Context Free Languages and Grammars

Lecture 7

Tuesday, September 15, 2020

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7.1
A fluffy introduction to context free languages, push down automatas

What stack got to do with it?

What's a stack but a second hand memory?

1. $\mathrm{DFA}/\mathrm{NFA}$/Regular expressions.
   $\equiv$ constant memory computation.
2. Turing machines $\mathrm{DFA}/\mathrm{NFA}$ + unbounded memory.
   $\equiv$ a standard computer/program.

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2. NFA $+$ stack
   $\equiv$ context free grammars (CFG).
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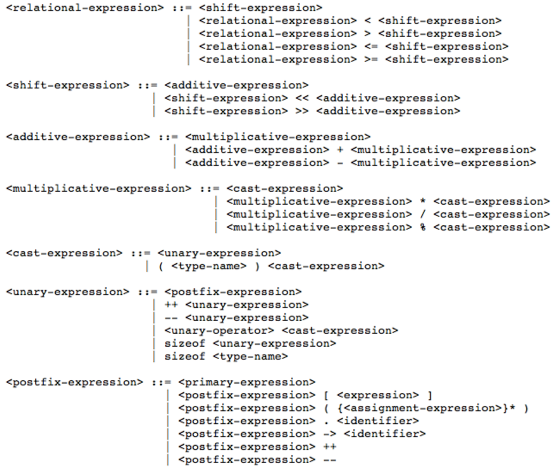
   $\equiv$ constant memory computation.
2. NFA $+$ stack
   $\equiv$ context free grammars (CFG).
3. Turing machines DFA/NFA $+$ unbounded memory.
   $\equiv$ a standard computer/program.
   $\equiv$ NFA with two stacks.

Context Free Languages and Grammars

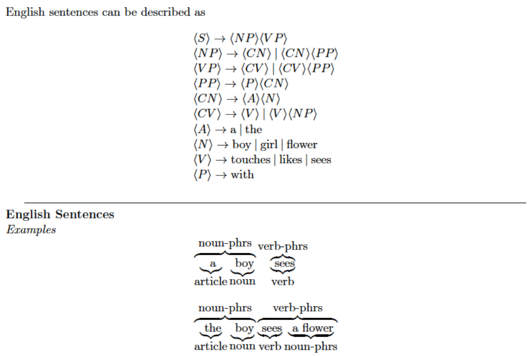
- Programming Language Specification
- Parsing
- Natural language understanding
- Generative model giving structure
- ...

Programming Languages



```
<relational-expression> ::= <shift-expression>
                          | <relational-expression> < <shift-expression>
                          | <relational-expression> > <shift-expression>
                          | <relational-expression> <= <shift-expression>
                          | <relational-expression> >= <shift-expression>

<shift-expression> ::= <additive-expression>
                     | <shift-expression> << <additive-expression>
                     | <shift-expression> >> <additive-expression>

<additive-expression> ::= <multiplicative-expression>
                        | <additive-expression> + <multiplicative-expression>
                        | <additive-expression> - <multiplicative-expression>

<multiplicative-expression> ::= <cast-expression>
                              | <multiplicative-expression> * <cast-expression>
                              | <multiplicative-expression> / <cast-expression>
                              | <multiplicative-expression> % <cast-expression>

<cast-expression> ::= <unary-expression>
                    | ( <type-name> ) <cast-expression>

<unary-expression> ::= <postfix-expression>
                     | ++ <unary-expression>
                     | -- <unary-expression>
                     | <unary-operator> <cast-expression>
                     | sizeof <unary-expression>
                     | sizeof <type-name>

<postfix-expression> ::= <primary-expression>
                       | <postfix-expression> [ <expression> ]
                       | <postfix-expression> ( {<assignment-expression>}* )
                       | <postfix-expression> . <identifier>
                       | <postfix-expression> -> <identifier>
                       | <postfix-expression> ++
                       | <postfix-expression> --
```

Natural Language Processing



English sentences can be described as

$$\begin{aligned}
&\langle S\rangle \to \langle NP\rangle\langle VP\rangle\\
&\langle NP\rangle \to \langle CN\rangle \mid \langle CN\rangle\langle PP\rangle\\
&\langle VP\rangle \to \langle CV\rangle \mid \langle CV\rangle\langle PP\rangle\\
&\langle PP\rangle \to \langle P\rangle\langle CN\rangle\\
&\langle CN\rangle \to \langle A\rangle\langle N\rangle\\
&\langle CV\rangle \to \langle V\rangle \mid \langle V\rangle\langle NP\rangle\\
&\langle A\rangle \to \text{a} \mid \text{the}\\
&\langle N\rangle \to \text{boy} \mid \text{girl} \mid \text{flower}\\
&\langle V\rangle \to \text{touches} \mid \text{likes} \mid \text{sees}\\
&\langle P\rangle \to \text{with}
\end{aligned}$$

English Sentences

Examples

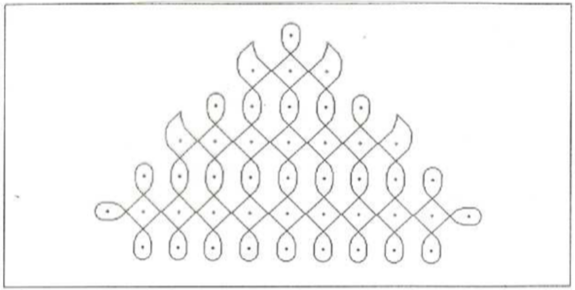
$$\overbrace{\underbrace{\text{a}}_{\text{article}}\underbrace{\text{boy}}_{\text{noun}}}^{\text{noun-phrs}}\ \overbrace{\underbrace{\text{sees}}_{\text{verb}}}^{\text{verb-phrs}}$$

$$\overbrace{\underbrace{\text{the}}_{\text{article}}\underbrace{\text{boy}}_{\text{noun}}}^{\text{noun-phrs}}\ \overbrace{\underbrace{\text{sees}}_{\text{verb}}\underbrace{\text{a flower}}_{\text{noun-phrs}}}^{\text{verb-phrs}}$$

Models of Growth

- ***L*-systems**
- `http://www.kevs3d.co.uk/dev/lsystems/`

Kolam drawing generated by grammar



THE END

...

(for now)