings

a b c d e f

terminology

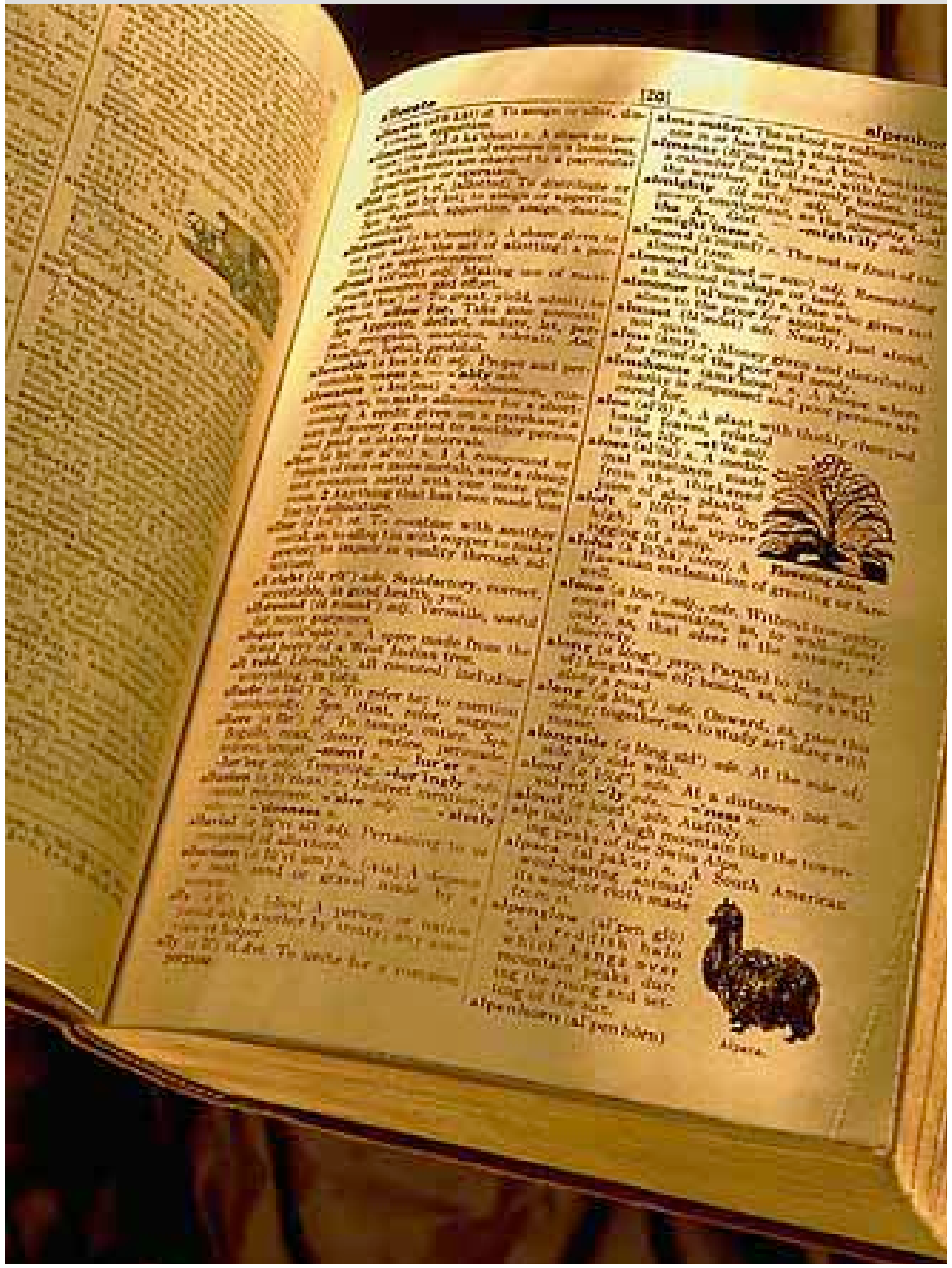


apple

Subject String

text that the regex is applied to

terminology

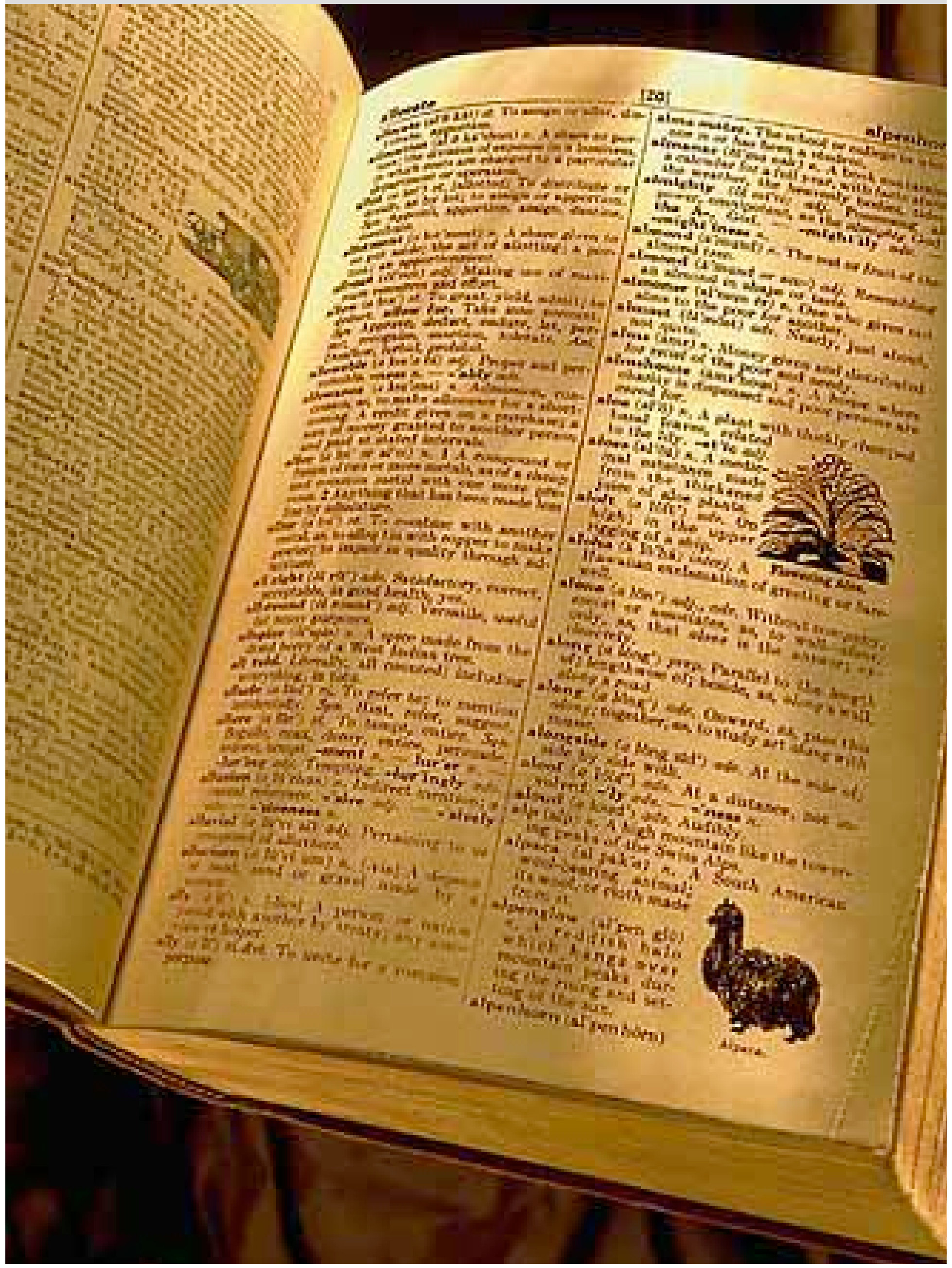


apple

Match

a portion of the string that is successfully described by the regex

terminology



Engine

A program or a library that obtains matches given a regex and a string

PCRE

regex flavors

Regular expressions are like ice cream

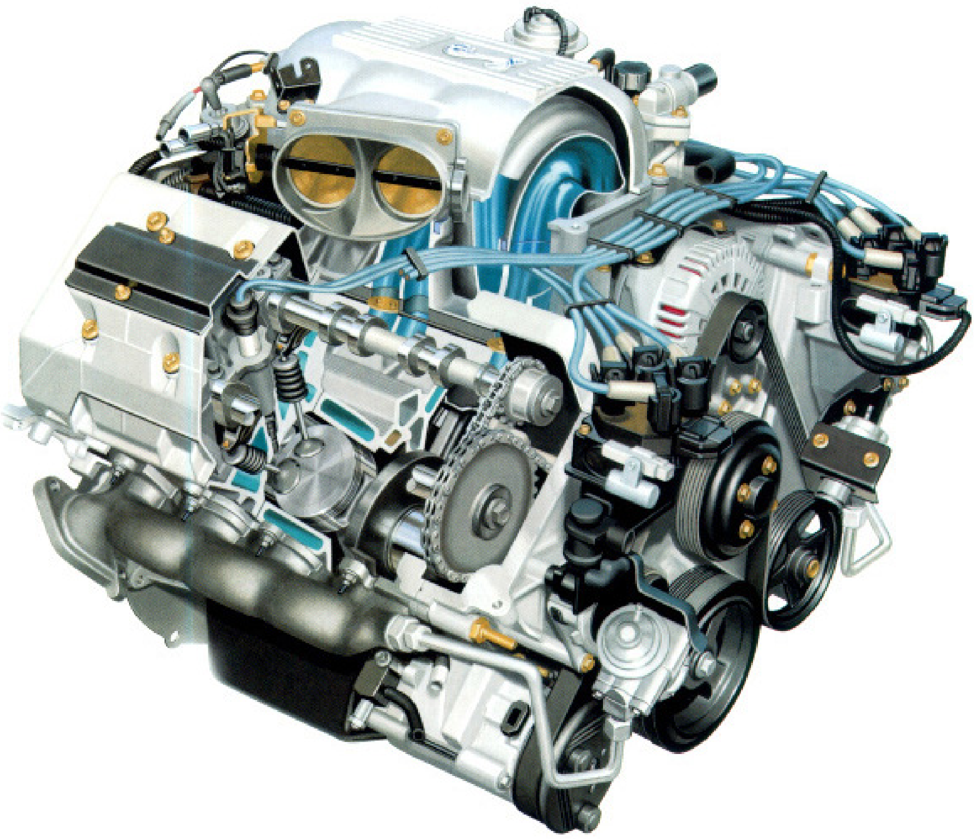
- Common base
- Many flavors

regex flavors

- Three main types of engines that determine how matching is done:
  - DFA
  - Traditional NFA
  - POSIX NFA
- For our purposes we discuss the regex flavor that PHPs' Perl-compatible regular expressions use

how an NFA engine works

- The engine bumps along the string trying to match the regex
- Sometimes it goes back and tries again

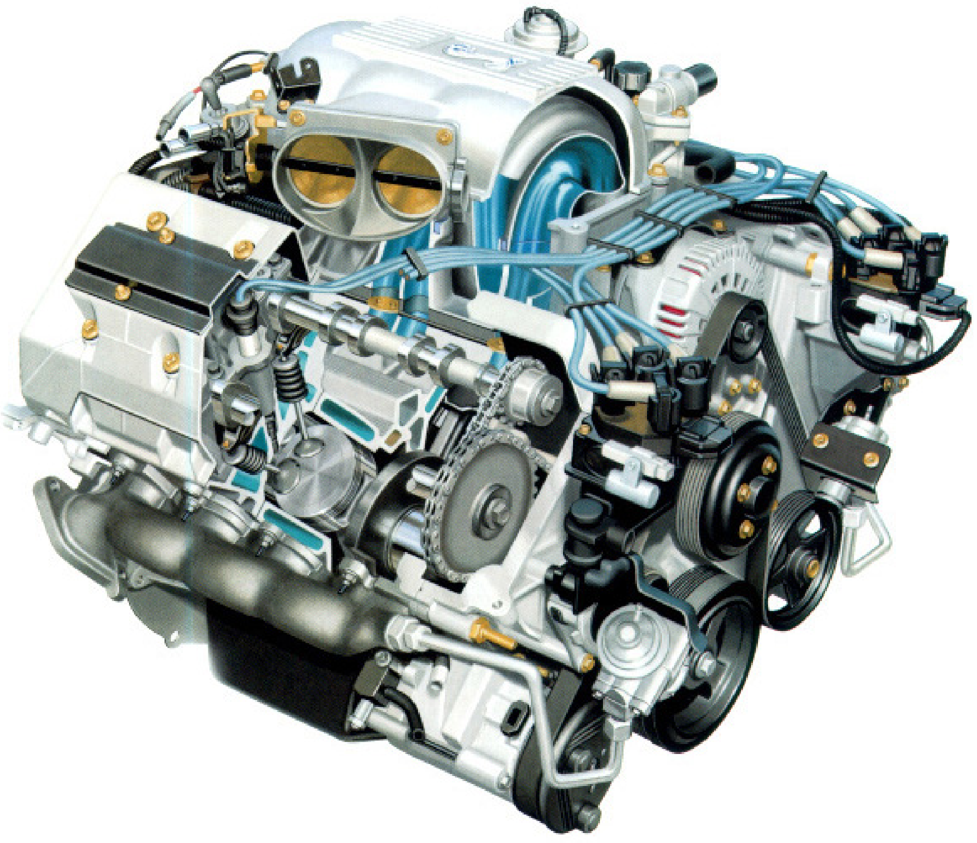


how an NFA engine works

- Two basic things to understand about the engine
  - It will always return the earliest (leftmost) match it finds

    The topic of the day is isotopes.

  - Given a choice it always favors match over a non-match



color legend

regular expression

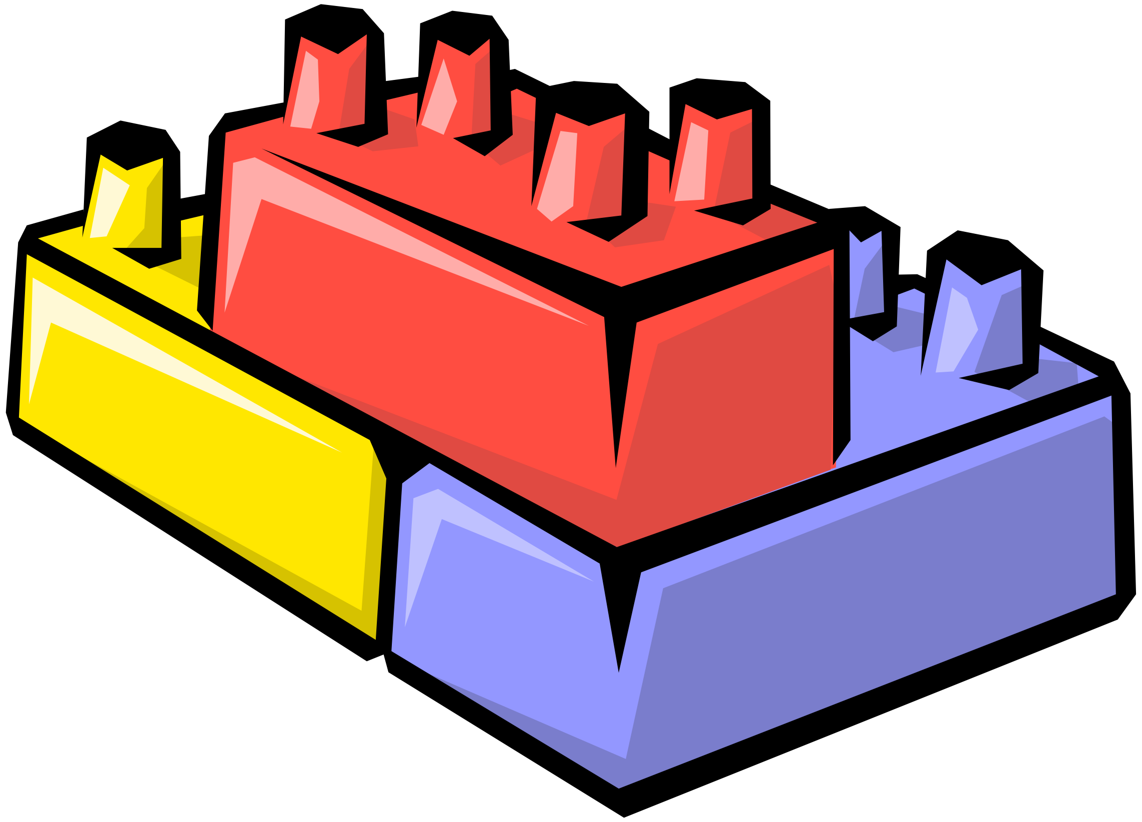
subject string

match

Syntax

building blocks

- Regexes are like LEGOs
- Small pieces combined into larger ones using connectors
- Arbitrarily complex



characters

ordinary

a 0 4 x K

special

* . ! ^ ?

characters

- Special set is a well-defined subset of ASCII
- Ordinary set consist of all characters not designated special
- Special characters are also called metacharacters

a 0 4 x K * . ! ^ ?

matching literals

123

- The most basic regex consists of a single ordinary character
- It matches the first occurrence of that character in the string
- Characters can be added together to form longer regexes

extended characters

- To match an extended character, use **\xhh** notation where **hh** are hexadecimal digits
- To match Unicode characters (in UTF-8 mode) mode use **\x{hhh..}** notation

Андрей

For example, the following regex matches my name in Cyrillic:

```
\x{0410}\x{043d}\x{0434}\x{0440}\x{0435}\x{0439}
```

extended characters

metacharacters

To use one of these literally, escape it, that is prepend it with a backslash

\$

. [] ()

^ $

* + ?

{} |

metacharacters

To escape a sequence of characters, put them between \Q and \E

Price is \Q$12.36\E

will match

Price is $12.36

. [] ()

^ $

* + ?

{} |

metacharacters

So will the backslashed version

Price is \$12\.36

will match

Price is $12.36

. [] ()

^ $

* + ?

{} |

character classes

[ ]

- Consist of a set of characters placed inside square brackets
- Matches one and only one of the characters specified inside the class

character classes

[ ]

- matches an English vowel (lowercase)

[aeiou]

- matches surf or turf

[st]urf

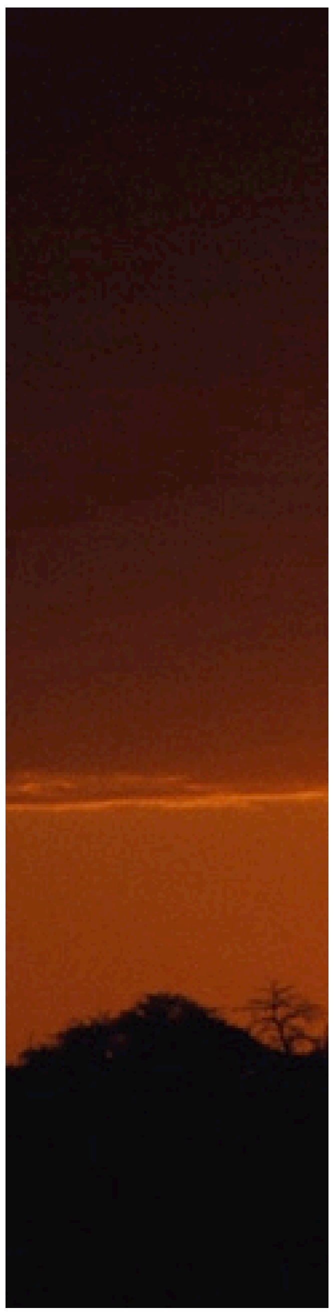
negated classes

[^]

- Placing a caret as the first character after the opening bracket negates the class
- Will match any character not in the class, including newlines
- [^<>] would match a character that is not left or right bracket

character ranges

[-]

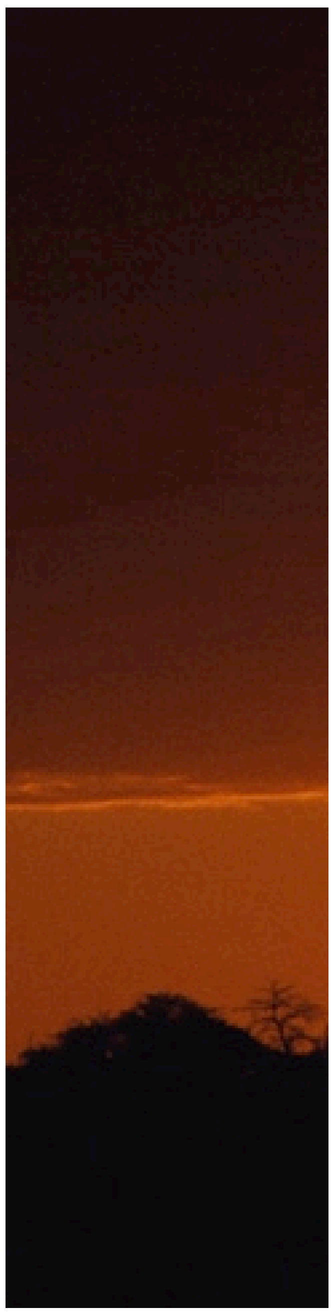


- Placing a dash (-) between two characters creates a range from the first one to the second one
- Useful for abbreviating a list of characters

[a-z]

character ranges

[-]

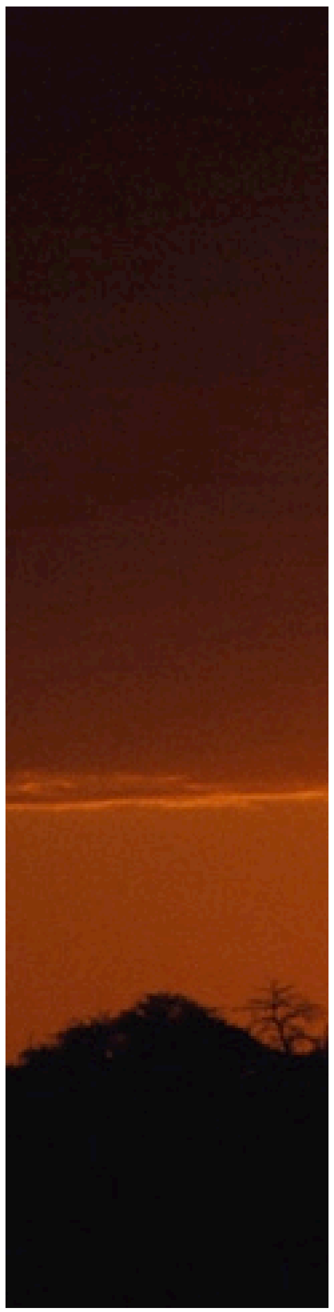


- Ranges can be reversed

[z-a]

character ranges

[-]



- Ranges can be reversed
- A class can have more than one range and combine ranges with normal lists

[a-z0-9:]

character ranges

[-]

[0-9/]	matches a digit or a slash
[z-w]	matches z, y, x, or w
[a-z0-9]	matches digits and lowercase letters
[\x01-\x1f]	matches control characters

shortcuts for ranges

[-]

Some ranges are so frequently used that it would be nice to have...

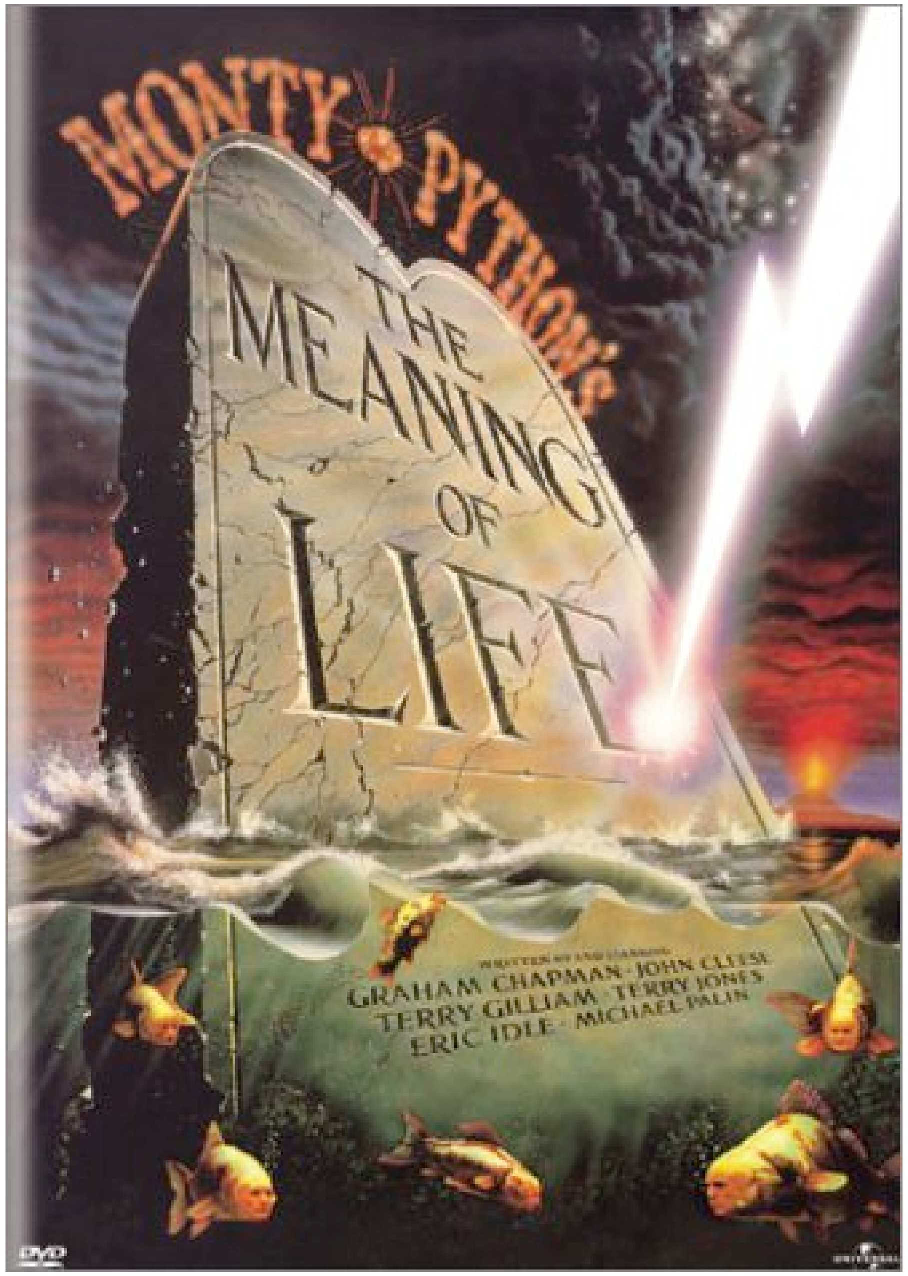
!

shortcuts

\w	word character	[A-Za-z0-9_]
\d	decimal digit	[0-9]
\s	whitespace	[\n\r\t\f]
\W	not a word character	[^A-Za-z0-9_]
\D	not a decimal digit	[^0-9]
\S	not whitespace	[^ \n\r\t\f]

shortcuts for ranges [-]

classes and metacharacters



- Inside a character class, most metacharacters lose their meaning

classes and metacharacters

]

\

^

-

- Inside a character class, most metacharacters lose their meaning
- Exceptions are:

classes and metacharacters

] \

^ -

- Inside a character class, most metacharacters lose their meaning
- Exceptions are:
  - closing bracket

classes and metacharacters

] \ ^ -

- Inside a character class, most metacharacters lose their meaning
- Exceptions are:
  - closing bracket
  - backslash

classes and metacharacters

] \

^ -

- Inside a character class, most metacharacters lose their meaning
- Exceptions are:
  - closing bracket
  - backslash
  - caret

classes and metacharacters

] \

^ -

- Inside a character class, most metacharacters lose their meaning
- Exceptions are:
  - closing bracket
  - backslash
  - caret
  - dash

classes and metacharacters

[ab\]]

[ab^]

[a-z-]

To use them literally, either escape them with a backslash or put them where they do not have special meaning

dot metacharacter

- By default matches any single character

dot metacharacter

- By default matches any single character
- Except a newline!

dot metacharacter

- By default matches any single character
- Except a newline!

dot metacharacter

Is equivalent to

```
[^\n]
```

dot metacharacter

- Use dot carefully - it might match something you did not intend
- 12.45 will match literal 12.45
- But it will also match these:

12345

12945

12a45

12-45

78812 45839

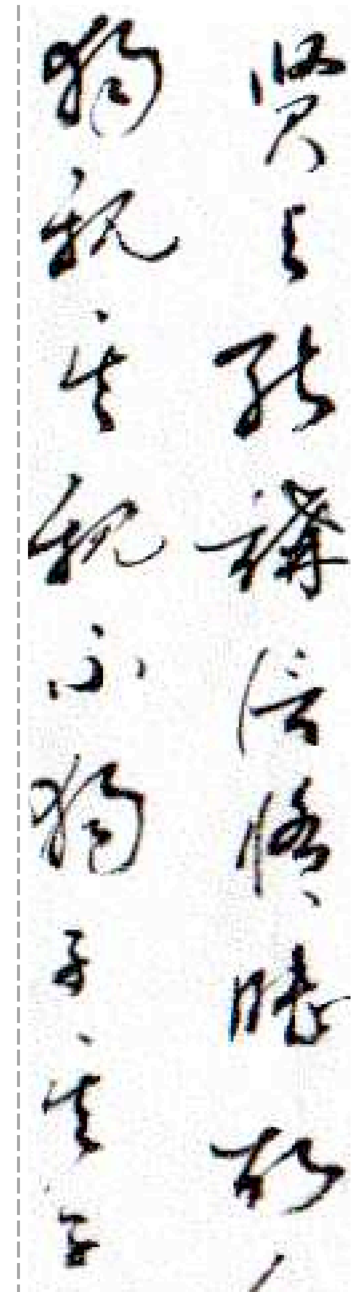
quantifiers

Or, Hit Me Baby One More Time

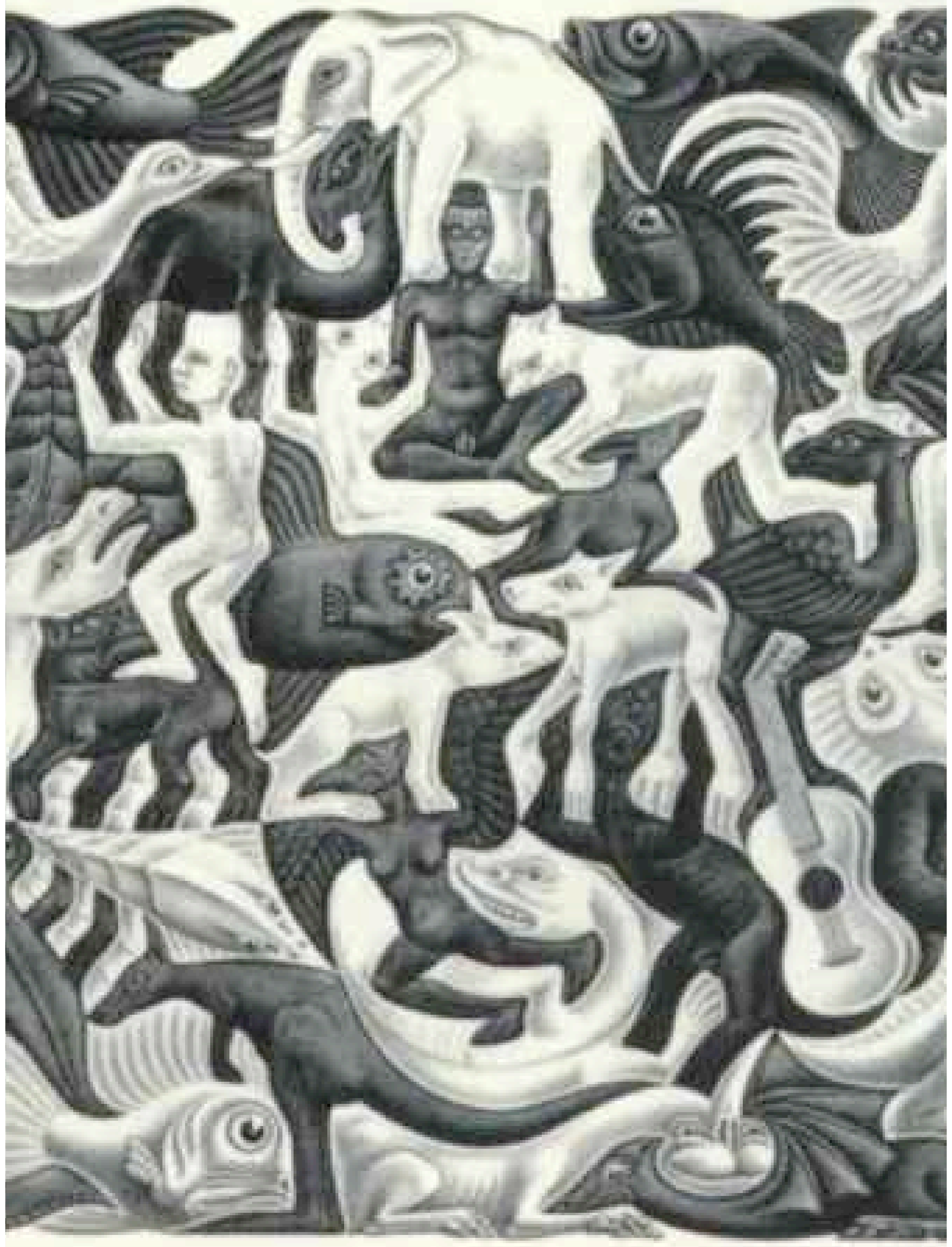
quantifiers

Confucius said,

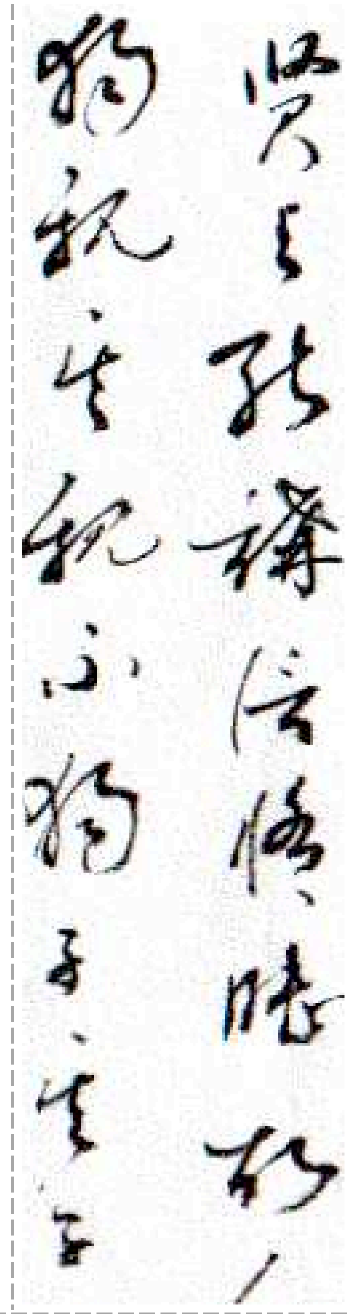
"Real knowledge is to know the extent of one's ignorance."



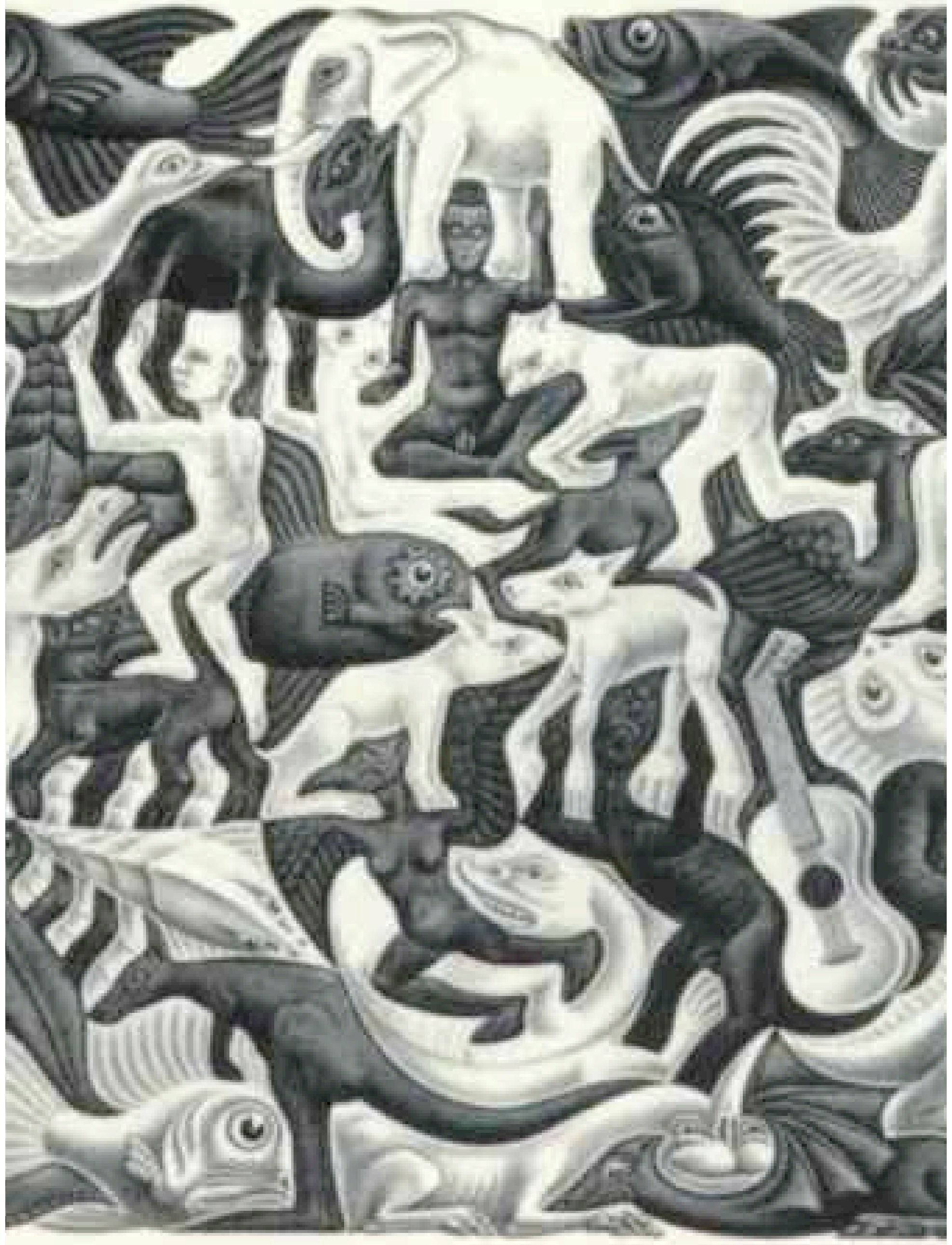
quantifiers



We are almost never sure about the contents of the text.



quantifiers



Quantifiers help us deal with this uncertainty

quantifiers

They specify how many times a regex component must repeat in order for the match to be successful

?

*

+

{ }

repeatable components

a

literal character

.

dot metacharacter

[ ]

character class

\w \d \s
\W \D \S

range shortcuts

subpattern

backreference

zero-or-one

?

- Indicates that the preceding component is optional
- Regex **welcome!?** will match either **welcome** or **welcome!**
- Regex **super\s?strong** means that **super** and **strong** may have an optional whitespace character between them
- Regex **hello[!?]?** Will match **hello**, **hello!**, or **hello?**

- Indicates that the preceding component has to appear once or more
- Regex a+h will match ah, aah, aaah, etc
- Regex –\d+ will match negative integers, such as -33
- Regex [^”]+ means to match a sequence (more than one) of characters until the next quote

one-or-more

+

zero-or-more *

- Indicates that the preceding component can match zero or more times
- Regex `\d+\.\d*` will match 2., 3.1, 0.001
- Regex `<[a-z][a-z0-9]*>` will match an opening HTML tag with no attributes, such as <b> or <h2>, but not <> or </i>

general repetition { }

- Specifies the minimum and the maximum number of times a component has to match
- Regex **ha{1,3}** matches **ha**, **haa**, **haaa**
- Regex **\d{8}** matches exactly 8 digits

general repetition { }

- If second number is omitted, no upper range is set
- Regex **go{2,}al** matches **gooal**, **goooal**, **gooooal**, etc

general repetition { }

{0,1}	=	?
{1,}	=	+
{0,}	=	*

greediness

“One of the weaknesses of our age is our apparent inability to distinguish our needs from our greeds.” — Don Robinson

greediness n., matching as much as possible, up to a limit

greediness

PHP 5?	PHP 5 is better than Perl 6
\d{2,4}	10/26/2004

greediness

- Quantifiers try to grab as much as possible by default
- Applying <.+> to <i>greediness</i> matches the whole string rather than just <i>

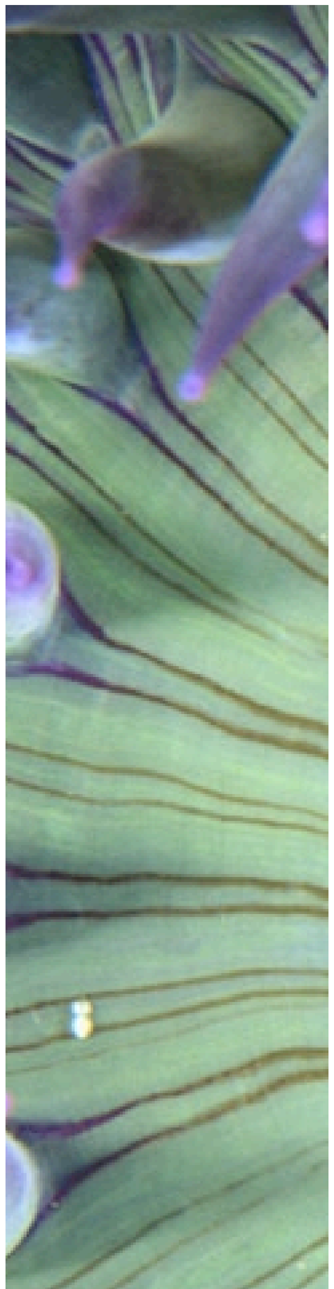
greediness

- If the entire match fails because they grabbed too much, then they are forced to give up as much as needed to make the rest of regex succeed

greediness

- To find words ending in ness, you will probably use \w+ness
- On the first run \w+ takes the whole word
- But since ness still has to match, it gives up the last 4 characters and the match succeeds

overcoming greediness



- The simplest solution is to make the repetition operators non-greedy, or lazy
- Lazy quantifiers grab as little as possible
- If the overall match fails, they grab a little more and the match is tried again

overcoming greediness

*?

+?

{ , }?

??

- To make a greedy quantifier lazy, append ?
- Note that this use of the question mark is different from its use as a regular quantifier

overcoming greediness

*?

+?

{ , }?

??

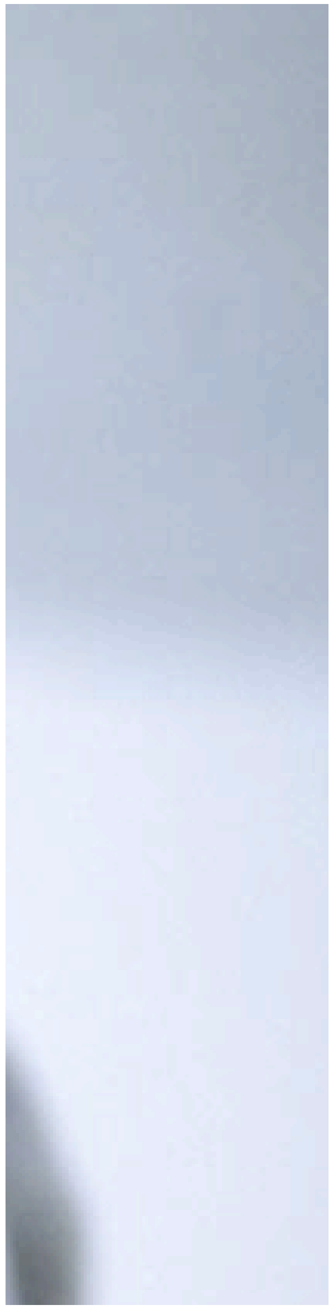
Applying <.+?>

to <i>greediness</i>

gets us <i>

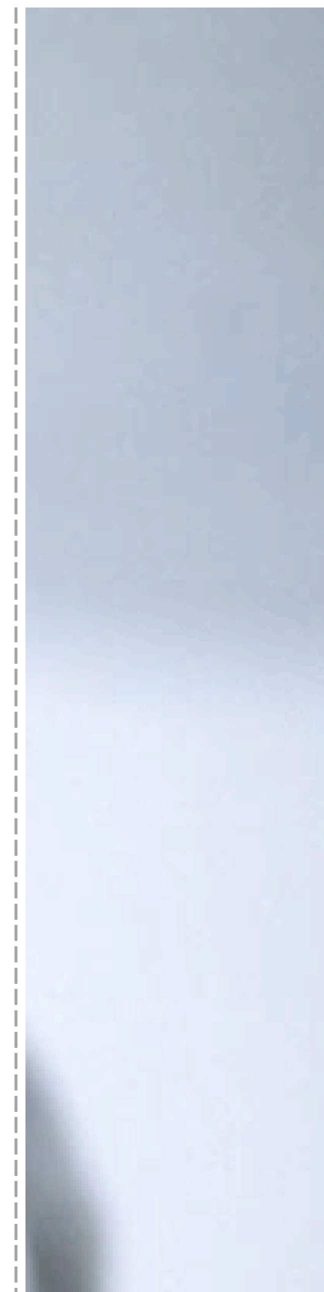
overcoming greediness

- Another option is to use negated character classes
- More efficient and clearer than lazy repetition



overcoming greediness

- `<.+?>` can be turned into `<[^>]+>`
- Note that the second version will match tags spanning multiple lines
- Single-line version: `<[^>\r\n]+>`



assertions and anchors

- An assertion is a regex operator that
  - expresses a statement about the current matching point
  - consumes no characters

assertions and anchors

- The most common type of an assertion is an anchor
- Anchor matches a certain position in the subject string

caret

^

- Caret, or circumflex, is an anchor that matches at the beginning of the subject string
- ^F basically means that the subject string has to start with an F

^F

Fandango

dollar sign

$

- Dollar sign is an anchor that matches at the end of the subject string or right before the string-ending newline
- \d$ means that the subject string has to end with a digit
- The string may be top 10 or top 10\n, but either one will match

\d$

top 10

multiline matching

- Often subject strings consist of multiple lines
- If the multiline option is set:
  - Caret (^) also matches immediately after any newlines
  - Dollar sign ($) also matches immediately before any newlines

^t.+

one
two
three

absolute start/end

- Sometimes you really want to match the absolute start or end of the subject string when in the multiline mode
- These assertions are always valid:
  - \A matches only at the very beginning
  - \z matches only at the very end
  - \Z matches like $ used in single-line mode

\At.+

three
tasty
truffles

word boundaries

\b \B

\bto\b

right |to| vote

- A word boundary is a position in the string with a word character (\w) on one side and a non-word character (or string boundary) on the other
- **\b** matches when the current position is a word boundary
- **\B** matches when the current position is not a word boundary

word boundaries \b \B

\bto\b

come <u>to</u>gether

- A word boundary is a position in the string with a word character (\w) on one side and a non-word character (or string boundary) on the other
- **\b** matches when the current position is a word boundary
- **\B** matches when the current position is not a word boundary

word boundaries

\b \B

\B2\B

doc2html

- A word boundary is a position in the string with a word character (\w) on one side and a non-word character (or string boundary) on the other
- **\b** matches when the current position is a word boundary
- **\B** matches when the current position is not a word boundary

subpatterns

( )

- Parentheses can be used group a part of the regex together, creating a subpattern
- You can apply regex operators to a subpattern as a whole

grouping

( )

- Regex **is(land)?** matches both **is** and **island**
- Regex **(\d\d,)*\d\d** will match a comma-separated list of double-digit numbers

capturing subpatterns ( )

- All subpatterns by default are capturing
- A capturing subpattern stores the corresponding matched portion of the subject string in memory for later use

capturing subpatterns ( )

- Subpatterns are numbered by counting their opening parentheses from left to right
- Regex (\d\d-(\w+)-\d{4}) has two subpatterns

(\d\d-(\w+)-\d{4})

↓

12-May-2004

capturing subpatterns

( )

- Subpatterns are numbered by counting their opening parentheses from left to right
- Regex **(\d\d-(\w+)-\d{4})** has two subpatterns
- When run against **12-May-2004** the second subpattern will capture **May**

(\d\d-(\w+)-\d{4})

12-May-2004

non-capturing subpatterns

- The capturing aspect of subpatterns is not always necessary
- It requires more memory and more processing time

non-capturing subpatterns

- Using **?:** after the opening parenthesis makes a subpattern be a purely grouping one
- Regex **box(?:ers)?** will match **boxers** but will not capture anything
- The **(?:)** subpatterns are not included in the subpattern numbering

named subpatterns

- It can be hard to keep track of subpattern numbers in a complicated regex
- Using **?P<name>** after the opening parenthesis creates a *named* subpattern
- Named subpatterns are still assigned numbers
- Pattern **(?P<number>\d+)** will match and capture **99** into subpattern named **number** when run against **99 bottles**

- Alternation operator allows testing several sub-expressions at a given point
- The branches are tried in order, from left to right, until one succeeds
- Empty alternatives are permitted
- Regex `sailing|cruising` will match either sailing or cruising

alternation

|

- Since alternation has the lowest precedence, grouping is often necessary
- sixth|seventh sense will match the word sixth or the phrase seventh sense
- (sixth|seventh) sense will match sixth sense or seventh sense

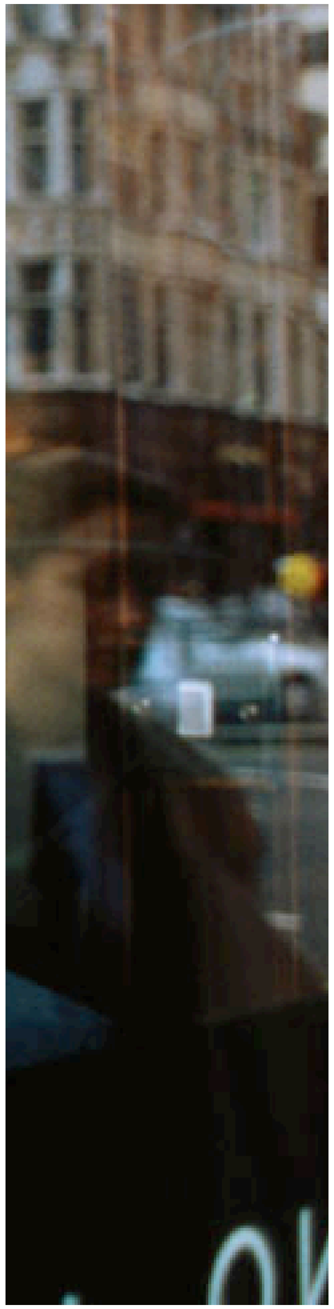
alternation |

- Remember that the regex engine is eager
- It will return a match as soon as it finds one
- **camel|came|camera** will only match **came** when run against **camera**
- Put more likely regex as the first alternative

alternation |

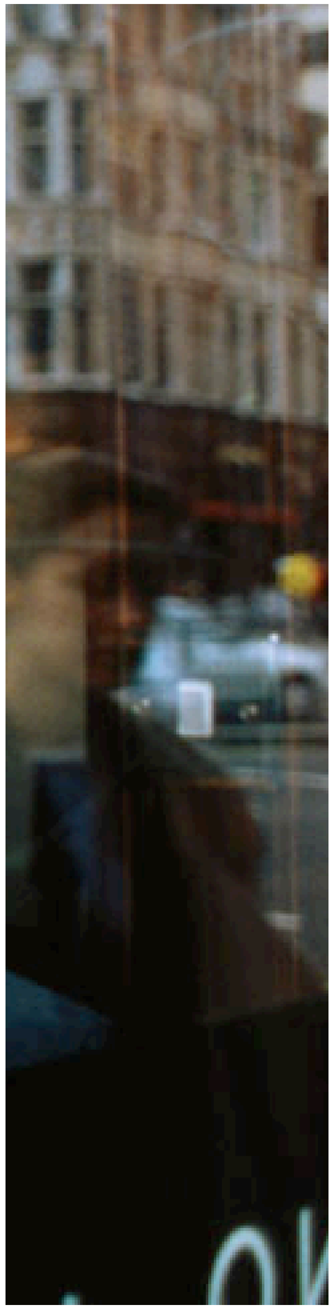
backtracking

- Also known as “if at first you don’t succeed, try, try again”
- When faced with several options it could try to achieve a match, the engine picks one and remembers the others

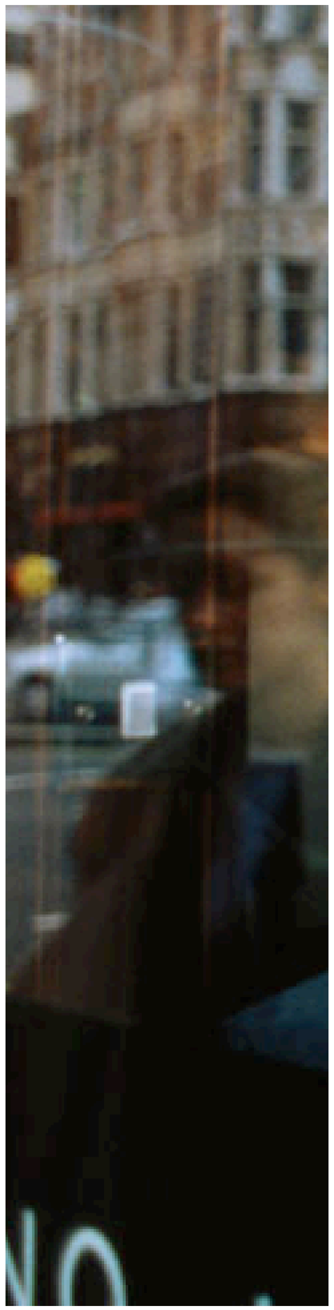


backtracking

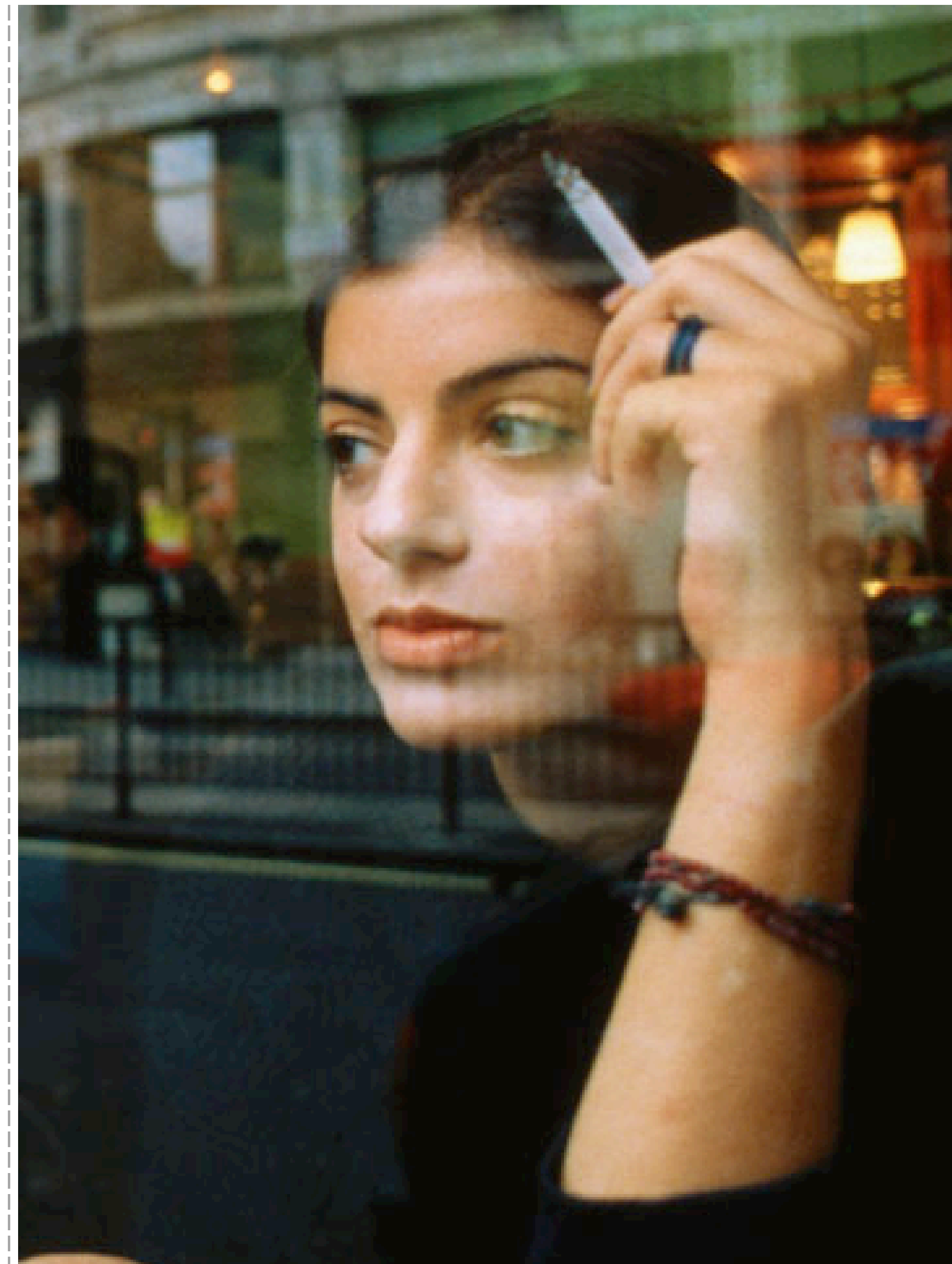
- If the picked option does not lead to an overall successful match, the engine backtracks to the decision point and tries another option



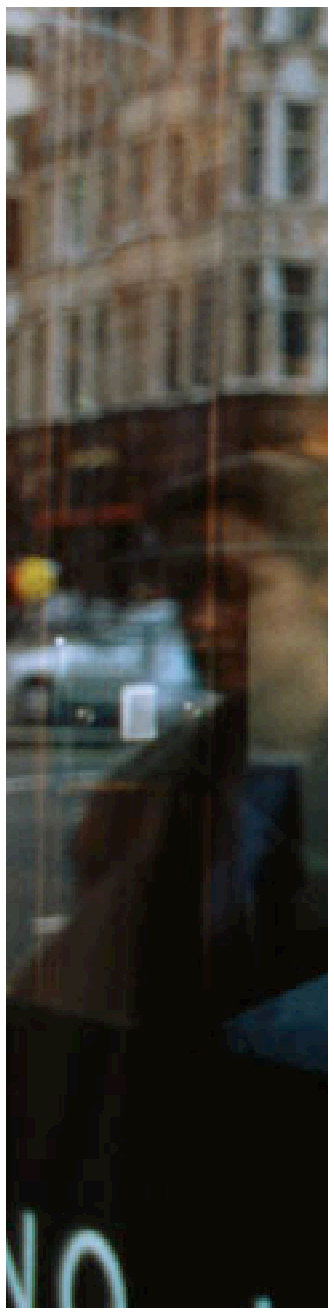
backtracking



- This continues until an overall match succeeds or all the options are exhausted
- The decision points include quantifiers and alternation

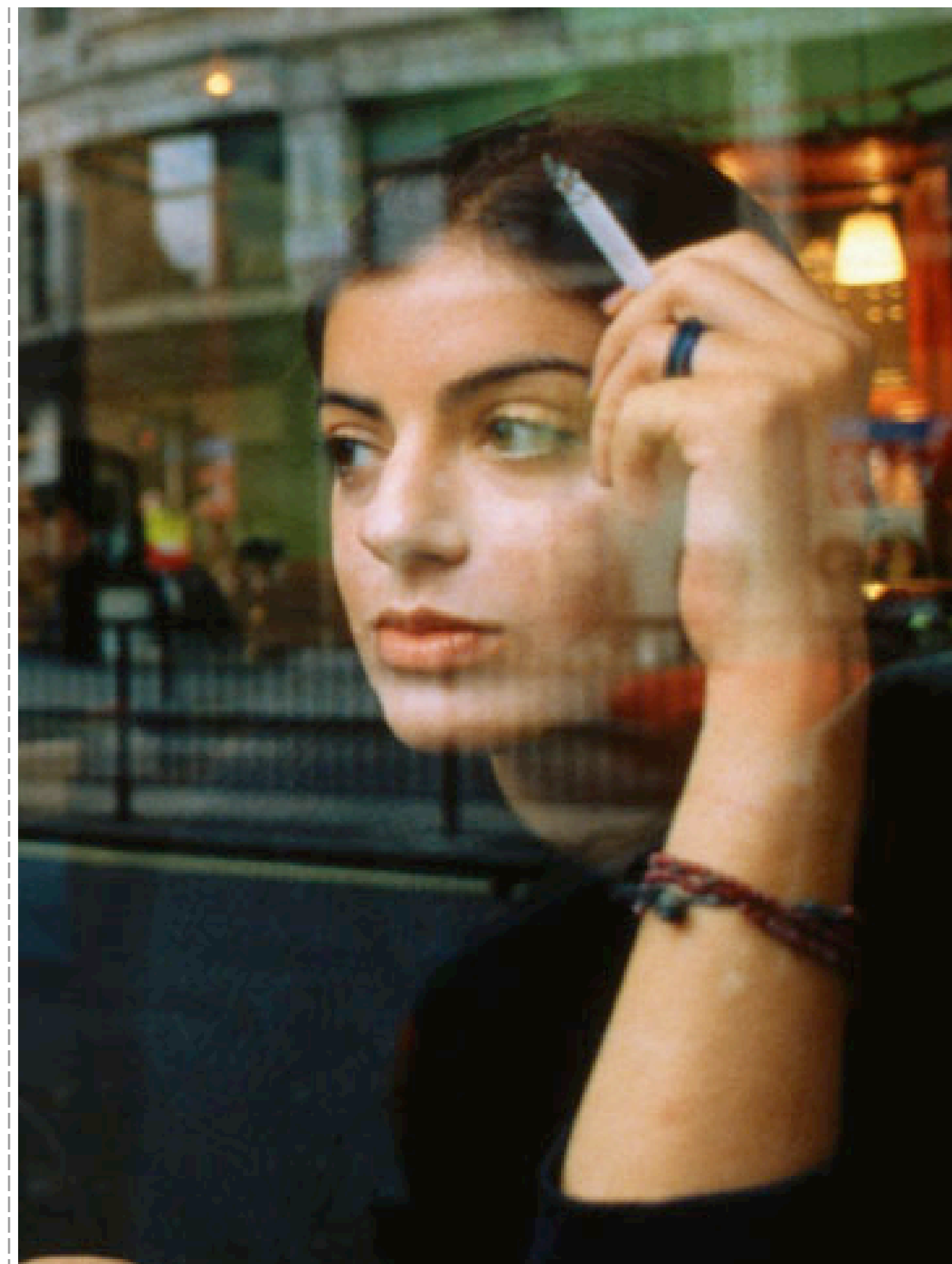


backtracking



Two important rules to remember

- With greedy quantifiers the engine always attempts the match, and with lazy ones it delays the match
- If there were several decision points, the engine always goes back to the most recent one



backtracking example

\d+00

12300

start

backtracking example

\d+00

12300

add 1

backtracking example

\d+00

12300

add 2

backtracking example

\d+00

12300

add 3

backtracking example

\d+00

12300

add 0

backtracking example

\d+00

12300

add 0

backtracking example

\d+00

12300

string exhausted
still need to match 00

backtracking example

\d+00

12300

give up 0

backtracking example

\d+00

12300

give up 0

backtracking example

\d+00

12300

add 00

backtracking example

\d+00

12300

success

backtracking example

\d+ff

123dd

start

backtracking example

\d+ff

123dd

add 1

backtracking example

\d+ff

123dd

add 2

backtracking example

\d+ff

123dd

add 3

backtracking example

\d+ff

123dd

cannot match f here

backtracking example

\d+ff

123dd

give up 3
still cannot match f

backtracking example

\d+ff

123dd

give up 2
still cannot match f

backtracking example

\d+ff

123dd

cannot give up more because of +

backtracking example

\d+ff

123dd

failure

backtracking example

ab??c

abc

start

backtracking example

ab??c

abc

add a

backtracking example

ab??c

abc

skip matching **b** at first

backtracking example

ab??c

abc

c cannot match here

backtracking example

ab??c

abc

go back and try matching b now

backtracking example

ab??c

abc

c can be matched

backtracking example

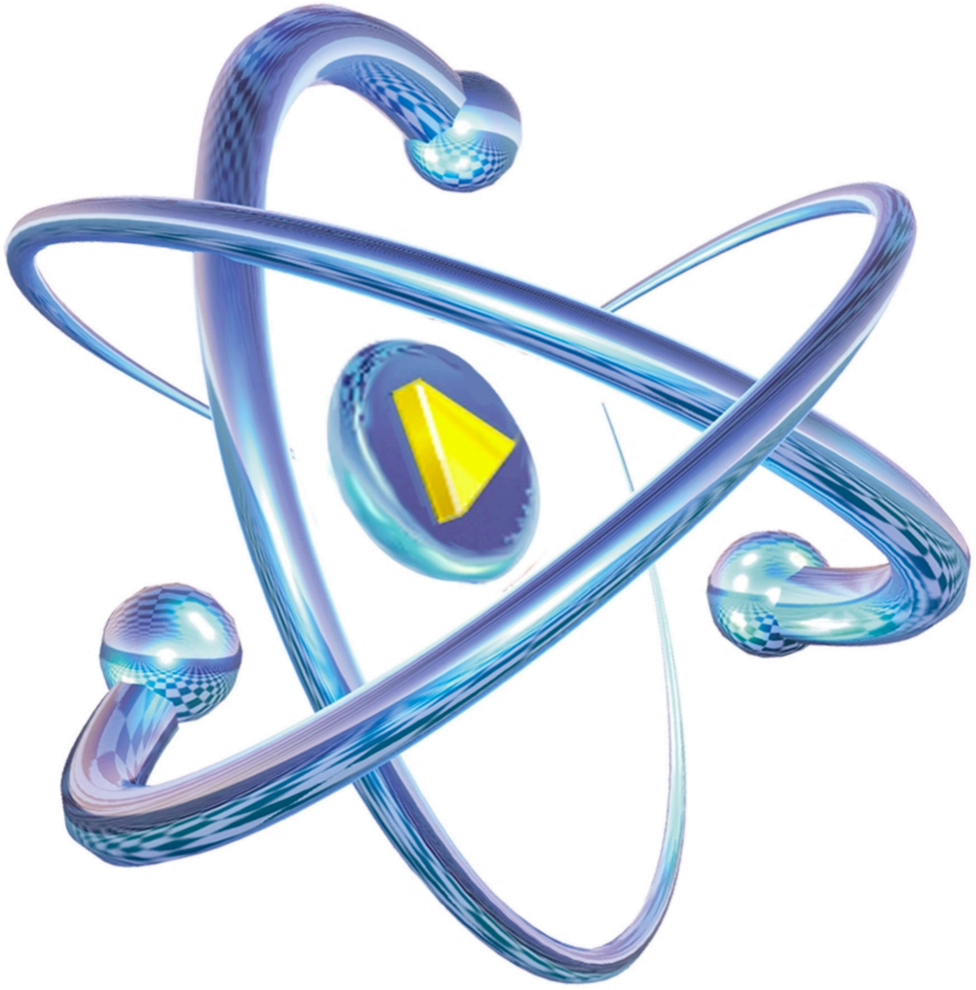
ab??c

abc

success

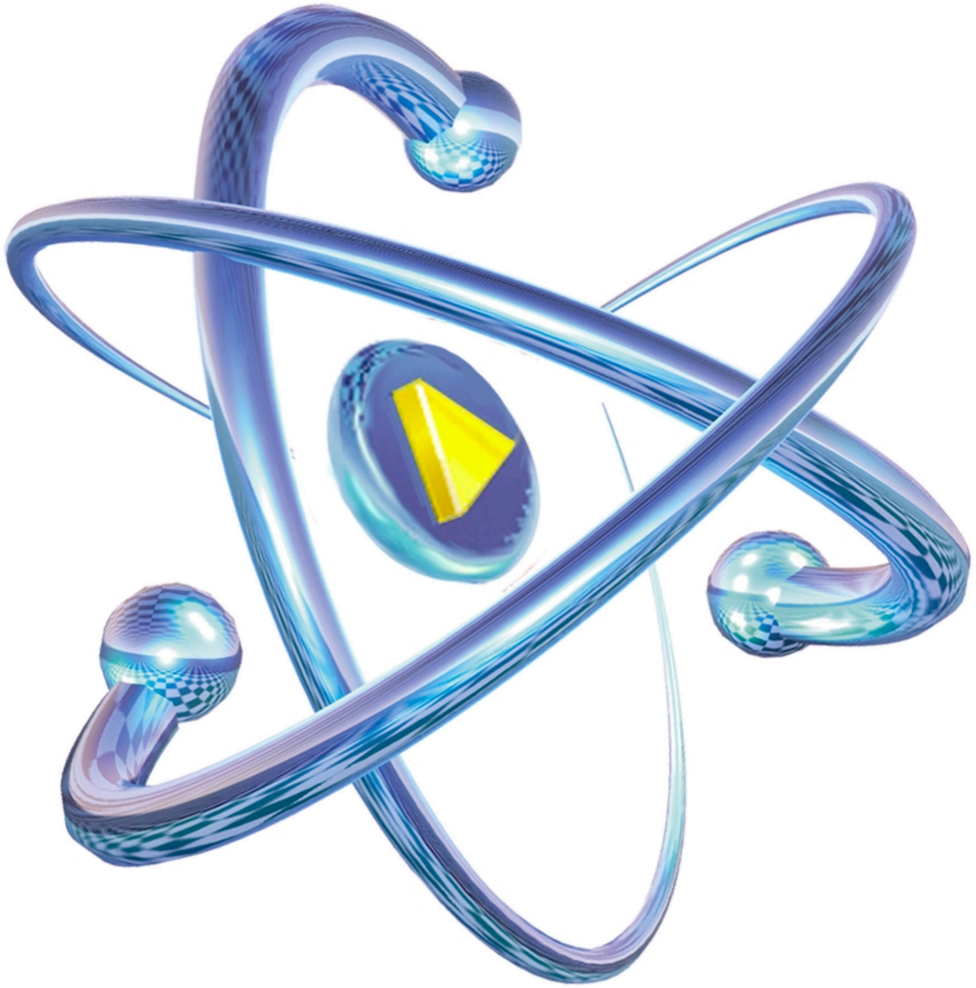
atomic grouping

- Disabling backtracking can be useful
- The main goal is to speed up failed matches, especially with nested quantifiers



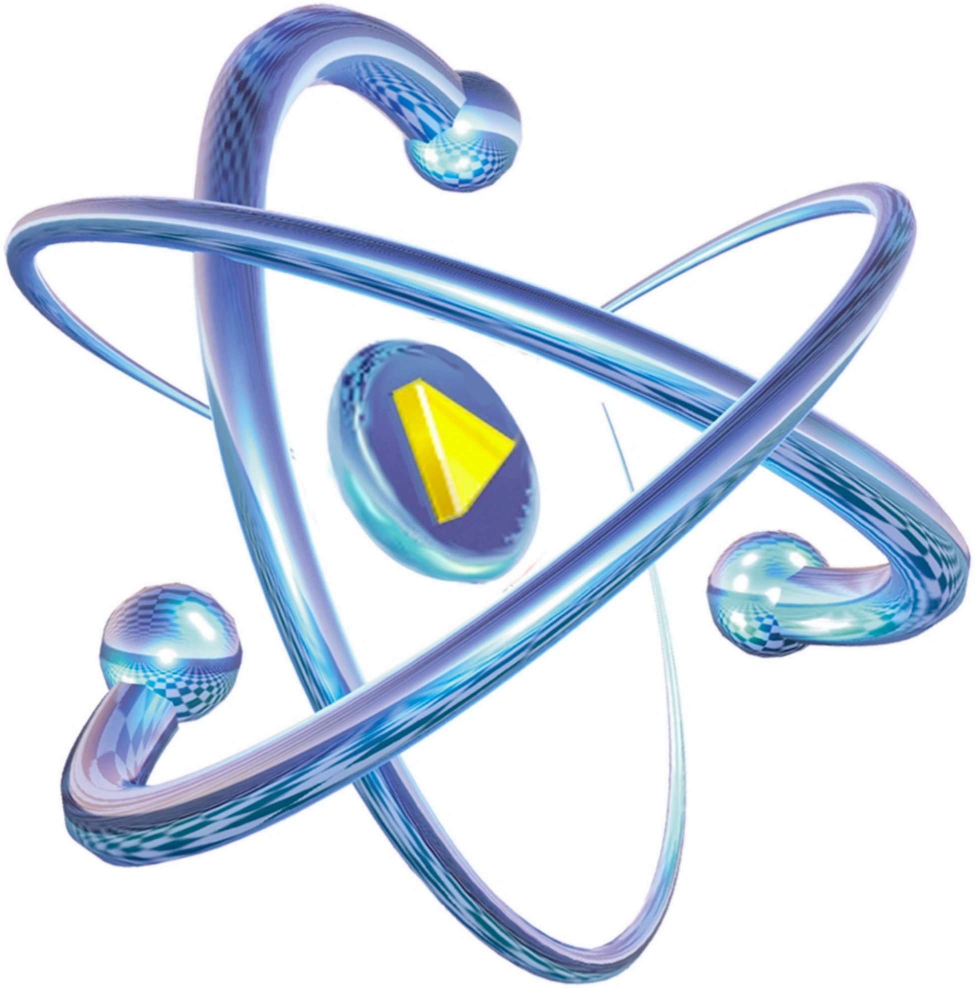
atomic grouping

- **(?>*regex*)** will treat **regex** as a single atomic token, no backtracking will occur inside it
- All the saved states are forgotten



atomic grouping

- **(?>\d+)ff** will lock up all available digits and fail right away if the next two characters are not **ff**
- Atomic groups are not capturing



possessive quantifiers

- Atomic groups can be arbitrarily complex and nested
- Possessive quantifiers are simpler and apply to a single repeated item

possessive quantifiers

- To make a quantifier possessive append a single **+**
- **\d++ff** is equivalent to **(?>\d+)ff**

possessive quantifiers

- Other ones are *+, ?+, and {m,n}+
- Possessive quantifiers are always greedy

do not over-optimize

- Keep in mind that atomic grouping and possessive quantifiers can change the outcome of the match
- When run against string abcdef
  - \w+d will match abcd
  - \w++d will not match at all
  - \w+ will match the whole string

backreferences

\n

- A backreference is an alias to a capturing subpattern
- It matches whatever the referent capturing subpattern has matched

backreferences

\n

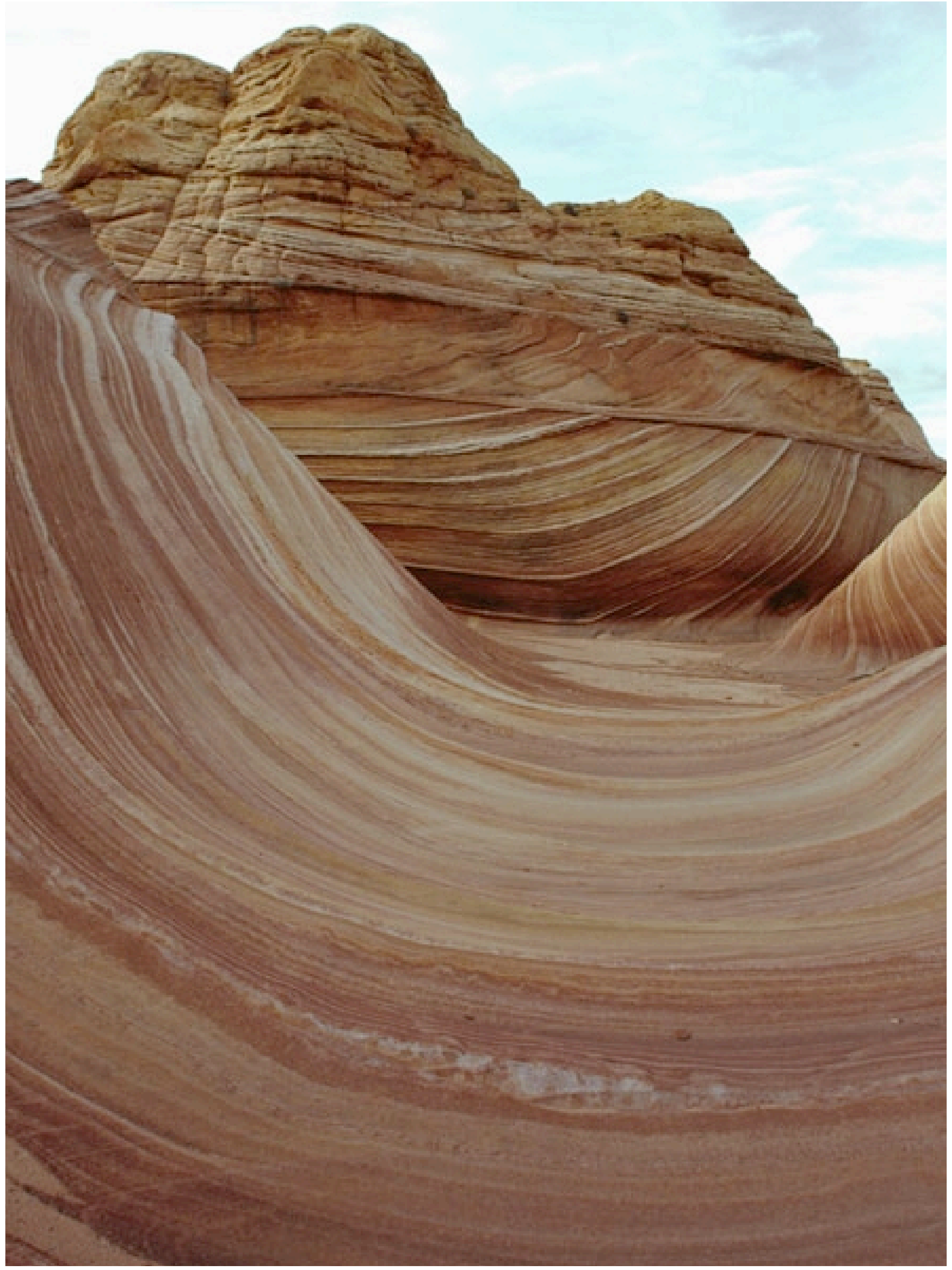
- (re|le)\w+\1 matches words that start with re or le and end with the same thing
- For example, retire and legible, but not revocable or lecture
- Reference to a named subpattern can be made with (?P=name)

lookaround

- Assertions that test whether the characters before or after the current point match the given regex
- Consume no characters
- Do not capture anything
- Includes lookahead and lookbehind

positive lookahead

(?=)



- Tests whether the characters after the current point match the given regex
- (\w+)(?=:)(.*) matches surfing: a sport but semicolon ends up in the second subpattern

negative lookahead (?!)

- Tests whether the characters after the current point do not match the given regex
- fish(?!ing) matches fish not followed by ing
- Will match fisherman and fished

negative lookahead (?!)

- Difficult to do with character classes
- **fish[^i][^n][^g]** might work but will consume more than needed and fail on subjects shorter than 7 letters
- Character classes are no help at all with something like **fish(?!hook|ing)**

positive lookbehind (?<=)

- Tests whether the characters immediately preceding the current point match the given regex
- The regex must be of fixed size, but branches are allowed
- **(?<=foo)bar** matches **bar** only if preceded by **foo**, e.g. **my foobar**

negative lookbehind (?<!)

- Tests whether the characters immediately preceding the current point do not match the given regex
- Once again, regex must be of fixed size
- **(?<!foo)bar** matches **bar** only if not preceded by **foo**, e.g. **in the bar** but not **my foobar**

conditionals

- Conditionals let you apply a regex selectively or to choose between two regexes depending on a previous match

  (?(condition)yes-regex)

  (?(condition)yes-regex|no-regex)

- There are 3 kinds of conditions
  - Subpattern match
  - Lookaround assertion
  - Recursive call (not discussed here)

subpattern conditions (?(n))

- This condition is satisfied if the capturing subpattern number **n** has previously matched
- **(“)? \b\w+\b (?(1)”)** matches words optionally enclosed by quotes
- There is a difference between **(“)?** and **(“?)** in this case: the second one will always capture

assertion conditions

- This type of condition relies on lookaround assertions to choose one path or the other

  `href=(? (?=[‘”]) ([“’])\S+\1 | \S+)`

  - Matches **href=**, then
  - If the next character is single or double quote match a sequence of non-whitespace inside the matching quotes
  - Otherwise just match it without quotes

inline options

The matching can be modified by options you put in the regular expression

(?i)	enables case-insensitive mode
(?m)	enables multiline matching for ^ and $
(?s)	makes dot metacharacter match newline also
(?x)	ignores literal whitespace
(?U)	makes quantifiers ungreedy (lazy) by default

inline options

(?i)

(?m)

(?s)

(?x)

(?U)

- Options can be combined and unset

  (?im-sx)

- At top level, apply to the whole pattern
- Localized inside subpatterns

  (a(?i)b)c

comments

?#

Here’s a regex I wrote when working on Smarty templating engine

```
^\$\w+(?>(\[(\d+|\$\w+|\w+(\.\w+)?)\])|((\.|->)\$?\w+))*(?>\|@?\w+(:(?>"[^"\\\\]*(?:\\\\.[^"\\\\]*)*"|\'[^\'\\\\]*(?\\\\.[^\'\\\\]*) *\'|[^|]+))*)*$
```

comments

?#

Let me blow that up for you

```
^\$\w+(?>(\[(\d+|\$\w+|\w+(\.\w+)?)\])|
((\.|->)\$?\w+))*(?>\|@?\w+(:(?>"[^"\\\\]*
(?:\\\\.[^"\\\\]*)*"|\'[^\'\\\\]*
(?\\\\.[^\'\\\\]*)*\'|[^|]+))*)*$
```

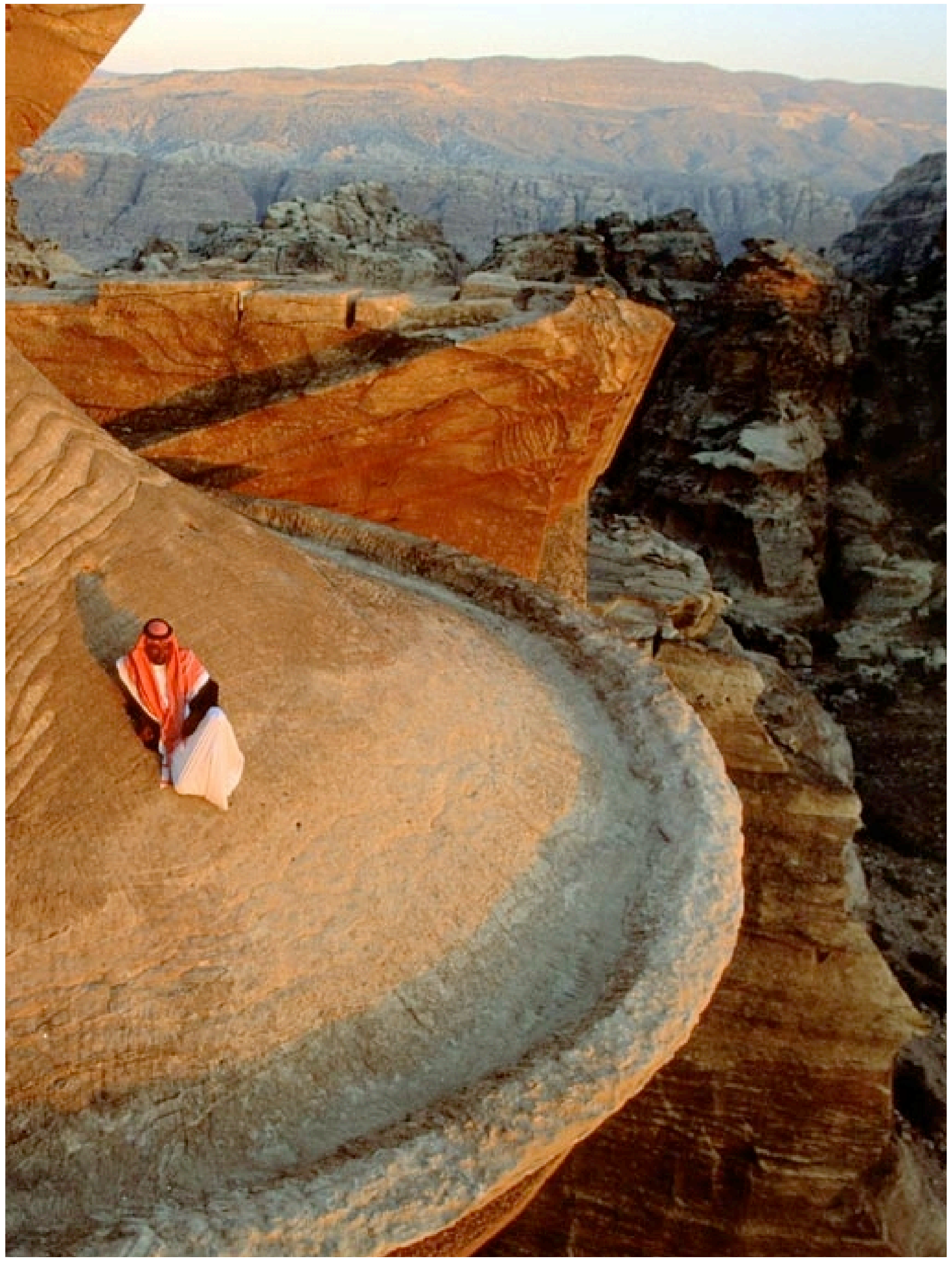
Would you like some comments with that?

comments

?#

- Most regexes could definitely use some comments
- (?#...) specifies a comment

\d+(?# match some digits)

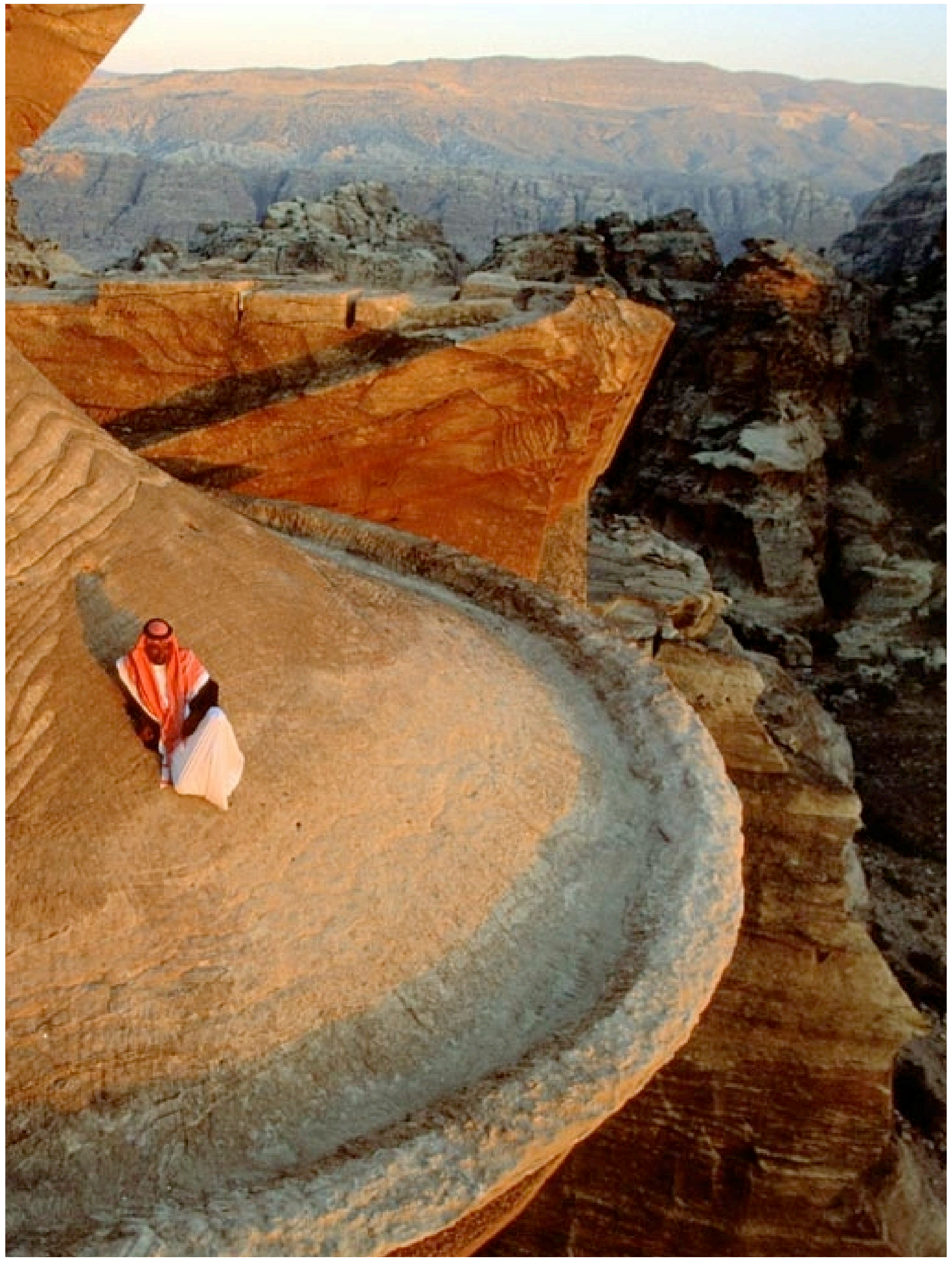


comments

?#

- If **(?x)** option is set, anything after **#** outside a character class and up to the next newline is considered a comment
- To match literal whitespace, escape it

```
(?x) \w+  # start with word characters
     [?!] # and end with ? or !
```



Regex API

Regex API

- Perl-compatible regex API (PCRE) was introduced in PHP 3.0.9
- Starting with PHP 4.2.0 the API is enabled by default
- Uses consistent pattern syntax
- All functions start with `preg_` prefix

pattern syntax

‘/[abc]+/’

“/[abc]+/”

- The regex must be enclosed in delimiters and passed as a single- or double-quoted string

pattern syntax

z[abc]+z

NO!

- The regex must be enclosed in delimiters and passed as a single- or double-quoted string
- Delimiter character cannot be alphanumeric or backslash

pattern syntax

`/<\/i>/`

- The regex must be enclosed in delimiters and passed as a single- or double-quoted string
- Delimiter character cannot be alphanumeric or backslash
- If the delimiter character has to be used in the regex, escape it with a backslash

pattern syntax

/<a.+?>/is

- The regex must be enclosed in delimiters and passed as a single- or double-quoted string
- Delimiter character cannot be alphanumeric or backslash
- If the delimiter character has to be used in the regex, escape it with a backslash
- The ending delimiter may optionally be followed by pattern modifiers

pattern modifiers

The first five should be already familiar

/i	enables case-insensitive mode
/m	enables multiline matching for ^ and $
/s	makes dot metacharacter match newline also
/x	ignores literal whitespace and allows # comments
/U	makes quantifiers ungreedy (lazy) by default

pattern modifiers

But there are some more

/A	anchors the pattern at the beginning of string (similar to \A assertion)
/S	performs additional analysis on the pattern
/u	enables UTF-8 mode
/e	explained in `preg_replace()` section

pattern examples

- Valid:
  - `/^\d{4}-\d\d(-\d\d)?/`
  - `/<(h\d)>.*?<\/\1>/iU`
  - `!^From: .* rasmus@!xm`

pattern examples

- Invalid:
  - !/.+$ - missing end delimiter
  - /ab(c|d)/J – unknown modifier J
  - /\s?*/ - compilation failure, misapplied quantifier *

PHP metacharacter issues

- PHP can interpret regex metacharacters as its own
- To avoid confusion:
  - Backslash the common metacharacters
  - Use single quotes to make life easier

PHP metacharacter issues

- Even with single quotes, the “leaning toothpick” syndrome may occur
- To match a single backslash, one has to use ‘/\\\\/’

‘/\\\\/’

PHP metacharacter issues

- Even with single quotes, the “leaning toothpick” syndrome may occur
- To match a single backslash, one has to use `‘/\\\\/’`
    - First, PHP interprets it as `‘/\\/’`

`‘/\\/’`

PHP metacharacter issues

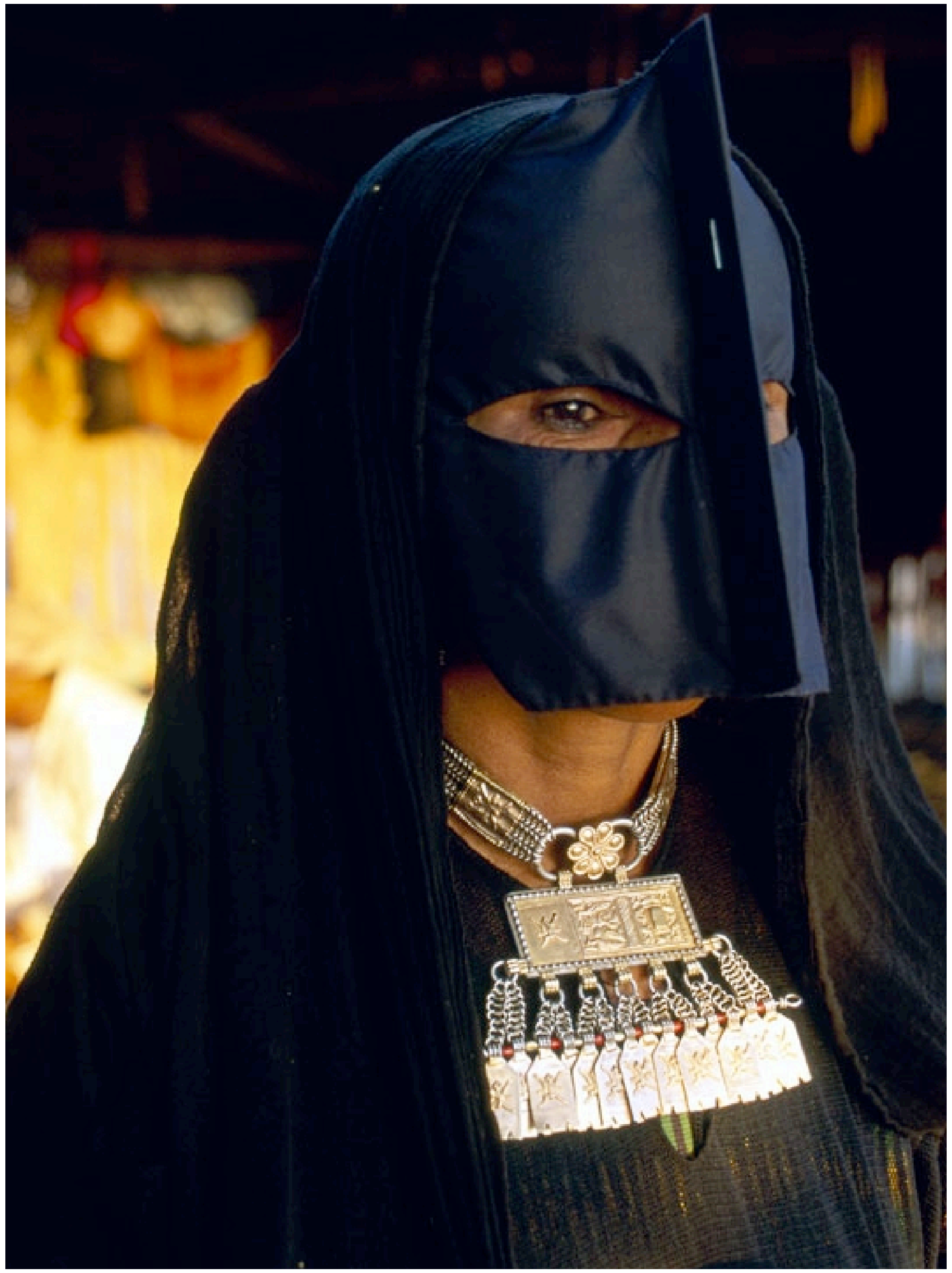
- Even with single quotes, the “leaning toothpick” syndrome may occur
- To match a single backslash, one has to use ‘/\\\\/’
  - First, PHP interprets it as ‘/\\/’
  - Then, regex engine sees it as an escaped backslash metacharacter

\\

locales

- Caseless matching and character class determination are affected by the current locale
- The locale can be changed via PHP's `setlocale()` function
- For example, `set_locale('fr_FR')` will set the French locale which will be used by the engine for `\w` for example

to save time...



Since all PCRE functions are described in the manual in exquisite detail, we'll just have a brief look at them...

preg_match(string regex, string subject, *array matches, int flags, int offset*)

- Tries to find the first occurrence of a pattern described by **regex** in the **string**
- Returns 0 or 1 (FALSE on error)
- If **matches** is provided, it is filled with the match results
- Stops after the first successful match
- Best used for validation

preg_match(string regex, string subject, *array matches, int flags, int offset*)

```
preg_match('!\w+!', 'a(bc)d'); = 1
preg_match('!\w+!', '**--**'); = 0

preg_match('!\b\d+(\.\d+)?\b!',
           'price: $3.14 for 2', $match); = 1
  $match[0] = '3.14'
  $match[1] = '.14'

preg_match('!\b\d+(?P<cents>\.\d+)?\b!',
           'price: $3.14 for 2', $match); = 1
  $match[0] = '3.14'
  $match[1] = '.14'
  $match['cents'] = '.14'
```

preg_match_all(string regex, string subject, array matches, *int flags, int offset*)

- Tries to find all patterns described by **regex** in the **string**
- Matching continues from the end of the last match
- Return number of successful matches or FALSE on error

```
preg_match_all('!\b\d+(\.\d+)?\b!',
               '12.2 times 2 is 24.4', $match); = 3
  $matches[0] = array('12.2', '2', '24.4')
  $matches[1] = array(  '.2', '',    '.4')
```

preg_replace(mixed regex, mixed replacement, mixed subject, *int limit*)

- **regex** to **subject**: Applies **regex** to **subject** and replaces matches with **replacement**
- **limit** specifies how many matches to replace, -1 means no limit (the default)
- Returns modified subject if matches are found
- **regex**, **subject**, and **replacement** can be one-dimensional arrays
- Allows for multiple searches and replacements on multiple strings at once

preg_replace(mixed regex, mixed replacement, mixed subject, *int limit*)

- **replacement** may contain references of the form **\\n** or **$n** (the preferred syntax)
- Such reference will be replaced by the text matched by the **n**'th capturing subpattern

```
preg_replace('!by (\w+) (\w+)!', '- $2, $1', 'Xdebug by Derick Rethans');
= 'Xdebug - Rethans, Derick'
```

preg_replace(mixed regex, mixed replacement, mixed subject, *int limit*)

- **/e** modifier on regex treats replacement as PHP code
- The references are resolved, the code is evaluated, and the result is used as the replacement
- If the resulting PHP code is invalid, a parse error will be issued

```
preg_replace('!\d+!e', '($0+1)', '2 is less than 3');
          = '3 is less than 4'
```

preg_replace_callback(mixed regex, mixed callback, mixed subject, *int limit*)

- Identical to `preg_replace()` except that the replacement is specified by a callback function
- For each match the **callback** is invoked with the match info and is supposed to return the replacement string

preg_split(string regex, string subject, *int limit, int flags*)

- Splits **subject** along boundaries matched by **regex**
- Returns an array of split pieces
- **limit** determines the maximum number of pieces, -1 means no limit (the default)
- The type of splitting can be controlled by **flags**

```
preg_split('/[?¿,.\s]+/', '¿Donde esta... nearest bar?');
 = array('', 'Donde', 'esta', 'nearest', 'bar', '')

preg_split('/[?¿,.\s]+/', '¿Donde esta... nearest bar?',
           3, PREG_SPLIT_NO_EMPTY);
 = array('Donde', 'esta', 'nearest bar?')
```

preg_grep(string regex, array input, *int flags*)

- Applies **regex** to each element of **input** array
- Return a new array consisting only of elements that matched
- If **flags** if PREG_GREP_INVERT, only the elements that did not match will be returned

Regex Toolkit

regex toolkit

- In your day-to-day development, you will frequently find yourself running into situations calling for regular expressions
- It is useful to have a toolkit from which you can quickly draw the solution
- It is also important to know how to avoid problems in the regexes themselves

matching vs. validation

- In matching (extraction) the regex must account for boundary conditions
- In validation your boundary conditions are known – the whole string

matching vs. validation

- Matching an English word starting with a capital letter

  \b[A-Z][a-zA-Z’-]*\b

- Validating that a string fulfills the same condition

  ^[A-Z][a-zA-Z’-]*$

- Do not forget **^** and **$** anchors for validation!

using dot properly

- One of the most used operators
- One of the most <u>misused</u>
- Remember - dot is a shortcut for [^\n]
- May match more than you really want
- <.> will match <b> but also <!>, < >, etc
- Be explicit about what you want
- <[a-z]> is better

using dot properly

- When dot is combined with quantifiers it becomes greedy
- <.+> will consume any characters between the first bracket in the line and the last one
- Including any other brackets!

using dot properly

- It’s better to use negated character class instead

  `<[^>]+>` if bracketed expression spans lines

  `<[^>\r\n]+>` otherwise

- Lazy quantifiers can be used, but they are not as efficient, due to backtracking

optimizing unlimited repeats

- One of the most common problems is combining an inner repetition with an outer one

(regex1|regex2|..)*

(regex*)+

(regex+)*

(.*?bar)*

optimizing unlimited repeats

- One of the most common problems is combining an inner repetition with an outer one
- If the initial match fails, the number of ways to split the string between the quantifiers grows exponentially

(regex1|regex2|..)*

(regex*)+

(regex+)*

(.*?bar)*

optimizing unlimited repeats

- One of the most common problems is combining an inner repetition with an outer one
- If the initial match fails, the number of ways to split the string between the quantifiers grows exponentially
- The problem gets worse when the inner regex contains a dot, because it can match anything!

(regex1|regex2|..)*

(regex*)+

(regex+)*

(.*?bar)*

optimizing unlimited repeats

- PCRE has an optimization that helps in certain cases, and also has a hardcoded limit for the backtracking
- The best way to solve this is to prevent unnecessary backtracking in the first place via atomic grouping or possessive quantifiers

(regex1|regex2|..)*

(regex*)+

(regex+)*

(.*?bar)*

optimizing unlimited repeats

- Consider the expression that is supposed to match a sequence of words or spaces inside a quoted string

  ["“’](\w+|\s{1,2})*["“’]

- When applied to the string “aaaaaaaaaa” (with final quote), it matches quickly

- When applied to the string “aaaaaaaaaa (no final quote), it runs 35 times slower!

optimizing unlimited repeats

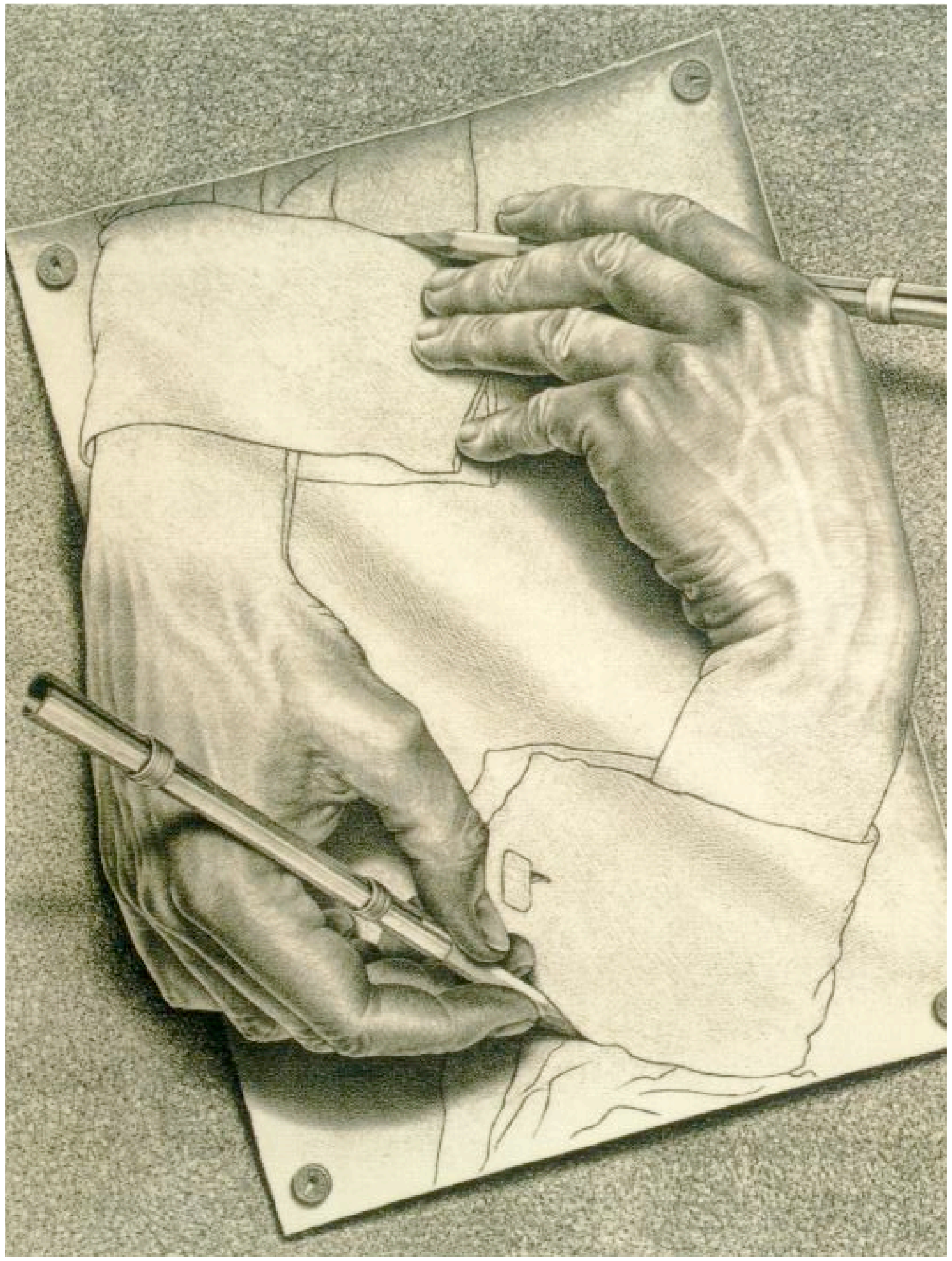
- We can prevent backtracking from going back to the matched portion by adding a possessive quantifier:

  [“’](\w+|\s{1,2})*+[“’]

- With nested unlimited repeats, you should lock up as much of the string as possible right away

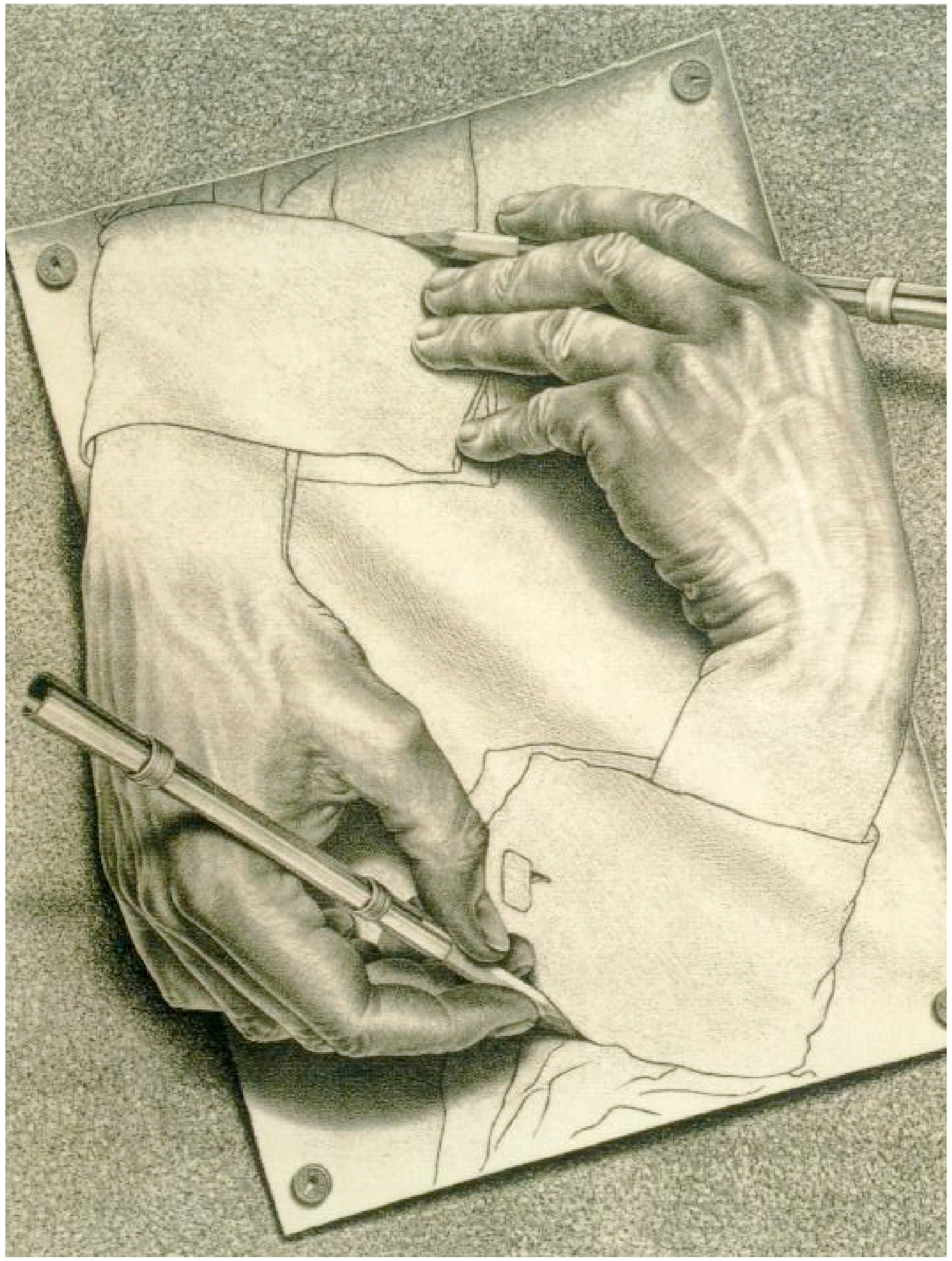
removing duplicate items

- Naïve implementation:
  - Match ([a-z]+) \1
  - Replace with $1
  - Has problems with This is island



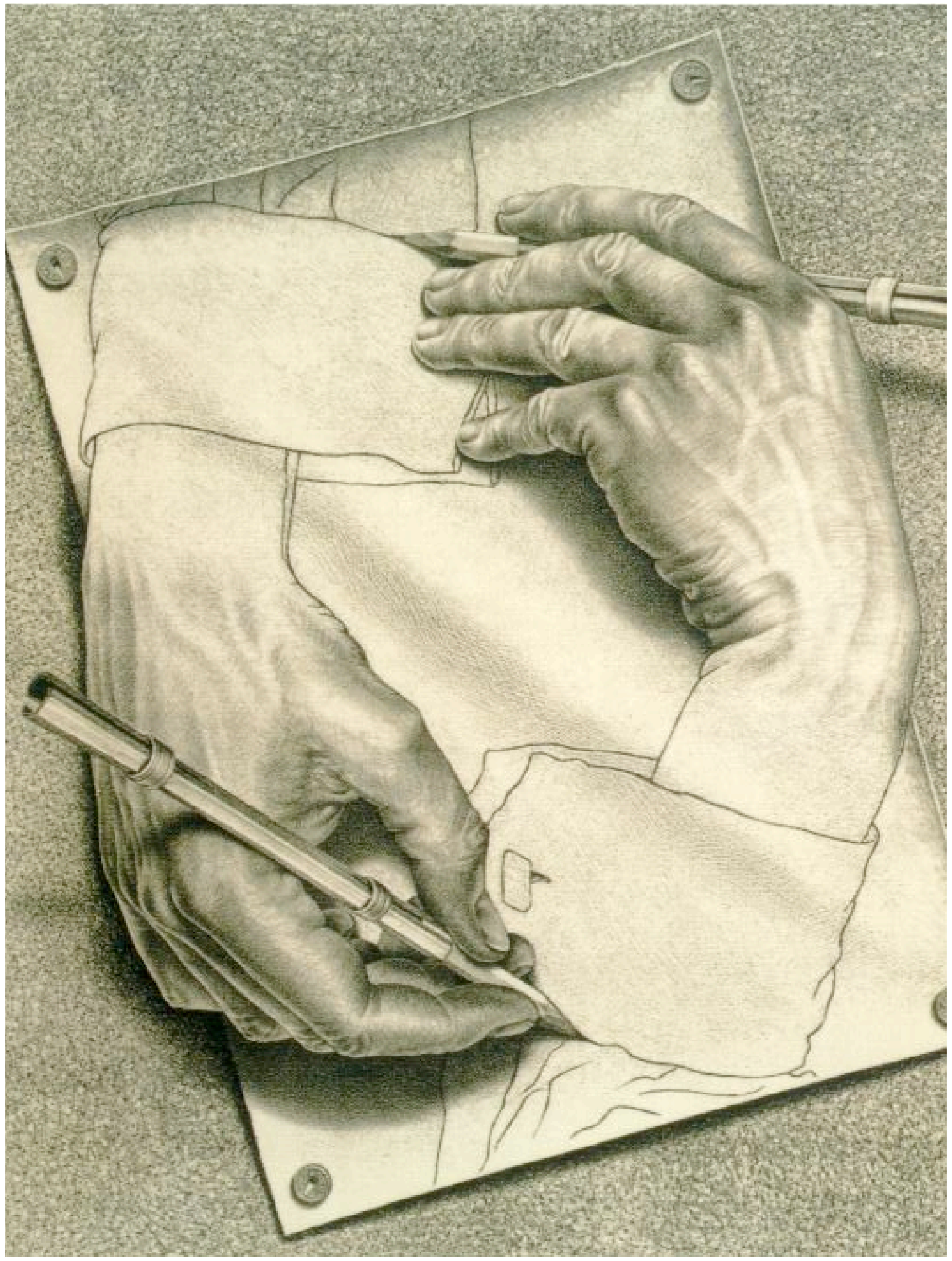
removing duplicate items

- Naïve implementation:
  - Match `([a-z]+)\1`
  - Replace with `$1`
  - Has problems with This is island



removing duplicate items

- Better approach:
  - Match `\b([a-z]+) \1\b`
  - Replace with `$1`
  - Handles This is island just fine



removing duplicate items

- Even better, concentrate on delimiters

```
(?<=[\s.,?!]|^)([^\s.,?!]+)([\s.,?!]\1)++(?=[\s.,?!]|$)
```

removing duplicate items

- Even better, concentrate on delimiters
- First match a non-delimiter sequence

```
(?<=[\s.,?!]|^)([^\s.,?!]+)([\s.,?!]\1)++(?=[\s.,?!]|$)
```

removing duplicate items

- Even better, concentrate on delimiters
- First match a non-delimiter sequence, that is preceded by a delimiter or beginning of string

```
(?<=[\s.,?!]|^)([^\s.,?!]+)([\s.,?!]\1)++(?=[\s.,?!]|$)
```

removing duplicate items

- Even better, concentrate on delimiters
- First match a non-delimiter sequence, that is preceded by a delimiter or beginning of string
- Then match atomically one or more duplicates of the first match, separated by delimiters

```
(?<=[\s.,?!]|^)([^\s.,?!]+)([\s.,?!]\1)++(?=[\s.,?!]|$)
```

removing duplicate items

- Even better, concentrate on delimiters
- First match a non-delimiter sequence, that is preceded by a delimiter or beginning of string
- Then match atomically one or more duplicates of the first match, separated by delimiters
- And make sure it is followed by a delimiter or the end of the string

```
(?<=[\s.,?!]|^)([^\s.,?!]+)([\s.,?!]\1)++(?=[\s.,?!]|$)
```

removing duplicate items

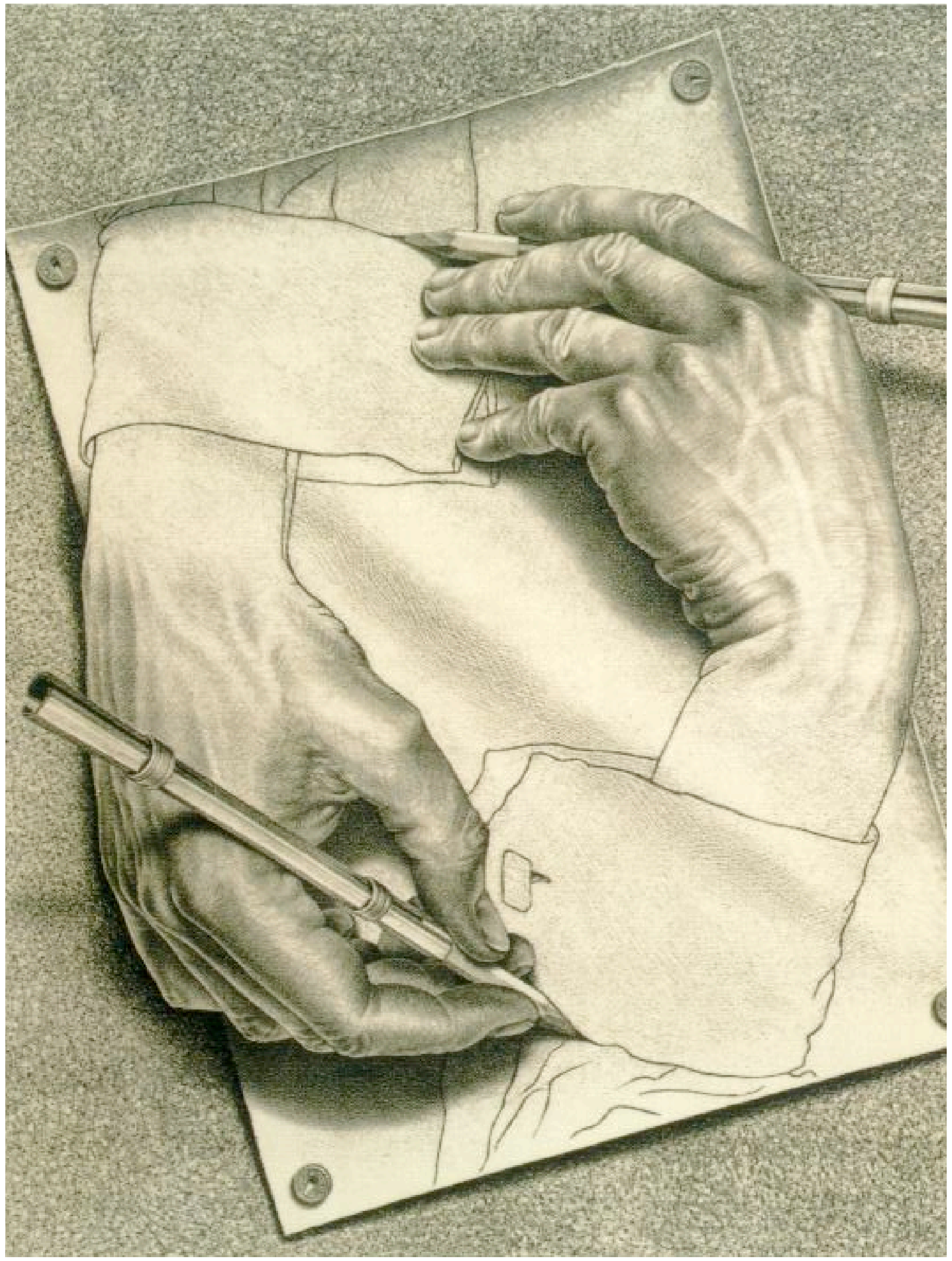
- Even better, concentrate on delimiters
- First match a non-delimiter sequence, that is preceded by a delimiter or beginning of string
- Then match atomically one or more duplicates of the first match, separated by delimiters
- And make sure it is followed by a delimiter or the end of the string
- Replace with **$1**

```
(?<=[\s.,?!]|^)([^\s.,?!]+)([\s.,?!]\1)++(?=[\s.,?!]|$)
```

removing duplicate items

This is unwieldy. Let's use PHP variable interpolation.

```
$dlm = '[\s.,?!]';
$n_dlm = '[^\s.,?!]';
$s = preg_replace("/
          (?<=$dlm|^)
          ($n_dlm+)
          ($dlm++\\1)+
          (?=$dlm|$)
     /x", '$1', $s);
```



removing multiline comments

- Simple, if the comments are not allowed to nest
- **!/*.*?*/!s** replaced with an empty string will work for C-like comments
- General pattern: **/start.*?end/s**
- For nested comments, a recursive pattern is necessary

extracting markup

- Possible to use **preg_match_all()** for grabbing marked up portions
- But for tokenizing approach, **preg_split()** is better

```
$s = 'a <b><I>test</I></b> of <br /> markup';
$tokens = preg_split(
     '!( < /? [a-zA-Z][a-zA-Z0-9]* [^/>]* /? > ) !x', $s, -1,
     PREG_SPLIT_NO_EMPTY | PREG_SPLIT_DELIM_CAPTURE);

result is array('a','<b>','<I>','test','</I>',
                '</b>','of','<br />','markup')
```

restricting markup

- Suppose you want to strip all markup except for some allowed subset. What are your possible approaches?
  - Use `strip_tags()` - which has limited functionality
  - Multiple invocations of `str_replace()` or `preg_replace()` to remove script blocks, etc
  - Custom tokenizer and processor, or..

restricting markup

```
$s = preg_replace_callback(
     '! < (/?) ([a-zA-Z][a-zA-Z0-9]*) ([^/>]*) (/?) > !x',
     'my_strip', $s);

function my_strip($match) {
    static $allowed_tags = array('b', 'i', 'p', 'br', 'a');
    $tag = $match[2];
    $attrs = $match[3];
    if (!in_array($tag, $allowed_tags)) return ‘’;
    if (!empty($match[1])) return "</$tag>";
    /* strip evil attributes here */
    if ($tag == 'a') { $attrs = ''; }
    /* any other kind of processing here */
    return "<$tag$attrs$match[4]>";
}
```

matching numbers

- Integers are easy: `\b\d+\b`
- Floating point numbers:
  - integer.fractional
  - .fractional
- Can be covered by `(\b\d+)?\.\d+\b`

matching numbers

- To match both integers and floating point numbers, either combine them with alternation or use: **((\b\d+)?\.)?\b\d+\b**
- **[+−]?** can be prepended to any of these, if sign matching is needed
- **\b** can be substituted by more appropriate assertions based on the required delimiters

matching quoted strings

- A simple case is a string that does not contain escaped quotes inside it
- Matching a quoted string that spans lines:

  “[^”]*”

- Matching a quoted string that does not span lines:

  “[^”\r\n]*”

matching quoted strings

Matching a string with escaped quotes inside

“([^”]+|(?<=\\\\)”)*+”

“	opening quote
(	a component that is
[^”]+	a segment without any quotes
|	or
(?<=\\\\)”	a quote preceded by a backslash
)*+	component repeated zero or more times without backtracking
“	closing quote

matching e-mail addresses

- Yeah, right
- The complete regex is about as long as a book page in 10-point type
- Buy a copy of Jeffrey Friedl's book and steal it from there

matching phone numbers

- Assuming we want to match US/Canada-style phone numbers

```
800-555-1212      1-800-555-1212
800.555.1212      1.800.555.1212
(800) 555-1212    1 (800) 555-1212
```

- How would we do it?

matching phone numbers

- The simplistic approach could be:

  (1[.–])? \(? \d{3} \)? [.–] \d{3} [.–] \d{4}

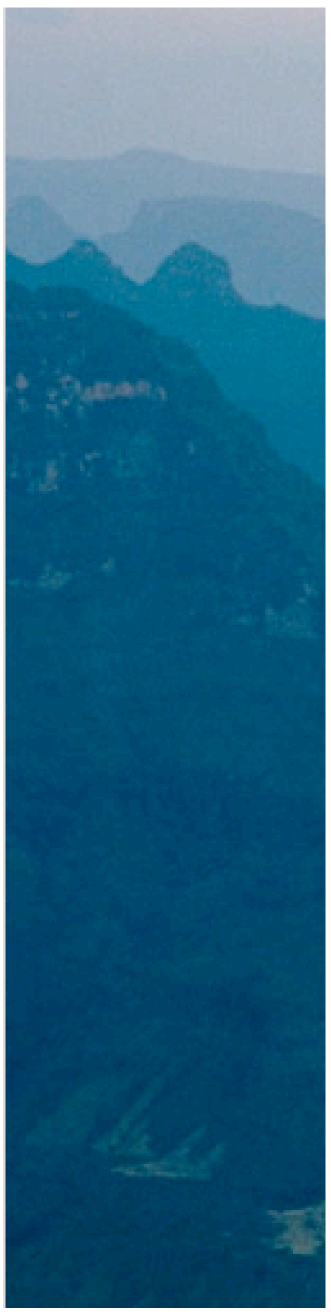
- But this would result in a lot of false positives:

```
1.(800)-555 1212  800).555-1212
1-800 555-1212    (800 555-1212
```

matching phone numbers

^(?:	anchor to the start of the string
(?:1([.-]))?	may have 1. or 1- (remember the separator)
\d{3}	three digits
((?(1)	if we had a separator
\1 |	match the same (and remember), otherwise
[.-]))	match . or - as a separator (and remember)
\d{3}	another three digits
\2	same separator as before
\d{4}	final four digits
|	or
1[ ]?\(\d{3}\)[ ]\d{3}-\d{4}	just match the third format
)$	anchor to the end of the string

tips



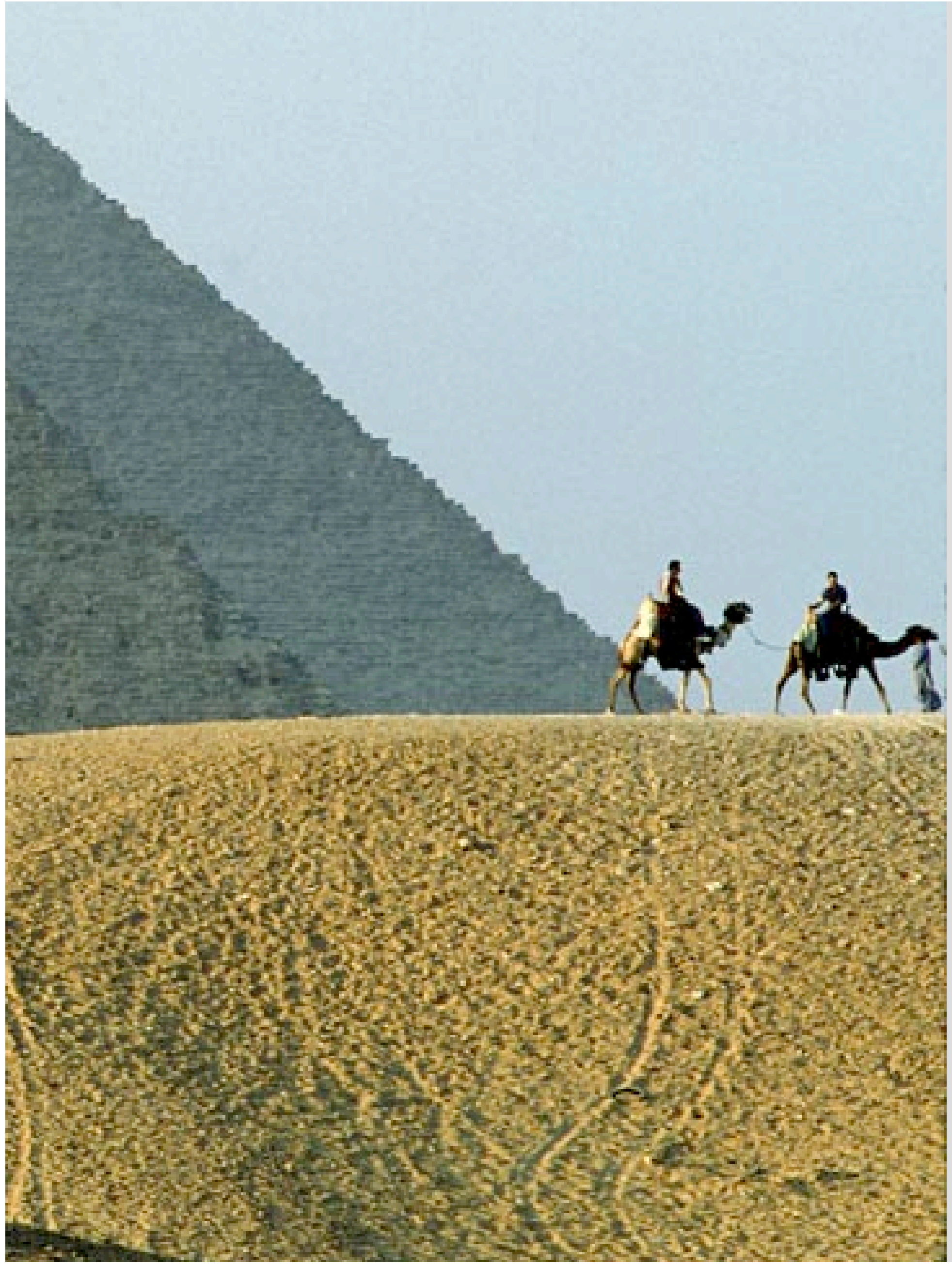
- Don't do everything in regex – a lot of tasks are best left to PHP
- Use string functions for simple tasks
- Make sure you know how backtracking works

tips

- Be aware of the context
- Capture only what you intend to use
- Don't use single-character classes

tips

- Lazy vs. greedy, be specific
- Put most likely alternative first in the alternation list
- Think!



Thank You!

Questions?