Artificial Intelligence∗
The Age-old Quest for Thinking Machines

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The phrase artificial intelligence has become common in our current day discourse. Fuelled by successes in machine learning, and applications interacting with us in speech and natural language, many commentators have made a leap of faith that behind these successes is a thinking machine, and this has even stoked fears of machines overcoming humankind. In this two-part article, we look at how close we are to the original quest for creating “machines who think”. In the first part, we trace the evolution of mechanical computers and also the notion of the mind up to the era before digital computers appeared on the horizon.

In these times, a day does not pass when one does not hear or read about artificial intelligence (AI). It has become a phrase bandied about by anyone and everyone, journalists, policymakers, academics and corporate honchos alike, often without any clarity on what it pertains to. It has been a blanket term used to talk about any new technology. In particular, it seems to include in its fold all of automation, which need not be AI-based, and a lot of statistical data processing often referred to as data science. It has almost become a marketing phrase for any new product or technology.

Yet, when the term AI was first coined in 1956 by John McCarthy (1927–2011), it had at its core, the idea of a thinking machine, in the true and proper sense of the word ‘thinking’. The idea of creating such an artificial thinking or sentient creature, in fact, predates electronic machines. It even predates mechanical moving statuettes constructed in medieval Europe and much before,

∗Vol.25, No.1, DOI: https://doi.org/10.1007/s12045-019-0920-3
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which invoked visions of manmade creatures. In this article, we look at the evolution of this idea leading up to present when the prospect of creating real artificial intelligence seems, by some accounts, imminent.

There are two strands to the evolution of the idea of AI. One is the evolution of mechanical devices, which can largely be called automation. In fact, Charles Babbage (1791–1871), who is often referred to as the father of computing, was a mechanical engineer who as a child was fascinated by such walking figurines displayed by a man called Merlin. Babbage described them as follows:

“One walked, used an eye-glass occasionally, and bowed frequently; her motions were singularly graceful. The other was a dancer, full of imagination and irresistible.”

The other strand is in the realm of philosophy and was concerned with the notion of the mind. This notion did not always exist and was thought up as the distinguishing feature of Homo sapiens. You might recall the famous quote by Rene Descartes (1596–1650), cogito ergo sum, (I think, therefore, I am). Naturally, this led to the debate on the nature of intelligence, and whether machines could aspire to be so.

Many of the protagonists during this period were scientists, engineers and philosophers, all rolled into one, and were involved with constructing machines as well as investigating thinking. We begin, though, with folklore.

Folklore and Literature

The desire to create artificial intelligence can be traced long back in folklore, particularly in Europe. Paracelsus (1493–1541), a Swiss physician and alchemist is said to have remarked, “We shall be like gods...we shall duplicate God’s greatest miracle – the creation of man”. He is said to have created a homunculus, or a little man.
Much earlier, towards the end of the 3rd century, the term *anthroparion*, also meaning a diminutive person, appeared in Greek literature and can be traced back to Zosimus the Alchemist. Anthropomorphic statues have been around for thousands of years. Totems used to cure diseases in various tribal cultures may not have been animated but may still have been thought of as ‘thinking machines’ by their progenitors and clients.

In Jewish folklore, a *Golem* is an animated anthropomorphic being, created entirely from inanimate matter. The Rabbi Judah Loew ben Bezalel, (1512–1609), widely known as the Maharal of Prague (*Moreina HaRav Loew* [“Our Teacher, Rabbi Loew”]), is said to have created one out of clay to protect his fellow Jews. It is said that only he could control it (*Figure 1*).

In 802 A.D., the Arab Caliph Haroun-al-Rashid is said to have presented Emperor Charlemagne with an elaborate clock which sent out a dozen cavaliers from a dozen windows each noon and sent them back again. Automata made its European debut in the 1600s. On display at the Bowes Museum in England, the Silver Swan, constructed in 1773, is a self-operating machine designed to automatically follow predetermined instructions. The author
Figure 2. The zairja.
(Source: http://zairja.org/quienes-somos.)

Mark Twain saw it at an exhibition in Paris in 1867 and described it as having “a living grace about his movement and a living intelligence in his eyes.”

Perhaps the most significant throwback to current day fears often invoked concerning AI goes back to the novel *Frankenstein* published in 1818 by Mary Shelley (1797–1851). The novel tells the story of Victor Frankenstein, a young scientist who creates a hideous sapient creature in an unorthodox scientific experiment. Since the novel’s publication, the name “Frankenstein” has often been used to refer to the monster itself. In the novel itself Frankenstein’s creation is identified by words such as “creature”, “monster”, “daemon”, “wretch”, “abortion”, “fiend” and “it”, and was eventually blamed for its creator’s death; an allegory still resonating in the fears of AI destroying humankind.

In 1863 Samuel Butler (1835–1902) published an article called *Darwin among the Machines*, where he raised the question of the evolution of consciousness among self-replicating machines that might supplant humans as the dominant species.

By the twentieth century, the art of making clockwork with animated figures was very popular, and added much credence to the belief that learned men kept robots. The word ‘robot’ was first used to denote a fictional humanoid in a 1920 play — R.U.R.
(Rossumovi Univerzální Roboti – Rossum’s Universal Robots) by the Czech writer, Karel Čapek (1890–1938), nominated for the Nobel Prize in Literature seven times, but never awarded.

Real Machines

A group of Arab astrologers is credited with constructing a thinking machine called the zairja (Figure 2) which was designed “to generate ideas by mechanical means do it with the help of the technique al-jabr, the technique of ‘breaking down’”. The modern word algebra is derived from al-jabr. Ibn Khaldun (1332–1406) of Tunisia, often considered as the first historiographer, later described the zairja as: “a branch of the science of letter magic, practiced among the authorities on letter magic, is the technique of finding out answers from questions by means of connections existing between the letters of the expressions used in the question...by combining number values associated with the letters and categories, new paths of insight and thought were created.”

The zairja caught the imagination of the Catalonian missionary Ramon Lull (1232–1315) who decided to build a Christian version called the Ars Magna – “to bring reason to bear on all subjects and, and in this way, arrive at truth without the trouble of thinking or fact-finding”.

Real progress happened starting with Blaise Pascal (1623–1662), who invented a mechanical calculator, later called Pascaline (Fig-
Figure 4. Trial model of a part of the Analytic Engine, built by Babbage, as displayed at the Science Museum, London. (Source: http://en.wikipedia.org/wiki/Analytic_Engine)

The Analytic Engine was a general-purpose computer indeed, but it was completely mechanical in nature. It is, however, only with the emergence of the electronic machines and the digital computer that programmable machines really took off.

Leibniz was a philosopher in the Age of Enlightenment, when the term encompassed all sciences and had contributions in many areas. He went beyond arithmetic and believed that much of human reasoning could be reduced to calculations of a sort, and that such calculations could resolve many differences of opinion. Ada Lovelace (1815–1852), often known as the first programmer, later echoed this sentiment. She imagined that the Analytic Engine (Figure 4), invented by her collaborator Charles Babbage, could go beyond number crunching and even be able to, for example, compose music. The Analytic Engine was a general-purpose computer indeed, but it was completely mechanical in nature. It is, however, only with the emergence of the electronic machines and the digital computer that programmable machines really took off.

Philosophy

Even while efforts to build mechanical machines were on going, the scientist philosophers had started grappling with the notion of the mind. This was the ‘stuff’ that John Haugeland (1945–2010) referred to as the essence of AI. In his words, – “The fundamen-
tal goal of Artificial Intelligence research is not merely to mimic intelligence or produce some clever fake. Not at all. AI wants the genuine article: machines with minds, in the full and literal sense.” – from his book *AI: The Very Idea*.

The notion of the mind as a separate entity first emerged when Nicolaus Copernicus (1473–1543) said that “It is the rotating Earth that creates the illusion of the Sun, the Moon and the stars moving in the sky” in *On the Revolutions of the Celestial Spheres*. Galileo Galilei (1564–1642), in *The Assayer* (published in 1623), echoed these sentiments by stating that “I think that tastes, odors, colors, and so on are no more than mere names so far as the object in which we locate them are concerned, and that they reside in consciousness”. The English philosopher Thomas Hobbes (1588–1679), often called the grandfather of AI, was the first to put forward the view that “thinking is the manipulation of symbols”. As an aside, Bill Waterson named the character of Hobbes in the comic books series Calvin & Hobbes after him. Calvin is named after John Calvin, the Protestant theologian who founded another strand of Christianity.

René Descartes said that “thoughts themselves are symbolic representations”. He asserted that the mind and body are different, leading to the paradox of mind-body dualism. How can non-matter interact with matter? If symbols are being meaningfully manipulated in the mind, then who is manipulating them? Descartes was often ridiculed by some of his contemporaries who said that a little man (homunculus) was manipulating the symbols in the heads of people. It was the Scottish philosopher David Hume (1711–1776), historian, economist, and essayist known especially for his philosophical empiricism and scepticism, and known as the Mental Mechanic, who responded. Hume was an admirer of Newton and said that just as heavenly bodies obeyed the laws of physics, so did symbols in the world of thoughts. He said that impressions and ideas were (like) the basic particles to which all mental forces and operations applied. It is interesting to note that the English mathematician George Boole (1815–1864), the inventor of Boolean algebra which lies at the foundations of computers, named his book *The Laws of Thought*.
the inventor of Boolean algebra which lies at the foundations of computers, named his book *The Laws of Thought*.

Nevertheless, the philosophical questions on the mind and whether machines can be intelligent or not continued. Eventually, the English mathematician, computer scientist, logician, cryptanalyst, philosopher and theoretical biologist Alan Turing (1912–1954), proposed his “Imitation Game”, which we now call the “Turing Test”. This held that if a machine could imitate human behaviour, it must be intelligent. The idea here is that if a human judge chatting with an unknown entity is unable to distinguish whether she is chatting with a human or a machine most of the time, the machine has passed the Turing test. The emphasis of the test is both on linguistic prowess, at that time well beyond machines, and the content of the utterances, based on knowledge and reasoning. It is still considered to be an unachieved goal, even though machines have become remarkably good at churning out text, particularly in restricted domains.

The Dartmouth Conference

The term Artificial Intelligence is attributed to John McCarthy who along with Marvin Minsky (1927–2016), Nathaniel Rochester (1919–2001) and Claude Shannon (1916–2001) organized a summer conference in 1956 in the Dartmouth College. Their proposal titled *Dartmouth Summer Research Project on Artificial Intelligence* read:

“We propose that a 2-month, 10-man study of artificial intelligence be carried out during the summer of 1956 at Dartmouth College in Hanover, New Hampshire. The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it. An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves. We think that a signifi-
cant advance can be made in one or more of these problems if a carefully selected group of scientists work on it together for a summer.”

The age of artificial intelligence had begun.

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