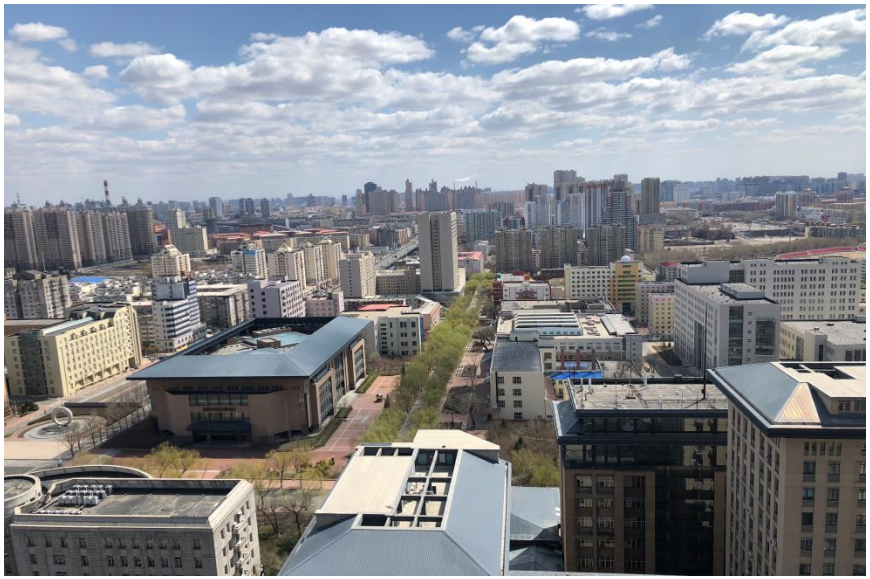
Morning

Formal Language And Automata

- ♥ Languages
- ♥ Automata
- ♥ Computation

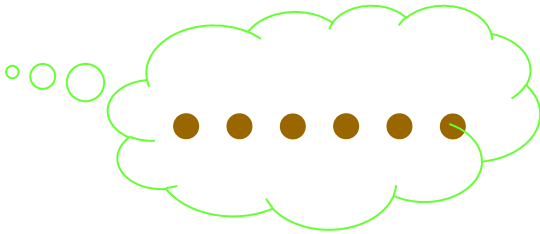


Language

What is a language ?

This is a sentence.

This is also a sentence.



So we have

{ sentence 1, sentence 2, sentence 3, ... }

the set of sentences $\Leftrightarrow$ Language

Sentence/String

Sentence, String, Word

(1 + 2) * (13 - 7)

To stay at home and save lives.

不聚集，戴口罩，勤洗手。

0, 1, 00, 01, 10, 000, 001, 1010, 00111100

String = sequence of symbols

chosen from the alphabet Σ

Alphabet

Alphabet = set of symbols

{ a, b, c, …,x, y, z }

{ 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, +, -, *, /, (,) }

ASCII, 中文国标, $\Sigma = \{ 0, 1 \}$

symbols $\Rightarrow$ strings $\Rightarrow$ language

Rules/Grammar

Rules : by which strings are generated

rules for English :

<sentence> → <noun-phrase><predicate>

<noun-phrase> → <article><noun>

<predicate> → <verb>

<article> → a|an|the

<noun> → wolf|sheep

<verb> → love|eat

I have a dream.

Example 1

alphabet : {0,1}

L={w|w consists of 0's and 1's,

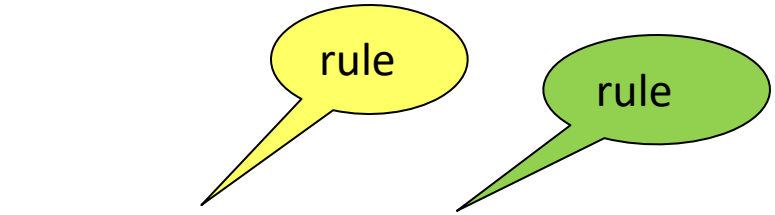
and end with 0 }

rule

L={ 0,00,10,000,010,100,110,0000,……}

11111100∈L, 1∉L, 0001∉L, 20∉L

Example 2



$L=\{ 0^n1^n \mid n \geq 0 \}$

alphabet = {0,1}

$L=\{\varepsilon, 01, 0011, 000111, 00001111, 0000011111, \ldots\ldots \}$

Empty string

Example 3

L={ w| w is a sentence in English }

Everyone loves his/her motherland. √

Sheep eat grass . √

Grass eat sheep . ?

♣ Formal language focus on form of string

not semantics/meaning

Operations of String

$w = a_1 a_2 \ldots\ldots a_m$ abc

$v = b_1 b_2 \ldots\ldots b_n$ 123456

- Concatenation

$wv = a_1 a_2 \ldots\ldots a_m b_1 b_2 \ldots\ldots b_n$ abc123456

$\neq$

$vw = b_1 b_2 \ldots\ldots b_n a_1 a_2 \ldots\ldots a_m$ 123456abc

- Reverse

$w^R = a_n a_{n-1} \ldots\ldots a_1$ cba

Operations on Languages

- Usual set operations

$$L_1 \cup L_2 = \{ w \mid w \in L_1 \text{ or } w \in L_2 \}$$

$$L_1 \cap L_2 = \{ w \mid w \in L_1 \text{ and } w \in L_2 \}$$

$$L_1 - L_2 = \{ w \mid w \in L_1 \text{ and } w \notin L_2 \}$$

- Reverse

$$L^R = \{ w^R \mid w \in L \}$$

- Concatenation

$$L_1 L_2 = \{ wv \mid w \in L_1 \text{ and } v \in L_2 \}$$

Example 4

$L = \{ ab, abc, abcd \} \Rightarrow L^R = \{ ba, cba, dcba \}$

$L = \{ a^n b^n \mid n \geq 1 \} \Rightarrow L^R = \{ b^n a^n \mid n \geq 1 \}$

$L = \{ a^n b^n \mid n \geq 1 \}$, $K = \{ 0^n 1^n \mid n \geq 1 \}$

$LK = \{ a^n b^n 0^n 1^n \mid n \geq 1 \}$ ×

$LK = \{ a^n b^n 0^m 1^m \mid n \geq 1 , m \geq 1 \}$

$L^2 = ?$

* / Star Operation on Languages

$\Sigma = \{ 0, 1 \}$

$\Sigma^* = \Sigma^0 \cup \Sigma \cup \Sigma^2 \cup \Sigma^3 \cup \ldots\ldots \cup \Sigma^n \cup \ldots\ldots$

$\Sigma^0 = \{ \varepsilon \}$, $\Sigma^n = \underbrace{\Sigma\,\Sigma \ldots\ldots \Sigma}_{n}$

$\{0,1\}^* = \{\varepsilon\} \cup \{0,1\} \cup \{0,1\}^2 \cup \ldots\ldots \cup \{0,1\}^n \cup \ldots\ldots$

$= \{ \varepsilon, 0, 1, 00, 01, 10, 11, 000, 001, 010, 011, 111, \ldots\ldots \}$

Empty string / language

Denote ε as empty string

$|\varepsilon| = 0, \quad w\varepsilon = \varepsilon w = w$

Denote ϕ as empty language

$\phi = \{\}, \quad \phi L = L\phi = \phi$

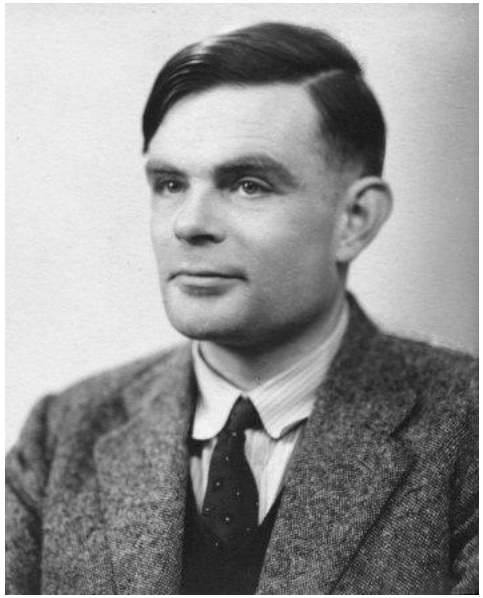
Denote $\Sigma^+ = \Sigma \cup \Sigma^2 \cup \Sigma^3 \cup \ldots\ldots \cup \Sigma^n \cup \ldots\ldots$

$= \Sigma^* - \Sigma^0$

$= \Sigma^* - \{\varepsilon\}$

Automata

Alan MarthisonTuring



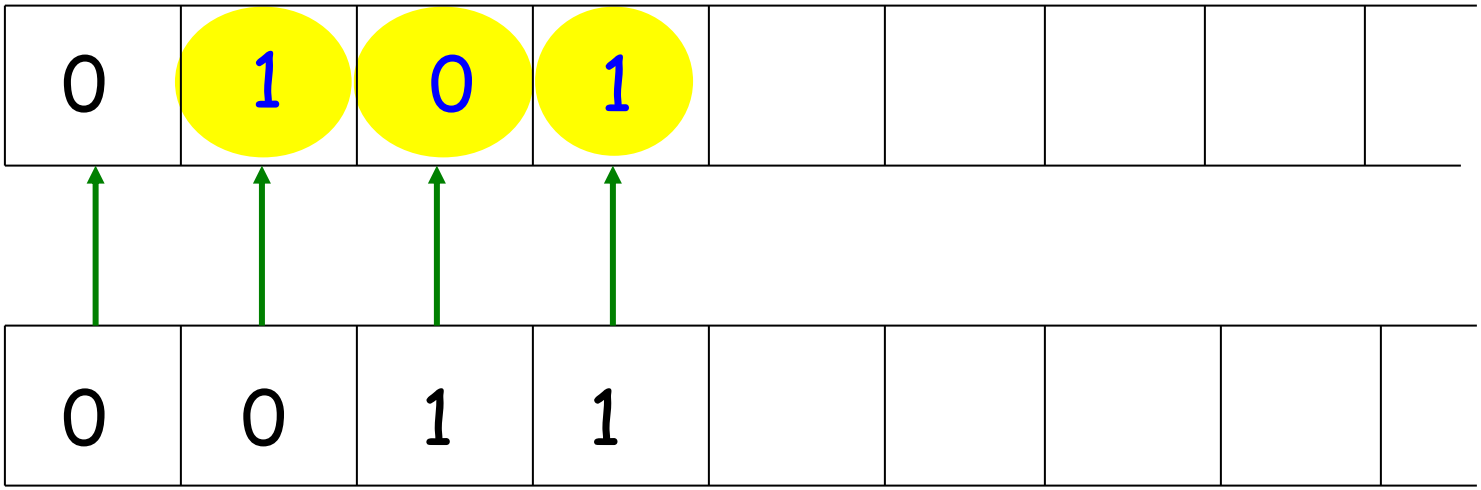
- On Computable Numbers
  With an Application to
  the Entscheidungs Problem
- Turing Machine

Automata

- Finite Automata
  - Deterministic Finite Automata
  - Non-deterministic Finite Automata
- Push Down Automata
- Turing Mashine

Computation

$$\begin{array}{r} 2 \\ +\ 3 \\ \hline 5 \end{array} \qquad \begin{array}{r} 0\,0\,1\,0 \\ +\ 0\,0\,1\,1 \\ \hline 0\,1\,0\,1 \end{array}$$



Computation

In our life

Coded

In computer

Process

0011101100001011 1100100111100
0011101100001011 11001001111000
001110110000010 11001001111

Compose

Automaton

Language

(formal description)

(set of strings)

Computation

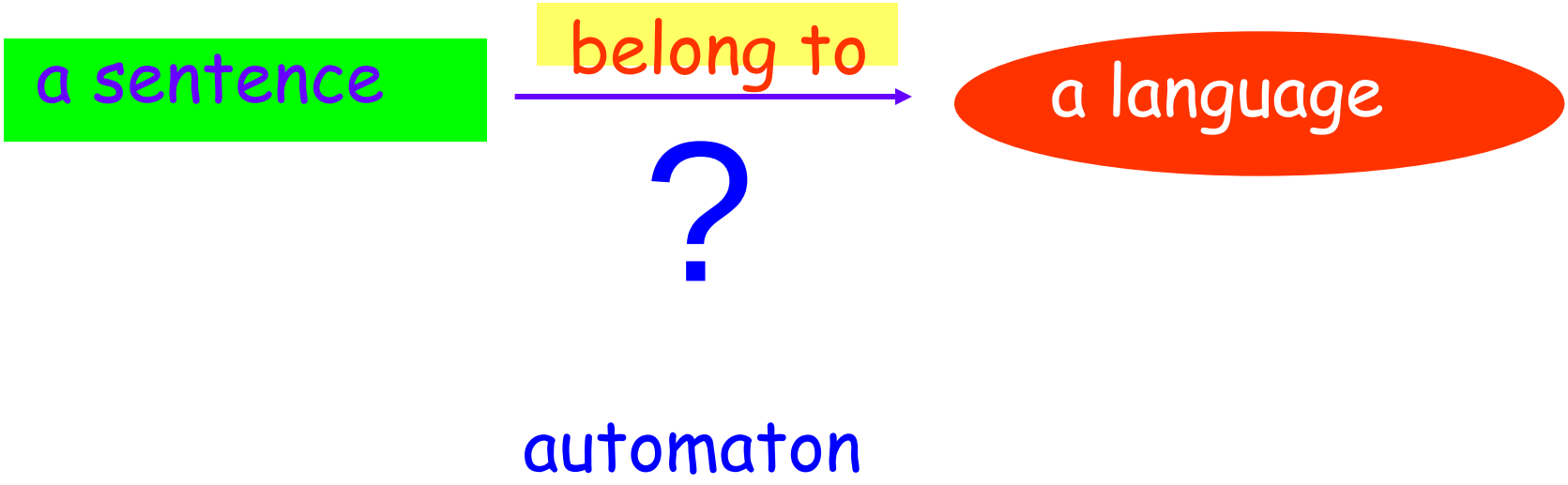
- Computable Problems
  - write a program to solve
- Intractable Problems
  - find someway to work around

Undecidable Problem

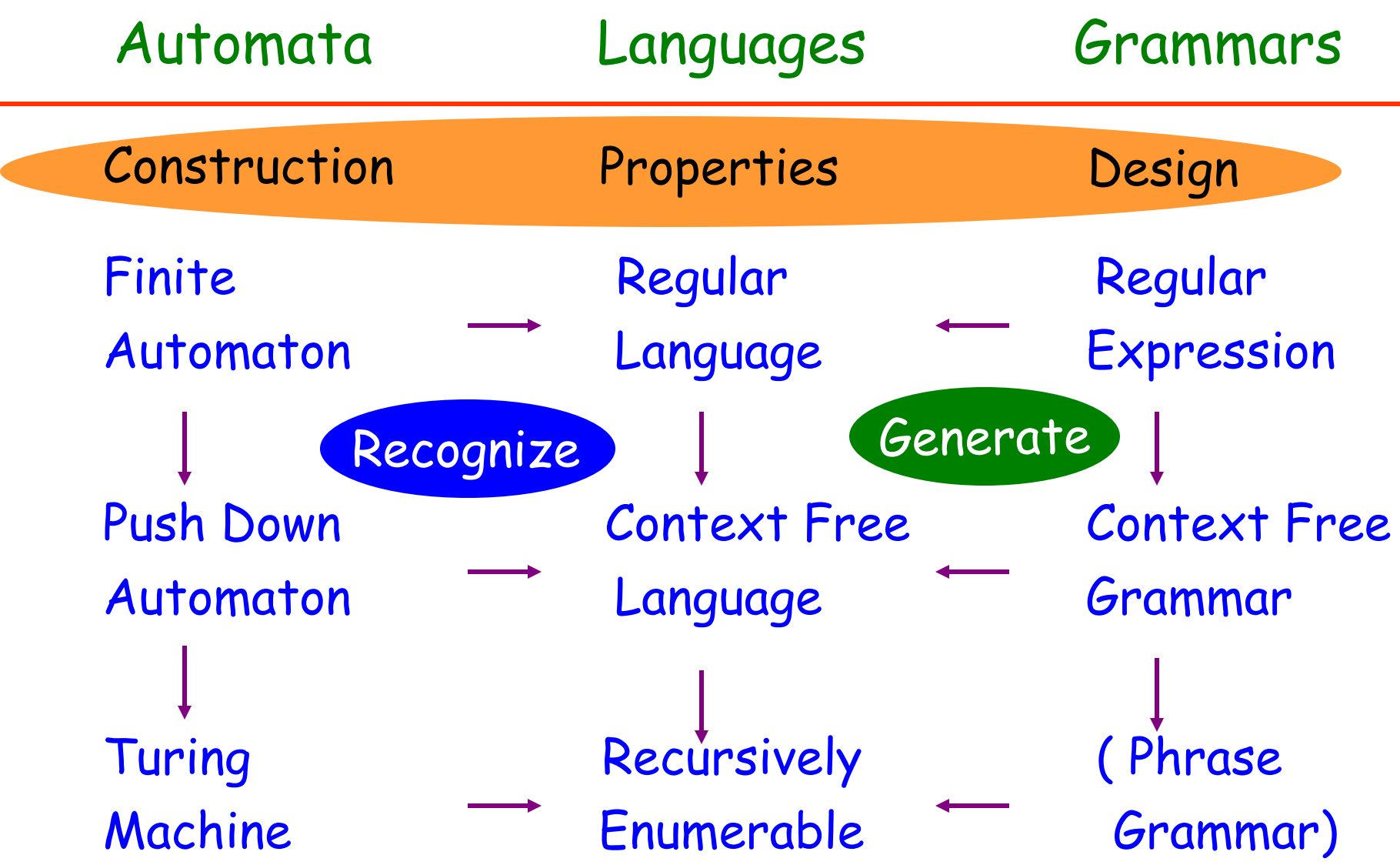
```
main ( )
{
    Int n, total, x, y, z ;
    scanf("%d", &n);
    total=3;
    while(1){
        for(x=1;x<=total-2;x++)
            for(y=1;y<=total-x-1;y++){
                z=total-x-y;
                if(exp(x,n)+exp(y,n)==exp(z,n))
                    printf("hello,world\n");
            }
        total++;
    }
}
```

$x^n + y^n = z^n$

Undecidable Problem

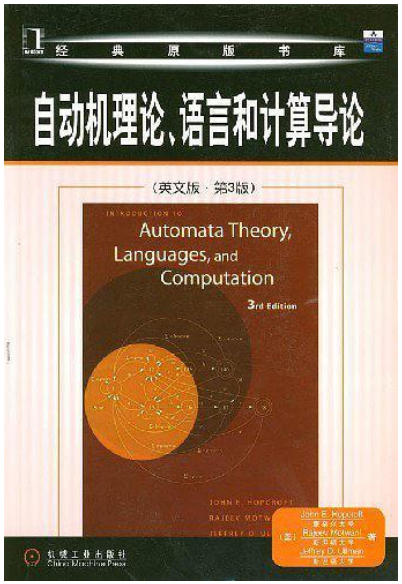


Content


Automata
Languages
Grammars
Construction
Properties
Design
Finite Automaton
Regular Language
Regular Expression
Recognize
Generate
Push Down Automaton
Context Free Language
Context Free Grammar
Turing Machine
Recursively Enumerable
(Phrase Grammar)

Text book

1. Introduction to Automata Theory , Languages , and Computation (Third Edition)



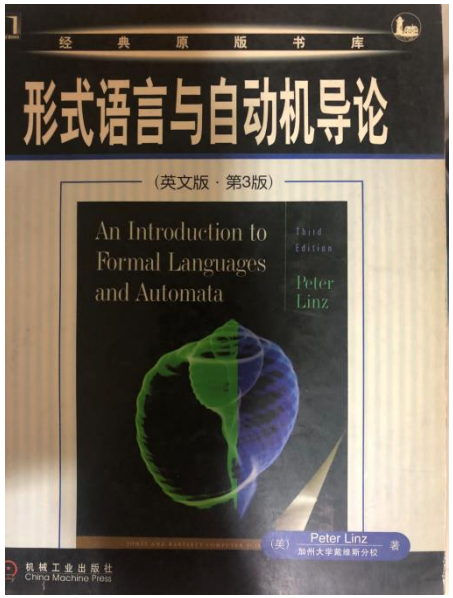
—— John E. Hopcroft

Rajeev Motwani

Jeffrey D. Ullman

Text book

2. An Introduction to Formal Languages and Automata (Third Edition)



—— Peter Linz

Goal

1. Understanding "theoretical" concepts

------ method of formal description

2. Get a sense of how to reason formally

3. Improving reading ability in English

Homework

- All exercises listed on qq-group
- Write on A4 papers
- Submit - nonditermine
- Discussions – maybe

Honor and Collaboration

- Collaboration is strongly encouraged
- Solutions must be written independently
- Responsible for Understanding and explaining

Examination

- Only final exam
- Closed exam

Nothing allowed except one pen

Grading Policy

- Homework : 20% //including Class Performance
- Final exam : 80%

Information

- Tutor ：孙大烈
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- 课程群： 自动机/104804608（qq）

- MOOC：

https://www.icourse163.org/learn/HIT-1206319802

Good good study day day up !