1. Basics

1.1 Artificial Intelligence

Artificial intelligence (AI) is intelligence demonstrated by machines, as opposed to natural intelligence displayed by animals including humans. Leading AI textbooks define the field as the study of "intelligent agents": any system that perceives its environment and takes actions that maximise its chance of achieving its goals.

Some popular accounts use the term "artificial intelligence" to describe machines that mimic "cognitive" functions that humans associate with the human mind, such as "learning" and "problem solving", however, this definition is rejected by major AI researchers.

AI applications include advanced web search engines (e.g., Google), recommendation systems (used by YouTube, Amazon and Netflix), understanding human speech (such as Siri and Alexa), self-driving cars (e.g., Tesla), automated decision-making and competing at the highest level in strategic game systems (such as chess and Go). As machines become increasingly capable, tasks considered to require "intelligence" are often removed from the definition of AI, a phenomenon known as the AI effect. For instance, optical character recognition is frequently excluded from things considered to be AI, having become a routine technology.

Artificial intelligence was founded as an academic discipline in 1956, and in the years since has experienced several waves of optimism, followed by disappointment and the loss of funding (known as an "AI winter"), followed by new approaches, success and renewed funding. AI research has tried and discarded many different approaches since its founding, including simulating the brain, modelling human problem solving, formal logic, large databases of knowledge and imitating animal behaviour. In the first decades of the 21st century, highly mathematical statistical machine learning has dominated the field, and this technique has proved highly successful, helping to solve many challenging problems throughout industry and academia.

The various sub-fields of AI research are centred around particular goals and the use of particular tools. The traditional goals of AI research include reasoning, knowledge representation, planning, learning, natural language processing, perception, and the ability to move and manipulate objects. General intelligence (the ability to solve an arbitrary problem) is among the field's long-term goals. To solve these problems, AI researchers have adapted and integrated a wide range of problem-solving techniques—including search and mathematical optimisation, formal logic, artificial neural networks, and methods based on statistics, probability and economics. AI also draws upon computer science, psychology, linguistics, philosophy, and many other fields.

The field was founded on the assumption that human intelligence "can be so precisely described that a machine can be made to simulate it". This raises philosophical arguments about the mind and the ethics of creating artificial beings endowed with human-like intelligence. These issues have been explored by myth, fiction, and philosophy since antiquity. Science fiction and futurology have also suggested that, with its enormous potential and power, AI may become an existential risk to humanity.

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1.2 Vector Space

In mathematics, physics, and engineering, a vector space (also called a linear space) is a set of objects called vectors, which may be added together and multiplied ("scaled") by numbers called scalars. Scalars are often real numbers, but some vector spaces have scalar multiplication by complex numbers or, generally, by a scalar from any mathematic field. The operations of vector addition and scalar multiplication must satisfy certain requirements, called vector axioms (listed below in ğ Notation and definition). To specify whether the scalars in a particular vector space are real numbers or complex numbers, the terms real vector space and complex vector space are often used.

Certain sets of Euclidean vectors are common examples of a vector space. They represent physical quantities such as forces, where any two forces of the same type can be added to yield a third, and the multiplication of a force vector by a real multiplier is another force vector. In the same way (but in a more geometric sense), vectors representing displacements in the plane or three-dimensional space also form vector spaces. Vectors in vector spaces do not necessarily have to be arrow-like objects as they appear in the mentioned examples: vectors are regarded as abstract mathematical objects with particular properties, which in some cases can be visualised as arrows.

Vector spaces are the subject of linear algebra and are well characterised by their dimension, which, roughly speaking, specifies the number of independent directions in the space. Infinitedimensional vector spaces arise naturally in mathematical analysis as function spaces, whose vectors are functions. These vector spaces are generally endowed with some additional structure such as a topology, which allows the consideration of issues of proximity and continuity. Among these topologies, those that are defined by a norm or inner product are more commonly used (being equipped with a notion of distance between two vectors). This is particularly the case of Banach spaces and Hilbert spaces, which are fundamental in mathematical analysis.

Historically, the first ideas leading to vector spaces can be traced back as far as the 17th century's analytic geometry, matrices, systems of linear equations, and Euclidean vectors. The modern, more abstract treatment, first formulated by Giuseppe Peano in 1888, encompasses more general objects than Euclidean space, but much of the theory can be seen as an extension of classical geometric ideas like lines, planes and their higher-dimensional analogs.

Today, vector spaces are applied throughout mathematics, science and engineering. They are the appropriate linear-algebraic notion to deal with systems of linear equations. They offer a framework for Fourier expansion, which is employed in image compression routines, and they provide an environment that can be used for solution techniques for partial differential equations. Furthermore, vector spaces furnish an abstract, coordinate-free way of dealing with geometrical and physical objects such as tensors. This in turn allows the examination of local properties of manifolds by linearisation techniques. Vector spaces may be generalised in several ways, leading to more advanced notions in geometry and abstract algebra.

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1.3 Turing Completeness

In computability theory, a system of data-manipulation rules (such as a computer's instruction set, a programming language, or a cellular automaton) is said to be Turing-complete or computationally universal if it can be used to simulate any Turing machine. This means that this system is able to recognise or decide other data-manipulation rule sets. Turing completeness is used as a way to express the power of such a data-manipulation rule set. Virtually all programming languages today are Turing-complete. The concept is named after English mathematician and computer scientist Alan Turing.

A related concept is that of Turing equivalence –two computers P and Q are called equivalent if P can simulate Q and Q can simulate P. The Church–Turing thesis conjectures that any function whose values can be computed by an algorithm can be computed by a Turing machine, and therefore that if any real-world computer can simulate a Turing machine, it is Turing equivalent to a Turing machine. A universal Turing machine can be used to simulate any Turing machine and by extension the computational aspects of any possible real-world computer.

To show that something is Turing-complete, it is enough to show that it can be used to simulate some Turing-complete system. For example, an imperative language is Turing-complete if it has conditional branching (e.g., "if" and "goto" statements, or a "branch if zero" instruction; see one-instruction set computer) and the ability to change an arbitrary amount of memory (e.g., the ability to maintain an arbitrary number of data items). No physical system can have infinite memory, but if the limitation of finite memory is ignored, most programming languages are otherwise Turing-complete.

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1.4 Turing Test

The Turing test, originally called the imitation game by Alan Turing in 1950, is a test of a machine's ability to exhibit intelligent behaviour equivalent to, or indistinguishable from, that of a human. Turing proposed that a human evaluator would judge natural language conversations between a human and a machine designed to generate human-like responses. The evaluator would be aware that one of the two partners in conversation is a machine, and all participants would be separated from one another. The conversation would be limited to a text-only channel such as a computer keyboard and screen so the result would not depend on the machine's ability to render words as speech. If the evaluator cannot reliably tell the machine from the human, the machine is said to have passed the test. The test results do not depend on the machine's ability to give correct answers to questions, only how closely its answers resemble those a human would give.

The test was introduced by Turing in his 1950 paper "Computing Machinery and Intelligence" while working at the University of Manchester. It opens with the words: "I propose to consider the question, 'Can machines think?'" Because "thinking" is difficult to define, Turing chooses to "replace the question by another, which is closely related to it and is expressed in relatively unambiguous words." Turing describes the new form of the problem in terms of a three-person game called the "imitation game", in which an interrogator asks questions of a man and a woman in another room in order to determine the correct sex of the two players. Turing's new question is: "Are there imaginable digital computers which would do well in the imitation game?" This question, Turing believed, is one that can actually be answered. In the remainder of the paper, he argued against all the major objections to the proposition that "machines can think".

Since Turing first introduced his test, it has proven to be both highly influential and widely criticised, and it has become an important concept in the philosophy of artificial intelligence. Some of these criticisms, such as John Searle's Chinese room, are themselves controversial.

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1.5 Expert System

In artificial intelligence, an expert system is a computer system emulating the decision-making ability of a human expert. Expert systems are designed to solve complex problems by reasoning through bodies of knowledge, represented mainly as if–then rules rather than through conventional procedural code. The first expert systems were created in the 1970s and then proliferated in the 1980s. Expert systems were among the first truly successful forms of artificial intelligence (AI) software. An expert system is divided into two subsystems: the inference engine and the knowledge base. The knowledge base represents facts and rules. The inference engine applies the rules to the known facts to deduce new facts. Inference engines can also include explanation and debugging abilities.

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1.6 AI winter

In the history of artificial intelligence, an AI winter is a period of reduced funding and interest in artificial intelligence research. The term was coined by analogy to the idea of a nuclear winter. The field has experienced several hype cycles, followed by disappointment and criticism, followed by funding cuts, followed by renewed interest years or decades later.

The term first appeared in 1984 as the topic of a public debate at the annual meeting of AAAI (then called the "American Association of Artificial Intelligence"). It is a chain reaction that begins with pessimism in the AI community, followed by pessimism in the press, followed by a severe cutback in funding, followed by the end of serious research. At the meeting, Roger Schank and Marvin Minsky—two leading AI researchers who had survived the "winter" of the 1970s—warned the business community that enthusiasm for AI had spiraled out of control in the 1980s and that disappointment would certainly follow. Three years later, the billion-dollar AI industry began to collapse.

Hype is common in many emerging technologies, such as the railway mania or the dot-com bubble. The AI winter was a result of such hype, due to over-inflated promises by developers, unnaturally high expectations from end-users, and extensive promotion in the media. Despite the rise and fall of AI's reputation, it has continued to develop new and successful technologies. AI researcher Rodney Brooks would complain in 2002 that "there's this stupid myth out there that AI has failed, but AI is around you every second of the day." In 2005, Ray Kurzweil agreed: "Many observers still think that the AI winter was the end of the story and that nothing since has come of the AI field. Yet today many thousands of AI applications are deeply embedded in the infrastructure of every industry."

Enthusiasm and optimism about AI has generally increased since its low point in the early

1990s. Beginning about 2012, interest in artificial intelligence (and especially the sub-field of machine learning) from the research and corporate communities led to a dramatic increase in funding and investment.

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1.7 ImageNet

The ImageNet project is a large visual database designed for use in visual object recognition software research. More than 14 million images have been hand-annotated by the project to indicate what objects are pictured and in at least one million of the images, bounding boxes are also provided. ImageNet contains more than 20,000 categories with a typical category, such as "balloon" or "strawberry", consisting of several hundred images. The database of annotations of third-party image URLs is freely available directly from ImageNet, though the actual images are not owned by ImageNet. Since 2010, the ImageNet project runs an annual software contest, the ImageNet Large Scale Visual Recognition Challenge (ILSVRC), where software programs compete to correctly classify and detect objects and scenes. The challenge uses a "trimmed" list of one thousand non-overlapping classes.

Please refer to `https://www.image-net.org`

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1.8 COCO

The MS COCO dataset is a large-scale object detection, segmentation, and captioning dataset published by Microsoft. Machine Learning and Computer Vision engineers popularly use the COCO dataset for various computer vision projects.

Understanding visual scenes is a primary goal of computer vision; it involves recognising what objects are present, localising the objects in 2D and 3D, determining the object's attributes, and characterising the relationship between objects. Therefore, algorithms for object detection and object classification can be trained using the dataset.

Please refer to `https://cocodataset.org`

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1.9 MNIST

The MNIST database (Modified National Institute of Standards and Technology database) is a large database of handwritten digits that is commonly used for training various image processing systems. The database is also widely used for training and testing in the field of machine learning. It was created by "re-mixing" the samples from NIST's original datasets. The creators felt that since NIST's training dataset was taken from American Census Bureau employees, while the testing dataset was taken from American high school students, it was not well-suited for machine learning experiments. Furthermore, the black and white images from NIST were normalized to fit into a 28x28 pixel bounding box and anti-aliased, which introduced grayscale levels.

The MNIST database contains 60,000 training images and 10,000 testing images. Half of the training set and half of the test set were taken from NIST's training dataset, while the other half of the training set and the other half of the test set were taken from NIST's testing dataset. The original creators of the database keep a list of some of the methods tested on it. In their original paper, they use a support-vector machine to get an error rate of 0.8%. An extended dataset similar to MNIST called EMNIST has been published in 2017, which contains 240,000 training images, and 40,000 testing images of handwritten digits and characters.

Please refer to `http://yann.lecun.com/exdb/mnist/`

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1.10 CIFAR-10

The CIFAR-10 dataset (Canadian Institute For Advanced Research) is a collection of images that are commonly used to train machine learning and computer vision algorithms. It is one of the most widely used datasets for machine learning research. The CIFAR-10 dataset contains 60,000 32x32 color images in 10 different classes. The 10 different classes represent airplanes, cars, birds, cats, deer, dogs, frogs, horses, ships, and trucks. There are 6,000 images of each class.

Computer algorithms for recognizing objects in photos often learn by example. CIFAR-10 is a set of images that can be used to teach a computer how to recognize objects. Since the images in CIFAR-10 are low-resolution (32x32), this dataset can allow researchers to quickly try different algorithms to see what works. Various kinds of convolutional neural networks tend to be the best at recognizing the images in CIFAR-10.

CIFAR-10 is a labeled subset of the 80 million tiny images dataset. When the dataset was created, students were paid to label all of the images.

Please refer to `https://www.cs.toronto.edu/~kriz/cifar.html`

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1.11 iris

The Iris flower data set or Fisher's Iris data set is a multivariate data set introduced by the British statistician and biologist Ronald Fisher in his 1936 paper The use of multiple measurements in taxonomic problems as an example of linear discriminant analysis. It is sometimes called Anderson's Iris data set because Edgar Anderson collected the data to quantify the morphologic variation of Iris flowers of three related species. Two of the three species were collected in the Gaspé Peninsula "all from the same pasture, and picked on the same day and measured at the same time by the same person with the same apparatus". The data set consists of 50 samples from each of three species of Iris (Iris setosa, Iris virginica and Iris versicolor). Four features were measured from each sample: the length and the width of the sepals and petals, in centimeters. Based on the combination of these four features, Fisher developed a linear discriminant model to distinguish the species from each other. Fisher's paper was published in the Annals of Eugenics and includes discussion of the contained techniques' applications to the field of Phrenology. This history has led some to suggest discontinuing use of the Iris dataset for teaching statistical techniques today and replacing it with less-controversial alternatives.

Please refer to `https://archive.ics.uci.edu/ml/datasets/iris`

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1.12 diamonds

This classic dataset contains the prices and other attributes of almost 54,000 diamonds. It's a great dataset for beginners learning to work with data analysis and visualisation.

Please refer to `https://www.kaggle.com/shivam2503/diamonds`

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1.13 tips

数据集部分

建议同学们可以以鸢尾花（iris）数据集、MNIST 手写数字数据集和钻石预测（diamonds）数据集作为开始阶段主要研究的数据内容。结合 python（推荐）、matlab、java 等编程环境进行数据的读取和可视化。以上三个数据集可以较好的衔接线性分类、线性回归、决策树、聚类分析、基础神经网络的实践研究。

Windows 操作系统配置独立 python 环境简介

- **Download** Anaconda 官网下载地址：https://www.anaconda.com/download/ 选择合适版本（例如：Python 3.X 64-Bit Graphical Installer XXX MB）进行安装。在 Option 部分请勾选'Add Anaconda to my PATH environment variable' 和'Register Anaconda as my default Python 3.X'。
- **Run**

不同于 windows 中自带的 cmd，运行 anaconda 建议用其提供的 Anaconda Prompt 作为命令行窗口的入口。进入后会自动运行 base 环境（显示在最左侧的括号中）。利用'conda create -n #name python=3.X' 进行新环境的创建。

- **Configuration**

  利用‘conda activate #name’进行环境激活，再根据实际需求进行环境包的安装。

1.14 推荐网课

- **MIT - Artificial Intelligence**

  Please refer to `https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-034-artificial-intelligence-fall-2010/`

  Please refer to `https://www.bilibili.com/video/BV1P7411Y7Ud?from=search&seid=15735912017069167604&spm_id_from=333.337.0.0`（B 站）

- **Stanford - Artificial Intelligence**

  Please refer to `https://stanford-cs221.github.io/autumn2021/`

  Please refer to `https://www.bilibili.com/video/BV1F5411577v?from=search&seid=6679675963457853344&spm_id_from=333.337.0.0`（B 站）