CS420
Operations on Regular Languages

Wed Sept 16, 2020

HWO Recap

HW0 Recap

- Read from stdin, write to stdout:
  - Python: `sys.stdin, print`
  - C++ `cin`, `cout`
  - Java: `System.in`, `System.out`
    - `Scanner scanner = new Scanner(System.in).readline` drops newlines!
- Power set of the empty set?
  - The power set of a set S is the set of all possible subsets of S
  - Including empty set, and S itself
  - {{}}
- XML parsing:
  - Java: `javax.xml.parsers`
  - Python: `xml.etree.ElementTree: parse and findall`
  - `C++: pugixml`
  - Regular expressions???

RegEx match open tags except XHTML self-con

Asked 10 years, 10 months ago Active 1 month ago Viewed 2.9m times

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I need to match all of these opening tags:

```
<p>
<a href="foo">
```

But not these:

```
<br />
<hr class="foo" />
```

4414

You can't parse [X]HTML with regex. Because HTML can't be parsec
Regex is not a tool that can be used to correctly parse HTML. As I h
HTML-and-regex questions here so many times before, the use of re
allow you to consume HTML. Regular expressions are a tool that is
sophisticated to understand the constructs employed by HTML. HTM
regular language and hence cannot be parsed by regular expressio
queries are not equipped to break down HTML into its meaningful pa
times but it is not getting to me. Even enhanced irregular regular exp
used by Perl are not up to the task of parsing HTML. You will never

HTML is a language of sufficient complexity that it cannot be parsed by regular expressions. Even Jon Skeet cannot parse HTML using regular expressions. Every time you attempt to parse HTML with regular expressions, the unholy child weeps the blood of virgins, and Russian hackers pwn your webapp. Parsing HTML with regex summons tainted souls into the realm of the living. HTML and regex go together like love, marriage, and ritual infanticide. The <center> cannot hold it is too late. The force of regex and HTML together in the same conceptual space will destroy your mind like so much watery putty. If you parse HTML with regex you are giving in to Them and their blasphemous ways which doom us all to inhuman toil for the One whose Name cannot be expressed in the Basic Multilingual Plane, he comes. HTML-plus-regexp will liquify the nerves of the sentient whilst you observe, your psyche withering in the onslaught of horror. Regex-based HTML parsers are the cancer that is killing StackOverflow *it is too late it is too late we cannot be saved* the trangession of a child ensures regex will consume all living tissue (except for HTML which it cannot, as previously prophesied) *dear lord help us how can anyone survive this scourge* using regex to parse HTML has doomed humanity to an eternity of dread torture and security holes *using regex* as a tool to process HTML establishes a brea*ch between this world* and the dread realm of corrupt entities (like SGML entities, but *more corrupt) a mere glimp*se of the world of reg**ex parsers for HTML will ins**tantly transport a p*rogrammer's consciousness i*nto a world of ceaseless screaming, he comes~~, the pestilent s~~lithy regex-infection wil**l devour your HT**ML parser, application and existence for all time like Visual Basic only worse *he comes he comes do not fi*ght h**e comes, hi**s unholy radiance de*stroying all enlightenment, HTML tags* ***leaking from your eyes like liq****uid* pain, the song of re̸gular expre~~ssion parsing~~ will exti*nguish the voices of mor**tal man from the sp**here I can see it can you see it it is beautiful t*he f`inal snuf`fing o*f the lie**s of Man ALL IS LOST ALL IS L*OST th*e pony he come*s he c*omes* ~~he comes~~ **t**he ich**or permeates all MY FACE MY FACE ᵒh god n*o NO NOOOO N**Θ stop t*he an*gles* `are` not rea**l ZALGO IS TONY THE PONY HE COMES**

Have you tried using an XML parser instead?

HW1

- Will include core set of pkgs
  - `python3`
  - `default-jdk`
  - `build-essential`
  - `nodejs`
- Any other libraries/tools:
  - manually install using in `Makefile` ``` `setup` ```
- Review slides about <u>math</u> vs <u>representation</u> in code

In-class example (from last time)

- Design machine M that recognizes: {w |w has exactly three 1's}
- Where Σ= {0, 1},
- Remember:

DEFINITION 1.5

A ***finite automaton*** is a 5-tuple $(Q, \Sigma, \delta, q_0, F)$, where

1. Q is a finite set called the ***states***,
2. Σ is a finite set called the ***alphabet***,
3. $\delta \colon Q \times \Sigma \longrightarrow Q$ is the ***transition function***,
4. $q_0 \in Q$ is the ***start state***, and
5. $F \subseteq Q$ is the ***set of accept states***.

Proving that a language is regular

- *Prove that this lang is regular*: {w |w has exactly three 1's}

A language is called a ***regular language*** if some finite automaton recognizes it.

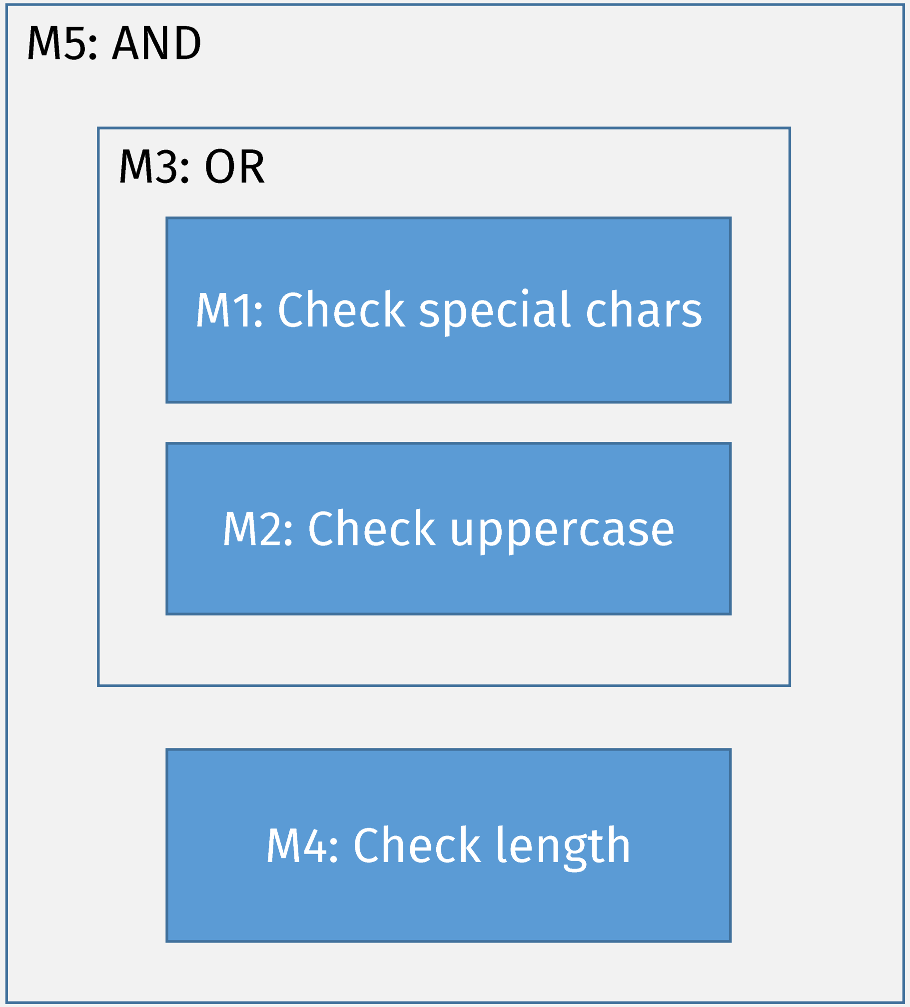
Operations on Regular Languages

From: https://www.umb.edu/it/password

Password Requirements

- Passwords must have a minimum length of ten (10) characters - but more is better!
- Passwords **must include at least 3** different types of characters:
    - upper-case letters (A-Z)
    - lower-case letters (a-z)
    - symbols or special characters (%, &, *, $, etc.)
    - numbers (0-9)
- Passwords cannot contain all or part of your email address
- Passwords cannot be re-used

Password checker



Want to be able to easily <u>combine</u> finite automata machines

To keep combining operations must be **closed**!

“Closed” Operations

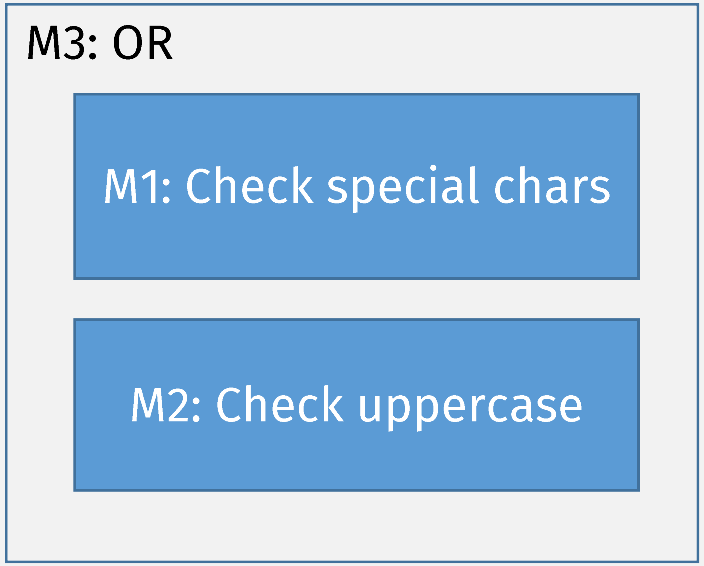
- Natural numbers = {0, 1, 2, …}
  - Closed under addition: if x and y are Natural, then z = x + y is a Nat
  - Closed under multiplication?
    - yes
  - Closed under subtraction?
    - no
- Integers = {…, -2, -1, 0, 1, 2, …}
  - Closed under addition and multiplication
  - Closed under subtraction?
    - yes
  - Closed under division?
    - no
- Rational numbers = {x | x = y/z, y and z are ints}
  - Closed under division?
    - No?
    - Yes if z !=0

Any set is **closed** under some operation if applying that operation to members of the set returns an object still in the set.

Why Closed Operations on RegularLangs?

- Closed operations preserves “regularness”
- I.e., it preserves the same computation model
- So result of combining machines can be combined again

Password checker: “Or” = “Union”



A Closed Operation: Union

THEOREM 1.25

The class of regular languages is closed under the union operation.

In other words, if A_1 and A_2 are regular languages, so is $A_1 \cup A_2$.

- How do we prove that a language is regular?
  - Create a FSM recognizing it!
- Create machine combining machines recognizing A_1 and A_2.

Kinds of Mathematical Proof

- Proof by construction
  - Construct the mathematical object in question
- Proof by contradiction
- Proof by induction

Union Closed?

THEOREM 1.25

The class of regular languages is closed under the union operation.

In other words, if A_1 and A_2 are regular languages, so is $A_1 \cup A_2$.

Proof (implement for hw1)

- Given: $M_1 = (Q_1, \Sigma, \delta_1, q_1, F_1)$, recognize A_1,
  $M_2 = (Q_2, \Sigma, \delta_2, q_2, F_2)$, recognize A_2,
- Construct a new machine $M = (Q, \Sigma, \delta, q_0, F)$ using M_1 and M_2
- *M* runs its input on both M_1 and M_2 in parallel, accept if either accepts
- states of *M*: $Q = \{(r_1, r_2) | \ r_1 \in Q_1 \text{ and } r_2 \in Q_2\}$.
  This set is the ***Cartesian product*** of sets Q_1 and Q_2
- *M*'s transition fn: $\delta\big((r_1, r_2), a\big) = \big(\delta_1(r_1, a), \delta_2(r_2, a)\big)$
- M start state: (q_1, q_2)
- M accept states: $F = \{(r_1, r_2) | \ r_1 \in F_1 \text{ or } r_2 \in F_2\}$

Another Operation: Concatenation

THEOREM 1.26

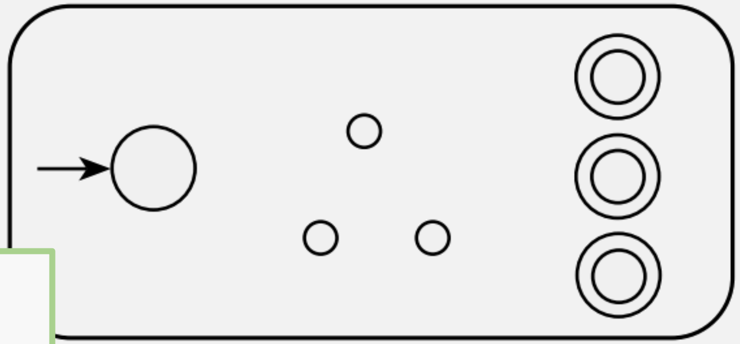
The class of regular languages is closed under the concatenation operation.

In other words, if A_1 and A_2 are regular languages then so is $A_1 \circ A_2$.

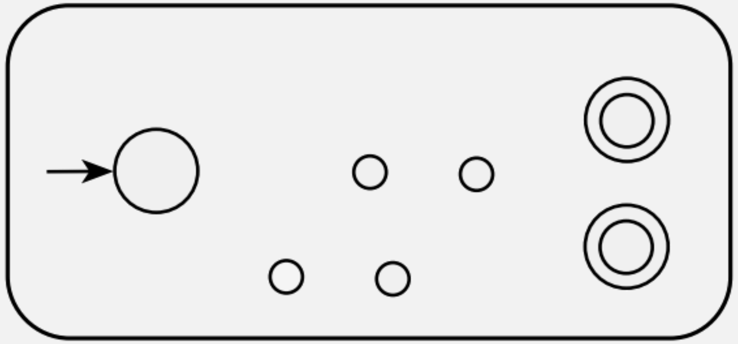
- Can't directly combine A_1 and A_2
  - don't know when to switch from A_1 to A_2 (can only read input once)
- It would create a new kind of machine!
- So is concatenation not closed???

Concatentation

N_1



N_2



N is a new kind of machine, an NFA!

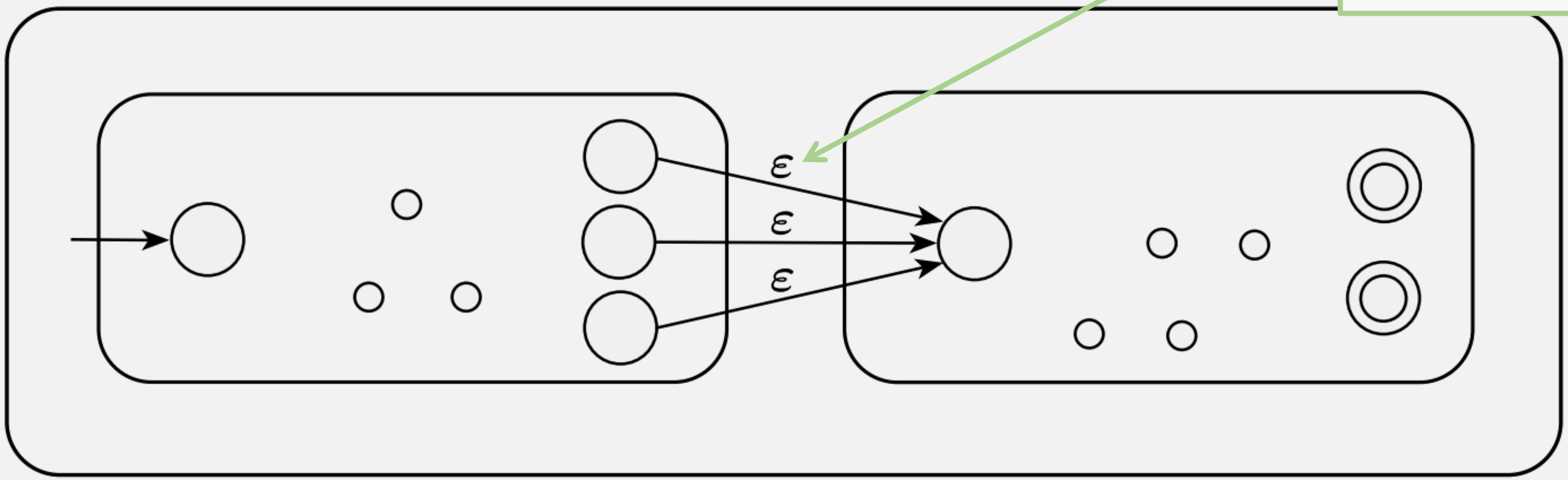
Let N_1 recognize A_1, and N_2 recognize A_2.

Want: Construction of N to recognize $A_1 \circ A_2$

ε = empty string = no input

So N can:
- stay in current state **and**
- move to next state

N



Check-in Quiz 2

On gradescope

End of Class Survey

See course website

HW1