Computer Science and Information Technology (I.T) throughout Medicine

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Declaration

I hereby certify that this material, which I now submit for assessment on the program of study as part of the continuous assessment for module CS275, is *entirely* my own work and has not been taken from the work of others - save and to the extent that such work has been cited and acknowledged within the text of my work.

Signed: Adam West Date: 24/01/2016

Abstract

Computer Science and Information Technology (I.T) have greatly affected medical practices since its introduction to the field of medicine. It has allowed general medicinal practices to improve and has increased efficiency throughout many areas of medicine and healthcare. Certain technologies such as 3D-printing have allowed surgical practices to become increasingly efficient and the introduction of handheld devices with patient records has made patient care more reliable and safer than ever. These are but a few of the new technologies which have caused increases in efficiency and safety. Other technologies which have also benefited medicine are e-learning in medical education, computer aided process engineering, nanotechnology and algorithms which have measured human anatomy. This article will set out to review and discuss how these new technological practices have been implemented into areas of medicine and healthcare. A description of these topics and how they are actually used will also be included throughout this article.

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Introduction

How has computer science and I.T helped in the advancement of medicine and its relevant areas? This is the question that will be investigated throughout this review and with the use of collected information and articles this question will be answered. This review will also identify retrieved literature and summarise its relevance to the chosen topic. This scoping review will focus on the general findings of research rather than how the research was instigated. In scoping reviews, the focus is on the research findings themselves, as opposed to the means used to obtain them(Weeks & Strudsholm, 2008). This is beneficial to this topic as it will discuss how Computer Science and I.T has benefited Medicine.

The introduction of technology and computation into the medical field has been responsible for breakthroughs in combating disease, detection of illnesses and a general increase in prolonging life, in both humans and animals. This review will discuss and inform the reader as to how these feats have been implemented throughout medicine and, in turn, society. Abnormalities can be detected well before they produce any clinical signs or symptoms. Undoubtedly, these technological advances have enhanced the physician's potential for understanding disease and treating patients (C. Black & Gilbert Welch, 1993). This review will discuss and inform the reader as to how these feats have been implemented throughout medicine and, in turn, society.

This review was carried out primarily using ScienceDirect. It holds a collection of science related articles, books and journals which are essential for any science related research. Keywords such as medicine, computer science, technology, etc. were used to easily search relevant topics. Keywords such as 3D-printing, nanotechnology, e-learning and anatomical algorithms were used to find a larger and more exclusive selection of relevant papers. Other resources such as Google Scholar were also used in searching for relevant topics/ articles.

Topics

Computer Aided Process Engineering

Computer aided process engineering has been substantially beneficial to medical sciences particularly in biology and chemistry. Computer aided process engineering can contribute to the significant recent developments in biology and to the way life scientists go about their business, and potentially help the way clinics diagnose and make operational decisions(Bogle, Allen, & Sumner, 2010). An example of these systems being used would involve the engineered systems outputting methods in which reliable system-wide predictions can be given in regards to quantitative data, blood glucose measurement for example. These systems would allow life scientists the ability to efficiently measure optimal dosages for patients/ animals and also ensure that correct medical practice would become easier and safer throughout the medical sector.

Algorithms for 3D measurement of Human Anatomy

Computer-assisted surgery, including 3-dimensional (3D) analysis and 3D preoperative planning and intra- operative guidance, has become well accepted in many orthopaedic areas(Vlachopoulos et al., 2015). The use of these algorithms has largely affected surgical procedures in many fields of medicine with orthopaedics being one of many. The introduction of computer aid into surgical practice has become the accepted norm from most surgeons, particularly surgeons who deal with complicated areas of the human body. By creating a 3D rendering of the area which will be operated on, it allows surgeons/ physicians to gain a greater insight into the problems which may be present throughout the upcoming surgery. Risk assessment benefits immensely due to these 3D renderings as it determines whether the area at risk is safe to operate on.

Impact of e-learning in medical education/ evidence based medicine

The introduction of electronic learning into medical education has been beneficial to current medical students and to currently active medical professionals. E-learning is the use of Internet technologies to enhance knowledge and performance(Ruiz, Mintzer, & Leipzig, 2006). It has been effective in complementing traditional practices such as human thought learning. The introduction of e-learning also correlates with an increase in adult learning, learning by one's self rather than being dependent on lecturers/ advisors. These lecturer's/ advisors sole responsibility will not just revolve around the distribution of content material, but also act as assessors and instigators of learning and competence.

E-learning and I.T are also shown to increase evidence-based medicine (EBM). A study was conducted using 38 paediatric residents who were all introduced to tablet computers and each were also given laboratory-based skill sessions with the hope of increasing EBM knowledge and also their skills and behaviour. Our change from a stand-alone teaching approach of EBM to paediatric residents to the provision of tablet computers combined with laboratory-based skill sessions not only improved the residents' EBM knowledge, but also improved their self-reported comfort with and use of EBM skills(Soma, Homme, & Jacobson, 2013). The study was a success and shows how medical knowledge and education has benefitted from the introduction of e-learning and I.T.

Nanotechnology

The nature of nanotechnology and its potential can be largely beneficial to medicine and operational procedures. Nanotechnology is the ability to work at the atomic, molecular and supramolecular levels (on a scale of ~1– 100 nm)(Roco, 2003). The applications available to nanotechnology includes the understanding of Biosystems, breaking down of hazardous cells such as cancer cells and the administration of even more accurate doses into a target location within the body. The understanding and increased interest in nanotechnology will cause a further increase in possible funding for future development projects. The possibilities stemming from nanotechnology and in turn biotechnology will lead to improvements within the understanding and implementation of further medical progress. The ability to explore the human anatomy at nanoscale will surely allow an even greater understanding of the human body with a depth which has never been explored before.

The expression 'nanomedicine' has become increasingly popular in relation to biotechnology in medicine. The aim of nanomedicine may be broadly defined as the comprehensive monitoring, control, construction, repair, defence and improvement of all human biological systems, working from the molecular level using engineered devices and nanostructures, ultimately to achieve medical benefit(Boisseau & Loubaton, 2011). There are multiple areas where the introduction of nanomedicine would be beneficial and these areas include 'Nanodrugs', the targeting of certain areas using nanoparticles, regenerative medicines where nanoparticles are used to influence/ help with the growth of cells and the interaction between biomolecules and nanoparticles.

While the advantages of nanotechnology are clear, the ethics surrounding certain progress in nanotechnology is up for debate. Will healthcare professionals be able to regulate it effectively? Will they respond correctly? These are popular questions regarding its ethnicity.

Applications of 3D printing in Medicine

What is rapid prototyping technology (3D printing)? It is the creation of 3D objects from a computer-aided design. Layers are built upon layers of a chosen material, plastic, metal, etc. and then an exact copy of the digital image is formed. It is implemented by the use of a 3D printer. Its use in the medical sector has increased in the last few years due to its ability to print an accurate model of organs, nerves etc. The possible advantages of 3D printing are also quite appealing to the area of medicine. It gives a true spatial relationship to allow tangible manipulation of the cardiac structures. A few case series and many case reports have demonstrated that this technique may improve safety and decrease operator time in complex cardiac surgeries and interventional procedures(Mishra, 2015). It also allows the ability for doctors to give an in depth explanation of surgical techniques to patients by using the 3D model as a guide. This allows patients to see their tumour/ vascular problems etc.

A relevant topic regarding 3D printing is organ printing. It is similar to 3D printing but it involves the printing of organic, cellular material. While this technology is not currently in practice globally, its feasibility is quite possible due to advances in both biological understanding of cells and the further developments of 3D printing technology. Organ printing, or computer-aided layer-by-layer assembly of biological tissues and organs, is currently feasible, fast- evolving and predicted to be a major technology in tissue engineering(Mironov, Boland, Trusk, Forgacs, & Markwald, 2003). The possibilities available from organ printing will certainly benefit the medical sector. If organ printing becomes an actual reality, then it may present a suitable solution to the organ donor shortages.

Further applications of 3D printing include printing prosthetic limbs and implants which may eventually allow cellular repair.

Discussion

The subsections described above explain the uses of computer science and technology throughout medicine. The above subsections share a common theme as each of them explain the benefits it has had in medicine and how the technologies in the above subsections are responsible for increases in both safety, understanding and efficiency in medical areas. Some scholars believe that the technologies at present are only ‘halfway’ technologies, that this way of viewing medicine goes against the ongoing view held by the public that these technologies have come almost its full distance, that we have had a long succession of "breakthroughs" and "major advances," and that now we should go beyond our persistent concern with research on what is called "curative" medicine and give more attention to the social aspects of illness and to preventive medicine(Thomas, 1977).

Process engineering allows medical professionals to simulate and investigate conditions within a biological or chemical system without the need to physically test with humans. It has increased the need to not have unnecessary risks on patients etc. Systems can be created and designed to implement test cases and provide a greater insight quantitative medical research.

The rendering of 3-Dimensional human anatomy will allow surgical procedures to become more efficient and effective in analysing and investigating the patient pre-operation. It may also provide a greater knowledge of risks and potential effects which may be caused to a patient. The benefits to risk assessment due to 3D rendering include an increase in safety and more information regarding the area at risk. Future improvements to rendering designs and its implementations will allow interactivity between doctor and patient to become even more understanding and peer-to-peer work may also benefit, particularly if this rendering technology

is improved upon with other technologies such as augmented realities, e.g. explaining a surgery using a floating hologram of a patient's cardiovascular problem.

The introduction of electronic learning has allowed medical students/ paediatric residents to engage in a greater and practical manner. It has not been thought to replace traditional learning but as a complement alongside it. It is also increases adult learning and provides medical students with a more interactive approach to learning. The introduction of tablet based products and I.T has proven to increase skills and behaviour amongst a study of paediatric residents as stated above. These technologies will become increasingly integrated into the healthcare sector and also into society itself. The future for e-learning may be that it takes over traditional means. These benefits to medical areas from technology once again show how computer science and I.T are helping throughout medicine.

The abilities of nanotechnologies can be invaluable in the medical field. The ability to fight pathogens at a molecular level with greater efficiency and productivity than our own cells will ensure great strides are taken in this field of technology. It will allow us to combat disease, infection and viruses much more effectively than today's antibiotics. The future possibilities for Nanomachines is potentially huge. Nanomedicines could ensure antibiotics are delivered to the target areas in extremely precise amounts, regenerative medicines may benefit due to Nano-particles that help in the reconstruction of damaged human tissue or cell creation. While these possibilities are quite promising there are worries regarding these nanomachines as some professionals believe they may not be able to be regulated effectively.

The applications of 3D printing have proven to be quite effective in furthering the understanding of surgeries especially amongst patients as the 3D print can be used to clearly explain the procedure. The possibilities from 3D printing are rather extensive particularly in possible organ printing. The future possibilities of organ printing may solve the organ donor

problem and ensure patients do not have to wait months on a replacement organ. 3D printing is also becoming quite popular in prosthetic limb replacement due to the ease at which it can be designed digitally and then printed.

Conclusion

The topics I have chosen all link together to answer the question asked previously. How has computer science and I.T helped in the advancement of medicine and its relevant areas? In this review I have discussed about the many benefits which arise in medicine throughout the use of technology. These topics have ranged from the incorporation of 3D printing into medical practices to electronic learning and its benefits to medical studies. I have also discussed nanotechnology and the possibilities which may arise from it, the introduction of algorithms to render the human anatomy and the creation of computer aided systems which allow predications to be made regarding quantitative data.

From studying these topics and researching other relevant articles regarding computer science and I.T, I can answer the question asked above. These technological breakthroughs and the integration of computer science have allowed medical practices to flourish due to the introduction of these new methods of procedure. These technologies have become integrated in the medical sector and are being used on a daily basis. Common forms of these technologies in hospitals include MRI machines, X-ray machines, dialysis machines etc. Although some of these machines have been around for decades, their integration into hospitals has shown how technology and medicine are both dependent on each other and how both areas drive future progression with one another. The future of medical practice will become more and more dependent on technological breakthroughs such as the possibilities from 3D organ printing or the development of Nanomachines. These new computer-aided technologies will ensure that

the progression and efficiency of medical practice and healthcare will continue to increase as we move forward.

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