

APT Session 6: Regular expressions and parsing



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2015-11-25

What to expect from this session

- 1 Using regular expressions in practise.
- 2 Building a parser.

Prerequisites

- 1 Have the programming language of your choice (e.g. Java, Python) installed and running on your computer.

Why regular expressions and parsing?

- Real programming languages *parse* user input. When you run something like `javac`, the compiler first parses the input, before compiling it into bytecode or machine code.
- So we need to have a knowledge of parsing in order to build a compiler (next week!).

Why regular expressions and parsing?

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- So we need to have a knowledge of parsing in order to build a compiler (next week!).
- And one of the easiest ways to build a parser is to use regular expressions (which are also useful in many other places).

Regular expressions: motivation

- A *Domain Specific Language (DSL)* for flexibly matching against text.
- Lots of minor variants, but the basic concepts shared by all implementations.
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- A *Domain Specific Language (DSL)* for flexibly matching against text.
- Lots of minor variants, but the basic concepts shared by all implementations.
- Packs very complex matching down to a few characters.
- Terseness a pro and a con. *Some people, when confronted with a problem, think "I know, I'll use regular expressions." Now they have two problems.* – Jamie Zawinski, 1997

Regular expressions: the basics

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- Individual letter and number atoms match themselves. i.e. 'normal' text matches as per 'normal' expectations.

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Exercises:

- 1 Download the [words file](#).
- 2 Write a program which loads the file in and prints out every line which contains the string 'aab' using normal string search.
- 3 Modify your program to do the same search, but using a regular expression. You will probably need to *compile* the regular expression to a *Pattern*; then use that compiled pattern to *match* against your string of interest and produce a *Match* which will tell you if the search succeeded or not.

Regular expressions: variable matching

- A '.' (dot) matches against any character.
- A '*' matches against 0 or more of the preceding atom. A '+' matches against 1 or more of the preceding atom. A '?' matches against 0 or 1 of the preceding atom.
- A character class [abc] matches against any of a, b, c. An initial '^' negates this: [^abc] matches any character except a, b, c.
- Character sets can contain ranges. [0-3] is equivalent to [0123]; similarly, [a-d] is equivalent to [abcd].

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Exercises:

- 1 Print out all lines which have a 'z', followed by one of 'f' or 'g'.
- 2 Print out all lines which have a 'z', followed by any character except 'f' or 'g'.
- 3 Print out all lines which have a capital letter followed later by a lower-case 'z'.

Regular expressions: anchoring

- '^' (caret) only matches at the beginning of a line.
- '\$' only matches at the end of a line.

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- '\$' only matches at the end of a line.

Exercises:

- 1 Print out all lines which have a 'z' at the beginning and a 'z' somewhere else in the word.
- 2 Print out all lines which have a 'z' at the beginning and end with a 'z'.

Regular expressions: groups

- Placing atoms within brackets () forms a new atom (so (a b) is an atom that contains two sub-atoms a and b).
- Brackets create groups, which can be referred to later, and sub-parts of text extracted.

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Exercises:

- 1 Find every word which contains a 'z', then one non-'z' character, and then another 'z'. Print out only those 3 characters for each match.
- 2 Find every word which contains a 'z' followed by one other arbitrary character, and a second 'z' followed by one other arbitrary character. Print out the 4 characters matched. Note: the 4 characters do not have to be consecutive.

Regular expressions: greediness

- * and friends are *greedy*: they matches as many characters as possible. Greedy matching is often dangerous; it's generally better to explicitly use non-greedy.
- Adding ? as a suffix to repetition operators (e.g. *?) uses non-greedy matching.

Regular expressions: greediness

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- Adding `?` as a suffix to repetition operators (e.g. `*?`) uses non-greedy matching.

Exercises:

- 1 Create a new file with the contents `bold`.
- 2 Find all matches of `b` followed by another character; print out only those 2 characters.
- 3 Print all HTML tags in the input file, each on a new line.

Regular expressions: other useful bits

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- You can use regular expressions to split apart strings.
- You can use regular expressions to replace strings.
- Unix's `grep` allows you to do regular expression searches over files and directories (albeit with a slightly limited variant of regular expressions). I use `grep` heavily when programming with unfamiliar codebases.
- My [srep](#) tool allows you to do regular expression search and replace over files and directories.

Parsing

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- Parsing is the first step in a compiler, analysing the user's text input and turning it into a tree to make later analysis possible.
- Simplest way of doing so: first *tokenize* the text (i.e. split it into separate words, removing whitespace); second *parse* into a tree.

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- Simplest way of doing so: first *tokenize* the text (i.e. split it into separate words, removing whitespace); second *parse* into a tree.
- There are *many* ways of doing parsing. Earley, GLR, LL, LR, PEG etc.
- We're going to start with the simplest: a recursive descent parser. You can use this technique easily in any programming language.

BNF grammar and recogniser

- We write computer grammars in BNF form: $R ::= S_1 S_2 \dots S_n$ where R is a rule name and S_n is a symbol. Symbols either reference tokens (e.g. ID) or other rules (e.g. R).
- Before we write a 'proper' parser, we can write a recogniser which says whether a string conforms to a grammar or not.
- A rule $R ::= X$ (where X is a token) becomes a function `parse_R(s, i)` where s is the string input and i is how far through we are trying to parse it. The function returns `-1` if it could not match; or a new i' (which must be $> i$) if successful.

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Exercises:

- 1 For the grammar `Assign ::= ID = INT ;` write a recogniser (ID is `[a-zA-Z_][a-zA-Z_0-9]*` and INT is `[0-9]+`).
- 2 Test your recogniser against the inputs `x = 2;` and `y = ;` and `x = y;` at a minimum.

Referencing rules

- Rules can call other rules. Failure propagates. Recursion is allowed provided at least one character is consumed first.
- *But* rules can specify alternatives. $R ::= A \mid B$ means one can parse R as A *or* B . [Note: in most parsing algorithms, neither A or B has priority. In recursive descent parsers, A is tried before B . This has some subtle effects which we'll ignore.]

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Exercises:

1 Write a recogniser for:

```
Assign ::= ID = Expr ;  
Expr   ::= INT + Expr  
        | INT
```

- 2 Test your recogniser against the inputs $x = 2;$ and $y = ;$ and $x = y;$ and $x = 2 + 3;$ and $x = 2 + 3 + 4;$ and $x = 2 + ;$ at a minimum.

Parse trees

- Recognisers are rarely useful. What we really want is a *parse tree*. e.g. $2 + 3 \Rightarrow \text{add}(\text{int}(2), \text{int}(3))$.
- Building up a tree as we go along is easy. For each element we want (e.g. *Add*), make a class which can hold its contents. When we parse such a thing, instantiate that element.
- Instead of just returning i' , return a pair (tree, i') .

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Exercises:

- 1 Write a parse-tree creating parser for:

```
Assign ::= ID = Expr ;  
Expr   ::= INT + Expr  
        | INT
```

- 2 Add a `pp` function to each parse tree element so that it can print itself out and you can see if the parsed tree is consistent with the input.

A realistic grammar

Exercises:

1 Write a parse-tree creating parser for:

```
Stmt    ::= Assign | While
Assign  ::= ID = Expr ;
Expr    ::= INT + Expr
         | INT
While   ::= WHILE Expr { stmt* }
```

Post-session exercises

Try these (no particular order):

- Discover how to encode precedences for $+ - * /$ and friends (hint: look for grammars which have rules with names like `factor` and `term`).
- Use a parsing toolkit like [ANTLR](#).
- Experiment with our [Eco editor](#), which uses grammars extensively.