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Regular Expression

A regular expression is a text string that specifies a pattern of characters. This facility allows you to write J programs using regular expressions to search arbitrary text. You can perform a search for a single or multiple matches, or extract the matched text from the string. You can also merge new text in to replace the matches, or apply a verb to the matched text in a string.

Utility verbs are included to assist in building regular expression patterns, as is a utility to search J scripts and other text files for patterns.

The primary definitions are in system\main\regex.ijs; utility verbs to build patterns are in system\packages\regex\regbuild.ijs.

The Find in Files utility, available from the Edit menu or by pressing Ctrl+Shift+F, can search for simple text, regular expression, or special patterns such as the assignment of a name.

Labs and a demo on regular expressions are available from the Studio menu.
Regular Expression Patterns

A regular expression pattern is a sequence of elements which matches successive portions of a character string. For example, simple letters are elements which match the same characters in the string. The asterisk indicates that the previous element should be matched 0 or more times. So, a pattern of abcd must match in the string exactly; a pattern of ab*cd matches the letter a followed by 0 or more occurrences of the letter b, followed by the letters cd. The particular elements of a pattern are described below.

Characters
Non-special characters match exactly. Non-special characters are anything other than:

[ ] ( ) { } $ . * + ? | \n
A special character is included as simple text by preceding it with a backslash.

Character sets
The special character . matches any character (except the null character, \0\{a. )

The special characters ^ and $ match the start and end of lines.

Sets of characters are defined by enclosing the list of characters in brackets:

[aeiou] matches a single vowel character

Ranges can also be included within the brackets:

[a-z] matches any lower case letter

Combinations of the above are acceptable:

[a-zA-Z13579] matches any lower case, upper case, or odd digit

Fixed sets (classes) of characters can be included in the list, as a name within bracket-colon pairs:

[#[[:digit:]abc]] matches the character #, a digit, or any of the letters a, b, or c

The character classes defined are:

<table>
<thead>
<tr>
<th>alnum</th>
<th>alphanumeric</th>
<th>alpha</th>
<th>alphabetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>blank</td>
<td>tab and space</td>
<td>cntrl</td>
<td>control chars</td>
</tr>
<tr>
<td>digit</td>
<td>digits</td>
<td>graph</td>
<td>printable (except space)</td>
</tr>
<tr>
<td>lower</td>
<td>lowercase</td>
<td>print</td>
<td>printable</td>
</tr>
<tr>
<td>punct</td>
<td>punctuation</td>
<td>space</td>
<td>whitespace</td>
</tr>
<tr>
<td>upper</td>
<td>uppercase</td>
<td>xdigit</td>
<td>hex digits</td>
</tr>
</tbody>
</table>

If a set begins with ^, then the pattern will match with any character not in the set.
Subexpressions
A series of elements may be combined by enclosing them in parenthesis. Subexpression are affected by closures such as \* just as simple characters are:

\(([a-z][0-9]*)\)* matches any number of occurrences of a letter followed by a digit

The result of searches for a pattern return a match for the overall pattern, and a separate match for each subexpression

A \ followed by a digit, N, matches the same substring which occurred in the Nth subexpression:

\(\([[:digit:]]+\)#\1\) matches one or more digits, followed by a \#, followed by the same string of digits

Closures
A \* following an element matches 0 or more occurrences of that element:

\([aeiou]*\) matches 0 or more vowels

A \+ following an element matches 1 or more occurrences of that element:

\([[:alpha:]]+\) matches 1 or more alphabetic characters

A \? following an element matches 0 or 1 occurrences of that element:

\?-\([[:digit:]]+\) matches an optional hyphen, followed by 1 or more digits

An interval expression, \{m, n\}, follows an element to allow it to match at least m, and no more than n, occurrences of the element:

\([[:digit:]]\{3,5\}\) matches 3, 4, or 5 digits

Alternation
Multiple regular expressions can be separated with a vertical bar | to match any of them:

\(\text{print|list|exit}\) matches any of the strings \text{print}, \text{list}, and \text{exit}

Matches
When searching for a pattern in a string, it is possible to find multiple substrings which match the pattern. The one that is returned is the one which starts earliest in the string. If more than one match starts at the same place, the longest one is returned.

Even once a particular match is located, it is possible for there to be multiple combinations of the contents of the subexpressions which make it up. As a rule, whenever possible the subexpressions which begin earlier in the string will be as long as possible.
The result of a match is a table which describes the match. The first row covers the whole match, and subsequent rows describe where the subexpressions in the pattern match in the string. Each row has two elements: index of the first character of the start of the match, and the length of the match. Any row which doesn't participate in the match is filled with _1 0.
Regular Expression Verbs

The standard regex verbs are defined in system/main/regex.ijs. The main verbs are rxmatch and rxmatches. The former locates the first occurrence of a match in the string; the latter locates all occurrences. Four other verbs create, list, display, and free up compiled patterns: rxcomp, rxhandles, rxinfo, and rxfree.

Most of the rest of the definitions either use the rxmatch or rxmatches verbs, or take the result of them as arguments.

match=. pattern rxmatch string Find first match

The result of rxmatch is a table, each row being an index/length pair. The first row describes the entire match, one row per subexpression follow which describes where each subexpression was found in the string. Where a match does not occur, _1 0 is returned.

matches =. pattern rxmatches string Find all matches

rxmatches returns a list of tables, with one item per match in the string. The shape of the result is #matches by #subexpr by 2.

phandle =. rxcomp pattern Compile pattern
rxfree phandle Release compiled pattern
phandles =. rxhandles '' Return all pattern handles
'nsub pat' =. rxinfo phandle Return #subexprs; pattern

The verbs rxcomp, rxhandles, rxinfo, and rxfree allow you to create pattern handles which are simple integers which represent compiled patterns. A handle can be used anywhere a pattern can be and, if used repeatedly, will avoid having to recompile the pattern on each call.

rxcomp compiles a pattern and returns a handle.

rxhandles returns a list of all existing handles.

rxinfo returns information about a handle. It currently returns a boxed list of 1 + the number of subexpressions and the original pattern. The length of the result may be extended (on the right) in the future.

rxfree releases all resources associated with a compiled pattern.

errtext =. rxerror '' Error text

The result of rxerror is a text string describing the last error from a regular expression verb.

ismatch =. pattern rxeq string 1 if entire string matches

Returns a 1 if the pattern fully describes the string. (Similar to = verb).
index = . pattern rxindex string     index of match or #string

The result of rxindex is the index of the first match, or #string if none. (Similar to i. verb).

mask = . pattern rxE string       mask: 1's start matches

rxE returns a boolean mask of length #string, with 1's to mark the start of a match. (Similar to E. verb).

sub = . pattern rxfirst string    first substring match

rxfirst returns the substring in the right argument which matches the pattern.

subs = . pattern rxall string     all substring matches

The result of rxall is a boxed list of all substrings in the right argument which match the pattern.

subs = . matches rxfrom string    select substrings matched

rxfrom returns a box containing the substrings described by each index/length pair on the left.

subs = . matches rxcut string     cut into alternating non-match/match

rxcut returns a boxed list which will match the original string if razed. The items alternate between non-matches and matches, always starting with a non-match.

newstr = . string rxrplc (pat;rplcstr) replace pat with rplcstr

rxrplc replaces substrings in the left argument. The right argument is a boxed list of the pattern and the replacement text.

newstr = . rplcstrs matches rxmerge string merge rplcstrs into string

rxmerge takes a table of matches as an argument, and returns a verb which merges the boxed strings in the left argument into those positions on the right. (Similar to } adverb).

newstr = . pattern f rxapply string apply f to each match

rxapply applies its verb argument to each of the substring in the right argument which match the pattern in the left argument.

All verbs which take a pattern as an argument can be called with either a character list containing a pattern or pattern handle (an integer resulting from rxcomp). For example,

'[[[:alpha:]]]+' rxmatches str  NB. match all sets of letters in str
handle=. rxcomp '[:alpha:]+'  NB. compile pattern into handle
handle rxmatches str  NB. do the match
rxfree handle      NB. (once handle is no longer required)

Notes

1. The `rmatch` and `rxmatches` verbs return either a single or list of matches, respectively, with each match being a table of index/length pairs for the match and each subexpression. Other verbs which use the result of `rxmatch` or `rxmatches` tend to only use the first row for each match, which represents the entire match.

2. If you're interested in one or more of the subexpressions, it is possible to identify the specific rows of the match which are to be returned by `rxmatch` and `rxmatches`. If a boxed array is passed rather than a character or numeric pattern, it is a 2-element list consisting of a pattern and a list of the indices of the important rows in a match.

For example, the pattern `(x+) ([:digit:])` matches one or more letters 'x', followed by a string of digits, with both the 'x's and the digits being subexpressions of the pattern. Each match will be returned as a three-row table, describing the entire match, just the 'x's, and just the digits.

```jscript
pat=. rxcomp '(x+) ([:digit:])'
str=. 'just one xxx1234 match here'
pat rxmatches str
9 7
9 3
12 4
(pat;1 2) rxmatches str  NB. just the 'x's and digits
9 3
12 4
```

```
pat |. rxapply str  NB. reverse the whole match
just one 4321xxx match here
(pat;,2) |. rxapply str  NB. reverse just the digits
just one xxx4321 match here
```

Examples

```jscript
pat=. '[:alpha:][[:alnum:]]*'  NB. pattern for J name
str=. '3,foo3=.23,j42=.123,123'  NB. a sample string
pat rxmatch str  NB. find at index 2, length 4
2 4

pat=. '([[:alpha:]][[:alnum:]]*) *=.[;]'  NB. subexp is name in assign

pat rxmatch str  NB. pattern at 2/6; name at 2/4
2 6
2 4

pat rxmatches str  NB. find all matches
```
]phandle=. rxcomp pat   NB. compile
1
   rxcomp '[wrong'   NB. a bad pattern
   domain error: rxcomp
   rxcomp'[wrong'

rxerror ''
Unmatched [ or [^

rxhandles ''   NB. just handle 1 defined
1

rxinfo phandle   NB. return (1+#subexp);pattern
+-+---------------------------------+
|2|\[[[:alpha:]][:alnum:][^_]]*\] *=[.;]|+-+---------------------------------+

   phandle rxmatches str   NB. use phandle like pattern
2 6
2 4
11 5
11 3

   phandle rxfirst str   NB. first matching substring
foo3=.

   phandle rxall str   NB. all matching substrings
+-+-----+
|foo3=.|j42=.|
+-+-----+

   phandle rxindex&> ' foo=.10';'nothing at all'   NB. index of match
2 14

   phandle rxE str   NB. mask over matches
0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

   '[[:digit:]]' rxeq '2342342'   NB. test for exact match
1
   '[[:digit:]]' rxeq '2342 342'
0
phandle rxmatch str
2 6
2 4

Entire and subexpression match

m=. phandle rxmatches str
phandle rxmerge str

|foo3=.|foo3|

phandle rxmatches str  NB. all matches
2 6
2 4
11 5
11 3

]m=.(phandle;,0) rxmatches str  NB. entire matches only
2 6
11 5

m rxcut str  NB. return alternating non-match/match boxes

|3,|foo3=.|23,|j42=.|123,123|

phandle |. rxapply str  NB. reverse each match
3,.=3oof23,.=24j123,123

(phandle;,1) |. rxapply str  NB. reverse just name part of match
3,3oof=.23,24j=.123,123
**Regular Expression Utilities**

The script `system\packages\regex\regbuild.ijs` contains definitions to for building regular expression patterns.

Many of the verbs below may enclose its argument in parentheses (to make it a subexpression). For example,

```
anyof 'abc' returns '(abc)*'.
```

The argument is only put in parentheses if necessary.

```
anyof set 'abc' is '[abc]*'.
```

The following verbs correspond directly to a feature of the regular expression notation:

- `set chars` returns set construction for chars
  - `set 'abc'` returns `[abc]`

- `not chars` set of non-matching chars
  - `set not 'abc'` returns `[^abc]`

- `sub pat` make a subexpression
  - `set 'abc' (abc)`

- `someof pat` pattern matching 1 or more pat
  - `someof 'abc' (abc)+`

- `anyof pat` pattern matching 0 or more pat
  - `anyof 'abc' (abc)*`

- `optional pat` pattern matching 0 or 1 pat
  - `optional 'abc' (abc)?`

- `(min,max) of pat` pattern matching `min` up to `max` of pat
  - `2 4 of 'abc' (abc){2,4}`

- `pat1 or pat2` pattern matching either `pat1` or `pat2`
  - `'abc' or 'd'

- `pat1 by pat2` pattern matching `pat1` immediately followed by `pat2`
  - `'action=' by 'move' or 'copy'`
action=(move|copy)

sub pat          makes pat a subexpression
    sub 'abc'
(abc)

bkref refnum     back-reference to a previous subexpression
    bkref 1
\1

Some nouns can be used as parts of regular expressions:

white           pattern matching one or more whitespace characters
owhite           "    "  optional whitespace
sol              "    "  the start of a line
eol              "    "  the end of a line
any              "    "  any character

Finally, some miscellaneous verbs

plain text       returns a regular expression matching the plain text
    plain 'dir j.*'
    dir j\.\*

pat1 between y   result is elements of y catenated together with pat1 between each
    ' * ' between 'abc'
a *b *c
    ' * ' between 'p1';'p2';'p3|p4'
p1 *p2 *(p3|p4)

comment nb pattern  add comment to pattern

Interpretation of a pattern always stops at the first null character (0{a.). The nb verb makes use
of this by catenating a null character and comment at the end of a pattern.

    p=. rxcomp 'some digits' nb '[:digit:]+'

    rxinfo p
    +---------+----------------------------+
    |1|[:digit:]+ NB. some digits|
    +---------+----------------------------+

setchars setpat     returns list of characters matching a set pattern
    setchars '[a-d[:digit:]]'
0123456789abcd

Character classes
The following nouns are strings which are used within sets to specify a character class:
alnum, alpha, blank, cntrl, digit, graph, lower, print, punct, space, upper, xdigit

For example,

\texttt{alpha=. '[:alpha:]'}

Corresponding nouns, named with a leading uppercase, are patterns specifying a set of the character class, for example,

\texttt{Alpha=. '[[[:alpha:]]]'}  \texttt{NB. (same as set alpha)}

**J patterns**
The following nouns, defined in packages\regex\regj.ijs, are patterns which match elements of J code:

- \texttt{Jname} matches a J name
- \texttt{Jnumitem, Jnum} matches a J numeric item or array (constant)
- \texttt{Jchar} matches a J character string
- \texttt{Jconst} matches a J numeric or character constant, include a. and a:
- \texttt{Jgassign, Jlassign, Jassign} matches J global, local, or either assignment
- \texttt{Jlpar, Jrpar} match J's left and right parentheses
- \texttt{Jsol, Jeol} match the start or end of a J sentence
  (ignores leading blanks and trailing blanks/comments)
Regular Expression Demo

This program demonstrates and allows you to experiment with regular expressions. Some standard text can be searched, or you can open any text file which will be displayed. When you type in a pattern and hit the Match button, the text will be searched for that pattern. All matches will be displayed in red and underscored.

A set of canned patterns can be tried by selecting them in the Patterns menu.

Run this demo from the Studio|Demos menu command. This demo requires a richeditm control and is only supported in the J Win95 and NT versions.
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[This is the first released version of the library GPL. It is numbered 2 because it goes with version 2 of the ordinary GPL.]

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