Research Achievements of the Youth Science and Technology Education Series by the Artificial Intelligence and Robot Education Professional Committee of the China Education Development Strategy Society

Teaching Guide for Artificial Intelligence Courses in Primary and Secondary Schools

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Publication Instructions

In July 2017, the State Council issued the "New Generation Artificial Intelligence Development Plan" (hereinafter referred to as the "Plan"). The Plan proposes that by 2030, China's artificial intelligence theory, technology and application will reach a world leading level, and will become the major artificial intelligence innovation center in the world. To achieve this magnificent target, it is of great significance to enhance the scientific literacy of artificial intelligence among all people, especially the young people. Therefore, the "Plan" clearly states that it is necessary to gradually carry out intelligent education projects for all and set up artificial intelligence related courses in primary and secondary schools.

In 2019, the Artificial Intelligence and Robot Education Professional Committee of the China Education Development Strategy Society listed "how to offer artificial intelligence courses in primary and secondary schools" as a key research topic, and organized senior experts in the field of artificial intelligence and education to conduct in-depth research for two years. The "Guidelines for Artificial Intelligence Courses in Primary and Secondary Schools" (hereinafter referred to as the "Guidelines") was the core research achievement of this topic. In the process of writing the "Guidelines", the research group compiled the artificial intelligence textbooks for secondary school based on the AI knowledge system determined in the "Guidelines", and improved and optimized them based on feedback and suggestions from some primary and secondary school teachers and students after trial reading. In April 2021, the China Education Development Strategy Society organized an expert demonstration meeting to review and demonstrate the "Guidelines", which received high praise from renowned experts in the field of artificial intelligence and education attending the meeting. At present, the "Guidelines" research group is developing series of artificial intelligence textbooks, supporting courses, and teaching equipment for each stage under the frame of the "Guidelines".

Part 1 Preface

In recent years, artificial intelligence (AI) has entered a historic period of technological innovation and large-scale application. AI technology has continuously made impressive progress, and the technological and industrial revolution represented by the new generation of AI is emerging. New industrial applications, formats, and models built around "intelligence+" are constantly emerging, which are having an extremely profound impact on the world economy, Human life and social progress.

In July 2017, the State Council issued the "New Generation Artificial Intelligence Development Plan"(hereinafter referred to as the"Plan"). The Plan proposes that by 2030, China's artificial intelligence theory, technology, and application will reach a world leading level, and will become the major artificial intelligence innovation center in the world. To achieve this magnificent target on schedule, talent cultivation is of utmost importance. Therefore, the "Plan" clearly states that it is necessary to gradually carry out intelligent education projects for all and set up artificial intelligence related courses in primary and secondary schools.

Learning artificial intelligence requires a certain level of knowledge in advanced mathematics and computer science, and the application of artificial intelligence technology also requires sufficient knowledge in fields such as mathematics, control, and mechatronics. Obviously, all of these knowledge contents far exceed the cognitive competence of primary and secondary school students (even high school students). It is difficult to achieve effect by presenting high-level knowledge that intersects multiple disciplines and fields prematurely to students with far less complete basic knowledge, and attempting to explain unfamiliar technical principles in terms that students do not understand. Therefore, how to design the teaching content of artificial intelligence textbooks for primary and secondary schools? How to position the teaching objectives of this course? This is a common problem that must be resolved when setting up artificial intelligence courses in primary and secondary schools, and it needs relevant institutions engaged in

artificial intelligence teaching and research conduct in-depth research and provide feasible solutions.

In order to adapt to the work and life in the era of intelligence, the Artificial Intelligence and Robot Education Professional Committee of the China Education Development Strategy Society has listed "How to Offer Artificial Intelligence Courses in Primary and Secondary Schools" as a key research topic, and organized experts in relevant fields to undertake the research of this topic. After more than one year of effort, the research results of this project are shared with everyone in the form of the "Guidelines for Artificial Intelligence Courses in Primary and Secondary Schools" (hereinafter referred to as the "Guidelines"). The "Guidelines" sorts out the knowledge system and interrelationships between various knowledge points in the field of artificial intelligence, summarizes the application scenarios of artificial intelligence technology in various industries, and pays attention to the convenience and impact of intelligent products on human work and life, which aims to guide and help various primary and secondary schools to smoothly carry out artificial intelligence teaching activities, help students understand the basic knowledge of artificial intelligence from a holistic perspective, and experience the sense of gain brought by artificial intelligence technology, as well as familiarize with the application scenarios of artificial intelligence technology, so as to promote the development of the innovation awareness, comprehensive ability, comprehensive scientific and humanistic qualities of the students, who will finally become builders with high AI scientific and technological literacy and be able to adapt to the development of the future intelligent era.

I. Nature

The " Guidelines " aims to promote the popularization of artificial intelligence courses in ordinary primary and secondary schools, foster innovation awareness and comprehensive abilities, and enhance scientific literacy in artificial intelligence. It is the basic basis for carrying out artificial intelligence teaching activities in primary and secondary schools, and also a guiding and suggestive outline

for designing textbooks, teaching content, teaching plans and teaching equipment for artificial intelligence courses in primary and secondary schools. The " Guidelines " has the following characteristics.

1. Comprehensive

The artificial intelligence course is a highly comprehensive course that involves interdisciplinary intersection, multi-method integration, and multi-technology integration. The " Guidelines " emphasizes the connection and comprehensive application of knowledge between various disciplines and fields. Comprehensive integration is a fundamental method for students to effectively solve problems in their future work and life. Diverse and flexible thinking training can lay the foundation for students' self-development and continuous development in a future learning and intelligent society.

2. Systematicity

The " Guidelines " systematically selects core knowledge points from artificial intelligence theories, methods, and technologies, and guides students from shallow to the deep to gradually understand, experience, familiarize, understand AI technology related knowledge as well as application scenarios based on the knowledge background, intelligence level, cognitive competence of students from different age groups.

3. Experience

The basic learning method of artificial intelligence courses in primary and secondary schools is to understand the functions of AI through practical activities such as experiencing AI technology and application scenarios, and then familiarize and explore relevant AI knowledge. The " Guidelines " suggests that courses should emphasize students' direct and personal experiences, based on the transition from "learning by playing" and "learning by doing" to "asking while learning" and "doing while learning".

4. Innovation

Artificial intelligence technology is a rapidly developing technology with innovative vitality. Therefore, the " Guidelines " emphasizes that artificial intelligence courses should not only impart knowledge, but also pay more

attention to foster students' innovative awareness and innovative spirit. Through the learning of AI courses, students are inspired to use their learned AI knowledge to solve various practical problems with great aspirations.

5. Humanity

The artificial intelligence course is designed to achieve the comprehensive development of students, reflecting both the spirit of science and technology and the spirit of humanity through appropriate and substantial technological connotations. The " Guidelines " emphasizes that the course should have both basic technological value and rich cultural value.

6. Inspiration

The " Guidelines " emphasizes that in the teaching of artificial intelligence, students should be the main body and be the masters of learning activities. To fully mobilize students' learning enthusiasm and initiative, guide them to think independently, pose questions, and actively explore, enabling them to consciously master artificial intelligence knowledge and improve their ability to analyze and solve problems.

II. Value

Through the "Guidelines", the majority of primary and secondary school teachers have rules to follow in the teaching of artificial intelligence courses, and can receive timely and effective help and professional guidance. In the teaching of artificial intelligence courses, it is possible to systematically and scientifically improve students' knowledge and literacy on the basic concepts, key technologies, and main applications of artificial intelligence in the learning of artificial intelligence courses, thereby promoting a scientific, standardized, systematic teaching of artificial intelligence in primary and secondary schools in China, as well as the overall teaching quality of artificial intelligence courses. Finally, to truly implement the requirements of the State Council's "New Generation Artificial Intelligence Development Plan" to gradually carry out intelligent education projects for all and

set up artificial intelligence related courses in primary and secondary schools.

III. Basic concepts

The artificial intelligence course in primary and secondary schools is a comprehensive quality education course aimed at fostering and enhancing students' scientific and technological humanities literacy, innovation awareness, and comprehensive abilities. Based on this course orientation, the following basic teaching concepts are proposed.

1. Integration of scientific education and humanistic education

Quality-oriented education should be achieved through the integration of two basic channels: "scientific education" and "humanistic education". The purpose of education with scientific education as its core content is to solve the problem of understanding the objective world, construct the knowledge and cognitive system of the educated, and develop their logical thinking. The purpose of education with humanistic education as its core content is to solve the problem of understanding the spiritual world, construct the value and ethical system of the educated, and develop the imaginal thinking of the educated. The quality-oriented education implemented through artificial intelligence courses should achieve a good integration of scientific education and humanistic education.

2. For all students

The fundamental purpose of setting up artificial intelligence courses in primary and secondary schools is to enhance students' AI technology literacy, and lay a solid foundation for all right-age students to learn, live, work, participate in social activities, and undertake social responsibility in an intelligent society. Therefore, the "Guidelines" is suitable for educational objects from primary school, junior high school to high school (or secondary vocational education). It is recommended that schools with conditions can put the artificial intelligence science popularization education that starts from primary school into their teaching plans to benefit all students.

3. Learn AI to adapt to future society

Compared to imparting artificial intelligence knowledge and technology itself to students, the "Guidelines" emphasizes students' comprehensive understanding and firsthand experience of various aspects such as artificial intelligence technology, application scenarios, and intelligent products. On the basis of learning and understanding important basic concepts and knowledge of artificial intelligence, they are familiar with the application scenarios of artificial intelligence, accustomed to using commonly used intelligent tools in daily life, and experience the sense of gain brought by AI technology empowerment. As the masters of the future intelligent society, it is necessary for primary and secondary school students to improve their technological literacy by learning the basic knowledge of artificial intelligence, in order to better adapt to the future life and employment environment.

4. Reflect the achievements of the new generation of artificial intelligence technology

The development of artificial intelligence technology changes with each passing day. Artificial intelligence courses in primary and secondary schools should appropriately reflect the latest achievements and applications of contemporary artificial intelligence technology, thereby enabling students to understand some easily recognizable modern artificial intelligence technology knowledge and understand the effect of modern artificial intelligence technology taken on improving people's material and spiritual lives, which make them aware of the close relationship between artificial intelligence technology and their own and social development, so as to aspire to innovation and service the society.

5. Inspire the aspirations of patriotism and building a strong country

In the field of artificial intelligence, China and the United States are both in the first tier. However, there are still many gaps in terms of top AI talents, basic AI theories, and AI technology innovation capabilities. China's "New Generation Artificial Intelligence Development Plan" proposes the strategic target of achieving a world-leading level in artificial

intelligence theory, technology, and application by 2030, and becoming a major innovation center for artificial intelligence in the world. The artificial intelligence curriculum in primary and secondary schools should inspire young people to establish a great ambition to achieve this strategic target and encourage them to become strong reserves of AI talents in China.

IV. Design mentality

1. Stage Design

According to the physiological and psychological characteristics of adolescent development, the artificial intelligence curriculum in the basic education stage must be gradual and from shallow to the deep. This "Guidelines" divides the 12-year learning period into four specific learning stages, and takes into account the course content of the 12-year period. The first stage is primary school grades 1-3, the second stage is primary school grades 4-6, the third stage is middle school grades 1-3, and the fourth stage is high school grades 1-3 or secondary vocational education grades 1-3.

2. Teaching content design

This "Guidelines" arranges 9 teaching modules and 1 comprehensive practical session based on the cognitive characteristics of students from different age groups. The nine teaching modules are: Artificial Intelligence Overview, Intelligent Tools and Social Ethics, Machine Perception, Machine Cognition, Machine Learning, Artificial Neural Networks, Knowledge Representation and Reasoning, Swarm Intelligence and Evolutionary Intelligence, and Human-Computer Interaction. The teaching content of different stages can be selected and combined from these modules.

(1) Artificial Intelligence Overview Module

The main content of the artificial intelligence overview module includes natural intelligence and artificial intelligence, the development process of artificial intelligence, the

difference in information processing capabilities between the human brain and computers, the classification of artificial intelligence, and the main application fields of artificial intelligence. The teaching content of each stage can be selected from it. The teaching focus of this module is to stimulate students' curiosity and interest in artificial intelligence, and help them know what artificial intelligence is? What are the important applications of artificial intelligence? This module is to lay the foundation for further learning.

(2) Intelligent tools and social ethics module

The so-called tools generally refer to all artificial products used for human work and life, including appliances, machines, software, etc. Intelligent tools and social ethics modules should reflect the concept of integrating scientific education and humanistic education, emphasizing that from agricultural society to industrial society, from information society to intelligent society, tools created and invented by humans have different technological imprints and ability characteristics of different eras. This module should focus on highlighting the intelligent tools and their application scenarios in the era of intelligence, the advantages and disadvantages of intelligent tools for social development, as well as the ethical issues of applying intelligent tools.

(3) Machine perception module

Transition from high school biology knowledge about the human sensory system, human perception ability, and sensory organs to machine perception system models and common sensors, emphasizing the important feature that tools of human creation are expanding human perception capacity by simulating and assisting humans. The main contents of machine perception module include basic knowledge of machine vision systems and image sensors, classification of sound waves and basic knowledge of sound sensors, basic knowledge of temperature sensors, basic knowledge of pressure sensors, basic knowledge of olfactory

sensors, basic knowledge of taste sensors, and basic concepts of multi-sensor fusion. Primary school students can see a large number of "detection" devices in their daily lives, such as thermometers, pressure gauges, electronic scales, cameras, etc. During the teaching of machine perception modules, such application examples should be made to help students understand basic concepts. Middle school students will learn a lot of sensory and sensing related knowledge in physics and biology courses, such as knowledge about eyes, ears, skin and so on in biology, while knowledge about piezoelectric effect, piezoresistive effect, acoustic wave propagation and so on in physics. The teaching content of this module should try to combine and deepen the knowledge learned by students in relevant courses.

(4) Machine cognition module

The machine cognition module mainly involves basic concepts and knowledge in the field of pattern recognition, including feature extraction and representation, linear and nonlinear classification, clustering and clustering centers, etc. In the teaching of this module, basic knowledge such as feature extraction, classification, and clustering should be understood by combining students' daily experiences and experiences. In the third and fourth stages, attention should be paid to combining linear equations, plane equations, as well as two-dimensional and three-dimensional space knowledge in mathematics classes to deepen the understanding of relevant knowledge.

(5) Machine learning module

The main contents of machine learning module include: basic knowledge about machine learning systems; basic knowledge about machine learning methods, such as supervised learning, unsupervised learning, semi-supervised learning, reinforcement learning and so on; basic knowledge about machine learning algorithms, such as linear regression, decision tree classification, mean clustering, principal

component analysis dimensionality reduction and other classic algorithms. These teaching contents involve a lot of technical terms, so special attention must be paid to the teaching method that teachers should deal with the teaching with an easy-to-understand approach, and try to combine with students' experiences and experiences in daily life as much as possible.

(6) Artificial neural network module

The main contents of artificial neural network module include: the information processing mechanism of biological neurons, the M-P model of artificial neurons, the artificial neural network model, the characteristics and functions of artificial neural networks, etc. In the teaching of this module, the third and fourth stages should combine the knowledge of biological neurons in biology courses to help students understand the structure, information processing methods, and mathematical models of artificial neurons, and familiarize themselves with several typical structures of artificial neural networks, as well as understand the relationship between artificial neural networks and deep learning.

(7) Knowledge representation and reasoning module

The main contents of knowledge representation and reasoning module include: basic knowledge about knowledge representation, such as first-order predicate, production rules, semantic networks and so on; basic knowledge about knowledge reasoning systems, such as forward reasoning, reverse reasoning, and hybrid reasoning; basic knowledge about state space search strategies, such as blind search and heuristic search; and the basic concepts and key technologies related to knowledge graphs. In the teaching of this module, the third and fourth stages should be combined with the relevant contents of the programming courses, which focus on fostering students' ability to write programs using Python language, and encouraging them to

try programming to achieve simple reasoning cases in the field of artificial intelligence.

(8) Swarm Intelligence and Evolutionary Intelligence Module

The main contents of swarm intelligence section include: basic concepts related to optimization problems, such as function combination and combinatorial optimization; the basic concepts and commonly used algorithms of swarm intelligence, such as ant colony algorithm, bee colony algorithm, fish swarm algorithm, bird swarm algorithm, wolf swarm algorithm and so on; the concept of intelligent agents and multi-agent systems. The teaching focus of the third and fourth stages is not to help students understand the mathematical principles of algorithms, but to combine the relevant knowledge of biology courses to make students realize that in a biotic population, each individual's ability is insignificant, but the whole group exhibits many incredible intelligent behaviors, such as: the self-organizing ability of ant colonies in the process of foraging, nesting and cooperative transportation, the role division and task allocation behavior of bee colonies, the bird flock gathers and flies from disorder to order, the wolf pack has a rigorous organizational system and exquisite collaborative hunting methods, the fish flock finds the water with the most nutrients through foraging, crowding, and tail chasing behavior, etc. These swarm intelligence, which have evolved over tens of thousands of years, provide many natural strategies for optimizing artificial systems that can be used for reference. Therefore, swarm intelligence algorithms is to use mathematical methods to simulate the intelligent behavior of certain biotic population in nature.

The main contents of evolutionary intelligence include: the characteristics and bottlenecks of conventional optimization algorithms, the inspiration of evolutionary theory and genetic genetics on complex problem

optimization, and how genetic algorithms bring in optimization mechanisms of "natural selection, survival of the fittest, survival of the fittest" to achieve optimization of complex problems.

(9) Human-computer interaction module

The main contents of human-computer interaction module include: natural language processing, speech interaction, emotional computing, action recognition, etc. Key points will be placed on introducing natural language processing technology and application scenarios, for example, applications in various fields related to natural language information processing, such as querying data, answering questions, excerpting literature and compiling materials, to help students of different learning stages understand, experience, and familiar with natural language processing technology.

3. Comprehensive Practice Link Design

The teaching content of the comprehensive practice of artificial intelligence is an important component of the artificial intelligence course, which is guided by a type of problem and enables students to actively participate in learning activities. In response to the specific problems presented in the comprehensive practice section, students comprehensively apply their learned AI knowledge and various subject knowledge, go through the whole process of discovering, proposing, analyzing, and solving problems, experience the connections between various artificial intelligence knowledge modules, familiarize themselves with the characteristics of commonly used artificial intelligence technologies, stimulate students' interest in learning artificial intelligence, and deepen their understanding of the basic concepts and knowledge they have learned.

The comprehensive practice process can be divided into categories such as experiential practice, developmental practice, and participation in artificial intelligence

competitions. It is recommended to build comprehensive practice venues such as primary and secondary school AI experience centers and practice bases, through innovative models for example production and education integration, meanwhile, encouraging enterprises to develop relevant AI teaching equipment and various AI application apps. We can try to connect the practical links of artificial intelligence, Python programming, and intelligent robots, and develop a mutually supportive practical link for the three courses. This not only significantly improves the efficiency of the comprehensive practice base, but also helps to enhance students' comprehensive abilities.

4. Implementation suggestions

In order to ensure the smooth implementation of the "Guidelines", implementation suggestions have been proposed for teaching activities, learning evaluation, textbook development, and teacher development.

V. Applicable scope

The "Guidelines" is mainly applicable to the education and teaching of artificial intelligence courses in ordinary primary and secondary schools in China. The teaching contents in high school can provide references for the teaching contents of similar courses in secondary vocational schools.

VI. Relationship with courses such as programming and robotics

“Setting up artificial intelligence courses in primary and secondary schools and gradually promoting programming education” is one of the science popularizations clearly proposed in the State Council's " New Generation Artificial Intelligence Development Plan ", while " intelligent robot " is one of the six emerging artificial intelligence industries mentioned in the" New Generation Artificial Intelligence Development Plan ".

The algorithms of artificial intelligence need to be implemented through programming, and the advantages of artificial intelligence are very suitable for presenting with intelligent robots. The knowledge in the three fields has their own systems, so their teaching contents should not be confused or replaced with each other. At the same time, the knowledge system of the three courses is closely related. If the school has the conditions to offer courses on artificial intelligence, Python programming, and intelligent robots at the same time, students can learn and understand the basic concepts of artificial intelligence through artificial intelligence courses, understand programming cases of various AI algorithms through Python programming courses, and experience how artificial intelligence empowers robots through robot courses. The three courses supplement and complement each other, so that a more ideal knowledge system will be formed together.

Part 2 Teaching Objectives

The overall teaching objective of artificial intelligence courses in primary and secondary schools is to systematically learn the basic concepts and knowledge of artificial intelligence, making students become builders with high AI technology literacy and able to adapt to the development of the future intelligent era. Through the study of this course, the following specific objectives should be achieved by the students.

1. Improve information literacy

Intelligence is an advanced stage of information technology development, and information technology is the foundation of artificial intelligence technology. Therefore, during the learning of artificial intelligence courses, attention should be paid to fostering students' information awareness, computational thinking, and digital learning abilities, so as to focus on improving students' information literacy.

2. Cultivate exploratory ability

The awareness and ability to explore and innovate, reflect diligently, and think independently are essential abilities for students to effectively respond to future social uncertainties. During the process of artificial intelligence learning, students should be encouraged to explore, question and experiment, so as to cultivate their scientific exploration spirit and ability.

3. Cultivate innovation ability

The fundamental purpose of learning artificial intelligence is to cultivate “creativity”. Therefore, the process and conclusions of learning artificial intelligence are open-ended, and different students can unleash their creativity and adopt different ways to achieve a certain goal. Such unique learning methods of artificial intelligence courses should be fully utilized to achieve this innovative ability cultivation.

4. Improve scientific literacy

During artificial intelligence learning, many concepts and knowledge such as sensors, control, communication, programming, systems, electromechanical and so on will be comprehensively learned. In the teaching process, it is necessary to fully utilize modern and cutting-edge scientific knowledge to expand students' horizons and enhance their scientific literacy.

5. Improve the ability to analyze and solve problems

The learning of artificial intelligence is a continuous process of discovering and solving problems. Enable students to learn, practice, and innovate in the process of discovering, analyzing, and solving real problems, learn to cope with the ever-changing and complex real-life world, and continuously improve their ability to analyze and solve problems.

6. Improve learning interest and ability

In the basic education stage, the characteristic of artificial intelligence learning is the combination of "learning by playing" and "playing while learning". We should guide students to be curious about artificial intelligence technological products, and we hope that artificial intelligence can bring them the power and surprises of technology. To make the learning process of artificial intelligence stimulate students' curiosity, and cultivate their interest in learning, so as to enhance their learning abilities.

Part 3 Teaching Contents

The "Guidelines" divides the knowledge system of artificial intelligence into nine modules, of which the core module content covers four learning stages. The content is presented in a progressive and systematic way, and the underlying AI ideas are consistent. Through understanding the essence through the phenomenon, profound ideas are presented in the superficial knowledge. This is the principle upheld in the content arrangement of the "Guidelines". It is also more conducive to cultivating the scientific literacy of students, stimulating in-depth thinking, and laying the foundation for the cultivation of innovation ability.

I. The first learning stage (primary school grades 1-3)

1.Overview of Teaching Content and Achievement Goals

The teaching contents and suggestions for achieving the goals for the first stage are listed in Table 1, with a suggested learning time of 56-64 class hours.

Table 1 Teaching Content and Suggested Objectives for the First Stage

Knowledge module	Knowledge points	Subdivision of knowledge points	Suggested goals to achieve
Artificial Intelligence Overview (4-6 class hours)	Concepts, Manifestations, and Relationships between Natural Intelligence and Artificial Intelligence (4-6 class hours)	Concept of Intelligence (1 class hour)	Knowing which human abilities can be called "intelligence".
		Natural Intelligence Manifestations (2-4 class hours)	(1) Understand, identify, or provide examples of intelligent manifestations in humans and other living organisms in the natural world, such as memory, association, recognition, language, reasoning, and interaction with the environment. (2) Understand, identify, or provide examples of intelligent manifestations in natural groups, such as the cooperation in ant colonies, bee colonies, wolf packs during foraging

			processes, as well as the division of labor and cooperation in human society.
		Basic Concepts of Artificial Intelligence (1 class hour)	Understand that "artificial intelligence" is the intelligence possessed by tools created by humans, which simulates and expands human or natural intelligence.
Intelligent Tools and Social Ethics (6 class hours)	Basic concepts of intelligent tools (2 class hours)	Tools, intelligent tools, intelligent technologies (1 class hour)	Understand what tools are (including tangible or intangible artificial products such as machines, equipment, software, etc.), what are intelligent tools, what are intelligent technologies.
		Main differences between intelligent and non-intelligent products (1 class hour)	Be able to give examples of the application of artificial intelligence in life and be able to distinguish typical intelligent products from non-intelligent products.
	Intelligent tool functions and application scenarios (2 class hours)	Common intelligent recognition technologies in daily life (2 class hours)	Using intelligent tools (such as smartphones, smart access control, smart locks, etc.) for handwritten character recognition, face recognition, fingerprint recognition, and experience the application scenarios of artificial intelligence technology.
	AI and Social Ethics (2 class hours)	The Impact of AI on Society (2 class hours)	Talk about the impacts of AI technology applications on people in daily life such as smart toys, smart speakers, and autonomous vehicles ? Development of human-machine integration.
Machine perception (12-14 class hours)	Biological perception (4 class hours)	Human sensation (3 class hours)	(1) Understand the human visual organs and functions. (2) Understand the human auditory organs and functions. (3) Understand the human tactile organs and functions. (4) Understand the human olfactory organs and functions. (5) Understand the human gustatory organs and functions.

			(6) Understand other human senses such as pain, temperature, balance, movement, and body awareness.
		Sensation and Perception (1 class hour)	Understand the differences between perception and sensation, for example the contents of perception generated after human sensation, such as cognition, judgment, and emotions generated after seeing images and hearing sounds.
	Machine perception applications (4-6 class hours)	Machine Vision (1-2 class hours)	(1) Identify visual sensors on common electronic devices. (2) Understand the basic uses of visual sensors.
		Machine Audition (1~2 class hours)	(1) Identify auditory sensors on common electronic devices. (2) Understand the basic uses of sound sensors and speakers.
		Machine Intelligence (2 class hours)	(1) Understand the difference between perception and sensation in machines, with examples illustrating intelligent machines and non-intelligent machines. (2) Discuss and initially clarify what makes machines intelligent.
	Other sensors (4 class hours)	Sensors for daily use (4 class hours)	(1) Understand temperature sensors and their basic uses. (2) Understand pressure sensors and their basic uses. (3) Understand distance sensors and their basic uses. (4) Understand light sensors and their basic uses.
Machine cognition (4-6 class hours)	Feature extraction and representation (2 class hours)	Features of things (1 class hour)	Understand what the features of things are and how to use them to describe things.
		Visual Features (1 class hour)	Understand the visual features of objects.
	Hierarchy of recognition (2-4 class hours)	Speech recognition: Speech unit (1-2 class hours)	Understand the phonetic units that make up Chinese: phonemes, syllables.

		Image recognition: foreground/background (1-2 class hours)	Understand the background and foreground structure in visual scenes, and know that computers must perform foreground/background segmentation to extract objects from images.
Machine learning (14-16 class hours)	Human learning and machine learning (2 class hours)	Human learning methods (1 class hour)	(1) Understand what human learning is. (2) Talk about the ways and examples of human learning, such as observation, demonstration, questioning, practice, experimentation, and learning from experience.
		Machine Learning Methods (1 Class Hour)	(1) Explain what machine learning is by analogy to human learning. (2)Experience how computers can learn through demonstrations of sample programs.
	Environment of machine learning (Data) (6 ~ 8 class hours)	Forms of Data (2 Class Hours)	Initially understand the form and types of environmental factors (data) in a machine learning system: information, data (such as images, sounds, gestures, expressions, weather).
		Labeled Data (2 Class Hours)	(1) Preliminary understanding of data labels. (2) Be able to preliminarily clarify the role of data features selection in predicting labels. (3) Be able to create simple labeled datasets with physical objects/images/example programs.
		Impact of Different Data on Learning Effectiveness (2-4 Class Hours)	(1) Demonstrate the impact of correctly labeled datasets on machine learning performance through example programs. (2) Demonstrate the impact of dataset with label errors on machine learning performance through example programs. (3) Observe the impact of small and large datasets on machine learning performance.
	Machine Learning Methods (2 class hours)	Supervised learning process (2 class hours)	(1) Demonstrate and experiencing computer learning by finding patterns in data through example programs (labeled datasets). (2) Understand the basic meaning of supervised learning and its connection with teacher guidance.

	Machine Learning Applications (4 class hours)	Image Recognition (2 class hours)	(1) Experience the application functions of intelligent electronic devices such as facial and fingerprint recognition, and observe which factors affect the recognition accuracy, such as lighting, angle, etc. (2) Experience the functions of the intelligent electronic device's object recognition app, talk about the recognition effect and what problems exist.
		Speech Recognition and Speech Generation (2 class hours)	(1) Experience the voice interaction function of intelligent electronic devices, observe which factors affect the recognition accuracy, such as noise, multiplayer factors, etc. (2) Experience the function of intelligent electronic devices to read text aloud, and talk about the effect.
Artificial Neural Network (4 class hours)	Biological Neural Network (4 class hours)	Structure of the brain (2 class hours)	Understand the basic structure of the brain.
		Functions of the brain (2 class hours)	(1) Understand the role of the brain's nervous system in human perception of the external world. (2) Understand the role of the brain's nervous system in controlling the body and mind.
Swarm Intelligence and Evolutionary Intelligence (6 class hours)	Biological Swarm intelligence, evolutionary phenomena: Swarm intelligence phenomena (6 class hours)	Intelligence of ant colony (2 class hours)	Understand the process of ant colony foraging and building bridges through video or actual observation, and experience the intelligent performance of the colony.
		Intelligence of bee colony (2 class hours)	Understand the activities of bee colony such as nest site selection and honey source seeking through video or actual observation, and experience the intelligent performance of the colony.
		Other Biological Swarm Intelligence (2 class hours)	Understand the foraging and formation activities of schools of fish and birds through video or actual observation, and experience the intelligent performance of the group.
Human-Computer Interaction (6 class hours)	Foundations of Human-Computer Interaction (4 class hours)	The way people communicate with each other (4 class hours)	(1) Be able to recognize words representing different moods and emotions in the text. (2) Be able to identify the emotions or sentiments expressed by people through facial expressions, body language, etc.

	Human-Computer Interaction Applications (2 class hours)	Experiencing Human-Computer Interaction (2 class hours)	Understand the applications of human-computer interaction in industries, education, entertainment, sports, daily life and so on through videos, visits, etc.

2. Design instructions for teaching content and achieving goals

The teaching content of the first learning stage includes 8 modules, covering the most core knowledge content in the current field of artificial intelligence. The selection of content in this stage focuses on intelligent phenomena, aiming to help students understand some basic concepts of artificial intelligence and establish an initial artificial intelligence mindset through observation and discussion of intelligent phenomena, so as to lay a good foundation for later experience of artificial intelligence technology and intelligent products. The following is an explanation of the teaching content and design ideas for achieving goals for each module, for reference by teaching staff, textbook and teaching aids developers.

(1) Artificial Intelligence Overview Module

Artificial intelligence originates from the simulation of natural intelligence, so the key content to be learned in this module in this stage is to experience the concept of intelligence and understand the manifestations of natural intelligence. By understanding these contents, we can clarify the objectives, possible approaches, and methods of artificial intelligence aims to achieve in the later stages. Understanding the concept of intelligence can guide students to gradually strengthen their understanding through the external manifestations of intelligence. Natural intelligence can be divided into individual intelligence and swarm intelligence. For individual intelligence, you can compare the natural manifestations of different organisms, for example, different organisms have some common, most

basic survival ability characteristics, but there are significant differences in their abilities in memory, association, recognition, language, reasoning, and environmental gameplay. By observing and understanding these phenomena, you can understand the connotation and scope of intelligence. For swarm intelligence, students can be guided to observe the differences between the capabilities of social groups, such as ants, bees, fish, and humans, and their individual abilities, and observe the impact of social division and cooperation on the enhancement of swarm capabilities, to experience the concept of swarm intelligence.

In summary, students can have a certain understanding and recognition of the concept of intelligence and naturally accept the concept: if the tools designed by humans can also show similar manifestations to natural intelligence, this is artificial intelligence. As for the technology used to implement artificial intelligence, it will be expanded one by one in the subsequent modules.

(2) Intelligent Tools and Social Ethics Module

This module is closely related to the concept of "artificial intelligence" discussed in the previous module. Providing students with intuitive experiences through a large number of man-made tools, it demonstrates the characteristics of intelligence embodied by the tools created by humans in the current era. In this study period, application scenarios and intelligent products related to students' lives and learning should be selected for experience and practical activities. For example, smartphones, smart door access control, intelligent translation software, smart speakers, and so on. On this basis, it enhances students' recognition ability, that is, being able to distinguish typical intelligent products and non-intelligent products. Through this module's teaching, students can further deepen their understanding of the concept of intelligence, have a further understanding of the application of artificial intelligence technology in life and related carriers,

and at the same time understand various commonly used intelligent tools and know some relatively mature intelligent technologies, thus stimulating their interest and motivation in using artificial intelligence technology to improve the quality of life.

(3) Machine Perception Module

This module first needs to clarify that intelligent machines perceive environmental information and their own state information through various sensors, whose functions are very similar to the human body's various sensory organs, and teaching can be conducted by comparing these sensors with the human sensory organs. Students can be asked to describe their sensory organs and their functions, understand what 'feeling' is, and on this basis, guide students to understand “perception” through experiences such as cognition, judgment, and emotions that arise after the occurrence of feelings. These contents need to be completed through practical activities that are easy to carry out, such as displaying pictures, playing music or singing, perceiving the natural world, etc. The focus of teaching is to inspire students to understand the concept of "sensation" and perceive the concept of "perception" through experiencing sensation and cognition. Based on the above human perception, the introduction of "machine perception" is relatively natural. This part of the content can be introduced through some common tools in daily life, such as motion-sensing lights, thermometers, smartphones and so on, guiding students to explore how these tools perceive, so as to understand and recognize some commonly used sensor names and purposes, such as temperature sensors for body temperature measurement, sound sensors for voice-controlled lamps, distance sensors for reversing cars, pressure sensors for weight measurement, and light sensors for street lamps. The above phenomena are more or less exposed to people in daily life and are easy to understand.

(4) Machine Cognition Module

This part focuses on the "knowledge" aspect. People obtain various types of knowledge in the process of recognizing and transforming the objective world, which mainly relies on human cognitive abilities. Cognitive abilities refer to the ability of the human brain to process, store, and extract information, which is generally referred to as intelligence, such as observation ability, memory ability, analytical ability, etc. In the early stage of individual intelligence development, it is generally to identify various different things first. Therefore, in this stage of the machine cognition module, it also starts from the foundation of recognition, including the cognition of things in a simple environment and the cognition of things in a complex scene. The cognition of things in a simple environment refers to the case where there is only one type of thing in the environment, and how to identify what that thing is, such as "this is a flower", "this is a tree". In complex scenes, the cognition of things requires distinguishing things from one another and understanding the relationship between things and the environment. For example, how to distinguish different things and their positional relationships in a real environment? How to identify which characters make up a word in a sentence, as well as the pronunciation and meaning of a character in the sentence.

The cognition of things in a simple environment is the foundation of all cognition, and the key to cognition is the extraction of “features". Therefore, this module includes two important components: the first is feature extraction and feature representation, the second is the hierarchical structure of recognition.

In the section of "feature extraction and representation", the main focus is to understand how to recognize objects in a simple environment and guide students to understand the concept of "features". Especially considering that machine

vision holds a significant proportion in artificial intelligence application scenarios, thus understanding the "visual features " of things such as color, shape, and size is the focus of this section. The teaching of the above content can be conducted through vivid and interesting practical activities, such as "guessing riddles", "you say I guess" and so on that collect pictures or specimens of various things for observation and classification.

In the "hierarchical structure of recognition" section, the content of speech recognition and image recognition will be selected, which will gradually deepen in subsequent stages. This section should select content that is appropriate for the cognitive ability and knowledge reserve of students in this term. For example, in speech recognition, considering that students have already learned Pinyin in grade one, the introduction of teaching content can be to understand the phonetic units in speech recognition: phonemes and syllables. In image recognition, the introduced teaching content can be about understanding the concepts of foreground and background in pictures, which is also matches with the ability to observe pictures required by students in the lower grade Chinese language class " reading pictures and writing words".

(5) Machine Learning Module

This module is the core content of artificial intelligence, so it holds a significant proportion in all four stages of study. Considering its certain learning difficulty, it is recommended to start teaching this module in the third grade of this stage, and the selection of teaching content and teaching methods should be as intuitive and visual as possible. This module includes four important knowledge points: first, human learning and machine learning; second, the environment of machine learning (data); third, machine learning methods; and fourth, machine learning applications.

The "Human Learning and Machine Learning" section focuses on understanding what learning is and what learning

methods humans have. Through a certain amount of learning experience in school, students have already gained certain learning experience and have practiced various learning methods. Therefore, they can understand the concept of learning through their own personal experiences. Teachers can provide multiple learning methods, such as observation, teaching, questioning, practice, experimentation, and examples of learning based on experience, or allow students to discuss and summarize their own learning. Based on the analysis and analogy of human learning, the concept and essence of machine learning are naturally introduced, and demonstrated through examples.

The part “The environment of machine learning (Data)” corresponds to the learning materials in human learning, and the quality and quantity of learning materials directly affect the learning outcome. In this learning stage, the "data" of machine learning is mainly presented in an intuitive way, such as raw images and audio in non-digital formats. In addition to the form of data, the key is to understand the concept of data labels. For example, the descriptive information of a picture, the name/style of a song, and the name of geometric figure, etc. are all data labels. In addition, one needs to understand the function of tagging as well as being able to create data with tags on software platforms (the data is mostly in the form of images, with tags being a category). Based on this understanding, we should also be aware of the impact that the quality of data has on machine learning results. For example, focusing only on a certain type of data in the data sample set, containing incorrect labels in the data, and the amount of data can all have an impact on learning effectiveness. This part is recommended to be taught in the second semester of third grade, combined with columnar statistics in mathematics. If the conditions are met, it is recommended that students operate these contents independently. If the conditions are limited, teachers can

provide hands-on instruction or demonstrate experimental results, while paying attention to encouraging students to observe and discuss experimental phenomena to deepen their understanding of data.

The "Machine Learning Method" section selects the most commonly used "supervised learning" method during the student's learning process. It can be understood through daily learning activities and program examples, with the focus on linking "label" with "supervision". During the teaching process, specific learning algorithms should be avoided, with a focus on understanding the methods and processes of “supervised learning”.

The "Application of Machine Learning" section helps students understand how machines acquire cognitive abilities similar to humans through common application scenarios such as image recognition and speech recognition. The task of this learning segment is to establish a basic concept of "machine learning", clarify the role of "machine learning" in artificial intelligence, understand the impact of the learning environment (data) on learning effectiveness, and be able to use relevant open platforms to build simple labeled datasets.

(6) Artificial Neural Network Module

Artificial Neural Networks (ANNs) are an important implementation method of machine learning. In recent years, deep learning research and applications have been flourishing, so to emphasize this part of the content, artificial neural networks have been divided into a separate knowledge module. This section mainly introduces the biological basis of artificial neural networks from a popular science perspective, including the structure and function of the brain, especially understanding the brain areas and nervous system. This part is different from the relevant content in the middle school biology curriculum, and only requires students to have a preliminary understanding of the

important role of the brain's nervous system in perception, cognition, and control of our body and mind.

(7) Swarm Intelligence and Evolutionary Intelligence Module

Swarm intelligence is an important content in China's "Next Generation Artificial Intelligence Development Plan". The artificial intelligence mentioned earlier mainly refers to individual intelligence, and the swarm intelligence mentioned in the overview module of artificial intelligence will be expanded in this module. The main learning task in this section is to observe the phenomena of swarm intelligence in nature, such as the division of labor and cooperation during ant colony work, and intelligent activities such as communication and contact during bee colony search for nectar sources. Through these vivid examples, students can understand that although each individual's ability is insignificant, the entire group can still exhibit amazing optimization intelligence through simple individual behavior rules, which provides a good inspiration and reference for people to solve complex problems.

(8) Human-Computer Interaction Module

The goal of human-computer interaction is to enable natural communication between humans and machines, similar to the way humans interact with each other. For example, machines can communicate with people using natural language, automatically recognize people's expressions, recognize other people's emotions, and use knowledge of social and cultural customs to infer the intention of human behavior, and so on. Before achieving this goal, it is necessary to have a certain understanding of how humans interact with each other. The learning content of this section can be combined with vocabulary learning in Chinese class to analyze the human emotions expressed by words in sentences. It can also analyze human emotions based on facial expressions and body language, in order to understand

the way people communicate with each other.

II. The Second learning stage (for primary school grades 4-6)

1.Overview of Teaching Content and Achievement Goals

The teaching contents and suggestions for achieving the goals for the second stage are listed in Table 2, with a suggested study time of 65-73 class hours.

For students who have not learned the teaching content of the first stage, it is recommended to supplement the following knowledge modules appropriately during this stage:

Module 2: Basic concepts of intelligent tools.

Module 4: Concepts of features.

Module 5: Supervised learning methods.

Table 2 Teaching Content and Suggested Objectives for the Second Stage

Knowledge module	Knowledge points	Subdivision of knowledge points	Suggested goals to achieve
Artificial Intelligence Overview (5-7 class hours)	Natural Intelligence and Artificial Intelligence (1 class hour)	Natural Intelligence (0.5 class hours)	Understand natural intelligence is intelligence carried by a biological brain.
		Artificial Intelligence (0.5 class hours)	Understand artificial intelligence is intelligence carried by a computer.
	Human Brain and Computers (2-4 class hours)	Computer Functions (1 class hour)	(1) Experience the daily use functions of a computer, such as document editing and storage, webpage search function, software download and installation, etc. (2) Talk about the advantages and disadvantages of computer in editing, storage, searching and so on.
		Different manifestations of Human Brain and Computer (1-3 class hours)	(1) Understand the diverse manifestations of human intelligences: for example, verbal-linguistic intelligence, mathematical-logical intelligence, visual-spatial intelligence, music-rhythmic intelligence, physical-kinesthetic intelligence, interpersonal communication intelligence, self-awareness intelligence, natural observation intelligence, and establishing a positive view of intellectual development. (2) Give examples to illustrate the different

			behaviors of the human brain and computers in processing information, and be able to conduct exploratory analysis of the reasons for their occurrence. (3) Be aware of the "Turing Test".
	Intelligent era (2 class hours)	Application of intelligent technology (2 class hours)	(1) Understand the manifestations of the development and changes of the times, the characteristics of the intelligent era, and how it differs from previous eras. (2) Able to give examples of applications of artificial intelligence in daily life, such as how smart speakers, smartwatches, smart air conditioners, etc. demonstrate intelligence. (3) Understand and give examples of the main application scenarios of intelligent technology. (4) Able to propose ideas and imaginations for artificial intelligence application in real-life scenarios.
Intelligent Tools and Social Ethics (4 class hours)	Intelligent tool functions and application scenarios (2 class hours)	Image recognition products and application scenarios (1 class hour)	Able to list at least two common image recognition products and their application scenarios in daily life.
		Language recognition products and application scenarios (1 class hour)	Able to list at least three common voice recognition products and their application scenarios in daily life.
	Impact of AI on Society (2 class hours)	Bias in AI systems (2 class hours)	Observe and understand whether there is bias in AI systems' decision-making, such as news recommendation preferences, language bias and gender bias in chatbots, etc. Learn how to design better AI systems.
Machine perception (10-16 class hours)	Biological perception (2 class hours)	Human Perception System (2 class hours)	(1) Understand the sensory mechanisms of the human body. (2) Understand the composition of the human sensory system. (3) Understand the different proportions and roles of human sensory transmission information. (4) Understand how the various senses of the human body work together.

	Machine perception system (2-4 class hours)	Fundamentals of Sensors (1-2 class hours)	(1) Understand the definition of sensors and know that sensors are detection devices. (2) Able to distinguish between internal sensors and external sensors and know their purposes. (3) Understand the basic uses and working processes of robotic visual sensors, auditory sensors, olfactory sensors, gustatory sensors, and tactile sensors. (4) Preliminary understanding of the significance of multi-sensor information fusion in machine perception.
		Machine perception model and working process (1-2 class hours)	Understand the model, components, and basic working process of machine perception systems.
	Machine perception application (4-6 class hours)	Machine Vision (2-4 class hours)	(1) Understand the basic concept of machine vision. (2) Understand the basic tasks of machine vision. (3) Understand the range and limitations of human , other organisms, and visual sensor perception. (4) Understand the storage methods and forms of images in computers. (5) Understand the role of image processing in machine vision.
		Machine Audition (2 class hours)	(1) Understand the basic concept of Machine audition. (2) Understand the basic tasks of Machine audition. (3) Understand the classification of sound waves, the range and limitations of human, other organisms and auditory sensors in perceiving sound.
	Other sensors and applications (2-4 class hours)	Intelligent scene application of sensors for daily use (2-4 class hours)	(1) Understand the measurement range and intelligent scenario applications of temperature sensors. (2) Understand the measurement range and intelligent scenario applications of pressure sensors.

			(3) Understand the measurement range and intelligent scenario applications of ultrasonic distance measurement sensors.
Machine cognition (6 class hours)	Basic concepts and tasks of pattern recognition (2 class hours)	Concept of Pattern Recognition (1 class hour)	Understand the basic concepts and procedures of pattern recognition.
		Pattern recognition task (1 class hour)	Understand mainstream pattern recognition tasks.
	Classification and classification algorithms (2 class hours)	Concept of classification (1 class hour)	Understand the basic meaning of classification and pattern matching.
		Classification task (1 class hour)	Understand specific classification tasks in reality.
	Hierarchy of recognition (2 class hours)	Speech recognition: Voice to word (1 class hour)	Understand the first step of speech recognition: converting from sound signals to candidate words.
		Image recognition: occlusion/defect situation (1 class hour)	Understand the need to consider the impact of occlusion/defect when recognizing objects in complex scenarios.
Machine Learning (16 class hours)	Human Learning and Machine Learning (2 class hours)	The essence of learning (2 class hours)	(1) Understand the plasticity of the brain. (2) Understand the definition of learning by cognitive psychologists. (3) Understand the definition of learning by artificial intelligence scholar Simon.
	Machine learning environment (data) (4 class hours)	Suitable dataset establishment (2 class hours)	(1) Able to establish a labeled dataset using tables, software platforms, etc. (2) Able to establish a data table for classification problems.
		Dataset characteristics and requirements (2 class hours)	(1) Able to perform some analysis on existing datasets and determine whether there are obvious deviations based on the statistical distribution of the data. (2) Able to conduct preliminary analysis on the sources of bias in biased datasets by examining the data features and labels.

			(3)Able to understand the diversity of data distribution through existing widely used datasets.
	Machine learning methods (2 class hours)	Reinforcement learning process (2 class hours)	(1) Experience computer learning through trial and error by demonstrating example programs, and experience the characteristics of reinforcement learning. (2) Understand the basic meaning of reinforcement learning and its connection with empirical learning.
	Machine Learning Models and Algorithms (2 class hours)	Construction of Decision Trees and Data Patterns (2 class hours)	(1) Understand what a decision tree is? (2) Able to construct decision trees for classification based on rules. (3) Understand the meaning of nodes in decision trees and their relationship to features and patterns in data. (4) Preliminary understanding of the meaning of terms such as models and parameters in machine learning.
	Machine learning model training, prediction, and evaluation (2 class hours)	Basic Implementation Process of Machine Learning Model (2 class hours)	(1) Understand training and testing sets. (2) Understand what training is and distinguish between training a model and using a trained model. (3) Understand the use of models, predict the output of new inputs using learned models, and analyze their accuracy. (4) Able to conduct simple analysis on the quality or quantity of data based on prediction results and propose improvement suggestions.
	Machine Learning Applications (4 class hours)	Image recognition (2 class hours)	(1) Experience the process of setting up intelligent electronic devices such as facial recognition, and experience the process of machine learning. (2) Experience the process of setting up intelligent electronic devices such as fingerprint recognition, and experience the process of machine learning.

		Speech Recognition (2 class hours)	(1) Understand speech recognition tasks, such as recognizing corresponding text, emotions, gender, accents, age, etc. (2) Understand the role of corpuses. (3) Practice training of speech recognition models on software platforms.
Artificial Neural Network (8 class hours)	Biological Neural Network (3 class hours)	Composition of biological neurons (1 class hour)	Familiar with the basic structure and function of biological neurons.
		Composition of Biological Neural Networks (1 class hour)	Understand the composition of biological neural networks.
		Factors affecting brain function (1 class hour)	(1) Understand the differences in neuronal connections are the main reason for differences between individuals. (2) Understand the characteristics of biological neural networks such as robustness.
	Fundamentals of Artificial Neural Network Models (3 class hours)	Neuron model (3 class hours)	(1) Understand the graphical model of neurons. (2) Understand the M-P model of neurons described in language. (3) Understand the input and output calculation process of a single neuron (threshold type).
	Feedforward neural network (2 class hours)	Threshold type single layer neural network model (2 class hours)	(1) Understand the similarities between artificial neural networks and biological neural networks in the human brain. (2) Understand the structure of threshold type single layer neural network (such as 1-3 inputs, single output, no hidden layer). (3) Explain how neural network with 1-3 neurons calculates its output (threshold type).
Knowledge Representation and Reasoning (6 class hours)	Knowledge Overview (1 class hour)	Concept of knowledge (1 class hour)	(1) Understand the concept of knowledge , talk about the knowledge and its uses in daily life. (2) Understand what artificial intellectuals are.
	Classification of knowledge	Categories of knowledge (0.5 class hours)	Understand the main categories of knowledge.

	(2 class hours)	Factual knowledge (0.5 class hours)	Able to provide examples of which knowledge belongs to factual knowledge and how to master it.
		Conceptual knowledge (0.5 class hours)	Able to provide examples of which knowledge belongs to conceptual knowledge and how to master it.
		Procedural knowledge (0.5 class hours)	Able to provide examples of which knowledge belongs to procedural knowledge and how to master it.
	Knowledge representation (3 class hours)	Factual knowledge representation (1 class hour)	Able to provide a structured description of the factual knowledge you have mastered (reference to rules or creative design).
		Conceptual knowledge representation (1 class hour)	Able to provide a structured description of the conceptual knowledge you have mastered (reference to rules or creative design).
		Procedural knowledge representation (1 class hour)	Able to provide a structured description of the procedural knowledge you have mastered (reference to rules or creative design).
Swarm Intelligence and Evolutionary Intelligence (6 class hours)	Biological swarm intelligence and evolutionary phenomena: analysis of swarm behavior (2 class hours)	Individual behavior analysis (0.5 class hours)	Understand the individual actions and performances of individuals in a certain biological group such as ant colonies when performing a certain task.
		Analysis of individual interaction behaviors (0.5 class hours)	Understand the actions and behaviors of mutual interactions between individuals in a certain biological group such as ant colonies when performing a certain task.
		Intelligent Emergence Phenomenon (1 class hour)	Observe the impact of changes in individual behavior and communication behavior on emergent group intelligence using open software platforms.
	Optimization problem (2 class hours)	Simple optimization problem (2 class hours)	(1) Able to provide examples of some optimization problems in life. (2) Able to understand mathematical models of simple optimization problems by combining relevant content in math courses. (3) Preliminary understanding of the concept of optimization, the goal of optimization, and the factors affecting the optimization goal.

	Ant colony algorithm (2 class hours)	Ant colony algorithm demonstration (2 class hours)	(1) Understand the process of ant colony foraging and its inspiration to humans. (2) Understand the optimization process of ant colony algorithm through the experimental platform.
Human-Computer interaction (4 class hours)	Fundamentals of Human Computer Interaction (2 class hours)	communication between people (1 class hour)	Understand the comprehensive way communicating and understanding between people: the comprehensive judgment results of language, expression, and body movements.
		Concept of human-computer interaction (1 class hour)	(1) Understand the definition of human-computer interaction. (2) Understand the scope of "people" in human-computer interaction. (3) Understand the scope of "machines" in human-computer interaction. (4) Understand the scope of "interaction" in human-computer interaction.
	Human-computer interaction application (2 class hours)	Analysis of human-computer interaction applications (2 class hours)	Analyze the advantages and disadvantages of products such as smartphones, smart home appliances in human-computer interaction.

2.Design Instructions for Teaching Content and Achievement Goals

The second learning stage is in the middle and upper grades of primary school, and the teaching content includes all 9 modules. Considering that students at this age have significant development in their logical thinking skills but still are in the stage of concrete thinking, the teaching characteristics of this stage are to use natural language to describe and explain classic artificial intelligence technologies and algorithms in an accessible way, avoiding the use of mathematical language to explain the “technical principles” and “mathematical methods” of artificial intelligence technologies and algorithms. This stage should focus on cultivating students' preliminary exploration ability, exploring the essence through phenomena, laying a foundation for gradually adopting abstract mathematical

language to learn artificial intelligence in the third and fourth learning stages. The following is an explanation of teaching content and design ideas for achieving goals for each module, for reference by teaching staff, textbook and teaching aid developers.

(1) Overview Module of Artificial Intelligence

In the first learning stage, students have gained a preliminary understanding of the concept of "intelligence" and the manifestations and connotations of natural intelligence. This stage focuses on the implementation foundation and main uses of artificial intelligence technology. Regarding the "Human Brain and Computer" section, it should be emphasized to compare the different performances of how the human brain and computer process various types of information. For example, why can "Alpha Go" completely defeat the world Go champion? Why do intelligent sweeping robots often display some "idiotic" behavior? Encourage students to discuss the characteristics of computer processing information through familiar examples and guide students to conduct in-depth analysis and discussion on the reasons behind it. Regarding the knowledge point of "Intelligent Era", it is recommended to focus on introducing how the tools and technologies created by humans have continuously evolved with the development of productivity and changes in the times, and guide students to observe how people's lifestyles and quality of life are closely related to intelligent technology in the intelligent era. At this stage, students already have a certain overall concept and logical thinking ability. Students can be required to conduct full imagination and creative design based on observing and analyzing intelligent living scenarios. For example, analyzing how intelligent technology can change the existing lifestyles through various devices such as household appliances, robots, and mobile phones, what areas are not as satisfying, and where improvement can be

made. It is recommended to guide students to provide design solutions in graphic and text form.

(2) Intelligent Tools and Social Ethics Module

This module includes two knowledge points. Regarding the knowledge point of "Intelligent Tool Functions and Application Scenarios", the teaching content of this stage is recommended to focus on image recognition and speech recognition products and their application scenarios. Because these two types of intelligent products are currently the most widely used and successful, and students with different living environments and interests can easily find application scenarios that they are interested in. For example, face payment, automatic grading, flower recognition, license plate recognition, and medical image recognition in image recognition application scenarios. Translation machines, intelligent customer service, voice input methods in speech recognition, etc. Such applications are common in daily life and often seen in a large amount of network information. Students can strengthen their understanding of intelligence through observing and describing intelligent products and their application scenarios, which also lays a foundation for learning subsequent modules such as machine perception, machine cognition, and machine learning.

Regarding the knowledge point of "Impact of AI on Society", students in this stage need to understand that although AI systems are machine systems, they do not necessarily represent objectivity and impartiality. The teaching focus is to observe and understand the bias phenomenon that exists in AI systems when making decisions, such as news recommendation preferences, language bias and gender bias that occur in chatbots, etc., so as to find improvement directions for designing better AI systems.

(3) Machine Perception Module

During the first learning stage, students have gained a preliminary understanding of the concepts of "sense" and

"cognition", and have gained a certain understanding of the sensory organs and functions of the human body, as well as a certain understanding of sensors in daily life. On this basis, there are three key points in this section: firstly, understanding the sensory mechanisms and sensory systems of the human body, and establishing the concept of "system" through comparing and understanding the composition of the machine perception system; secondly, deepen understanding of the definition and entity of sensors; thirdly, further understanding of the application of machine perception, such as machine vision and machine audition. In terms of the arrangement of knowledge points, the first step is to understand the sensory mechanism and system of the human body from a systematic perspective. By analogy with the human sensory system, students are guided to think about what components should be considered in establishing a machine perception system. By understanding the proportion of various sensory transmission information and the information processing preferences of human individuals, we will preliminarily explore how to utilize sensory information when designing a machine perception system. For example, analyzing which sensors should be installed in the perception system of the "tea delivery" service robot, and how the robot utilizes multiple sensory information to plan its actions during the task. During the process of learning the knowledge point "Machine Perception System", the focus is on understanding the basic knowledge of commonly used sensors. From the initial recognition of the role of sensors in the first semester, to the definition of sensors and the understanding of sensor entities in this semester, especially the basic uses and working processes of visual sensors, auditory sensors, olfactory sensors, taste sensors, and tactile sensors corresponding to the five sensory organs of the human body, including eyes, ears, nose, tongue, and skin. Understanding that only recording sensor information is "

sensation " rather than "perception", and adding recognition and other functions can make a machine have a certain "knowing" ability. And preliminarily understand the significance of multi-sensor information fusion in machine perception. In the knowledge point "Machine Perception Application", the focus is to enable students to understand the basic concepts and tasks of machine vision and machine audition, the way images are stored in computers, and how machine vision and machine audition have overcome human visual and auditory limitations. In addition, it is recommended to introduce the basic functions and applications of commonly used sensors such as temperature, pressure, and ultrasound as appropriate.

(4) Machine Cognition Module

The Machine Cognition module mainly focuses on learning the basic knowledge of pattern recognition. Pattern recognition includes core concepts such as feature extraction, classification, clustering, and features are the foundation for recognizing different things. Based on the first semester, this semester begins to introduce relatively abstract concepts such as pattern, pattern matching, classification, etc. The focus of learning is to gradually establish the concept of pattern recognition and understand the basic process: information acquisition (sensors) → feature extraction (information processing) → judgment (pattern recognition). As these concepts are relatively abstract, the pattern recognition and classification process of specific things that students are familiar with should be selected in teaching to help students understand. For example, given the classification standards for fruits, judge their grades according to features such as size and color (classification).

The knowledge point of "Recognition Hierarchy" still takes speech recognition and image recognition as the entry points. As for speech recognition, students have already understood what phonemes and syllables are in the first

semester, and this stage focuses on "from sound to character". Software can be used to record different students reading the same syllable or the same student reading different syllables, allowing students to understand the correspondence relationship between different sound waves and candidate words through observation. As for image recognition, students have already understood the concepts of foreground and background in the first semester, but images in this semester are more complex. For example, objects in images may be occluded or damaged, which requires pattern recognition technology to have certain associative abilities. The focus of learning in this part is to guide students to think about how technology workers can solve problems when experiencing speech recognition and image recognition technologies, For example, how to make a one-to-one correspondence between sound waves and candidate words, how to solve the problem of occlusion or damage in image recognition, etc.

(5) Machine Learning Module

In the first semester, students have gained a certain understanding of the concept and process of "learning" through some specific examples. In this semester, we will gradually introduce some abstract concepts to lay the foundation for building machine learning models. In the knowledge point of "The Nature of Learning", it is emphasized that the fundamental reason why the human brain can learn is that the neural connections in the brain are malleable. Therefore, the key to establishing a machine model with learning capabilities is that the parameters in the model can change with the change of learning content and the increase of learning time. The main teaching goal to be achieved in this stage is to continuously adjust the parameters of the machine learning model based on the learning content. To deepen the understanding of the learning process and function, the definition of learning by

cognitive psychologist and artificial intelligence scholar Simon is introduced, with the aim of analyzing the conditions for achieving learning functions and processes through learning elements.

The following five knowledge points include machine learning environments (data), machine learning methods and machine learning models, machine learning model training, prediction and evaluation, and machine learning applications. In terms of "Machine Learning Environments (Data)", students have encountered learning samples composed of concrete data such as images and speech in the first semester. In this semester, we will introduce tables to represent learning samples and use classification problems as an example to help students understand the data features and labels in the sample set, and establish sample datasets according to a certain format. Considering that students have certain logical thinking abilities in this stage, we need to analyze the impact of data quality as a learning environment factor on learning effects, and understand the characteristics that a suitable dataset should possess. In terms of the knowledge point of "Machine Learning Methods", students have already learned the concept of supervised learning which is a learning process with correct answers in the first semester. However, in reality, there is still a large number of learning that only results in rewards and punishments - reinforcement learning. By understanding the characteristics of reinforcement learning, students can realize that humans improve their behavior through continuous experimentation and error correction. Human learning is completed through the brain, while machine learning is completed through various learning models. The "learning" process of these models involves repeatedly training the data of sample sets through some learning algorithms to automatically discover the inherent relationship between input samples and corresponding labels, and optimizing the model by

continuously adjusting its parameters. In the knowledge point of "Machine Learning Models and Algorithms", students should be guided to establish the concept that machine learning is achieved through repeated training, and the "knowledge" learned by machines through training is the inherent relationship between input data and corresponding labels. As students in this semester have not established the concept of functions yet, we choose “decision trees” as an intuitive algorithm model to explain the machine learning process. Decision trees organize a series of hierarchical judgments in the form of a tree, with difficulties and focuses on understanding the meaning of nodes in decision trees and their relationship with pattern data features. The knowledge point of "Machine Learning Model Training, Prediction and Evaluation" involves how to use constructed learning models to make predictions for unknown input samples (samples without labeled labels). Here, we briefly understand the process of implementing a machine learning model: model establishment, model training, and model prediction, which can be based on a given model, call existing learning algorithms and training sets to train models (without worrying about details of learning algorithms, only the concept and role of training), and test model performance using test sets. Teachers should guide students to observe the predicted effects of model prediction, analyze problems in the model through predicted effects, and propose ideas or directions for improvement. The knowledge point of "Machine Learning Applications" should deepen students' understanding of machine learning goals and processes through specific application scenarios and case studies. For example, face unlocking on mobile phones and fingerprint unlocking all involve a setup process, which is a learning example process. Additionally, voice interaction systems require learning large amounts of speech corpora ahead of time, and chess software needs to learn large amounts of

chess manuals, and so on.

(6) Artificial Neural Network Module

This module first introduces the structure and connection of neurons, as well as the composition of biological neural networks. Students must realize that the distributed storage and parallel processing of information by neural networks allows the brain to have strong fault tolerance, and damage to some neurons does not affect brain function. Similarly, it is acceptable to appropriately remove some neurons from the artificial neural network model. The second knowledge point is "Artificial Neural Network Model". On the basis of understanding the structure and function of a single biological neuron, students understand the graphical model of artificial neurons and the M-P model described in language, and know the terms such as input, output, net input, and threshold. In a single neuron model with a threshold-type transfer function, the main operations are addition, subtraction, comparison, and segmented output, making it suitable for students of this age to learn. The learning focus is by understanding the structure and function of individual neurons, as well as simple input and output calculations, to understand that artificial neural networks, as a model, can process input information. The implementation of this computation activity can be carried out in a specific application scenario, such as a single-input and single-output application scenario [determining whether to go to the movies (output) based on movie ratings (input)] or a multiple-input and single-output application scenario [determining whether to travel (output) based on weather conditions (using temperature, humidity, wind force, etc. as inputs)].

(7) Knowledge Representation and Reasoning Module

Knowledge is the outcome of human beings' understanding of the objective world (including human beings themselves) through practice, and is also the basis of

human wisdom, including facts, concepts, rules, or principles in various fields and industries. Artificial intelligent systems require not only perception, cognition and learning abilities, but also knowledge to empower them. Knowledge includes various types, such as conceptual knowledge, factual knowledge, and procedural knowledge. Different types of knowledge require different ways of acquisition. Proper organization and representation of knowledge can help people to master knowledge, such as symbols, block diagrams, and mind maps are examples of knowledge organization forms. Similarly, for artificial systems, knowledge needs to be represented in order to achieve inference. This section first introduces the basic concepts and commonly used expressions in the field of artificial intelligence. In the knowledge point of "Overview of Knowledge", let students have a perceptual understanding of knowledge commonly encountered in their daily lives, and initially establish the concept of knowledge. In the knowledge point of "classification of knowledge", guide students to understand the diversity of knowledge and the characteristics of different knowledge by collecting different types of knowledge in their lives and learning, such as factual knowledge, conceptual knowledge, and procedural knowledge. Just as humans have many established rules for language and body language, knowledge needs to follow certain rules in expression. Additionally, knowledge is stored in human brains and books, and if it can be used by a computer, it must first be stored and represented in a computer. To achieve this goal, it is necessary to have a certain understanding of the structured representation of knowledge, which is the content that needs to be learned in the knowledge point of "Knowledge Representation". It is recommended that students be creative and refer to existing rules to design their own rules to represent knowledge. The purpose of learning is not only to master existing rules, but

also to establish the awareness that establishment of artificial knowledge systems requires a certain regular expression of knowledge.

(8) Swarm Intelligence and Evolutionary Intelligence Module

The first learning stage focuses on observing phenomena and understanding the intelligent performance of biological groups. This stage of study observes the swarm intelligence of organisms from a detailed perspective, including individual behavior and interactions between individuals. The impact of individual behavior and communication behavior changes on swarm intelligence behavior can be observed through software platforms such as Netlogo. The swarm intelligence involved in the field of artificial intelligence is achieved by borrowing behavioral rules of individuals from biological populations, with the aim of solving complex optimization problems that mathematical models cannot be established. Therefore, in this section of the study, it is necessary to initially establish the concept of optimization, guide students to list optimization problems encountered in their daily lives, and combine relevant content in math classes to understand the mathematical model of simple optimization problems. For example, how to choose the most time-saving travel route for a given destination? How to divide the work among the team members for a given task to achieve the highest efficiency, and so on. As students in this stage of study have not yet established the concept of functions, mathematical descriptions of optimization algorithms will not be provided. Instead, it is necessary to have a preliminary understanding of the concept of optimization, the goals of optimization, and the factors that affect the optimization goals. For an understanding of swarm intelligence algorithms, it is recommended to take the example of the "Ant Colony Algorithm" for analysis and explanation. First, understand the

process of ant colony foraging, and guide students to think about the role of individual behavior and communication methods in the foraging process, as well as what inspirations they can provide for us. Then, understand the optimization process of the ant colony algorithm through the experimental platform, especially observe the impact of parameter changes on optimization.

(9) Human-Computer Interaction Module

Firstly, it is important to guide students to recognize that communication, exchange, and understanding between people are often a comprehensive function of language, tone, facial expression, and body movements, which is precisely the difficulty of human-computer interaction. In addition, it is necessary to introduce the basic concepts of human-computer interaction, the definition of human-computer interaction, the scope of "human" and "computer", and the meaning of "interaction". It is recommended to experience human-computer interaction through various practical activities and analyze the advantages and disadvantages of products such as smartphones, and smart appliances in human-computer interfaces.

III. The third learning stage (for junior high school grades 1-3)

1.Overview of Teaching Content and Achievement Goals

The teaching content and suggestions for achieving the goals for the third learning stage are listed in Table 3, with a suggested study time of 72-76 class hours.

For students who are learning artificial intelligence courses for the first time, it is recommended to supplement the following knowledge content appropriately:

Module 1: Application level of existing intelligent technologies.

Module 2: Basic concepts of intelligent tools.

Module 3: Sensory organs and perception systems of the

human body.

Module 4: Basic concepts and tasks of pattern recognition.

Module 5: Ways of human learning, the essence of learning.

Module 7: Concepts and classification of knowledge.

Table 3 Teaching Content and Suggested Objectives for the Third Stage

Knowledge module	Knowledge points	Subdivision of knowledge points	Suggested goals to achieve
Artificial Intelligence Overview (4 class hours)	Basic Concepts of Artificial Intelligence (1 class hour)	Basic Concepts of Artificial Intelligence (1 class hour)	Understand the Classic Definition of Artificial Intelligence.
	Human Brain and Computers (1 class hour)	Human Brain Information Processing (0.5 class hour)	(1) Understand the basic structure of the human brain. (2) Understand the information processing process of the human brain. (3) Understand the characteristics of information processing of the human brain.
		Computer Information Processing (0.5 class hour)	(1) Understand the basic structure of computers. (2) Understand the information processing process of computers. (3) Understand the characteristics of information processing of computers.
	Brief History of Artificial Intelligence Development and Approaches to Imitation Intelligence (2 class hours)	Brief History of the Development of Artificial Intelligence (1 class hour)	(1) Understand several important periods in the development history of artificial intelligence. (2) Understand several significant events in the development history of artificial intelligence. (3) Understand the current stage and level of artificial intelligence development.
		Main Genres of Imitation Intelligence and Their Characteristics (1 class hour)	(1) Understand the main characteristics and representative achievements of Connectionism. (2) Understand the main characteristics and representative achievements of Symbolism. (3) Understand the main characteristics and representative achievements of Behaviorism.

Intelligent Tools and Social Ethics (4-5 class hours)	Evolutionary History of Tools (1 class hour)	Evolutionary History of Human Tools (1 class hour)	Understand common tools and the level of tool capabilities in different eras of human society.
	Functions and Applications of Intelligent Tools (2 class hours)	Functions of Intelligent Tools (1 class hour)	Understand the functions of existing intelligent tools or technologies.
		Applications of Intelligent Tools (1 class hour)	Able to design intelligent tools for simple scenario applications.
	AI and Social Ethics (1-2 class hours)	Causes of Bias in AI Systems (1-2 class hours)	Analyze the causes for bias in AI systems, such as data-driven bias, interaction bias, emergent bias, similarity bias, and conflicting goal bias.
Machine Perception (9-10 class hours)	Machine Perception Systems (2 class hours)	Analog Signals (0.5 class hour)	(1) Understand the concept of analog signals. (2) Understand common analog signals. (3) Understand the transmission and storage of analog signals.
		Digital Signals (0.5 class hour)	(1) Understand the concept of digital signals. (2) Understand common digital signals. (3) Understand the transmission and storage of digital signals.
		Analog-to-Digital and Digital-to-Analog Conversion (1 class hour)	(1) Understand the reasons for the need for converting between analog and digital signals. (2) Understand the basic applications of A/D and D/A converters.
	Machine Perception Applications (4 class hours)	Machine Vision (2 class hours)	(1) Understand the enhancement and restoration operations of digital image, and be able to practice using available software. (2) Understand the encoding and compression operations of digital image, and be able to practice using available software. (3) Understand visual perception tasks such as face detection, facial expression recognition, object recognition, obstacle detection, etc.
		Machine Audition (2 class hours)	(1) Understand the sampling of sound waves. (2) Understand pre-processing such as quantization and encoding of sound waves. (3) Understand auditory perception tasks such as speech recognition, music recognition, etc.

	Other Sensors (3-4 class hours)	Gyroscope Sensor (1 class hour)	(1) Understand the concept and basic characteristics of gyroscopes. (2) Understand the fundamental properties of gyroscopes. (3) Understand the basic principles of gyroscopes. (4) Know intelligent scene applications of gyroscopes.
		Accelerometer Sensor (1 class hour)	(1) Understand the definition of accelerometer sensors. (2) Understand the basic principles of accelerometer sensors. (3) Know intelligent scene applications of accelerometers sensors.
		Multi-Sensor Fusion (1-2 class hours)	(1) Understand the basic concept of multi-sensor fusion. (2) Understand the framework of multi-sensor fusion systems. (3) Able to provide examples of how intelligent machines work through multi-sensor fusion, such as driver state recognition.
Machine Cognition (6 class hours)	Feature Extraction and Representation (1 class hour)	Concept of Feature Vectors (0.5 class hour)	Understand feature vectors.
		Vector Space (0.5 class hour)	Understand two-dimensional vector space.
	Classification and Classification Algorithms (2 class hours)	Mathematical Meaning of Classification (0.5 class hour)	Understand the Mathematical Meaning of Classification.
		Linear Separability (0.5 class hour)	Understand linear classification and linear separability.
		Classification Algorithms (1 class hour)	Understand training sets and experience the perceptron classification algorithm.
	Clustering and Clustering Algorithms (1 class hour)	Concept of Clustering (0.5 class hour)	Understand the basic meaning of clustering.
		Clustering Tasks (0.5 class hour)	Understand specific clustering tasks in reality.
	Hierarchy of Recognition	Speech Recognition:	Understand how to recognize characters and characters as words, and understand

	(2 class hours)	From Characters to Words (1 class hour)	information in higher-level representations can be used to solve ambiguity in lower level language abstraction processes.
		Image Recognition: Edge Detection (1 class hour)	Understand how to combine edge detection to form more complex feature detection.
Machine Learning (19 class hours)	Human Learning and Machine Learning (1 class hour)	Meaning, Content, and Applications of Machine Learning (1 class hour)	(1) Familiar with the basic meaning of machine learning. (2) Understand the main content of machine learning research. (3) Understand the primary applications of machine learning.
	Composition of Machine Learning Systems (1 class hour)	Functions and composition framework of a learning system (0.5 class hour)	(1) Understand the functions that a machine learning system should implement. (2) Understand the framework of a machine learning system.
		Meaning and Function of Components in a Learning System (0.5 class hour)	(1) Understand the meaning and function of the component-environment. (2) Understand the meaning and function of the component-earning phase. (3) Understand the meaning and function of the component-knowledge base. (4) Understand the meaning and function of the component-execution phase.
	Machine Learning Environment (Data) (3 class hours)	Building a Dataset (1 class hour)	(1) Understand the basic concepts of a dataset: the concepts of dataset, samples, features, and labels. (2) Able to recognize the datasets established by the table. (3) Able to understand the content represented by rows and columns in a table (number of data points, feature values, labels, etc.). (4) Understand training sets and prediction sets.
		Quantitative Encoding of Data (1 class hour)	(1) Understand the quantization and encoding methods of data. (2) Observing the impact of different quantitative encoding methods on model predictions through experiments.

		Characteristics and Requirements of Datasets (1 class hour)	(1) Labeling issues in complex data (image segmentation and labeling). (2) Labeling issues and industrialization in big data. (3) Able to understand how biases in data can affect the predictive behavior of classifiers.
	Machine Learning Methods (3 class hours)	Reinforcement Learning and Supervised Learning Process (1 class hour)	(1) Compare the differences between reinforcement learning and supervised learning in the learning process. (2) Compare the differences between reinforcement learning and supervised learning from feedback signals .
		Unsupervised Learning (2 class hours)	(1) Understand the basic meaning of clustering learning. (2) Understand the data forms used in unsupervised learning. (3) Understand how unsupervised learning discovers patterns from unmarked data. (4) Understand the differences between unsupervised learning and supervised learning from the perspective of sample data and algorithm principles.
	Machine Learning Models and Algorithms (3 class hours)	Concepts of Learning Algorithms (1 class hour)	(1) Understand what learning algorithms are. (2) Understand the functions of learning algorithms. (3) Understand what training is and distinguish the difference between training models and using trained models.
		Linear Regression (1 class hour)	(1) Understand the geometric interpretation of linear equations. (2) Understand linear regression analysis. (3) Understand the meaning of parameters in linear regression.
		Decision Trees (1 class hour)	(1) Familiar with the structure of decision trees. (2) Familiar with the functions of decision trees. (3) Understand the ideas behind one of the following algorithms: ID3, C4.5, or CART.
	Machine Learning Model	Step 1: Data Preparation	(1) Able to partition datasets, establish training and prediction sets. (2) Able to use software to normalize and preprocess datasets.

	Training, Prediction, and Evaluation (2 class hours)	Step 2: Model Selection and Initialization	(1) Different models adapt to different problems, understand the areas where models such as decision trees and neural networks excel, and make choices based on the problem. (2) Able to initialize the model.
		Step 3: Model Training	Understand how to set basic training parameters for models like decision trees or neural networks on software platforms or programming.
		Step 4: Model Prediction	Able to use the trained model for prediction.
		Step 5: Model Performance Evaluation and Improvement	(1) Able to conduct statistical analysis on prediction results, such as calculating mean squared error or accuracy. (2) Able to analyze the evaluation results to a certain extent.
	Machine Learning Applications (6 class hours)	Image Recognition (2 class hours)	(1) Implement image acquisition, storage, and retrieval using software platforms or programming. (2) Implement image feature extraction using software platforms or programming. (3) Implement machine learning model training using software platforms or programming. (4) Implement prediction and evaluation of machine learning models using software platforms or programming.
		Speech Recognition (2 class hours)	(1) Implement sound waveform acquisition, storage, and retrieval using software platforms or programming. (2) Implement feature extraction from sound waveforms using software platforms or programming. (3) Implement training of acoustic models using software platforms or programming. (4) Implement prediction and evaluation of acoustic models using software platforms or programming.

		Natural Language Processing: Text Classification (2 class hours)	(1) Understand the process of text classification: text preprocessing, feature extraction, classification model training, result analysis. (2) Implement text preprocessing such as Chinese word segmentation using software platforms or programming. (3) Implement text feature extraction using software platforms or programming. (4) Implement classification model training and result analysis using software platforms or programming.
Artificial Neural Network (4 class hours)	Biological Neural Networks (1 class hour)	Information Processing Mechanisms (1 class hour)	(1) Understand the generation, transmission, reception, and integration of information in biological neurons. (2) Understand the information processing characteristics of biological neural networks.
	Fundamentals of Artificial Neural Network Models (1 class hour)	Neuron Models (1 class hour)	Understand the M-P model described by formulas.
	Feedforward Neural Networks (2 class hours)	Threshold-Type Single-Layer Neural Network (2 class hours)	(1) Familiar with the structure of threshold-type single-layer neural networks. (2) Familiar with the correspondence between input nodes and data inputs in threshold-type single-layer neural networks. (3) Familiar with the correspondence between output nodes and data labels in threshold-type single-layer neural networks. (4) Familiar with the relationship between weights in threshold-type neural networks and data patterns.
Knowledge Representation and Reasoning (6 class hours)	Knowledge Representation (2 class hours)	First-Order Predicate Logic Representation (1 class hour)	Understand first-order predicate logic representation.
		Production Rule Representation (1 class hour)	Understand production rule representation.
	Knowledge Reasoning (4 class hours)	Components of Knowledge Reasoning	Understand knowledge reasoning systems.

		Systems (1 class hour)	
		Forward Reasoning (1 class hour)	Familiar with forward reasoning.
		Backward Reasoning (1 class hour)	Familiar with backward reasoning.
		Hybrid Reasoning (1 class hour)	Understand hybrid reasoning.
Swarm Intelligence and Evolutionary Intelligence (12 class hours)	Optimization Problems (2 class hours)	Basic Concepts of Optimization (1 class hour)	(1) Understand the concept of function optimization and some typical problems. (2) Understand the concept of combinatorial optimization and some typical problems.
		Three fundamental elements of optimization problems (1 class hour)	(1) Understand the optimization objective. (2) Understand the concept of solutions to optimization problems. (3) Understand the concept of constraints.
Swarm Intelligence and Evolutionary Intelligence (12 class hours)	Common optimization methods (2 class hours)	Gradient descent method (1 class hour)	(1) Understand the basic idea of gradient descent method for optimization. (2) Understand the characteristics, application scope, and limitations of gradient descent method for optimization.
		Enumeration method (0.5 class hour)	(1) Understand the basic idea of enumeration method for optimization. (2) Understand the characteristics, application scope, and limitations of enumeration method for optimization.
		Random search method (0.5 class hour)	(1) Understand the basic idea of random search method for optimization. (2) Understand the characteristics, application scope, and limitations of random search method for optimization.
	Ant Colony Algorithm (2 class hours)	Foraging inspiration of Ant Colony (0.5 class hour)	(1) Understand the concept of diversity in swarm intelligence reflected by ant colony foraging. (2) Understand the concept of positive feedback in swarm intelligence reflected by ant colony foraging. (3) Understand the concepts of optimization, optimal solutions, and suboptimal solutions in swarm intelligence reflected by ant colony

			foraging.
		Meaning of Parameters in Ant Colony Algorithm (1 class hour)	(1) Understand the significance of population parameters and be able to adjust experimental parameters according to the problem in the software platform. (2) Understand the perception range and environmental information and be able to adjust relevant experimental parameters according to the problem in the software platform. (3) Understand foraging rules, movement rules, obstacle avoidance rules, and pheromone rules, and be able to adjust relevant experimental parameters according to the problem in the software platform.
		Characteristics and Applications of Ant Colony Algorithm (0.5 class hour)	(1) Understand the characteristics of ant colony algorithms. (2) Understand the applications of ant colony algorithms.
	Multi-agent systems (2 class hours)	Intelligent Agents (1 class hour)	(1) Understand the proposal and concept of intelligent agents. (2) Understand the characteristics of intelligent agents, such as autonomy, sociality, reactivity, and proactivity. (3) Understand the ways to implement intelligent agents.
		Concept and composition of multi-agent systems (1 class hour)	(1) Understand the basic concept of multi-agent systems. (2) Understand the fundamental components of multi-agent systems. (3) Understand the applications of multi-agent systems, such as drone swarms.
	Biological evolution phenomenon (1 class hour)	Biological evolution phenomenon (1 class hour)	(1) Understand the earliest biological forms on Earth. (2) Understand the process of biological evolution on Earth through videos and understand the connections between some existing and ancient organisms. (3) Understand the relationship between

			biological evolution and the environment, and preliminary establish the concept of "survival of the fittest".
	Genetic algorithm (3 class hours)	Inspiration from evolution theory and genetics (1 class hour)	(1) Understand the role of genetics. (2) Understand the role of mutation. (3) Understand the role of natural selection. (4) Understand the role and function of genes. (5) Understand the effects and roles of gene hybridization and gene mutation.
		Basic principles of genetic algorithm (2 class hours)	(1) Understand the correspondence between chromosome encoding and problem solutions. (2) Understand the concepts of population and individuals. (3) Understand the role of selection in genetic algorithms. (4) Understand the operations of crossover and mutation. (5) Demonstrate the optimization process of genetic algorithms through numerical examples.
Human-Computer Interaction (8-10 class hours)	Foundation of Human-Computer Interaction (2 class hours)	Development history of HCI (1 class hour)	(1) Understand the human-computer interaction methods during the early manual labor stage. (2) Understand the human-computer interaction methods at the stage of job control language and interaction command language. (3) Understand the human-computer interaction methods during the graphical user interface (GUI) phase. (4) Understand the human-computer interaction methods in network user interfaces.
		Development status and trends in Human-Computer Interaction technology (1 class hour)	(1) Understand the current stage of intelligent human-computer interaction, which involves multiple channels and multimedia. Understand various forms of interaction such as tactile interaction, eye tracking interaction, voice interaction, gesture interaction, etc. (2) Understand the core concept of "natural interaction".

	Natural Language Processing (2-4 class hours)	Goals, tasks, and applications of Natural Language Processing (1-2 class hours)	(1) Understand the goals of natural language processing research. (2) Understand the core tasks of natural language processing: natural language understanding and natural language generation. (3) Understand the application scenarios of natural language processing technology, such as machine translation, character recognition, speech recognition and text-to-speech conversion, information retrieval, information extraction and filtering, text classification and clustering, sentiment analysis, opinion mining, question answering systems, etc.
		Implementation process of Natural Language Processing technology (1-2 class hours)	Understand the implementation process of natural language processing technology based on traditional machine learning: Corpus preprocessing -> Feature engineering -> Classifier selection
	Voice Interaction (2 class hours)	Concept and process of Voice Interaction (1 class hour)	(1) Understand the concept of voice interaction. (2) Understand the process and elements of voice interaction: acoustic speech analysis, natural language understanding, providing feedback, and speech synthesis output.
		Advantages and disadvantages of Voice Interaction and trends (1 class hour)	(1) Understand the advantages of voice interaction. (2) Understand the disadvantages of voice interaction. (3) Understand the applicable scenarios and the reasons for voice interaction , such as home automation, in-car systems, enterprise applications, education, etc. (4) Understand the applicable devices and the reasons for voice interaction , such as tablets, televisions, light, etc. (5) Understand the development trends in voice interaction, such as wake-up free interaction, multi-channel interaction, etc.
	Human-Computer Interaction Applications	Natural Language Interaction Applications (2 class hours)	Able to implement a simple chatbot based on software platforms or programming.

	(2 class hours)		

2.Design Description of Teaching Content and Achievement Goals

The junior high school stage (the third learning stage) includes all nine modules. With the development of logical thinking and abstract thinking abilities in junior high school, the learning content arranged in this section gradually adopts mathematical language to explain and express the principles and methods of artificial intelligence, which is also an important foundation for understanding artificial intelligence. The main mathematical knowledge involved includes plane Cartesian coordinate systems, first-order functions, and equations. This stage aims to guide students to gain a deeper understanding of the core technologies and applications of artificial intelligence, and enhance their technological literacy in AI. The following describes the design ideas of the teaching content and achievement goals of each module, for reference by teaching staff, textbook and teaching aid developers.

(1) Artificial Intelligence Overview Module

The Artificial Intelligence Overview Module first emphasizes the differences and similarities in information processing between the human brain and computers. By comparing the information processing capabilities of the two, it is pointed out that there are advantages and disadvantages in existing computer processing information, as well as possible directions for intelligent development. Secondly, it introduces a brief history of the development of artificial intelligence, enabling students to understand the historical background, development trends, major academic schools and achievements, and future development directions of the discipline of artificial intelligence. By analyzing and comparing the characteristics of the three major academic schools of artificial intelligence, guide

students to think about the future development directions of artificial intelligence.

(2) Intelligent Tools and Social Ethics Module

This module explores the evolution of human-invented tools from the perspectives of history and productivity development (it is recommended to combine with relevant content from middle school history classes), aiming to enable students to understand the development pattern of human-made tools constantly upgrading and replacing with the development of productivity. In terms of capabilities and literacy, this learning stage aims to guide students to creatively design scenarios for the application of intelligent tools. During the design process, it is necessary to consider whether these intelligent tools exhibit biases in decision-making and how to eliminate such biases through design. For example, is there homogeneity when browsing news or listening to online music? Is there any discrimination when screening resumes? Teachers can use case studies to prompt students to consider the reasons behind these issues and discuss what considerations should be taken into account in the design of intelligent systems.

(3) Machine Perception Module

In the previous two learning stages, students have been introduced to and gained an understanding of various commonly used sensors. On this basis, the Machine Perception module begins by learning the forms, acquisition, storage and conversion of signals, including analog signals, digital signals, and the uses of analog-to-digital and digital-to-analog converters. Students in this learning stage do not need to grasp the principles of signal conversion but should understand the process of information transfer from sensors to signal processors (computers). The above is the content of the knowledge point "Machine Perception System". Regarding the applications of machine perception, the focus remains on machine vision and machine audition, as in the

previous learning stages. This learning stage will concentrate on the internal workings of machine perception systems and understand how machines process visual and auditory signals. In terms of machine vision, students should understand the applications of visual perception (such as facial recognition, fruit classification, image recognition, etc.), and be able to use relevant software to preprocess tasks such as image enhancement, restoration, encoding, compression, etc. For machine audition, students should understand the tasks involved in auditory perception (such as speaker identification, speech recognition, etc.), and be able to preprocess sound signals through sampling, quantization, encoding, etc. Additionally, this module should introduce several other types of commonly used sensors, such as gyroscopes, accelerometers, and sensor fusion, thereby broadening students' knowledge in terms of sensor types, basic principles and applications. The learning of the above content extends from the external functionality of a system to its internal working processes, which is more in-depth compared to the learning content in primary school.

(4) Machine Cognition Module

The Machine Cognition module begins to attempt to describe relevant concepts and methods using mathematical language, which will facilitate the later implementation of programming in Python. For example, feature extraction and representation were described using natural language in the previous two learning stages, however, students' mathematical thinking ability at junior high school level can already support the use of mathematical language to describe abstract concepts in related content teaching. For instance, the mathematical representation of feature vectors and their geometric interpretation in a two-dimensional space. Similarly, understanding the concept of classification and classification algorithms through the geometric interpretation of linear classification and linear separability in

a two-dimensional space. This module introduces the concept of clustering for the first time. Students should be able to explain the main characteristics of both classification and clustering problems, as well as what are the similarities and differences in the training sample sets of the two? Regarding the section on "Hierarchy of Recognition," this module delves into a deeper level based on the continuation of the previous two learning stages. For example, in the hierarchy structure of speech recognition, the first learning stage introduces phonemes in conjunction with Pinyin, the second learning stage establishes the connection between sound waveforms and candidate characters, and the third learning stage needs to understand the transition from candidate characters to words. Students will gradually realize that the determination of characters and words is based on higher-level relationships between words or contexts. In the hierarchy structure of image recognition, students in the first learning stage have established the concepts of foreground and background, and in the second stage, they have learned that the objects to be recognized in the image may be occluded or damaged, and have learned about the storage and representation of images in computers. In the third learning stage, the focus is on identifying object contours through edge detection in images, laying the foundation for further object classification.

(5) Machine Learning Module

The content of the Machine Learning module significantly increases in proportion in the third learning stage. Students have already established a preliminary understanding of datasets and the basic process of machine learning in the previous two learning stages. In this learning stage, they will systematically learn about the complete process of machine learning. Firstly, the "Human Learning and Machine Learning" section provides the basic definition and main research areas of machine learning. In the "Machine

Learning Systems" section, students understand the functions and components of a machine learning system, as well as the requirements for each component, thereby establishing a relatively comprehensive system concept. In the "Machine Learning Environment (Data)" section, it is necessary to gradually become familiar with datasets stored in tabular form, including how to represent samples, features, and labels? Why data needs to be quantitatively encoded? How to construct complex datasets and big datasets? Students will transition from understanding simple datasets to real-world application datasets. In the "Machine Learning Methods" section, considering the enhancement of students' critical thinking abilities, a more in-depth comparison can be made between supervised learning and reinforcement learning in terms of learning process and feedback signals, which strengthens their understanding of these two learning algorithms. Additionally, unsupervised learning methods used to solve clustering problems should also be introduced, emphasizing the essential differences in sample data, and algorithm principles compared to supervised learning. The topic of "Machine Learning Models and Algorithms" covers the key and challenging aspect of artificial intelligence - learning algorithms. The key knowledge that students should focus on is that the machine learning process includes two stages: training and working phases. In the machine learning model section, it is recommended to emphasize linear regression models and decision tree models, understanding the significance of parameters in both models and gaining insight into the basic idea behind decision tree learning algorithms. In the section on "Training, Prediction, and Evaluation of Machine Learning Models," a complete machine learning process and steps are explained. It is recommended that after learning the artificial neural network module, this part of the content be comprehensively practiced through a software platform, with a focus on gaining an overall

understanding of the machine learning process and steps, including datasets, model training, prediction and evaluation. The emphasis should be on understanding the meaning of model parameters and the adjustment process. Regarding machine learning applications, it is recommended to use examples such as image recognition, speech recognition, and natural language processing, and be practiced through software platforms or programming to carry out complete process activities. By conducting appropriate practical activities, students can gradually become familiar with commonly used self-learning intelligent products in daily life, from experiencing their functionalities to gain a basic understanding of how they work. The learning of this section is no longer just about experiencing and observing. It is necessary to fully stimulate students' curiosity, encourage them to actively explore the working principles of commonly used intelligent products, and use software platforms to personally design and implement them.

(6) Artificial Neural Network Module

This learning stage uses mathematical language to describe artificial neural network models, requiring students to be able to manually calculate the parameters and network outputs of simple artificial neural network models, deepening their understanding of the working principles and processes of artificial neural networks. Firstly, starting from biological neurons, the information processing mechanisms are detailed, aiming to lay a biological foundation for understanding the information processing methods of artificial neural networks. Then, based on the six assumptions of the M-P model regarding the working mechanism of neurons, artificial neural network models are established, and expanding from a single neuron model to an artificial neural network model composed of multiple neurons connected. The focus is on studying the structure, functionality, the relationship between weight parameters and data patterns in

threshold-type single-layer neural networks. The difficulty of learning is to understand the impact of adjusting weight parameters on network performance. It is recommended to integrate the relevant content of this module with the related content from the machine learning module to conduct comprehensive practical activities.

(7) Knowledge Representation and Reasoning Module

This module introduces several widely used methods for knowledge representation and reasoning. The purpose of knowledge representation is to facilitate the use of computers for storage and processing. In the first-order predicate logic representation method, the focus is on understanding the predicate logic representation of knowledge, the definition and elements of predicate formulas, and being able to use predicate formulas to express knowledge. In the production rule representation method, the emphasis is on understanding the basic form and characteristics, as well as the method of representing knowledge using triplets. The "Knowledge Reasoning" section elaborates on the core modules of knowledge reasoning system: inference machine, rule base, and database, as well as the functions of each module. Students are expected to understand the basic ideas and processes of forward reasoning and backward reasoning, as well as the basic ideas behind hybrid reasoning.

(8) Swarm Intelligence and Evolutionary Intelligence Module

The first part of this module focuses on observing swarm intelligence phenomena, while the second part gradually introduces optimization problems and the working process of a typical swarm intelligence algorithm-Ant Colony Optimization. In this module, on the one hand, it further strengthens the understanding of optimization problems and swarm optimization algorithms, and on the other hand, combines biological knowledge to understand evolutionary

intelligence. In the "Optimization Problems" section, students are guided to summarize from their life experiences which problems can be categorized as function optimization problems and which ones are combinatorial optimization problems. And learn to describe optimization problems using the three elements: optimization objectives, solutions, and constraints. On this basis, it is suggested to use discussions, practical activities, and other methods to learn optimization methods, which can guide students to think about how to solve optimization problems such as maximizing profits, minimizing resource usage, and maximizing efficiency. By studying conventional optimization methods such as gradient descent, enumeration, and random optimization, understand the characteristics, application scope, and limitations of various methods, and understand the connections and differences between traditional optimization methods and swarm intelligence optimization methods. It is recommended to set up a group discussion session, provide a scenario for group optimization, experience the iterative process and results of multiple rounds of scheme optimization, and help students understand the ideas of group optimization in practice. This module uses ant colonies as an example to introduce one of the most commonly used swarm intelligence algorithms-the Ant Colony Optimization algorithm, including the inspiration of ant foraging activities on ant colony algorithm, as well as concepts such as population diversity, positive and negative feedback from foraging results, optimal and suboptimal solutions. The focus is to gradually establish the connection between the algorithm and optimization problems, understand the meaning of algorithm parameters, and be able to utilize software platforms to design and adjust parameters based on real-world problems to improve algorithm performance and solve practical problems. Based on the understanding of algorithms and their characteristics, understand the

application examples of algorithms. Additionally, it is possible to learn about multi-agent systems based on the concept of swarm intelligence, using drone swarms as an example for illustration. Regarding the "Evolutionary Intelligence" topic, it is recommended to study it in conjunction with relevant knowledge from biology. By analyzing biological evolutionary phenomena and drawing inspiration from concepts such as survival of the fittest, natural selection, and genetic inheritance to solve complex optimization problems, and then understand the basic principles of genetic algorithms. The two difficulties in learning include: firstly, establishing the connection between the algorithm and the optimization problem, including establishing the corresponding relationship between problem solutions and genetic algorithm chromosome coding, as well as the connection between optimization problem objective functions and genetic algorithm fitness ; The second is the role and implementation principles of various operators within the algorithm, including the concepts of population and individuals, and the effects of selection, crossover, and mutation operators. It is suggested to reinforce the understanding of genetic algorithms by demonstrating the optimization process through a simple example.

(9) Human-Computer Interaction Module

The first step in this module is to understand the development history of human-computer interaction (HCI) technology, allowing students to experience the characteristics and issues of HCI at different stages, as well as the efforts made by people to solve these problems. The focus is on understanding that current HCI is in the stage of multi-channel, multimedia intelligent interaction, and various interaction methods such as tactile interaction, eye-tracking interaction, speech interaction, and gesture interaction are emerging, and understand the core concept of natural interaction in HCI. Natural language processing (NLP) is one

of the important concept in HCI , as well as the difficulty in achieving human-computer interaction and the core of multiple interaction technologies. This module introduces the basic concepts and working process of NLP. Regarding its applications, it is recommended to combine it with relevant content from the machine learning module and engage in comprehensive practical activities. The "speech interaction" topic is related to speech recognition in machine learning but with a different focus. The focus is on the level that speech interaction can currently achieve, the advantages and disadvantages in interaction, and the applicable scenarios. The knowledge about the future of speech interaction should be regularly updated with the development of new technologies to broaden students' knowledge base. It is recommended to guide students to build simple voice interaction agents using programming languages such as Python in this learning stage, and to familiarize themselves with the implementation process of voice interaction and practical issues that need to be considered in design through practical activities.

IV. The fourth learning stage (for high school grades 1-3)

1.Overview of Teaching Content and Achievement Goals

The teaching content and suggestions for achievement goals for the fourth learning stage are listed in Table 4, with a suggested study time of 70-72 class hours.

For students who are learning artificial intelligence courses for the first time, it is recommended to supplement the following knowledge content appropriately.

Module 1: Development history, level, and application status of current intelligent technologies in artificial intelligence, main academic schools of AI and their characteristics.

Module 3: The human sensory organs and sensory systems, the concept of sensors, machine perception models, analog signals, digital signals, and their conversion.

Module 4: Basic concepts and tasks of pattern recognition, the meaning and mathematical significance of classification.

Module 5: The ways and essence of human learning, the meaning of machine learning, the composition of machine learning systems, the main methods of machine learning (including basic concepts and principles of supervised learning, reinforcement learning, and unsupervised learning), the basic concepts of learning algorithms, the structure and function of decision trees.

Module 6: Biological neurons and biological nervous systems.

Module 7: The concept and classification of knowledge, first-order predicate logic representation and production rule representation of knowledge representation, the composition of knowledge reasoning systems, forward reasoning, backward reasoning, and mixed reasoning.

Module 8: Interaction and intelligence emergence of individual behavior in swarm intelligence phenomenon, conventional optimization methods (such as gradient descent method, enumeration method, and random method), the basic principle of ant colony algorithm, the concept of agent and multi-agent systems.

Module 9: The communication mode between humans, the concept, development history and current situation of human-computer interaction, the concept, process and characteristics of voice interaction.

Table 4 Teaching Content and Suggested Achievement Goals for the Fourth Learning Stage

Knowledge module	Knowledge points	Subdivision of knowledge points	Suggested goals to achieve
Artificial Intelligence Overview(3 class hours)	Natural intelligence and artificial intelligence (1 class hour)	Natural intelligent system (0.5 class hour)	Understand and be able to provide examples of the composition and functions of natural intelligence systems.
			Understand and be able to provide examples of the composition of artificial intelligence systems and the work

		Artificial intelligence system (0.5 class hour)	process of the AI system to achieve intelligence.
	Human brain and computers (1 class hour)	Brain-computer interface (1 class hour)	(1) Understand the implementation methods and related experimental cases of outputting brain information to machine. (2) Understand the implementation method and related experimental cases of feedback of machine information to the brain.
	Intelligent era (1 class hour)	Development level and new trends (1 class hour)	(1) Understand the development level, main intelligent products, and research hotspots of artificial intelligence in the world. (2) Understand the new trends in the future development of artificial intelligence. (3) Understand the main content of the national artificial intelligence development strategy.
Intelligent Tools and Social Ethics (4~6 class hours)	Intelligent tool functions and application scenarios (2 class hours)	Working process of intelligent technology (1 class hour)	Understand the working process of intelligent technology in application scenarios.
		Application of intelligent technology in design scenarios (1 class hour)	Able to integrate multiple intelligent technologies to design scenario applications.
	AI and Social ethics related (4~6 class hours)	Social Impact of AI Systems (1~2 class hours)	Able to explore and analyze the positive and negative impacts of AI systems on society.
		Ethics in AI System Design (1~2 class hours)	Understand the current AI ethics standards proposed by some countries or organizations, explore what ethical and ethical considerations need to be considered when designing AI systems to solve specific social problems, and how to reflect them in the design?
Machine perception (8 class hours)	Applications of Machine perception (2 class hours)	Machine Vision (1 class hour)	(1) Understand the advantages of visual sensors, such as being able to detect bands that cannot be seen by the human eye.

			(2) Understand the limitations of visual sensors, such as limited camera resolution, dynamic range, and spectral sensitivity.
		Machine Audition (1 class hour)	(1) Understand the advantages of auditory sensors, such as being able to detect bands that cannot be heard by the human ear. (2) Understand the limitations of auditory sensors, such as limited sensitivity and frequency response of microphones.
	Other sensors (6 class hours)	Radar (1 class hour)	(1) Understand the concept of radar. (2) Understand the classification of radar. (3) Understand the working principle of radar. (4) Understand the application of radar.
		Laser radar (LiDAR) (1 class hour)	(1) Understand the concept of LiDAR. (2) Understand the classification of LiDAR. (3) Understand the working principle of LiDAR. (4) Understand the application of LiDAR.
		Global satellite navigation system (1 class hour)	(1) Understand the concept of satellite positioning systems. (2) Understand the basic working principles of satellite positioning systems. (3) Understand the application of satellite positioning systems. (4) Understand the major global satellite positioning and navigation systems, such as GPS, Beidou, GLONASS, and GALILEO.
		Indoor positioning technology (1 class hour)	(1) Understand the main techniques of indoor positioning. (2) Understand the main applications of indoor positioning technology.
		Design of multi-sensor fusion system (2 class hours)	Able to utilize multi-sensor fusion for functional design of intelligent systems for a specific application scenario.
Machine Cognition	Feature extraction and	Vector space	Understand N-dimensional vector space.

(6 class hours)	representation (2 class hours)	Feature extraction of speech and image (1 class hour)	Able to explain how to extract features from sound waveforms and images.
	Clustering and clustering algorithms (2 class hours)	Similarity measure (1 class hour)	Understand Cluster Centers and Similarity Measures.
		Clustering algorithm (1 class hour)	Understand basic clustering methods—using the "winner take all" algorithm as an example.
	Hierarchy of recognition (2 class hours)	Speech recognition: ambiguity resolution (1 class hour)	Understand the abstract hierarchical structure of speech comprehension from sound waveforms to sentences, and explain how to use each level of knowledge to solve ambiguity in lower levels.
		Image recognition: scene understanding (1 class hour)	Understand how to use lower-level abstractions to gradually complete perceptual reasoning at higher levels, such as the hierarchical structure of scene object edge pixel.
Machine learning (14 class hours)	Machine Learning Environment (Data) (3 class hours)	Building a Data Set (1 class hour)	(1) Understand the main methods for creating datasets, such as the MATTER (MATTER Cycle) method. (2) Understand commonly used machine learning databases, such as UCI databases, Kaggle databases, etc. (3) Understand the mathematical symbol description of the dataset (including dataset, sample pairs, feature inputs, labels, and predicted values). (4) Understand the ways to obtain datasets and the main methods of annotation: internal annotation, third-party annotation, crowdsourcing annotation. (5) Understand the space and cost required for data storage and so on.

		Dataset processing and analysis (2 class hours)	(1) Understand the preprocessing methods for datasets: processing missing data, normalization, etc., and be able to use programming tools for processing. (2) Understand how machine learning algorithms can reduce training errors when data is imbalanced: down sampling, cross validation, etc. (3) Understand the partitioning methods of standard datasets, such as cross validation, which can be processed using programming tools. (4) Understand the evaluation methods of datasets: binary classification situation. (5) Able to use data visualization tools such as Excel, MATLAB, or Python to perform statistical analysis on data to discover unevenness or imbalance in the data.
	Machine Learning Models and Algorithms (4 class hours)	Linear regression algorithm (1 class hour)	(1) Familiar with the basic meanings of linear regression analysis and nonlinear regression analysis. (2) Familiar with the basic principles and functions of least squares method. (3) Familiar with the steps of regression analysis.
		K-means clustering algorithm (1 class hour)	(1) Understand the basic meaning and functions of K-means clustering algorithm. (2) Understand the steps and applications of K-means clustering algorithm.
		Principal component analysis dimensionality reduction algorithm (2 class hours)	(1) Understand the significance of data dimensionality reduction. (2) Understand the basic principles of principal component analysis algorithms. (3) Understand the basic applications of principal component analysis algorithms.
	Training and Evaluation of Models (3 class hours)	Step 1: Preparation of data	(1) Able to use validation sets. (2) Differentiate classification, regression, and clustering issues based on data.

		Step 2: Model selection and initialization	(1) Choose an appropriate model based on actual problems. (2) Understand the Objective Function Setting of Regression Problems. (3) Understand the objective function settings for classification problems.
		Step 3: Model training	Understand how to set the basic training parameters of the selected model on a software platform or programming.
		Step 4: Model prediction	Able to use trained models for prediction.
		Step 5: Evaluation and improvement of model performance	(1) Understand the indicators for classification performance include accuracy(Ac), sensitivity (Sn), specificity(Sp), and Matthew correlation coefficient (MCC). (2) Understand the commonly used indicators for evaluating the performance of regression models: determining the coefficient(R^2) , Mean Square Error (MSE) and Root Mean Square Error (RMSE).
	Application of Machine Learning (4 class hours)	Image recognition (2 class hours)	(1) Able to preprocess images. (2) Understand the basic principles and methods of image feature extraction. (3) Understand commonly used models for image recognition, such as training 2D convolutional networks. (4) Understand quantitative evaluation methods for image recognition effectiveness.
		Speech recognition (2 class hours)	(1) Understand the quantification methods of sound waveforms. (2) Understand the MFCC characteristics of sound waves. (3) Understand the basic principles of acoustic models. (4) Understand Language Models. (5) Understand the training stages of acoustic and language models. (6) Understand the recognition stages of acoustic and language models.

Artificial Neural Network(ANN) (10 class hours)	Fundamentals of Artificial Neural Networks (1 class hour)	Classification methods and typical models (0.5 class hour)	(1) Understand classification methods and typical models based on topological structure. (2) Understand classification methods and typical models based on information flow.
		Basic features, functions, and applications (0.5 class hour)	(1) Familiar with the basic structural features of artificial neural networks. (2) Familiar with the basic ability characteristics of artificial neural networks. (3) Familiar with the basic functions and main applications of artificial neural networks.
	Feedforward neural network (2 class hours)	Structure and role of each layer of feedforward neural networks (1 class hour)	(1) Understand the structure of feedforward neural networks. (2) Understand the correspondence between the layers of feedforward neural networks and data
		Training of feedforward neural networks (1 class hour)	(1) Explain the forward output calculation process of feedforward hierarchical networks. (2) Understand the basic ideas of error backpropagation algorithms. (3) Understand the training process of feedforward neural networks. (4) Understand the prediction of feedforward neural networks.
	Deep Neural Network (7 class hours)	The proposal of deep networks (1 class hour)	Understand the background and basic ideas behind the proposal of deep networks.
		Convolutional Neural Networks (CNN) (2 class hours)	(1) Understand the structure of CNN. (2) Understand the basic working principles of CNN. (3) Understand the characteristics and application scenarios of CNN.
		Recursive Neural Networks (RNN) (2 class hours)	(1) Understand the structure of RNN. (2) Understand the basic working principle of recursive RNN. (3) Understand the characteristics and application scenarios of RNN delivery.
		Generative Adversarial Networks (GAN)	(1) Understand the structure of GAN. (2) Understand the basic working principles of GAN.

		(2 class hours)	(3) Understand the characteristics and application scenarios of GAN.
Knowledge representation and reasoning (8 class hours)	Knowledge Representation (1 class hour)	Semantic Network Representation Method (1 class hour)	Understand Semantic Network Representation.
	Knowledge reasoning: state space search strategy (4 class hours)	Basic concepts of state space search (1 class hour)	Understand the basic concepts of state space search.
		Blind search strategy (1 class hour)	Understand blind search strategies.
		Heuristic search strategy (1 class hour)	Understand heuristic search strategies.
		Basic process of knowledge reasoning application (1 class hour)	Understand the basic process of knowledge reasoning application.
	Knowledge Graph (3 class hours)	Basic concepts of knowledge graph (0.5 class hour)	Understand the basic concepts of knowledge graph.
		Basic components of knowledge graph (0.5 class hour)	Understand the basic components of a knowledge graph.
		Key technologies of knowledge graph (2 class hours)	Understand the key technologies for building a knowledge graph.
Swarm Intelligence and Evolutionary Intelligence (10 class hours)	Optimization problem (2 class hours)	Function optimization (1 class hour)	(1) Understand the concept of function optimization and be able to identify typical problems. (2) Understand the mathematical model of function optimization.
		Combinatorial optimization (1 class hour)	(1) Understand the concept of combinatorial optimization and be able to identify typical problems. (2) Understand the mathematical model of combinatorial optimization.

	Artificial bee colony algorithm (4 class hours)	Inspiration from bee swarm honey collecting (1 class hour)	(1) Familiar with the task division in swarm intelligence reflected by bee honey gathering. (2) Familiar with the information exchange in swarm intelligence reflected by bee honey gathering. (3) Familiar with the collaborative thinking reflected in swarm intelligence in bee honey gathering.
		Basic principles and implementation of artificial bee colony algorithm (2 class hours)	(1) Understand the components of bee colony algorithm: food sources, hired bees, and non-hired bees. (2) Understand the behavioral patterns of bees. (3) Understand the optimization mode of bee colony algorithm. (4) Understand the pseudo code of bee colony algorithm. (5) Able to adjust the algorithm parameters in the software platform and observe the operation results.
		Characteristics and applications of artificial bee colony algorithm (1 class hour)	(1) Understand the characteristics of artificial bee colony algorithm. (2) Understand the application of artificial bee colony algorithm.
	Other swarm intelligence algorithms (1 class hour, 1 out of 3)	Artificial fish school algorithm (1 class hour)	(1) Understand the biological background of artificial fish school algorithms. (2) Understand the basic ideas and characteristics of the artificial fish school algorithm.
		Artificial bird swarm algorithm (1 class hour)	(1) Understand the biological background of bird swarm algorithm. (2) Understand the basic ideas and characteristics of artificial bird swarm algorithm.
		Artificial wolf swarm algorithm (1 class hour)	(1) Understand the biological background of artificial wolf pack algorithms. (2) Understand the basic ideas and characteristics of the artificial wolf pack algorithm.

	Genetic Algorithms (GA) (3 class hours)	Basic Operations of Genetic Algorithms (2 class hours)	(1) Familiar with the basic implementation process of genetic algorithms. (2) Familiar with the chromosome encoding method of genetic algorithms, able to conduct binary code of the solutions based on problems. (3) Familiar with the concept of fitness functions in genetic algorithms, and master the design of fitness functions for function optimization problems. (4) Familiar with the selection operation principles of genetic algorithms, master and implement roulette wheel selection methods. (5) Familiar with the crossover operation principle of genetic algorithms, master and implement single point crossover methods. (6) Familiar with the mutation operation principles of genetic algorithms, master and implement uniform mutation methods. (7) Able to perform calculations or programming with simple examples.
		Application of Genetic Algorithm (1 class hour)	(1) Understand the application of genetic algorithms in knapsack problems. (2) Understand the application of genetic algorithms in TSP problems.
Human-computer interaction (7 class hours)	Natural Language Processing (NLP) (2 class hours)	Difficulties in Natural Language Understanding (1 class hour)	(1) Understand the basic implementation ideas of natural language understanding at present. (2) Understand the difficulties of AI in understanding conversational intention: diversity of expressions, contextual context, robustness of language, and knowledge background of language.
		Implementation process of natural language processing technology (1 class hour)	Understand the implementation process of natural language processing technology based on deep learning.

	Emotional Computing (3 class hours)	Fundamentals of emotional computing (1 class hour)	(1) Understand the concept of emotional computing. (2) Understand the role of emotional computing in human-computer interaction. (3) Understand the ways humans express emotions. (4) Understand the ways humans perceive emotions.
		Emotional computing model (1 class hour)	(1) Understand the main content of emotional computing. (2) Understand the inputs of emotional computing models. (3) Understand the functions of emotional computing models.
		The Ways of emotional computing (1 class hour)	(1) Understand the basic principles of human facial expression recognition. (2) Understand the basic principles of emotion recognition through posture. (3) Understand the basic principles of emotion recognition through language. (4) Understand the role of multimodal computing in emotional computing.
	Application of human-computer interaction (2 class hours)	Application of natural language processing (2 class hours)	(1) Know the basic principles of machine translation and the problems in the application. (2) Know the basic principles of question answering systems and problems in the application.

2.Design Description of Teaching Content and Achievement Goals

The fourth learning stage is the high school stage or equivalent education stage, and the teaching content includes nine modules. Compared with the third learning stage, this stage has higher requirements for students' systematic view, abstract level, and dialectical thinking ability. The following describes the design ideas of the teaching content and achievement goals of each module, for reference by teaching staff, textbook and teaching aid developers.

(1) Artificial Intelligence Overview Module

Firstly, analyze the composition of a natural intelligence

system, the elements contained in the system, and the basic principles of system operation from a systematic perspective, in order to clarify which elements, links, and working processes should be included in an artificial intelligence system. Regarding the knowledge points of "human brain and computer", the previous grade introduced the differences and similarities between the human brain and computer in terms of information processing. This learning stage introduces knowledge about brain-computer interaction and some application results. The knowledge point "Intelligent Era" elaborates the development level and trends of artificial intelligence technologies and products in the world , as well as the strategic goals for the development of artificial intelligence in China , helping students better adapt to the work and life of intelligent era and enhancing their artificial intelligence technology literacy and professional competitiveness.

(2) Intellectual Tools and Social Ethics Module

The "Intellectual Tools and Social Ethics Module" section requires students to be able to understand the working process of intelligent technology in the application scenario, and know the roles played by various technologies in the scene, such as recognition, analysis, decision-making, etc. During the learning process, on one hand, students should be encouraged to make full use of various intelligent tools to improve learning efficiency and enhance life quality, fully enjoy the various conveniences brought by artificial intelligence technology; on the other hand, attention should be paid to guide students to think about the positive and negative impacts of intelligent tools on human society, and understand the AI ethical standards proposed by some countries or organizations, and through analyzing the advantages and disadvantages of existing intelligent tools, stimulate thinking about artificial intelligence ethics. This is also the content required in the "Ethics and Responsibility in

AI System Design" section. The above open topic can be considered in conjunction with courses on ethics and the rule of law.

(3) Machine Perception Module

The learning content of the machine perception module includes two key points: firstly, from the basic principles of perception to the technical details, which technical details need to be considered; the second is to broaden sensor knowledge. The knowledge point of "Machine Perception Application" still focuses on machine vision and Machine audition, strengthening the understanding of the performance and detection range of visual sensors and auditory sensors, helping students understand their advantages and limitations. For the knowledge point of "Other Sensors", it is recommended to incorporate popular high-end perception technologies such as LiDAR, global navigation satellite systems, indoor positioning technology, and multi-sensor fusion technology into the curriculum. These contents help students broaden their horizons, enrich their knowledge, and improve their scientific literacy. This part should focus on answering questions that arise in practical applications, such as whether there are limitations in machine vision resolution and dynamic range? What requirements do autonomous vehicles have for ranging and tracking? What are the differences between indoor and outdoor positioning requirements? And so on. When explaining scientific principles, technologies, and methods, it is necessary to guide students to think about how scientific and technological work proposes solutions to these problems? What problems have not been solved yet? This kind of thinking is greatly beneficial for strengthening innovative thinking training and expanding thinking depth and breadth.

(4) Machine Cognition Module

In this learning stage, the study of the knowledge point "Feature Extraction and Representation" can be extended

from 2D vector space to N-dimensional (N>3) vector space. As for the knowledge point "Clustering and Clustering Algorithms", it is recommended to take the "Winner Take All" algorithm as an example to understand the competitive and self-organizing process of clustering training, realize that clustering centers are typical representatives of similar things, and achieve "classifying by similarity" through similarity measurement. In terms of "Recognition Hierarchy", the hierarchical structure of speech recognition and image recognition will be comprehensively understood. It is recommended to understand the hierarchical structure and approach of machine recognition by comparing the hierarchical structure of human recognition. An important way to achieve artificial intelligence is to simulate and draw from human (or other biological) intelligence. In teaching, students should be guided to pay special attention to this characteristic. At the same time, it is also important to understand the huge differences between the ways of accepting and processing information between machines and humans.

(5) Machine Learning Module

Most of the content in this module is a strengthening and deepening of the content in the third learning stage. The knowledge point "Machine Learning Environment (Data)" includes the establishment, processing, and analysis of data sets. This part explains commonly used methods for creating datasets (such as MATTER), as well as the process of testing, evaluating, and modifying data sets. In addition, it is necessary to have an understanding of data set acquisition, annotation, and storage, as well as machine learning databases often used by researchers and enterprise developers, such as UCI database, Kaggle database, etc. In the part "Data Processing and Analysis", the most basic normalization method is extended to relatively complex processing methods for various practical problems, such as

missing data, small samples, unbalanced data, etc. In addition, students are required to be able to use basic data visualization tools for data analysis. In the part "Machine Learning Models and Algorithms", this learning stage focuses more on understanding learning algorithms, including linear regression model least squares algorithm and K-means algorithm. When learning algorithms, the focus is on explaining the thinking process of solving problems in a simple and intuitive way, rather than emphasizing complex mathematical derivations. For example, do different clustering algorithms such as winner-takes-all and K-means clustering produce different results? Is the difference in results related to the algorithm? Which parts of the algorithm are related to? And so on. In the part "Model Training and Evaluation", the validation set is introduced on the basis of the content related to the third learning stage, and students are required to be able to set target function and model parameters for specific problems. In terms of evaluation, more performance indicators should be understood (which can be selected according to specific arrangements). In the part "Machine Learning Applications", compared with the content of the third learning stage, the implementation process of image recognition and speech recognition is described in a more detailed and quantified way, and it is recommended to introduce newer technological achievements such as convolutional networks. At present, machine learning is a hot topic in the field of artificial intelligence, and this module should combine more with the latest developments in the field to carry out teaching.

(6) Artificial Neural Network Module

The learning content of this module includes three key points: firstly, to have an understanding of the full picture of the classification, characteristics, and functions of artificial neural networks; secondly, to understand the structure, learning algorithm, and functions of classical neural network

models - multi-layer feedforward neural networks; thirdly, to understand the ideas and typical models of hot research direction "deep neural networks". Firstly, students will understand the classification of neural networks based on their topological structure and information flow, and explain their functional characteristics and main uses, so that students will have a comprehensive understanding of neural network models. Then focus on introducing multi-layer feedforward neural networks, which are the most commonly used neural network models with a relatively simple structure. The focus is on understanding their training process and the basic idea of error backpropagation algorithm. For deep neural networks, it is necessary to understand their connection and difference compared with traditional neural networks, as well as the impact network depth increase has on the performance of neural network models and their application ways and scope. It is recommended to popularize three types of deep neural networks with the widest application at present: convolutional neural networks, recurrent neural networks, and generative adversarial networks. The first two mainly used in supervised learning fields, playing important roles in image recognition, speech recognition and text processing respectively. Adversarial generative networks are one of the most promising methods in unsupervised learning field in recent years with unique application effects. Deep neural networks and deep learning are currently hot research topics. The main purpose of introducing this content in this section is to broaden students' horizons and cultivate their innovative spirit.

(7) Knowledge Representation and Reasoning Module

The Knowledge Representation and Reasoning Module still conducts teaching from two aspects: "representation" and "reasoning". In the "Knowledge Representation" section, the representation method of semantic networks is introduced, which is easier to convert from natural language

and can represent knowledge deeply for easy retrieval and reasoning. In the "Knowledge Reasoning" section, more complex state space search strategies are introduced. This part of the teaching can be combined with the conventional optimization methods in the "Swarm Intelligence and Evolutionary Intelligence" module of the third semester. For example, blind search includes search strategies such as depth-first search and breadth-first search, which can be combined with enumeration method for teaching; heuristic search includes search strategies such as local optimization search method (such as blind hill-climbing) and best-first search method (such as ordered search), which can be combined with gradient method for teaching. It is recommended to explain with specific examples during teaching. Knowledge graph is a research hotspot in the field of artificial intelligence in recent years. Currently, Many intelligent products have embedded knowledge graphs, such as search engines, virtual students who can write and draw, and adaptive AI education systems. It is recommended to incorporate knowledge graph knowledge into the teaching content of this module. Students only need to have a preliminary understanding of its basic concepts, components, and key technologies.

(8) Swarm Intelligence and Evolutionary Intelligence Module

This module should further strengthen the understanding of optimization problems, understand commonly used group intelligence algorithms such as bee colony algorithms, and gain an understanding of multi-agent systems. In terms of evolutionary intelligence, it is recommended to introduce the most commonly used genetic algorithm. As for "optimization problems", students have learned the concept of optimization before and are familiar with optimization goals, optimal solutions or plans, etc. This section describes function optimization problems and

combinatorial optimization problems from the perspective of mathematical models using mathematical language, which will lay a foundation for programming implementation. Bee colony algorithm is a commonly used group intelligence optimization algorithm inspired by bee honey collection process. When explaining this algorithm, it is important to focus on reflecting the division of labor, information exchange, and collaboration ideas in the bee honey collection process, as well as how these three aspects are implemented in the bee colony algorithm. Students need to further understand the flow of the algorithm and pseudo code, and further understand the meaning of parameters and their impact on optimization results through software platforms or programming languages, in order to enhance their understanding of algorithm ideas and implementation processes. In addition, other group intelligence algorithms can also be introduced, such as fish school algorithm, bird school algorithm, and wolf school algorithm, etc. Through analogy, understanding of swarm intelligence ideas can be strengthened. In the teaching process, it is necessary to focus on differences and similarities as well as commonalities between these algorithms: individual encoding, individual behavior, interaction behavior, evaluation function, etc., paying attention to clarify the basic ideas of these algorithms, so that similarities can be found in different areas and differences can be distinguished in similar areas. Genetic algorithm is a classic evolutionary computation method. Students have learned about evolution theory and genetics knowledge in biology courses before, so it is possible to guide students to gain inspiration from this knowledge and try to give an implementation process of genetic algorithm based on these inspirations, including individual coding methods, individual selection, crossover and mutation operations. It is recommended to take binary encoding as an example for students to demonstrate and understand the

core process of genetic algorithm. In addition, it is possible to understand how genetic algorithms solve practical problems, that is, how the solution of practical optimization problems is converted into the iterative process of optimization algorithms.

(9) Human-Computer Interaction Module

The Human-Computer Interaction Module focuses on introducing natural language processing. Language is one of the most important ways for humans to communicate, so in order to make machines understand humans, it is necessary to solve the conversion process from text to intention, which is also the core and difficulty of natural language processing technology. IThis section first introduces the basic implementation ideas of natural language understanding, and then analyzes the difficulties of AI in understanding of conversational intentions. And it introduces the implementation process of current advanced natural language processing technologies based on deep learning. Regarding "affective computing", it first analyzes the communication methods between people, establishes machine affective computing models through analogy, and understands how machines recognize emotions through facial expressions, body language, and language tone. As for "human-computer interaction applications", it focuses on understanding applications of natural language processing, such as machine translation and Q&A systems.

Part 4 Teaching Implementation Suggestions

I. Teaching suggestions

Artificial intelligence teaching should focus on improving students' AI literacy, fully understanding the basic concepts of the course, accurately grasping the goals and values of the course, enriching teaching content, creating a learning atmosphere which is conducive to students' active innovation, reasonably select and explore new teaching methods and models, pay attention to the cognitive characteristics and differences of students at different stages of education, guide students to personally experience the process of discovering, analyzing and solving problems by using artificial intelligence knowledge and technology, cultivate students' adaptability to the development of artificial intelligence technology and the comprehensive quality of technology and humanity integration.

This "Guidelines" suggests that the teaching activities of artificial intelligence consist of three parts: classroom teaching, design and development, and participation in activities. Through classroom teaching, knowledge acquisition is achieved. Through the development and production of experiential AI technology, students' learning effectiveness is tested. By participating in various activities, students' perspectives are expanded. At the same time, artificial intelligence technology should be fully utilized in three teaching activities to experience the scene and achievements of artificial intelligence empowering education.

1. Classroom teaching - an important platform for knowledge acquisition

The classroom teaching of artificial intelligence courses is an important platform for students to acquire knowledge of artificial intelligence, and also an important stage to show the personal talents of teachers. The theory of effective teaching considers that the effectiveness of teaching equals the total amount of teaching content multiplied by the

percentage of students accepting content. Therefore, the determining factors of effective teaching are students' enthusiasm, initiative, and concentration on classroom learning. In order to improve the effectiveness of classroom teaching, this "Guidelines" proposes the following suggestions.

(1) Change teaching concepts

Artificial intelligence course teachers, as organizers and guides of classroom teaching, play a leading role in optimizing classroom teaching. The quality of teachers' teaching concepts and professional skills plays a crucial role in optimizing classroom teaching. Therefore, teachers should follow the basic teaching guidance, and carefully design and implement classroom teaching.

(2) Advocate for new learning methods

China's basic education overemphasizes on receptive learning, rote memorization, and mechanical training. Therefore, artificial intelligence courses should emphasize changing students' learning methods and advocate the establishment of new learning methods, including autonomic learning, cooperative learning, and inquiry learning. Students are the main body of learning and they should be advocated for participation in determining learning goals, learning progress, and evaluation goals. In order to achieve interactive and communicative cooperative learning, and provide opportunities for students at different levels to participate in learning and experience success, during the inquiry learning, problem situations should be set up to encourage students to think actively, ask questions voluntarily, identify problems independently and autonomously, and learn through problem solving.

(3) Research on teaching content and methods

The content of artificial intelligence teaching should be adapted to the cognitive level of the teaching object, not only respecting the objective fact that students from

different regions have different starting points, but also assessing students' cognitive level to ensure the appropriateness of teaching goal positioning. Targeted teaching methods and strategies should be adopted for different teaching contents. Good teaching methods can enable students to grasp the organic connection and integration among knowledge points, and the key and difficult points of teaching can get effective breakthroughs. Teachers should adjust the preset teaching plan in a timely manner during the teaching process, and try to use vivid teaching language to present content, express concern and master the classroom. Teachers should have their own creativity in their lesson plans and teaching based on references to classic cases.

Teaching is a skill as well as an art. As a skill, it requires scientific teaching design and standardized implementation. As an art, teaching has the law, but no definite methods. Teachers should be able to transcend stereotypes and assumptions, learn to create classrooms, and stimulate the vitality of the classroom. It is recommended that teachers design contents from the perspective of teaching design and implement the classroom from the perspective of teaching art. Efforts should be made to achieve artistic teaching language, flexible teaching methods, emotional teaching processes, and strategic educational methods.

2. Practice link - the main battlefield for fostering comprehensive qualities

Students are the protagonists of artificial intelligence learning activities, while teachers are the organizers, leaders, and close partners of artificial intelligence learning activities. Teachers and students have complementary responsibilities. Teachers are responsible for developing correct teaching strategies to meet the different needs of different students. Therefore, in terms of teaching behavior, teachers should establish a teaching concept of "emphasizing experience,

experience and discover", provide students with opportunities for hands-on activities as much as possible, and let them learn and experience artificial intelligence on their own. The focus of artificial intelligence teaching is to guide each student through the process of "doing while learning" and "learning by doing", so that students can experience and discover in the process of active participation and initiative. Thus, stimulating students' interest and desire to learn artificial intelligence, lets them unconsciously enter the best state of learning and experience the endless joy of learning artificial intelligence.

According to the conditions of different schools and the learning content of different students, this "Guidelines" suggests that the practical aspects of artificial intelligence teaching can be divided into three types.

(1) Experience

The experiential learning of artificial intelligence requires students to "feel" through "doing", which pays more attention to inward learning, and emphasize the unity of knowledge and action. Traditional learning methods are like "observing swimming", while experiential learning methods are like "swimming on your own". During traditional learning the correct posture is explained through teachers and books, but students cannot learn to swim without experiencing it themselves. For everyone, learning from experience is the most basic and natural way of learning. Therefore, the enormous potential of experiential learning should be fully utilized in artificial intelligence teaching.

(2) Programming and Debugging

The practical aspect of programming and debugging is an important way to achieve the goals of artificial intelligence courses. During the process of using various programming platforms to write and debug artificial intelligence programs by students, learning interest can be effectively fostered, in the meantime, logical thinking ability, exploration ability, and

innovation ability can be improved.

(3) Participate in activities

The common forms for students to participate in artificial intelligence activities include: artificial intelligence competitions, artificial intelligence summer camps, artificial intelligence exhibitions, etc. Among them, various artificial intelligence competitions are the most attended, economical and popular activities. Artificial intelligence competitions are not only an objective test of learning effectiveness, but more importantly, they can cultivate students' rigorous and realistic work style and teamwork spirit. During the competition, students often encounter strong opponents, intense competition and unexpected problems. Encourage students to face difficulties and dare to compete, guide them to be good at analyzing and solving problems, as well as be good at negotiation, collaboration, mutual assistance and communication, and foster their team awareness and teamwork ability.

3. Reflect the integration of technology and humanities

The integration of technology and humanities is an inevitable way to cultivate high-quality talents. The focus of artificial intelligence teaching is not only on the knowledge of artificial intelligence itself, but more importantly, it is to cultivate, develop and enhance students' comprehensive qualities through artificial intelligence teaching.

The teaching of artificial intelligence should consider artificial intelligence knowledge and technology as the foundation and carrier, with the value and purpose of improving scientific and technological humanities literacy. To provide students with a good technological and humanistic environment, immersing them in an organic unity of scientific and humanistic spirit, not only allowing them to learn and master artificial intelligence knowledge and technology, but also allowing them to feel the significance of AI technology in improving their quality of life.

II. Evaluation suggestions

1. Main functions of the evaluation system

Evaluation is an organic component of artificial intelligence teaching and has a strong guiding effect on artificial intelligence learning. It is recommended that the artificial intelligence teaching evaluation system have the following main functions.

(1) Orientation function

Different evaluation criteria will produce different evaluation results, so the evaluation criteria are like a "baton" with guiding functions. Establish an evaluation system and develop evaluation standards based on course objectives. When formulating quality evaluation standards, attention should be paid to updating the education quality concept, promoting the transformation from exam-oriented education to quality education, and guiding teaching concepts, teaching methods, students' self-development needs to meet the overall direction and goals of artificial intelligence quality education from the perspective of improving the quality of talent cultivation and comprehensive quality.

(2) Diagnostic function

By implementing specific assessment content and methods for individual students, they can further accurately understand their abilities and specialties, face their weaknesses and deficiencies, identify gaps in various aspects, and develop their acquired qualities in a direction that is conducive to the development of their innate qualities. On the other hand, it is also beneficial for teachers to implement individualized teaching based on students' subjective and objective conditions.

(3) Incentive function

By comparing with the requirements of the evaluation system, teachers and students can be given the motivation to promote their performance, thereby better promoting their enthusiasm and initiative in teaching and learning,

motivating teachers and students to improve and catch up with the advanced.

(4) Communication and facilitation functions

During the evaluation process, through communication between evaluator and the appraised, as well as between each appraised, one can see the strong points of others and also can take notice of one’s own shortcomings, which is beneficial for different teachers or students to learn from each other and complement each other.

2. Design of teaching evaluation system

This "Guidelines" suggests that when designing an artificial intelligence course evaluation system, the following three aspects should be considered as the main focus.

(1) Evaluation content

The evaluation content should include two parts: classroom teaching evaluation for teachers and learning evaluation for students.

Classroom teaching evaluation: The establishment and implementation of an artificial intelligence classroom teaching evaluation system can promote teachers to quickly change their educational thinking, better leverage their educational innovation awareness in classroom teaching, and achieve the goal of improving classroom teaching. Classroom teaching evaluation can effectively evaluate the status, advantages and disadvantages of teachers' classroom teaching. It can also enable teachers to learn from each other in mutual listening/evaluation activities, and stimulate internal needs and motivation in communication, which is an important method to promote teachers' professional development. At the same time, classroom teaching evaluation is not only an important component of teacher job evaluation, but also the core content of the school evaluation system. By conducting scientific and effective classroom teaching evaluations, teachers' teaching attitudes, teaching quality, work abilities, and professional skills can be

effectively identified, making school management more systematic and decision-making more scientific.

Student learning evaluation: From the perspective of evaluation timing, the evaluation of student learning can be divided into two categories: process evaluation and summary evaluation. The evaluation of artificial intelligence courses should focus on students' self-reflection during the activity process. Diversified evaluation methods can help comprehensively reflect the knowledge gained by students in the course and their flexible application of knowledge. The evaluation should focus on students' performance and substantive achievements in the practical stage, and combined with AI knowledge test scores.

(2) Evaluation methods and means

Process evaluation: The "process" of process evaluation is relative to the "result" emphasized in summary evaluation, focusing on the process results of students' ability and quality development in the teaching process. Timely judgment of students' learning quality and level, affirmation of grades and identification of problems are important aspects of process evaluation. The main function of process evaluation is to reflect students' learning situation promptly, prompting them to actively reflect and summarize the learning process, rather than ultimately giving students a conclusion. Compared with other disciplines, the process evaluation methods in artificial intelligence courses are more diverse and easier to implement. We should pay attention to the comprehensive use of multiple evaluation methods and complement each other.

Summary evaluation: The design and implementation of summary evaluation should strive to comprehensively evaluate the true level of artificial intelligence literacy of each student, avoiding only emphasizing knowledge memory and skill practice, and neglecting students' ability to use learned knowledge to solve practical problems. Meanwhile, avoid

using exam systems or software with fixed questions and rigid forms to stifle students' desire for expression and creativity. In terms of evaluation methods, it is necessary to comprehensively use various methods and means such as paper-and-pencil tests, computer operation, social practice and process evaluation to evaluate students' learning outcomes and levels. Special attention should be paid to combining students' social practice and process evaluation results, and changing the one-sided approach of evaluating students' learning situation for a semester or the entire learning period solely based on a single test or exam. In terms of examination methods, objective items such as choice questions, gap filling, sequencing questions can be used for the assessment of basic knowledge and skills. Paper-and-pencil tests or computer-based exam systems can both be used. The design of questions and test papers should not only cover the knowledge and skills, but also awaken students' learning or operating experience through the design of the procedural characteristics of the questions, in order to improve the effectiveness of student skill evaluation. For ability assessment, it is necessary to use question types such as programming debugging for practical operations, or product design and production.

(3) Evaluation subject

The main participants in classroom teaching are teachers and students, so the design of teaching evaluation should require teachers and students to play a greater role in the evaluation. Modern teaching evaluation emphasizes self-renewal and self-regulation, and evaluates teaching jobs more from the perspective of self-acceptance. In terms of evaluation methods, self-evaluation is the main focus, constantly judging, reflecting and analyzing one's own classroom teaching activities, continuously improving oneself, and promoting the professional development of artificial intelligence course teachers.

Teaching evaluation should establish a diversified evaluation subject mainly based on teacher self-evaluation, with the participation of school leaders, students, teachers, experts, and patriarch, that is, combining self-evaluation, peer evaluation, expert evaluation, student evaluation, patriarch evaluation and leadership evaluation, so that teachers can obtain evaluation information from multiple channels and perspectives, continuously reflect on and improve themselves.

Establishing a multi-dimensional, multi-agent network evaluation system that combines external evaluation and self-evaluation, as well as internal and external evaluation, which is not only conducive to fully mobilizing the enthusiasm of teachers and students so that they can actively participate and cooperate in evaluation work, but also enhancing their awareness and ability of self-evaluation, which is conducive to self-feedback, self-regulation, self-education and self-improvement, thus promoting artificial intelligence course teachers to improve the education and teaching quality.

III. Suggestions for textbook compilation

Textbooks are an important carrier of courses, providing students with learning themes and knowledge structures, which are the main basis for students to engage in learning activities, and are important resources for teachers to achieve the goals of artificial intelligence courses and implement artificial intelligence teaching.

1. Positioning and Characteristics of Textbooks

The positioning of this "Guidelines" for artificial intelligence textbooks in primary and secondary schools is: a science and technology literacy education textbook aimed at cultivating students' thinking mode, technological perspective, innovation awareness and technological humanistic literacy in the era of intelligence. It is suggested to highlight the following teaching objectives and

characteristics:

(1) Enable students to understand that artificial intelligence uses artificial methods to present artificial systems with a certain level of intelligence, thereby making tools made by humans more labor-saving, time-saving, and worry-free to use. Intelligence is an inevitable trend in the development of information technology!

(2) Enable students to understand the basic concepts and problem-solving approaches of artificial intelligence. Pay attention to using easy-to-understand language, knowledge from high school related courses, and daily life experience to explain the relevant principles involved in artificial intelligence, rather than attempting to explain relevant algorithms or technical principles using knowledge in fields such as mathematics, control and mechatronics.

(3) Cultivate students' correct understanding of artificial intelligence, help teenagers understand the application scenarios of AI technology, experience the sense of gain brought by AI technology, eliminate strangeness and fear, and become masters of the era of artificial intelligence.

(4) Artificial intelligence is a comprehensive science of multiple disciplines, and the learning materials selected in textbooks should appropriately reflect the development and application of these disciplines, and be linked to students' life experiences and cognitive characteristics.

(5) The presentation of textbook content should reflect the overall nature of artificial intelligence knowledge, as well as the emergence, development, application process of the important artificial intelligence technologies.

(6) The compilation of textbooks should be conducive to mobilizing the initiative and enthusiasm of teachers, and be conducive to their creative teaching.

2. Content organization and exploration

The artificial intelligence knowledge system recommended in this “Guidelines" provides a basic basis for

organizing the content of artificial intelligence textbooks for each stage. Artificial intelligence technology covers a wide range of subject knowledge. The "Guidelines" has conducted in-depth and systematic exploration and sorting of the content of artificial intelligence courses in primary and secondary schools, which has formed nine knowledge modules. However, there is obviously still vast space for textbook developers and implementers to explore. Therefore, the textbook should not only reflect the basic requirements of the "Guidelines", but also provide more vivid and rich details in the course content.

3. The Value of Content

(1) Provide convenience for implementing comprehensive quality training

The content design of textbooks should facilitate teachers to organize students to raise questions, guess results, develop plans, observe experiments, engage in hands-on and brainstorming activities, personally practice, participate in competitions and exchanges, meanwhile, provide convenience for implementing comprehensive quality cultivation based on perception and experience. So as to achieve the goal of improving students' comprehensive quality, rather than simply imparting AI knowledge to students through lectures.

(2) Emphasize students' life experiences

The "Guidelines" emphasizes the role of students' life experiences in learning artificial intelligence courses, and the content of the textbook should reflect this spirit. Through the integration of theory with practice, students will be trained to use the knowledge learned in artificial intelligence courses to solve practical problems, so that students can understand the practical value of artificial intelligence technology.

(3) Facilitate students to build knowledge and improve abilities

The content of the textbook should comply with the

cognitive rules of students in each stage, from easy to difficult, from concrete to abstract, from simple to complex, and step by step, in order to facilitate students' gradual construction of knowledge and improvement of abilities. Primary school textbooks mainly focus on cultivating students' strong interest, understanding, and experience in artificial intelligence. Junior high school textbooks mainly aim to stimulate students' initiative in learning artificial intelligence, and learn the basic knowledge and concepts of artificial intelligence. High school (or secondary vocational education) textbooks mainly focus on learning concepts, principles, and methods related to artificial intelligence, cultivating students' innovative spirit and practical abilities, and conducting comprehensive practical exploration activities.

4. Presentation of content

(1) The form is vivid and lively

The presentation form of the textbook should be lively and illustrated. The written description should be in line with the age characteristics of each stage of study, making it easy for students to read and understand. Pictures are an important form of presenting scientific contexts, and their characteristics of being vivid, intuitive, easy to understand, and interesting should be fully utilized.

(2) Transmit multiple messages

Textbooks should convey various valuable educational information, which are valuable resources and have a subtle educational effect on students. For example, the development and application of artificial intelligence technology contains humanistic spirit, permeates the cultivation of social responsibility, reflects the scientific guidance of students' correct value orientation, emphasizes the modern consciousness of coordinated development between humans, nature, society, and so on.

5. Content flexibility

Artificial intelligence education in primary and secondary schools in China has just started, and there are significant differences in funding, infrastructure, teacher level, evaluation system, and other aspects of implementing artificial intelligence education in different regions. The course offerings are uneven, and there are significant differences in student starting points. Therefore, on the premise of meeting the basic requirements, the content of artificial intelligence textbooks should reflect a certain degree of flexibility to meet the different needs of students and facilitate teachers to play roles in their teaching creativity.

IV. Suggestions for Teacher Development

In order to strengthen the construction of the talent team of artificial intelligence teachers in primary and secondary schools, quickly fill their teaching positions, fully play roles in their creativity, as well as improve the teaching level of artificial intelligence courses, the development suggestions for artificial intelligence teachers in this "Guidelines" are as follows.

1. Improve ideological and political qualities and strengthen teacher ethics construction

This course aims to comprehensively improve students' comprehensive quality with artificial intelligence as the carrier, and requires teachers to possess comprehensive ideological and political qualities to help and guide students to form correct worldviews, outlooks on life, and values.

Carry out various forms of teacher ethics education, pay attention to teacher professional ideals, professional ethics, academic norms, mental health education, and undertake the heavy responsibility of imparting knowledge and cultivating people.

2. Strive to improve professional abilities and focus on interdisciplinary knowledge learning

Artificial intelligence teachers are the core force in the

implementation of this course. In addition to possessing the basic abilities of a teacher, they should strive to improve their professional abilities. Teachers should not only proficiently master the basic knowledge related to artificial intelligence courses, but also understand the significant technological advancements and latest application achievements in the field of artificial intelligence, as well as important domestic and international artificial intelligence competitions, and guide students to actively participate.

According to the characteristics of artificial intelligence as a comprehensive multidisciplinary discipline, teachers are required to have the ability to connect artificial intelligence knowledge with other disciplines in primary and secondary schools from an interdisciplinary perspective.

3. Establish a learning, training and communication mechanism

To adapt to the rapid development of artificial intelligence technology, it is necessary to establish a teacher learning and training mechanism, accelerate knowledge updating, learn new knowledge with specific characteristics of the times, absorb new concepts, and continuously enrich the ability to connect theory with practice and solve practical problems.

Strengthen communication and exchange between artificial intelligence teachers, achieve information exchange, learn from each other's strong points to offset one’s weakness, and continuously improve teaching standards. Teachers of artificial intelligence courses should regularly attend technical lectures by experts and scholars in artificial intelligence, so that they can utilize opportunities to communicate with various artificial intelligence teaching experts and course experts, which can explore and exchange new trends in the development of artificial intelligence technology and artificial intelligence education, so as to improve academic level.

4. Improve practical and innovative abilities

Encourage teachers to participate in high-level artificial intelligence teaching and research innovation teams, actively participate in various teaching and research activities at all levels, undertake relevant teaching and research topics on their own initiative, actively carry out comprehensive practical activities of artificial intelligence, adhere to bold exploration in practical teaching, innovate teaching models and methods, and finally improve teachers' practical and innovative abilities.

附录　人工智能常用术语中英文对照

阿西莫夫（机器人)三守则	Asimov’s laws
半监督学习	semi-supervised learning
编码	coding
变换	transform
变异	mutation
遍历搜索	ergodic search
表示与推理	representation & reasoning
波形	waveform
波形编码	waveform coding
波形分析	waveform analysis
不确定性	uncertainty
布尔逻辑	Boolean logic
采样,抽样	sampling
操作，运算	operation
槽	slot
槽名	slot name
槽值	slot value
策略	policy，strategy
查询	query
产生式规则	production rule
产生式系统	production system
抽取	elicitation
初始化	initialization
传感器	sensor
传感系统	sensory system
词频分布	word frequency distribution
词素	morpheme
倒谱分析	cepstral analysis
递归，回归	regression
迭代算法	iterative algorithm
定理证明	theorem proving
多传感器信息融合	multi-sensor information fusion
反馈	feedback
反向传播算法,BP 算法	back-propagation algorithm
分布式处理	distributed processing
分类	classification
蜂群算法	bee colony algorithm
冯·诺依曼计算机	Von Neumann computer (machine)
服务机器人	service robot

符号函数	sign function
符号推理	symbolic reasoning
符号主义	symbolism
概率	probability
感受器	receptor
感知器	perceptron
工业机器人	industrial robot
规划、计划	planning
规则	law，rule
规则库	rule base (RB)
轨迹	trajectory
猴子和香蕉问题	monkey and bananas problem
回归神经网络	Regression Neural Network (GRNN)
机器定理证明	mechanical theorem proving
机器翻译	Machine Translation (MT)
机器人	robot
机器视觉	machine vision
机器学习	machine learning
机器智能	Machine Intelligence (MI)
激活函数	activation function
监督学习	Supervised learning
建模	modeling
交叉	crossover
交互	interaction
进化算法	Evolution Algorithm (EA)
竞争学习	Competition Learning (CL)
矩阵	matrix
句法分析	syntactic parsing
聚类	clustering
卷积	convolution
卷积神经网络	Convolution Neural Network (CNN)
决策	decision, decision making
决策支持系统	Decision Support System (DSS)
宽(广)度优先搜索	Breadth First Search (BFS)
狼群算法	wolf colony algorithm, wolf pack algorithm
粒子群算法	particle swarm optimization
联结主义	connectionism
联想记忆	association memory
聊天机器人	talk bot
邻域	neighborhood
路径规划	path planning

盲目随机搜索法	blind random search
枚举法	enumeration method
描述	description
命题	proposition
模板	template
模式	pattern
模式匹配	pattern matching
模式识别	pattern recognition
目标跟踪	object tracking
目标函数	object function
目标检测	object detection
期望值	expected value
启发式规则	heuristic rule
启发式搜索	heuristic search
前馈网络	Feed Forward Network (FFN)
强化学习，增强学习	reinforcement learning
情感计算	affective computing
穷举法	exhaust algorithm
权，权重	weight
权矩阵	weight matrix
全局极小，全局最小	global minimum
全局优化	global optimization
确定性	deterministic
群体智能	Swarm Intelligence (SI)
染色体表达	chromosome representation
人工神经网络	Artificial Neural Network (ANN)
人工生命	artificial life
人工智能	Artificial Intelligence （AI）
人机交互	Human-Computer Interaction (HCI)
人机接口	human-machine interface
人机界面	man-machine interface
人脸表情识别	facial expression recognition
人脸识别	face recognition
人造皮肤，人工皮肤	artificial skin
人造系统	artificial system
认知	cognition
认知神经科学	cognitive neuroscience
认知生理学	cognitive physiology
任务，作业	task
容错性	tolerance error
融合	fusion

三目图像	trinocular image
三维视觉	three-dimension vision
上下文,语境	context
上下文无关语言	context-free language
上下文相关语言	context-sensitive language
深度神经网络	Deep Neural Network (DNN)
深度学习	deep learning
深度优先搜索	depth first search
神经元	neuron
生物传感器	biosensor
生物神经网络	Biological Neural Network (BNN)
生物特征识别	biometric recognition
声纹	voiceprint
声音识别系统	sound recognition system
胜者全得，胜者为王	winner-take-all
识别率	rate of recognition
示教学习	learning from induction
示教再现型机器人	Playback robot
试探法	heuristic approach
视觉传感器	vision sensor
适应度	fitness
适应性，自适应性	adaptivity
适者生存	survival of fitness
收敛	convergence
手写体汉字识别	hand-written Chinese character recognition
输出层	output layer
输入层	input layer
输入输出模型	input-output model
树突	dendrite
数据变换	data transformation
数据采集	data collection
数据仓库	data warehousing
数据处理	data processing
数据建模	data modeling
数据结构	data structure
数据可视化	data visualization
数据库	Data Base (DB)
数据驱动	data driven
数据融合	data fusion
数据挖掘	data mining

数字图像	digital image
双目图像	binocular image
说话人识别	Speaker Recognition (SR)
说话人无关识别	speaker-independent recognition
说话人相关识别	speaker-dependent recognition
搜索策略	searching strategy
搜索空间	search space
搜索求解	search finding
搜索算法	searching algorithm
搜索图	searching graph
搜索引擎	search engine
算法	algorithm
随机搜索	stochastic searching
随机性	randomness
拓扑学	topology
贪心搜索	greedy search
特征	feature
特征描述	characteristic description
特征识别	feature recognition
特征提取	feature extraction
特征向量	feature vector
特征选取	feature selection
特征值	eigenvalue
梯度	gradient
梯度下降算法	gradient descent Algorithm
听觉传感器	acoustic sensor
统计法	statistical approach
突触	synapse
突触间隙	synaptic cleft
突触可塑性	synaptic plasticity
图灵测试	Turing test
图像	image
图像采集	image capture
图像赴理	image processing
推理，推断	inference
推理机	inference machine
外感受器	exteroceptor
网格计算	grid computing
位置传感器	position sensor
谓词	predicate
谓词符号	predicate symbol

谓词公式	predicate formula
谓词逻辑	predicate logic
谓词演算	predicate calculus
温度传感器	temperature sensor
文(字)-语(音)转换	text-to-speech conversion
文本	text
文本数据挖掘	text mining
文本无关识别系统	text-independent recognition system
文本相关识别系统	text-dependent recognition system
文本信息抽取	text information extraction
稳定性	stability
问答系统	question answering system
问题表示	problem representation
问题求解	problem solving
无监督学习	unsupervised learning
误差	error
误差反向传播算法	error back-propagation algorithm
误差分析	error analysis
误差函数	error function
习（获)得	acquisition
系数	coefficient
系统	system
细胞神经网络	Cellular Neural Network (CNN)
先验知识	prior knowledge
线性分类	linear classification
线性回归	linear regression
线性可分的	linearly separable
线性判别函数	linear discriminant function
香农采样定理	Shannon sampling theorem
向量，矢量	vector
像素	pixel
信号处理	signal processing
信息抽取	information extraction
信息技术	information technology
行为主义	actionism
形式逻辑	formal logic
虚拟现实	Virtual Reality (VR)
学习机	learning machine
训练	training
训练过程	training procedure
训练集	training set

训练数据	training data
压觉传感器	pressure sensor
演绎	deduction
样本集	sample set
一阶逻辑	first-order logic
移动式机器人	mobile robot
遗传算法	genetic algorithm
遗传算法	Genetic Algorithm (GA)
蚁群算法	ant colony algorithm
音素	phoneme
音文转换	speech to text
隐(藏)神经元	hidden neuron
应力传感器	stress sensor
用户词典	user specific dictionary
优化技术	optimization technique
鱼群算法	fish swarm algorithm
语料库	corpus
语音处理	speech processing
语音识别	speech recognition
阈值	threshold
噪声	noise
掌纹识别	palmprint recognition
正向传播	forward propagation
正向搜索	forward search
正向推理	forward reasoning
支持向量机	Support Vector Machine(SVM)
知识表示	knowledge representation
知识抽取	knowledge elicitation
知识处理	knowledge processing
知识发现	knowledge discovery
知识工程	knowledge engineering
知识获取	knowledge acquisition
指纹识别	fingerprint recognition, fingerprint identification
智能，智力	intelligence
智能车	intelligent vehicle
智能传感器	intelligent sensor
智能的	intelligent
智能机器人	intelligent robot
智能决策	intelligent decision making
智能搜索引擎	intelligence search engine

智能体	agent
智能体	intelligent agent
种群，群体	population
主成分(分量)分析	Principal Component Analysis (PCA)
专家系统	expert system
自然语言处理	Natural Language Processing(NLP)
自然语言理解	natural language understanding
自适应	adaptive, self-adapting
自学习	self learning
自诊断能力	self detective ability
自主机器人	autonomous robot
自组织	self organizing
最小二乘法	Least Square Method (LSM)
最小化	minimizing
最优化	optimization