Grammar-1

COM S 319

Objectives

1. Learn formal and informal definitions of Grammar.
2. Learn about types of Grammar (Chomsky Hier..)
3. Learn about regular Grammar
4. Learn about recognizer for regular Grammar
5. Learn about LEX

What is grammar?

- We have learnt how regular expressions are used to indicate a family of strings.
  - example: a+ indicates strings a, aa, aaa, etc

- We will show another way (Grammar) to express a family of strings.

Grammar related terms -1

- Symbol: A symbol here is the smallest distinguishable element in a written language.
  - Example: a is a symbol for english language
  - Example: Θ is a symbol for greek language
  - Example: ♩is a symbol for written music.
  - Also called TERMINALS

- Alphabet: An alphabet is a FINITE set of symbols.
  - Note that it has to be FINITE set.
  - Example: { '0', '1'} is an alphabet. It just consists of two symbols.

Grammar related terms -2

- Non-Terminals: Non-terminals are variables which represent parts of a language.
  - Example: SENTENCE → NOUN_PHRASE VERB_PHRASE

- Production Rules: Production rules relate non-terminals recursively in terms of each other and terminals. They have a Left Hand Side and a Right Hand Side separated by the symbol →
  - Example: SENTENCE → NOUN_PHRASE VERB_PHRASE

Grammar related terms -3

- Language: A language is a set of strings of symbols from some alphabet.

- Example language is { a, ab, b }
- This one is finite!

- Another example is the infinite set {a, aa, aaa, … }

Grammar

A Grammar G is a four tuple { V, T, P, S} where :

- V and T are finite sets of variables and terminals (or symbols). They are disjoint.
- P is a finite set of production rules.
- S is a special variable called the start symbol.

Example Grammar

Example: G1 = {V, T, P, S} where

- V = {E},
- T = { +, -, (,), id },
- S = E,
- P = rules below

  (rule1) E → E + E,

  (rule2) E → E - E,

  (rule3) E → (E),

  (rule4) E → id

Showing that "i + (i + j * i + (i + j))" is in the Grammar

- by rule 1: E + E
- by rule 4: i + E
- by rule 3: i + (E)
- by rule 1: i + (E + E)
- by rule 4: i + (i + E)
- … (after many similar steps)
- finally we will get the string "i + (i + j * i + (i + j))"

(rule1) E → E + E,
(rule2) E → E - E,
(rule3) E → (E),
(rule4) E → id

Grammar SELF CHECK-1

- V = {S, A, B, C}, T = {a, b, c}
- S→ A
- A → aA
- A → B
- B → bC
- C → cC
- C → ε

Q: What are some example strings in the language?

Grammar SELF CHECK-2

- V = {S, A, B, C}, T = {a, b, c}
- S→ aAc
- A → aAc
- A → b

Q: What are some example strings in the language?

Grammar SELF CHECK-3

Write a Grammar i.e. {V,T,P,S} to generate a+bc+

T = {a, b, c}

V = {S, ??? }

P = ?

RECAP SO FAR…

1. Grammar (a 4-tuple)
2. language (sets of strings)
3. terminals (symbols)
4. non-terminals (variables)
5. production rules
6. start symbol (a special variable)

TYPES OF GRAMMARS

We know regular expressions already.

The regular expression a[bc]d will accept the language {abd, acd}.

We can express it as a Grammar where

V = {start, next}

T = {a, b, c, d}

P is {

rule1: start -> a next,

rule 2: next -> b end | c end,

rule 3: end -> d

}

S is start

Consider the strings

aabb, aaabbb, aaaabbbb etc

Q: Can you write a regular expression to express it?

The answer is NO.

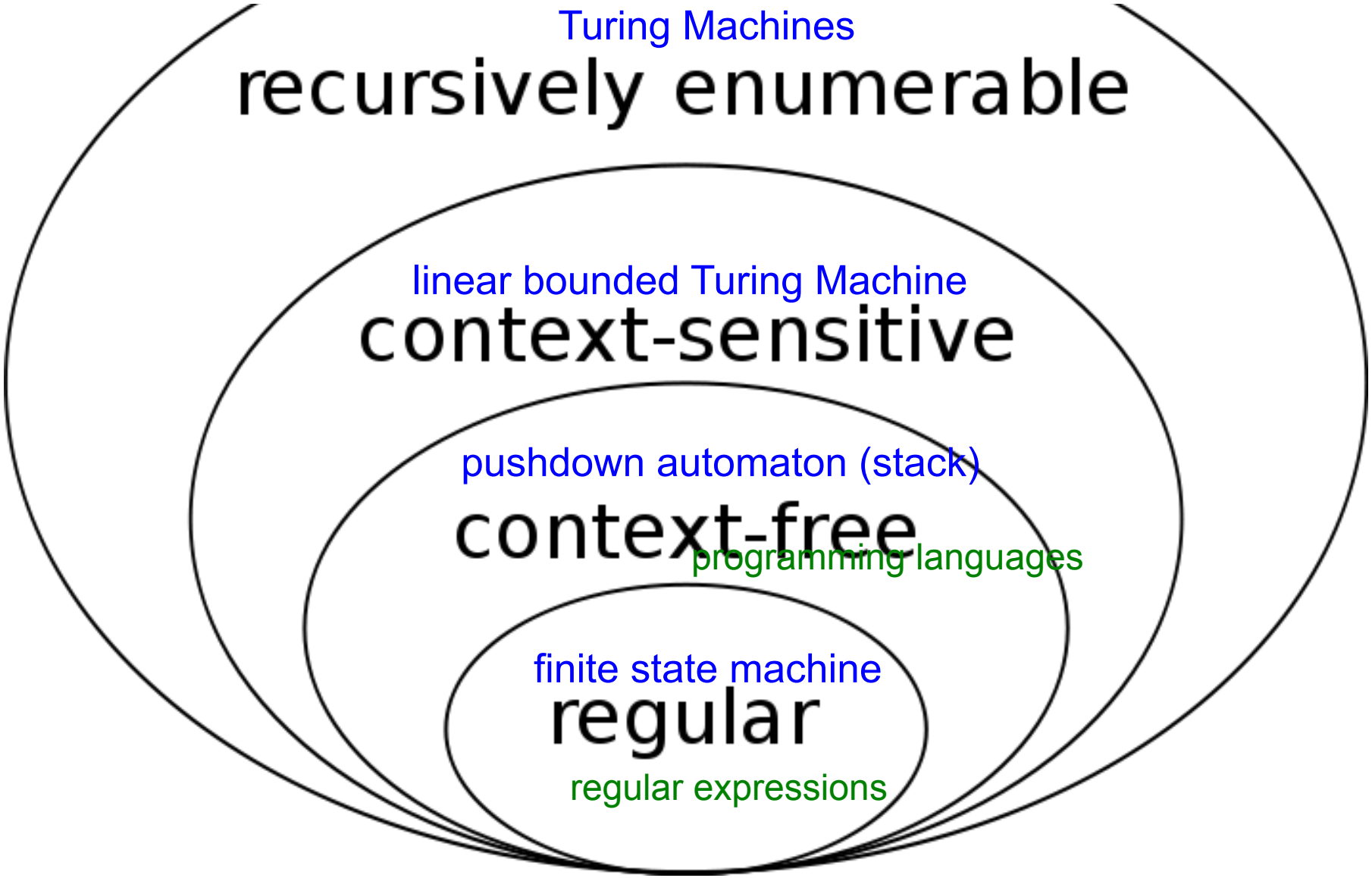
So clearly, there are at least TWO types of languages (or sets of strings).

1. We can write regular expressions for one type
2. We CANNOT write regular expressions for the other type.

Q: Are there other types of languages as well?

Q: How do the Grammar rules for these types of languages differ?

Chomsky hierarchy



Chomsky hierarchy

- type-3 or regular Grammar (regular expressions)
  - can express a^n
  - accepted by finite automaton (limited memory needs)
- type-2 or context-free Grammar (progmmg langs)
  - can express $a^n b^n$ (matching parenthesis, expressions)
  - accepted by pushdown automaton (uses stack)
- type-1 or context-sensitive Grammar c
  - an express $a^n b^n c^n$
  - accepted by Linear bounded Turing machines
- type-0 Grammars (accepted by Turing Machines)

Q: Are there other types of languages as well?

Yes! regular, context free, context sensitive, etc

Q: How do the Grammar rules for these types of languages differ?

Next …