CTIS Assignment – AI in surgery

## Technology / Topic Overview

Artificial Intelligence, or the intelligence demonstrated by machines (Shi, Yang, Yang, & Zhou, 2022) is a complex branch of computer science, concerned with attempting to replicate human-like intelligence within modern computers. It has revolutionized IT and has begun to drastically shape the way that modern society lives and functions. As the technology behind has matured, AI has been adopted further and further within many fields, from industrial manufacturing to autonomous navigation to medicine and surgery. It is the final point, surgery, that this assignment aims to address, first examining AI and its main components, next investigating the opportunities given to surgery using AI. Following this we will look to see both what choices it gives, as well as the risks posed by early adoption. Finally, we will present an ethical reflection of the topic.

Artificial Intelligence itself is broken up into multiple sub-topics, but there are three main ones that will be studied today. The first topic, Machine Learning, refers to the system’s ability to learn and merge new information learned through large scale observations, improving and extending it’s knowledge base autonomously rather than being directly programmed (Woolf, 2009). This directly facilitates self-improvement of the system, with experienced surgeons being able to assist in manually training the system to increase accuracy by noting any defects in automated analysis as they occur. major way that machine learning self-improves is through the tutor – student principle. Through this, the system takes in a large quantity of surgical examples, learning directly off surgeons – observing, evaluating, and analysing their actions, creating a pool of experience to draw from.

The next sub-topic of note is that of neural networks. Neural network models are one type of AI model that imitates how the human brain functions (Casas, 2020). They were first created to solve geographic issues in the 1990s but have recently flourished with modern advancements in computing power, data availability and AI technology (Casas, 2020). One of the main benefits to using a neural network as opposed to a different model is their strong ability to “detect complicated trends in high-dimensional datasets” (Guenther, 2001). Because of this, neural network models are of particular interest within the medicinal and surgical field, where data is both highly complex and highly specific.

Computer Vision is the final topic of interest. Here images are processed with the goal of extracting high level information (Brill, Erukhimov, Giduthuri, & Ramm, 2020). There are a number of noted uses for this, including in automotive applications, where work on advanced self-driving assistance systems and self-driving cars is progressing rapidly, surveillance applications, where face recognition is already accurate and well used, and the medical industry. Here, computer vision is widely used for a number of uses, including computer-aided diagnostics, image-guided radiation therapy and imaging genomics, among many other uses (Dey, Konar, De, & Bhattacharyya, 2021).

These three fields barely begin to scratch the surface of what modern applications of artificial intelligence can accomplish, but they serve as a suitable basis for this investigation. Each of these three fields have applications that can aid surgical practice greatly, but their true strength comes in combination. This becomes particularly apparent when looking at the nature of the data present within the medicinal industry – whereas AI often relies on structured, repetitive data, medical data is highly unstructured and of a very high volume, the application of traditional algorithms is still unproven. As such, a hybrid machine – intelligence system offers both a more robust design as well as a significant increase in performance (Dey et al., 2021).

## Opportunities given by the technology

Another important thing to investigate is the opportunities presented to surgery with further implementation of AI. There are a number of current opportunities that span across all phases of the surgery – from pre-operative screening of patients to identify tumours to real-time risk analysis and assessment for surgeons. There is also a huge scope for future opportunities, extending as far as offering robotic assistance for difficult surgeries. This could ultimately result in a lower failure rate for these difficult surgeries, making them more appealing and thus accessible, resulting in a greater standard of healthcare for the general population.

AI has already been used for a while in the pre-operative phase of the surgical process. There are multiple solutions that have been investigated, including solutions focused around creating preoperative plans for orthopaedic surgery (Lambrechts, Wirix-Speetjens, Maes, & Van Huffel, 2022), risk-stratifying models for hospital patients (Kendale, 2022) and general surgical planning (Lambrechts, n. d.), utilising surgeon’s individual past operations to tailor plans to the individual surgeon. It is interesting to note that there has already been a high degree of accuracy improvements, and many of these algorithms are still in their infancy. There has been a ~40% reduction in the number of corrections required to be made to a pre-operative plan required for knee arthroplasty observed when the plan was created by AI rather than by the manufacturer (Lambrechts et al., 2022). A >10% increase in implant size accuracy was observed when an AI created plan was used as against the manufacturer’s recommendation also (Lambrechts et al., 2022).

Risk analysis is another area within which AI solutions have already been developed (Hospital, n. d.). Amongst other things, current solutions are aimed to assist surgeons with decision making, counselling and outcome prediction (Hospital, n. d.). Another feature of these tools is their accessibility for medical staff, with many of them offering smartphone applications to ease access where possible.

A future opportunity that AI is looking to fulfil is the opportunity to perform robotic surgery. This has already been implemented with robotic assistance in mildly invasive surgery, resulting in a noticeable reduction in both surgical trauma and recovery time (Kwo, 2021). Having proved the effectiveness of robotic surgical assistance, the next goal is to scale the principle up – utilising robotics to assist in performing difficult surgeries, like keyhole or gastro-intestinal surgery. In January 2022, researchers succeeded in performing keyhole surgery on a pig without human help (Gregory, 2022). Furthermore, this was done to a higher standard than a human surgery, producing “significantly better results” (Gregory, 2022).

## Choices that the technology gives

Having explored the opportunities presented by Artificial Intelligence within modern surgery, it has become clear that it presents a number of choices for practitioners of modern surgery. As is outlined in the opportunities section above, there are a number of applications that surgeons and practitioners can take advantage of throughout the surgical process – ranging from pre-operative applications through to peri-operative and post-operative products also.

The majority of the pre-operative choices that are given involve choosing to take advantage of a solution or not. In the orthopaedic scenario given above, if the practitioner decided to adopt an AI created treatment plan over the manufacturer’s provided on, they would typically see a significant increase in accuracy, with a notable decrease in corrections required in the plan (Lambrechts et al., 2022). Another choice practitioners are now given is the opportunity to utilise AI-powered tumour detection software (Radiology, 2022). This gives surgeons who may be inexperienced a chance to use this to learn from, offering a more accurate diagnosis as well as offering a simple way for more experienced surgeons to get a second opinion on their diagnosis.

There are a couple of peri-operative choices that are given. As mentioned in the ‘Opportunities’ section, one option involves future use of robotic surgical assistants to either assist or perform surgical operations on patients. Further investigation into automated drug delivery, anaesthesia prediction and monitoring of surgical complication has been conducted (Solanki et al., 2021), resulting in the practitioners again having the choice to either utilise automated delivery or control anaesthetic and other drug distribution manually.

The final choice of note in this report is the ability to seek robotic assistance within the practice. As mentioned above, robotic assistance is progressing at a great rate, and as such in the near future robotic assistance, particularly with difficult surgery such as gastrointestinal or keyhole surgery, will become commonplace. There are advantages to taking advantage of this assistance – from current trials it is seen that robotic surgery has both a lower error rate and a higher recovery speed. There are downsides naturally – any errors that may occur during the robotic surgery can be of unforeseen consequence, and it can reduce the demand for particularly skilled surgeons, but on the whole, from an outside perspective, it seems that this would be a significant step forward in the realm of surgical treatment.

## Risks presented by the technology

As was hinted at in the ‘Choices’ section, there are a number of potential risks that may be of issue during the adoption of Artificial Intelligence into the surgical paradigm. To name a few, these include the risk of failure or unforeseen error in the surgery, the risk of bias and the risk of

The first of these, the risk of failure or unforeseen error, is higher when the algorithm is first adopted, as this is the time where there will be the least data available and thus the largest scope for errors. If an AI system were to recommend the incorrect drug for a patient, miss a tumour on a radiological scan or incorrectly allocate a hospital bed for a patient when another needed it more injury or death could result (II, 2019). While many errors like this exist in medicine today, the repercussions could be different if these were due to a software error rather than simply human error. Furthermore, if one system were to be used across multiple clinics, one error could cause tens of thousands of injuries, rather than just a few if it were human error.

Any implicit bias gained due to systemic bias in data collection within clinics can affect the patterns recognised by the AI (Hashimoto, Rosman, Rus, & Meireles, 2018). This is something that researchers and practitioners must be closely aware of, and as such they should work with the data scientists developing the models to limit this as much as possible (II, 2019). Issues could arise if patients decide to leave one treatment provider, switching to another midway through treatment, leaving a gap in the datasets of both clinics. This creates fragmentation, both decreasing the comprehensiveness of the dataset as well as the risk of error. This also increases the cost of gathering data, creating a higher barrier to entry to creating effective health care AI (II, 2019).

Alongside the issue with inherent bias if clinical data collection is done improperly, there is another potential risk of bias – insufficient training data. As AI systems learn from the data on which they are trained, if this is performed improperly inherent bias accrued from the training data can be incorporated into their data (II, 2019). For instance, if a system was trained off data gained from one population only, then used in an area with a completely different population, any issues or diseases that are more common in the new area may not be treated appropriately, as the system may not have adequate experience with these differing issues.

The final risk of note in this report involves the privacy of sensitive medical data. As AI systems require large datasets to train effectively, developers are incentivised to conduct large-scale datasets from patients. There is a concern that this data collection may infringe on patient privacy, as medical data is sensitive and highly personal. Additionally, there is a risk that AI systems could predict or reveal highly personal outcomes for patients, even if this is not something that was disclosed to the system. An example of this could involve recognising that a person may have Parkinson’s disease through the shaking of a computer mouse. Some patients may consider this a privacy violation, especially if the AI’s inference was available to third parties (II, 2019).

## Ethical Reflection

Who is at fault if the AI makes a mistake? Important to reflect that for the foreseeable future there must be a surgeon present to monitor all decisions and give the final ok

A key issue that is often raised around the principle of involving AI in difficult decisions, like using a self-driving car or involving robotics in a manufacturing process is the question of who would be at fault if something were to go wrong in the process. It seems like, at least at first when implementing AI within surgery, patients and their families may have a difficult time coming to terms with this as an issue. If complications arose due to a mistake made by a surgeon or another error that would be one thing, but having them be at the fault of an AI might be difficult for them to accept. At that point, the question of who would be at fault would arise too, and as such at this point I feel that for the application of AI in modern surgery to be successful, at least at first, it must only be used in addition to a competent surgeon or medical professional. This way, the practitioner is still in control of the process, simply receiving advice from the computer. This way, in the future when the technology is proven, complete AI takeover would be possible within surgery, when delivering drugs or any other time along the process. At this point, the wider population would likely be more comfortable with the proposition.

Overall however, I believe the advancement of the AI field within modern surgery is a hugely positive process. It advances everything – providing further training and assistance to those new to the field as well, producing a hugely net – positive result in general.

# Reference

Brill, F., Erukhimov, V., Giduthuri, R., & Ramm, S. (2020). Chapter 1 - Introduction. In F. Brill, V. Erukhimov, R. Giduthuri, & S. Ramm (Eds.), *OpenVX Programming Guide* (pp. 1-13): Academic Press. Retrieved from <https://www.sciencedirect.com/science/article/pii/B9780128164259000073>. <https://doi.org/https://doi.org/10.1016/B978-0-12-816425-9.00007-3>

Casas, I. (2020). Networks, Neural. In A. Kobayashi (Ed.), *International Encyclopedia of Human Geography (Second Edition)* (pp. 381-385). Oxford: Elsevier. Retrieved from <https://www.sciencedirect.com/science/article/pii/B978008102295510410X>. <https://doi.org/https://doi.org/10.1016/B978-0-08-102295-5.10410-X>

Dey, S., Konar, D., De, S., & Bhattacharyya, S. (2021). Chapter 1 - An introductory illustration of medical image analysis. In T. Gandhi, S. Bhattacharyya, S. De, D. Konar, & S. Dey (Eds.), *Advanced Machine Vision Paradigms for Medical Image Analysis* (pp. 1-9): Academic Press. Retrieved from <https://www.sciencedirect.com/science/article/pii/B9780128192955000019>. <https://doi.org/https://doi.org/10.1016/B978-0-12-819295-5.00001-9>

Gregory, A. (2022). *Robot successfully performs keyhole surgery on pigs without human help*. Retrieved from <https://www.theguardian.com/technology/2022/jan/26/robot-successfully-performs-keyhole-surgery-on-pigs-without-human-help>

Guenther, F. H. (2001). Neural Networks: Biological Models and Applications. In N. J. Smelser & P. B. Baltes (Eds.), *International Encyclopedia of the Social & Behavioral Sciences* (pp. 10534-10537). Oxford: Pergamon. Retrieved from <https://www.sciencedirect.com/science/article/pii/B0080430767036676>. <https://doi.org/https://doi.org/10.1016/B0-08-043076-7/03667-6>

Hashimoto, D. A., Rosman, G., Rus, D., & Meireles, O. R. (2018). Artificial Intelligence in Surgery: Promises and Perils. *Annals of surgery, 268*(1), 70-76. <https://doi.org/10.1097/SLA.0000000000002693>

Hospital, M. G. (n. d.). *Predicting Surgical Risk Using Artificial Intelligence*. Retrieved from <https://www.massgeneral.org/compass/patient-and-provider-education/artificial-intelligence-risk-modeling>

II, W. N. P. (2019). *Risks and Remedied for Artificial Intelligence in Health Care*. Retrieved from <https://www.brookings.edu/research/risks-and-remedies-for-artificial-intelligence-in-health-care/>

Kendale, S. (2022). The role of artificial intelligence in preoperative medicine. *International Anesthesiology Clinics, 60*(1).

Kwo, L. (2021). *The power of AI in surgery*. Retrieved from <https://www.mobihealthnews.com/news/contributed-power-ai-surgery>

Lambrechts, A. (n. d.). *How AI Will Change the Way We Do Pre-Surgical Planning: A Study of Total Knee Arthroplasty*. Retrieved from <https://www.materialise.com/en/resources/medical/webinar-recording/how-ai-will-change-way-we-do-pre-surgical-planning>

Lambrechts, A., Wirix-Speetjens, R., Maes, F., & Van Huffel, S. (2022). Artificial Intelligence Based Patient-Specific Preoperative Planning Algorithm for Total Knee Arthroplasty. *Frontiers in Robotics and AI, 9*. <https://doi.org/10.3389/frobt.2022.840282>

Radiology, A. (2022). *AI A Promising Tool for Breast Cancer Detection*. Retrieved from <https://appliedradiology.com/communities/Artificial-Intelligence/ai-a-promising-tool-for-breast-cancer-detection>

Shi, Y., Yang, K., Yang, Z., & Zhou, Y. (2022). Chapter One - Motivations and organization. In Y. Shi, K. Yang, Z. Yang, & Y. Zhou (Eds.), *Mobile Edge Artificial Intelligence* (pp. 3-5): Academic Press. Retrieved from <https://www.sciencedirect.com/science/article/pii/B9780128238172000103>. <https://doi.org/https://doi.org/10.1016/B978-0-12-823817-2.00010-3>

Solanki, S. L., Pandrowala, S., Nayak, A., Bhandare, M., Ambulkar, R. P., & Shrikhande, S. V. (2021). Artificial intelligence in perioperative management of major gastrointestinal surgeries. *World journal of gastroenterology, 27*(21), 2758-2770. <https://doi.org/10.3748/wjg.v27.i21.2758>

Woolf, B. P. (2009). Chapter 7 - Machine Learning. In B. P. Woolf (Ed.), *Building Intelligent Interactive Tutors* (pp. 221-297). San Francisco: Morgan Kaufmann. Retrieved from <https://www.sciencedirect.com/science/article/pii/B9780123735942000071>. <https://doi.org/https://doi.org/10.1016/B978-0-12-373594-2.00007-1>