CSC2208 Artificial Intelligence

Introduction to Artificial Intelligence(AI)

Overview

- - Definition and history of AI
- - Applications and scope of AI
- - AI ethics and societal impact
- - Tools and programming languages for AI

Definition and History of AI

- • Definition: AI is the simulation of human intelligence processes by machines.
- *AI* is technology that enables computers and machines to simulate human learning, comprehension, problem solving, decision making, creativity and autonomy

A Brief History of AI: 1950s

- Computers were thought of as an electronic brains
- Term "Artificial Intelligence" coined by John McCarthy
  - John McCarthy also created Lisp in the late 1950s
- Alan Turing defines intelligence as passing the Imitation Game (Turing Test)
- AI research largely revolves around toy domains
  - Computers of the era didn't have enough power or memory to solve useful problems
  - Problems being researched include
    - games (e.g., checkers)
    - primitive machine translation
    - blocks world (planning and natural language understanding within the toy domain)
    - early neural networks researched: the perceptron
    - automated theorem proving and mathematics problem solving

The 1960s

- AI attempts to move beyond toy domains
- Syntactic knowledge alone does not work, domain knowledge required
  - Early machine translation could translate English to Russian ("the spirit is willing but the flesh is weak" becomes "the vodka is good but the meat is spoiled")
- Earliest expert system created: Dendral
- Perceptron research comes to a grinding halt when it is proved that a perceptron cannot learn the XOR operator
- US sponsored research into AI targets specific areas – not including machine translation
- Weizenbaum creates Eliza to demonstrate the futility of AI

1970s

- AI researchers address real-world problems and solutions through expert (knowledge-based) systems
  - Medical diagnosis
  - Speech recognition
  - Planning
  - Design
- Uncertainty handling implemented
  - Fuzzy logic
  - Certainty factors
  - Bayesian probabilities
- AI begins to get noticed due to these successes
  - AI research increased
  - AI labs sprouting up everywhere
  - AI shells (tools) created
  - AI machines available for Lisp programming
- Criticism: AI systems are too brittle, AI systems take too much time and effort to create, AI systems do not learn

1970s

- AI researchers address real-world problems and solutions through expert (knowledge-based) systems
  - Medical diagnosis
  - Speech recognition
  - Planning
  - Design
- Uncertainty handling implemented
  - Fuzzy logic: **Fuzzy Logic** is a form of logic used in Artificial Intelligence and decision-making that deals with reasoning that is approximate rather than fixed and exact. Unlike classical (binary) logic, where variables must take values of either **0 (false)** or **1 (true)**, fuzzy logic allows variables to have a degree of truth ranging between **0 and 1**.
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1990s: ALife

- The dumbest smart thing you can do is staying alive
  - We start over – lets not create intelligence, lets just create "life" and slowly build towards intelligence
    - Alife is the lower bound of AI
  - Alife includes
    - evolutionary learning techniques (genetic algorithms)
    - artificial neural networks for additional forms of learning
    - perception and motor control
    - adaptive systems
    - modeling the environment
- Let's disguise AI as something new, maybe we'll get some funding that way!
  - Problems: genetic algorithms are useful in solving some optimization problems and some search-based problems, but not very useful for expert problems
  - perceptual problems are among the most difficult being solved, very slow progress

Today: The New (Old) AI

- Look around, who is doing AI research?
- By their own admission, AI researchers are not doing “AI”, they are doing
  - Intelligent agents, multi-agent systems/collaboration
  - Ontologies
  - Machine learning and data mining
  - Adaptive and perceptual systems
  - Robotics, path planning
  - Search engines, filtering, recommendation systems
- Areas of current research interest:
  - NLU/Information Retrieval, Speech Recognition
  - Planning/Design, Diagnosis/Interpretation
  - Sensor Interpretation, Perception, Visual Understanding
  - Robotics
- Approaches
  - Knowledge-based
  - Ontologies
  - Probabilistic (HMM, Bayesian Nets)
  - Neural Networks, Fuzzy Logic, Genetic Algorithms

AI Definitions

- The study of how to make programs/computers do things that people do better
- The study of how to make computers solve problems which require knowledge and intelligence
- The exciting new effort to make computers think … machines with minds
- The automation of activities that we associate with human thinking (e.g., decision-making, learning…)
- The art of creating machines that perform functions that require intelligence when performed by people
- The study of mental faculties through the use of computational models
- A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes
- The branch of computer science that is concerned with the automation of intelligent behavior

Thinking machines or machine intelligence

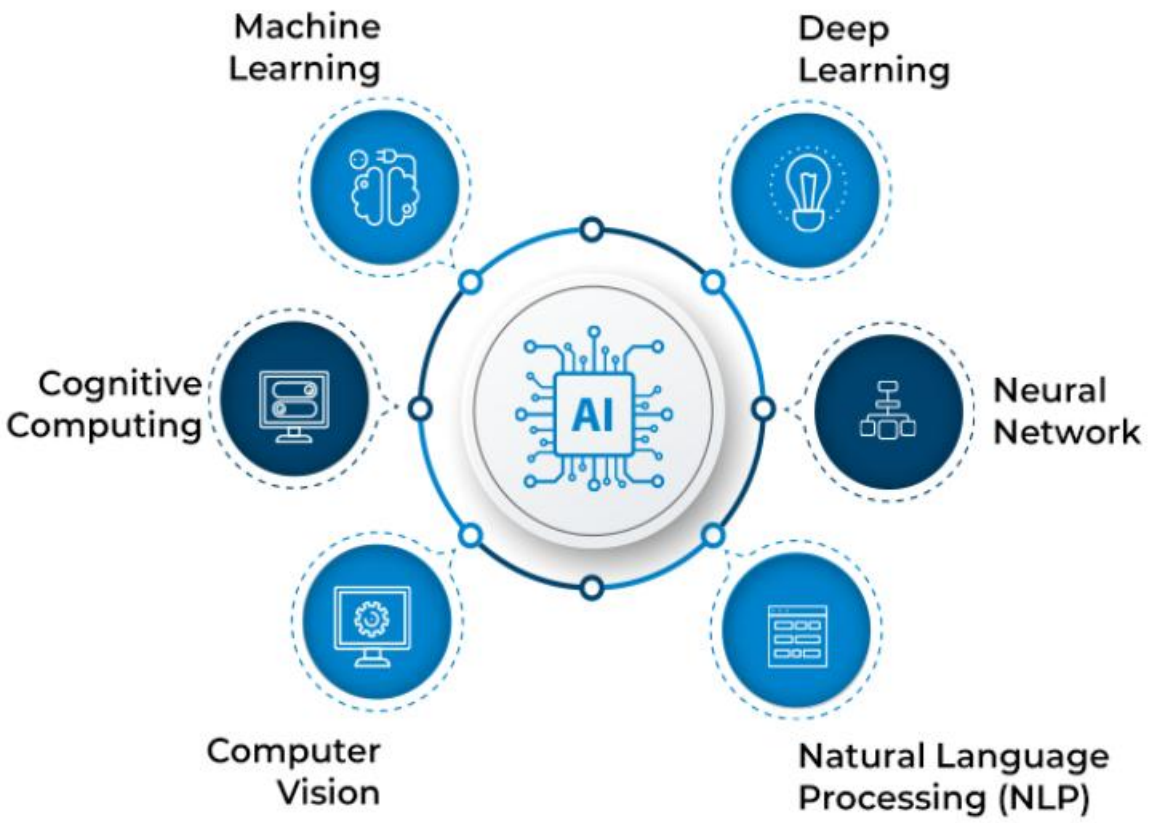
Studying cognitive faculties

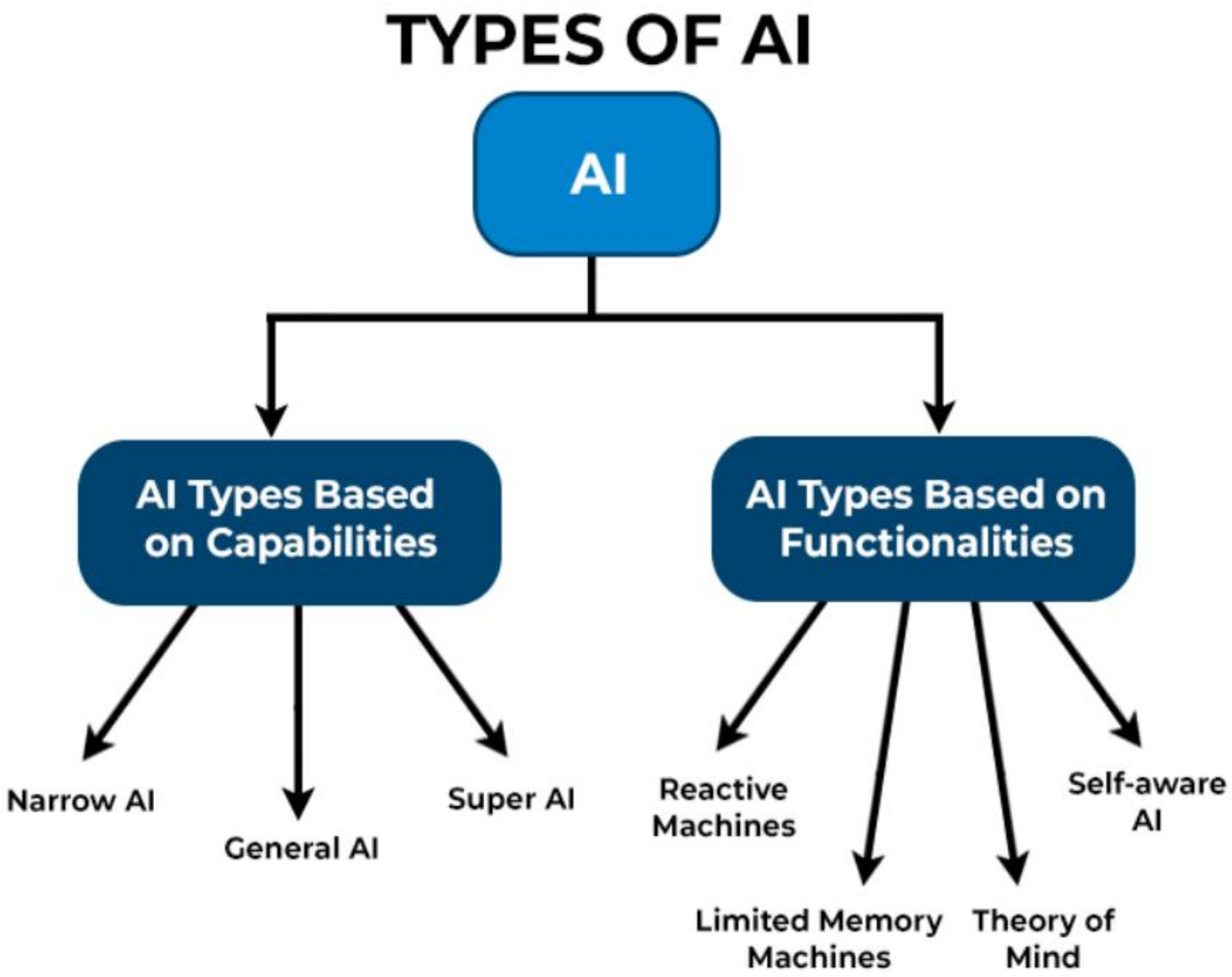
Problem Solving and CS

Components of AI

AI needs a combination of

1. the ability to learn
2. inference
3. perception
4. language understanding
5. emotion




TYPES OF AI
AI
AI Types Based on Capabilities
AI Types Based on Functionalities
Narrow AI
General AI
Super AI
Reactive Machines
Limited Memory Machines
Theory of Mind
Self-aware AI

A. Based on Capabilities (How "intelligent" they are)

- **Artificial Narrow Intelligence (ANI)**
- Also called **Weak AI**.
- Designed for a **specific task only**.
- Cannot perform outside its domain.
- Examples:
    - Siri, Alexa (voice assistants).
    - Spam filters.
    - Chess-playing AI.
- **Artificial General Intelligence (AGI)**
- Also called **Strong AI**.
- Has **human-like intelligence** across multiple tasks.
- Can learn, adapt, and apply knowledge in different contexts.
- Still **theoretical** (not yet achieved).
- **Artificial Superintelligence (ASI)**
- A level of intelligence **beyond human capability**.
- Would outperform humans in all aspects: creativity, reasoning, problem-solving.
- Exists only in **theory and speculation** (often discussed in ethics and philosophy of AI)

Based on Functionality (How they work/act)

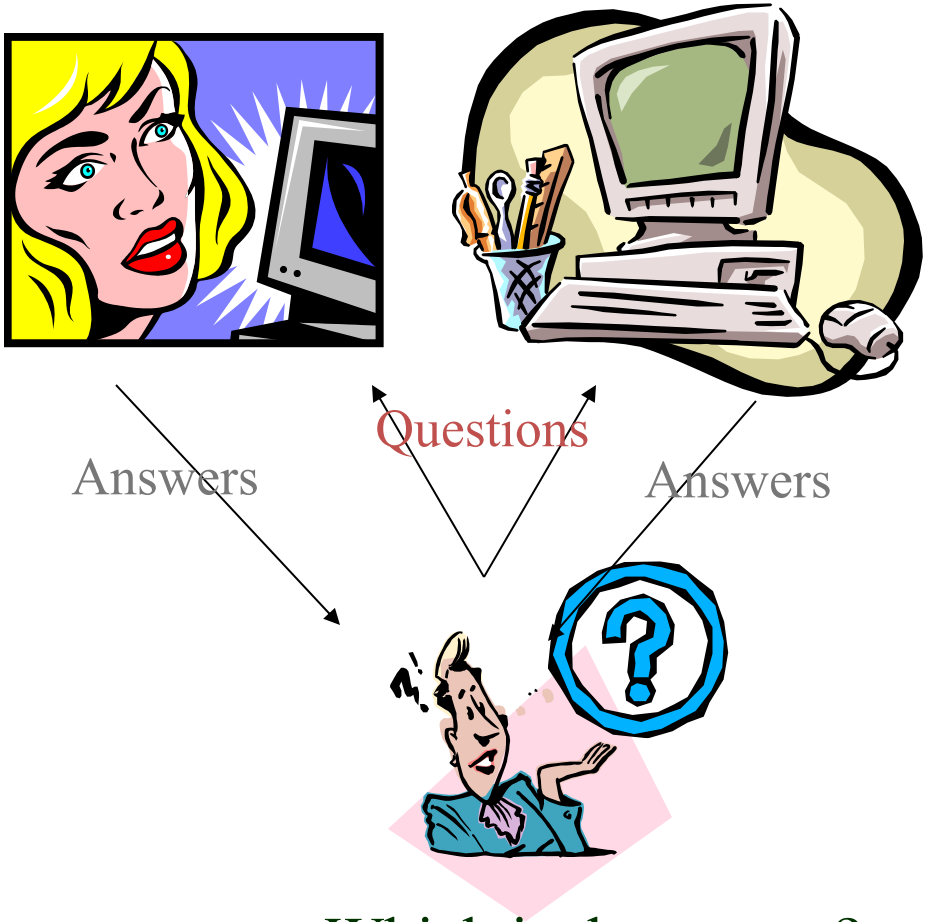
- **Reactive Machines**
  - Simplest type of AI.
  - No memory, no learning, only reacts to current input.
  - Example: IBM's **Deep Blue** (chess-playing computer).
- **Limited Memory AI**
  - Can use **past data** for a short time to make decisions.
  - Most modern AI systems fall here.
  - Example: Self-driving cars (learn from traffic patterns, sensor data).
- **Theory of Mind AI** *(still under research)*
  - AI that can understand **emotions, beliefs, and intentions** of humans.
  - Would enable advanced human–machine interaction.
  - Example: Social robots under development.
- **Self-aware AI** *(hypothetical)*
  - AI with **consciousness, self-awareness, and emotions**.
  - The ultimate stage of AI evolution.
  - Not yet existing—more philosophical than practical today.

What is Intelligence?

- Is there a "holistic" definition for intelligence?
- Here are some definitions:
  - *the ability to comprehend; to understand and profit from experience*
  - *a general mental capability that involves the ability to reason, plan, solve problems, think abstractly, comprehend ideas and language, and learn*
  - *is effectively perceiving, interpreting and responding to the environment*
- None of these tells us what intelligence is, so instead, maybe we can enumerate a list of elements that an intelligence must be able to perform:
  - perceive, reason and infer, solve problems, learn and adapt, apply common sense, apply analogy, recall, apply intuition, reach emotional states, achieve self-awareness
- Which of these are necessary for intelligence? Which are sufficient?
- Artificial Intelligence – should we define this in terms of human intelligence?
  - does AI have to really be intelligent?
  - what is the difference between being intelligent and demonstrating intelligent behavior?

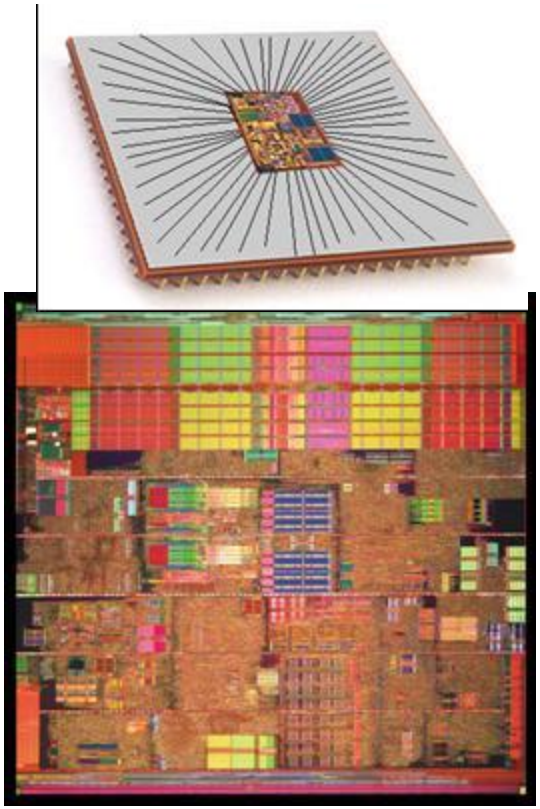
The Turing Test

- 1950 – Alan Turing devised a test for intelligence called the Imitation Game
  - Ask questions of two entities, receive answers from both
  - If you can't tell which of the entities is human and which is a computer program, then you are fooled and we should therefore consider the computer to be intelligent



Brain vs. Computer

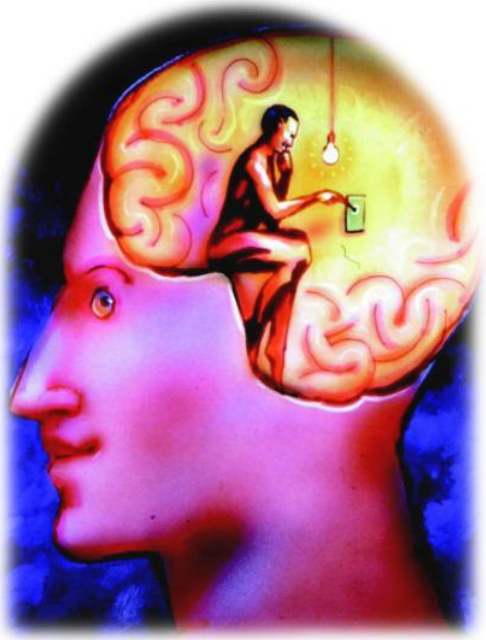
- In AI, we compare the brain (or the mind) and the computer
  - Our hope: the brain is a *form* of computer
  - Our goal: we can *create* computer intelligence through programming just as people become intelligent by learning



But we see that the computer is not like the brain

The computer performs tasks without understanding what its doing

Does the brain understand what its doing when it solves problems?



Two AI Assumptions

- We can understand and model cognition without understanding the underlying mechanism
  - That is, it is the model of cognition that is important not the physical mechanism that implements it
  - If this is true, then we should be able to create cognition (mind) out of a computer or a brain or even other entities that can compute such as a mechanical device
    - This is the assumption made by symbolic AI researchers
- Cognition will emerge from the proper mechanism
  - That is, the right device, fed with the right inputs, can learn and perform the problem solving that we, as observers, call intelligence
  - Cognition will arise as the result (or side effect) of the hardware
    - This is the assumption made by connectionist AI researchers
- Notice that while the two assumptions differ, neither is necessarily mutually exclusive and both support the idea that cognition is *computational*

Problems with Symbolic AI Approaches

- Scalability
  - It can take dozens or more man-years to create a useful systems
  - It is often the case that systems perform well up to a certain threshold of knowledge (approx. 10,000 rules), after which performance (accuracy and efficiency) degrade
- Brittleness
  - Most symbolic AI systems are programmed to solve a specific problem, move away from that domain area and the system's accuracy drops rapidly rather than achieving a graceful degradation
    - this is often attributed to lack of common sense, but in truth, it is a lack of any knowledge outside of the domain area
  - No or little capacity to learn, so performance (accuracy) is static
- Lack of real-time performance

Problems with Connectionist AI Approaches

- No “memory” or sense of temporality
  - The first problem can be solved to some extent
  - The second problem arises because of a fixed sized input but leads to poor performance in areas like speech recognition
- Learning is problematic
  - Learning times can greatly vary
  - Overtraining leads to a system that only performs well on the training set and undertraining leads to a system that has not generalized
- No explicit knowledge-base
  - So there is no way to tell what a system truly knows or how it knows something
- No capacity to explain its output
  - Explanation is often useful in an AI system so that the user can trust the system’s answer

Table-Lookup vs. Reasoning

- Consider two approaches to programming a Tic-Tac-Toe player
  - Solution 1: a pre-enumerated list of best moves given the board configuration
  - Solution 2: rules (or a heuristic function) that evaluate a board configuration, and using these to select the next best move
- Solution 1 is similar to how Eliza works
  - This is not practical for most types of problems
  - Consider solving the game of chess in this way, or trying to come up with all of the responses that a Turing Test program might face
- Solution 2 will reason out the best move
  - Given the board configuration, it will analyze each available move and determine which is the best
  - Such a player might even be able to "explain" why it chose the move it did
- We can (potentially) build a program that can pass the Turing Test using table-lookup even though it would be a large undertaking
- Could we build a program that can pass the Turing Test using reasoning?
  - Even if we can, does this necessarily mean that the system is intelligent?

But Computers Solve Problems

- We can clearly see that computers solve problems in a seemingly intelligent way
  - Where is the intelligence coming from?
- There are numerous responses to Searle's argument
  - The System's Response:
    - the hardware by itself is not intelligent, but a combination of the hardware, software and storage is intelligent
    - in a similar vein, we might say that a human brain that has had no opportunity to learn anything cannot be intelligent, it is just the hardware
  - The Robot Response:
    - a computer is void of senses and therefore symbols are meaningless to it, but a robot with sensors can tie its symbols to its senses and thus understand symbols
  - The Brain Simulator Response:
    - if we program a computer to mimic the brain (e.g., with a neural network) then the computer will have the same ability to understand as a human brain

Applications and Scope of AI

- • AI in healthcare: Diagnosing diseases, personalized medicine.
- • AI in finance: Fraud detection, algorithmic trading.
- • AI in transportation: Autonomous vehicles.
- • AI in daily life: Virtual assistants (e.g., Siri, Alexa).

AI Ethics and Societal Impact

- • Ethical considerations:
- - Bias in AI systems.
- - Privacy concerns.
- - Accountability for AI decisions.
- • Societal impact:
- - Job displacement vs. job creation.
- - Enhancing human capabilities.

Tools and Programming Languages for AI

- • Popular programming languages:
- - Python: TensorFlow, PyTorch, scikit-learn.
- - R: Data analysis and visualization.
- • Tools for AI development:
- - TensorFlow: Open-source machine learning framework.
- - PyTorch: Deep learning framework.
- - Jupyter Notebooks: Interactive coding environment.