Regular Expressions

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Introduction

Regular Expressions

A sequence of characters that forms a **search pattern**.

Used in:

- Data validation.
- Search and Replace.
- Parsing.

Variants

- There are **several** different regular expression **processors**.
- All of them translate regular expressions into a Nondeterministic Finite Automaton **(NFA)**.
- But can have slightly **different syntaxes**.

Matching

- Matching is the process of **applying** a regular expression **pattern** to a text string and finding strings that are represented by that pattern.
- When **validating**, we normally expect the **whole** string to match the pattern.
- When **searching**, we expect a **substring** of that string to match the pattern.

References

- Online Regular Expression Tester
- Regular Expressions Tutorial
- Regex Golf
- Mail RFC822 Regexp

Literal Characters

Literal Characters

A literal character matches the first occurrence of that character in the string.

```
a
```

ﬂ I ate an apple.

You can tell the processor to match all occurrences if needed.

ﬂ I ate an apple.

Literal Characters

A series of literal characters, matches those same characters in the same order.

```
at
```

I ate an apple.

Special Characters

There are twelve characters that have special meanings in regular expressions:

```
\ ^ $ . | ? * + ( ) [ {
```

To match any of these symbols, you need to escape them with a **backslash**.

```
\+
```

ﬂ 1+1=2

All other characters should **not** be escaped as the backslash also has special meaning.

Non-Printable Characters

- `\t` - tab
- `\r` - carriage return
- `\n` - line feed

Character Classes

Character Classes

A character class, or set, matches **only one** out of several characters.

```
gr[ae]y
```

ﬂ gray or grey

Ranges

You can use an hyphen to specify ranges in a character class.

```
[0-9a-fA-F]
```

This matches all digits from 0 to 9 and all letters (both in lowercase and uppercase).

ﬂ The cat is inside the box.

Negated

A **caret**(^) after the opening square bracket negates the character class.

```
[^A-Za-f]
```

This matches all letters except those in uppercase and from *a* to *f*.

fl The cat is inside the box.

Special Characters

Inside a character class, the only special characters are:

```
] \ ^ -
```

All others do not need to be escaped.

Shorthand Character Classes

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

Dot

The **dot(.)** matches any character except line breaks.

```
c.t
```

ﬂ The cat is inside the box.

Zero Length Matches

Anchors

Anchors can be used to specify the position of the matched string.

- The **caret**(^) matches the position before the first character in the string.
- The **dollar sign**($) matches right after the last character in the string.
- We can use both anchors to validate a string.

```
boys$
```

Matching all occurrences:

> ﬂ Everyone knows boys will be boys

Word Boundaries

- The metacharacter **\b** is an anchor.
- It matches at a position that is called a *word boundary*.
- It always produces a zero-length match.
- This allows you to do whole word searches.

```
\bis\b
```

ﬂ This island is beautiful.

Alternation

Alternation

The **vertical bar**(|) allows you to match a single regular expression out of several possible regular expressions.

```
cat|dog
```

Matching all occurrences:

ﬂ I like both cats and dogs.

Quantifiers

Optional Items

The **question mark**(?) makes the preceding token in the regular expression optional.

```
colou?r
```

Matching all occurrences:

ﬂ Do you write color our colours?

Repetion quantifiers

Repetition **quantifiers** allow the preceding token to repeat:

- The **star**(*) allows the token to repeat 0 or more times.
- The **plus**(+) allows the token to repeat 1 or more times.

```
[0-9]+
```

ﬂ My phone number is 12345.

The **question mark**(?) is also a repetion **quantifier** that allows the token to repeat 0 or 1 times.

Custom Repetitions

Using **curly brackets**({}) we can specify the maximum and minimum number of repetions:

Repeat exactly 9 times:

```
[0-9]{9}
```

Repeat between 1 and 3 times:

```
[0-9]{1,3}
```

Repeat at least twice:

```
[0-9]{2,}
```

Repeat at most three times:

```
[0-9]{,3}
```

Repetitions are Greedy

By default, regular expression processors try to match as many characters as possible when handling repetitions.

```
<.+>
```

ﬂ This tea is <strong>good</strong>.

This might cause unexpected effects.

Lazy Repetitions

To make repetitions lazy, we add a **question mark**(?) after the repetition operator.

```
<.+?>
```

Matching all occurrences:

ﬂ This tea is <strong>good</strong>.

Being lazy is hard work!

The reason why repetitions are greedy by default, is because being lazy forces the processor to **backtrack** more often.

An **alternative** would be using **negated classes**:

```
<[^>]+>
```

Matching all occurrences:

ﬂ This tea is **<strong>**good**</strong>**.

Grouping and Capturing

Grouping

Putting part of a pattern inside **parentheses** creates a group.

Groups can be used to apply **quantifiers** and **alternation** to specific parts of the pattern.

```
((https?|ftp)://)?www\.example\.com
```

Matching all occurrences:

ﬂ ftp://www.example.com or just www.example.com

Capturing

Groups are automatically **captured** and **numbered**.

This allow you to **extract** different parts of the matched expression.

```
(cats|dogs) are (lazy|smart)
```

ﬂ i think cats are lazy

- Group #0: cats are lazy
- Group #1: cats
- Group #2: lazy

The **complete** match is always group **#0**.

Capturing

Other Example

```
((https?|ftp)://)?www\.example\.com
```

ﬂ http://www.example.com

- Group #0: http://www.example.com
- Group #1: http://
- Group #2: http

Non Capturing

Sometimes we want to create a group without capturing it. To do that we start the group with a **question mark**(?) and a **colon**(:):

```
(?:(?:https?|ftp)://)?www\.example\.com
```

ﬂ http://www.example.com

- Group #0: http://www.example.com

Backreferences

Backreferences

Backreferences can be used to match the same text twice.

Some regular expression processor use \n to reference captured groups while other use $n.

Number with at least 3 digits and where the first number is the same as the last.

```
([0-9])[0-9]+\1
```

ﬂ 1231

Backtracking

Backtracking

Although regular expression processors are greedy, they can backtrack if they fail to find a match.

```
([0-9])[0-9]+\1
```

ﬂ 41231

Here, the processor starts by matching the 4 but when it fails to find another 4 in the text it backtracks and tries to start with the 1.

ﬂ 41231

Lookaround

Lookahead and lookbehind

Lookahead and **lookbehind** are **zero-length assertions** (just like the start and end of line and word boundaries)

- These are also called **lookaround** assertions.
- They match characters but then **give up the match** without consuming the characters.
- They only **assert** whether a match is possible or not.

Positive lookahead

Matches something followed by something else.

```
(cat|dog)(?=s)
```

Matches *cat* or *dog* if followed by an *s*:

ﬂ My dog is not like other dogs.

Negative lookahead

Matches something not followed by something else.

```
(cat|dog)(?!s)
```

Matches *cat* or *dog* if not followed by an *s*:

ﬂ All the cats are smarter than my cat.

Positive lookbehind

Tells the processor to temporarily **step backwards** in the string and check if the text inside the lookbehind can be **matched** there.

```
(?<=is)land
```

Matches *land* if preceeded by *is*:

ﬂ England is part of an island.

Negative lookbehind

Tells the processor to temporarily **step backwards** in the string and check if the text inside the lookbehind **cannot** be matched there.

```
(?<!some)thing
```

Matches *thing* if it is not preceeded by *some*:

ﬂ There is something about this thing.

Nondeterministic Finite Automaton

Regular Expressions are NFAs

Deterministic Finite Automaton (DFA) are finite state machines where:

- each of its transitions is **uniquely** determined by its **source** state and **input** symbol, and
- reading an input symbol is **required** for each state transition.

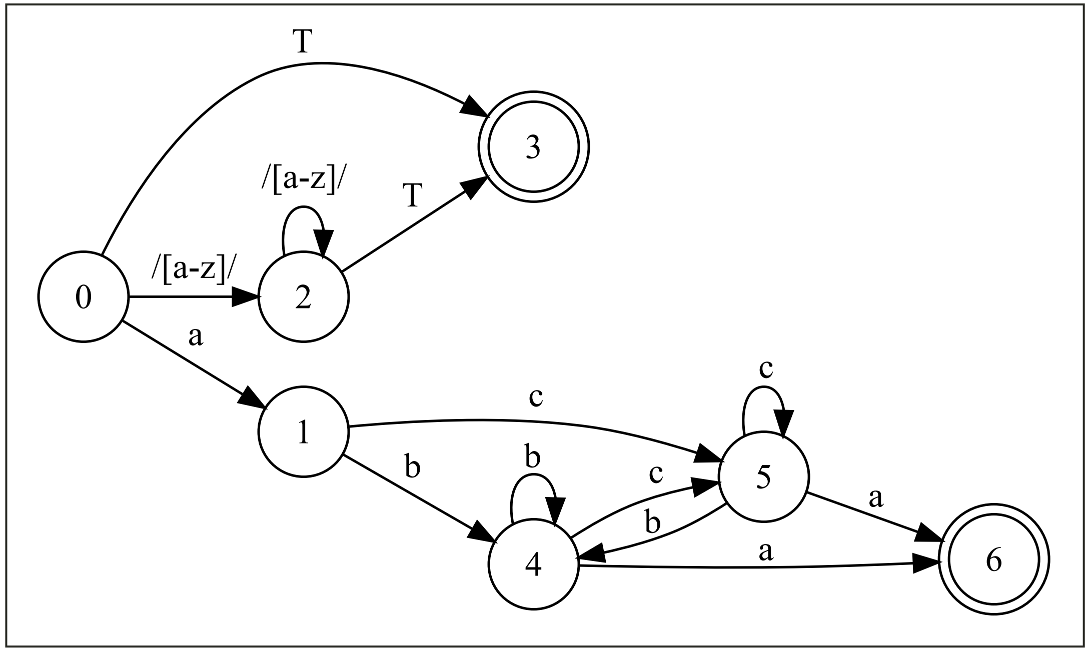
Nondeterministic Finite Automaton don't need to obey these restrictions.

Regular expressions can easily be transformed into NFAs. And NFA can easily be transformed into DFAs.

http://hackingoff.com/compilers/regular-expression-to-nfa-dfa

Example

```
(a(b|c)+a)|([a-z])*T
```



In HTML

In HTML, input elements have a pattern attribute that can contain a regular expression pattern specifying the allowed values of the field.

```html
<input type="text" pattern="\d{9}|\d{3}-\d{3}-\d{3}">
```

In PHP

Patterns

- PHP uses Perl-Compatible Regular Expressions (PCRE)
- In PHP, patterns must be delimited by either **forwardslashes** (/), **hash** signs (#) or **tildes** (~).

```
/ab|c/
```

- This means that the chosen delimiter must be **escaped** inside the pattern.
- You may add pattern modifiers after the ending delimiter.

```
/ab|c/i
```

For example, the **i** pattern modifier makes the pattern case **insensitive**.

preg_match

```
int preg_match ( string $pattern , string $subject [, array &$matches ])
```

The preg_match, searches *subject* for a match to the regular expression given in *pattern*.

- If matches is provided, then it is filled with the results of the search.
- Returns 1 if the pattern matches given subject, 0 if it does not and false if an error occurred.

```php
<?php
  preg_match('/(\d{4})(?:-(\d{3}))?/', '4100-122', $matches);
  print_r($matches);
?>
```

```
Array
(
    [0] => 4100-122
    [1] => 4100
    [2] => 122
)
```

preg_match_all

```
int preg_match_all ( string $pattern , string $subject [, array &$matches ])
```

The preg_match_all, searches *subject* for **all** matches to the regular expression given in *pattern*.

- If matches is provided, then it is filled with all the results of the search in a multi-dimensional array.
- Returns the number of full pattern matches and false if an error occurred.

```
<?php
  preg_match_all('/(\d{4})(?:-(\d{3}))?/', '4100-122 4200', $matches);
  print_r($matches);
?>
```

```
Array
(
    [0] => Array ([0] => 4100-122 [1] => 4200)
    [1] => Array ([0] => 4100 [1] => 4200)
    [2] => Array ([0] => 122 [1] => )
)
```

preg_replace

```
mixed preg_replace ( mixed $pattern , mixed $replacement , mixed $subject )
```

The preg_replace function, searches *subject* for matches to *pattern* and replaces them with *replacement*.

- The replacement can contain backreferences in the form n or {n}.

```
<?php
  echo preg_replace('/(cat|dog)/', 'my $1s', 'dog are dog');
?>
```

```
my dogs are my dogs
```

Validation

Using the **preg_match** function, we can easily validate data using regular expressions:

```
function is_phone_number($element) {
    return !preg_match ("/^\d{9}|\d{3}-\d{3}-\d{3}$/", $element);
}
```

Don't forget the beginning and end of string anchors.

Cleaning

You can also use the **preg_replace** function to clean up input data before storing it in the database.

```
$text = preg_replace('/[^\w\d\s\.!,\?]/', '', $_GET['text']);
```

In Javascript

Patterns

- In javascript, patterns must be delimited by **forwardslashes** (/).
- This means that the forwardslashes must be **escaped** inside the pattern.
- You may add modifiers after the ending delimiter:

The **g** modifier is used to perform a global match (find all matches).

The **i** modifier is used to perform a case insensitive match.

test

```
regexObj.test(str)
```

The test function, tests for a match in a string. It returns true or false.

```
console.log(/(\d{4})(?:-(\d{3}))?/.test('4100-122'));
```

```
true
```

match

```
str.match(regexp)
```

The match function, executes a search for a regular expression in a string.

```
console.log('4100-122 4200'.match(/(\d{4})(?:-(\d{3}))?/));
console.log('4100-122 4200'.match(/(\d{4})(?:-(\d{3}))?/g));
```

```
["4100-122", "4100", "122", index: 0, input: "4100-122 4200"]
["4100-122", "4200"]
```

search

```
str.search([regexp])
```

If successful, search returns the index of the first match of the regular expression inside the string.

```
console.log('My zip code is 4100-122'.search(/(\d{4})(?:-(\d{3}))?/));
```

```
15
```

replace

```
str.replace(regexp, replacement)
```

- The replacement can contain backreferences in the form $n.

```
console.log('dog are dog'.replace(/(cat|dog)/, 'my $1s'));
console.log('dog are dog'.replace(/(cat|dog)/g, 'my $1s'));
```

```
my dogs are dog
my dogs are my dogs
```

Validation

Using the **test** function, we can easily validate data using regular expressions:

```
function is_phone_number(element) {
  return /^\d{9}|\d{3}-\d{3}-\d{3}$/.test(element);
}
```

Don't forget the beginning and end of string anchors.