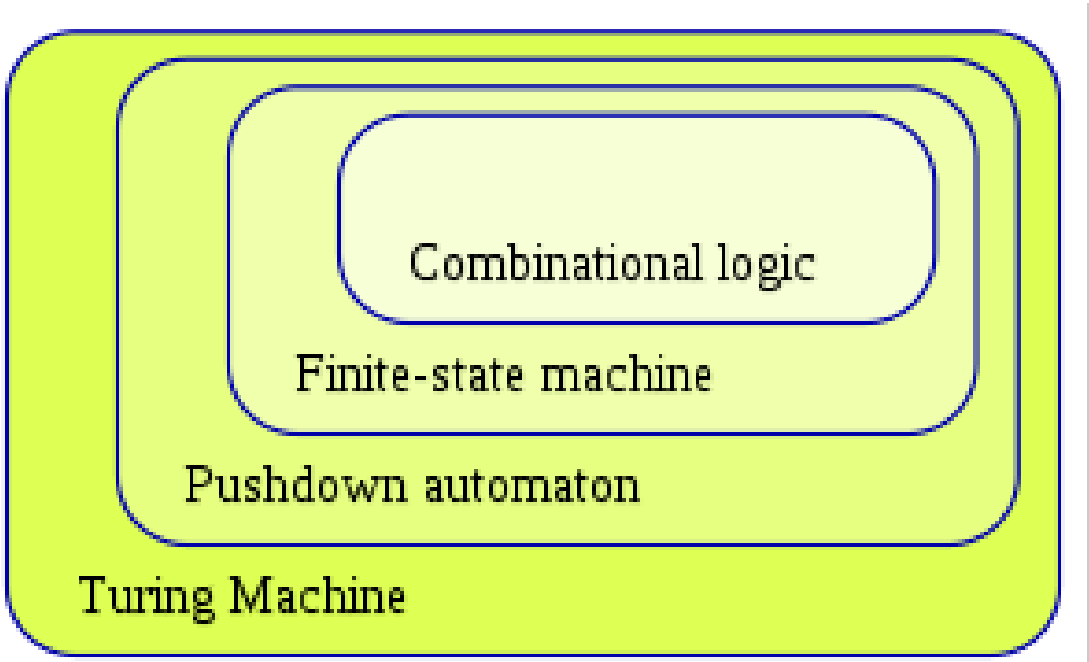
Computational models



Classes of automata

https://en.wikipedia.org/wiki/Automata_theory

Automaton
Deterministic Finite Automaton (DFA) -- Lowest Power
(same power) || (same power)
Nondeterministic Finite Automaton (NFA)
(above is weaker) ∩ (below is stronger)
Deterministic Push Down Automaton (DPDA-I)
with 1 push-down store
∩
Nondeterministic Push Down Automaton (NPDA-I)
with 1 push-down store
∩
Linear Bounded Automaton (LBA)
∩
Deterministic Push Down Automaton (DPDA-II)
with 2 push-down stores
||
Nondeterministic Push Down Automaton (NPDA-II)
with 2 push-down stores
||
Deterministic Turing Machine (DTM)
||
Nondeterministic Turing Machine (NTM)
||
Probabilistic Turing Machine (PTM)
||
Multitape Turing Machine (MTM)
||
Multidimensional Turing Machine

(Formal) grammars

N. Chomsky: separation of syntax and semantics

A grammar is formally defined as the tuple (N, Σ, P, S)

Transformational grammar/rewrite system

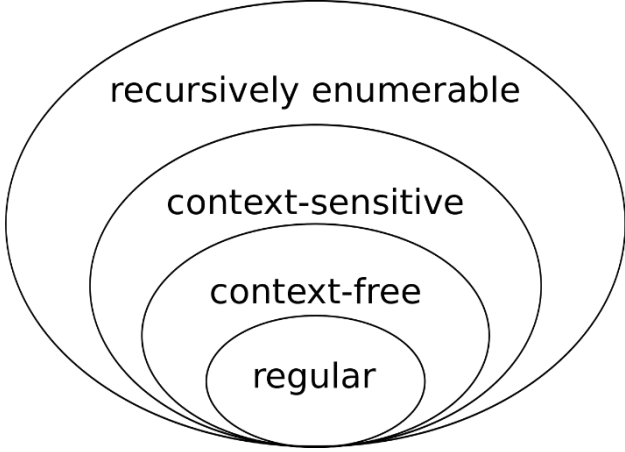
- A finite set *N* of *nonterminal symbols*, that is disjoint with the strings formed from *G*.
- A finite set Σ of *terminal symbols* that is disjoint from *N*.
- A finite set *P* of *production rules*, each rule of the form

  $$(\Sigma \cup N)^* N (\Sigma \cup N)^* \to (\Sigma \cup N)^*$$

- A distinguished symbol $S \in N$ that is the *start symbol*, also called the *sentence symbol*.

https://en.wikipedia.org/wiki/Formal_grammar

The Chomsky hierarchy



Grammar	Languages	Automaton	Production rules (constraints)*	Examples[3]
Type-0	Recursively enumerable	Turing machine	$\alpha A \beta \to \gamma$	$L = \{w \mid w \text{ describes a terminating Turing machine}\}$
Type-1	Context-sensitive	Linear-bounded non-deterministic Turing machine	$\alpha A \beta \to \alpha \gamma \beta$	$L = \{a^n b^n c^n \mid n > 0\}$
Type-2	Context-free	Non-deterministic pushdown automaton	$A \to \alpha$	$L = \{a^n b^n \mid n > 0\}$
Type-3	Regular	Finite state automaton	$A \to \mathrm{a}$ and $A \to \mathrm{a}B$	$L = \{a^n \mid n \geq 0\}$

* Meaning of symbols:

- a = terminal
- A, B = non-terminal
- α, β, γ = string of terminals and/or non-terminals
  - α, β = maybe empty
  - γ = never empty

https://en.wikipedia.org/wiki/Chomsky_hierarchy