

Abstract

Artificial Intelligence (AI) is a general term that implies the use of a computer to model intelligent behavior with minimal human intervention. AI is generally accepted as having started with the invention of robots. The term derives from the Czech word *robota*, meaning biosynthetic machines used as forced labor. In this field, Leonardo Da Vinci's lasting heritage is today's burgeoning use of robotic-assisted surgery, named after him, for complex urologic and gynecologic procedures. Da Vinci's sketchbooks of robots helped set the stage for this innovation. AI, described as the science and engineering of making intelligent machines, was officially born in 1956. The term is applicable to a broad range of items in medicine such as robotics, medical diagnosis, medical statistics, and human biology—up to and including today's “omics”. AI in medicine, which is the focus of this review, has two main branches: virtual and physical. The virtual branch includes informatics approaches from deep learning information management to control of health management systems, including electronic health records, and active guidance of physicians in their treatment decisions. The physical branch is best represented by robots used to assist the elderly patient or the attending surgeon. Also embodied in this branch are targeted *nanorobots*, a unique new drug delivery system. The societal and ethical complexities of these applications require further reflection, proof of their medical utility, economic value, and development of interdisciplinary strategies for their wider application.

Introduction

Artificial intelligence (AI) is generally accepted as having started with the invention of robots. The word robot, spelled *robota* in Czech, was introduced into the literature by the writer Karel Capek in his 1921 play, “R.U. R” (*Rossum's Universal Robots*). It signified a factory where biosynthetic machines are used as forced labor. In the middle of the last century, Isaac Asimov immortalized the word “robot” in a collection of short stories of modern science-fiction. The first mention of a humanoid automaton, however, can be traced back to the third

century in China when a mechanical engineer, Yan Shi, presented to the Emperor Mu of Zhou, a human shaped figure of mechanical handiwork built with leather, wood and artificial organs [1].⁰ In the 12th century, a Muslim golden age scholar, polymath, inventor, and mechanical engineer named al-Jazari created a humanoid robot able to strike cymbals. During the Renaissance period, Leonardo da Vinci made a detailed study of human anatomy to design his humanoid robot. His sketches drawn in 1495, were only rediscovered in the 1950s. Leonardo's robot was a *knight robot* that was able to stand-up, sit-down, wave arms and move head and jaw. It was operated by pulleys and cables. More important than his accomplishments in this area, da Vinci's sketchbooks were a source of inspiration for a generation of robotic researchers, some of whom worked at NASA. In medicine, a surgical system made by the American company, *Intuitive Surgical*, was named *Da Vinci* in recognition of his inspirational impact. It was approved by the Food and Drug Administration (FDA) in 2000, and the number of units in operation around the world is now over 5000. *Da Vinci* surgical systems facilitate complex surgery using a minimally invasive approach, and can be controlled by a surgeon from a console. The system is commonly used for prostatectomies and gynecologic surgical procedures. It is starting to be used for cardiac valve repair. The evolution of robots made a change in direction with the first robot to be recognized as revolutionary in its mechanical realistic conception being the “Flute Player”, conceived in the 18th century by the French inventor, Jacques de Vaucanson, as an innovative “automaton” playing the pipe. It had a repertoire of 12 songs. Two centuries later, William Gray Water became famous in 1948 for the fabrication of the first electronic autonomous robot, which he named *Machina Speculatrix*. His goal was to demonstrate how the brain functions. It revealed that connections between a small number of “brain cells” could lead to very complex behaviors. John McCarthy coined the term “artificial intelligence” (AI) in 1955, defining it as “the science and engineering of making intelligent machines”. He was very influential in the early development of AI. With his colleagues he founded the field of AI in 1956 at a Dartmouth College conference on artificial intelligence. The conference gave birth to what developed into a new

interdisciplinary research area. It provided an intellectual framework for all subsequent computer research and development efforts.

During the following years, computers started to solve many complex mathematical problems that soon became of interest to the Department of Defense of the USA. Then, after a period of slowdowns in the 80's, a new golden era restarted with the use of logistic data mining and medical diagnosis. Instruments with increasing computational power were developed. This new capability allowed *Big Blue* to finally beat the world Chess champion, Gary Kasparov on May 11, 1997.

Today, AI is considered a branch of engineering that implements novel concepts and novel solutions to resolve complex challenges. With continued progress in electronic speed, capacity, and software programming, computers might someday be as intelligent as humans. One cannot neglect the important contribution of contemporary cybernetics to the development of AI.

Defined as a trans-disciplinary approach, cybernetics aims for control of any system using technology that explores system regulation, structure and constraints, most notably mechanical, physical, biological, and social. The origin of cybernetics is attributed to Norbert Wiener [2], who formalized the notion of feedback, with implications for engineering, systems control, computer science, biology, neuroscience, philosophy, and the organization of society. Fields that were most influenced by cybernetics are (if we exclude game theory) systems theory, sociology, psychology (especially neuropsychology and cognitive psychology), and theory of organizations.

Today literature on AI is abundant and unbridled. AI was portrayed as a possible threat to the world economy during the 2015 economic forum held at Davos, where Stephen Hawking even expressed his fear that AI may one day eliminate humanity [3]. We will not discuss here the use of this rapidly developing field in military, security, transport or manufacturing; instead, the focus of our chapter is on medicine and health systems.