



Best practice guidelines

Artificial intelligence in medicine

A B S T R A C T

Artificial Intelligence (AI) is based on accurate decision-making processes which can be carried out independently by a machine. AI may be subdivided into strong AI (with consciousness and intentionality) and weak AI (lacking both and programmed to perform specific tasks only). With AI currently making rapid progress in all domains, including those of healthcare, physicians face possible competitors. Various types of AI programs are already available as consultants to the physician, and these help in medical diagnostics and treatment. At the time of writing, extant programs constitute weak AI. This paper will explore the development of AI and robotics in medicine, and will refer to *Star Trek's* "Emergency Medical Hologram", who is portrayed as a strong AI program. This paper will also briefly explore the issues pertaining to AI in the medical field and will show that weak AI should not only suffice in the demesne of healthcare, but may actually be more desirable than strong AI.

1. Introduction

Artificial Intelligence (AI) is a relatively new field in science and engineering. Work in this domain commenced in earnest soon after the Second World War, and the term Artificial Intelligence was coined in 1956 [1]. AI is based on an accurate decision-making process which can be carried out independently by a machine. The earliest research into thinking machines was inspired by a confluence of ideas that became prevalent in the late 1930s, 40s and early 50s. Research in neurology had shown that the brain was an electrical network of neurons that fired in all-or-nothing pulses. Norbert Wiener's theory of cybernetics described control and stability in electrical networks, while Claude Shannon's information theory described digital signals. Furthermore, Alan Turing's theory of computation conjectured that any form of computation could be described digitally. The close relationship between these ideas suggested that it might be possible to construct an electronic decision-making brain [2].

Indeed, AI researchers did not shy from making predictions of the anticipated coming successes in the development of strong AI. The following statement by Herbert Simon in 1957 is often quoted:

It is not my aim to surprise or shock you – but the simplest way I can summarize is to say that there are now in the world machines that think, that learn and that create. Moreover, their ability to do these things is going to increase rapidly until – in a visible future – the range of problems they can handle will be co-extensive with the range to which the human mind has been applied [3].

With AI currently making vast and uninterrupted progress in the domain of medical health and elsewhere, physicians are now facing new challenges. This paper aims to explore the use of AI in medicine and the impact AI has and will continue to have on medicine. It will also seek to analyze the implications this will have on medical doctors and healthcare.

2. Artificial intelligence in medical diagnosis and interventions

Medical diagnostic programs may serve as useful tools in today's overburdened health care system. For example, IBM's Watson provides many unique and transformative possibilities to resolve challenges associated with medical diagnosis and treatment. Such medical applications may help physicians navigate through a complex set of patient symptoms, laboratory data and imaging results to come up with a set of 'most likely' clinical diagnoses and treatment options. Software of this nature may ultimately improve patient outcomes and reduce health care costs [4]. Two important features of the prototype software are the ability to provide multiple possible diagnoses and treatment options with relative confidence levels, as well as the ability to trace the information utilized to make a recommendation [4].

AI is also being used in the field of cardiology. The Imaging in FOCUS (Formation of Optimal Cardiovascular Utilization Strategies) quality improvement, an initiative of the American College of Cardiology, was recently introduced so as to channel the utilization of diagnostic imaging through the arrangement of AI that tracks appropriate use criteria [5]. After images are acquired, additional AI tools may help physicians provide accurate interpretation of cardiac imaging studies [6].

Technology is also revolutionizing the medical field through the creation of robotic devices and complex imaging. Robotic surgery, computer-assisted surgery and robotically-assisted surgery are terms for technological developments that use a robotic system to aid in surgical procedures. Robotically-assisted surgery was developed to overcome the limitations of pre-existing minimally-invasive surgical procedures and to enhance the capabilities of surgeons performing open surgery.

The first documented use of a robot-assisted surgical procedure was in 1985 when the PUMA 560 robotic surgical arm was used in a delicate neurosurgical biopsy, an open and therefore non-laparoscopic procedure [7]. This led to the first laparoscopic procedure in 1987, involving a robotic system to carry out a cholecystectomy [8]. The following year, the same PUMA system was used to perform a robotic surgical transurethral prostate resection. In 1990, the AESOP system produced by

Computer Motion became the first system approved by the Food and Drug Administration (FDA) for endoscopic procedures [8].

In 2000, the *da Vinci* system broke new ground by becoming the first robotic surgery system approved by the FDA for general laparoscopic surgery [9]. This was the first time the FDA approved an encompassing system of surgical instruments and camera-scopic utensils. The *da Vinci* system's three dimensional magnification screen allows the surgeon to view the operative area with the clarity of high resolution.

Robotic surgery is at the cutting edge of precision and miniaturization in the realm of surgery, and has become a successful option in neurological, gynecological, cardiothoracic and numerous general surgical procedures [9]. It is reasonable to assume that the current advantages of robotic surgery systems will be expanded with the next generation of medical robotics. Removing human contact during surgery may be taken to the next level with robotic surgery systems becoming capable of functioning at greater distances between surgeons' control consoles and the patient side table robotics. This would allow robotic surgery to be conducted with patients in a nearby 'clean room', reducing the risk of intraoperative infection [9]. Major strides are also being made in creating robotic surgery systems which are more capable of replicating the tactile feel and sensation which a surgeon experiences during more invasive traditional procedures, allowing the operator the precision and advantages of minimally invasive procedures without losing the sensory information that is so helpful in making judgment calls during robotic surgery [9].

3. Weak AI and strong AI

There are two major ways to think about the current utilization and power of artificial intelligence. The weak AI hypothesis states that a machine running a program is at most only capable of simulating real human behaviour and consciousness. Artificial intelligence such as that being used in medical diagnosis and certain interventions are examples of weak AI because they are focused on one narrow task. Weak AI justifies the claims that a running AI program is at most a simulation of a cognitive process but is not itself a cognitive process. Strong AI, on the other hand, purports that an (as yet to be written) program running on an (as yet to be designed) machine is actually a mind – that there is no essential difference between a piece of software exactly emulating the actions of the brain, and the actions of a human being, including their understanding and consciousness.

The debate between the two opposing forces of weak AI and strong AI is intense, with scientists and philosophers of both camps foregrounding claims to support their hypotheses. John Searle's Chinese Room Argument (CRA), a celebrated thought experiment designed to refute the hypothesis, that 'the appropriately programmed computer really is a mind' [10], concludes that an AI program could give the impression of intelligence to an external observer, but completely lacks understanding. Thus a weak AI is only capable of simulating real human behaviour and consciousness, without intentionality. Searle further purports that causal features of the brain are necessary and crucial for intentionality.

"Could a machine think?" [...] only very special kinds of machines, namely brains and machines with internal causal powers equivalent to those of brains. And that is why strong AI has little to tell us about thinking, since it is not about machines but about programs, and no program by itself is sufficient for thinking [10].

It is therefore Searle's contention that strong AI may share our behavioural and functional equivalence, without being a conscious system, since consciousness requires not only a computational organization but also a specific and unknown way in which functional organization is implementing in the biology of the organism. This is because Searle believes that the human brain is able to conjure "perceptual aboutness" [11] and that:

The brain's causal capacity to produce intentionality cannot consist in its instantiating a computer program, since for any program you like it is possible for something to instantiate that program and still not have any mental states. Whatever it is that the brain does to produce intentionality, it cannot consist in instantiating a program since no program, by itself, is sufficient for intentionality [10].

Colin McGinn further argues that the famous Chinese Room *gedankenexperiment* provides strong evidence that the debate revolves around whether a machine can be shown to be actually conscious as opposed to the theory that a machine can be conscious [12]. This type of AI is even more commonly depicted in popular culture, recently and famously in *Ex Machina* [13] and *Transcendence* [14]. Searle, however, doubts that true consciousness in an android could ever be possible with our present state of knowledge.

This is contrary to the tenets of strong AI which state that computational states are functionally equivalent to mental states [15]. The Emergency Medical Holographic program (EMH) created in the fictional *Star Trek* future is indeed a prototype of strong AI. The EMH is portrayed as a sophisticated hologram developed in the early 2370 s and used on most Federation starships in the late 24th century. It was designed to provide short-term advanced assistance during emergencies in sick bay to the extent of literally replacing a starship's medical officer. The EMH Mark 1 was first activated in 2371, and is programmed with over five million possible treatments from the collective information of 2000 medical references and the experience of forty seven individual medical officers. The EMH is also supplemented with contingency programs and adaptive programs to learn while serving as a supplement of a normal medical staff in cases of emergency. It contains fifty million 'gigaquads' of computer memory, which is 'considerably more than most highly developed humanoid brains' [16].

While the EMH may seem preposterous, a technological 'singularity' may make it possible. The concept of Singularity was succinctly set out by the statistician I. J. Good in his 1965 article 'Speculations Concerning the First Ultra-intelligent Machine'.

Let an ultra-intelligent machine be defined as a machine that can far surpass all the intellectual activities of any man however clever. Since the design of machines is one of these intellectual activities, an ultra-intelligent machine could design even better machines; there would then unquestionably be an 'intelligence explosion' and the intelligence of man would be left far behind. Thus the first ultra-intelligent machine is the last invention that men need ever make [17].

David Chalmers further argues that this intelligence explosion may be combined with another potentiality, the 'speed explosion.' The singularity proposed by Chalmers depends on an uncritical acceptance of the 'assumption that there is such a thing as intelligence and that it can be measured' [18].

4. Conclusion

These attributes all point to the thesis that ultimately, AI will function independently and will constitute a major part of the work force. This strongly suggests a major transition in the medical health field, where doctors, nurses and the rest of the multidisciplinary team will work alongside stronger intelligences. Chalmers maintains that once a strong AI begins to function independently, the only viable option for human beings is 'integration,' where human beings become 'superintelligent systems' themselves [18]. He avers that:

In the long run, if we are to match the speed and capacity of non-biological systems, we will probably have to dispense with our biological core entirely. This might happen through a gradual process through which parts of our brain are replaced over time; or it happens through a process. Either way, the result is likely to be an

enhanced non-biological system, most likely a computational system [18].

In view of this advanced technological setting human beings need to learn how to adapt and integrate with strong AIs as he sustains that an ‘intelligence explosion’ will happen in the coming decades, changing the conventional ways individual are accustomed to [18].

For all intents and purposes however weak AI would actually suffice for medical purposes. Such systems do not need to have intentionality and self-awareness to function well. The present AI programs available on the market come with a computational sufficiency and serve as useful tools in today's overburdened health care system. Medical aided programs are providing correct diagnoses within minutes if not seconds, while robotic surgery is making huge advances in the field. Furthermore a strong AI might not necessarily be better in this demesne. A weak AI would be controllable due to lack of intentionality and independence, a mind of its own. The lack of consciousness and intentionality in a weak AI make it what it simply is – a programmable machine. On the other hand, a strong AI will be able to function independently, possessing the attributes of free will and the moral conscience to choose right from wrong. The dilemma lies here: while a strong AI might appeal for tomorrow's world because it fulfills all the requirements being sought in the Singularity, a weak AI is what human beings might actually need. *Homo sapiens* has reigned supreme in the animal kingdom since the beginning of his existence – relegating any portion of his power to a strong AI might not be on his agenda for many years to come, making him think twice about the creation of such machines.

Declaration of competing interest

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Mariella Scerri*, Victor Grech,

E-mail address: mariellascerri@hotmail.com (M. Scerri).

* Corresponding author at: 18, York, N. Caruana Dingli Street, Mellieha MLH 1709, Malta.