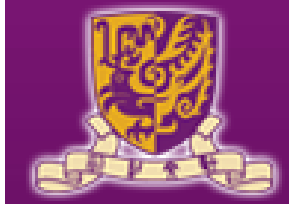


香港中文大學（深圳）
The Chinese University of Hong Kong, Shenzhen

Introduction to AI Programming

Lecture 1 Introduction

Prof. Junjie Hu

School of Artificial Intelligence

Contact

- Email: hujunjie@cuhk.edu.cn
- Office hour: Fri. 10 am – 11 am
  (Teaching A 409 B)

群聊: AIE1001-L03

该二维码7天内(9月7日前)有效，重新进入将更新

Go-to Person

- Lectures: Me
- Assignments: TA
  - The corresponding TA name and email will likely be on the assignment.
  - Different assignments have different TAs
- Tutorials: TA
  - Different tutorial sessions have different TAs

Learning Objectives

- The basics of computer programming using Python
- Basic elements of computer systems, key programming concepts, problem solving and basic algorithm design
- Program AI applications using Python

(Video: What is AI?)

Key Topics

- Introduction to modern computers
- Preliminary knowledge for computer programming
- Basic introduction to Python language
- Data types and operators in Python language
- Input/output
- Flow control and loop
- Function
- Basic data structure
- Recursion
- Introduction to algorithm design
- Introduction to object oriented programming
- Introduction to AI applications (CV, NLP)
- Introduction to AI-assisted programming

Assessment

Assignments	40%
Mid-term quiz	20%
Final exam	40%

Assignments (40%)

Online Judge Quiz	**2%**
Assignments	**(8+10+10+10)%**

- Please come to our first tutorial session, where we will introduce how to use the Online Judge platform, which will be used for most of the assignment submission.
- The submission of a simple task will account for 2% of the grade in the course.

Course Materials

- All lecture notes and sample code used in classes will be provided to students via Blackboard

- Recommended readings
  - Online resources: https://www.python.org/doc/
  - Online book: https://www.composingprograms.com/
  - Learning Python, 5th Edition, by Mark Lutz, Publisher: O'Reilly media

Course Components

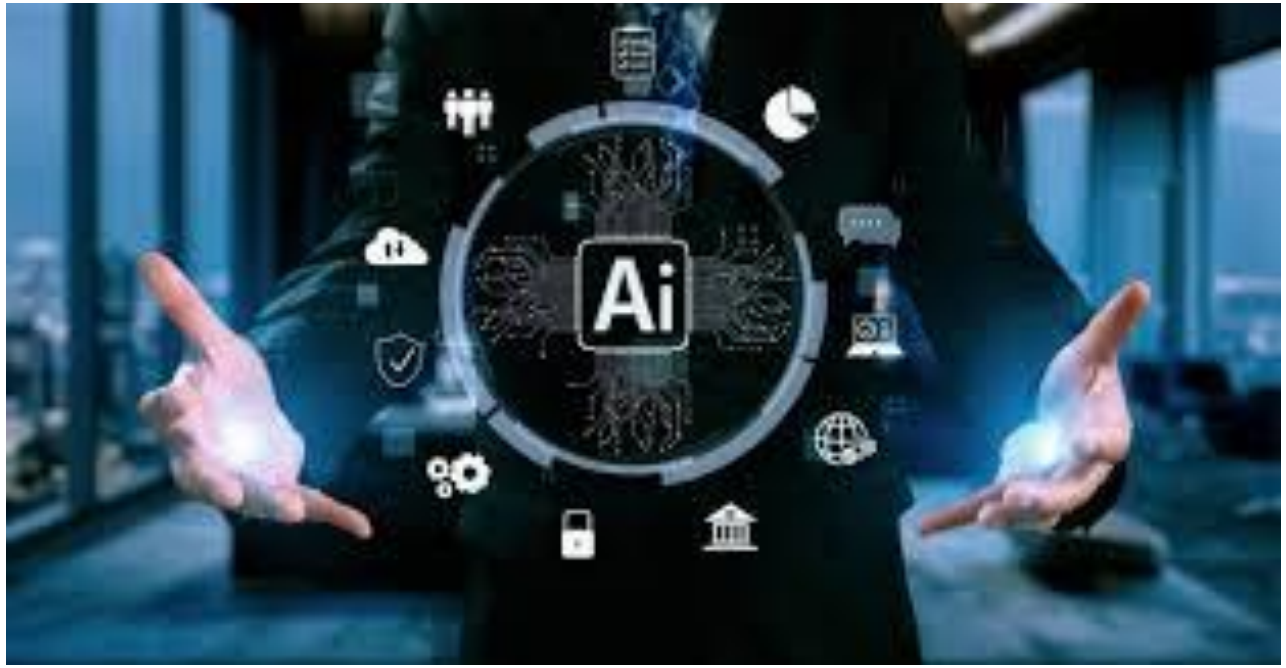
Activity	Hours/week
Lecture	70+10 minutes × 2
Tutorial	50 minutes × 1

Note: Tutorial starts from next week. This week we don’t have tutorials!

Indicative Teaching Plans

Week	Content/ topic/ activity
1	Introduction to modern computers; Preliminary knowledge for computer programming;
2	Basic introduction to Python language; Data types and operators in Python language; Input/output;
3	Flow control and loop;
4	Function;
5	List, dictionary, tuple;
6	Recursion and algorithm design
7	Review and Midterm
8	Introduction to object oriented programming, part I
9	Introduction to object oriented programming, part II
10	Data structure
11	Image processing
12	Natural language processing
13	Programming in the era of AI
14	Review for final exam;

What is Artificial Intelligence



(Video: AI)

Impact of AI

- The First Industrial Revolution: Steam engine
- The Second Industrial Revolution: Electricity
- The Third Industrial Revolution: Information technology
- The Forth Industrial Revolution: **Artificial Intelligence**

Impact of AI

中国国际科技交流中心
https://www.ciste.org.cn › gzdt › kjyq › art

科技动态｜出口管制与中美人工智能竞赛的未来

中美人工智能竞赛，已超越单纯技术比拼，演变为战略耐力的较量。DeepSeek的崛起，不仅是中国技术实力的证明，更是对全球人工智竞争格局的重塑。未来，这场竞赛的胜负，将 ...

RFI
https://www.rfi.fr › 法广 › 中国

美中AI冷战升温：帕兰泰尔Palantir执行长警告“不是美国赢

5天前 — 卡普一直积极倡导美国在AI领域的主导地位。他认为，美国和中国之间的AI竞赛，最终将以一个国家胜出而告终，而美国需要“举全国之力”，以开发更先进的AI ...

Al Jazeera Chinese
https://chinese.aljazeera.net › 科技 › 贸易战

关于中美人工智能战的细节

2025年4月30日 — 中国和美国在全球范围内为争夺人工智能霸权而展开的激烈斗争正在决定未来数字基础设施的控制权。

联合早报
https://www.zaobao.com.sg › story20250610-6638601

徐奇渊、王亚强：特朗普会令AI竞赛倒向中国一边吗?

3天前 — 特朗普削减研究经费和限制移民的做法，进一步削弱美国在AI竞赛中的地位。比如今年2月就解雇了美国国家科学基金会的170名员工（包括多名AI专家），并提议将 ...

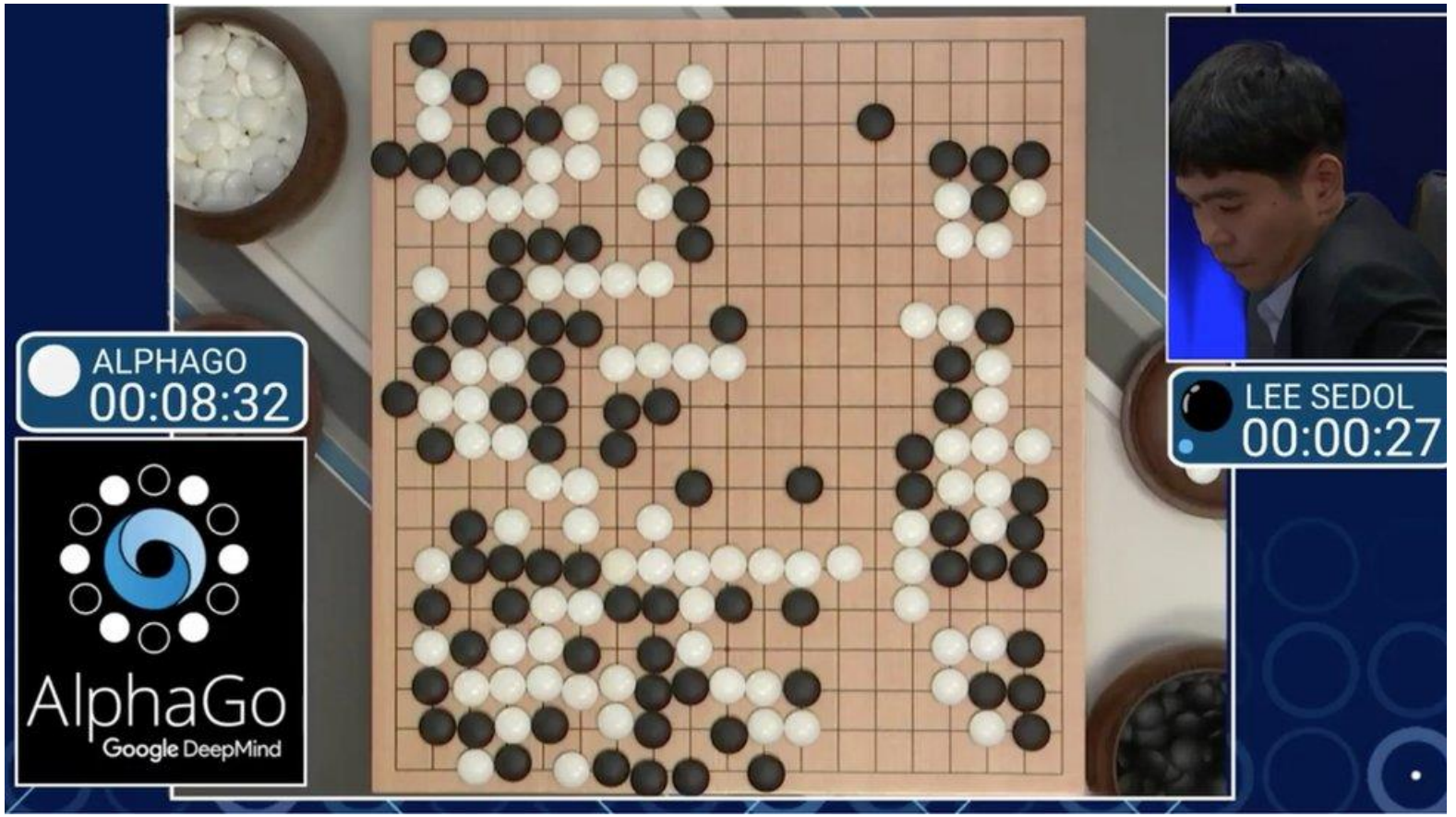
The China-US AI Race Enters a New (and More Dangerous) Phase

A new tech cold war is underway — and accelerating.

By **Marina Yue Zhang**
May 16, 2025

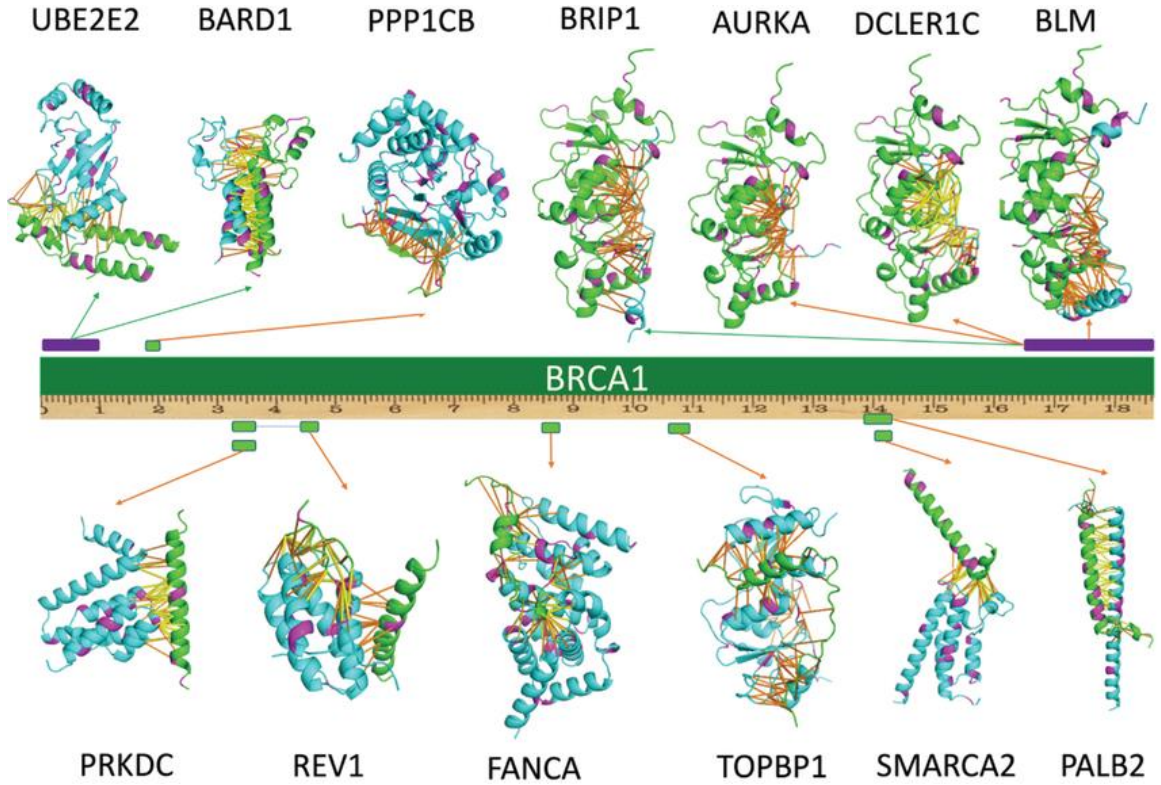
What Can AI Do?

- Go



What Can AI Do?

- Protein structure prediction-AlphaFold (Nobel prize)



What Can AI Do?

- Video generation

What Can AI Do?

- Voice generation

What Can AI Do?

- Self-driving Car

What Can AI Do?

- Robot locomotion

What Can AI Do?

- Robot manipulation

Current AI Limitations

- Not robust
- Not generable in 3D real-world
- Highly training cost
- Relying on large models
- Relying on huge amount of data
- etc.

(Video: Failure cases)

Your chance!

Why learn programming?

- Computer is built to help people solve problems
- (Video: computer science basics, hardware and software)
- Computer does not understand what we say
- We need to communicate with computers using their languages (computer programming language)
- Assembly, C, C++, Java and Python

AI Programmer

- Professional programmer writes computer programs and develops software

- A programmer can earn up to 500k – 1m USD in Google!!

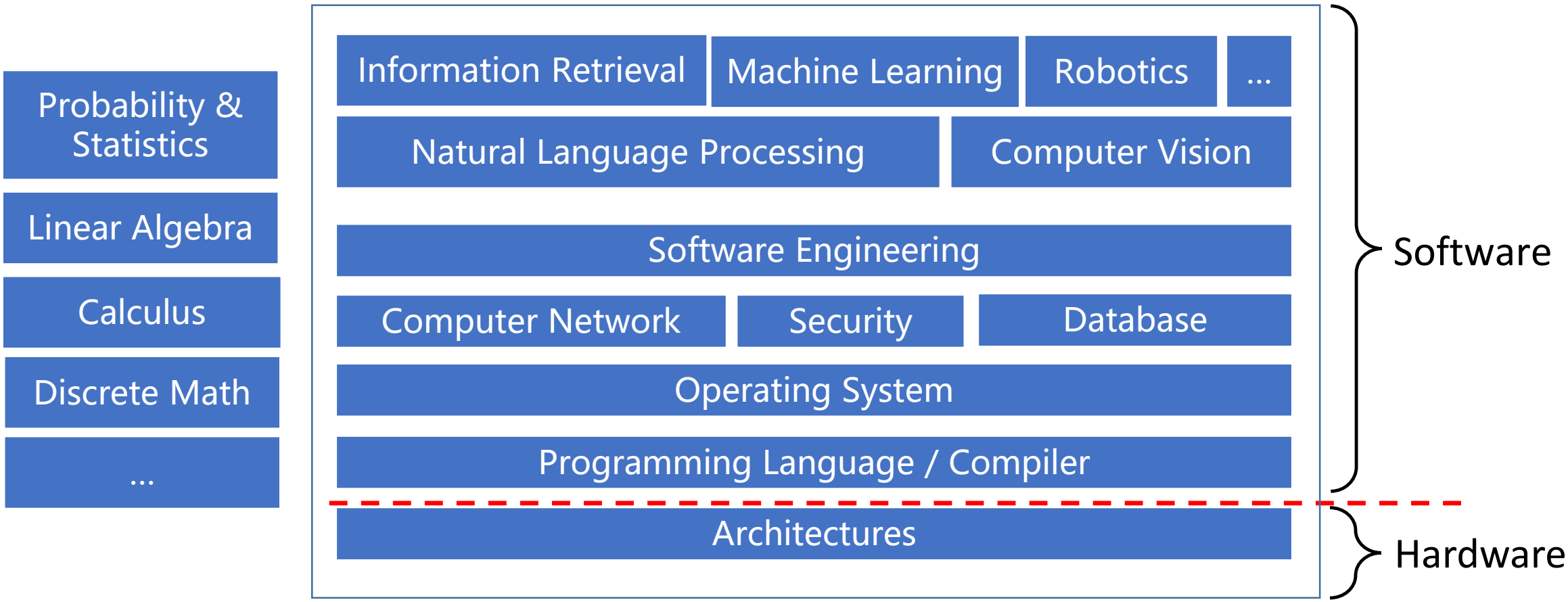
- Software and AI are huge industries.

Why be a AI programmer?

- Programming is pervasive in your life, even if you are NOT in the IT industry
  - Electrical/electronic engineer – control program
  - Economist – mathematical modeling
  - Salesman – analyzing sales data
  - …

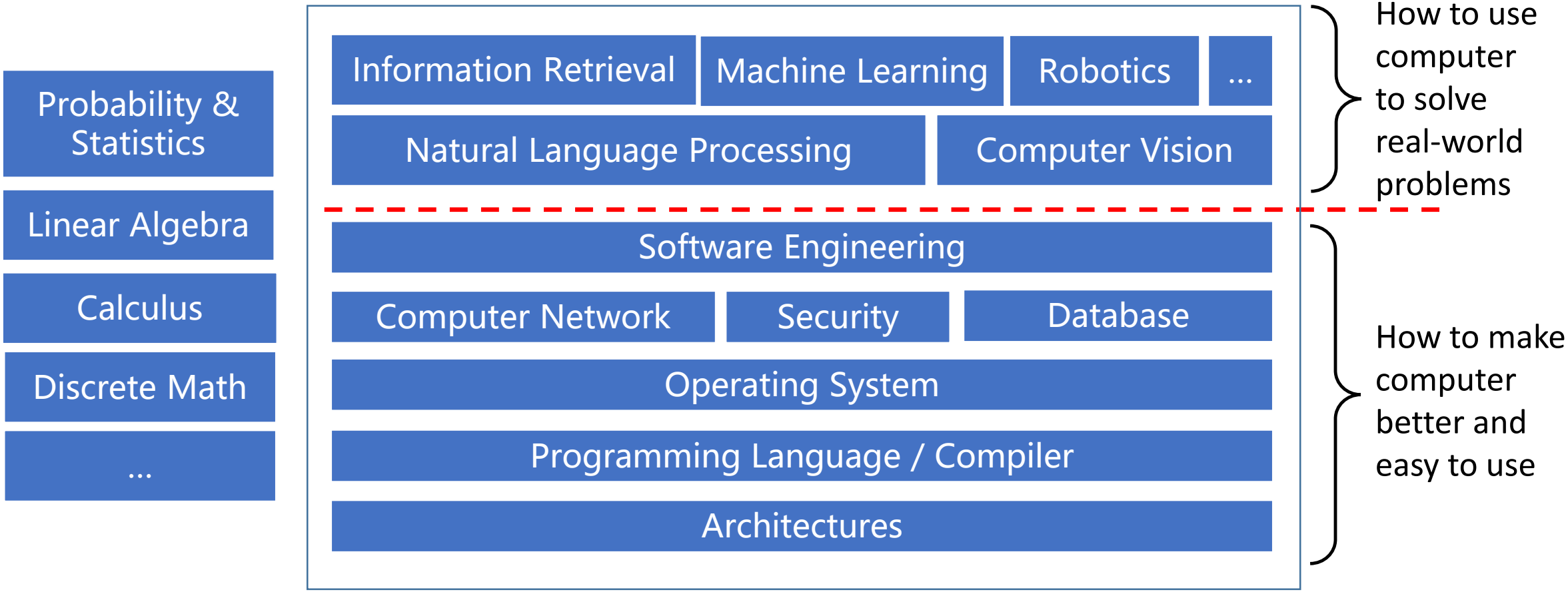
(Video: Should I learn to code?)

What is computer science and AI: big picture



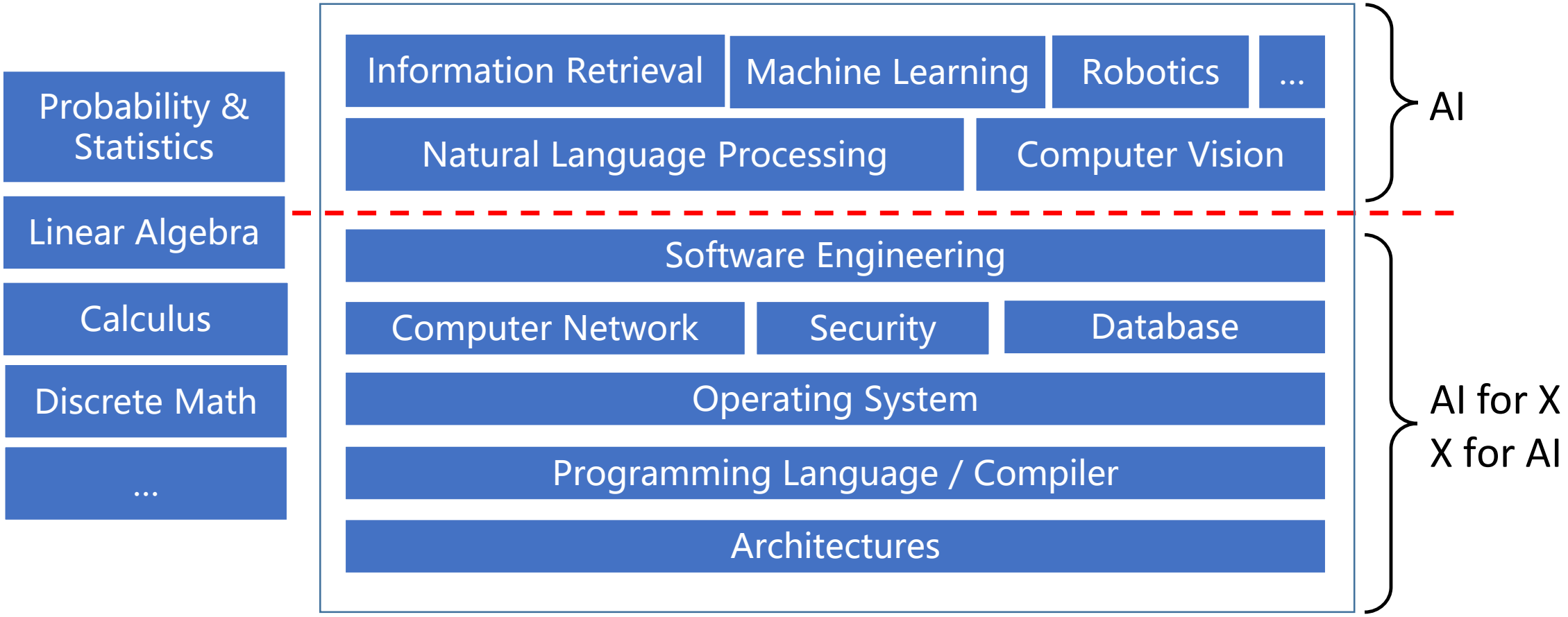
Slides adapted from NJU SICP

What is computer science and AI: big picture



Slides adapted from NJU SICP

What is computer science and AI: big picture



Slides adapted from NJU SICP

What is Code? Software? Program?

- A sequence of instructions
- Computers take the instructions and execute them
- It is a little piece of our intelligence in the computer
- Intelligence is re-usable

Programs for human

- Making an instant coffee
  1. Boil water (about 200 ml for one cup).
  2. Put **1–2 teaspoons** of instant coffee granules into a cup.
  3. Pour the hot water into the cup.
  4. Stir well until fully dissolved.
  5. Add sugar, milk, or cream if desired.
  6. Enjoy your coffee.

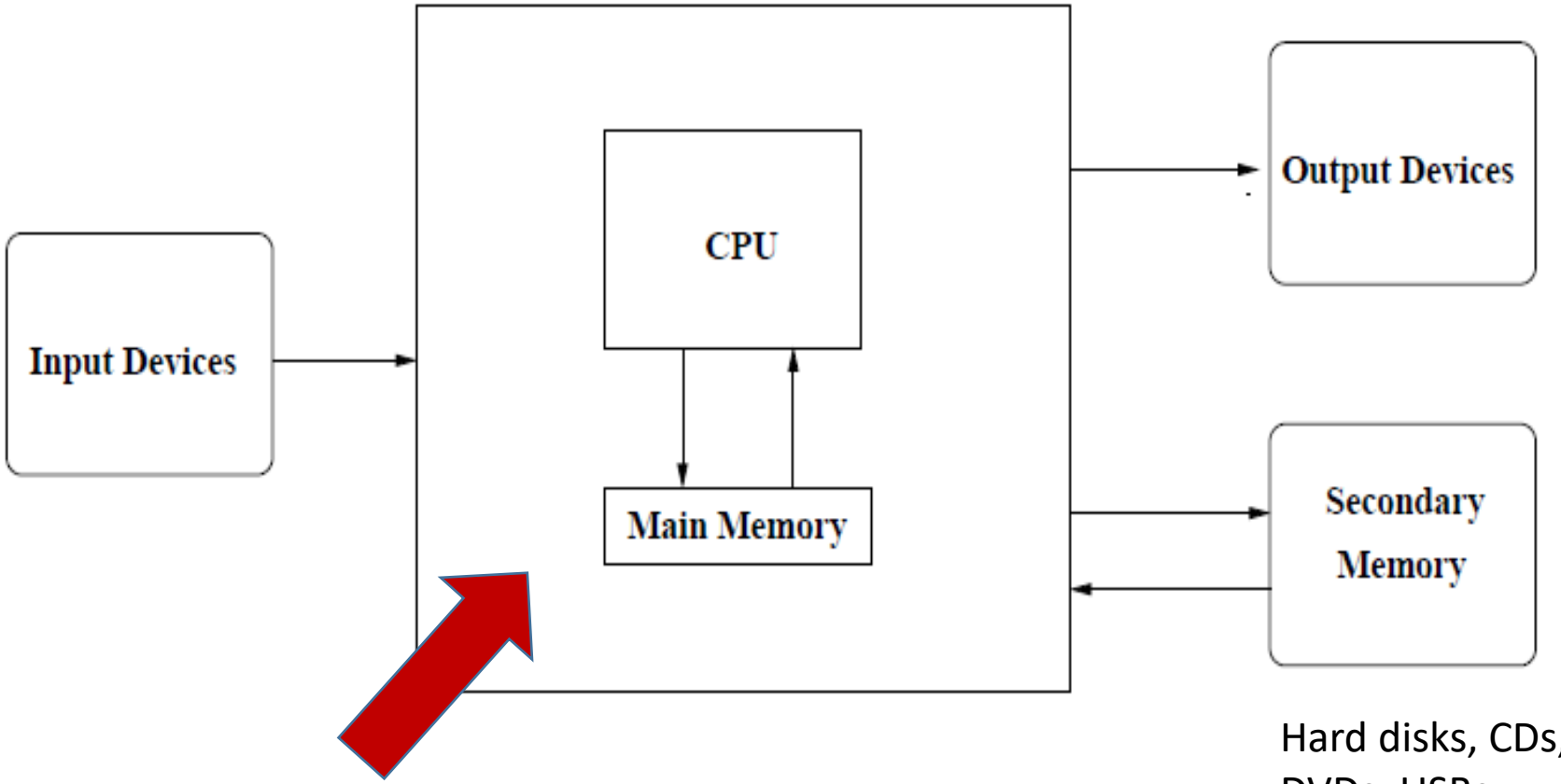
(Video: Algorithms)

Computers are good at following instructions

- Humans can easily make mistakes when following a set of instructions

- On the contrary, computers (usually) won’t make mistakes, regardless of they are given 10 or 10 billion instructions !!

Computer Hardware



Hard disks, CDs, DVDs, USBs

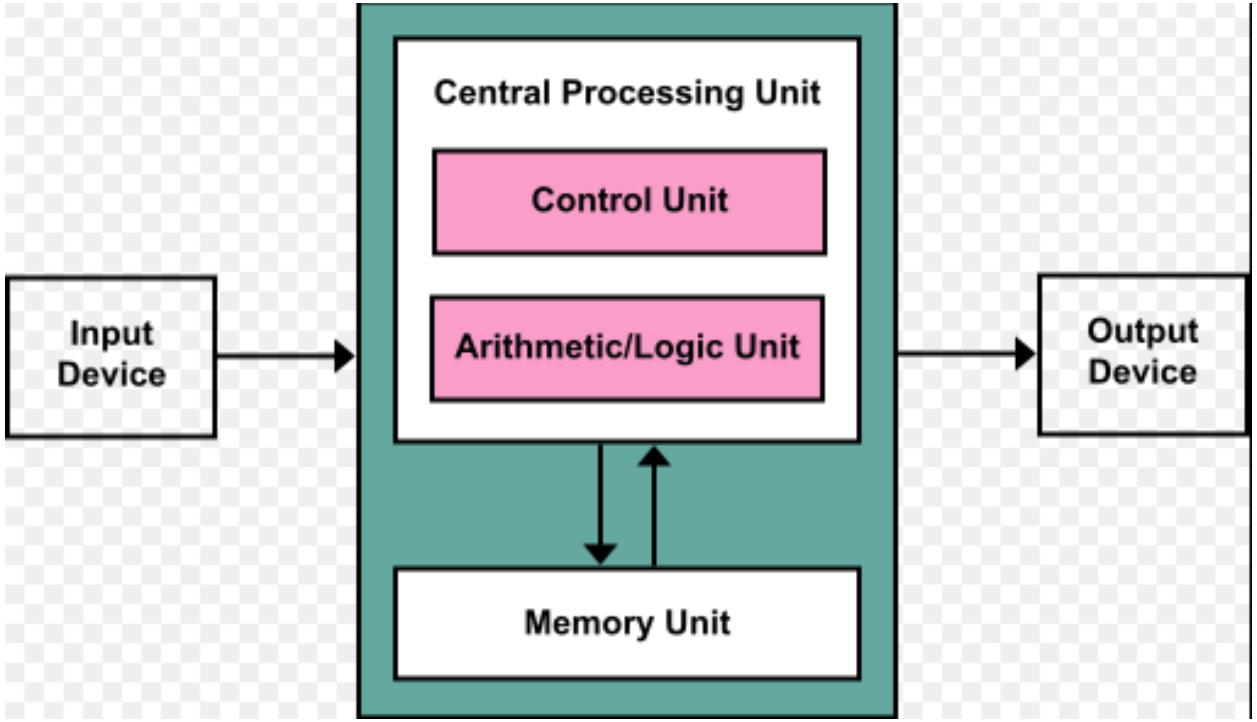
Program

Key components in a computer

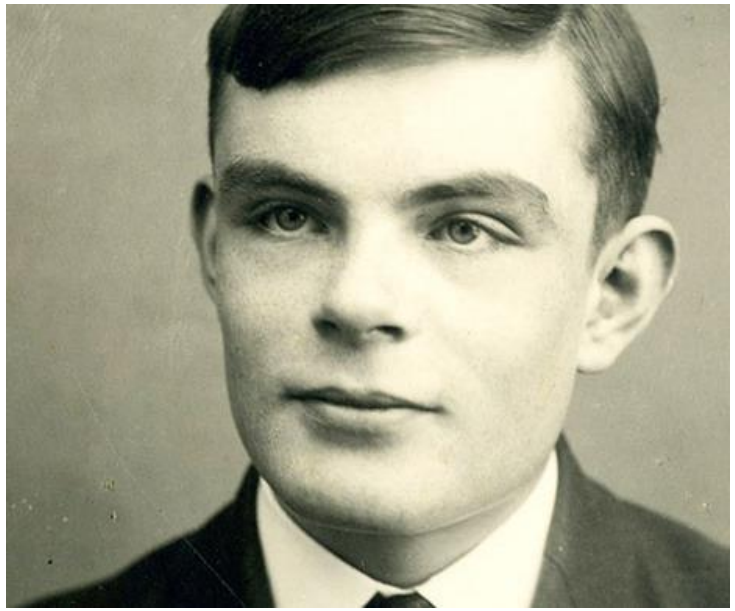
- Central processing unit (CPU): execute your program. Similar to human brain, very fast but not that smart
- Input device: take inputs from users or other devices
- Output device: output information to users or other devices
- Main memory: store data, fast and temporary storage
- Secondary memory: slower but large size, permanent storage

Von Neumann Architecture

- The modern computer architecture is proposed by John Von Neumann



The theoretical foundation of computer science



- The theoretical foundation of computer science is built by Alan Turing

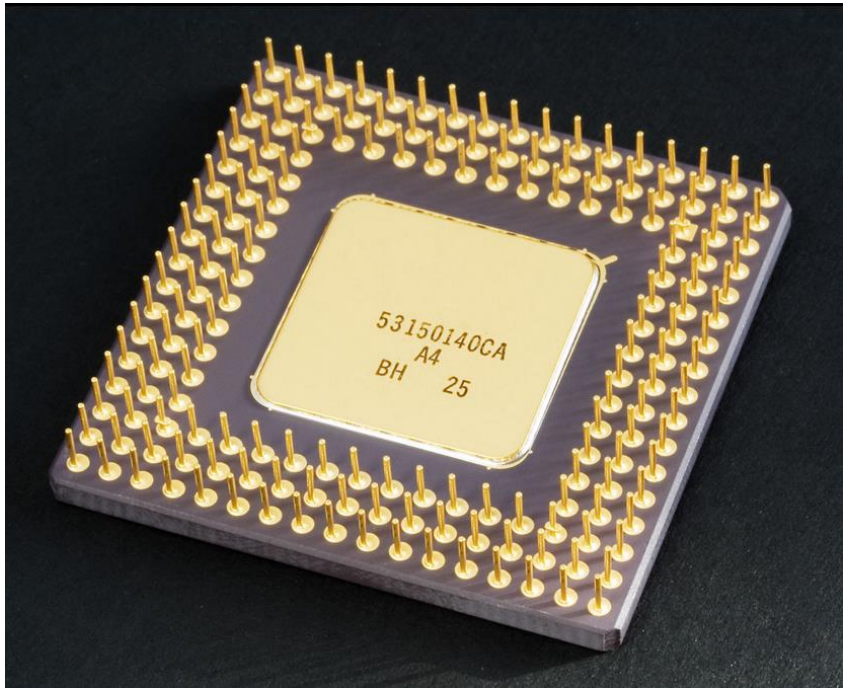
- Father of theoretical computer science and artificial intelligence

- Computability theory and Turing test

Central Processing Unit

- A processor contains two units, a control unit (CU) and an arithmetic/logic unit (ALU)
- CU is used to fetch commands from the memory
- ALU contains the electric circuits which can execute commands

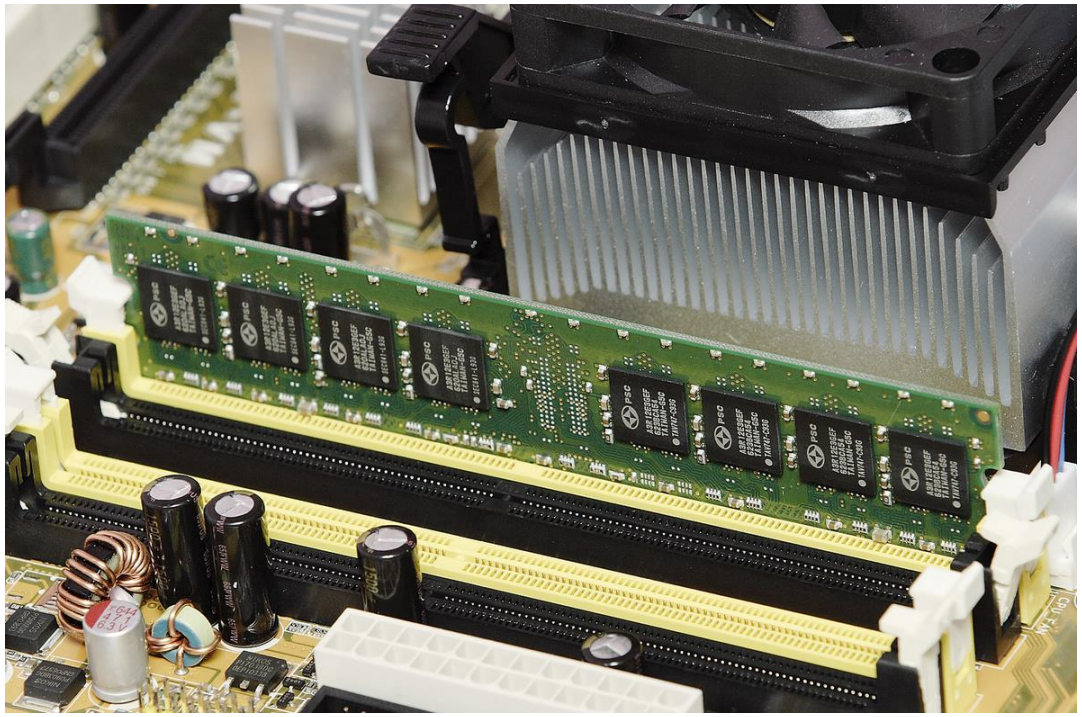
Central Processing Unit



- Processor manufacturer: Intel, AMD, ARM, etc

Memory/Storage

- High speed cache
- Internal RAM
- Internal ROM
- Flash
- Hard disk



Input/output devices

- Input devices: mouse, keyboard, panel, touch screen, audio input, mind reading, etc

- Output devices: screen, audio output, etc

How the hard disk works

What can a computer actually understand?

- How can a computer understand a number (e.g., 8)?

Low level language – Assembly Language

- An assembly language is a low-level programming language, in which there is a very strong (generally one-to-one) correspondence between the language and machine code instructions.

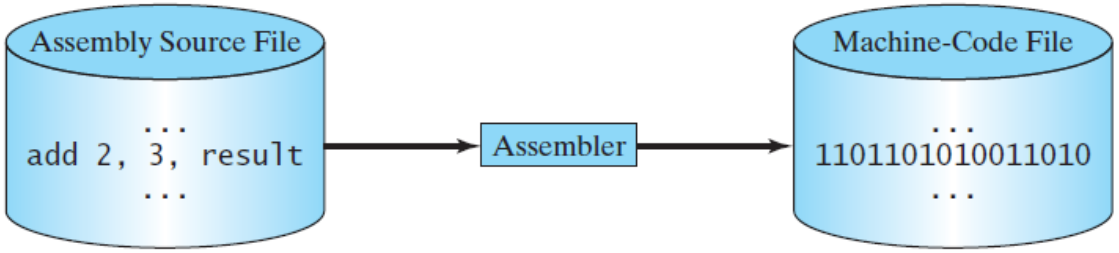
- Each assembly language is specific to a particular computer architecture

- Assembly language is converted into executable machine code by a utility program referred to as an assembler

```
                        ****************************************
                        * FUNCTION: INHEX - INPUT HEX DIGIT
                        * INPUT: none
                        * OUTPUT: Digit in acc A
                        * CALLS: INCH
                        * DESTROYS: acc A
                        * Returns to monitor if not HEX input

C01E 8D F0      INHEX   BSR     INCH        GET A CHAR
C020 81 30              CMP A   #'0         ZERO
C022 2B 11              BMI     HEXERR      NOT HEX
C024 81 39              CMP A   #'9         NINE
C026 2F 0A              BLE     HEXRTS      GOOD HEX
C028 81 41              CMP A   #'A
C02A 2B 09              BMI     HEXERR      NOT HEX
C02C 81 46              CMP A   #'F
C02E 2E 05              BGT     HEXERR
C030 80 07              SUB A   #7          FIX A-F
C032 84 0F      HEXRTS  AND A   #$0F        CONVERT ASCII TO DIGIT
C034 39                 RTS

C035 7E C0 AF   HEXERR  JMP     CTRL        RETURN TO CONTROL LOOP
```



C Language (1969 - 1973)

- C was developed by Dennis Ritchie between 1969 and 1973 at AT&T Bell Labs
- One of the early high-level programming language
- Somewhere between assembly and other high level languages
- Provide powerful functionalities for low level memory manipulations
- Have the highest efficiency within high level languages
- Very widely used in low level applications, such as operating systems, embedded programming, super computers, etc

C++ Language (1979)

- C++ was developed by Bjarne Stroustrup at Bell Labs since 1979
- Inherent major features of C
- An object oriented programming language, supporting code reuse
- High efficiency and powerful in low level memory manipulation
- Still platform dependent

Java Language (1995)

- Java was developed by James Gosling at Sun Microsystems (which has since been acquired by Oracle Corporation) and released in 1995
- A new generation of general-purpose object oriented programming language
- Platform independent, “"write once, run anywhere” (WORA)
- Java is one of the most popular programming languages currently in use

Python (1991)

- Developed by Guido van Rossum in 1989, and formally released in 1991
- An open source, object oriented programming language
- Powerful libraries
- Powerful interfaces to integrate other programming languages (C/C++, Java, and many other languages)
- Programming language of the year 2010

Language efficiency v.s. development efficiency

- High level languages cannot be executed directly
- High level languages must be converted into low level languages first
- Lower level languages have higher language efficiency (they are faster to run on a computer)
- Higher level languages have higher development efficiency (it is easier to write programs in these languages)
- (Video: Programming Languages)

Operating Systems

- The operating system (OS) is a low level program, which provides all basic services for managing and controlling a computer's activities

- Applications are programs which are built based upon an OS

- Main functions of an OS:

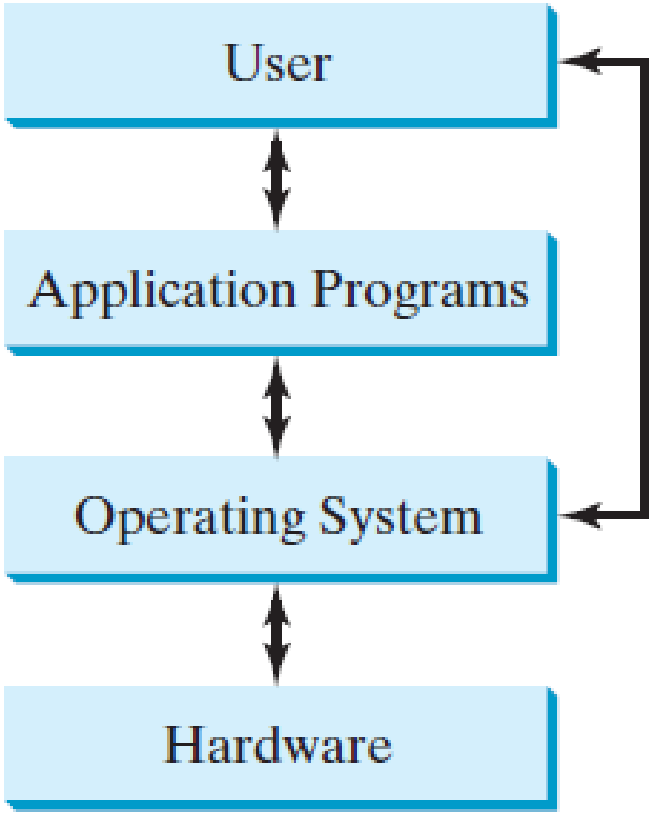
✓ Controlling and monitoring system activities

✓ Allocating and assigning system resources

✓ Scheduling operations

(Demo: mac terminal)

- Popular OS: Windows, Mac OS, Linux, iOS, Android…



(Video: Operating System)

Abstraction

- Machine language -> Assembly -> C -> Python
- Hardware -> OS -> Apps/Software applications
- Binary digits -> Primitive data types -> Data structures

Data Representation and Conversion

- We use positional notation (进位记数法) to represent or encode numbers in a computer

  1 0

- Data are stored essentially as binary numbers in a computer

- In practice, we usually represent data using either binary (二进制), decimal (十进制), octal (八进制) or hexadecimal (十六进制) number systems

- We may need to convert data between different number systems

  (Video: Binary)

The basic idea of positional notation

- Each positional number system contains two elements, a base (基数) and a set of symbols
- Using the decimal system (十进制系统) as an example, its base is 10, and the symbols are {0, 1, 2, 3, 4, 5, 6, 7, 8, 9}
- When a number “hits” 9, the next number will not be a different symbol, but a “1” followed by a “0” (逢十进一)

Decimal number system

- In the decimal number system, the base is 10, the symbols include 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
- Every number can be decomposed into the sum of a series of numbers, each is represented by a positional value times a weight
- $N = a_n \times 10^n + a_{n-1} \times 10^{n-1} + a_{n-2} \times 10^{n-2} \ \ldots\ldots + a_0 \times 10^0 + a_{-1} \times 10^{-1} + a_{-2} \times 10^{-2} \ldots$
- a_n is the positional value (ranging from 0 to 9), while 10^n represents the weight

Binary number system

- In the binary system, the base is 2, we use only two symbols 0 and 1
- "10" is used when we hit 2 (逢二进一)
- $N = a_n \times 2^n + a_{n-1} \times 2^{n-1} + a_{n-2} \times 2^{n-2} \ \ldots\ldots + a_0 \times 2^0 + a_{-1} \times 2^{-1} + a_{-2} \times 2^{-2} \ldots$

$$9_{(10)} = 1\times 2^3 + 0\times 2^2 + 0\times 2^1 + 1\times 2^0 = 1001_{(2)}$$

- a_n is the positional value (ranging from 0 to 1), while 2^n represents the weight

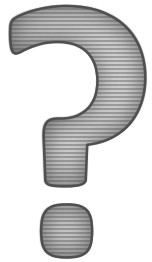
Why use binary number?

- Easy to implement physically
- Simple calculation rules
- Easy to combine arithmetic and logic operations

Hexadecimal number system

- In the hexadecimal system, the base is 16, we use 16 symbols {0, 1, 2, 3, 4, 5, 6, 7, 8, 9, a, b, c, d, e, f}
- “10” is used when we hit 16 (逢十六进一)
- $N = a_n \times 16^n + a_{n-1} \times 16^{n-1} + a_{n-2} \times 16^{n-2} \ \ldots\ldots + a_0 \times 16^0 + a_{-1} \times 16^{-1} + a_{-2} \times 16^{-2} \ldots$
- a_n is the positional value (ranging from 0 to 15), while 16^n represents the weight

Octal number system



Converting binary number into decimal number

Example $(1101.01)_2$

$$=(1\times2^3+1\times2^2+0\times2^1+1\times2^0+0\times2^{-1}+1\times2^{-2})_{10}$$

$$=(13.25)_{10}$$

Practice $(10110.11)_2=(?)_{10}$

Converting binary number into decimal number

Answer

(10110.11)

$=(1\times2^4+0\times2^3+1\times2^2+1\times2^1+0\times2^0+1\times2^{-1}+1\times2^{-2})_{10}=(22.75)_{10}$.

Converting octal number into decimal number

Example $(24.67)_8=(2 \times 8^1+ 4 \times 8^0+6 \times 8^{-1}+7 \times 8^{-2})_{10}$

$=(20.859375)_{10}$

Practice $(35.7)_8= (?)_{10}$

Converting octal number into decimal number

Answer

$$(35.7)_8=(3\times8^1+5\times8^0+7\times8^{-1})_{10}$$
$$=(29.875)_{10}$$

Converting hexadecimal number into decimal number

Example $(2AB.C)_{16}$

$$=(2\times16^{2}+10\times16^{1}+11\times16^{0}+12\times16^{-1})_{10}$$

$$=(683.75)_{10}$$

Practice $(A7D.E)_{16}= (?)_{10}$

Converting hexadecimal number into decimal number

Answer

$$(A7D.E)_{16}=(10\times16^{2}+7\times16^{1}+13\times16^{0}+14\times16^{-1})_{10}$$
$$=(2685.875)_{10}$$

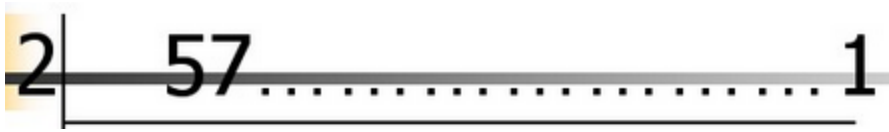
Converting other number system into decimal system

- Other number system can also be converted into decimal system in a similar way

- We just need to change the corresponding base

Converting decimal integer into binary integer

Example: $(57)_{10} = (?)_2$



Lower position

Higher position

(Video: decimal to binary)

Converting decimal fraction into binary fraction

Example: $(0.875)_{10} = (?)_2$

$0.875 \times 2 = 1.75$ Integer part: 1

$0.75 \times 2 = 1.5$ Integer part: 1

$0.5 \times 2 = 1$ Integer part: 1

Higher position

Lower position

Answer: $(0.875)_{10} = (0.111)_2$

Practice: $(0.6875)_{10} = (?)_2$

Converting decimal fraction into binary fraction

Answer:

$0.6875 \times 2 = 1.375$ Integer part: 1
$0.375 \times 2 = 0.75$ Integer part: 0
$0.75 \times 2 = 1.5$ Integer part: 1
$0.5 \times 2 = 1$ Integer part: 1

Higher position

Lower position

So, $(0.6875)_{10} = (0.1011)_2$

Converting decimal number into binary number

- For a decimal number that has both integer and fractional parts
- Convert the integer and fractional parts separately
- Example: $(215.6875)_{10} = (?)_2$

Converting decimal number into binary number

Answer:

$$(215)_{10}=(11010111)_2$$
$$(0.675)_{10}=(0.1011)_2$$
$$(215.675)_{10}=(11010111.1011)_2$$

Correction: should be 6875

The one-to-one relationship between binary and octal numbers

There is a “one-to-one” (一一对应) relationship between three digits binary number and one digit octal number

$$
\begin{aligned}
(0)_8 &= (000)_2 \\
(1)_8 &= (001)_2 \\
(2)_8 &= (010)_2 \\
(3)_8 &= (011)_2 \\
(4)_8 &= (100)_2 \\
(5)_8 &= (101)_2 \\
(6)_8 &= (110)_2 \\
(7)_8 &= (111)_2
\end{aligned}
$$

Converting octal number into binary number

- Convert each octal digit into binary number of three digits
- Keep the digit order unchanged
- Example: $(0.754)_8 = (?)_2$

$$(0.754)_8 = (\underline{000}.\underline{111}\ \underline{101}\ \underline{100})_2$$
$$= (0.1111011)_2$$

- Practice: $(16.327)_8 = (?)_2$

Converting octal number into binary number

Answer:

$$(16.327)_8$$
$$= (\underline{001\ 110}.\ \underline{011}\ \underline{010}\ \underline{111})_2$$
$$= (1110.011010111)_2$$

Converting hexadecimal number into binary number

- Convert each hexadecimal digit into binary number of four digits

- Keep the digit order unchanged

- Example: $(4C.2E)_{16} = (?)_2$

$$
\begin{aligned}
&(4C.2E)_{16} \\
&= (\underline{0100}\ \underline{1100}.\underline{0010}\ \underline{1110})_2 \\
&= (1001100.0010111)_2
\end{aligned}
$$

- Practice: $(AD.7F)_{16} = (?)_2$

Converting hexadecimal number into binary number

Answer:

$$(AD.7F)_{16}$$

$$= (\underline{1010}\ \underline{1101}.\underline{0111}\ \underline{1111})_{2}$$

$$= (10101101.01111111)_{2}$$

Converting binary number into octal number

- Starting from lower positions, convert every three digits of the integer part into a octal digit
- When there is not enough higher positions in the integer part, fill with 0
- Starting from higher positions, convert every three digits of the fractional part into a octal digit
- When there is not enough lower positions in the fractional part, fill with 0
- Keep the digit order unchanged

Converting binary number into octal number

Example:

$(0.10111)_2 = (\underline{000}.\ \underline{101}\ \underline{110})_2 = (0.56)_8$

$(11101.01)_2 = (\underline{011}\ \underline{101}.\ \underline{010})_2 = (35.2)_8$

Practice:

$(1101101.011)_2$

Converting binary number into octal number

Answer:

$$(1101101.011)_2 = (\underline{001}\ \underline{101}\ \underline{101}.\ \underline{011})_2$$
$$= (155.3)_8$$

Converting binary number into hexadecimal number

- Starting from lower positions, convert every four digits of the integer part into a octal digit
- When there is not enough higher positions in the integer part, fill with 0
- Starting from higher positions, convert every four digits of the fractional part into a octal digit
- When there is not enough lower positions in the fractional part, fill with 0
- Keep the digit order unchanged

Converting binary number into hexadecimal number

Example:

$$(11101.01)_2 = (\underline{0001}\ \underline{1101}.\ \underline{0100})_2$$
$$= (1D.4)_{16}$$

The units of information (data)

- Bit (比特/位): a binary digit which takes either 0 or 1
- Bit is the smallest information unit in computer programming
- Byte (字节): 1 byte = 8 bits, every English character is represented by 1 byte
- KB (千字节)：1 KB = 2^10 B = 1024 B
- MB (兆字节)：1MB = 2^20 B = 1024 KB
- GB (千兆字节)：1GB = 2^30 B = 1024 MB
- TB (兆兆字节)：1TB = 2^40 B = 1024 GB

Memory and addressing

- A computer's memory consists of an ordered sequence of bytes for storing data
- Every location in the memory has a unique address
- The key difference between high and low level programming languages is whether programmer has to deal with memory addressing directly