Exploring Regular Expression Usage and Context in Python

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Why regular expressions?

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- Everyone writes regexes! (we think...)
- Regexes are hard to read/write! (again, we think...)

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We don't know how/when/why developers use regexes!

Research goals

Explore regex

1. Context (developer survey)
2. Features (repository analysis)
3. Use cases (similarity analysis)

Regular expressions: The basics

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  - ✓ y
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Part 1

RQ1

In what contexts do professional developers use regular expressions?

Survey context

- 18 professional developers
- 9 years average development experience
- Small mobile payment management company
- 30 questions in a Google form

How frequently do developers use regexes?

- 50% – at least once per week
- Regexes are most frequently composed within command line and text editor tools
- 2 developers write more than 50 regexes annually in general programming languages (e.g., Java)
- Database queries using regexes were rare

Common regex activities

How often do you use regexes for...

Activity	Frequency
Locating content within a file or files	4.4
Capturing parts of strings	4.3
Parsing user input	4.0

Key: 6 = very frequently, 5 = frequently, 4 = occasionally, 3 = rarely, 2 = very rarely, 1 = never

Testing regular expressions

Developers test regular expressions less often than other code.

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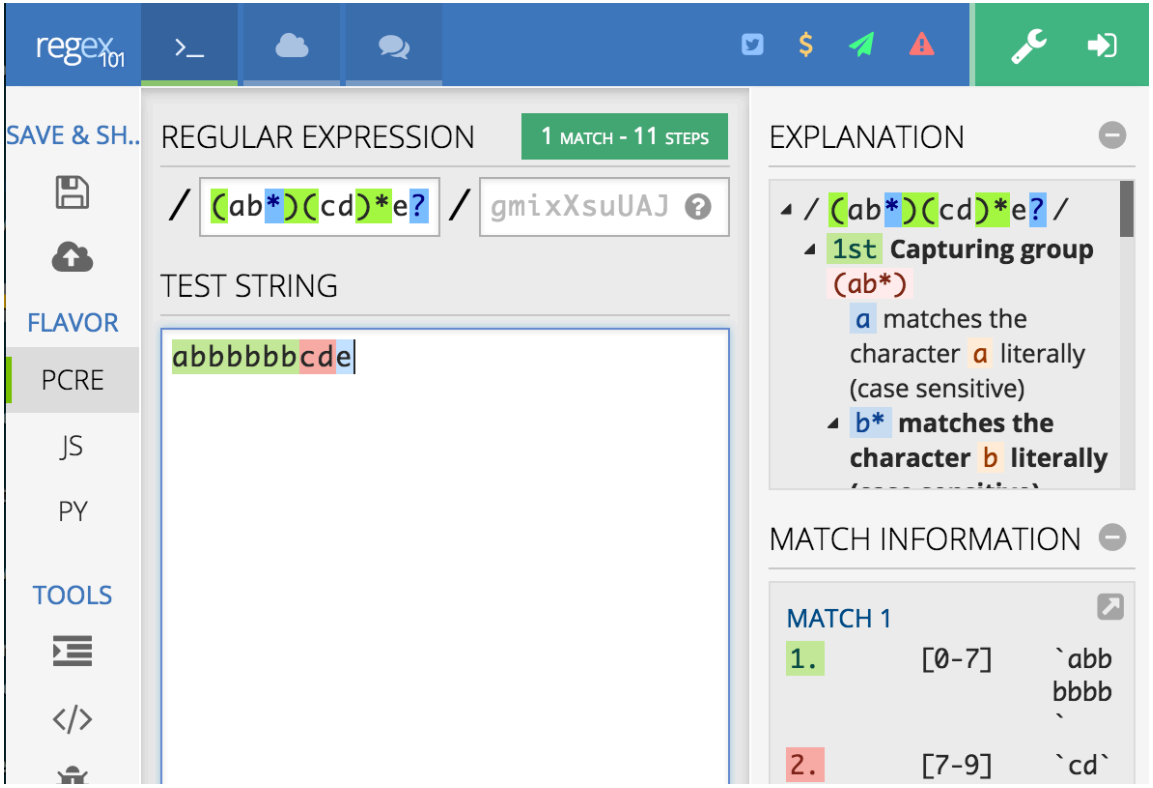

50% say they use testing tools like www.regex101.com

Pain points

hard to compose (11 = 61%)

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It is terrible to read (especially later after initial development)

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inconsistency across implementations (3 = 17%)

Differences in implementation across languages

Some regexes work differently (or don't work) in some languages.

Notable Observations

- Regexes are composed fairly frequently by developers
- Testing regexes is less common than testing other code
- Developers find regexes hard to read and write

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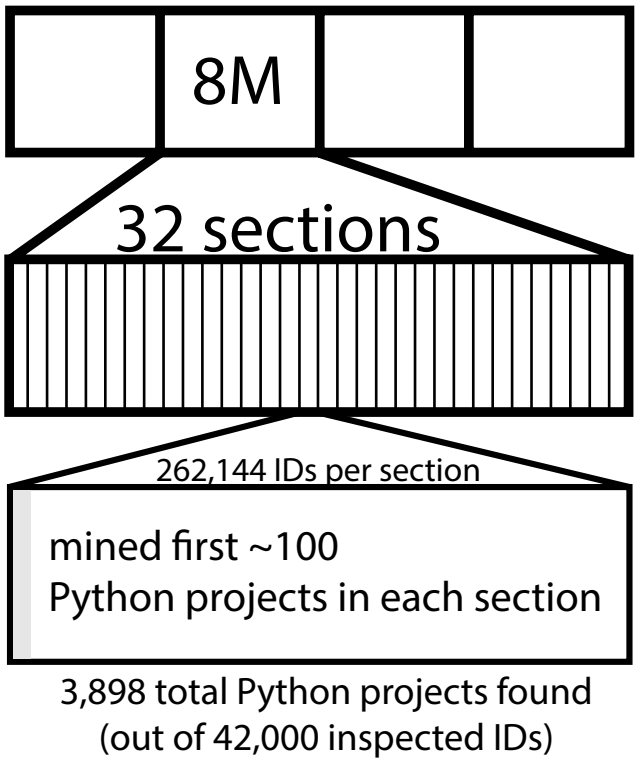
How do developers really use regexes?

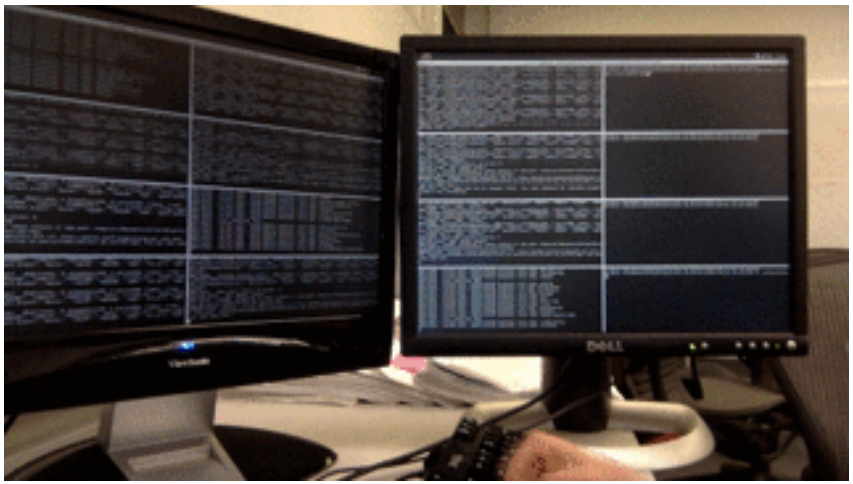
Part 2

RQ3

Which regular expression language features are most commonly used in Python?

Project selection with the GitHub API





Out of 3,898 pseudo-randomly selected Python projects, 1,645 (42%) contained one or more regex utilization.

In Python: Utilizations of the re module

function pattern flags

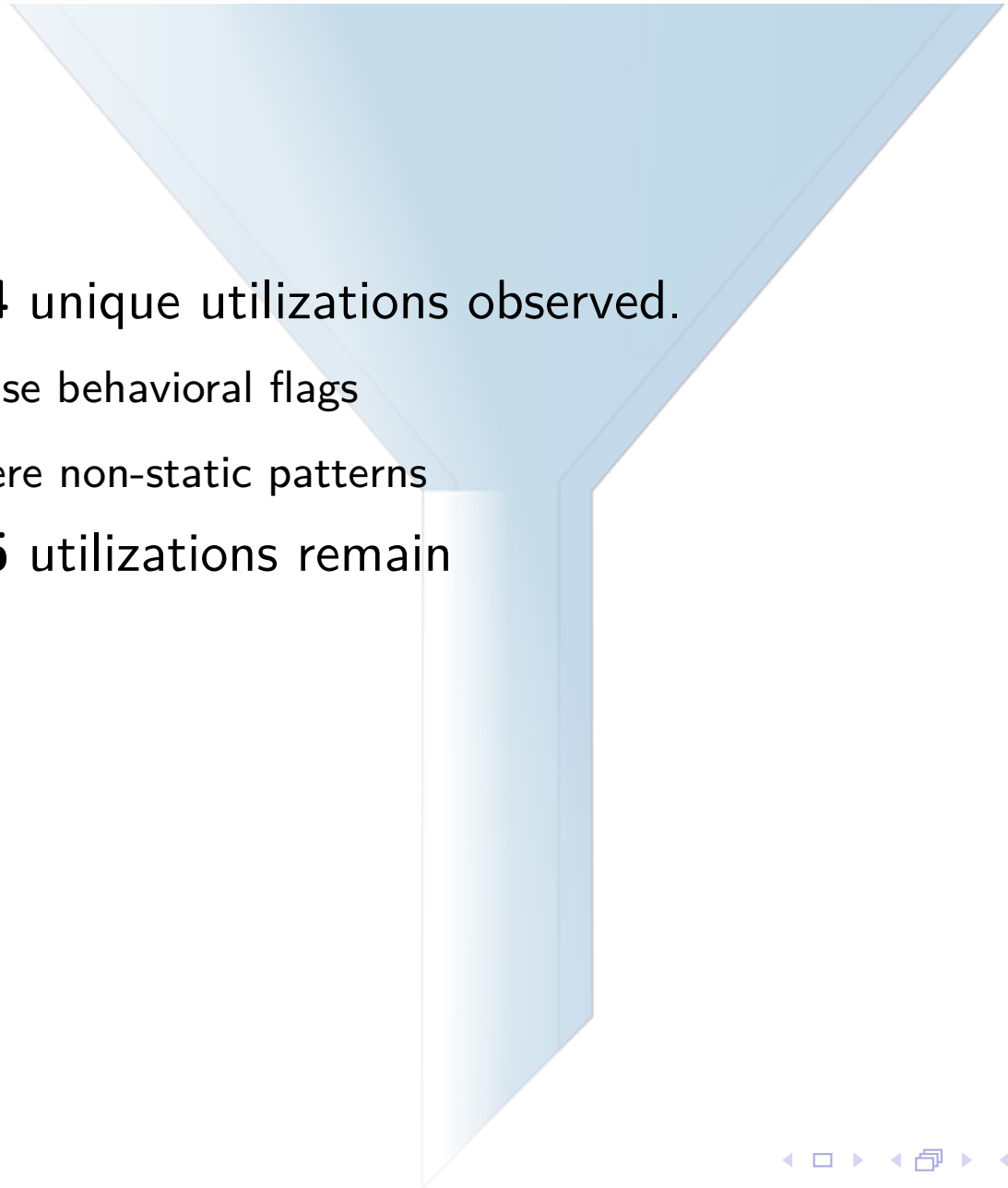
```
r1 = re.compile("(0|-?[1-9][0-9]*)$", re.MULTILINE)
```

function which function of the re module is called?

pattern string used to specify regex behavior

flags modifies the regex engine

Filtering utilizations and patterns



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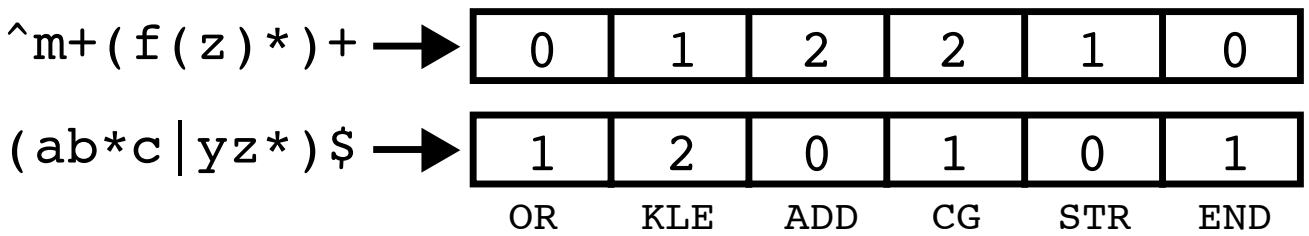
13,597 usable patterns from 1,645 projects remain for analysis

PCRE parsing patterns



Feature statistics - Top 8

Rank	Code	Example	% Projects	% Patterns
1	ADD	`z+`	73.2	44.1
2	CG	`(caught)`	72.6	52.4
3	KLE	`.*`	66.8	44.3
4	CCC	`[aeiou]`	62.4	32.9
5	ANY	`.`	61.1	34.3
6	RNG	`[a-z]`	51.6	19.3
7	STR	`^`	51.4	26.2
8	END	`$`	50.3	23.3

Regex research tools

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How well do past and present regex research tools meet the needs of developers? (Hampi, Rex, RE2, brics)

Which features are supported by analysis tools?

Rank	Code	Example	Brics	Hampi	Rex	RE2
1	ADD	`z+`	●	●	●	●
2	CG	`(caught)`	●	●	●	●
3	KLE	`.*`	●	●	●	●
4	CCC	`[aeiou]`	●	●	●	●
5	ANY	`.`	●	●	●	●
6	RNG	`[a-z]`	●	●	●	●
7	STR	`^`	○	●	●	●
8	END	`$`	○	●	●	●
9	NCCC	`[^qwxf]`	●	●	●	●
10	WSP	`\s`	○	●	●	●
11	OR	`a|b`	●	●	●	●
12	DEC	`\d`	○	●	●	●
13	WRD	`\w`	○	●	●	●
14	QST	`z?`	●	●	●	●
15	LZY	`z+?`	○	●	○	●
16	NCG	`a(?:b)c`	○	●	○	●
17	PNG	`(?P<name>x)`	○	●	○	○

Rank	Code	Example	Brics	Hampi	Rex	RE2
18	SNG	`z{8}`	●	●	●	●
19	NWSP	`\S`	○	●	●	●
20	DBB	`z{3,8}`	●	●	●	●
21	NLKA	`a(?!yz)`	○	○	○	○
22	WNW	`\b`	○	○	○	●
23	NWRD	`\W`	○	●	●	●
24	LWB	`z{15,}`	●	●	●	●
25	LKA	`a(?=bc)`	○	○	○	○
26	OPT	`(?i)CasE`	○	●	○	●
27	NLKB	`(?<!x)yz`	○	○	○	○
28	LKB	`(?<=a)bc`	○	○	○	○
29	ENDZ	`\Z`	○	○	○	●
30	BKR	`\1`	○	○	○	○
31	NDEC	`\D`	○	●	●	●
32	BKRN	`\g<name>`	○	●	○	○
33	VWSP	`\v`	○	○	●	●
34	NWNW	`\B`	○	○	○	●

Survey vs. Repository

How often do you use....

Group	Code	Survey	Repo Rank
endpoint anchors	(STR, END)	4.4	7, 8
capture groups	(CG)	4.2	2
word boundaries	(WNW)	3.5	22
lazy repetition	(LZY)	2.9	15

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What are the regexes doing?

Part 3

RQ4

How behaviorally similar are regexes across projects?

How to find common behaviors?

1. ~~thorough inspection of 53K utilizations~~

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2. ~~cluster by syntactic similarity like Jaccard or longest substring~~
3. ~~formal analytical subsumption, no sufficient tools at the moment~~
4. Chosen technique: cluster by behavioral similarity using Rex

Example

A `(ab*c|yz*)$`

- abbbbbbbc
- y
- abcy
- pac
- abcyzzz

B `(ab*c|yz*)`

- y
- abc
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B matches $5/5 =$ 100% of A's strings

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B matches $5/5 =$ 100% of A's strings

A and B are 80% similar

Similarity Matrix → MCL

	A	B	C	D
A	1.0	0.0	0.9	0.0
B	0.2	1.0	0.8	0.7
C	0.6	0.8	1.0	0.2
D	0.0	0.6	0.1	1.0

→

	A	B	C	D
A	1.0			
B	0.1	1.0		
C	0.75	0.8	1.0	
D	0.0	0.65	0.15	1.0

Rex generates
400 strings for each regex.
Average scores to
half-matrix for MCL

Scope

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- 2,871 patterns analyzed from 722 (44%) of the projects

Clustering Results

From 2,871 distinct regexes:

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$\rightarrow$ 2,042 unclustered regexes

Clustering Results

Example Cluster

Index	Pattern	NProjects	Index	Pattern	NProjects
1	`\s*([^: ]*)\s*:(.*)`	9	7	`[:]`	6
2	`:+`	8	8	`([^:]+):(.*)`	6
3	`(:)`	8	9	`\s*:\s*`	4
4	`(:+)`	8	10	`\:`	2
5	`(:)(:*)`	8	11	`^([^:]*):[^:]*$`	2
6	`^([^:]*): *(.*)`	8	12	`^[^:]*:([^:]*)$`	2

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Six Categories Of Clusters

Category	Clusters	Patterns	Projects	% Projects
Multi Matches	21	237	295	40%
Specific Char	17	103	184	25%
Anchored Patterns	20	85	141	19%
Two or More Chars	16	40	120	16%
Content of Parens	10	46	111	15%
Code Search	15	27	92	13%

Multi Matches `(\s)` , `,|;`

Specific Char `:+` , `}` , `%`

Anchored Patterns `^[-_A-Za-z0-9]+$`

Two Or More Chars `@[a-z]+`

Content of Parens `<(.+)>` , `<[^>]*?>`

Code Search `.*rlen=([0-9]+)`

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- Similarity metric is approximate
- Metric is perhaps too sensitive to differences in literals

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Migration Support for Developers

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Identifying Best Practices?

Could impact regex education and improve comprehension.

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- Regexes are hard to read/write! (this is a pain point)

also...

- Current tools support most of the most common features
- Regexes are often used for code search
- Many opportunities for future work!

Questions?

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(psst! Graduate students! I'm hiring!)