

# How Artificial Intelligence and Deep Learning are Changing the Healthcare Industry

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**Abstract-** This research paper will discuss the various technological innovations that have been developed within the past, are being developed in the present and will be developed in the future to bring progressive change within the healthcare industry. In particular, the way artificial intelligence and deep learning has brought about new methods for making task more efficient, less time consuming, and possibly more accurate. This study will discuss the different positive and negative effects of these technological methods to best see how artificial intelligence (AI) and deep learning is impacting the health industry in all areas. With supportive interviews from medical professionals, data scientist, and machine learning researchers, the analysis of real-world experiences and scenarios will provide more insight to what is beneficial or ineffective. The study utilizes extensive literary works to examine in detail the current AI and deep learning new approach to medicine, the risk and ethical concerns, the technological challenges from determining the best algorithms, and myths versus reality surrounded by this subject.

## I. Introduction

To first establish some preliminary understanding, artificial intelligence is programming a computer or machine to think and draw conclusions similar to humans. Deep learning is a category under artificial intelligence that uses neural networks – computing algorithms that contain layers of neurons to learn an input of data to provide an output based on its understanding of it- to learn large amounts of data and solve complex problems.

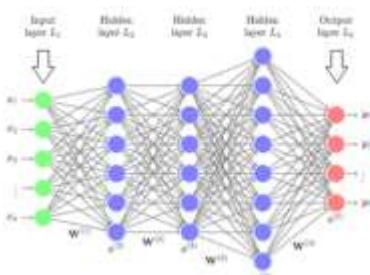


Figure 1: Deep Learning Network

In our world today, the direction in which we are headed contains a future that will heavily depend on artificial intelligence and deep learning technologies. There are currently some technologies that implement artificial intelligence and deep learning that has helped our way of living. The most relatable that we tend to miss as users, is our cellphones and computers. These devices have programs installed that use algorithms to help shift how we receive data. As it relates to our health, we no longer have to calculate all of our workouts or intake of calories and derive conclusions on our health based on what our devices have picked up on. For example, there are programs that will tell you based on your diet & body, of what is suggested for you to do to progress. On a complex level with physicians using this new approach of deriving solutions from these technologies come with new risks, challenges and benefits which will further be discussed throughout this research.

## II. Methodology

This study will use a combination of literature review and interviews to collect data and gather results directly related to our thesis. Each stage of our methodology is explained as follows:

### A. Literature Review

This paper will discuss the various developments of technologies centered around health and medication; and risks associated with the use of them by relating to scholarly articles and research reports of researchers and experts in the area of artificial intelligence and deep learning. Analyzing through these reports will provide a foundation to grow our research on and will present itself to support the findings from the other methods used to collect data. References to news articles will also be used in order to relate our research findings to current events related to.

### B. Interviews

There has been data collected about our topic by interviewing several individuals who are proficient in the field of artificial intelligence and health care. The interview process will involve approximately six experts, 2 medical professionals and 4 professional researchers. The medical professionals will share their personal knowledge and experience on working with artificial intelligence & deep learning technologies in the health care and/or how they can potentially see it being used to make a beneficial impact in their respective fields. The

professional researchers will share their personal knowledge and experience on working with artificial intelligence & deep learning technologies to determine that what they have used in their studies can bring massive changes in the healthcare industry. Each individual will also share the risk and negative impact that can come from using the new innovations that will be discovered within the research. Our two intended targets who are in the medical field are Dr. Rodney Ellis and Dr. Laura Gray. Dr. Rodney Ellis is a board-certified Internal Medicine Specialist in Lanham, MD. He graduated from Stanford University medical school in 1975 and has been in the medical field for the past 45 years. Dr. Laura Gray is an Attending Psychologist within the Pain Medicine Clinic at Children's National Hospital. She received her PhD at George Washington University and conducts interventions such as behavioral pain management strategies incorporating cognitive behavioral therapy, acceptance and commitment therapy, and biofeedback. The two professional researchers are Dr. Kyle Johnsen and Dr. Moayed Daneshyari. Dr. Kyle Johnsen is currently an Associate Professor in engineering at the University of Georgia and has focused research in Simulation-based Training, Natural Interfaces, Human-Computer Interaction, Serious Games, Virtual Humans, Virtual Reality, Computer Graphics, Computer Vision. Dr. Moayed is a previous Assistant Professor, Graduate Program Coordinator, in Computer Science at Hampton University. His expertise is in Deep Learning, Machine Learning, Computational Intelligence, Bio-inspired Algorithms, Robotics, and Networking, and has over 10 publications in this area of study.

### III. Results

This section will cover the cumulative results obtained from our research methodology outlined in Section II.

#### A. AI & Deep Learning Technologies Currently Used

The focus of artificial intelligence within deep learning being used in the healthcare industry can be overlooked at times since some professionals who are using these technologies know how to use them but not completely understand what causes the technology to fall under deep learning. Within the findings of this research, it was found that there were both simple and complex usages of deep learning within healthcare that is occurring at this moment. These areas that will be highlighted will include deep learning being used in Electronic Health Records, applications to detect health conditions, diagnosing cancer, and disease prediction and treatment [5]. Electronic Health Records, or EHR, is technology used by doctors to store data from patients related to personal information, lab results and medical history. Through the use of deep learning algorithms, EHR condenses the time it would usually take to obtain a prognosis. How does the algorithm work? It will use data recorded in the EHR to find patterns in health trends and develop inferences from the findings. A static prediction and a prediction based on a collection of inputs are the major ways EHR is used. Respectively, researchers can provide the system with data sets from the International Statistical Classification of Diseases and Related Health Problems, or after entering inputs of an individual patient into the system a prediction can be made [3].

- Google developed a combined team at UC San Francisco, Stanford Medicine, and the University of

Chicago Medicine to work on an algorithm that analyzed over 46 billion data points out of 216,000 EHRs within two hospitals. The deep learning technology was able to increase the accuracy of normal approaches for finding unforeseen patients that readmit into hospitals, predicting how long they will stay, and speculating the mortality of a patient being treated at a hospital [8].

Furthermore, if data is not as excessively available, then Generative Adversarial Networks are used in order to predict rare diseases or unique cases. One Artificial Neural Network is created to generate new data instances from a given data set, while another ANN is used to discriminate the data set being formed by the first ANN by being given the original set of data and faulty set of data to determine which is real to provide the first ANN more quality data to generate [5].

Now moving onto applications to detect health conditions, deep learning techniques used in EHR can allow physicians to analyze information and detect heart problems, determine the amount of glucose in a diabetic patient, interpret MRI's and CT scans with minor human supervision, to search for cancer cells and diagnose a patient with the type of cancer, and even to find tumors [7].

- Enlitic had a research team that introduced a tool which went beyond the combined abilities of specialized radiologists at identifying lung cancer nodules in CT images, where the testing conditions reached a 50% higher detection rate [5].

Predicting the health condition and providing treatment before detecting it is much more valuable to both the patient and physician. In 2006, half of about 4 million patients hospitalized for preventable hospitalizations suffered from diabetes and heart problems and cost the US more than \$30 billion [5]. Deep learning can and is being used to reduce the time of developing a prognosis to reduce the number of hospitalizations. Some applicable findings include a deep learning model used to prevent blindness from diabetes, Diabetic Retinopathy (DR). In 2017, scientist from Claremont Graduate University, Johann Radon Institute, and Vanderbilt University found that patients' glucose levels could be monitored so that a patient can respond to the levels by treating it with insulin or a snack with high sugar [16]. HIV is also a virus that over 30 million people struggle from, but a deep learning model called Reinforcement Learning is used to track where the virus would be in the body to provide the most practical way of altering the drug sequence because HIV rapidly mutates.

#### B. The Future Impact AI and Deep Learning Will Have on Health Care

Due to the head start artificial intelligence and deep learning has in the clinical setting, the future for health care taking bigger approaches technologically looks to bring promising results. Scientists and medical professionals are seeking to improve the way patients and consumers interact with healthcare systems. This research will take a look at both the small and grand scale of technologies, ranging from wearable technology to cloud computation [19].

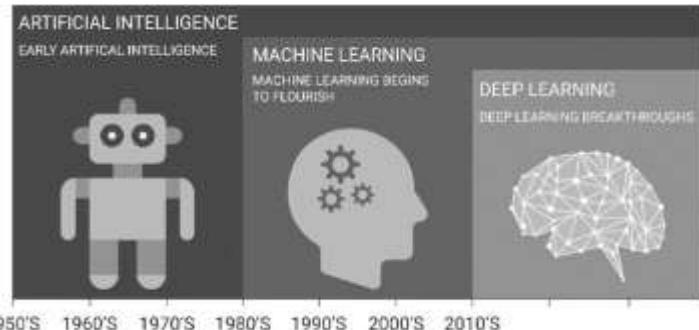


Figure 2: Change in AI

With the transformational outcomes that have been processed from deep learning algorithms currently, on a much smaller scale, clinical applications that are centered around consumer facing technology can change how patients depend on physicians and nurses. The implementation of chatbots and virtual assistants in healthcare isn't used as much as it is in business offices but based on the global virtual healthcare assistant market being valued at \$376 million in 2018, it's looking to increase by over 24% by 2025 [3]. The most popular use of these technologies includes Alexa, Siri, and Google Assistant. The benefits from these systems can come in the form of providing chronic disease management programming within patient's homes, daily availability to simple triage, and effective ways of accomplishing administrative tasks [8].

After researching to determine the larger scale impact that the future of deep learning will take place within the healthcare industry, it was discovered that the main focus can be centered around voice recognition technologies, cloud computation, robotics surgery, public health and patient monitoring. Thankfully the progression that has been made outside of the healthcare industry with these technologies and areas of impact has made it more of a reality to see occurring for where the future is headed, even when it can be more complex.

Google is currently working with physicians and data scientists at Stanford University to see how their technology can bring more change within the clinical setting besides its current capabilities of transcribing notes. Automatic speech recognition solutions can be used as a model to develop the control of handling complex medical diagnosis [8]. AI systems such as Google Cloud Platform can be used to access and assess data information from a patient, but on the platform of private clouds instead [9]. Public health is just as essential as the private health of patients, and a prime solution can be finding the best algorithm for mapping patient location to prevent major health crises [3]. The possibility of predicting outbreaks that can vastly spread will benefit the population by taking less time to develop a plan for assisting patients and creating a vaccine. Lastly, patient monitoring can really alter a patient's chances in living or dying. Between the time of scheduled visits, it is not promised that a physician will be able to react to adverse events if they are not able to physically be there in time. With the ability to receive alerts and monitor in real time, physicians will have the chance to determine the probability of an emergency before it can be found with a bedside visit from data being put into predictive analytic techniques [3].

### C. Myths vs Reality

With new technologies on the rise, minimal common definitions, and the lack of common validity for the best practices, different myths start rumors within the field of AI and the use of big data. This research will identify these myths in order to shed light to what's factual, so that the best approaches can be conducted when applying deep learning to the healthcare industry. The focused myths that will be discussed are the need for large volumes of data, the need for cleaned data, and managing the data from deep learning technologies requires a lot of money or many data scientists [3]. In reality, none of these are the case for implementing deep learning within the healthcare industry. These few reasons are why some companies or organizations shy away from advancing their innovative systems in the workplace. If people haven't realized already, big data already exists within the healthcare industry. Some that can be identified are images, semi-structured text, streaming, social media, and structured data. Images can come from radiology, MRI's, ultrasounds, and nuclear imaging which can be used for improved pattern recognition and reduce active storage requirements. Examples of semi-structured text include clinical narratives, the notes of a physician, summaries that are done after a discharge, and reports conducted from pathology. Based on comparing the various ways, semi-structured text is used the most within all healthcare enterprises. Streaming technology examples include remote monitors, implants, wearable technology, and the cellphone's we use today. Even though the amount of available storage can be low in numbers, how frequently this data is produced is at a high level [3]. The main forms of structured data can be seen from Natural Processing Language annotations and Electronic Health Records. Because this brings context to the big data used for deep learning, then it should primarily be used as a source for it. While some of these forms of data can be extreme or not as consistent with each other, it is good because it allows for the deep learning algorithm to become more intelligent as it refines what it's being given [3].

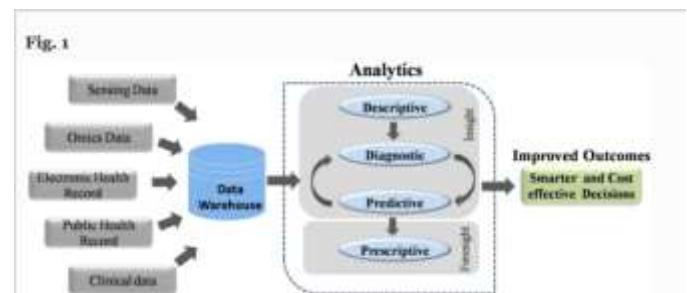


Figure 3: Input/output of data processed thru deep learning technologies [3]

The last myth that will be discussed relating to big data and deep learning is that it requires a lot of money or many data scientists to manage it. If the situation was to be looked at financially, then currently the cost of cloud options are reducing, and healthcare companies can start out looking to invest in open-source technologies. A good team of data scientists can become challenging to hire since they are in high demand and require a high salary. So, if the corporation is not large, it is suggested to start out using the data scientist that is hired to the company's advantage. Use their projected skills and assets to focus on what looks probable of accomplishing [3].

On the contrary to the myths that were presented the reality and best approaches include, but are not limited to having a scope, variety, data flow diagrams, and cyber security [3]. The scope for where the data is coming from and how it's analyzed will decrease the chances of being overwhelmed with data management. The variety of data will have a greater effect on the deep learning algorithm so it can produce better results for the business. The data flow diagram will include different parts needed by uses cases that the healthcare organizations can utilize for a more accurate perspective of what can occur when computing the data in deep learning technologies.

Lastly, cyber security is one of the most important factors to following a safe approach for managing the data. A lot of the information can be sensitive and personal information, and in the wrong hands will put both the organization and patient in jeopardy of other privacy related risk which will be discussed in depth throughout the paper [3].

#### *D. Scientific AI Challenges*

Artificial intelligence is still progressing and is still fairly new to the healthcare industry in comparison to other technologies that's been implemented through various businesses or organizations within the healthcare industry. However, with studies still being discovered there are still some adversities to face and limitations that will come across before scientists and researchers apply more technologies in the real-world for clinical practice. Some of the challenges that are faced include differences within the available algorithms, machine learning difficulties, changes within datasets, and generalizations that impact new environments [12].

The difficulty that physicians will face when finding which algorithm works excellent for patients is having various results from executing variable methodologies on a variety of populations that are made up of multiple characteristics. Without focusing each AI algorithm on the same type of group of people, then it will be hard to determine the most accurate results of which algorithm is best. A good practice to avoid an approach that won't provide usable results is to select data and patients being tested from the technologies, from their natural state [12].

Machine learning has its own difficulties as well when it relates to the science of it. Before the application process there are situations and considerations that need to be analyzed. Those key details include changes within datasets, widely spreading unplanned biases within doctor's or physician's work, estimating how reliable a deep learning model will be, and looking upon a population with generalizations [12]. In particular, the changes within datasets that occur overtime can cause AI and deep learning algorithms to degrade and not be as efficient. This causes research professionals to be in position to reexamine the algorithms and determine if they should only update the model or completely retrain it so it can do what it was designed to do to the best of its ability.

Throughout this research, there's a recurring discussion about generalizations in populations, and this section will lastly cover the barriers that are faced centered around this. Making dependable general inferences on a population can be far in reach because the approaches that doctors and physicians

make within their line of work is not always consistent. The type of equipment and systems that are being used can be different across the healthcare industry. So, the best way to defend this barrier is by providing training to find irregular inputs so that modeling outputs are not generating incorrect data for healthcare professionals to draw conclusions on. The data sets being given have to also be distinctly immense in size and diverse in quantity from the provider of training the model and outside of those institutions. If this is conducted, then the challenge can be easier to face when reflecting the differences amongst patients and their health conditions in practical situations [12].

#### *E. Risk and Vulnerabilities*

There are some clear-cut risks that can be thought of from just thinking about implementing artificial intelligence and deep learning into the healthcare industry simply because people's lives are at stake. This is a more serious situation than others that may be able to take considerations with a less serious approach, such as video games, that can leave room for errors here and there. As it was touched on in the last section, the risk of the algorithms and technologies being faulty and not producing the most accurate outputs can lead to misinforming patients with information which will ultimately have a rippling, devastating effect. To be more specific in detail, the technology could potentially suggest a patient to prescribe to drugs that they did not need, miss predicting cancer or inaccurately detecting a tumor, or assigning a doctor to treat the wrong patient before the other by assessing both patient's current health condition with the belief that one person needed attention before the other. Even though this may already happen without artificial intelligence and deep learning today because doctors are humans and are not 100% right in every situation, the main difference would be that these technologies and methods would spread throughout clinical practices, therefore the chances of it happening again with the system could be very likely. Which would mean there has to be more algorithmic training, or a complete overhaul of the method being used. If one doctor is wrong about assessing the situation with a patient, then only that doctor is limited to impacting that one patient. However, if technology is commonly used on different patients then more people will be negatively impacted [11].

Next, one of the biggest risks that comes with implementing artificial intelligence and deep learning in the healthcare industry is privacy and security. The most immediate vulnerability that comes with protecting the privacy of a patient, stems from them having to provide the artificial intelligence systems with so much sensitive data. This data can potentially get in the hands of other scientists and developers who have to manage the data and technologies since deep learning technologies and models would be new to clinical practices. Patients have the right to view this as data-sharing which puts them in position to think about loss of privacy or lawsuits to be made [11]. The deep learning system could also produce outputs that draw conclusions that include private information that it never received from the patient; therefore, the patient would need to be in agreement with the system now having such data on file. This is dangerous, however, because the technology can be shared with middleman financial or life insurance businesses.

Large datasets were stated to be essential for effective artificial intelligence systems in the healthcare industry. Unfortunately, with it being stored in a centered location it will attract hackers for a spot to attack. SAS Institute is a software company that provides analytical, artificial intelligence and data management technology to organizations across multiple nations. They recently conducted a survey two years ago, and received results showing that 60% of participants would agree to sharing information and data from wearable devices. 40% of the participants younger than the age of 40 would allow for artificial intelligent technology assisting with their surgeries. The amount of people that felt safe with their data being shared to physicians and doctors using this technology to store the data, decreased from both of these scenarios to only 35% of participants feeling safe. There is still research that needs to be done in order to find a definitive solution to securing information stored in these systems, and one in particular that is currently being suggested to be used in the healthcare industry by Harvard University is Blockchain. The complex name for this technology represents how it was simply designed to securely store data within a database related to financial transactions. Institutes such as Harvard, ONC, and PCORI will work towards developing a new feature that allows patient data to be safely stored [13].

#### *F. Ethical Concerns*

The risks that were covered in the section above are key factors to observe in the discussion of what is considered an ethical approach in order to limit those specified risks. Similar to the risk being identified, there are some ethical concerns that can be easily identified and addressed such as informed consent, the choice for patients to share their data, and ownership of their data [3]. Some ethical challenges that require a more in-depth look would be related to the algorithms such as discrimination and racial bias, corruptible designs of the machine learning system, and the potential overpowering authority of a system.

First, this section will discuss how informed consent, the choice for patients to share their data, and ownership of their data impacts ethical challenges in the healthcare industry. When a patient is aware of how the data they are voluntarily providing is being used for the deep learning and artificial intelligence systems, then healthcare providers are able to apply good ethical decisions. Patients should have a choice to freely share their data and decide who they are sharing their data with, however, this isn't ideal to always happen in the real world [3]. As artificial intelligence and deep learning becomes more progressive within the healthcare industry, patients will have to decide if they want the opportunity to use their data for predicting future events. Therefore, the ethical dilemma that is faced is being able to provide patients the same results and treatment as those who decide to share their data for the use of artificial intelligence and deep learning, if they choose to go a more historical approach by not wanting to share their data. Lastly, who owns the data becomes an ethical concern when patients volunteer to share it. There are two important factors that occur when handling data: data controllers and data processors [3]. Those that store, control and use the data for their own agenda are considered data controllers. Those that process the data under the terms created by the data controllers are known as data processors. In order to practice good ethics, health organizations should make a clear distinction between

the two so that patients don't have to worry about ownership of their data. As it relates to ownership of the data there is also an ethical dilemma where a patient may not want to provide their data, but it could be used for progressing medical understanding for the state of humankind. Would it be non-ethical if a person decided to withhold such information that could possibly save a person's life? These are questions that have to be asked before health organizations dive into applying data into artificial intelligence and deep learning technologies in the near future.

The last ethical challenges that will be discussed are the ones that require health organizations and businesses to go beyond the surface. The way health care is provided to people is already differed by race. When training an algorithm, careful observation of discrimination has to occur because past data and results may have been racially biased. Therefore, if this data is used to train the algorithm then it is highly likely the algorithm will produce biased decisions as well [14]. Corruptible designs of the algorithm would be unethical also. Data processors under private sectors and health organizations can skew the algorithms to produce better results for business metrics and to increase profits [14]. Lastly, with a more innovative approach to providing health care solutions from machine learning and artificial intelligence, there is the potential for overpowering authority of the systems to occur. Even though there are amazing new technologies that can shift this industry with its positive impact, there is a risk for patients to be receiving their answers from systems and not personal doctors with real world experience and knowledge [14]. With the technologies moving away from being a support tool, they would have to also ethically be aligned with the ethical operations of the medical professionals, such as respect for patients.

#### *G. Interview Responses*

After providing an interview questionnaire to four professionals, two within the medical field and two researchers studying artificial intelligence and machine learning, I've been able to receive responses to support the literary study that was conducted within the research. This also gives an opportunity to get a better understanding from those who have valuable professional experience because their opinions can highlight differences within the research as well. Since this data is qualitative and not quantitative, this subsection will discuss the exact responses from the interviewees. The next section will go further to explain similarities and differences in perspectives from both sides of the professionals to suggest important considerations in regard to topics discussed in this current section. The first part of this subsection will highlight the responses from the medical professionals who perform clinical work. Below will list the questions that were asked specifically to them and their relative responses:

- Have you ever used AI technology in your area of work?
  - Dr. Ellis: Yes
  - Dr. Gray: Maybe
- If selected no or maybe please answer this: <https://novatirosolutions.com/10-common-applications-artificial-intelligence-healthcare/> : This link leads to a list of potential uses of AI technology in the healthcare industry. Please list at least three

of which you believe would be most impactful in your field and why?

- Dr. Ellis: "I did not select no or maybe."
- Dr. Gray: "AI for health monitoring (fit bits, sleep tracking - this is what patients have used to help us make behavioral health changes; more of this would be helpful so we know what patients are ACTUALLY doing and how well they are moving toward their goals). AI for review of health records would be helpful & for system analysis (to see what components are most helpful in patients who make the most progress, identify errors, etc)"
- If selected yes: How has this AI technology impacted the healthcare/medical industry? If it has not, how can you potentially see this technology bringing change to the healthcare/medical industry?
  - Dr. Ellis: "It has helped in diagnosis and treatment support in my practice. For example if I diagnose a patient with low back pain, my electronic medical record has built in to it the next step an array of choices such as ordering physical therapy, back X-rays, medications often used, etc. This helps the practitioner recall the full spectrum of decisions to be made, and to speed the process during the encounter. Further, I understand that certain kinds of computerized programs which look at a biopsy of tissue can more objectively grade the level of malignancy. For example in prostate cancer tissue, the Gleason Score depends on an estimate by the pathologist as to how many of the cells have a malignant appearance. A computerized program has been applied to this process, thus reducing the human input into such judgement. A similar process has been established for looking at pictures of skin lesions when judging a possible skin cancer called melanoma. In both these cases, the role of the doctor is replaced by a computerized program."
  - Dr. Gray: "AI could help to make big data more accessible to providers and help providers make decisions to guide individual treatment progress based on more data/info (either from that patient or from other patients)"
- What are positive and negative effects that you can see occurring if this technology was used in your field?
  - Dr. Ellis: "Positive: greater speed and efficiency in managing patient care in the case of diagnosis and decision support. Greater objectivity in the grading of visual clinical data in the case of biopsies and pictures as described above. Negative: the human elements of listening carefully to establish the source of a problem, showing

care and empathy to the patient during encounters, and performing "hands on" physical examination of the patient is all too often being diminished in patient encounters. They are being replaced by a reliance on tests, imaging, and patient surveys (like this) regarding things like depression. This reduces the somewhat subtle but important human aspect of a practitioner being a healer that gives the patient a sense of confidence in his/her care."

- Dr. Gray: "Negatives could be patients using/misinterpreting information, mass availability of individual patient data (patient confidentiality). Benefits are more information to guide decisions."

Next, the responses from the researchers in artificial intelligence and deep learning that volunteered to interview will be expressed below. Two questions are slightly tailored to fit their profession because technology is where they are most experienced:

- What Artificial Intelligence technology have you used or discovered within your field of research/work? (List 1-3 of the ones you find most valuable)
  - Dr. Johnsen: "That's a pretty broad question. Most of my data analytics work is done in Python, so the SciPy stack of technologies. I also used Unity3D for interactive graphics."
  - Dr. Moayed: "I have used the Chaotic Neural Network, Swarm Intelligence, and Evolutionary Algorithms as well as Deep Learning. Currently, the most valuable technologies in AI are all in the area known as Deep Learning and include in (in no specific order) (1) Transformers (and its predecessors such as Google-developed BERT, OpenAI-developed GPT-1,2,3 used for Natural Language Processing), (2) Generative Adversarial Networks (GANs) (3) Convolutional Neural Network (CNN) and (4) Deep Reinforcement Learning (DRL). These areas are fast-changing and as we speak new areas of AI are emerging such as Meta-learning."
- What are their purposes and functionalities?
  - Dr. Johnsen: "Much of the work is data wrangling, which is elegant using Python. Unity3D is used more for developing intelligent agent simulations that you can interact with."
  - Dr. Moayed: "Deep learning (DL) since 2012, has changed many industries from speech recognition, machine translation, context comprehension, to machine vision, autonomous robotics/driving, and context generation."

- How has this AI technology impacted the healthcare/medical industry? If it has not, how can you potentially see this technology bringing change to the healthcare/medical industry?
  - Dr. Johnsen: "I don't think AI has had a huge impact yet on the medical industry as a whole. I do see fields like Radiology being dramatically transformed in the near future though, because it is so heavily based on human analysis of images. Intelligent agents can be and are used for teaching purposes. In the much farther future, we could see some types of surgery being automated through robotics. Perhaps we will see some innovation with AI and electronic health records, though for any given individual, the data is extremely sparse. A much greater benefit could be gained from AI that helps individuals make better choices."
  - Dr. Moayed: "So far, the role of DL and AI has been assistive in helping doctors and healthcare professional in diagnosis or robotics surgery. One reason is that the changes in medical fields need to pass its test of time and be approved through rigorous procedure by the medical authority such as FDA. But to my point of view, this will not stop there, and it will change the medical field dramatically to a point that AI diagnosis will be much more accurate than the human diagnosis. There have been many similar success scenarios in the last few years that makes me hopeful that this is happening sooner than later. Stories such as the impossible Alpha-Go victory in 2014 in which nobody (even the most optimistic AI researchers had not seen that coming) had no expectation that an AI would win a game that literally needs human intuition."



**Figure 4: Robotics Surgery**

- What positive and negative effects have you seen (or can potentially see) with the technology being used in the situation from the last question?
  - Dr. Johnsen: "Greater standardization amongst the medical community is an important side-effect of the use of more AI. This potentially frees up more human

beings for providing services through face-to-face contact. I haven't seen much AI impact our daily lives yet, unfortunately. Much of this is due to various legal issues surrounding its use, which largely protect us from "bad" or "biased" AI being employed. If and when AI systems can perform various roles in the healthcare industry reliably, they will be replaced, and the world will likely be better for it. But this is only going to happen when the healthcare industry can lower costs and not get sued for doing it. The same situation is happening now with autonomous vehicles. The industry is almost to the point where they can let cars drive themselves safely. The next steps are lowered costs, and then adoption will be immense. The "natural" environment of the human body and human interaction is a much more difficult problem for AI, so it's going to take a bit longer for AI systems to become reliable."

- Dr. Moayed: "Like any other new technology in the last hundred years, AI can come with its positive and negative effects. The most frightening situation I would see is AI being in the hands of a few to create a class of useless people\* (term used by Yuval Noah Harari in "Homo Deus: The History of Tomorrow"). The positive effects of AI are beyond imaginations, from regular applications such as automations, robotics to and giving humanity a chance to be independent from needing to work to live. For the first time in human history, humanity will not be defined by what they work as their profession because there won't be need for that workforce and they can potentially be free to think and blossom their creativity and thoughts for the better of mankind. At the end, I want to express this quote from Andrew Ng (former Stanford AI professor, and co-founder of Google Brain), "AI is the new electricity". Imagine how electricity have changed the world and now our world cannot function without it. That is how it would be in one to two decades from now with respect to Artificial Intelligence."

#### IV. Analysis of Results

This section will analyze the responses from both professional groups and draw out qualitative information from each to base the educated probability on their similarities and differences.

##### A. AI and Deep Learning Technologies Currently Used Analysis

When analyzing both groups of interviewees, there are some distinct differences in the technologies being used in their perspective fields. This is likely because of their particular

practices and how they have made an impact within each industry as practitioners and developers. However, one reoccurring theme that stands out as a similarity between the doctors and the researchers is the use of electronic health records to make diagnosis and draw other conclusions. Dr. Ellis stated that he currently uses it to receive the next steps for what a patient should do for their current condition such as ordering physical therapy, back X-rays, and suggest medications to use. Dr. Gray analyzed what forms of AI and deep learning is used in her field and came to the realization that electronic health records would be prioritized as most beneficial because she would be able to use it for effectively identifying patient progression. Dr. Moayed and Dr. Johnsen also touched on the use of electronic health records being essential for patient diagnosis as well. With this information coming from both parties, it can be highlighted as important, qualitative data that can be used to suggest that AI and deep learning should build upon the use of electronic health records so that it's innovative functionalities can bring about even more results.

#### *B. The Future Impact AI and Deep Learning Will Have on Health Care Analysis*

The future impact that artificial intelligence and deep learning will have on healthcare is limitless. Yes, this sounds touché, but because we're still at the early stages of development we can say that there is so much ahead of us to see and experience. Based on some important details from the interviewed professionals that will be discussed in this section as well, the future of health care is headed in on an innovative path.

Between the two groups of professionals, there is a difference of perspective of where AI and deep learning is now, but a similarity in where the future for the impacting technology will bring in the clinical field. The difference lies in the explanation of Dr. Ellis, the clinical professional, stating the use of AI is currently being used in his field to analyze images of skin lesions to diagnose patients with a specific cancer. He emphasized that this program replaces the efforts doctors are making for this scenario. Dr. Johnsen believes that radiology will be dramatically changed in the future but based on Dr. Ellis confirming the literature research it can be concluded that it is already being transformed. With taking both statements into account, it can be said that with the current use of AI and deep learning in radiology there is a solid foundation to effectively shift the way radiology will be conducted in the future. The same can be said for Dr. Johnsen and Dr. Moayed's contrasting beliefs on the topic of robotics in health care. Dr. Johnsen sees the far future having robotics in surgery, while Dr. Moayed discussed that AI and deep learning currently plays a role in robotics surgery. With the analysis of each statement, it can be conducted that Dr. Johnsen's belief can be seen as something that will occur more popularly as Dr. Moayed's belief assists with providing confirmation of the literature research expressing it currently being implemented in some areas.

#### *C. Positive and Negative Impact Analysis*

Both parties who responded to the question centered around what are the positive and negative effects that the AI and deep learning technologies they've had experienced with or can see

being used in the future has had on the healthcare industry. This is probably the most important question because before anything should be implemented, developers, scientists, medical professionals and even patients should all be providing their belief as to how they can see the change being made with the new technology will be for the greater good or will take the industry on a decline. This also helps prevent a lot of negative situations that can be avoided if a conversation discussing these matters was to take place.

As each answer was read from above in the interview results, it is seen that there are some promising benefits that can change the world as we know today for a better tomorrow. However, there are some distinct ethical concerns found in the responses that can be related to what was covered in the literature review that have to be taken seriously as well. This section will begin discussing both views of the positive and negative effects to see either similarities or differences to make an educated analysis.

First, the responses towards the positive impact AI and deep learning has on the healthcare industry will be analyzed. The medical professionals determined that from their professional experience they believe that the positive impact resides in efficiency and objectivity. The professional researchers believed that the positive impact will include standardization of the technology being used, the opportunity for people to have the time for creative freedom, and freedom of constant work. Based on these responses, it is important that innovators shift their focus towards what they believe will bring about these impacts, but also evaluate to see which is more beneficial and which would need to be sacrificed. Not everyone will be able to be pleased in this situation, as the impact for freedom of constant work can be seen as a negative which was highlighted in the response of one of our medical professional's response.

If we take a look at what was said from Dr. Ellis in regard to more technology can mean less human interaction with doctors and patients which can be bad for the patients because there will be a lack of emotion, empathy, physical examination that already gets overlooked, and the confidence a patient may have in the doctor they've been consistently been relying on. The difference with this response is that the professional researchers believe that less human interaction frees up time and space to do other important things that will allow for them to be "independent for the need to work to live", and to not be defined by what people do. Essentially having the opportunity to invest in finding more creative solutions for humanity as technology does most of the hands-on work.

It is difficult to say what should be sacrificed because both perspectives are extremely valuable to the progression that is desired to be made for the healthcare industry. Which on the other hand helps us make a sounder decision because we know that the ultimate goal is to push for positive change in the health care industry. The next section below will discuss recommendations for how to select which path to choose to benefit those that have to take care of patients, those that need medical attention and those that have to develop the technology to assist the medical professionals.

## V. Recommendations

From what has been able to be analyzed, I would recommend that we take into account what every group of people are saying who play a role in this process of making the healthcare industry change for the better with the next technology, which also includes the patients who tend to be overlooked most times. I see from the literature review when looking at ethical concerns is that patients don't get informed as much as they should and neither do, they have a say until what's being developed has already been implemented into practice. Taking these concerns into account will possibly help save money from the aspect of developing something that may not want to be used by patients, or any other risk that could be associated with it.

With that being said I believe that users of different applications and patients who will be partaking in various AI and deep learning led clinical treatments should educate themselves on the privacy laws and policies, what type of data they are giving up, and all of the other important information they'll be signing up for before carelessly selecting that they are okay with what is being done. I believe partially it is difficult as a user to desire to read everything, and so with the interface just being a large document with tons of words that may not be fully understood that's preventing a user to move on to the next step, their natural inclination is to just say yes and move forward. If developers can create a more simplified way for users to read and understand the documentation of what they are choosing to do with the applications, then that would attempt to allow users to be in position to better know what is occurring behind the application.

I believe it is also essential to get more doctors and medical professionals across the board more educated with artificial intelligence and deep learning technologies. Based on Dr. Gray's response we can assume that other professionals may not be using this form of technology yet for their practice. They are one of the ones who will be impacted the most in this innovative change for the healthcare industry, therefore they should at least keep up to date and see where they can potentially add AI and deep learning to their practice.

## VI. Conclusion

In conclusion, the healthcare industry is still at the beginning stages in regard to the implementation of AI and deep learning technologies in practice when comparing where the future is headed to. There are small usages and complex usages in today's time, but as said before it's not standardized for the community of physicians and medical professionals. It will take years, but the amount of time to invest in this is quality and valuable. This process should not be rushed because people's lives are at stake, and with the proper precautions and risk evaluations that need to constantly take place then it will be clear that the benefits outweigh the deficits.

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