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Artificial Intelligence in the medical sector: Aid in decision making or Outsourcing of the human decision?

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Index of acronyms and abbreviations

AI : Artificial Intelligence

NCIL: National Commission for Informatics and Liberties

HDS: Healthcare Data Host

CEO : Chief executive officer

GAFA : Google, Apple, Facebook, Amazon

GAFAM : Google, Apple, Facebook, Amazon, Microsoft

PPV: Positive predictive value

NPV: Negative predictive value

NHS: National Health Service

SCP: Surgical Care Practitioners

Introduction

Nowadays, we can often hear about Artificial Intelligence (AI), risks related to it, or even about the war of intelligence. Yet in everyday life few of us are confronted with it. We even come to the point of asking ourselves; what is it concretely? Nevertheless, although we do not always realize it, AI is already part of our lives. The latter is integrated in vehicles, smartphones or even powerful computing machines, such as those with computer algorithms and which allow high-frequency trading. It is especially since the end of the 1990s, the popularization of the Internet, then the appearance of Big Data, that the AI started a very fast development, because the barriers and the problems which prevented its development were from now on behind us. Artificial Intelligence, which was considered as science fiction by a large majority of the population 15 years ago, has since seen technological advances that will certainly disrupt our society in the near future. Its development is incredibly fast and that will certainly not slow down in the years to come.

With this development, AI often divides people into two camps. There are those who believe in AI and want it to develop as quickly as possible in every imaginable area. But there are also those to whom the AI is scary or who prefer to approach the subject gently. For example, Stephen Hawking, who recently left us, was not alone in questioning the rapid emergence of AI.

He said: "*The primitive forms of artificial intelligence that we already have, have proved very useful. But I think that the development of a complete artificial intelligence could put an end to humanity*". And he specifies: "*Once the men would have developed the artificial intelligence, this one would take off alone, and redefine itself more and more quickly. Humans, limited by slow biological evolution, could not compete and would be overwhelmed*".¹

¹ Nicolas Martin. (2018). A quand un Nobel pour une intelligence artificielle ?

At the same time, other scientists or bosses of large companies known of all, such as Bill Gates or Elon Musk are also reluctant to this progress. This can also seem surprising since they invest themselves in this technology. Elon Musk, best known for developing and using AI for his Tesla vehicles or SpaceX space shuttle, has created Neuralink. A company whose primary goal is to protect against the probability of the destruction of humanity by AI by integrating electronic components that can merge with the human brain to increase its capabilities. This is the essence of Transhumanism, which advocates increasing the intellectual and physical attributes of humans by integrating biotechnologies or nanotechnologies.

One thing is certain, though, is that AI will undoubtedly be a key success factor for every business in the near future, regardless of the industry. The economic outlook is torrential. Indeed, "*the AI could contribute 15,700 billion dollars to the world economy in 2030*", according to consulting firm PWC. AI is developed in different forms (machines, robots, processors, chatbots, etc.) and by many research centers, companies or start-ups.²

For this study, we will focus on the medical branch, which in this sense is one of the most interesting to study. Indeed, medicine must progress and for this the use of AI seems unavoidable. This AI can have a considerable contribution to the rapid development of medical techniques, the discovery of new treatments, the improvement of diagnoses, the prevention and even the reduction of health costs.

Today, medical studies are those that last the longest, and for good reason, nobody is ready to entrust his life or his health to a doctor who knows only superficially his field. However, a person is not able to retain a very large number of information and a surgeon does not necessarily have the experience of another, practicing in the same field, because he could never have been confronted with such a situation or having read a particular medical book.

² PWC. (2017). Intelligence artificielle : un potentiel de 15 700 milliards de dollars de gains pour l'économie mondiale d'ici 2030.

The establishment of a reliable diagnosis would therefore involve bringing a large number of doctors who have had different experiences, who have read different books or who have practiced in different situations. But even in this case, we cannot be sure that the diagnosis would be reliable, because the opinions could be divergent.

This is where the AI can help. Indeed, theoretically, the AI would be based on an infinite quantity, on a human scale, of data concentrated thanks to Big Data. It would therefore be able to sort information from different times, countries, authors, analyze it and give an accurate diagnosis, which would be based on previous experiences. This analysis would take a minute time compared to the analyzes performed by a person and would not be biased by cultural, religious, experiential, social, etc. influences.

At this point, it is normal to ask the following question: but systems of help to doctors already exist, is it Artificial Intelligence? Unfortunately, everything is not so simple. What differentiates AI from powerful computers that have been present in medicine for a number of years is, like a biological brain, the ability to formulate logical reasoning from a database and therefore, make a decision.

It is precisely this notion of decision that brings us to the heart of the matter. According to Thierry Souccar: "*The decision is defined as a judgment providing a solution to a problem.*

Basically, the steps of decision-making are:

- *Define the problem*
- *Collect information*
- *Seek solutions to the problem*
- *Choosing the best solution*
- *Apply the chosen solution to the problem*
- *Validate the correctness of the chosen solution»³*

³ Thierry Souccar. (2017). Qu'est-ce qu'une décision ?

Obviously, the AI as its developers want to see it, is able to go through all these steps to reach a solution and make the decision. But a problem then appears. If Artificial Intelligence is more efficient than humans in analysis, diagnosis and is able to make correct decisions based on it, then it would be logical to leave the decision-making power to Artificial Intelligence. Except, once again, it is difficult for the moment to imagine that the human being is ready to entrust entirely his health, even his life to the decision of a machine.

All these elements push our thinking to the following question:

"Artificial Intelligence, would it be a decision-making aid in the medical sector, or an outsourcing of the decision of the doctor"

We will study this question by trying to provide some answers to the following hypotheses:

- *Some medical professions related to areas such as imaging or radiology would disappear for the benefit of AI, which would seem to be more effective than humans in the collection, analysis and comparison of a large amount of data.*
- *In the domains mentioned in hypothesis 1 (ex: imagery), decision-making would therefore be outsourced and performed by the AI, because the doctor cannot reach the level of analysis of the AI to take the risk of contradicting the decision. Indeed, after a thorough analysis of 20 terabytes, any doctor would simply sign the paper without being able to bring arguments against this analysis.*
- *In contrast, the AI would be an aid to the decision-making of the doctor in areas such as surgery. Indeed, it is always the doctor who would carry out the operation and would therefore be responsible for any problem. Moreover, during a surgical procedure, a part of intuition and the senses are essential. These are things the AI does not have.*

- *The health of tomorrow would be completely under the control of Silicon Valley, because they are giants with astronomical budgets, who invest a lot in the AI and its development. They have specific goals and already employ as many doctors and scientists as developers or engineers.*

To carry out our study, we will at first briefly look at the history of Artificial Intelligence, define the main terms, make the link with Big Data and see what the potential of AI is, but also what limitations this technology presents. Then, we will study what disruptive evolutions AI can bring to the medical sector and what problems it will face.

In a second step, we will ask ourselves what is the importance of decision-making in the medical sector and what role would AI play in this decision-making?

Finally, after this theoretical study, we will look for answers in the field, with health professionals, AI developers and potential customers to conduct a qualitative study and analyze its results in order to affirm or decline the initial assumptions.

Part I: Artificial Intelligence and its application in the medical sector

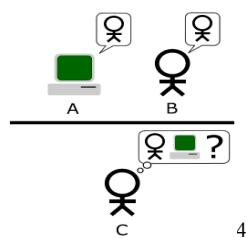
A- Artificial Intelligence

1.) History

It is directly after the second world war that the term Artificial Intelligence (AI) appears for the first time. Indeed, great intellectuals, engineers, mathematicians or scientists have begun to discuss the possibility of creating an intelligent machine, which, through specific programs and algorithms, will have the opportunity to perform creative functions and even to learn by itself. What has traditionally been considered something of a man's own, was now controversial.

In 1956, things came to fruition and AI was founded as an academic discipline, thanks to John McCarthy, who is one of the leading pioneers of AI. The latter is even distinguished by the price of Turing in 1971 for his work on AI. Turing meanwhile, is known thanks to the test of which he is the author and which consists for a machine to imitate a human conversation. More concretely, if a person starts a conversation with two interlocutors (a man and a machine) without seeing them and is not able to define which of them two is a machine, it is considered that the machine has passed the test successfully. This test is well illustrated in the movie of Alex Garland, released in 2015 and entitled "Ex-machina".

Figure 1: Schema of the Turing Test:



⁴ Léa Farine. (2016). Test de Turing

Over the years, the AI continues its evolution and it is in 1985 that it is confronted in a game of chess to Garry Kasparov, considered as the best chess player of all time. That day, Kasparov simultaneously beats 32 computers with special algorithms. So, it was a disappointment.

However, in 1997, 12 years later, the AI took revenge by beating the world champion. It was Deep Blue, a computer developed by IMB and programmed to play chess. It was then a sign. Developers have learned from their mistakes and improved algorithms.

As a result of his failure, Garry Kasparov spends a lot of time studying the man - machine relationship and clearly becomes a pro - AI. He also observes another tournament, where 2 Americans with a relatively weak laptop beat pro players with big machines, simply because they were more complementary. He then creates the following formula:

$$\text{Weak human} + \text{weak computer} > \text{strong human} + \text{strong computer}^5$$

What makes the big difference according to him is the man - machine interface. In other words, the ability to associate to make better use of one and the other.

The performance of the man - machine device is not equal to product of human performance and machine performance.

« *Here is a mathematical simplification:*

$$P(h, m) \neq h \cdot m$$

$$P(h, m) = (h \cdot m / (1 + F))$$

⁵ Diego Rasskin-Gutman. (2010). Chess Metaphors: Artificial Intelligence and the Human Mind

*With F, which measures the difficulties encountered by the man and the machine to cooperate ».*⁶

Since then, the development of AI is constantly accelerating, with many companies, states, research centers investing huge sums.

So, comes AI as we know it today. For example, in the voice or facial recognition systems of our mobile phones, chatbots embedded in websites or social networks, or driver assistance systems in vehicles with the option of autonomous driving.

But the biggest rebound and sign of the advance of the AI comes in 2016. The Google Deep Mind beats Lee Sedol, world champion, in the game of GO, thanks to its program "AlphaGo". It was a real test, a kind of border to cross for AI. The game of GO is considered more complete than the chess game, since it has more than 70 billion different combinations, 5 times more than the game of chess. Moreover, it is considered to be much more intuitive and not simply limited to a large computing capacity.⁷ AlphaGo was thus able to learn by itself and perceive signals inaccessible to the human understanding. Thus, this victory marked a point of no return, encouraging for the continuation, but equally worrying.

2.) Definition of AI, operating principle, different forms and fields of application

Artificial intelligence was defined by one of its creators, namely, Marvin Lee Minsky, as: "*The construction of computer programs that engage in tasks that are for the moment, performed more satisfactorily by human beings because they require high-level mental processes such as: perceptual learning, memory organization and critical reasoning*".⁸

⁶ Antoine Henin. (2015). L'avenir de la relation homme/machine : l'exemple de la santé

⁷ Marc Zaffagni. (2017). AlphaZero : l'IA de Google DeepMind devient imbattable aux échecs.

⁸ Marvin Lee Minsky. (1956).

We had the opportunity to see a brief overview of the history of AI in the previous chapter but what interests us is the AI today and what it will become in the future at short, medium and long term.

Before we look at the application of AI in the medical sector, to fully understand all forms of AI that exist today, we will first see its scope. This will help you become more familiar with AI, understand how it works, develop and what it can bring.

The development of AI accelerates in the 2000s and in particular thanks to Big Data and Machine Learning, which one can simply define as the capacity of a machine to learn, especially thanks to the data.

To put it simply by taking a concrete example, this process can be compared to the learning of a biological brain, that of a child for example. Indeed, Big Data is used as observations or memories. For example, a child who would see the sun rise for the first time, would find it just strange and would seek information from his parents. It's a bit the same for AI.

Thanks to a huge database provided by Big Data, the machine would look for similar information and eventually realize that the phenomenon of sunrise occurs constantly, regardless of other factors. Thanks to this accumulation of observations, the machine will be able to draw a conclusion and foresee events.

Nowadays, the AI has several fields of application and is used in the fields of:

Smartphones: Indeed, every smartphone user today knows the personal assistance of his phone. That goes through assistants like Siri at Apple, Bixby at Samsung or the intelligent interface of Huawei.

Automotive: Tesla was the first consumer car to be marketed with an autonomous driving option, unlike other vehicles that offered only more powerful driver aids.

Real Estate: Smart assistants who run the house. For example, close shutters once night falls, thanks to sensors, turn on the light, heat as soon as the temperature reaches a minimum threshold, send SMS to the owner in case of problems, etc.

Trade and customer relationship: In this case, the AI is more often used in the form of a chatbot, which questions customers with more and more precise questions in the form of a funnel, where each subsequent question depends on the response of the customer to the previous question. This allows one side to improve the customer experience and satisfy the latter by offering for example the clothing that best suits him, but also to increase the turnover of the brand.

Justice: Yes, AI is even used in justice today, always in the form of chatbot most often. As an example, we can cite the "Do Not Pay" chatbot, which helps customers to help them contest any kind of fines or even claim compensation from airlines, to follow up on problems, cancellation of theft, loss of luggage, etc.

Art: Even more surprising, the AI is now able to reproduce paintings with a few details near the greatest painters, thanks to increasingly powerful algorithms.

It is normal to say, that to reproduce is not to create and to realize. It is therefore legitimate after this example to question the creative abilities of AI. But there is an even more disturbing example. Indeed, in 2016, a short film of 9 minutes was made by a neural network (AI), called *Benjamin*. The latter was developed by director Oscar Sharp and scientist Ross Goodwin. *Benjamin* wrote himself a science fiction script that was called "Sunspring".

AI now exists in many forms and is far from resembling AI as can be seen in the movies, for example "Ex-machina" in the form of robots virtually identical to human beings. Indeed, as mentioned above, it can be similar to Chatbots, Data Mind, TALN, Deep Learning, etc.

Chatbots

« A Chatbot is a conversational agent. This word is made from the English word "Chat", which can be defined as a conversation and "bot" which is simply the contraction of the word robot ».⁹ It is a software that includes a database of questions and answers and knows how to recognize independently what answer corresponds to which question. In itself, Chatbots have been around since the early 2000s, but they were very limited algorithms and are not always positively perceived by users.

Today, the Chatbot has been reinvented. The role of the AI is therefore to transform this user experience by providing a conversational agent, which ideally, pass without problem the Turing test, mentioned above. These Chatbots equipped with Artificial Intelligence, allow the user not to select pre-established questions, but to use his natural language. From there, the AI is able to recognize the request, "read between the lines", that is to say identify sub-understandings, characterize the request and thus provide the answer that the user expects. If the AI does not have enough information to answer the question precisely, it is able to ask questions in order to deepen the understanding of the request. It would be closer to a simple conversation between two humans. Indeed, the AI also allows to have a very varied and rich vocabulary, as well as the use of a certain humor which can refer in a certain way to feelings.

To facilitate the exchange of information, systems such as TAL (automatic language processing) or TALN (automatic natural language processing) are also used. These are programs, which allow the AI to understand and extract the information of users' sentences, recognize the languages used but also understand the idea behind a particular question. Thanks to these systems, the Chatbot can give an adapted answer and using the correct language.

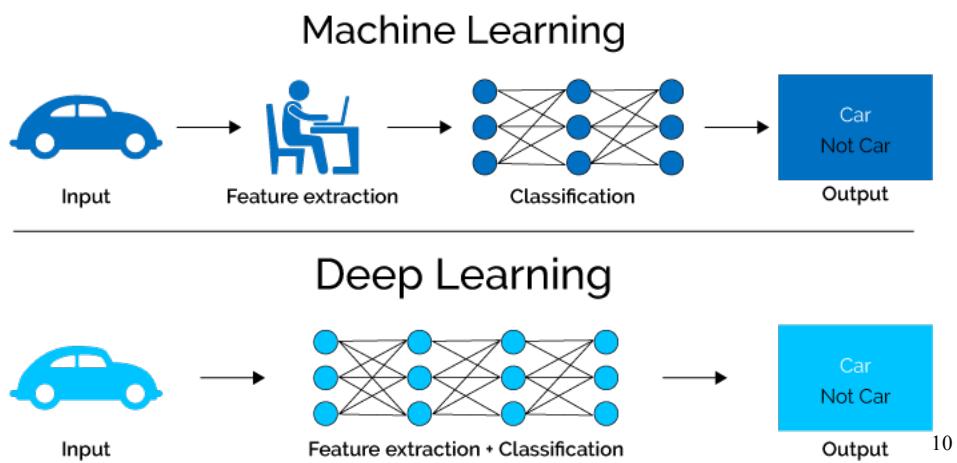
⁹ Luc Pierron, Antoine Evennou. (2017). La santé à l'heure de l'intelligence artificielle

It should be understood, however, that behind this type of technology, this hides the use of Machine Learning, that is to say the ability of a machine to learn through a large database, as previously defined and Deep Learning.

Deep Learning

Deep Learning is complementary to the Machine Learning and is broken down into two different learning techniques; Supervised Learning and Unsupervised Learning. The operation of Artificial Intelligence is therefore similar to the functioning of a human brain. It is also a network of "neurons" that exchange signals. Deep Learning allows the learning of these neurons, always in the image of a human brain.

Figure 2: Comparative diagram of Machine Learning and Deep Learning



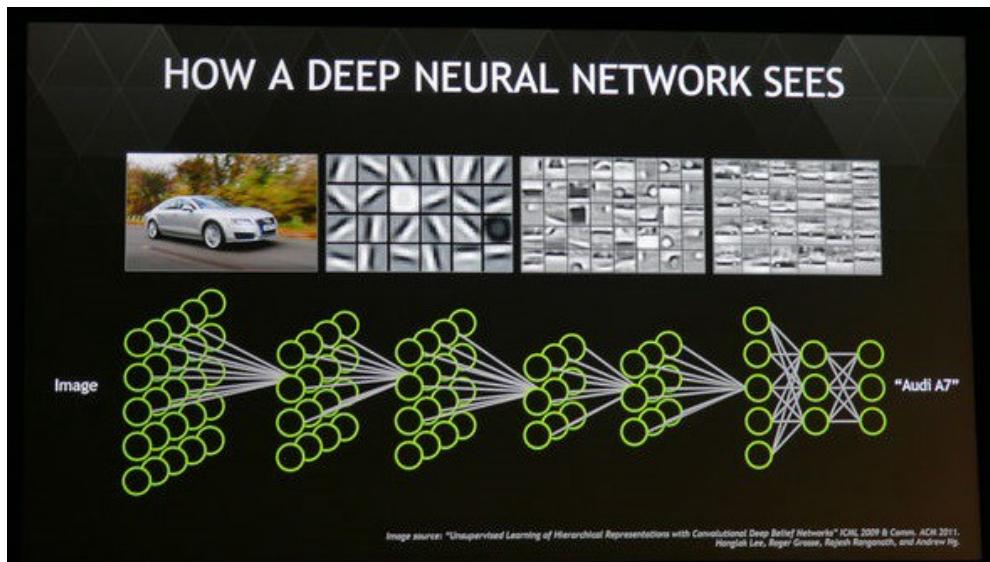
To better understand, we will study a concrete case taking as an example a car. First of all, it is necessary to use examples of everyday life to understand the process, then we will see in detail how these processes work in medicine.

¹⁰ George Seif. (2018). I'll tell you why Deep Learning is so popular and in demand

To recognize a car, the machine needs training, because it does not know what it is the first time it sees it. For this purpose, we will submit to the machine a set of images to train. The latter will have thousands, even millions of images. To recognize a car on an image, this network of algorithms must be able to recognize a car from different angles, in different situations and in all its forms, colors, etc.

At the end, the machine will gather all the data and information in order to deduce that it is a car and especially, which one is it.

Figure 3: Schema of the Deep Neural Network



In the case of the supervised learning technique, the AI will compare its responses obtained after analysis with those provided by humans. If the answers are correct, the AI will save their answers. Otherwise, it will take note of its error and go back to the faulty neuron to make a correction.

¹¹ Shamane Siriwardhana. (2017). Introduction to Convolutional Neural Nets.

In the case of the Unsupervised Learning technique, AI does not have human-provided answers and simply relies on models or samples within the set of data provided by Big Data to form by itself. Obviously, this does not only concern images, but also words, expressions, languages, situations, etc.

3.) Big Data

The term Big Data was born in 1997 and was mentioned by scientists working for NASA to represent data that has become too big and far too difficult to process. Thanks to Big Data, researchers do not need to create new data or tests that are often very expensive, because now they have access to a huge amount of data they can re-use as much as they want, according to the aims of the research.

Big Data is an essential part of Artificial Intelligence. These are gigantic amounts of information organized or not and which represent in a way the memory of AI, always comparing it to a biological brain. These data help AI to develop, including the accumulation of observations as discussed in previous sections. These are the data that the machine processes and apprehends through Machine Learning, which it classifies and then allows it to draw conclusions and make decisions. This unquestionably opens the door to incredible study opportunities and applications to multiple fields of research.

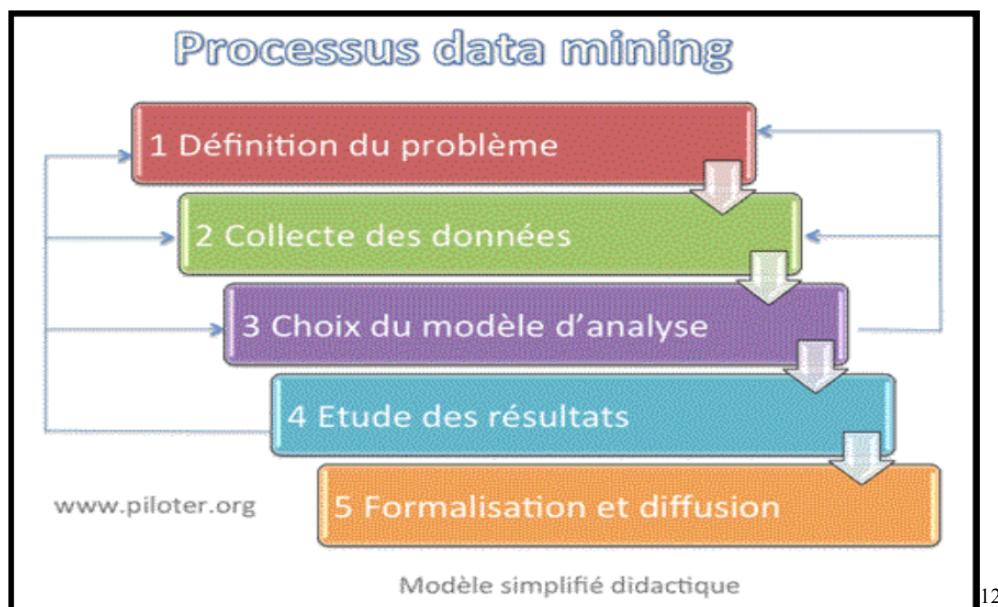
However, Big Data does not just have advantages. They pose a lot of ethical and even legal problems. Moreover, the medical sector is a very good representation, because in particular to advance the research, we need a lot of medical data. This raises the issue of medical confidentiality and the confidentiality of this data. But we will come back to this later.

Also, there are issues related to the exponential growth of storage volumes. Data is increasingly diverse; in the form of images, videos, texts, audios, etc.

For example, more than 90% of global data has been created in just the last two years, and experts expect to produce as much as 1.7 megabytes of data per second per person in 2020, which is simply staggering.

However, the combination of Big Data and Artificial Intelligence should be complementary. Indeed, the process of Data Mining, which could be defined as the search and then the exploitation of data, would allow the IA to sort. In order to reach a solution, the AI will have to go through 5 steps. Here is the representation.

Figure 4: Principle of operation of Data Mining



Translation:

- 1.) Problem definition
- 2.) Collection of data
- 3.) Choice of analysis model
- 4.) Study of the results
- 5.) Formalization and diffusion

¹² Alain Fernandez. (2018). Data Mining, explorer les données du Data Warehouse.

As we can see here, point 2 is a key step in the process. And this is where AI will be much more efficient than humans in processing a large amount of data in order to transform raw data into useful information, analyze the results and thus reach a synthesized conclusion.

4.) Potential and limits of AI

Like every new invention or method, AI has its advantages and disadvantages, regardless of the field of application. It is therefore interesting to study what they are, before plunging into the heart of the subject.

In addition to the fact that you can imagine the application of AI in an infinite number of industries or fields, it is important to go to the basics. Admittedly, the AI is very powerful for everything related to very complex calculations, storage, analysis, data processing, etc. But, calculators or powerful computers also have this capability. Except, unlike its latest, the AI can detect errors and take into account parameters that they cannot. For example, units of measurement, variable writings, etc.

But the most important is elsewhere. Regardless of its use, AI has a major advantage: It can theoretically perform the same tasks as man, but it never has physical constraints. Indeed, it does not feel tired and does not need rest. As a result, AI can work day and night, making it a lot more productive than men. Also, it does not need to drink, eat, it does not get sick. While technical or electrical problems may occur, but these are problems that are occasional and easily adjustable.

However, there are also nuances to consider. AI cannot have feelings, feel things, use intuition. Feelings cannot be programmed and this is a real problem when it comes to applying AI in an area where it will need to be in contact with humans who are not directly concerned with AI. Moreover, many people are hostile to the development of AI. On the one hand, it is perceived as a possible threat to the survival of humanity if given full autonomy.

On the other hand, the development of this one would lead to the suppression of many posts that require repetitive tasks or calculations. As an example, we could mention the accountant position. Also, whether we like it or not, the AI will remain dependent on the man, at least initially, since it is the human who will program the machine.

B- Towards what disruptive evolutions in the medical sector

With what we have seen previously on AI, it is normal to wonder why we do not develop this technology more quickly in order to improve medicine and overall well-being in society. It can be said that medicine lacks flexibility in the deployment of new technologies compared to other sectors such as the military or space sectors.

But it is important to understand that the primary goal of the medical sector is not to win the race for technology, but to provide solutions to reduce the mortality rate due to various diseases and to increase life expectancy. The real project is therefore to provide effective solutions and to take into account the respect for human life and not just to go fast.

It is very complicated at the moment to make predictions about the application of Artificial Intelligence in the medical sector, because the possibilities are limitless. Of course, it could be very useful for researching, analyzing a large number of medical data, diagnosis and therefore prevention. But to what extent can AI bring innovative solutions in this sector and what difficulties can it face? This is what we will see in the following chapters.

1.) What could AI bring to the medical sector

Today, a lot of companies and especially the giants of Silicon Valley, like Google, Facebook or Microsoft are investing in the health of tomorrow. They buy more and more Start-ups and already have as many doctors and scientists as engineers and developers on their premises. They have understood that the challenge of tomorrow is in human health. In addition, the market that will be boosted by the deployment of the AI is very promising and is growing day by day.

But apart from the fact that this disruption will allow large companies to earn even more money and to have a stake in the health of tomorrow, these innovations will undoubtedly have beneficial effects for all men having access to these new technologies.

First, the AI could provide an improvement in the techniques and processes of care. Indeed, heart disease is the leading cause of death. What is indecent is that in most cases, it is very simple to prevent these diseases, it is enough to pass electrocardiogram tests, which allow to accurately see the anomalies, to predict their evolution and therefore prevent any kind of problem. Only less than 10% of people do it. And for good reason, general practitioners are not great professionals in every branch of medicine, which is quite understandable because their primary role is to recognize symptoms and refer the patient to a specialist. But if the symptoms are not recognized, it is obviously impossible to start treating the problem, especially since only very good cardiologists are able to accurately decipher the curves of the electrocardiogram.

AI, for its part, would be able to decrypt the curves very quickly and much more effectively than a human, moreover it would have access to a gigantic database from around the world, different times and languages to compare and give a reliable diagnosis. It could use many more examples than any doctor and make a diagnosis much faster.

Therefore, the introduction of this technology would, in this case, popularize this type of test by detecting upstream possible diseases and thus prevent them while improving the health and well-being of humans.

But this is obviously not the only field of application where AI could be useful. AI could also bring a lot of research into different types of cancer. AI prototypes, which are considered weak, can already detect cancer 1000 times faster than the best oncologists and by 2030, this figure should increase to 1 million times faster. Truly, the AI has the ability to see what the man does not see, like shades of color on radios for example. Thus, it detects more quickly if a mole is benign or malignant and advises to extract well before possible complications. Or, it could be very useful for the dental industry, because AI is not limited to a 3D vision, it sees well beyond. Thus, it could establish an optimal order of tooth movement, etc.

On the other hand, thanks to AI, we can use genomic data. That is, we are not focusing on a single gene, but we can study genome-wide processes that represent all of the genetic material. This makes it possible to anticipate the development of diseases from birth, well before the first symptoms appear and thus prevent them much more effectively.

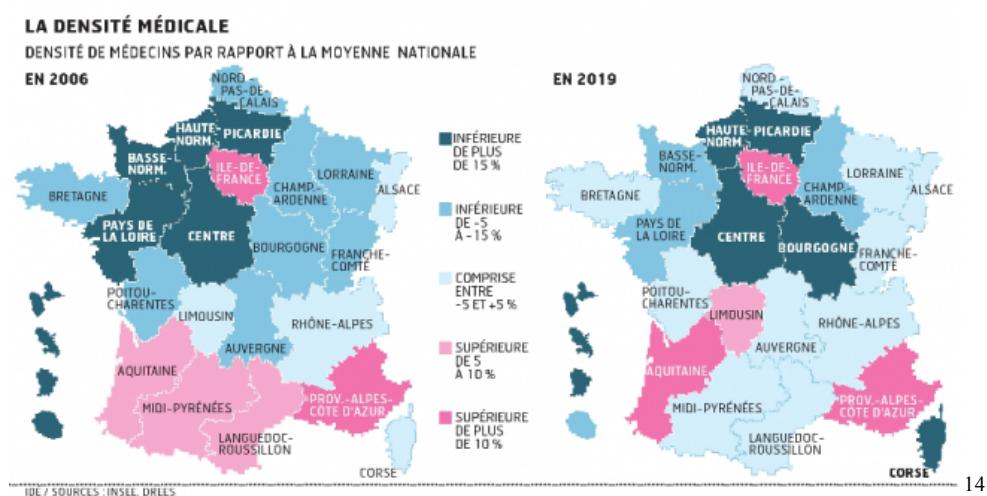
Without AI the study of these genomic data is not possible since they are counted in tens, hundreds or thousands of terabytes and each person has about two million mutations compared to the reference genome. As a result, no human is able to use his data even during a lifetime.

Also, precision medicine would become more and more present. You should know that a drug produced today, can help a person while not giving the expected effect to 10 others. This is a real problem, which thanks to AI, could be reviewed by adapting more and more treatments to each individual.

Moreover, AI would have a very important role in assisting health personnel. The patient would become an actor of his health and the AI would allow an improved follow-up, in particular at a distance, outside the hospitals or the centers of care. This could be done through connected bracelets that would take the tension, heart rate, body temperature and more. Then, this bracelet could alert the patient to remind him to take a treatment or to alert a doctor directly in case of any anomaly that may occur. As a result, the workload of the nursing staff would be minimized. This would reduce the costs related to health. In fact, this will lead to the congestion of care centers as a whole and will allow reinvesting the money saved in research, innovation, etc.

Following the same logic, we also have no trouble imagining AI as a solution to medical deserts. On the map below, we can see that there will still be many areas that will be affected by medical desertification in 2019, including the regions of central France. We must find a solution and the AI seems to be the perfect candidate. As Guy Vallancien says: « *To ensure a medical presence that meets the expectations of the population throughout the country, it is first of all necessary to increase the number of health centers, but also to rely on advances in robotics and artificial intelligence* ».¹³

Figure 5: Representative Map of Physician Density in 2006 and 2019 Compared to the National Average



¹³ Guy Vallancien. (2017). En finir avec les déserts médicaux. *Les Echos* <https://proxy.escape.larochelle.fr:2131/docview/1970510555?accountid=35036>

¹⁴ Insee.fr

Indeed, the AI as it is conceived, is able to listen to the patient, search for information, treat the data and establish a diagnosis in order to prescribe this or that treatment to a patient. The intervention of a doctor in rural areas will therefore be occasional and only for interventions requiring his physical presence.

After this in-depth study of AI, the medical field and the application of AI in this field, it appears that the use of Artificial Intelligence is essential to allow the medical sector to develop and move to preventive medicine. Indeed, if we believe Laurent Schlosser, a senior Microsoft executive: « *98% of health today is healing. Artificial intelligence will switch to a more preventive medicine* ».¹⁵

2.) Difficulties and limits to overcome

Despite all its good improvements that AI can bring us, there are still many barriers that it can meet before its popularization.

Many people have ambiguous feelings about Artificial Intelligence. Often the first reaction of the majority is the fascination, but then come the questions and especially the fear. Indeed, many fear the fact that the AI could exceed the man, then exterminate him. And it's certainly not the fantastic consumer films that we see in recent years that make things right. This is a first barrier that AI developers have to overcome.

A second barrier would be the need for training of doctors. Indeed, the school in the broad sense, even that of medicine, prepares for the trades of yesterday, without considering the unprecedented evolution of technologies. The medical professions as a whole are not as confronted with computers as other professions. Training will be very expensive and will take a lot of time. But these will be essential.

¹⁵ Laurent Schlosser. (2017). L'IA au service du traitement du cancer.

As with the arrival of the computer, the workers have been slow to tame the machine, but now it is difficult to work without. So, we have to know how to make a concession and take your time today to win it later.

On the other hand, as mentioned in the previous parts, some trades may disappear. This would mainly concern professions related to medical imaging, radiology, etc. This does not necessarily mean that the work will disappear and the number of unemployed will increase. Many trades disappear from one century to another, but as many new professions appear. This means that the trades will mutate and reinvent themselves, men will work in areas where they will be better than the AI, namely the trades where there is need for creativity, intuition, meaning and well-being with other humans.

These would be, for example, care related to listening, where there is need to reassure the patient, provide support. Moreover, it is not impossible that Human Resources merged with the IT department in the future to manage both the biological and computer brains.

One of the possible problems would be related, in particular in France, to the CPAM and the various mutuals or insurances. Indeed, the AI would predict and prevent diseases well before they arrive. But this will cause problems with the reimbursement of expenses for caring for deviant people, such as those that will continue despite prohibitions to consume alcohol, smoke, do not respect different doses of drugs, etc.

Of course, to each problem has its solution and each question has its answer. Nevertheless, while there is no better purpose than to improve care, reduce health costs, prevent disease and increase life expectancy, while enabling patients to become actors of their own health, the AI still has a lot of evidence to make men entrust their lives to them. Playing chess or GO games does not have a lot of direct impact on humans, but it's totally different when it comes to saving lives.

3.) Ethical and legal issues

The application of Artificial Intelligence can, however, lead to ethical and legal problems. Indeed, the use by the AI of Big Data poses a big problem here. On the one hand, the laws are not adapted to this application. Indeed, if the collection of data is not really a problem, it is their use that remains very difficult.

To hold the medical data of a patient, a hospital center needs to have its agreement. This goes through a process where the application framework is clearly stated to the patient. The subject of data ownership and medical confidentiality remains essential and every hospital center must ensure that these principles are respected.

But there is a concern in the incompatibility of this procedure with the operating principle of Big Data. One thing to understand is that it is better to have a weak AI with a large database than a strong AI with limited data. In this logic, to change things, Big Data requires a lot of data and it therefore seems unethical not to share and allow everyone to use their data to save lives. Just as it is not ethical to go against the will of a patient who does not wish to disseminate his data or wishes to preserve his anonymity.

Today in France, the National Commission for Information Technology and Liberties (CNIL), which works to defend the privacy of the French, is working on this topic and rightly so. Moreover, from 2019, all servers that host medical data must submit a certification issued by an accredited body.

« The ISO 27000 standard, which aims at information security, will be subject to control. This HDS certification (health data host) will concern any server likely to have an operational infrastructure to meet the needs of a health information system ».¹⁶

¹⁶ SCC. (2017). Santé connectée : la protection des données est-elle assurée ?

However, research centers complain about the loss of quality and relevance of the data after their anonymization, which prevents science from moving forward. As Guillaume Jeannerod, CEO of the Start-up "Epiconcept" explains: « *Vigilance is a very good thing, but it can also be a real brake* ».¹⁷

Ideally, states and lawyers should make joint efforts to open up debates and reform in one way or another the laws concerned by this problem. This must be done in order to enable science to move the medical sector forward towards an ambitious future, while allowing every citizen to own their personal data.

After leaving this problem in the hands of specialists in the field, another question remains open. This is the question of responsibility. Indeed, it will also be important to establish laws that will accurately indicate who in a particular situation is responsible for a problem or litigation. Indeed, the machine having no legal personality granting it the ability to hold rights and duties, cannot be prosecuted in case of misconduct. It is therefore necessary to establish laws from probable situations to make a hospital center, a health professional, a computer scientist or the company developing the machine responsible if there is a programming error, a bad diagnosis, or a serious consequence for the patient after intervention of the AI.

4.) The health of tomorrow and Silicon Valley

Nowadays, no research center, no state, no company, invests as much in the development of Artificial Intelligence in the medical sector as the giants of Silicon Valley, like Google, Microsoft or Facebook. Billions are invested every year and health professionals are recruited around the world. In this way, as surprising as it may seem, today there are as many doctors working for these mastodons of new technologies as engineers or developers. They have the hand on the sector and are the creators of almost every new thing related to this sphere. They are just as active in buying and cannibalizing start-ups offering solutions in this area.

¹⁷ Guillaume Jeannerod. (2017). L'intelligence artificielle au service de la santé : entre révolution et prudence. Innovasso.

All this is done in particular to achieve the desire of Sergei Brin, co-founder of Google to fight death. He has also set itself the following goal « *to eradicate all human diseases by 2100* ».¹⁸

On the other hand, it is not difficult to see that all objects today are connected to the Internet permanently, which allows them to access a large amount of data. What is problematic is the intrusion of his businesses into the personal lives of people. For example, facial recognition systems on our smartphones, which detect signs of tiredness or our mood, in order to propose activities or products that would suit us best, can also be used for permanent monitoring of individuals. It is here that this dependence of Silicon Valley, although very important for the good and rapid development of the AI, rejoins the problem mentioned previously, related to the medical data. The philosopher Éric Sadin, author of an essay against Silicon Valley and its transhumanist dream, mentions: « *The GAFA is at the origin of a commodification of life and the divestiture of the human decision* ».¹⁹ It also draws our attention to changes in the core business of these companies who are no longer content to offer online research services or software by customizing the offer through connected objects.

For him, the issue is much more important. Indeed, connected objects spread in an extremely fast and massive way. This concerns health as well as autonomous vehicles, the connected home, etc. He says: « *The industrial challenge is to lean on every moment of life* ».²⁰ This suggests a threat to the individual and his way of life.

¹⁸ Michel Lévy-Provençal. (2016). Nos politiques oublient le futur. *Les Echos* <https://proxy.esc-larochelle.fr:2131/docview/1830483914?accountid=35036>

¹⁹ Ivan Best. Sylvain Rolland. (2017). La Silicon Valley vise la conquête intégrale de la vie.

Following this logic and in order not to lose the decision-making power for the benefit of GAFAM, the States and the adapted structures must show firmness and adapt their legal regimes to the protection of their data. In this way, health institutions will provide the means for a soft digital transformation, which will not jeopardize the development of technologies that can improve the human condition, while preserving the medical confidentiality of patients.

Part II: The role of AI in medical decision-making

A- The decision and its application in the medical sector

1.) What is a decision and by which factors is it influenced?

As stated before, a decision is a choice that pushes or not to act. A choice that is made among others since it is considered more judicious. This choice is based on knowledge, beliefs, the ability to clearly define one or more problems, a social environment, age, cultural influences, etc.

These elements undoubtedly influence the process of decision-making. Indeed, a person would not make the same decisions as she is 16 years old or 80 years old, because the ambitions are not the same, the future is not perceived in the same way and how not to mention the experience of the life that plays incontestably its role.

In the same way, a person who lives in a developed country, feels safe, has a social life that makes him feel supported, would probably not make the same choices as a person living on the street, in a poor country, where crime or repression would be a commonplace thing, in similar situations. Also, a person would not make the same decision in case if she knows that it will influence other people.

This reasoning also seems similar for the animals and depends on the level of danger felt, the lack of food, etc. These factors would drive a wild animal, in the same way as a man, to make choices. For example, to migrate to find food or a climate more conducive to survival, to make reserves or to hide so as not to fall into the sights of a hunter or predator.

Finally, only the final result will show if the decision was the right one, but no one can know in advance what the right decision will be. Therefore, in making a decision, everyone must also take responsibility for what it will entail.

In the case of a decision made by Artificial Intelligence and as we have seen previously, these factors are not really taken into account. Indeed, if we can program AI to learn to recognize a danger or to differentiate between good and bad, it would be very difficult to think that a machine, made up of a network of neurons that are ultimately only servers, could feel cultural, social or sentimental influences in its decision-making process. Indeed, if it can easily understand the concept of patriotism or friendship, or even imitate it, it is on the contrary almost unimaginable that a machine really feels these feelings and make its decisions accordingly.

This leads us to wonder if it's a good thing. But the answer remains very vague. Indeed, in a court decision process for example, this can be a plus. AI would not be influenced by sympathy with the alleged offender or the victim, nor would take into account the nationality or ethnicity of the protagonists. On the contrary, it would be based on the facts that have occurred to give a verdict as fair and impartial as possible. Considering of course that no human intervention took place in its decision-making process.

On the other hand, if we entrust the responsibility to make a political decision to the Artificial Intelligence, it does not say that the decision is the good one. Indeed, it would always remain very logical and rational. Nevertheless, what knowledge would it be based on? On the thoughts of Karl Marx, Adolph Hitler, Charles de Gaulle? This is where things get complicated. AI would tend to make economically rational decisions because it would not be able to feel the human side of things, which could lead to discontent, revolutions, even wars.

So, we will see how important the decision is in the medical sector and then consider whether the full decision-making of the AI would be a good thing in this area.

2.) The importance of the decision in the medical field

There is no doubt, the right decision in the medical field is crucial since this decision depends on the health or even the life of a person. Even a small mistake in one of the stages of the medical process can be fatal, that is why it is very important to make the right decision. To avoid any problem, the doctor must have all the important elements, the necessary knowledge, the precise gestures, the effective drugs or the reassuring words.

Today, a doctor makes decisions based on a diagnosis. These decisions are made from collected elements, from tests, symptoms, radios, blood tests, or from the direct conversation with the patient, etc. Then, these elements are analyzed thanks to personal knowledge, information provided by help systems, books, from colleagues.

It is, in a way, an investigation conducted by the doctor. Indeed, the skills of a doctor are determined by the volume of his knowledge. In the same way that the skills of an AI flow directly from the database that it has.

In any case, the doctor always makes decisions in a climate of uncertainty. Indeed, elements may have escaped him, but also and as mentioned before, his influences or convictions may distort the analysis.

There are two methods of reasoning: categorical heuristics and conjectural heuristics. The first method would rather depend on the pure logic, as for the second, it would take into account any uncertainties that may arise.

Categorical heuristics therefore imply that the physician's decision is made in a certain environment, that no data that can influence the right decision has been ignored. In this method, uncertainty is not taken into account. The reasoning is therefore completely deductive. However, it is obvious that such situations, where the certainty of information reaches 100%, are exceptional or non-existent.

Conjectural heuristics, on the other hand, take uncertainties into account and allow recognition through the assembly and classification of particular symptoms or signs into categories representing each different disease.

These conjectural heuristics lead us to the « *Bayesian theory* »²¹ of probabilities, which advocates that a diagnosis is established by the evolution of the probabilities of the presence of each disease according to the test that is used.

So:

- A positive predictive value (PPV) of a disease test is the probability of the presence of this disease if the test response is positive.
- A negative predictive value (NPV) is the probability of absence of the disease if the test response is negative.

²¹ Christian Gagné. (2016). Théorie bayésienne de la décision.

Figure 6: Formula illustrating the probability of a disease M knowing that the answer to the test is R:

$$p(M|R) = \frac{p(M \text{ et } R)}{p(R)}$$

22

Where " $p(M / R)$ " reads: probability of M if R

This theory is one of the reasons that push the medical industry today to the development of Artificial Intelligence, since this one, as we have seen previously is more powerful than the man to find the useful data, to classify them and analyze them. Therefore, nowadays, there are 3 major axes of development which are presented below:

- The AI which allows a documentary assistance: indirect help with the decision making. The objective is to facilitate access to information and its processing as soon as possible.
- The AI that alerts the doctor in case of error. This makes it possible to reconsider a diagnosis. It does not make decisions.
- The AI that would consult the doctor by providing arguments and conclusions about a problem. There is therefore a reasoning, choices made and a solution provided. So, the decision process exists.²³

²² Mireille Cléret *et al.*, « Les systèmes d'aide à la décision médicale », *Les Cahiers du numérique* 2001/2 (Vol. 2), p. 125-154.

²³ Christian Gagné. (2016). Théorie bayésienne de la décision.

Overall, it seems that in the very near future, the first axis is the most relevant because it implies substantial help to the doctor. In addition, tests already made today, show that a weak AI would be able to use these probabilistic methods to detect common diseases.

However, the rare diseases, foresee the development of a strong AI that would be able to make a complete reasoning in order to arrive at a diagnosis leading to the decision making.

B- AI and decision-making

1.) How would the AI decision be made

As we have seen above, what differentiates AI from simple computers with powerful algorithms is the ability to learn by itself, and make a more or less right decisions.

As mentioned, AI does not have intelligence in the true sense of the term because it has no feelings, meaning, only limited creativity and above all it does not have intuition. It takes a lot more time than the man to adapt to a new situation, never seen before. So, where man can make a decision quickly, Artificial Intelligence, without a sufficient database, would be helpless.

However, the AI is much more powerful than the man in the treatment of gigantic data, the comparison of its data through times, countries, different professions and even different fields. Man is no longer able to manage the data contained in Big Data, which is why it requires help to analyze this data. For example, there is a database called PubMed, which focuses on books, articles and analyzes related to the medical field. In this database, more than 3,000 items appear each day. It is obviously not possible for man to read such a large amount of data. AI, for its part, can do it. Moreover, the conclusions that would be drawn at the end of the analysis and lead to decision making, would not be biased by stress, fatigue, mood, or as previously mentioned cultural, social, etc. influences.

According to Eric J. Horvitz, John S. Breese and Max Henrion: « *The process of decision-making by Artificial Intelligence, goes through the coding of all the information, the reproduction of a reasoning similar to that of the man, then the use of the information processed for the taking of decision* ».²⁴

On the other hand, AI would be able to filter information and adapt to a particular person, without being limited to a generality. This would undoubtedly lead to a reliable diagnostic, prediction or prescription decision.

For this, the main objective today is to create a large medical database that is gathered together and easily accessible and takes into account all the nuances that will be negotiated (related to the anonymization of data, legal problems, technical issues, etc.).

However, it would be necessary to take great care with the programming of machines and the risk of piracy. Indeed, today, at the development stage of this technology, there are many possibilities to deceive the AI. For example, it has happened that the AI built into an autonomous vehicle has lost its means in front of a reflective tape attached to a panel.

This kind of thing seems innocuous, but where a human brain directly targets the problem and adapts accordingly, the artificial brain, will not necessarily identify the anomaly, because of the lack of flexibility and lack of this kind of information in the database. This could lead to very serious consequences for the passengers or other actors of the road. That is the problem of the thing. Indeed, when one aims to allow an AI system to reason in a context of real problems, the computational representation of the protagonists, their relations, or objects that surround them, must be simplified to the maximum. This simplification inevitably leads to uncertainties and unpredictable consequences. Well, it's the same in the medical sector, where from the decision of the machine could depend on human life.

²⁴ Eric J. Horvitz, John S. Breese et Max Henrion. (1988). Decision Theory in Expert Systems and Artificial Intelligence.

In this regard, Antonio Damasio concluded that: « *Emotions, feelings, intelligence, but also the most complex forms of culture and social organization are rooted in the oldest living organisms. The mind is the product of interactions between the body and the brain. It is not a purely cerebral phenomenon. This is why coding and algorithms will not allow for a very long time the manufacture of an artificial intelligence substitutable for that of man. Reassuring, in short*

²⁵.

2.) Who would make the decision when the AI intervenes in a specific medical field

We have seen previously that the application of AI is essential to the development of medicine and to minimize all kinds of diseases and to move towards immortality. While the development of the AI leads to certain better results that will allow the improvement of treatments and prevention, one question remains open: By whom would be made the medical decisions, the doctor or the Intelligence Artificial? Here the experts' opinions are for the moment just as divergent as they are uncertain, for all the reasons mentioned so far.

The process of decision-making by the doctor is one of the most important things in medicine since its inception. But according to Mireille Cléret, Pierre Le Beux and Franck Le Duff: « *Today, we arrive at a stage where medical information exceeds the capabilities of the management of its data by a doctor*

²⁶.

To make a prescription, the doctor must be sure to make the right decision about the drugs chosen, the duration of the treatment, as well as the follow-up. For this purpose, it is necessary to detect in the best ways the symptoms and doing relative analyzes and examinations, speaking directly to the patient, etc.

²⁵ Antonio Damasio. (2017). L'ordre étrange des choses. p.392. Odile Jacob.

²⁶ Mireille Cléret, Pierre Le Beux et Franck Le Duff. « Les systèmes d'aide à la décision médicale », Les Cahiers du numérique 2001/2 (Vol. 2), p. 125-154.

He then makes his decision in relation to the information received but also considering his personal knowledge and the current progress of technologies and science. As a result, it is most likely to make decisions in a climate of uncertainty, notably because of a medical book that he would not have read and where he could have found a very important information or by detecting symptoms that may be similar in several diseases or on the contrary, exist without the disease is there.

However, the decision of the doctor will be all the closer to optimal if he could handle as much information as possible. This is where the AI comes in and can be very useful. It should be able to immediately provide a summary of information processed instantly, to help the doctor in his decision-making process.

From previous chapters there follows a relatively easy trend to notice. Indeed, there is a difference between the human brain and the artificial brain. The studies of Luc Perron and Antoine Evennou show us that the AI is much more powerful than the man for the memorization, thanks to the giant data of Big Data which it can easily handle. But also, it is more powerful than the man in the field of imaging because it has many more sensors and can more easily see shades of colors, very small anomalies, etc.²⁷

But Artificial Intelligence is not limited to that. Indeed, Deep Learning gives machines the ability to not just follow the programmed algorithms but also to analyze the results and consequences in order to react immediately to improve and keep them in memory. This allows it to always improve gradually.

In this way, we can no longer simply speak of a machine with significant computing power but of a machine capable of drawing conclusions from its own analyzes and behaviors in order to constantly improve its answers to problems posed by crossing an infinite number of data.

²⁷ Luc Pierron et Antoine Evennou. (2017). La santé à l'heure de l'intelligence artificielle

Moreover, some experts say that thanks to this faculty of AI to make decisions, to guide the medical staff, medical studies will be reduced.

For example, « *English National Health Service (NHS) to Promote Surgical Care Practitioners (SCP)* ».²⁸ Either nurses who can operate without having made surgical studies. Indeed, a simple additional training would be enough to be able to practice the intervention thanks to the help and the guidance of the AI. This novelty would in particular reduce by three the costs of health. In addition, it would free up the time of an experienced surgeon to seize more complex operations requiring his experience and intuition.

For now, the assumption of AI assistance in making the decision of the doctor seems to predominate. This is especially true with IBM's Watson system, which was designed in 2011. « *It is an augmented intelligence system, based on learning and rules of artificial intelligence, which is designed to accompany decision-making* »,²⁹ summed up Pascal Sempé, Health Watson Director at IBM Europe.

This technology is therefore required to analyze data collected from the patient by converging them with data from the global medical literature and recommendations from clinical practice. Watson is already used by some 30 hospitals around the world and mainly in the field of cancer. Indeed, this is an area where the speed of analysis and diagnosis makes treatment more effective.

It follows that for the moment the IA is attending, but will it make decisions in the near future? Well, it's still very difficult to answer this question because we do not know how fast the AI will evolve. Also, we don't know how the doctor would react to a machine that performs better than him and that will indicate that a certain probability of cancer is X%. We either do not know what machine to believe in case of contralateral disagreement from two AIs. This will certainly depend on the legislation that will focus on the perpetrator in case of a bad decision that would lead to serious consequences.

²⁸ Guy Vallancien. (2017). Vers la fin des chirurgiens ? Les Echos <https://proxy.esc-larochelle.fr:2131/docview/1970039741?accountid=35036>

²⁹ Eliane Kan. (2017). Une aide à la décision pour le diagnostic et le traitement. https://www.lesechos.fr/20/04/2017/LesEchos/22429-147-ECH_une-aide-a-la-decision-pour-le-diagnostic-et-le-traitement.htm

All in all, an AI with no feelings or intuition, could not react to a patient's words. That he feels fear, hesitation, need help or support. It is therefore obvious that an essential part of tomorrow's medicine will involve human relations, whatever the medical field. As a result, neither patients nor physicians will be able to rely entirely on decisions made by Artificial Intelligence that lacks nuance, compassion or empathy. « *The human will come to make the final decision and therefore take the responsibility* ».³⁰ – Olivier Lucidarme, Head of Multipurpose Radiology and Oncology at the Pitié-Salpêtrière hospital. The AI would therefore remain in the near future, a main ally, which would help the decision making.

Conclusion of the theoretical part

This theoretical study shows us that the future of medicine is not possible without the use of Artificial Intelligence. The latter will allow humanity to move from curative medicine to preventive medicine. This will be done thanks to its superior diagnostic capacity or its genomic study skills. It will help men cope with a huge flow of knowledge generated by Big Data and use it wisely. Precision medicine will grow and health costs will be reduced. The patient, meanwhile, will become a player in his health being accompanied by AI. This one would deliver a constant follow-up via gadgets of the daily life like bracelets.

However, States must undoubtedly work towards the creation of laws that, without jeopardizing the progress of research and science, must protect the privacy of each individual.

Also, whole and powerful teams will have to be created in order to work day and night to ensure the safety of the machines to avoid being victims of the cyber-attacks or hacks, which could foresee disastrous consequences.

³⁰ Olivier Lucidarme. (2017). L'intelligence artificielle révolutionne la médecine.
<https://experiences.microsoft.fr/business/intelligence-artificielle-ia-business/intelligence-artificielle-medecine/>

AI would also improve surgical practices. In particular by allowing the doctor to perform extremely fine gestures by converting the large gestures of the surgeon in millimeter units, which would be very useful during ocular or cardiac procedures.

Moreover, this will lead to a certain revolution in the medical sector, where trades will have to change and studies will take into account the evolution of technologies.

Finally, this study shows that the doctor would still have the last word and will be the source of a decision that would lead to action. Although in fact, in the field of medical imaging for example, it is obvious that a doctor will certainly take the responsibility of signing a paper, but could not review the conclusion of an AI that would have analyzed several terabytes of data before. Therefore, it would seem that the man is mistaken in wanting to give himself the importance of the decision-making that would not be really his own and that he would take in spite of himself. However, his presence in the decision-making process would be indispensable because, being faced with very urgent and rare situations, he would be more efficient, notably thanks to those faculties possessed by man and which are called intuition, compassion or humanity.

Part III: Field study

A- Methodology

1.) Choice of the sample and the method

After the literary research and the theoretical study, it is important to carry out a field study in order to definitively confirm or reject the initial hypotheses. In addition, this field study allows to exchange with health professionals, innovative business leaders or research professors to deepen research and to have details that are not found in books, academic articles, etc.

To carry out this study, a qualitative analysis was chosen. Indeed, it seems better suited to the subject. Truly, the subject is still quite prospective today and relatively few people today use Artificial Intelligence or will use it in the near future. Many do not even know how to define it. In that sense, a quantitative analysis is not relevant at the moment, because it could skew the study and lead us to results that are not suitable.

Therefore, for this qualitative analysis, a sample of 7 people was chosen. This sample is presented in the table below.

Name	Sex	Age range	Job and Company
Benoît ITOUA	M	40-60 years	Radiologist Hospital Center (Niort)
Barbara MONGET	F	20-40 years	General practitioner / Pediatrician Private cabinet (Lausanne)
Vincent ATTALIN	M	20-40 years	General practitioner / nutritionist and founder of AVIITAM (the smart health book) Hospital Center (Montpellier)
Jean-François THORON	M	40-60 years	Radiologist Private Medical Imaging Center (Paris)
Hervé NIETO	M	40-60 years	Orthopedic surgeon Hospital Center (Niort)
Mehdi BENCHOUFI	M	20-40 years	Member of the Scientific Council, e-Health Teacher Private clinic head (Paris)
Christophe GAPANY	M	40-60 years	Orthopedic surgeon Private clinic (Lausanne)

To interview these persons, individual interviews were set up to avoid any influence on the opinions of each specialist from the part of others. These include telephone interviews or interviews via Skype. This qualitative study makes possible, thanks to unencrypted data, to understand more deftly and in depth what it really is from the point of view of specialists concerned, or potentially concerned. Thus, it will be possible, by a comparison of the theoretical part with the field part, to bring the elements of answers as fair as possible to the subject and to endorse the hypotheses.

The interview technique chosen is the semi-directive technique. Indeed, according to Alexandra Baud, this is: "*a technique that allows us to guide the interlocutor with flexibility while maintaining a benevolent neutrality to understand the level of his knowledge*". A red thread will be set up through questions that will go from the most general to the most particular, with a structure called "funneling". It is a method developed by psychology, where the interviewer keeps a neutral attitude towards the interviewee, so as not to influence the answers of the interviewee. The goal is to guide the interview with flexibility to understand the speaker and allow the formulation of ideas and conscious and unconscious reasoning. A system of closed questions will also be set up punctually to confirm the level of understanding and to be sure to have correct answers. Questions of reminders to deepen thoughts, are also likely to subsist. The goal is to have objective and impartial answers by allowing the interviewee to respond freely without departing from the subject.

2.) Action Plan

This field study follows a very precise plan of action. That is to say that the appointments for the interviews are taken in advance and the approximate time of the duration is specified to the interlocutor. The questionnaires are prepared in advance and adapted to the position held by the person in question. Interviews are done by phone or Skype mainly. Once the interview is over, the results are ranked, considering the differences of the interlocutors. Then, these results will be analysed and compared with the theoretical study to give a conclusion and answers to the hypotheses and the problem. The phrasing of the questions during the interview is simple and clear to be understood by all.

B- Analysis

1.) Analysis of the results

The analysis of the results is "*a set of techniques of analysis of the communications aiming by systematic and objective procedures of the descriptions of the contents of the messages, to obtain indicators allowing the inference of knowledge relating to the conditions of reception of these messages*" (Bardin, 2003, 47)

To analyze the results of the field study, the interviews were broken down into 4 parts that will be analyzed separately. Full interviews are available in attachments.

The 4 parts are as follows:

- Artificial intelligence and its integration in the medical sector
- The transformation of the professions of medicine
- Ethical and legal aspects
- The role of AI in making the medical decision

Artificial intelligence and its integration in the medical sector:

	Good points	Negative points	Remarks
Benoît ITOUA	<ul style="list-style-type: none"> - AI does not experience tiredness or feelings - This is a tool that will release the doctor because it will take a huge workload 	<ul style="list-style-type: none"> - A good thing to quantify, but poor in quality - The human side is lost - We do not really know where we are going 	<ul style="list-style-type: none"> - The AI still has a lot of proofs to show that it is reliable - The human side of the job is essential and must be preserved
Barbara MONGET	<ul style="list-style-type: none"> - An indicative overview can be obtained from percentages calculated with data from a patient 	<ul style="list-style-type: none"> - Cannot really replace the human - We do not know what it can really bring 	<ul style="list-style-type: none"> - This area is not well known for the moment, so fears exist - The human side must be preserved
Vincent ATTALIN	<ul style="list-style-type: none"> - Strong interest in the medicine we build - Superior to humans in many areas 	<ul style="list-style-type: none"> - No negative points 	<ul style="list-style-type: none"> - No fear as far as things are framed
Jean-François THORON	<ul style="list-style-type: none"> - Good substitution to man in repetitive tasks - Absolutely indispensable help to a doctor often overwhelmed 	<ul style="list-style-type: none"> - Many risks (power outages, poor programming, etc.) - Intellectual imposture. AI is now confused with robotics. 	<ul style="list-style-type: none"> - Already used AI for his work
Hervé NIETO	<ul style="list-style-type: none"> - Remote patient monitoring - Compensation for the shortage of doctors 	<ul style="list-style-type: none"> - Risks related to computers - Risk related to medical data 	<ul style="list-style-type: none"> - Only positive. Anyway, we will not escape the "Revolution"
Mehdi BENCHOUFI	<ul style="list-style-type: none"> - Improved patient care - Speed of diagnosis - Predictability - Care better and upstream - Unvaluable doctor assistance 	<ul style="list-style-type: none"> - We do not anticipate enough the transformation of medicine - Limited vision - Time to find the right algorithms 	<ul style="list-style-type: none"> - Invaluable help to the doctor. The sooner the AI becomes integrated in the medical field, the better it is.
Christophe GAPANY	<ul style="list-style-type: none"> - More precision - More data 	<ul style="list-style-type: none"> - Multiple 	<ul style="list-style-type: none"> - We must not lose supervision on the machine

Analysis:

If we summarize this table, we see that overall, these health professionals see in the integration of Artificial Intelligence in the medical sector as many positive points as negative points.

They all agree that AI would be a great help. It would relieve the doctor of repetitive and tiring tasks. Artificial Intelligence does not need to sleep, eat, etc. It can work continuously on tasks requiring calculations or data cross analysis. This would compensate for the shortage of doctors and give them the opportunity to focus on more human tasks, such as listening, expressing feelings, etc.

At the level of risks, the computer risks and the risks related to poor programming are most often mentioned. Also, some of them believe that another negative point is to lose the human side of the job by including AI in the process of monitoring patients.

Another risk could be related to the lack of anticipation of this revolution that is happening in the medical sector.

Finally, it turns out that the integration of Artificial Intelligence in the medical sector is a very good thing, since it would be an important aid to doctors in all medical fields. However, this integration must be carried out with great care because many risks exist. In addition, care must be taken not to dehumanize the medical professions, because everyone agrees that a patient needs to be in contact with another human being.

The transformation of the professions of medicine:

	Which sector (s)?	How would the AI be better?	When?
Benoît ITOUA	- Medical imaging	- Very great help to the doctor and probably more efficient	- In the medium-long term
Barbara MONGET	- Imaging - Diagnostic	- Certainly more powerful than man thanks to a larger database - Helps the doctor to make a decision about the diagnosis	- In the medium-long term
Vincent ATTALIN	- Imaging - Radiology - Biology	- Convinced that AI is superior to humans in these areas because of its better analytical capacity, databases and high-performance sensors	- In the short-medium term
Jean-François THORON	- Radiology - Diagnostic	- More efficient to detect tumors and interpret them as abnormal or pathological	- In the very long term
Hervé NIETO	- Not more one domain than another, they will all be concerned and transformed	- Better analysis of images - Follows patients by saving doctors time - Improves accuracy, guide	- In the short-medium term
Mehdi BENCHOUFI	- All professions in medicine will be concerned	- Man does not have the abilities of the AI - Information processing, memorization, data crossing, sensors - IT doesn't need to sleep, it doesn't get tired, it doesn't have mood jumps	- In the short term, we have to prepare for it

Christophe GAPANY	- Diagnostic - Radiology	- It doesn't need to learn by attempts and mistakes, it has a huge database accumulating dozens of years of experience	- Lack of creative aspect and clinical sense (feeling, intuition) - Long-term
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Analysis :

All interviewees generally agree that a transformation of the medical professions will take place. This transformation would mainly affect professions related to medical imaging, diagnostics, radiology and biology. This would be related to the ability of Artificial Intelligence to perform better than humans to analyze particular images with very powerful sensors, able to see many more shades of colors and detect more easily and quickly anomalies. This result is even more relevant because two radiologists have contributed.

Also, the AI would make more accurate diagnoses because it would have access to a large database and could transcribe in percentage the risk of a particular disease.

Finally, it seems that the question of the transformation of medical professions is no longer relevant. We should rather be wondering when it would happen. Here, opinions are very divergent to try to represent a global trend. In any case, it appears that nobody expects big changes in the next 5-10 years.

Ethical and legal aspects:

	Risks	The role of the authorities	Remarks
Benoît ITOUA	- The patient must be an actor and be able to choose whether to share his medical data - High risk of piracy	- Must put in place devices protecting personal data without compromising research	- Every health institution and the States more generally must make efforts to fight against cybercrime
Barbara MONGET	- The patient must agree that his data would be used for the purpose of developing medical research	- Authorities must frame the process	- An anonymisation process is essential - Rare pathologies must be shared
Vincent ATTALIN	- The medical secret is totally flouted - The risks of hacking are high	- Everyone must take steps to protect themselves from hacking - Frame the data sharing process	- We cannot protect ourselves from piracy at 100%, but we can multiply umbrellas
Jean-François THORON	- Anything can be hacked, this is the main risk	- It is necessary to robotize the machines and to make sure that they are not connected to a shared network like Internet - Do not give any data holding rights to private Big Data groups	- Medical secret is exaggerated in our time and compromises medical development
Hervé NIETO	- High risk of piracy. It's even risk number one. - Medical secret no longer exists, so it's not a problem	- Ensure technological progress - Medical secret is not important as the progress will trivialize the diseases	- When we prescribe a sick leave to a person and send it to his boss or when we talk on TV about celebrity diseases, it proves that medical secrecy doesn't exist
Mehdi BENCHOUFI	- IT risks are high - In our time, medical secret no longer matters, so no fears	- The legislation must be adapted accordingly	- Today we have all the necessary devices to anonymize the medical data

Christophe GAPANY	<ul style="list-style-type: none"> - High computer risks, as in every trade, possibility of serious consequences 	<ul style="list-style-type: none"> - Private initiatives must fight, the state is not effective 	<ul style="list-style-type: none"> - Medical secret doesn't exist, it's a legend, a myth - Possibility of anonymisation anyway
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Analysis :

In terms of ethical risks, everyone is not of the same opinion. Some say that medical secret is paramount and must be kept unless authorized by the patient. Others think that this can hinder research and believe that medical secret is not as important as advancement. In this logic, medical development would trivialize diseases. That is to say that no one would be afraid to say that he has this or that disease because it would be something commonplace and it could be easily cured (we can compare with a flu or a cold today). Still others believe that medical secret is very exaggerated in our time or no longer exists for a very long time. For example, when a doctor prescribe a sick leave to a person and send it to its boss or when we talk about celebrity diseases on television, that proves that medical secret doesn't exist. Despite these disagreements, it turns out that this should not be a problem, as today we have all the necessary mechanisms to anonymize the data.

For the legal side, everyone agrees that there is a lot of work to do at this level to protect patients, increase the number of umbrellas against piracy and put in place devices to be able to point a responsible in case of errors made by the AI.

To do this, health institutions must work closely with engineers, researchers and computer scientists to find the best tools. But everything must be under control and funding from the state.

The role of AI in making the medical decision:

	Help in decision making	Outsourcing of the human decision	Remarks
Benoît ITOUA	- Yes, it helps the doctor	- Yes, in a way, since a doctor is not able to contradict a machine, which is more efficient than him	- We can trust the machine as another human (which can be wrong). No more, no less
Barbara MONGET	- Yes, indispensable assistance in decision-making	- Yes in some areas	- AI can be a decision-making aid, just like an outsourcing of human decision, but only if its reliability has been proven
Vincent ATTALIN	- Yes, help, because it's always up to the doctor to have the last word	- No, a machine should not decide instead of the man	- The AI will undoubtedly exceed us in the ability of diagnosis and even treatment, but it is up to the doctor to have the last word
Jean-François THORON	- Yes, in the short and medium term - No need to replace the man for now, just help him to be more efficient	- No in the short and medium term - Yes in 200 years	- The AI will take over the man but in a very long time, because for the moment it is capable of nothing alone
Hervé NIETO	- Yes, certainly very useful to help doctors make decisions	- It can propose solutions and we can trust - But we have to be sure of its reliability	- We will not remove the doctor, but he would have a different role
Mehdi BENCHOUFI	- Yes, it will help the decision in the areas where it is not more efficient than the man, (ex: surgery)	- Yes, it is necessary to outsource it where it's the best solution, like the fields of medical imaging	- It would be both, a kind of hybridization between man and machine

Christophe GAPANY	<ul style="list-style-type: none"> - Certainly, yes - Fundamental and complementary to human decision 	<ul style="list-style-type: none"> - I'm considering it, but I do not want it 	<ul style="list-style-type: none"> - Need to prove
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Analysis:

The interviews show that all interviewees agree that Artificial Intelligence is a decision aid for the doctor and even speak of an indispensable assistance.

Some interviewed are firm in their response when talking to them about outsourcing the human decision. For them, the AI must not decide, because it is the role of the doctor.

Despite this, some keep a critical eye on the thing. Although they agree that the doctor should have the last word, they are aware that the doctor is not able to contradict a decision of the AI when it analyses a quantity of data inaccessible to the man, or remarks things that the human eye is not able to notice. In sum, it's all about time. When talking about 200-300 years, the interviewees, imagine quite easily the machine to exceed the man.

Finally, a majority agrees on the following logic: Artificial Intelligence is an outsourcing of human decision in areas where it would perform better, such as the field of medical imaging for example. The doctor, meanwhile, would not disappear, it would simply have a different role, which would certainly be related to listening and dialogue with the client.

Then, the Artificial Intelligence would be a decision aid of the doctor in the fields where the man would remain more efficient. For example, in surgery, where the senses and intuition remain indispensable.

2.) Comparison of the results with the initial hypotheses

This field study was undoubtedly very useful in our analysis and made it possible to answer the initial hypotheses.

The first hypothesis is confirmed. Indeed, the literary study, as well as the field study, show us well that certain professions of the medicine would be brought to disappear, in favor of the Artificial Intelligence which would be more efficient and effective in these domains. It would mainly involve professions related to medical imaging and diagnosis. Indeed, in these areas, the human side does not seem to be as important as in the follow-up of patients or in surgery for example. What will matter here is rather the quality of the analyses and the correctness of the verdict.

The second hypothesis also seems to be confirmed, because in the fields where Artificial Intelligence would be more efficient than the man, we would not be legitimate to contradict the system. Therefore, the human decision would be outsourced despite the doctor, who would have the last word, but can only confirm the accuracy of the decision of the IA. What remains uncertain is the time it will take to develop an Artificial Intelligence that will prove its reliability.

The third hypothesis is also correct, since the theoretical study, like the field analysis, show that for the moment, if people are ready to trust a diagnosis made by an Artificial Intelligence, they are not ready at all to trust a surgery performed independently by the AI. Moreover, the surgeons surveyed told us that the AI would be a huge help, especially because it allows the surgeon to see things he does not see, to take action in real time or to guide the actions of the surgeon. However, a surgeon told during the interview that even with the help systems he uses today, he is forced to quit about one in twenty operations because the machine makes bad decisions. That is why AI would be a help to the doctor in areas such as surgery, since human life is at stake and a machine cannot have any sense, something that is essential during the surgical intervention.

The fourth hypothesis was not retained. Indeed, despite the huge investments of Silicon Valley companies in the research and development of Artificial Intelligence, especially in the medical sector, there is no evidence today that the health of tomorrow would be controlled by Silicon Valley. Health institutions and States would have a role, at least equally important to play.

CONCLUSION

As we saw in the first part, Artificial Intelligence is not a new thing. Appeared in the 1950s, it followed a slow development until the 2000s because of several barriers that it had to face. But the engineers and developers were able to learn from their mistakes and improve this AI that finally won a game of GO, which marked a point of no return in its growth. The multiplication of Big Data was essential to stimulate this advancement. Techniques such as Machine Learning or Deep Learning have been developed to allow AI to grow on its own.

Although it still has a long way to go to reach the level at which its developers want to see, the AI quickly conquered many sectors, such as telephony, computers, automotive, banking or real estate. Even in the sectors where it was least expected, such as justice, education or cinematography, it continues to develop.

We were interested in the development of Artificial Intelligence in the medical sector. First, it is a growing sector, and secondly, AI is the solution that will help research, especially in the development of treatment solutions for serious diseases, such as cancer or AIDS, because it could analyse inaccessible data for a human brain, synthesize them and propose solutions.

It could also help detect diseases upstream. For example, its sensors would be able to see thousands of times more shades of color on a radio than a human eye. Tumors would be detected well before and the treatment would be more effective. Moreover, this treatment would become more personalized, in order to have a beneficial effect for everyone, while avoiding collateral risks. Also, AI would allow dentists, for example, to see well beyond the 3 dimensions in order to choose an optimal order to move the teeth. It would even be useful in surgery to guide the doctor or reduce his large gestures in millimeter units, which is very useful during ocular or cardiac operations.

In addition, Artificial Intelligence, would allow the passage of a curative medicine, to a preventive medicine, in particular thanks to its capacity to study the pathologies at the level of the genome. Finally, this preventive medicine, would reduce the burden of medical personnel, track patients remotely through any type of gadgets and even reduce health costs. So, its potential is well established, the development of AI in the medical sector has only good horizons. This development will be accelerated thanks to companies like GAFAM and will automate a number of things.

All that has been mentioned, will ultimately and paradoxically bring much to the human side of these trades, since it would free doctors from repetitive tasks and transfer a number of medical professions to listening and customer relations, which according to our theoretical and field studies, seems to be very important for everyone.

The confirmation of hypothesis 1, also shows that the first professions to be involved will be professions related to medical imaging, diagnosis or even biology to a lesser extent. Indeed, these are areas, where the machine will be more efficient without any doubt, since it will be able to process a large amount of data and examine things that the doctor would not even suspect the existence, because of the lack of the ability of a biological brain to process too much information, lack of access to a lot of data or reduced ocular capabilities.

However, a number of devices will need to be put in place to minimize computer-related risks such as poor programming, or the risks of hacking systems or medical data. On the other hand, lawyers and States must work together to develop laws that will allow the establishment of medical data anonymization devices for clients who wish it, in order to preserve medical confidentiality without compromising the research.

Finally, our main question concerned the role of Artificial Intelligence in making the medical decision. We wanted to provide some answers to the following problem:

« Artificial Intelligence, would it be an aid in decision-making process in the medical sector, or an outsourcing of the decision of the doctor »

It follows from our theoretical and field studies, that globally and for the moment, neither doctors nor patients, are ready to rely completely on the decision taken by Artificial Intelligence. For good reason, the lack of confidence in a system that has not proved anything yet, that would say that the decision made by the AI is better than that made by the doctor.

However, specialists, doctors, engineers, philosophers, all agree that AI is an invaluable aid to health professionals in absolutely every field. So, in the short-to-medium term, the AI will be a help in making the decision of the doctor.

Nevertheless, the prospective side of this Thesis has allowed us to look further, in the long run. Here, the conclusion is quite different. Indeed, the same specialists mentioned above, agree that the machine will exceed men in many areas.

A surgeon said during his interview that he is more confident to ride in a plane stuffed with electronics and algorithms, than in a simple cuckoo. And this idea seems to be generalizing. Many people would already trust a diagnosis or prescription provided by the AI. Indeed, when we go to the scanner, we trust a machine. When we take a blood test, these are algorithms that count the number of red blood cells and not humans. This is why the long-term conclusion of the problem would be the following; the medical decision would be outsourced despite the doctor in some areas, the first concerned will be imaging. Quite simply, AI would be more successful than the man in these areas. While in other areas, such as surgery, AI would still be less effective than men, given the gaps in meaning, feelings or intuition. Therefore, it would remain an aid to the doctor's decision in these areas.

Attachments

List of attachments:

Attachment 1: Interview Benoît ITOUA (*Radiologist, Hospital center, Niort*)

Attachment 2: Interview Barbara MONGET (*General practitioner / pediatrician, private cabinet, Lausanne*)

Attachment 3: Interview Vincent ATTALIN (*President of Aviitam, the smart health book, general practitioner / nutritionist, Montpellier*)

Attachment 4: Interview Jean-François THORON (*Radiologist, Private Medical Imaging Center, Paris*)

Attachment 5: Interview Hervé NIETO (*Orthopedic Surgeon, Hospital Center, Niort*)

Attachment 6: Interview Mehdi BENCHOUFI (*Chief of Clinic, Member of the Scientific Council, e-Health Teacher, Paris*)

Attachment 7: Interview Christophe GAPANY (*Orthopedic surgeon Private clinic, Lausanne*)

Attachment 1:

Interview Benoît ITOUA (Radiologist, Hospital center, Niort)

- Can you briefly define Artificial Intelligence in your own way?

Artificial Intelligence is an organ that is not human and will become the tool that will help the doctor. It will give the verdict of the diagnosis.

- Have you ever had the opportunity to use it and if not, would you like it and why?

I had the opportunity to use an intermediary tele-transmission organ, which in my opinion is a step towards AI. It's a tool that helps doctors at night especially and it's a remote radiologist who gives instructions to the machine. To be honest, it works moderately well. It is more useful to treat in quantity than in quality

- What do you think of its integration in the medical sector (positive / negative points and risks)?

Positive points: Today there is a lack of a big number of medical staff in medical institutions. So, it's going to take a quantitatively large workload and offload the doctors who will be able to devote their time to something else. For me, this is like a colleague, that can be infallible because he would not feel fatigue, needs, etc.

Negative points: The human side is lost. It is essential to preserve it because a patient needs reassurance. He needs someone who has the same emotions, fears, etc. and can share them with him. We will never replace a man. Patients need a man to tell them a verdict. The AI cannot transmit all these emotions even if we make a talking robot.

Possible risks: We do not know where we are going, we trust a tool that can surpass us.

- What do you think about the holding of medical data by Big Data centers (often private groups)? What becomes of the medical secret?

My opinion is very negative. The patient has the right to control his medical data.

- Do you think that it is possible to respect the privacy of patients, without compromising medical research and technological advance?

If we respect the privacy of patients, it will undoubtedly slow down development. Because useful data will not be given to the AI. So, that can slow down the evolution of medical research.

- In your opinion, in what fields could it be the most useful?

In imaging, it would be very useful because it would take a considerable amount of work.

In surgery, I don't think so. In my opinion, people would be afraid overall.

For the follow-up of the patients, I don't believe it, because the people want to humanize their pathology, need to meet another man, to be listened to and to feel that someone else is concerned by that.

- Do you think it is more successful than the man in the field of imaging? Why?

No, for the moment I would not trust a machine, so I cannot say that it is more efficient.

- As a patient, would you trust a diagnosis or prescription made entirely by the AI?

I would trust as much as one person. No more no less. Since the man can also be wrong. However, I would still like to have the advice of a doctor.

- What about surgery?

In surgery, I would only trust an experienced doctor.

- What do you think about the risks of bad programming or hacking?

I think that the risks of hacking are very high in general, especially in medicine. There is a need to create effective bodies that will fight against these risks.

- Do you think that the medical imaging professions could disappear with the growth and development of AI?

I think that's part of the risk. But I believe in power and the ability of computers. So, in the long run I'm not scared.

- What about the importance of the decision in the medical field?

I am convinced that it is up to the man to make the decision. If we want to give AI a decision-making power, we need an organ that unites all the medical professions at once.

- What do you think of the decision-making power of the AI?

For me, AI does not make the decisions. For that, it would need a multiplicity of ideas, which in my opinion it does not have.

- Do you expect that one day, AI will be able to make decisions in place of humans in the areas of medical imaging? Why?

No. In any case, not in the decades to come, for the reasons mentioned previously.

- Finally, for you, Artificial Intelligence, would it rather help decision-making or outsourcing human decision?

It would be an aid to the decision-making of the doctor, regardless of the field. Medicine without a soul, cannot exist.

Attachment 2:

Interview Barbara MONGET
(General practitioner / pediatrician, private cabinet, Lausanne)

- Can you briefly define Artificial Intelligence in your own way?

For me, Artificial Intelligence is a reasoning done by a machine type computer. A computer program somehow.

- What do you think of its integration in the medical sector (positive / negative points and risks)?

I do not know what that can bring. But I'm currently using a software in my work that may be related to my opinion. It is a software in which I enter the parameters of the patient (age, sex, weight, etc.), then the symptoms. This program gives me percentages of diseases or pathologies that may exist. I find it a very useful program, although as a professional in the field, I realize that my diagnoses are about the same. However, it allows me to affirm my thoughts. And I do not see any risk in that if everything remains under the control of the doctor.

- In what areas could it be the most useful?

In imaging I do not know, I would like to answer no, but if the machine interprets results and analyses, then yes, I think it can be very useful. But in my opinion, it takes tremendous progress to get there.

In surgery I do not think, I would rather prefer robots to assist the surgeon in the intervention. I do not think it's Artificial Intelligence.

For diagnostics, yes, I think it would be useful. *See answer to the previous question.*

- Do you think it's better than the man in these areas? Why?

So, following the development of technologies, I think that in imaging, it could be more efficient. But need experience to see if it's reliable.

- In your opinion, can AI be a solution to medical desertification?

No, the current state of affairs does not allow an AI to replace a general practitioner. It is not enough to fill out a questionnaire and have a diagnosis.

It needs a human contact, which can examine you, discuss with you, intervene when needed.

- Do you think that some medical professions are likely to disappear with the growth and development of AI?

I do not know, in my opinion it will not come right away.

- What do you think about the holding of medical data by Big Data centers (often private groups)? What becomes of the medical secret?

I do not have any worries about this, there are already externalized databases and it is not a problem, I do not have any anxiety.

If we are dealing with rare pathology, I am even in favor of sharing data. In case of more "ordinary" cases, if the patient has agreed or it remains reserved or anonymized, I do not see any problem either. Generally, people who have rare pathologies, are happy to share it, to help research to progress.

- As a patient, would you trust a diagnosis or prescription made entirely by the AI? Why?

No, not today, because the machine cannot take into account all the data.

- What about surgery? Why?

No more, for the same reasons. It's very dangerous.

- What about the importance of the decision in the medical field?

The decision in my job is essential and several times a day. If we (the doctors) were not able to make decisions, the patients would not heal.

- What do you think of the decision-making power of the AI?

I think AI has decision-making power. But is it still a question, are his decisions good or not? For the moment, as far as I know, nobody has shown it.

- Do you think that one day AI can make decisions in place of humans in some areas of medicine? Why?

I have a lot of trouble to consider it in a general way. I do not see how it could integrate all the elements that doctors integrate when we see a patient, we examine it, etc. A machine for me, is not able to do it, at least for the moment.

- Finally, for you, Artificial Intelligence, would it rather help decision-making or outsourcing human decision?

Definitely help. But in some areas, over time, she may have to exteriorize the decision, subject of course, to keep a step back and make sure that it is reliable.

Attachment 3:

Interview Vincent ATTALIN
(President of Aviitam, the smart health book, general practitioner / nutritionist, Montpellier)

- Can you briefly define Artificial Intelligence in your own way?

I would define Artificial Intelligence as being able to decide with a non-human entity.

- What do you think of its integration in the medical sector (positive / negative points and risks)?

Its integration into the medical sector would be a good thing.

Positive points: I am strongly convinced of the interest of AI in the medicine we are building today.

Negative points and risks: I do not see because I'm not afraid to the extent that things are well framed.

- In what areas could it be the most useful?

I do not have an aprioris on this, I think AI can be useful in absolutely any medical field.

- Do you think it's better than the man in these areas? Why?

I am absolutely convinced of it. The AI will be much better than the man for many things. This is related to its ability to analyze and its precision.

- Do you think that some medical professions are likely to disappear with the growth and development of AI?

Yes, it will be imaging, radiology and biology

- In your opinion, can AI be a solution to medical desertification? Explain yourself.

It can help, but it cannot be the solution itself.

The current development of AI does not allow it to be 100% autonomous and I think that the human factor will always be and whatever happens important in medicine.

- As a patient, would you trust a diagnosis or prescription made entirely by the AI? Why?

No, I only trust a health professional. On the other hand, there is no problem for him to be helped by the AI.

- What about surgery? Why?

I would trust because I am convinced that AI thanks to sensors and a robotic body, will be able to perform operations better than a human.

- What do you think about the risks of bad programming or hacking? How to fight, especially at the technical and legal level?

The risk is very high, you can never be 100% sure. On the other hand, we can multiply umbrellas. Everyone must be aware of it and do their part, including the state.

- What do you think about the holding of medical data by Big Data centers (often private groups)? What becomes of the medical secret?

I think the detention of medical data by big data groups is something neutral. But the medical secret is flouted.

- Do you think that it is possible to respect the privacy of patients, without compromising medical research and technological advance?

Yes, you just have to encrypt and anonymize the data.

- What do you think of the role of Silicon Valley in this evolution of medicine?

I've no idea.

- What about the importance of the decision in the medical field?

This is the most important thing since the health or life of others depends on it.

- What do you think of the decision-making power of the AI?

I think it has no decision-making power, it helps to make the right decision through more in-depth diagnoses.

- Do you think that one day AI can make decisions in place of humans in some areas of medicine?

Yes, but not right now. The level of its development will first have to reach a certain threshold.

- Finally, for you, Artificial Intelligence, would it rather help decision-making or outsourcing human decision?

It would be more of a help to human decision, especially in the years to come.

Attachment 4:

Interview Jean-François THORON (Radiologist, Private Medical Imaging Center, Paris)

- Can you define Artificial Intelligence in your own way?

Artificial Intelligence is a substitution of the human brain by the machine. Not to replace it but rather to substitute it for repetitive tasks that lead to fatigue.

- Have you ever used it, if not, do you think it can be interesting? Why?

Yes, I've already used diagnostic tools, but it's not really AI, because AI implies that the machine has intelligence in the true sense of the word, for it, it must be endowed with meaning (vision, hearing, etc.)

But the concept may be very interesting because it is a huge help to the doctor.

- What do you think of its integration in the medical sector in general (positive / negative points and risks)?

I think AI will not be integrating into the medical sector until the next 40 years.

Positive points: Absolutely helpful, especially in repetitive tasks. Can work 24 hours a day.

Negative points: Significantly reduces the human factor, which in my opinion is the most important in medicine. In addition, its reliability must be proven.

Risks: This is an intellectual sham. There is always this question of time. For the moment AI in the true sense of the term does not exist, but we believe (including Laurent Alexandre) that in 10 years it will replace many trades. The AI that we have today and that we will have in the coming years is machines with algorithms that humans program. All it takes is a power failure so that it does not work anymore. Do not confuse AI and robotics.

- In your opinion, in what fields could it be the most useful?

In surgery - certainly not. It's impossible for an AI to work on its own (always in the short or medium term). Unless it serves as a 3rd arm to the doctor.

In radiology - yes, certainly. Being a radiologist, I would like to have a powerful machine that assists me by examining the radios and gives me a complete diagnosis on which I could rely. It would give me time to listen to my patients.

Help with diagnosis - yes, essential for detecting signs, analyzing them and giving a diagnosis.

- More specifically, would AI be useful in medical imaging? Specify why and what it could be used for.

Certainly yes. It would help to detect tumors, tasks more easily on radios and interpret them as abnormal or pathological. *See answer to the previous question.*

- Do you think it is more successful than the man in the areas mentioned? Why?

No, it will not perform better than the man in any field in the next 40 years. Even for autonomous cars; Just look at the Google car that spit after 3 days. Or even the accidents of Tesla. However, computers and machines are becoming more efficient and will be a very good help for doctors in particular.

To be more efficient than the man, the AI needs sense, of know-how of the correct associations. There is a scam in the word intelligence right now.

- As a patient, would you trust a diagnosis or prescription made entirely by the AI?

No, for lack of confidence. And this, until we have indisputable proof that we can trust it at least as much as a man.

- What about surgery?

Even less. The machine does not make sense, only sensors that can experience failures. There is a need to enter data and parameters into the machine. But what happens if there is forgetfulness? The consequences can be very serious at this level.

- What do you think about the risks of bad programming or hacking?

These risks are very high. Nowadays, you can hack anything. Hackers are always one step ahead. It would be necessary to robotize the machine and to make sure that it is not connected to the various networks.

- What do you think of the holding of medical data by Big Data centers (often private groups)? What becomes of the medical secret?

This is a very big risk, especially for piracy. Medical secrecy meanwhile, is mocked.

- Do you think that it is possible to respect the privacy of patients, without compromising research and medical technology?

Medical secrecy is fundamental because it protects the patient, but it is very exaggerated in our time. Doctors do not even have the right to say that you have a cold, while everyone sees it. On the other hand, if it is something that is more serious, we obviously have to respect it.

So medical secrecy is important but it should not be a drag on research and development.

- Do you think that the medical imaging professions could disappear with the growth and development of AI?

Yes, it's even certain. But that will not happen until 2100.

- What about the importance of the decision in the medical field?

The decision in the medical sector is not as important as we might think. Sometimes there is no decision, just a diagnosis. So, the decision is not fundamental. Medicine is even total indecision, we constantly weigh the pros and cons.

- What do you think of the decision-making power of the AI?

For the moment nothing. But in 100-200 years, it will be unquestionably high.

- Do you expect that one day AI will be able to make decisions in place of humans in the areas of medical imaging? Why?

Yes, but not earlier than in 100-200 years. For now, we have to make the difference between robotics and AI. *See previous answers.*

- Finally, do you think that Artificial Intelligence is rather a help to the decision-making of doctors or an outsourcing of human decision?

In the short and medium term, this is an unquestionable aid. Currently and in the near future, it will not be able to do anything alone. However, if I press a button and the AI analyzes 18,000 cases, then gives me a diagnosis with a percentage of 90%, it is a phenomenal help.

However, it will be necessary to think of including a margin of error. It will be necessary to be certain that the AI is reliable, because it is not only a question of terabytes or the volume of data analyzed.

Then finally, why replace the human? We must help him! We will not get tired of performing tasks if the machine is able to do it.

So, it will be a help for the moment, which will gradually replace the man in certain tasks, then domains. But for this, it must master self-learning, which will occur in a very long time.

Attachment 5:

Interview Hervé NIETO (Orthopedic Surgeon, Hospital Center, Niort)

- Can you briefly define Artificial Intelligence in your own way?

Artificial Intelligence is the help provided by the computer in any field.

- What do you think of its integration in the medical sector (positive / negative points and risks)?

I see it very positive. Then anyway, we will not escape, it comes in a logical continuity of development of medicine. It can for example help in monitoring patients remotely, which is not negligible. Especially when we know the shortage of doctors that there are in certain regions of France.

The risks, for me, would be everything related to computers and medical data.

- In your opinion, in what fields could it be the most useful?

As I said earlier, I think in patient monitoring, it can be very useful. But, no more in one area than in another.

When I think about the radiologist for example, I can easily see the IA to analyze images. Even in surgery, we already use tools that help to improve the precision of the gestures, specify the cut of the bone for example. Thanks to sensors, the machine knows the depth. I as a doctor, I cannot have all these data.

- Do you think it is better than the man in these areas? Why?

Yes, certainly in surgery. It could better, cut, screw, etc. There are things you do not know without the machine. So, if in addition we give it the opportunity to think and guide us, it would be great. You know, the way of operating has changed. During the operations that I realize, 80% of the time I look at the screen of the computer and not the patient. Because I have all the data and measurements that I need, on the screen. In my opinion, AI would allow operations to be completed faster and more efficiently. AI could improve gesture accuracy, positioning of parts, etc.

- Do you think that some professions of medicine could disappear with the rise of AI? If yes, which ones?

It can in any case limit them and open the way to other trades. You see, before and today, doctors are doing very long studies because there is a great need for training. Thanks to AI, it can change I think. With the aid of diagnosis, decision, gestures, less qualified personnel could carry out operations. However, I feel that the presence of an experienced doctor would be necessary to supervise.

- As a patient, would you trust a diagnosis or prescription made entirely by the AI?

Yes, why not. For a blood test for example or a flu, I do not see where the problem is.

- What about surgery?

I would not trust if a machine must perform the operation independently. At least not for now. You know, today I interrupt the operation 1 time out of 20, because I realize that the computer is wrong. That does not mean that I do not believe in progress, but only that I think it has to be controlled.

- How could we point a responsible in case of error on the part of the AI?

It will already be necessary to know where the error comes from. This is the same procedure as with a surgeon today. Before deciding who to punish, it must be determined whether it is a programming error, a precision, a computer error, a maintenance error, a human error, etc. We cannot plan for the moment. Whatever happens, we should find the cause before pointing someone.

- What do you think about the risks of bad programming or hacking? How to fight?

I think that's the risk! These are huge risks. We should fight at the computer and legal level above all.

- What do you think about the holding of medical data by Big Data centers (often private groups)? What becomes of the medical secret?

I have absolutely nothing against it. Everything will change, the medical secret will disappear. Moreover, currently it does not exist anymore. Only politicians can talk about it to make themselves feel good. When we prescribe a sick leave to someone and send it to their boss, do you think the medical secret is kept? When we speak on television and radio of celebrity diseases, is this secret kept? No, certainly not!

- Do you think that it is possible to respect the privacy of patients, without compromising medical research and technological advance?

The privacy of patients is over. Anyway, the progress will be such that it will trivialize certain diseases and no one will be afraid to say "I have this or that disease", a bit like when we talk about a flu or a gastroenteritis today. So, the medical advance would not be affected.

- What about the importance of the decision in the medical field?

I would say that it is fundamental. We spend our time making decisions. And specially to try not to be wrong.

- What do you think of the decision-making power of the AI?

I think it can make decisions, but I repeat, it must be under the control of a competent person.

- Do you envisage that one day the AI can make decisions in the place of the man in certain fields of the medicine? Why?

No, I think the man will always want to keep the top on the machine.

- Finally, in your opinion, would the AI be rather a medical decision aid or an outsourcing of the human decision?

In my opinion, it can propose decisions and we can trust. But the diagnosis is not unique, there can be consequences. To be truly effective, the AI must contain cross-data from all medical fields.

So, in my opinion, it would be a help. It will not remove the doctor, but he would have a different role.

Attachment 6:

Interview Mehdi BENCHOUFI (Chief of Clinic, Member of the Scientific Council, e-Health Teacher, Paris)

- Can you briefly define Artificial Intelligence in your own way?

It is the set of automated processes, which aim to achieve defined objectives. It is an automation of processes with predictive vocation with the aim of distant or even inaccessible perspectives.

- Have you ever had the opportunity to use it?

This is not a standard today. However, we have more and more algorithms that are trained on a database, with the aim of boosting research and decision.

I am currently working on algorithms development projects, able to predict colon cancer. But there are a lot of problems with having certifications for this kind of algorithms. We must first ensure their validity through comprehensive tests, etc.

- What do you think of its integration in the medical sector (positive / negative points and risks)?

This is an extremely strong current, a computer hurricane that will affect medicine in its entirety. I think we have to prepare for it.

Positive points: They are of many kinds. Above all, it is an improvement in the care of patients, the speed of diagnosis, earlier predictability. It would prevent, treat better. From the doctor's point of view it is an invaluable help.

Negative points and risks: The risk is not to anticipate the transformation of medicine as a whole and not to have a broad vision of the evolution that we will live in the coming years.

Another negative point is how long it takes to find the right combination of algorithms.

- In what areas could it be the most useful?

In all professions of medicine. Imaging, diagnosis, follow-up, etc. In addition, she could help in biology, to make genome level analyzes. It is a huge progress. AI could help synthesize countless numbers of data.

- Do you think it's better than the man in these areas? Why?

Certainly yes! The man is not able to do what I mentioned in the previous answer. Like many other things besides. AI has capabilities that a man does not have. In particular the processing of information, memorization, cross-data, sensors and scanners. It does not need to sleep, it does not get tired, it does not have mood jumps, addictions, feelings.

- In your opinion, can AI be a solution to medical desertification?

Not alone. It is an indisputable help tool but not a solution to global organizational problems.

- Do you think that some medical professions are likely to disappear with the growth and development of AI?

Yes, absolutely. The medical imaging professions will be the first to suffer the consequences, because already today, there are systems that are more efficient than doctors in this area. They see details that are not accessible to the naked eye and can say with 99% certainty what it is.

The problem is that we do not anticipate the evolution of trades. There are no retraining formations. School trains us for the trades of yesterday's medicine and not of tomorrow.

- As a patient, would you trust a diagnosis or prescription made entirely by the AI?

Yes of course! Today, if we go to the scanner, we have confidence. Personally, when I get on a plane stuffed with technology and electronics, I have more confidence than if I climbed a cuckoo. When you take a blood test, these are algorithms that count the number of red blood cells you have in the blood, not people.

Only, It is necessary to observe and document the results to improve the reliability of the thing.

- What about surgery?

There we will have complicated objects, robotic systems, guided by Artificial Intelligence. Comparable to autonomous cars, whose reliability is not at this moment present.

So, for me, a pure surgical procedure, must remain in the hands of the doctors for a moment yet.

- What do you think about the risks of bad programming or hacking? How to fight?

The risks are high, we must certainly look for solutions to reduce them to the maximum. How ... That's a good question.

- What do you think about the holding of medical data by Big Data centers (often private groups). What becomes of the medical secret?

I have no fear at this level, today we have all the necessary devices to anonymize the medical data. Then, to be honest, in our time, the medical secret does not matter much and does not really exist.

- What do you think of the role of Silicon Valley in this evolution of medicine?

I think it is essential. It is still these wealthy companies that invest the most and have the most convincing results today.

- What do you think of the decision-making power of the AI?

It has and will have the ability to make decisions, that's undeniable.

- Do you think that one day AI can make decisions in place of humans in some areas of medicine? Why?

Yes, simply because it will perform better than the doctor in some areas. Why give decision-making power to someone who is less good? It's absurd.

- Finally, in your opinion, would the AI be rather a medical decision aid or an outsourcing of the human decision?

It would be both in my opinion. We can even imagine a kind of hybridization between men and the machine.

Then I see no problem in outsourcing the human decision. Since the dawn of time the man outsources a lot of things like the hammer for example, which extends the arm and is more effective for certain tasks than the hand of man.

It must therefore be outsourced where it is the best solution, such as the areas of medical imaging. Then, help the decision of the doctors in the fields where the Artificial Intelligence is not more powerful than the man, for example in surgery, where the human senses in particular are indispensable, but the AI will not possess them.

Attachment 7:

Interview Christophe GAPANY (Orthopedic surgeon, Private clinic, Lausanne)

- Can you briefly define Artificial Intelligence in your own way?

This would be the decision-making by IT entities. This decision would be based on large volumes of data and learning methodologies.

- What do you think of its integration in the medical sector (positive / negative points and risks)?

I think it is inevitable and already current.

Positive points: As long as we keep autonomy and supervision on the machine, I see only advantages. I saw a report the other day on television, where it was said that current algorithms are able to say more accurately than a dermatologist if a mole is benign or malignant. And I think that's great.

Negative points and risks: The risks begin here, where we lose the supervision on the machine.

- In your opinion, in what fields could it be the most useful?

I think it would be essentially diagnosis-related areas. Also, radiology.

- Do you think it's better than the man in these areas? Why?

Of course. We are learning about the principle of attempts and mistakes, while Artificial Intelligence could accumulate decades of experience and use it directly.

It will be less good in the creative aspect and that of the feeling, what is called the clinical sense. But ultimately, it's all about time.

- Do you think that some professions of medicine could disappear with the rise of AI? If yes, which ones?

I do not think they will disappear, but rather evolve, adapt accordingly.

- As a patient, would you trust a diagnosis or prescription made entirely by the AI?

No, not for the moment, not in complete autonomy.

- What if we talked about surgery?

Same thing.

- How could we point a responsible in case of error on the part of the AI?

I have no response. This is the same scenario as autopilots in vehicles. Is it the designer of the algorithm, the seller, the passenger? We cannot incriminate a machine

- What do you think about the risks of bad programming or hacking? How to fight?

These risks are present as in all other trades. I encounter errors every day, with fortunately little consequence. But if autonomous AI intervention takes place, errors can have serious consequences.

To fight it will be private initiatives mainly, the state has never done anything for that, they don't know nothing.

- What do you think about the holding of medical data by Big Data centers (often private groups)? What becomes of the medical secret?

Medical secrecy does not exist, it's a legend, a myth. The person who cleans my office can read the letters lying on my table. As well, people who work in insurance companies, have access to all the information.

So, keeping data by big data is not a problem, the problem is knowing what they do with it.

- Do you think that it is possible to respect the privacy of patients, without compromising medical research and technological advance?

Yes, with data anonymization processes. It's very easy to do, if you take the trouble. But not sure that this is the priority of the people who take care of it.

- What about the importance of the decision in the medical field?

The decision is permanent. It's a decision-making profession.

- What do you think of the decision-making power of the AI?

It is fundamental and certainly very complementary to that of man. I see a lot of positive.

- Do you envisage that one day the AI can make decisions in the place of the man in certain fields of the medicine? Why?

I'm considering it, but I do not want it.

- Finally, in your opinion, would the AI be rather a medical decision aid or an outsourcing of the human decision?

It must be further proved that the fact that the AI is able to process a lot more data, makes a difference in the diagnosis. But it is certain that it allows to exceed the knowledges of the man.

Sincerely, I do not know.

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Abstract

Nowadays, Artificial Intelligence knows a very fast development, that concerns practically all domains and shows its inevitable role in our daily life of tomorrow. More and more research centers, states, corporations, including the Silicon Valley giants, are investing heavily in this new technology, to reap benefits from it thereafter.

The medical sector is not an exception, since the integration of Artificial Intelligence would solve a large number of problems related to preventive and personalized medicine. It would bring hope to eradicate serious diseases such as cancer or HIV.

Many devices will have to be put in place to limit the risks related to the introduction of Artificial Intelligence in this sector. Indeed, the stakes in terms of medical data are questioned because of Big Data that make controversy.

A question arises however; would the doctor's decision be alienated by the machine? Are there areas where the machine would perform better than the man, to decide in his place? The purpose of this Thesis is to conduct a study that would answer a number of related questions.

Keywords: Artificial Intelligence, Big Data, Machine Learning, Deep Learning, Medicine, Decision