

What is Artificial Intelligence?

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Artificial Intelligence (AI) is usually defined as the science of making computers do things that require intelligence when done by humans. AI has had some success in limited, or simplified, domains. However, the five decades since the inception of AI have brought only very slow progress, and early optimism concerning the attainment of human-level intelligence has given way to an appreciation of the profound difficulty of the problem.

What is Intelligence?

Quite simple human behaviour can be intelligent yet quite complex behaviour performed by insects is unintelligent. What is the difference? Consider the behaviour of the digger wasp, *Sphex ichneumoneus*. When the female wasp brings food to her burrow, she deposits it on the threshold, goes inside the burrow to check for intruders, and then if the coast is clear carries in the food. The unintelligent nature of the wasp's behaviour is revealed if the watching experimenter moves the food a few inches while the wasp is inside the burrow checking. On emerging, the wasp repeats the whole procedure: she carries the food to the threshold once again, goes in to look around, and emerges. She can be made to repeat this cycle of behaviour upwards of forty times in succession. **Intelligence--conspicuously absent in the case of *Sphex*--is the ability to adapt one's behaviour to fit new circumstances.**

Mainstream thinking in psychology regards human intelligence not as a single ability or cognitive process but rather as an array of separate components. Research in AI has focussed chiefly on the following components of intelligence: learning, reasoning, problem-solving, perception, and language-understanding.

Learning

Learning is distinguished into a number of different forms. **The simplest is learning by trial-and-error.** For example, a simple program for solving mate-in-one chess problems might try out moves at random until one is found that achieves mate. The program remembers the successful move and next time the computer is given the same problem it is able to produce the answer immediately. **The simple memorising of individual items--solutions to problems, words of vocabulary, etc.--is known as rote learning.**

Rote learning is relatively easy to implement on a computer. More challenging is the problem of implementing what is called generalisation. Learning that involves generalisation leaves the learner able to perform better in situations not previously encountered. A program that learns past tenses of regular English verbs by rote will not be able to produce the past tense of e.g. "jump" until presented at least once with "jumped", whereas a program that is able to generalise from examples can learn the

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"add-ed" rule, and so form the past tense of "jump" in the absence of any previous encounter with this verb. Sophisticated modern techniques enable programs to generalise complex rules from data.

Reasoning

To reason is to draw inferences appropriate to the situation in hand. Inferences are classified as either deductive or inductive. An example of the former is "Fred is either in the museum or the café; he isn't in the café; so he's in the museum", and of the latter "Previous accidents just like this one have been caused by instrument failure; so probably this one was caused by instrument failure". The difference between the two is that in the deductive case, the truth of the premisses guarantees the truth of the conclusion, whereas in the inductive case, the truth of the premiss lends support to the conclusion that the accident was caused by instrument failure, but nevertheless further investigation might reveal that, despite the truth of the premiss, the conclusion is in fact false.

There has been considerable success in programming computers to draw inferences, especially deductive inferences. However, a program cannot be said to reason simply in virtue of being able to draw inferences. Reasoning involves drawing inferences that are relevant to the task or situation in hand. One of the hardest problems confronting AI is that of giving computers the ability to distinguish the relevant from the irrelevant.

Problem-solving

Problems have the general form: given such-and-such data, find x. A huge variety of types of problem is addressed in AI. Some examples are: finding winning moves in board games; identifying people from their photographs; and planning series of movements that enable a robot to carry out a given task.

Problem-solving methods divide into special-purpose and general-purpose. A special-purpose method is tailor-made for a particular problem, and often exploits very specific features of the situation in which the problem is embedded. A general-purpose method is applicable to a wide range of different problems. One general-purpose technique used in AI is means-end analysis, which involves the step-by-step reduction of the difference between the current state and the goal state. The program selects actions from a list of means--which in the case of, say, a simple robot, might consist of pickup, putdown, moveforward, moveback, moveleft, and moveright--until the current state is transformed into the goal state.

Perception

In perception the environment is scanned by means of various sense-organs, real or artificial, and processes internal to the perceiver analyse the scene into objects and their features and relationships. Analysis is complicated by the fact that one and the same object may present many different appearances on different occasions, depending on the angle from which it is viewed, whether or not parts of it are projecting shadows, and so forth.

At present, artificial perception is sufficiently well advanced to enable a self-controlled car-like device to drive at moderate speeds on the open road, and a mobile robot to roam through a suite of busy offices searching for and clearing away empty soda cans. One of the earliest systems to integrate perception and action was **FREDDY**, a stationary robot with a moving TV 'eye' and a pincer 'hand' (constructed at Edinburgh University during the period 1966-1973 under the direction of Donald Michie). FREDDY

was able to recognise a variety of objects and could be instructed to assemble simple artefacts, such as a toy car, from a random heap of components.

Language-understanding

A language is a system of signs having meaning by convention. Traffic signs, for example, form a mini-language, it being a matter of convention that, for example, the hazard-ahead sign means hazard ahead. This meaning-by-convention that is distinctive of language is very different from what is called natural meaning, exemplified in statements like 'Those clouds mean rain' and 'The fall in pressure means the valve is malfunctioning'.

An important characteristic of full-fledged human languages, such as English, which distinguishes them from, e.g. bird calls and systems of traffic signs, is their *productivity*. A productive language is one that is rich enough to enable an unlimited number of different sentences to be formulated within it.

It is relatively easy to write computer programs that are able, in severely restricted contexts, to respond in English, seemingly fluently, to questions and statements, for example the [Parry](#) and [Shrdlu](#) programs described in the section Early AI Programs. However, neither Parry nor Shrdlu actually understands language. An appropriately programmed computer can use language without understanding it, in principle even to the point where the computer's linguistic behaviour is indistinguishable from that of a native human speaker of the language (see the section [Is Strong AI Possible?](#)). What, then, is involved in genuine understanding, if a computer that uses language indistinguishably from a native human speaker does not necessarily understand? There is no universally agreed answer to this difficult question. According to one theory, whether or not one understands depends not only upon one's behaviour but also upon one's history: in order to be said to understand one must have learned the language and have been trained to take one's place in the linguistic community by means of interaction with other language-users.

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