

ly the interrelationships existing among them, and between them and the doctrines derived from them.

See Also: DEPOSIT OF FAITH; DOGMA.

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[P. F. CHIRICO]

ARTIFICIAL INTELLIGENCE

Artificial intelligence (AI) is that division of science, particularly of computer science, which attempts to emulate and extend with programmed and fabricated elements the cognitive and affective functions of animals and human beings. AI can be viewed as a division of “artificial life” (AL) whose principal findings come from biology, psychology, and sociology. The definition and history of artificial intelligence, the principal divisions of the field, its tools, influential persons and overall significance, along with sources for further information, are considered in this article.

The phrase “artificial intelligence” first gained general acceptance after John McCarthy used it as the title of a summer 1956 Dartmouth College computer conference. It eventually replaced other terms such as “machine intelligence,” “complex information processing,” and “heuristic programming,” each of which indicated a particular emphasis or approach to the field.

The somewhat amorphous character of AI research is a result of its shifting frontiers, which continually redefine AI’s major focus. In any given period fundamental problems and processes that extend beyond the then better understood and more structured forms of information handling are discovered. In general these are problems whose formalized descriptions do not indicate the implementation of simple algorithmic methods for their solution. They are therefore said to call for “intelligence.” For example Arthur Samuel’s Checker Player, a pioneering computer program (proposed 1947, master level play 1961) that was among the first to “learn” from its mistakes, has in time been supplanted as a paradigm for a stream of AI research by backgammon and chess-playing programs and machines. These are yielding in turn to “games” of greater combinatorial complexity and logical ambiguity or probability.

In these AI research areas the common and what have proven to be difficult tasks include the identification and in some sense formalized articulation of the underlying “intelligence” problems. Despite, and to an extent

because of, major technological advances, the obstacles encountered have led to a more sophisticated appreciation of the richness of intelligence and its subtle possibilities. This appreciation stands in marked contrast to earlier optimism regarding near-term “thinking machines” and “mechanical brains” (cf. Perceptron). Consequently, cognate disciplines such as cognitive and animal psychologies, neurology, various kinds of material or semantic logics as well as “fuzzy set” and other theories in mathematics and philosophy are increasingly being drawn upon for the light they might cast on the generalized problematic of intelligence. Consciousness, particularly human subjective or self-reflexive consciousness of relations of second or higher degree, represents one of AI’s major hurdles.

Chief Topics. The principal sub-topics of current AI research include continuous-speech recognition and synthesis, natural language interpretation, generation, and translation, the processing of stereoscopic visual patterns, the extension of such sensory receptors and effectors as tactile and auditory elements in robots, signal and symbol processing, machine learning and reasoning, inductive logic programming, neural networks with parallel processing, aspects of computer-assisted instruction (CAI) and computer-assisted design and manufacture (CAD/CAM) especially in the computer field itself, automatic programming, and more generally expert or knowledge-based systems.

Expert systems usually consist of an extensive database of facts and rules about some domain such as diesel-locomotive repair (Delta), emergency room medical diagnosis (Internist, Caduceus), mineral exploration (Prospector), the structure of organic molecules (Dendral) or world-class chess-playing (Deep Blue). The facts are incorporated via a “knowledge representation” into a model of the system in question or, alternatively, with a series of heuristic rules which attempt to capture the expertise of accomplished human practitioners in that domain.

Besides such particularized efforts, the overall process of creating expert systems in any field is undergoing automation. “Knowledge engineering” topics such as generalized inference engines, problem solving in a large search space, subgoaling, abstraction, forms of knowledge representation involving the predicate calculus, semantic primitives and networks, frames and scripts all contribute to the building and use of expert systems in many domains; these broader considerations in turn clarify the more general AI “intelligence” tasks described above.

In a reciprocal almost symbiotic manner the HUMAN GENOME Project, genomics, and proteomics use AI to re-

produce the evolutionary history of human beings, thus displaying the brain's "blueprint" which in conjunction with its past environments reveals to cognitive science more of the nervous system's physiological capacities, more challenges for AI.

Programming languages and environments developed for AI work include John McCarthy's LISP and Alain Colmerauer's PROLOG (1973)—with important French, British, and Japanese developments. Progress is being made in supercomputer and LISP machines and parallel processing with not only electromechanical and electronic but also optical and experimental biological computing machines in the offing. Somewhat more speculative are the varieties of quantum computing that have been proposed.

In addition to the classical contributions of the Greek logicians, of Ramon Lull, G. Leibnitz, B. Pascal, G. Boole, and K. Goedel, leading figures in recent AI work have included Alan Turing, Claude Shannon, Allen Newell, Herbert Simon, Hubert Dreyfus, and Roger Penrose.

Scientific advances in AI can be viewed in the context of philosophy's mind-body problematic and religious assertions regarding the unique dignity and immortal destiny of the human person. Recent efforts have helped clarify such assertions and indicated the shortcomings of earlier somewhat simplistic reductionist claims. For the short-term at least, man-machine interactions via "agents" and "bots" (software robots) appear to offer the most promising ways of enhancing human activities.

For ongoing developments cf. *AI Magazine*, a serial publication of AAI, *The American Association for Artificial Intelligence*, founded in late 1979 (first annual conference 1980) and the major professional society of the discipline, as well as *Artificial Intelligence: An International Journal* (Amsterdam: North-Holland).

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[J. F. SMOLKO]

ARTUSI, GIOVANNI MARIA

Music theorist of the Roman conservative circle; b. Bologna, Italy, 1540 (1545?); d. Bologna, 1613. By 1562 he was a canon of the Congregation of the Saviour. Though his polemics against MONTEVERDI put him in the early Italian baroque, it is difficult not to classify him

with the Renaissance. He took exception not only to the *seconda prattica* of Monteverdi, but also wrote against Gesualdo, Vincentino, Rore, and A. Gabrieli, showing how they had strayed from classical Renaissance traditions. In *L'Arte del contrapunto* (1586–89; microprint, Rochester, N.Y. 1954) he showed himself a conservative student of Zarlino, but later attacked even him. Other writings were *L'Artusi, ovvero delle imperfettioni della moderna musica* (1600) and *Considerazioni musicali* (1603). He remained a defender of the old styles until the end, but in later life he softened with regard to Monteverdi's music, which he even professed to admire. Of his compositions a book of four-voiced *Canzonette* is well known (1598).

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[F. J. SMITH]

ARUNDEL, THOMAS

Archbishop, chancellor of England, foe of Lollards; b. 1352; d. Feb. 19, 1414. He was the son of Richard Fitzalan, Earl of Arundel, whose title he used as a surname; his mother, Eleanor, his father's second wife, was daughter and coheiress of Henry, Earl of Lancaster. His studies at Oriel College, Oxford, were terminated by his exceptionally early promotion to the bishopric of ELY, to which he was provided by the pope (Aug. 13, 1373) in opposition to both King Edward III and the cathedral chapter. On the same day that he was consecrated bishop (April 9, 1374) he was ordained both deacon and priest. During the turbulent reign of RICHARD II, Arundel joined his brother Richard, Earl of Arundel, in opposition to the king. He supported the Lords' Appellant (1386–88) and served as Lord Chancellor (1386–89). When Abp. ALEXANDER NEVILLE of York was translated *in partibus* to the schismatic See of Saint Andrews, Scotland (see WESTERN SCHISM), Arundel was translated to YORK (April 3, 1388). In May 1389 he relinquished the great seal to William of WYKEHAM, but he resumed the chancellorship in 1391