theory of formal languages

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Note: This entry is very rough at the moment, and requires work. I mainly wrote it to help motivate other entries and to organize entries on this topic and point out holes in our coverage. Right now, it is mainly a list of entries, many of which have not been written yet. Under the first heading, there is short paragraph. Eventually, there should be such a paragraph under each entry and a bibliography at the end. However, this is a lot of work for one person, so this entry is world editable in the hope that others who are knowledgable in this topic will contribute their expertise.

1 Basic concepts and terminology

Loosely speaking, a formal language is a language whose structrure can be specified with mathematical precision. The study of formal languages is not only interesting as a mathematical discipline in its own right, but also because of its relevance to the foundations of mathematics, its applications, and surprising connections with other branches of mathematics.

- alphabet

- automaton

- concatenation

- derivation

- grammar

- homomorphism of languages

- isomorphism of languages

- language

- abstract family of languages (AFL)

- reversal or mirror image

- initial symbol

- production

- rewriting rule

- semantics

- syntax

- terminal symbol

- non-terminal symbol

- word

2 Classification of languages

- Chomsky Hierarchy

- regular language

- context-free language

- context-sensitive language

- phrase-structure language

- type-3 language

- type-2 language

- type-1 language

- type-0 language

3 Regular (type 3) languages

- regular expression

- Kleene star

- Kleene algebra

- left-linear grammar

- right-linear grammar

- finite automaton

4 Context-free (type 2) languages

- Chomsky normal form

- derivation tree

- intersection of context-free and regular languages is context-free

- leftmost derivation

- rightmost derivation

- Greibach normal form

- pumping lemma

- pushdown automaton

- deterministic pushdown automaton

- a language is context-free iff it can be recognized by a pushdown automaton

- Earley's algorithm

- ambiguous grammar

- `http://planetmath.org/LLk` $LL(k)$ grammar

- left-factored grammar

- `http://planetmath.org/LRk` $LR(k)$ grammar

- every $LR(k)$ grammar can be recognized by a deterministic pushdown automaton

- every language which can be recognized by a deterministic pushdown automaton can be described by an $LR(1)$ grammar

5 Context-sensitive (type 1) languages

- Kuroda normal form

- length-increasing grammar

- a language is context-sensitive iff it can be generated by a length-increasing grammar

- linear bounded automaton

- a language is context-sensitive iff it can be recognized by a linear bounded automaton

6 Phrase-structure (type 0) languages

- recursive language

- recursively enumerable language, co-recursively enumerable language

- language that is neither recursively enumerable, nor co-recursively enumerable

- every phrase-structure language is recursively enumerable

7 Other types of languages and automata that describe them

- star-free language versus aperiodic finite automaton

- a star-free language is regular, but not conversely

- mildly context-sensitive language versus embedded pushdown automaton

- tree-adjoining grammar

- languages generated by tree-adjoining grammars are exactly the mildly context-sensitive languages

- a context-free language is mildly context-sensitive, but not conversely

- indexed language versus nested stack automaton

- a mildly context-sensitive language is indexed, but not conversely

- an indexed language is context-sensitive, but not conversely

8 Connection to group and semigroup theory

- finitely presented group

- automatic group

- http://planetmath.org/SemiThueSystemsemi-Thue system

- Post system

- word problem

- Post correspondence problem

- conjugacy problem

9 Decidability

- membership problem

- emptiness problem

- recursively enumerable language

- recursive language

10 Special languages

- Dyck language

- derivation language