Universidade de Aveiro
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Departamento de Comunicação de Arte

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Ficção Científica e Medicina: Elaborando uma *Framework* para Auxiliar o Desenvolvimento de Artefactos Médicos

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Science Fiction and Medicine: Devising a Framework to Support the Development Medical Artifacts

Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Comunicação Multimédia, realizada sob a orientação científica do Professor Doutor Nelson Troca Zagalo, Professor Associado da Universidade de Aveiro e da Professora Doutora Paula Alexandra Silva, Professora Auxiliar do Departamento de Engenharia Informática da Faculdade de Ciências e Tecnologia da Universidade de Coimbra.

o júri

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agradecimentos

Gostaria de agradecer a todos os participantes do meu estudo, não só por tirarem tempo das suas vidas ocupadas como profissionais médicos, não só por fazerem parte do meu estudo, mas também por me ajudarem a encontrar outros que estivessem dispostos a fazer o mesmo.

Gostaria ainda de reconhecer a ajuda que o Professor Mário Vairinhos da Universidade de Aveiro, bem como o Professor Henrique Girão e a Luísa Carreira da Faculdade de Medicina da Universidade de Coimbra me deram ao reunir comigo e tornarem-me consciente do processo de desenvolvimento de artefactos médicos, entre outros detalhes.

Por último, queria agradecer aos meus orientadores, que estiveram sempre dispostos a responder às minhas perguntas, apoiaram os caminhos que quis seguir com o meu trabalho e aceitaram o meu ritmo acelerado, apesar das suas vidas extremamente ocupadas.

acknowledgements

I would like to thank all the participants in my study, not only for taking the time out of their busy lives as medical professionals in order to take part in my study, but also for helping me find others willing to do the same.

I would also like to acknowledge the help that Professor Mário Vairinhos from University of Aveiro, as well as Professor Henrique Girão and Luísa Carreira from the Faculty of Medicine of the University of Coimbra provided, by meeting with me and making me more aware of the process of developing Medical Artifacts, among other details.

Lastly, I would like to thank my supervisors, who were always available to all my questions, supported the paths I wanted to follow in my work and accepted my high-speed rhythm, despite their extremely busy lives.

palavras-chave

Ficção Científica, Artefactos Médicos, Tecnologia, Medicina, Design Fiction

resumo

Com o avanço tecnológico, o ser humano torna-se cada vez mais dependente da tecnologia. Usamo-la para trabalhar, para melhorar a nossa experiência social, para aprender, etc. e a medicina não é uma exceção. É comum ouvirmos falar de conceitos originários da Ficção Científica ganharem vida em áreas como a exploração espacial ou até a comunicação, e ver como ajuda as equipas a saber o que os consumidores esperam do futuro. No entanto, raramente ouvimos falar da sua influência nas tecnologias que nos mantêm vivos. Terá sido a medicina também beneficiado dos mundos de Ficção Científica na criação ou aperfeiçoamento dos seus artefactos? Este género literário e cinematográfico supera as barreiras do que é pensado como "possível" ao idealizar artefactos que vão para além do que é concebível no seu tempo. É um escape para aqueles que querem imaginar o que o futuro nos espera, sem esquecer de distinguir o possível ou plausível do fantástico. Nesta dissertação, vamos ver como a Ficção Científica pode ser usada como um guia para desenvolver artefactos médicos, bem como elaborar uma *framework* para ajudar os seus criadores a tomar decisões mais informadas. MADIS - Design de Artefactos Médicos Inspirados pela Ficção-científica - é uma *framework* que incorpora o conhecimento adquirido durante a pesquisa e as entrevistas feitas a profissionais médicos para criar uma ferramenta que suporta o desenvolvimento de Artefactos Médicos através da Ficção Científica.

keywords

Science Fiction, Medical Artifacts, Technology, Medicine, Design Fiction.

abstract

With technological advances, the human being becomes more and more reliant on technology. We use technology to work, to improve our social experiences, to learn, among many other activities. Medicine is no exception to this. It is common to hear about concepts originated on Science Fiction coming to life in areas such as spatial exploration or even communication. It is important to realise how Science Fiction helps teams working in those domains, as well as understand what consumers expect for the future. However, we rarely hear about Science Fiction directly influencing Medicine. Has this field also benefited from Science Fiction to create new or enhanced existing artifacts? This literary and cinematic genre pushes the boundaries of what is thought "possible" by idealizing artifacts that go beyond what is conceivable in their time. It is an outlet for those who want to imagine what the future might hold, without forgetting to distinguish the possible or plausible from the fantastical. In this dissertation, we go through how Science Fiction can be used as a guide to developing Medical Artifacts, as well as devise a framework that has the potential to help their developers make more informed decisions about the characteristics of those artifacts. MADIS - Medical Artifact Design Inspired by Science Fiction - is a framework that incorporates the knowledge acquired during the research and interviews with medical professionals to create a tool which supports the development of Medical Artifacts through the lens of Science Fiction.

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1. Introduction

In this dissertation we will be looking at how Science Fiction could affect the development of artifacts, especially when it comes to Medicine. This study will mainly be done through theoretical research, however we also carried out interviews with medical professionals in order to understand their stands regarding Science Fiction and Medicine. Besides this, we devise a framework, MADIS - Medical Artifacts Design Inspired by Science Fiction, which can help developers of Medical Artifacts to take advantage of Science Fiction to make more informed decisions in different phases of their work. By "developers of Medical Artifacts" we refer to every person that integrates a team working on Medical Artifacts. In the current chapter (**1.**), we can read about the context in which this dissertation was developed, including where the idea came from, the background of the author and what it will add to the field. In chapter **2.** there is the description of our plan for this study, including the Research Question, the Hypothesis, and the Research Goals, as well as the research plan. In Chapter **3.** we present the concepts that appear throughout the dissertation, explain their background and why we use them. Chapter **4.** focuses on the State of the Art of both Science Fiction and Medical Artifacts, as well as existing methods that already use this literary and cinematic genre to help bring ideas to life. Chapter **5.** Is dedicated to the methodology used for the analysis of documents, for the interviews and for the framework to be devised. Chapter **6.** marks the beginning of the more practical side of the dissertation, describing the study and its results, that are then interpreted in chapter **7.** It is in chapter **8.** that we present our framework and explain each of its components. In chapter **9.** and **10.** we reflect upon the work done and what could have been done differently, as well as what can still be done in the future. In chapter **11.** we discuss our hypothesis, answer our Research Question and make our final remarks.

1.1 Motivation

Enrolling in a master's degree in Multimedia Communication was an interesting experience, coming from a Languages Literatures and Cultures background. However, the will to pursue a different area spoke louder, as well as the hope to find some connection between the two subjects. This was what we found in this dissertation: an opportunity to bring together knowledge and appreciation of more traditional arts, in particular literature, and newly acquired experiences with new technologies. Besides this,

the author comes from a household of two health professionals, which always ignited a certain curiosity to know more about science in general, but in particular those that impact our lives on a daily basis or, in this case, that can save them.

The idea for this theme of research came from the interest of looking at the future of Medicine with a broader knowledge of how artifacts are developed in this field. There are two main focuses regarding the Master's in Multimedia Communication, especially on the Interactive Multimedia branch, that are crucial in this research: technology and communication. On the one hand, we look at artifacts and current technology used in Medicine, trying to understand not only how they work and what can be improved, but also what can we do to make sure it can be developed faster, more effectively and using less resources. This understanding will culminate in the creation of a framework to help the development of Medical Artifacts.

On the other hand, we are looking at how people communicate their ideas, for instance through Science Fiction, and how they manage to translate that into real, useful artifacts. Besides, by analysing how artifacts are used and have evolved, we can understand a lot about how the techniques, knowledge and perspectives on Medicine have evolved throughout the ages. Furthermore, it is important to accomplish faster and more efficiently build Medical Artifacts and to enable people from different areas to work together for a common goal. On a more practical level, we will also discuss issues such as teamwork dynamics inside medical facilities and the way new technologies are presented to people in general.

1.2 Why is it important to study the influence of Science Fiction on Medicine?

Literature is quite important to our understanding of how the world works. Most of what we know from the times before technology appeared came from some kind of storytelling: first with rupestre paintings, then with *voiage* diaries and ultimately with fiction. Contrary to what one might think, Literature plays a role in understanding the life in which it was written in, as we have to take into consideration that each writer has individual experiences, which will affect their perspectives on certain topics and, therefore, their writing. Let's take what is arguably the first Science Fiction novel ever written: *Frankenstein* by Mary Shelly (1818). If you read this novel without knowledge of the writer, you may think that this novel was made to terrify its readers, but when you know the story of Mary Shelley, you understand that many aspects of the novel can be linked to the author's life (Mellor, 1990).

As we will see later on, sometimes the lines between reality and fiction are more blurred that one might think. As argued by Alkon (1994), imagination does not come from nothing, it always draws back to past experiences to form a new idea. So, could Medical Artifacts be drawing their inspiration from Science Fiction? Vint (2007) also brings up this idea when she says “Although set in the future or elsewhere, Science Fiction is commonly understood to be about the moment contemporary to its productions and the anxieties and anticipations that form that moment.” As we have seen in the previous paragraphs, writers are human beings in a context and are therefore influenced by it. A very important part of the creation of Science Fiction consists of the knowledge that the world was starting to change, what became especially evident after the industrial revolution, but that most people probably would not be there to experience it. So, naturally, they started to imagine what the future could be like, as Isaac Asimov argued in an interview with Maria Popova (1988). As it was also claimed in this instance, before the industrial revolution life had always been the same - same professions, same methods of agriculture, same living spaces, etc. - but with steam engines and coal, everything changed. It is natural for humans to fear the unknown, and in no other time the human race faced this situation so much as it did in the turn of the 19th century. Science Fiction took advantage of this, and still does, by creating future scenarios of dystopian nature, where we are threatened by that which we are creating in the present, whether that is in terms of political changes, environmental issues or even the works of society in general. However, these stories also create ways of trying to fight the adversities of this ‘future’, many times by conceiving new inventions that solve problems that cannot be solved in the time of writing. Menadue et al. (2019) state that "Science Fiction, as creative writing about scientific, technology-focused and plausible worlds, may be a socio-cultural manifestation of the human concept of techne”. In other words, Science Fiction helps us project our scientific dreams and ideas, in a creative, non-judgemental way, into a future where it may or may not be possible that these advances exist. These ‘futures’ created in Science Fiction works, therefore, end up reflecting not only the way in which we think we will evolve as a species and as a society in general, but also our desires for future accomplishments, reaffirming Schneider’s (2009) statement. Alkon (2002) comments that this genre “touches on so many urgent human concerns and draws more widely on the resources of previous literature.” By looking towards the future, these authors were identifying our expectations, desires and fears about it, in all aspects of human life, especially those neglected on a daily basis. Alkon also talks about how Science Fiction

excels at speculating about the good and bad implications that emerging technologies might have in our future, “in an age when science has accelerated the proliferation of technologies once beyond even the reach of fantasy”(Alkon, 2002). Because of this futuristic, and sometimes pessimistic, vision of what is to come, Science Fiction may be a very important tool to help scientists and engineers understand how the world will react to the technologies being developed today, even though the genre is not supposed to be very scientific at all.

1.3 Who will benefit from this study

Although fictional, Science Fiction, especially literature, differs from other genres in the sense that it is somewhat between fantasy and plausibility. As Alkon (1994) puts it, “Science Fiction can only exist when it is possible to distinguish in this way between the natural and the supernatural.” Science Fiction focuses on what is, or could be, real, because of which, we can trace it back and forward to reality. This is also why it is more likely to influence scientists than any other genre. As mentioned previously, Science Fiction is a tool that can be used by scientists to go beyond what is already known in the present, by letting their imagination flow and by contemplating what would be plausible as well as interesting to have in the future. It can also take those ideas and help bring them to life. Hubble says “Realistic fiction sets out to describe the world; Science Fiction sets out to change it”, claiming that it does not only concern exact sciences (such as biology, engineering, etc.) but it can also be related to the social sciences (for instance sociology) which can help predict the reaction of society to the insertion of certain technologies on its environment. Hubble writes particularly about George Orwell’s opinion on the relation between H. G. Wells’s work and the real world. In *Wells, Hitler and the World State* (1941) Orwell explores the fact that one of the ways of “predicting” the future is simply to observe the desires of the people. Orwell (1941) notes: “A decade or so before aeroplanes were technically feasible, Wells knew that within a short period of time men would be able to fly.” He knew because he himself wanted to fly, and therefore felt sure that research in that direction would continue.” He also argues that Wells was able to have an effect on how people thought, especially when it comes to the way they thought society would evolve. Humanity will always run towards their objectives, so, sometimes, we can logically predict what the future will hold, based on the desires of the present.

Markussen and Knutz (2013) understand that Utopias, for instance, have been used to experiment “with alternative models for society or possible futures” not only by artists, but also by designers and architects. The use of fictional scenarios by professionals are becoming more popular, as they begin to be seen as “viable roads for producing valid knowledge in design research and science” (Markussen and Knutz, 2013). This way, it is possible to find a balance between what we know and experience - which brings nothing new to the equation - and what the fictional scenarios that influence and inspire us. Besides, the utopian futures portrayed in Science Fiction books, represent worlds that we will never come across - therefore the term “utopian” - for they simply are not plausible, although a version of them could correspond to reality in the future. As Mubin et al. (2016) put it: “HCI researchers can learn what not to design or how not to design based on negative content (or dystopian views) portrayed in science fiction”, that is, by creating a fictional future and inserting a certain technology or artifact into this fictional society, one can play out the consequences.

By understanding the influence that Science Fiction has on science, it is possible to devise a method for scientific or technological development based on Science Fiction. This can bring this genre into a new light as visionary literature, instead of purely as fictional content. As it is claimed by Mubin et al. (2016), “the designer can use the storytelling capabilities of Science Fiction, as an informative tool to extract user requirements for future technologies, through various mechanisms such as storyboards, storytelling, scenarios and even participatory design/co-design.” Therefore, teams working on the development of Medical Artifacts will be able to use a tool that will help them make the most of what has already been done in Science Fiction, in order to use less time and resources to execute their ideas.

Besides this, Science Fiction authors will also have in their hands an opportunity to see their creations come to life, within reasonability and possibility, which may lead to more conscious, but also more accurate, stories in the future. When bringing together the visionary and creative minds of Science Fiction authors and the intellect and skills of scientists, designers and engineers, we might witness a new era of technological and scientific development. Ideally, both the writers and the teams working on projects connecting Medicine to Science Fiction will benefit, in some way, from the association between this literary and cinematic genre and technological advancement. Overall, it is in the combination of the technological and the humane that makes Multimedia Communication, and that is the perspective we want to bring to the field.

2. My Approach

This dissertation was guided by a Research Question and three hypotheses, discussed below.

2.1 Research Question: Could Science Fiction allow for a more informed creation of future artifacts used in Medicine?

With this study we aim to understand whether Science Fiction could be a tool for developers of Medical Artifacts to make more informed decisions regarding their work. Making informed decisions, that is, making decisions based on full knowledge on the subject, will theoretically lead to better results. This question will mainly be addressed through deductions based on research and interviews.

2.2 Hypotheses

H1: Science Fiction helps developers of Medical Artifacts develop a better understanding of how their inventions can help doctors or healthcare providers.
H2: A framework will help developers of Medical Artifacts to take advantage of Science Fiction to make more informed decisions when it comes to the artifacts they are developing.
H3: Medical professionals with different levels of work experience will have similar opinions when it comes to the impact of a framework to help the development of Medical Artifacts.

2.3 Research Goals

The major goal of this research is to understand whether there is a relationship between Science Fiction literature and the evolution of Medical Artifacts, as well as developing a framework that will support Medical Artifacts developers creating them in a more informed way. As technologies evolve and integrate every aspect of our lives, the real world gets closer to the literary world imagined by authors like Isaac Asimov, Arthur C. Clarke, William Gibson. These are, as previously stated by Jordan (2019), some of the Science Fiction writers with the most influence on scientific work. Each day we are confronted by new gadgets and artifacts that make justice to what we had imagined for our future, and, in some fields, we have even exceeded our expectations. The goal for this dissertation is to understand how the ‘Science Fiction’ literary and cinematic genre can influence modern day Medical Artifacts, inspire scientists, engineers, inventors

and/or doctors to create tools that medical professionals can use to improve their job. Based on what is found during the research process, a framework is devised, intending to help teams that are idealizing or developing artifacts in Medicine making more informed decisions. The goal is to give these teams knowledge on how to more efficiently take advantage of the ideas developed in Science Fiction to help apply them to a real context. Through the analysis of Science Fiction and its influence on science and technology, perhaps some steps of conceptualization can be facilitated or even skipped, leading to a faster, cheaper and overall smoother process of artifact creation. As we are specifically talking about Medical Artifacts, we will also take into account the challenges, needs and perspectives related to this field.

To sum up, the goals of the research are the following:

a) Understand whether Science Fiction has had a relevant influence on the development of Medical Artifacts and to what extent;
b) Determine if developers of Medical Artifacts and medical staff in general might take advantage of having a Science Fiction-based tool to help them on their work;
c) Create a framework that can support the development of Medical Artifacts with the help of Science Fiction.

2.4 Plan of Action

This dissertation is organised in two main parts: the theoretical part, which includes the state of the art, theoretical context as well as all the methodologies used, and planning for the second part. The second part consists of the analysis of 22 articles present in Jordan's Thesis, *A Meta-Study and Content Analysis of Science Fiction* and the interviews that will be made to medical professionals. At the end, the results from these will be compared and incorporated in a framework with the goal of supporting Medical Artifact Development.

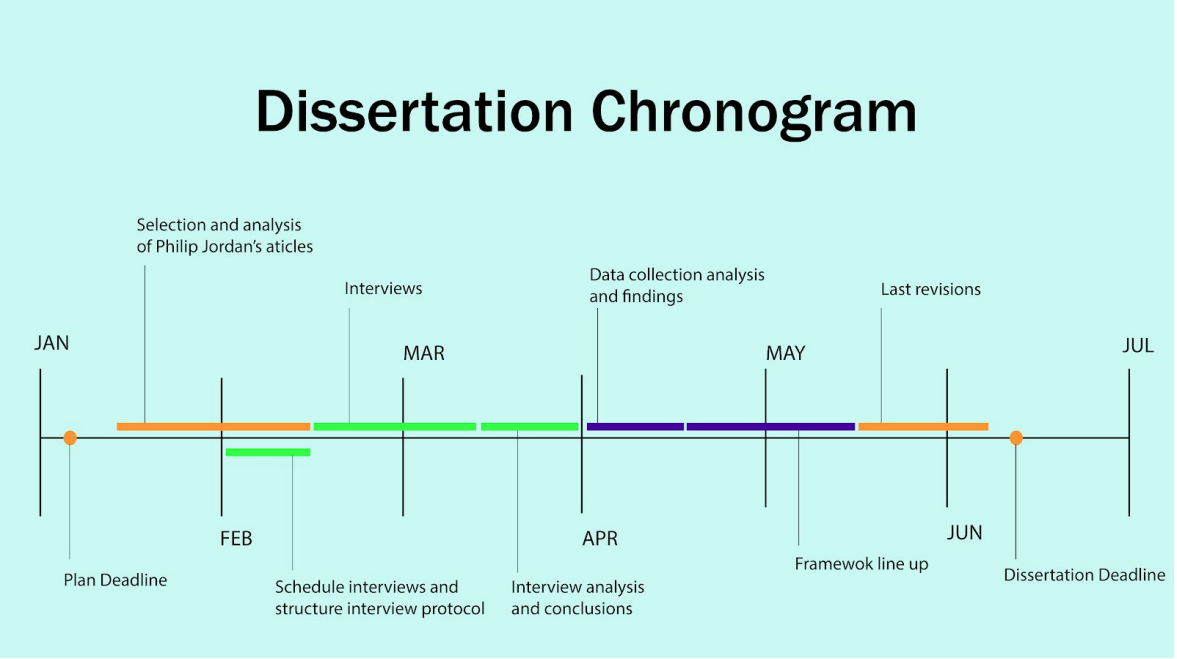


Image. 1 - Dissertation Chronogram

The plan for this research, according to the Academic Calendar of University of Aveiro is the following:

- In **January**, the focus is on selecting and analysing the works previously analysed by Jordan (2019), reading the texts, defining which are more important and what conclusions can be taken regarding the influence of Science Fiction - especially literature - in Medicine, namely the development of artifacts;
- In **February**, it turns to the Interviews, which are scheduled, structured and carried out in this month, as well as the beginning of the next;
- In late **March**, all the data collected is analysed;
- **April** consists in analysing the data collected on the previous months, in order to draw up satisfying conclusions;
- In **May**, all the work previously done will culminate in the creation of a framework to help developers of Medical Artifacts use Science Fiction as an advantage for their work;
- The first week of **June** is focused on the last revisions, before handing out and presenting my dissertation.

3. Concepts and Context

In this section we will cover the key concepts used in this dissertation, defining the meaning to which I will refer to when using them in this dissertation, as well as giving some context behind them. These concepts will be roughly defined from the vaguest to the most specific ones regarding the object of the study, starting from the first concept present in the title: Science Fiction.

It has always been difficult to define Science Fiction as a genre, both because of how wide it is in terms of covered topics or because of its ambiguous origins. The term first appeared in *Amazing Stories* in 1926, an American magazine that published short stories of this genre (Carl Freedman, 2000). Freedman, however, considered this an "extremely narrow construction" for it excludes "Mary Shelley, Poe, Verne, and H. G. Wells (works by the later three were reprinted by Gernsback in his inaugural issue), not to mention contemporary British work by writers such as Stapledon, C. S. Lewis, and Aldous Huxley, as well as the rich Russian and East European traditions." Many of these authors, some of the most famous Science Fiction writers, never even heard the term in their lifetime, which means that this genre existed way before there was a name for it. This fact accounts for, perhaps, the main reason for how difficult it is to define Science Fiction.

During the nineteenth century there were many changes in all areas of life that affected how people thought, and therefore wrote, about it. James (1994) discusses this, saying that people were "fully conscious that the lives of their children, even more than their own, were going to be transformed" by the changes that were taking place. The industrial revolution and the steam engine were groundbreaking changes, as well as others that came with them, such as mechanized factories, locomotives and other steam-powered engines. Not long after, gas and electricity started replacing coal, as the twentieth century unfolded.

Adam Roberts (2000) presents four definitions of Science Fiction, two of which I are particularly interesting, one of which is from Suvin:

> "a literary genre whose necessary and sufficient conditions are the presence and interaction of estrangement and cognition, and whose main formal device is an imaginative framework alternative to the author's empirical environment." (Suvin, 1979)

There are two main points in Suvin's definition worth highlighting. The first is the reference to the unknown, that is not only present, but also most of the times the

protagonist must interact with it. Freedman (2000) considers the refusal of the "mundane environment" as a critique of the author's own actual circumstances. This comes to enforce the idea mentioned earlier in this document (**Why is it important to study the influence of Science Fiction on Medicine?**) that this genre reflects the fears and expectations of what is to come. The other aspect worth emphasising is that Suvin points out that Science Fiction worlds are beyond the author's reality, that is, they do not depict his life but something that is completely different, sometimes even opposite. Carl Freedman (2000) affirms that the "estrangement", that is the unknown, is what ends up differentiating Science Fiction from more realistic literature. This is complemented in the next definition, that refers to the ever changing nature of our society. Broderick (1995) says:

> "Sf [Science Fiction] is that species of storytelling native to a culture undergoing the epistemic changes implicated in the rise and supersession of technical-industrial modes of production, distribution, consumption and disposal. It is marked by (i) metaphoric strategies and metonymic tactics, (ii) the foregrounding of icons and interpretative schemata from a collectively constituted generic 'mega-text' and the concomitant de-emphasis of 'fine writing' and characterisation, and (iii) certain priorities more often found in scientific and postmodern texts than in literary models: specifically, attention to the object in preference to the subject."

In addition to the already mentioned detail, Broderick's definition also touches on some of the themes that Science Fiction often covers. These are fairly important to recognise whether a text is Science Fiction, and if so, distinguish it from both realism and fantasy. Besides these, other common themes amongst the genre, as covered by Edward James (1994), are "what if" scenarios, destruction of civilization, genetic mutation, human and machine relationships, time travel and social or political satire.

Another aspect of why Science Fiction is so difficult to define has been mentioned before: the fact that sometimes it cannot be easily distinguished by more realistic fiction. One of the reasons why this has to do with what is fiction, and what is reality, in the time of writing. As we have seen before, it is common in Science Fiction texts to make assumptions about what the future holds for us, and as we have also confirmed, these assumptions do come true in some cases. This raises the question: does the text that accurately "predicted the future" cease to be

Science Fiction in order to become Realistic Fiction? The same problem appears on the other way around, if the future is not confirmed, it is only then considered Science Fiction? Carl Freedman (2000) asks “Must we wait for a scientific consensus on the matter before deciding whether the text is science-fiction or fantasy?” Should we have waited until 2015 to confirm if the happenings of *Back to The Future Part II* (1989) corresponded to reality and only then determine the genre of the film? These blurred lines between fact and fiction come from the fact that what we know now to be scientifically correct, one day was considered impossible, even fantasy. Therefore, what we consider now as impossible, might one day actually be possible.

It is important to know that, despite having “science” in its designation, Science Fiction does not intend to be scientific, in the sense that it does not reflect actual science that is being practiced during the time of writing, but mainly prognosis about what the author thinks will exist in the future. James (1994) mentions Suvin’s opinion about how this genre should be written “in a realistic mode” (Suvin, 1979), and the same is discussed by Dani Cavallero (2000). Here, the author extensively addresses the way in which Science Fiction texts are written to simulate scientific discourse, although with any intention to fool the readers into thinking that it is actual science. As mentioned in Alkon’s (2002) book, Bodin (1834) coined the term, defending that this kind of novel is “an artistically satisfying vehicle for rational speculation”, exactly because of this socio-speculative aspect of it. Science Fiction gives us new, more creative perspectives of what science can be that might have existed had only the scientists thought about it. When writing a fictional novel, it is not within the author’s concern whether the writing corresponds to the scientific truth of the time, or not. By freeing oneself from the restrictions of thinking and writing only about what we consider possible now, the writer can bring to light ideas that could be brought up otherwise. Moreover, through research, experiment, and the right resources, these ideas might result in a final prototype or even be an inspiration to others that will be possible to develop in the future. This is what this work aims to understand: is Science Fiction a source of inspiration to the creation of concepts, prototypes or even actual Medical Artifacts? As it is argued by Mubin et al. (2016), after some studies done with scientists watching Science Fictions films, these scientists were analysing the films through the lenses of scientific knowledge, as well as subconsciously wondering about the possibility of

having those in real life. So could Science Fiction be influencing the way we think, design and develop artifacts to help in the field of Medicine? After all, before science, there is always an initial idea, and as we have seen before Science Fiction is the “Literature of Ideas” (Isaac Asimov,1975).

The last thing to address before moving on to other concepts is the terms in which “Science Fiction” will be used. Because of the author’s background as a Literature graduate, this research will be mainly based in Science Fiction Literature as opposed to Science Fiction Cinema. Nonetheless, as we can see in the previous paragraph, this category will not be utterly discarded. Although the initial intention was to focus on Science Fiction Literature, especially on classic works such as the likes of H. G. Wells, Jules Verne or George Orwell, it promptly became clear that Science Fiction films could not be kept apart from this work. The reason for this is primarily for their popularity as well as the influence that these films had not only on other Science Fiction works but also in pop-culture in general - take, for instance, the case of the *Star Wars* saga (Lucas, 1977) and the influence it had in TV shows such as *The Big Bang Theory* (2007-2019), for example. The truth is that a significant part of Science Fiction films are based on books, for instance from the 10 films mentioned by Boutillette et al. (1999), seven are directly based on books with the same or similar names. Nonetheless, when the term Science Fiction is mentioned henceforth, it will be referring to Science Fiction Literature, unless it is stated otherwise.

Another concept present in the title is “Medicine.” At the beginning of my work, it was not clear if the term used would be “health” or Medicine.” When searching the meaning of “Medicine” in the Oxford Online Dictionary - Lexico - I came across two different definitions that I could consider going forward, being:

1. “The science or practice of the diagnosis, treatment, and prevention of disease (in technical use often taken to exclude surgery)”
2. “A drug or other preparation for the treatment or prevention of disease.”

When searching in the same dictionary for “health”, what came up was the following:

1. “The state of being free from illness or injury.
   ‘he was restored to health’
   1.1 A person's mental or physical condition.
   ‘bad health forced him to retire’ ”

As the second definition was too broad for what was intended, especially because the intent to include elements such as pharmaceutical treatments and surgery on the table, as well as the fact that diagnosis and prevention are two areas where I believe works such as mine can have an influence in the near future. Therefore, the first concept was chosen for the purposes of this dissertation, although surgery will be considered part of it. However, there has been work developed regarding the influence of Science Fiction on Health, which was will be published on AVANCA | CINEMA 2020 and is entitled *The Influence of Science Fiction in Healthcare Technology* (2020). In this article, the author explores a similar theme to the one we are discussing here, however the article focuses on health in general (instead of a particular practice). Furthermore, it also leans more towards cinema, as it was included in a conference about cinema.

In this dissertation we focus on Internal and Intensive Medicine. According to a webpage (www.sgu.edu/blog/medical/what-is-internal-medicine/ , 2018) from St. George's University (Grenada, Caribbean) with the intent to clarify doubts of medical students regarding certain specialities, a practitioner of Internal Medicine (Internist) - is "well equipped to handle many different conditions", as they can work in various services within the hospital and come into contact with all kinds of diseases and conditions. Dr. Albert Fuchus (2018) explains, as stated in the same webpage, that these doctors are concerned with performing exames, making diagnosis, prescribing treatment and medication and recommending preventive measures, as well as forward the patient to a specialist. When working in Internal Medicine, one has to have a certain level of social skills, either to interact with the patients, or to work well as a team, in addition to leading it. Moreover, and perhaps the most important asset, is the need to make good decisions under pressure and in the smallest amount of time possible.

Intensive Medicine is the area of Medicine that concerns intensive care of patients. According to the Cambridge Dictionary, intensive care is "(in a hospital) continuous treatment for patients who are seriously ill, very badly injured, or who have just had an operation". As stated in an article about this speciality in the website Health Careers, it deals with patients that are recovering from or at risk of getting into a situation in which their life is threatened (for instance, organ failure). The doctors working in Intensive Care, often including Internists, are responsible to guarantee that the organ system is assisted, investigate certain cases and give diagnosis, as well as giving support to the families and, in some cases, end-of-life care. In a nutshell, Intensive

Medicine is an area that focuses on prolonging the life of severely ill patients enough so that they can either cure them or give them a better, less painful death.

This leads us to the next concept to define: “Medical Artifacts.” When speaking about the objects used for assistance in Medicine, the terms regularly used are “instrument” or even “technology”, although none of them transmit the idea we wanted to reflect when using the term “artifact”. Let us look at the definitions of “Medical” and “Artifact” in Lexico:

> **Artifact:**
>
> “An object made by a human being, typically an item of cultural or historical interest.” “Something observed in a scientific investigation or experiment that is not naturally present but occurs as a result of the preparative or investigative procedure.”
>
> **Medical:**
>
> “Relating to the science or practice of Medicine.”

Hence, a Medical Artifact could be said to be an object created by men to assist works related to the science or practice of Medicine, which typically evolves and adapts parallelly to developments in science and technology. Nonetheless, there is also another definition of artifact that has to do with *something observed in a scientific investigation or experiment that is not naturally present but occurs as a result of the preparative or investigative procedure* (Lexico): we will not be referring to this definition in this dissertation.

The fact that in this document the term “Artifact” is applied in detriment of the others mentioned lays in the fact that it conveys a more organic and humane aspect that often is not considered in terms such as “instrument”, and which comes across almost as an antonym for “technology”. Simon and Wiedmer (2010) say about artifacts that they “are an entrance point for critical thinking about the self evident, not only as the world could be, but rather to find a new, distant perspective on reality as it is.” Moreover, when we use terms such as “instrument” or “technology” it is implied that those are finished works, whereas “artifact” is often still in process, has not been implemented or has not yet reached its utter potential. Hence, when we refer to “Medical Artifact” we have to take into account:

- Their use/creation specifically in/for Medicine;

- They are meant to aid medical professionals in their jobs;
- There was human effort and creativity involved in the process of creating them;
- There was also recent (at the time) technology involved in the process of creating them;
- They might not have reached their full potential yet.

By taking these aspects into consideration, we will be able to distinguish an "artifact" from "instrument" or "technology", although all of these can, and do, cross paths both in practical terms as in this dissertation.

Finally, it is important to define the concept of a Diegetic Prototype, since it is a key element of the framework developed. The term "diegetic prototype" was coined by Kirby to define "cinematic depictions of future technologies are what I term diegetic prototypes that demonstrate to large public audiences a technology's need, benevolence and viability" (Kirby, 2010). They are a type of speculative prototype, that is, a prototype that is not built, but conceptualized, imagined, and inserted into a hypothetical scenario, that usually consists of a plausible near future. As Joseph Lindley (2015) explains, the term "diegesis" alludes to what Lindley calls 'world of story', hence the adoption of the term "diegetic." Usually associated with Design Fiction, these prototypes have two main purposes: to understand the interaction that they would have with the people and the environment of that near future, and to present their plausibility and usefulness, as well as how they function. After their conceptualization they are often shown to an audience (for instance, in form of a film - *Threshold*, 1981) in order to understand, and sometimes even change, their opinion about the prototype. As we can see by the example of *Threshold*, diegetic prototypes are usually considered in a cinematic context, which is another reason why we could not focus solely on literature, in this dissertation. Notwithstanding, nowadays we cannot really separate literature from cinema, especially when considering Science Fiction, as not only many films are based on its book version (although the opposite has also happened) but also because the actual written script of the production can be considered a literary piece - so much so that it has become common in the past few years for the scripts of films to be released in book form.

4. State of the Art and Theoretical Context

There is not a lot of discussion about both Science Fiction *and* Medicine, as is the case with Colombo et al. (2018) and Emily York et al. (2019). There are, however, various

articles about techniques for using Science Fiction as a prototyping or designing method - such as Simon Grand's (2010) and Michael Postada and Jan Zybura's (2014) - as well as ones that wonder about the future of Medicine - for instance, Haghi Haghi et al. (2017) and Fang Hu et al. (2013). Notwithstanding, it is worth mentioning the work of Philipp Jordan, a University of Hawai'i at Mānoa Ph.D. Alumni. Jordan (2019) analysed a series of science publications related to Science Fiction. Although this work is not exactly focused on the relationship with Science Fiction and Medicine, it does cover many articles related to Medicine, as we will see further on in this dissertation.

4.1 Anticipating the future?

The idea that this literary and cinematographic genre has been "predicting" the future is not new, in fact there are some interviews in which Science Fiction authors are directly asked about how they are able to so accurately see far into the future (Zach Baron, 2014). However, this does not say much about it serving as an inspiration for the development of technologies, nor if these were projected or were a mere coincidence. By projected, I am referring to technologies that were imagined by Science Fiction writers in their texts, although they did not exist at the time, but later actually became real, either because there were efforts to make them true or by coincidence. Some of the Science Fiction technologies that became real are Virtual Reality - imagined by William Gibson in *Neuromancer* (1989), the exploration of the deep oceans - present in Jules Verne's *Twenty Thousand Leagues Under the Sea* (1870), space exploration was dreamt about in countless stories - including H. G. Wells *The First Man in the Moon* (1901), smart virtual assistants like Google Home - for instance in the Disney Film *Smart House* (LeVar Burton, 1999), among many others. On the other hand, when we identify inventions as being similar to the ones mentioned on a certain work of Science Fiction, but its developers were by no means influenced or inspired by them, we can say that it was a coincidence. Baron mentions how in *Peripheral* (2014) the writer talks about an Ebola Outbreak and about conflicts in Gaza and Syria. We can never be sure if this could have been deduced through signs or circumstances prior to the events, however we can at least hope that there were no efforts made towards illness or war, making these "predictions" a coincidence. Nonetheless, we cannot ignore the fact that fictional stories are able to explore ideas that might not always be well received by the public, or as Kirby (2010) puts it, "create images of 'technological possibilities in the audience's mind". As the author remarks, space exploration has been particularly benefited by the genre, whether

by inspiring engineers and scientists for the general ideas of the technologies they were developing, as well as their design and also for securing funding and promoting their research. Has Medicine also been influenced by Science Fiction?

4.2 Medical Artifacts and Science Fiction

It was in the twentieth century that we began to see in real life artifacts that seem to have been ripped out of a Science Fiction novel, as Schneider (2016) covers. It was in 1960 that the first implant of a technological nature on a mouse took place, as Schneider explains in the book. Less than 30 years after, in 1998, Kevin Warwik, who was determined to become a "cyborg" himself, implanted a chip in his arm that helped him open doors for him and switch "circuits" on and off. The term cyborg was also coined during the twentieth century by Nathan Kline, and first appeared in his work with Manfred Clynes entitled *Drugs, Space and Cybernetics* (1961). By the end of the following *millennium* (early 2000s) these kinds of implants were not only being improved and taken further by Warwik, but also by many others, for instance, as Schneider writes, by the University of Tokyo. This, however, may not come as a surprise, since as we can read in Schneider's work (1994), by 1900 around 10% of Americans were already considered cyborgs, which included people with pacemakers, prosthetics and other artificial enhancements. At this time, people seemed to believe that the goal was to create hybrids between man and machine, which would help the human in things such as breathing, digesting and keeping awake, as well as giving them feedback about his/her body. Schneider (2009) even claims that this would ultimately enable humans to live outside of planet Earth. Besides outer space, the way in which the body could be enhanced by technological means was also in early Science Fiction connected to the pursuit of immortality, as perhaps still is today. This matter is extensively addressed by Stephen R. L. Clark (1995), who covers different ideas portrayed over the years in Science Fiction of how one could defeat death. In the works mentioned, the characters were commonly frozen before death until a cure was discovered, and there was even talk about creating a society of so-called "long-livers", that is, people that lived longer than normal. This specific idea, in fact, which was featured in *Methuselah's Children* (1941) by Heinlein, was decades later covered by Richard Darwin in *The Selfish Gene* (1976) and was centered around the idea of genetics and how to use them in human's advantage, so that we can live longer lives.

Kirby (2010) highlights the influence that Science Fiction can have on the development of Medicine, as a way of preparing the public opinion for the technological changes that are entering this area of life. The author reflects about *Threshold* (1981), a film centered on topics such as the human condition and the separation between human and machine. It helped the public to have a less prejudiced opinion about a medical advance, in this case, an artificial heart. The way cyborgs - that is, people with machine parts integrated in their biological body - acted, lived and felt in the story. This ends up creating empathy, or at least acceptance, of these enhancing artifacts, which were previously seen, for their artificial nature, as strange and unwelcomed. The fact that people were exposed to this idea, even before it existed in real life, helped them process what they thought and felt about it and, ultimately, accepted it as a harmless object, prone to save lives. Lastly, Baron (2014) talks of terms like “cyberspace” and “the matrix”, which were coined and popularized by William Gibson, but found their way into mainstream language fairly easily. Mubin et al. (2016), who have studied the influence that Science Fiction has had in different fields of science and technology, stated that both of these “learn from and inspire each other.” The authors also affirmed that Science Fiction has compelled scientists to adapt fictional concepts into real world appliances, adding that “HCI researchers naturally benefit from Science Fiction more than from other genres, as the ideas presented usually combine facts and fiction.”

As technology evolves and becomes more and more present in our daily lives, it also makes its way into Medicine and healthcare. Appliances such as prosthetics and other medical devices were already being used by ancient Egyptians, as it is addressed by Weber (2018). However, according to the same author, as well as Fang et al. (2013), it has been becoming a trend in the 20th and 21st centuries. Weber (2018) discusses a system used by Biotronic, a German Company, that monitors the heart through an “implanted sensor in the chest,” that communicates the information it gathers to a smartphone and, if need be, calls for help, which leads us to one of the burning themes of every area of study at the moment, and Medicine is no exception: the Internet of Things (IoT).

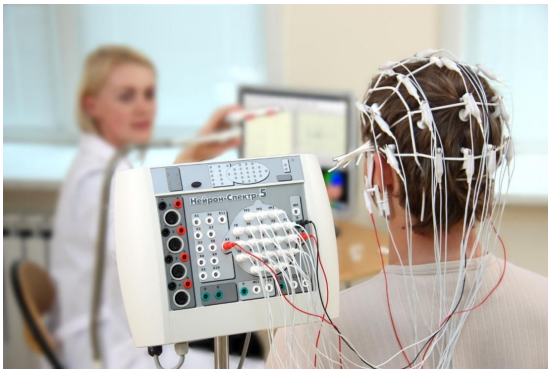
Many of the developments we are witnessing in technology for health rely on, or are somehow related to, the concept of IoT, which Fang et al. (2013) define as “a kind of technology that embeds wireless sensors in medical equipment, combined with the internet and integrates with hospitals, patients and medical equipment to promote the new development of modern medical model.” According to Haghi et al. (2017), there are

already some achievements when it comes to Vital Sign Measurement, for instance with electrocardiogram, electroencephalogram and even skin temperature, among others. An example of an instrument with these characteristics is a Continuous Glucose Monitor (CGM), which is a device that takes the glucose levels of a diabetic person and sends them to a smartphone to be analysed. This device can be helpful not only to diabetic people, but also to their caregivers, especially when the patient is an elder or a child, since these groups are less independent. The device is quite interesting from the perspective of IoT, especially because nowadays the patient simply has to do a gesture with the smartphone (or other device) towards the CGM and it will automatically inject insulin, making the process quicker and more discreet than it ever was.

Image. 2 - CGM retrieved from from www.niddk.nih.gov

However, these solutions are not yet efficient when it comes to power consumption and performance. Moreover, when it comes to people's health, there is already a considerable amount of confidential information about the patient that the health facility has access to, especially when it comes to children, for instance. When we connect medical devices to the internet, the risk of this information being leaked raises exponentially, which has been one of the reasons why IoT has been put a bit on the side in the fields of Medicine and healthcare. These ethical issues have been present since the middle of the 20th century, as Weber argues, rising with the use of "machine-aided medical interventions" (2018) which helped prolong the patient's life. These interventions included technologies such as "iron lungs, positive pressure artificial ventilators, and Automated External Defibrillators (AEDs), etc." (2018).

Another type of technology mentioned by Fang et al. (2013), although still in an early stage, is smart clothing, that might be helpful for constant monitoring of some diseases or conditions in the future. Constant Real-Time Monitoring enables doctors to "prevent and control the appearance and development of diseases, reduce medical costs, and improve the quality of life". Julia E. Mück et al. (2019) say that "smart clothing has increased considerably in interest", and there are given some examples of where it is being applied recently, in which remote monitoring and healthcare at home are referred as some of the most common uses of wearables in Medicine.



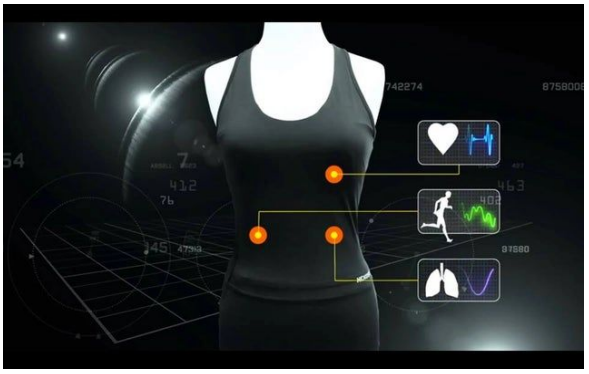


Image. 3 - Electroencephalogram retrieved from www.medicalnewstoday.com

Image. 4 - Smart Clothing retrieved from www.inews.co.uk

Wearable devices that constantly monitor our bodies are becoming smaller and smaller, as discussed in Fang et al. (2013), as well as becoming able to measure more accurately and to communicate with other devices, as said previously. One of the more important milestones, though, that we still have not surpassed yet is that, as for now, these devices "are not suitable for the medical monitoring of high risk patients" as Haghi et al. discuss, whether this is because they are not enough to keep the patient risk-free or because they are not prepared to deal with more complicated diseases.

Yet another area of technology that has been growing in the field of Medicine is robot assistants. These come in various shapes and forms, from chatbots, to Artificial Intelligence that help doctors make diagnosis and even ones that enable long distance surgery, with or without AR or VR on the side of the doctor. In Greene et al. (2019) cover some of the applications of Chatbots and Artificial Intelligence in Medicine. Most of it has to do with data processing, since Artificial Intelligence can process an extreme amount of data in a time-span in which it would be impossible for humans to do so. Therefore, by applying AI to, for instance, Chatbots - but really to any kind of interface that shows the result of a research - the program can process the information about the patients and

their symptoms and give us a quick diagnosis, for instance. These types of programs can be used both by doctors and patients, depending on the situation. However, Greene affirms that “they have even more potential for improving the patient experience.” Overall, one of the greatest pros of using AI is reducing human error. When it comes to AR and VR, Riva and Wiederhold (2015), covers some of the medical uses of, especially, VR at the moment. Riva and Wiederhold, in this article, distinguish two main uses of VR: to represent reality in an interactive way, so that it can be used, for instance, to prepare for surgery or for medical training; and to help with anxieties related to certain medical procedures, for instance distract children while the doctor examines them. In my research, I have also noticed that as of right now, 2019, the use of VR and AR in medical training is increasing (Riva and Wiederhold, 2015), which makes sense, since the doctors-to-be can practice surgery or examinations, without the potential risk of harming a patient.

Weber (2018) creates a table inspired by Schweikard, which focuses on the ethics surrounding the interaction between man and machine. Below we can see this table, containing the types of Robots which Weber describes as “commonly used in Medicine and healthcare” (2018). In the table below, we can look at the examples that Weber gave, as well as their description and use.

Robot Type	Description and Use
Rehabilitation / Prosthetic Robots	Primarily used for victims of stroke, these machines can be assistive (help to carry out lost functioning), or help in training and therapy to restore lost motor skills. Electronic Exoskeletons may substitute for musculoskeletal movement of the human body.
Patient Support Robots	There are a wide range of patient support robots that can aid in decision-making, mobility, companionship and conversation via intelligent personal assistants that adapt to the patient. Subtypes: Personal Care Robots (PCR), Person Carrier (PCaR), Physical Assistant Robots (PAR), and Mobile Servant Robots (MSR).
Surgical Robots	Surgical robots include computer guided laparoscopes sometimes with sophisticated vision and guidance systems as well as human guided devices such as the Da Vinci Robot that scales down human hand motions to precise movements.
Imaging and Navigation Robots	This class of robots serves as adjunct technologies to surgical robots, and can assist in diagnosis and biopsy.
Decision Making Robots (software)	Clinical Decision Support System (CDSS) software assists in clinical diagnosis at point of care and can be integrated with Electronic Health Records (EHR).
Bionic Robots	Bionic robots integrate electronics with biological structures and processes forming hybrid systems.
Automated Pharmacy Robots	These systems measure and dispense medications and can respond to data from the EHR or adaptive learning software and may be integrated with CDSS.

Table 1 - “Taxonomy of Medical Robots” retrieved from *Emerging Medical Ethical Issues in Healthcare and Medical Robotics* (Weber, 2018)

As we can see in the table, we can distinguish a key aspect of these robots is Artificial Intelligence and Machine Learning, present in the table above in “Patient Support Robots”, “Decision Making Robots” and “Automated Pharmacy Robots”. Besides this, we can distinguish those who help the human go beyond his/her capacities, namely “Bionic Robots”, “Surgical Robots”, “Imaging and Navigation Robots” and “Rehabilitation/ Prosthetic Robots.” From this table, we can also conclude that most of these robots focus on helping doctors make more accurate decisions both when it comes to diagnosis and when it comes to treatment.

We have seen before in this section that it is becoming more and more important for the patient to use technology to gain independence in their treatment, for instance with CGMs, which reflects how technology has slowly been integrated in all stages of

Medicine - diagnosis, treatment and maintenance. Presently, a problem that we face is companies not having enough tools or expertise to envision or investigate profoundly ways of using technology to enhance their current systems, which means that most of the times they just stick to what has been done for the last decades as affirmed by Colombo et al. (2018), where it is also argued that it is especially true when it comes to health in general. It is crucial to look at our medical facilities, for this reason, and understand what equipment is obsolete, in order to understand the areas in which we could invest to enhance medical assistance and increase longevity.

Lastly, it is also important to note why the center of this dissertation resides on artifacts, instead of other aspects of Medicine. Xiao (2015) refers to the importance of physical objects in the day-to-day life of medical professionals, including artifacts - even including a chapter on “Artifacts as mediator of collective work”. These objects are especially important, Xiao argues, for teamwork in medical facilities, as everyone is on the same page about what is happening. The author gives the example of the spinning wheel used in restaurants so that the waiters and cooks can have access to the orders at all times, saying that the medical equivalent can be the white magnetics boards that are often found in hospitals. However, artifacts are not only helpful for teamwork, but essential for most steps in medical performance, from diagnosis, to treatment and recovery. Artifacts are the product of the society that built them, reflecting the technology, challenges and beliefs that were at work during the time in which they appeared (Simon and Wiedmer, 2010) . For this reason, it is important to study Medical Artifacts alongside Science Fiction, in order to create a more informed vision of the evolution of medical practice and how it will evolve in the future.

4.3 Prototyping through Science Fiction

As we have seen previously, one of the goals of this research is to develop a framework that will hopefully help the creation of a methodology to support developers of Medical Artifacts using works of Science Fiction to enhance their work. However, we are not the first ones to consider Science fiction to be a good starting point for the development of technology. In this section we will cover some other methods that base themselves in fiction work to have a better understanding of how their artifacts will be received by the public, of how they can have a more adequate design, or simply to imagine a situation in which said artifact would be useful.

According to Brown (2008), Design Thinking is “a methodology that imbues the full spectrum of innovation activities with a human-centered design ethos”, that is, a methodology that puts future users and their culture and habits in the center of the design. The goal of Design Thinking is to understand exactly what “people want and need in their lives and what they like or dislike about the way particular products are made, packaged, marketed, sold, and supported” (Brown, 2008), in order to create more adequately designed products. The author even gives us two examples that are quite relatable to this dissertation, for they took place in a healthcare facility. One of those, for instance, requires surgeons to explain the designers what they needed for a certain tool that was being developed, so “one of the designers grabbed a whiteboard marker, a film canister, and a clothespin and taped them together” (Brown, 2008). Turns out, that is roughly similar to what they needed, and with some adjustments to this “prototype”, per say, they were able to meet the needs of the doctors. In order to better explain the process of Design Thinking (Image. 4), drawn from Brown's article.

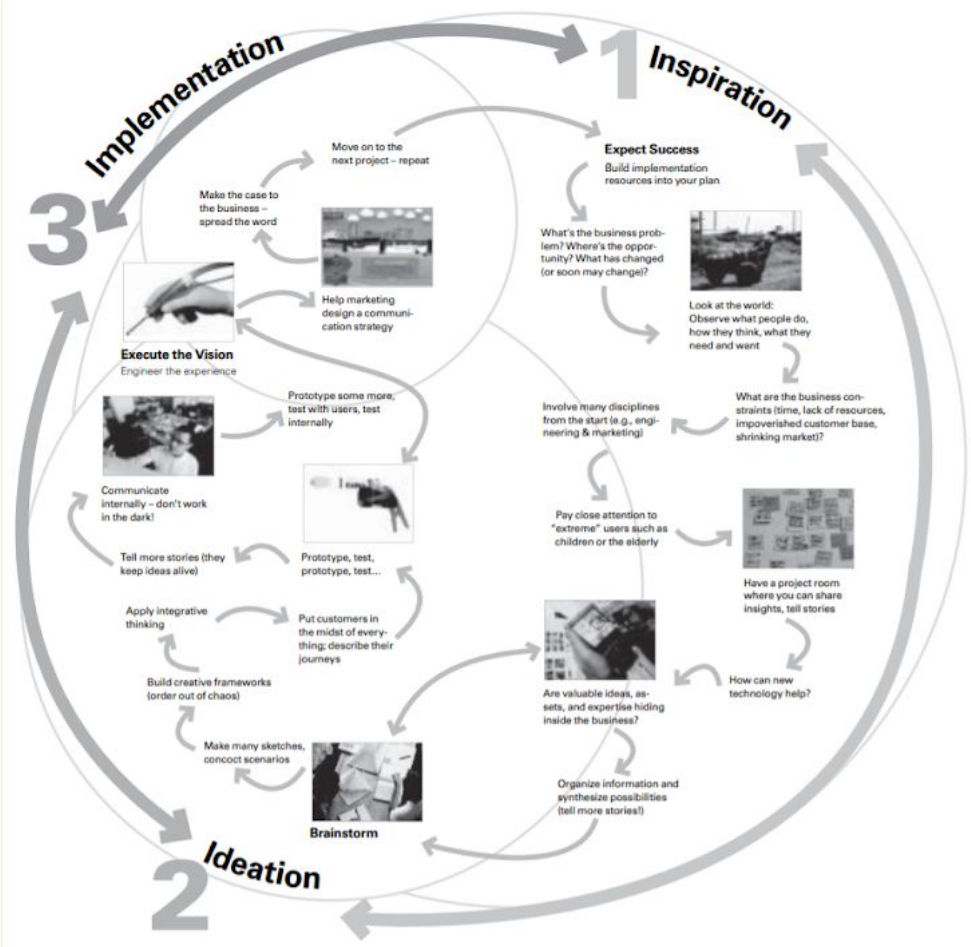


Image. 5 - Design Thinking retrieved from *Design Thinking* (Brown, Tim, 2008)

As we can see in the image, Design Thinking implies a back and forth between the designer's ideas and the necessities of the future users of the product. By doing this, the edges will become smoother and smoother until the product fulfills its goal.

The second methodology to cover is Design Fiction. The term Design Fiction, first coined by the author Sterling (Knutz, 2014), refers to a type of Speculative Design that focuses on the context and utility of a product that might be created on a speculated future. As Lindley (2016) explains, Speculative Design does not focus solely on the "materialization of a future product or object" but focuses on "producing insights about the future possibilities (Lukens & DiSalvo 2011)." Meaning that instead of prototyping for the future of tools and beliefs that we have now, one considers the ones that most likely will be at work in a certain future. This strategy enables the designer to, based on emerging technologies, project into the future an artifact that may not be possible to produce at present time - for example for lack of technological advance - or that might not be of use yet, but may be one day - as in the cases of products that might aid people in potential dystopian futures. This type of design helps us speculate about whether the artifact will (or will not) be necessary, and how it will be developed and the implications of it in the context in which it will be introduced (Lindley, Coulton & Sturdee, 2017). It is crucial to note, as Lindley et al. (2015) mention, that Design Fiction is a method of research (Markussen & Knutz 2013; Grand & Wiedmer 2010), meant to be taken into account before (and sometimes to prevent) any major use of time, money and resources on a physical prototype. Design Fiction according to Colombo et al. (2018) has three main steps, which are represented below in Image. 5: Research, Design and Refinement. The fact that the creation of fictional narratives is used to enhance the process is mainly what distinguishes this strategy from others among Speculative Design.

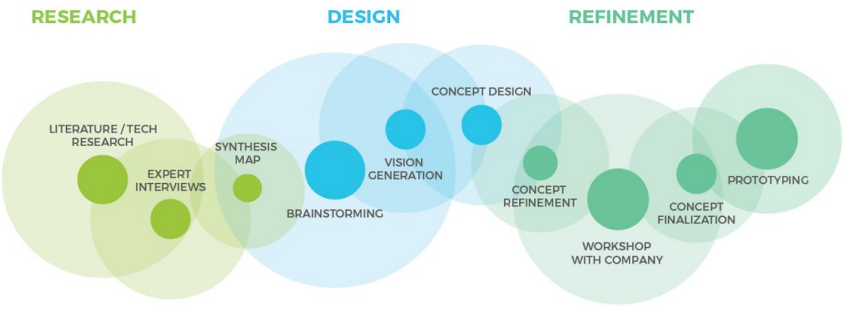


Image. 6 - Methodology in *Augmented Health and Safety: Exploring Future Scenarios through Design Fiction* (Colombo et al., 2018)

Design Fiction focuses on the creation of "what if" scenarios that reflect a possible future in which humanity can project themselves into. These scenarios, often utopian or dystopian, raise questions about future challenges that might be presented to humanity, whether they are technical, ethical or even social, which makes this design strategy useful in various areas. Knutz et al. (2014) gives the example from Auger & Loizeau about an "Audio Tooth Implant." Beside explaining this implant, which would enable people to enhance their bodies by combining them with technology, it is also raised the question of, in the words of Knuz et al., "shrinking mobile technologies" and some of the implications that derive from it. When it comes to the matter of this dissertation we can look to Stephen R. L. Clark (1995), who explains that it would be helpful for us to anticipate what diseases we will have in the future. This way we can start working on a solution before the problem even starts. By taking in consideration possible future wars, natural disasters, virus outbreaks and so on, we could have a base for the creation of Design Fiction stories that might result in prototypes.

Similar to these methodologies, but even closer to the object of our study, is SFP, Science Fiction Prototyping, explained by Potstada and Zybura (2014). The authors highlight the difficulty that is designing for the future when they say "one of the major challenges in engineering research, design and associated fields lies in starting to build today what will be feasible several product cycles in the future" and their methodology aims to help developers overcome some of the obstacles associated with this. In SFP the team working on a determined project will create a small narrative, such as short stories, comics, plays and so on, that puts a set of characters in a certain situation in the future. This way, the team is able to understand "both benefits and pitfalls before they actually occur and can overcome several limitations of quantified trend and future analyses that

rest on data from the past." The Image below shows a representation of what SFP aims to accomplish. We see that we take our creativity to place the technology we are working on in a future context through the means of a short narrative. The first thing they do in the narrative is describing the world as they believe it will be in the time the story takes place, explaining the future context. Then they proceed to present the characters and their relationship to the theme and through that, the story unfolds.

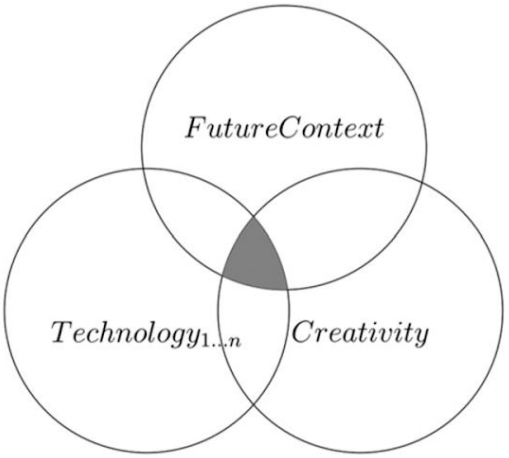


Image. 7 - retrieved from *The Role of Context in Science Fiction Prototyping* (Knutz, et al., 2014)

By creating a whole context in which these characters are placed, it is also possible to explore other aspects of society, such as new business models of the overall interaction between the general public and the technology that is being conceptualized. There are also different types of SFP depending on whether the narrative focuses more on the product and its utility or on the context surrounding it. However, it is always important to note that "the prototype in SFP is not tangible and not an actual product we are building. It is merely an approximation of what we might be able to build" (2014).

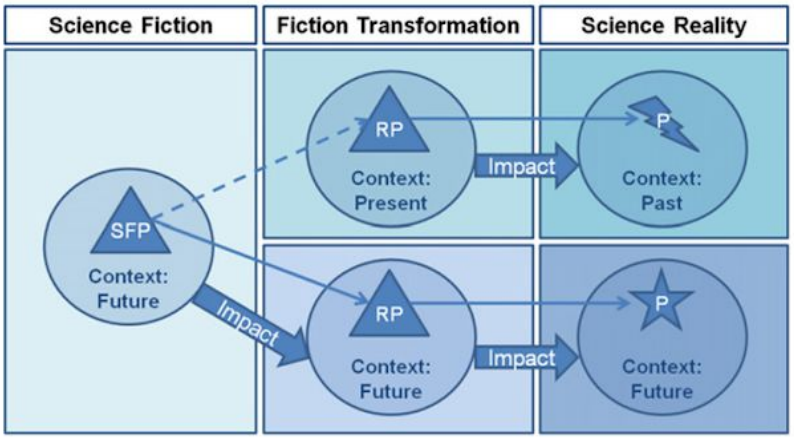


Image. 8 - retrieved from *The Role of Context in Science Fiction Prototyping* (Knutz, et al., 2014)

As we have seen until now, we can conclude that Science Fiction can be an important tool in the development of new technologies or artifacts, including within the areas of health and Medicine. However, it seems to have been underused in these fields, as we can conclude from the lack of work reflecting the use of strategies such as Design Fiction on these areas mentioned in the beginning of this chapter. This may be seen as an obstacle for the creation or idealization of more visionary, future-oriented artifacts that could be both useful and life-saving in the future. This relates to the intent of this dissertation (**goal b)**), to develop a framework for teams working on developing artifacts for medical use to make more informed decisions, based on what is portrayed in Science Fiction. This will hopefully guide them in the process from Science Fiction to reality when creating a Medical Artifact, taking advantage of the genre to make more informed decisions along the way. As we will see further on, we have leaned more towards Design Fiction, which was the chosen method for the framework developed.

4.4 Overview of the Work Presented in this Chapter

In this chapter we looked at three main themes: what has been studied regarding the influence of Science Fiction on the real world, especially when it comes to Medicine; the State of the Art of Medical Artifacts and its resemblance or possible relationship to Science Fiction; and the methods that are already in place to use this genre as a tool to build artifacts. We learned that we can never affirm with certainty that a given object or technologie comes from Science Fiction without actually asking their inventor, although the research indicates that there seem to be similarities between real and fictional

artifacts - even if it was a coincidence - indicating that, as a society, we all have similar ideas and expectations about the future. We also realised that there is not a lot of research done when it comes to Science Fiction and Medicine, however, the whole overview of Medicine today, with extremely advanced prosthetics, IoT devices and smart clothing that tells us everything from our heartbeat to the calories we have burnt, all looks a lot like a Science Fiction scenario. Lastly, we became acquainted with two main design methods that directly use Science Fiction: Design Fiction and Science Fiction Prototyping. Design Fiction creates “what if”, plausible future scenarios in which a developing artifact is placed in order to identify errors, understand the dynamics of use and try to predict the interaction people will have with it. Science Fiction Prototyping is more specific to using Science Fiction narratives, as well as their characters or worldbuilding to test the artifacts, many times recurring to already existing ones.

5. Methodology

The first part of this work consists of theoretical research, focused on the state of the art and contextualization of the areas studied. This research is mainly done online, with resources such as Google Scholar, Pocket articles, books from the library of University of Aveiro (Universidade de Aveiro) and articles which were sent or indicated to me by the dissertation committee. Within the latter, there was a PhD thesis, concluded the year prior to this dissertation, on the topic of Science Fiction in Computer Science Research entitled A Meta-study and Content Analysis of Science Fiction in Computer Science Research (Jordan, 2019). This was then considered a key resource and starting point for this dissertation. The results of this review help to understand the influence that Science Fiction has in different areas, and what has been done in terms of technology in the field of Medicine throughout the years. Ultimately, it allows the understanding of what will be possible to accomplish in the next few years, especially if we combine all of these elements: Medicine, technology and the influence that Science Fiction can have on them. In this part of the research the articles derive from three main areas: influence of Science Fiction in science and technology, what is being done in terms of Medical Artifacts and influence of Science Fiction on Medicine.

After grasping the context, the next step is to do a more practical research, with the intent of understanding some of the perspectives that health professionals have in regards to the future of medical technology, more specifically, Medical Artifacts. This is

divided into two different steps, which results are then compared and merged, enabling the formulation of a framework to help developers of Medical Artifacts take advantage of the genre.

5.1 Philipp Jordan's Articles

Jordan's PhD thesis analysed 284 articles that mentioned Science Fiction texts, films or authors and divided them in different categories. Jordan analysed a database with more than two thousand articles containing the words "science fiction" from IEEE Xplore Digital Library, which he refined in order to meet his criteria. Taking stock from Jordan's work, we analysed a subset of the articles analysed by Jordan, i.e.: those which focused on health. These articles fitted the topic of investigation of this dissertation and will be thoroughly analysed, as a means to understand how Science Fiction as a genre has influenced Medicine in general, though highlighting the ones mentioning the development of artifacts. In the first instance of my analysis of Jordan's work, there is the analysis of the selected documents, chosen by the concept to which they are associated. From the table of concepts of this dissertation, these were considered:

Concept	**References**
Asimov's Three Laws of Robotics	7
Brain–computer Interfaces	7
Humanoid Robots	5
Artificial Life	3
Exoskeletons	3
Nanotechnology	3
Biometrics	2
Brain-machine Interface	2
Cyborgs	2
Exoskeleton	2
Medical Tricorder	2
Tiny Surgical Robots	2
Viruses and Worms	2

Advanced Nanotechnology	1
Anthropomorphic Robots	1
Biomedical Instruments	1
Brain Implants	1
Brain–Neural Machine Interfaces	1
Cultured Cells	1
Cyborgs / Wearable Computing	1
Gesture-based Human Computer Interface	1
Human Augmentation	1
Human Enhancement Engineering	1
Implantable Medical Devices	1
In-vitro fertilization and Pre-implantation	1
Medical Nanotechnology	1
Microbots	1
Neural Interfaces	1
Neurocontrollers	1
Wearable Devices	1
Wireless Capsule Endoscopy	1

Table 2 - concepts to analyze. Adapted from *A Meta-study and Content Analysis of Science Fiction in Computer Science Research* (2019)

The first thing to do after reading these articles is to understand if the Science Fiction mentioned in them qualifies as Science Fiction Literature or is related to it (for instance a film that is based on a book), since these articles might also talk about other forms of media, as well as if they speak about Medicine in the cases in which it is not clear from the name of the category. This brings down the number of documents from 31 to 21, which can be consulted in annex 1. Next, the focus will be on the ones left, which will be analysed, looking for common aspects regarding the relationship between Science Fiction and the development of the artifact that it is written about. The goal of this

analysis is to understand how Science Fiction has influenced the development of Medical Artifacts, although not all articles analysed will be specifically about “Artifacts” because of its difficult definition, discussed in **Concepts and Context**. After having a more concrete idea of this relationship in the past, comes the structure of the interviews, in order to understand the opinions of medical professionals about how it will affect future developments.

To analyse these documents we performed a thematic analysis, where each piece of relevant information was included under five main themes. The first theme is the **General Topic of the Article**. We want to understand the areas, within health and medicine, that are more commonly spoken about alongside Science Fiction or related topics. Then, we have **Future Used for Technology**, which tells us the expectation of experts in health and medicine regarding the areas they think we should be focusing on when projecting future technologies. The next theme, **Future Perspectives on Technology** is even more specific, as it tells us what technologies, artifacts or even softwares the experts expect to be available in the future. Then, we will look for **Reference to Science Fiction**, in order to understand if this genre was in any way relevant for the research or technological development disclosed in each article. Finally, we need to pay attention to any information that might help us structure both **the Interviews and the Framework**, as whether they are comments or examples of similar procedures that we can apply to our methodology in order to improve it.

5.2 Interviews

According to Liew et al. (2013), when in a less formal setting, people tend to feel more free to speak about their expectation, since it is less probable that they will be held accountable or even accused of lying if some of those happened to not be verified. Since we are asking the participant to imagine what they believe about the future, it makes sense to use a method of gathering information that is open, leaving space for them to wonder without being restrained or influenced by the limitations such as multiple questions on an inquiry or direct, closed question on a survey. The interview (**Annex 3**) is composed of 16 open questions that might have been replaced by slightly modified ones, depending on the way the conversation happened. Each session was supposed to have between 30 and 45 minutes, which might get expanded if the interviewee has extra information to share. Besides, when talking about the future, there are not many possible answers to choose from: it is a blank page that only time will enable us to write on. For

that reason, by using the method of interview, we are drafting possible futures, with no influences, commitments or prejudices. It is also worth mentioning that I changed some of the terms used in this document, for they are too complex and would be a barrier to the efficiency of the interview. Those terms were “artifact”, that was mainly replaced by “technology” or “instrument”, as they are broader terms; and “framework”, which besides being a new, complex term, does not have an accurate translation to portuguese, and was therefore switched to “guide” (guia).

The sample is composed of six participants organized in two groups: **group A** is composed of three interns of Internal Medicine and **group B** is composed of three more experienced doctors, already working in areas dealing with urgent cases, intensive care or other types of situations in which one might act rapidly and efficiently. These were the chosen practices because these professionals are used to confronting not only quite challenging medical cases, but also ones that are related to various fields. For that reason, they might be more prepared to give us a broader perspective on the current state and future perspectives of technology in Medicine, since they come into contact with different areas. It is also interesting to us hearing the opinion of people who deal with urgent cases that need to be fixed rapidly, since most current uses of technology in Medicine are focused on long-time treatment/assistance of programmed surgery, which leaves a lot of room for improvement in the field of emergencies.

In order to make our search for the participants more concise and less time-consuming, it was decided that the center of the interview would be the University of Coimbra (UC). This is one of the most prestigious universities in Portugal, however, it is also the oldest, and therefore holds a more traditional education. These two factors helped pick this university as the center of our investigation, which will include people that study, have studied or are somehow connected to medical education in UC. By going to one of the most traditional universities, we hope that our participants will not be influenced by the optimism that is sometimes associated with more future-oriented universities’ view on the future of technology - for this optimism can deceive us into believing that some technologies will be available sooner, more useful or well-received by the public that what will actually happen, for instance. Another reason to choose UC is for convenience. Not only is it one of the closest universities to Aveiro offering Medicine as a university course (as of 2020), but it is a place where the research team has some acquaintances in the area of Medicine and biomedical investigation, which is important when reaching busy people such as medical doctors or interns. By having only one or

two degrees of separation between these people, the process of reaching, and therefore interviewing them, is a lot simpler and less time-consuming. Although all of the people interviewed had some connection to University of Coimbra, only two of them are working in that city at the moment. Of the other four, two are based in Figueira da Foz - where they were interviewed, and the other two in Chaves - being that one of them was interviewed in Oporto and the other via video call.

The questions will be the same for both groups mentioned previously, however, they can give us different information. **Group A**, with less than 10 years of experience, includes people who are not working fully independently yet. They can tell us the artifacts they are ready to operate and if they are (or are not) obsolete. Their views about what they think or would like to be able to use in the future is also crucial. **Group B**, having a greater experience, can help us understand how the artifacts used by doctors have evolved through the decades and, through that lense, see how they expect them to continue their evolution. They can also tell us the drawbacks of the technology we use at the moment, the challenges that come with it and which of them we might be able to solve or improve in the future, with the help of technology. Furthermore, they will help to understand if medical professionals are ready to handle, that is, work with future technologies that might cross their paths in the future.

5.3 Devising a Framework

In this stage of the dissertation all the information gathered on the previous steps will be used to conceptualize a framework, that will perhaps lead to the creation of a methodology to help developers of Medical Artifacts take advantage of Science Fiction to enhance their work. This methodology will be inspired from techniques such as Design Fiction and Science Fiction Prototyping, in the sense that it will maintain certain core aspects of these types of Speculative Design, namely:

- Creating a narrative for the use of the artifact we aim to create;
- Take into consideration the technologies most likely to be ready to use in the next few years, therefore creating a possible future scenario;
- Using fictional characters to try to predict how the public will react to the artifact, once it is ready for use.

It will also have some aspects that will not come from Speculative Design, but from what will have been previously concluded about the relationship between Science Fiction and Medical Artifact development, as well as looking at this genre for inspiration.

5.3.1 Why a Framework

Although the central idea of this study was to understand the influence of the literature of Science Fiction on the development of Medical Artifacts, it would be good to consider adding a more practical element. As this is a master's thesis, this could not be something more elaborate, like a methodology, only some guides to help developers apply the knowledge acquired during this study. Ultimately it was agreed that the best option was to devise a framework, as simple as possible whilst being useful, that could lay the base for future work, if someone was to build, for instance, a methodology from it.

We have to bear in mind, especially when it comes to drawing concepts from Science Fiction, that what is portrayed in these imaginary worlds may not always correspond to reality. Omar et al. (2016) warn us about this, since we cannot accurately predict the reactions people will have, nor the usage they will attribute to the artifacts we create. However, by using a strategy of Speculative Design, such as Design Fiction, we can predict more accurately these phenomena. As we have seen previously, Science Fiction can help us understand not only what kind of technology people expect to see in the future, but also have an idea of how they would react to those technologies entering our daily lives, as well as the social, ethical or ideological issues that may come with them. Some of the advantages of having a framework (and perhaps, in the future, a methodology) that would help teams developing Medical Artifacts use Science Fiction to their advantage would be the following:

- Build an understanding of how the public would react to what was being created, through Design Fiction;
- The possibility of understanding the situations in which the artifact would be, or would not be, of use, also using Design Fiction;
- Looking to the works of visionaries for inspiration, as well as having in consideration the expectations of the public;
- Letting go of prejudices related to the future of science by looking beyond the scientific dogmas of present time;
- The above mentioned can reduce time and costs related to idealizing and testing the product;
- Creating room for new business models and projects that look towards the future.

Although it was mentioned before SFP as a design method more directly related to the use of Science Fiction instead of other genres, it was decided not to follow it strictly in this framework. This is mainly because this methodology is already quite steady by itself, but also because it is very much focused on prototyping, whereas it is also intended to focus in other stages and aspects of design, namely research. The difference between SFP and Design Fiction lies in the fact that the first is predominantly a prototyping method, and the second is a research method. Moreover, Design Fiction does not only concern Science Fiction: it is a broader term that refers to fictional scenarios, whether they represent more immediate futures, or they are looking further down the line. Science Fiction Prototyping, on the other hand, tends to look into more distant future scenarios. We believe that by looking at a wider angle - that is, to Design Fiction, a more flexible method - we will not be so hooked on an already existing methodology such as SFP, being able to bring different contributions to the table. That said, it will undoubtedly have an influence on this work.

There are also some disadvantages worth mentioning of using this kind of framework:

- Although we might think we are designing for a certain time in the future, the technologies needed might still not be ready;
- The time used to create a narrative might not be worth it in the end;
- It can be difficult to pinpoint what challenges will be the same in the future, which may not exist anymore, and those who may unfold meanwhile.

All in all, it will depend on the goals of the teams that decide to use a framework like this. For now, the focus in on realising if the medical professionals agree that it will be adding to the field, realize where Science Fiction has already helped the development of Medical Artifacts and how, and create a framework so that, in the future, we can indeed make the most of this genre to support developments in Medicine.

6. Study and Results

In this chapter we look at the study carried out, starting with the analysis of Jordan's research, followed by its results. Then, we describe the structure and sample of the interviews and present the results.

6.1 Analysis of Jordan's Research

As previously mentioned, when analysing the articles Jordan included in his research, which after sorting when brought down to 21 articles (see annex 1) considered relevant for my topic of research, they were taken into consideration regarding the following categories:

- General topic of the article,
- Future uses for technology,
- Future perspectives on technology,
- References to Science Fiction.

Besides these, paying attention to some other comments and observations made on the documents might help write interviews, in order to improve some details of the framework later on, as well as some general notes that did not fit into any of the mentioned categories.

The goal of reading these documents is to get a better understanding of the questions that should be sought to answer with the interviews, so that then the data can be crossed. The questions were elaborated taking into consideration the notes in each of those categories, therefore being based on the perspectives, fears and expectations of those working in the field of medical technology in the last 10 years, and that have also somehow included Science Fiction in their work. Through this analysis, it will be possible to conduct the open interview, so that their answers can help to devise the framework.

6.1.1 Results of the Analysis

6.1.1.1 Future Uses for Technology

Most of the technologies that were mentioned in the documents from Jordan's research have to do with overcoming disability or other kinds of body enhancement, such as implants. There is also a great part concerning devices for monitorization of different types of vital signs, as well as advances in the field of surgery, especially in order to make them as non-invasive as possible.

6.1.1.2 Future Perspectives on Technology

Three main tendencies emerged when it comes to future expectations seen in Jordan's research, those being monitorization, treatment and mainstream consumption. Monitorization ends up making a lot of sense, since we live in an aging society and it

becomes more important to pay attention to slight differences on vital signs and other indicators that something might be wrong. Then, we have treatment, which is connected to other common tendencies, like surgery and disability. At last, we have the goal of mainstream consumption, that is, creating Medical Artifacts that patients will manage to use individually.

6.1.1.3 References to Science Fiction

Science Fiction has always been known as a genre where new ideas were born and spread, and we cannot deny that it has influenced some aspects of our lives, as we have seen previously. Lexicons we use today regarding technology, for instance, have their origins in works of science fiction: words like cyberspace (coined W. Gibson), robot (by Karel Capek), and robotics (by Isaac Asimov). Nonetheless, there are still concerns about Science Fiction nowadays,we should be careful of how we look at it. However, we could use it to look more positively into the future. In Science Fiction we can test plausible future scenarios and environments, hypothetically, anticipating the dangers, fears and problems adjacent to them, even before they become real. We often see in Science Fiction a depiction of the worst or the most extreme scenario, which may help us prepare for less extreme versions of it, once or if they come to pass. According to Mills and Fleddermann (2005) "The early stages of a technology life-cycle are driven by the dreamers and the visionaries who, of necessity, focus on the gleaming possibilities, to the exclusion of the drawbacks". Despite this, there are some prejudices that prevail regarding taking Science Fiction as an inspiration for technological development. People like Jonathan D. Moreno, author of "Mind Wars: Brain Research and National Defence" (2012), have been criticized for drawing inspiration, for instance, from the show *Star Wars* (Lucas, 1977), according to Wigan (2017). Notwithstanding, some of what we thought Science Fiction was a fews years ago is now a reality, which says something about how the genre can unwind new, innovative ways of thinking. Some of these are programmable calculators, described by Isaac Asimov about two decades before it appeared (Vos Post and Kroeker, 2000); prosthetics, often portrayed in shows like *Star Wars* (Lucas, 1977); and even genetic manipulation, which is now performed in some areas (Issues in Ethics the ethics of creating designer children, Fielder, 2003). There is even a link between Science Fiction Films and the development of biomedical instruments, according to Boutillette et al. (2015). Even the perspective on artificial enhancement is changed: people are more willing to try new procedures, especially if the alterations are not

noticeable at first sight. The influence of Science Fiction on the public is more pronounced than in the scientific community, especially when it comes to fears about the future. The majority of the people get their health and Medicine information on mainstream media, as Monteiro et al. (2013) claim by revealing that “The majority of the interviewees [made by Monteiro in his study] claim to know about it, but it seems that the knowledge is superficial and based on broad science diffusion media.” Thus creating a relation between media and entertainment and the public’s opinion and expectations about what is to come in terms of technological development, among other areas. According to Getting the Best from Nanotechnology: Approaching social and ethical implications openly and proactively (Mills and Fleddermann, 2005), people nowadays are less accepting of scientific mistakes than they have been in the last few decades. Could this be because of the futuristic technological advances appearing in our screens? "Perhaps science fiction isn't all that different from plain old product proposals and the spec sheets that chart the effects of a new technology on our lives" (Vos Post and Kirk L., 2000), we just need to know how to take advantage of them.

6.1.1.4 Interviews and Framework

As mentioned before, one of the intents of analysis of these documents is to have an overview of Medical Artifacts today, in order to make more informed decisions both when preparing the interviews and when devising the framework. The main goal of this framework is to perfect the conceptualization of the prototype, before building it, which lays mostly on predicting errors and flaws beforehand. For that reason, and as we have seen mentioned in the analysed documents, it is crucial for us to understand who will use the artifact - from their role in society to their education, skills and access to technology; where it will be used - is it an underdeveloped country? Is it a village with low accessibility? Are there different laws or even prejudices worth taking into account?; why will it be helpful to introduce this technology there - understand if this artifact is really necessary and how/if it will positively influence life in general; and when it will be possible to accomplish this, given the technology that is emerging today. It is also essential to incorporate in the team people of all the areas that have to do with the product, including medical professionals, patients, and above all experts on Medical Ethics (as we will discuss further later on in this dissertation.

6.2 Interviews

First of all, it is important to understand the people interviewed. As explained before, there were two groups, in which **Group A** was composed of three interns of Internal Medicine with one to two years of experience. **Group B** is composed of three doctors that are currently working in areas of quick-action, namely Intensive Medicine and Anesthesiology. One of them is also, at the moment, occupying an administrative position. We have spoken with doctors working in four different hospitals: Chaves, Figueira da Foz, Gaia and Hospital Universitário de Coimbra. The following table describes the six participants in this study.

Interview number	Gender	Group	Years of Experience
1	F	A	1
5	F	A	1
6	F	A	2
3	F	B	9
4	M	B	39
2	M	B	30

Table 3 - description of the interviewees

In order to facilitate the comparison between the articles from Jordan's Research (2019) and the interviews, these were structures following the same four topics used to analyse the documents:

- General topic of the article,
- Future uses for technology,
- Future perspectives on technology,
- References to Science Fiction.

The 16 questions made in the interview (**Annex 6**) will be listed below, followed by a summary of the answers obtained.

Warm Up Question: What are your usual professional daily activities?

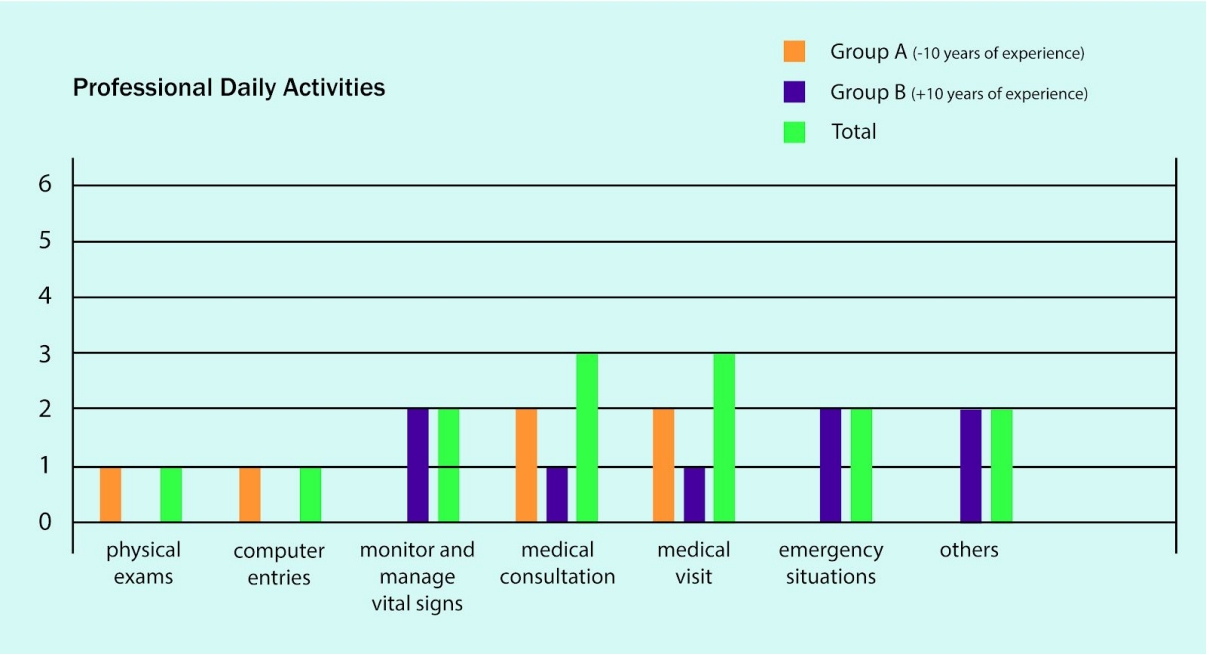


Image. 9 - Professional Daily Activities

In the image above (Image. 9) we can see that interns have mentioned not only less tasks, but also more low-risk ones, such as performing physical exams, writing computer entries about their patients, as well as consultations and visiting the patients that are hospitalized. These last two were also mentioned by the more experienced group, although more high-risk tasks appeared in more interviews, such as monitoring and managing the patient's vital signs and acting in emergency situations. On the "others" field, there are tasks related to the administrative position that one of the interviewee is occupying right now, as well as the discussion with specialists about difficult cases.

a) The Context of Technology Today

Q.1 What technologies do you usually use in your professional quotidian?

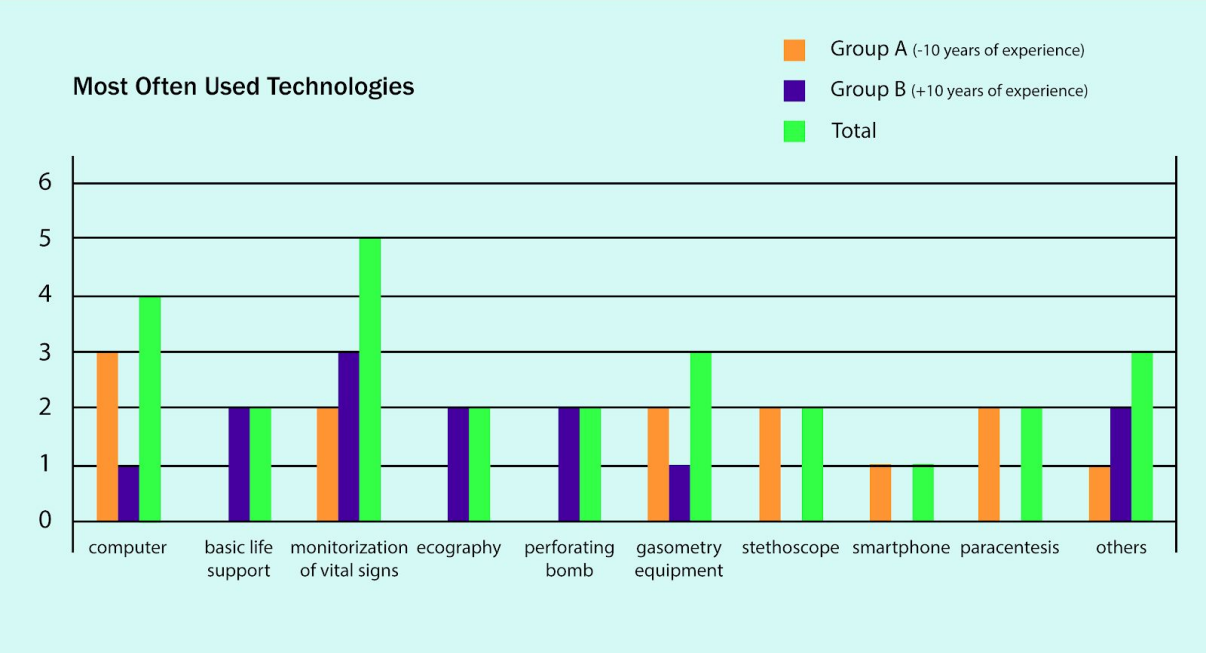


Image. 10 - Technologies most often used by the participants

We can see in the image that the technologies that were mentioned by the two groups seem to be in agreement to the tasks they affirm they perform on their daily professional lives: **group A** mentioned technologies such as the computer, where they do their entries, the stethoscope, paracentesis, gasometry and monitorization of vital signs, as well as the smartphone, where they might use apps to facilitate their work, such as *Calculate* and *UpToDate* (mentioned in interview nr. 5, group A). As for the **group B**, we can see similarities, such as in the computer, monitorization devices and gasometry equipment, alongside some other ones such as basic life support machines, ecography - which more than one intern referred not being able to use yet - and perforating bombs.

Q.2 Do you feel comfortable using these technologies?

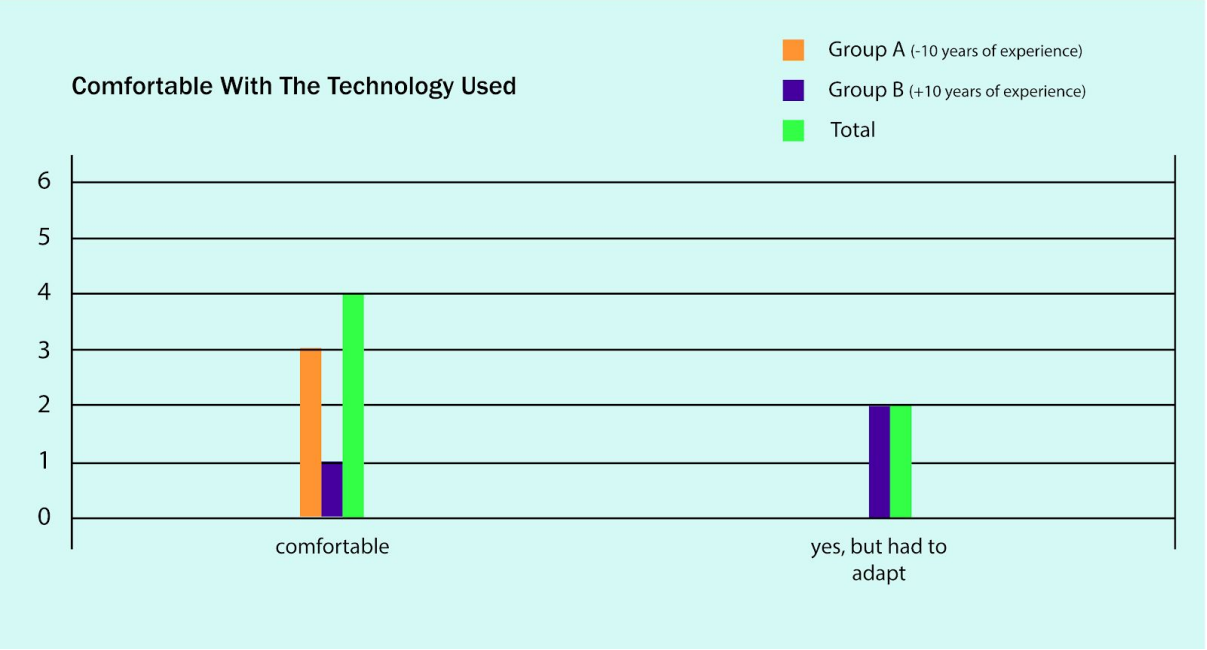


Image. 11 - Level of comfort of the participants when using the technology available at the moment

Although none of the interviewee claimed to be uncomfortable handling the technology that they have at their disposal, two participants on **group B** highlighted the fact that they had (and have) to adapt to technologies that did not exist when they were studying. One of them says “A lot of the technology that exists today, did not exist when I was completing my training in this area”[1]. The elements of **group A** all affirmed that they were comfortable with the technology they come into contact with, although of them commented that some technology act as obstacles for her job “for me it is a barrier, for instance, a printer that does not print a hospital discharge report or the labels don't come out”[2].

Q.3 What technologies from your quotidian do you consider crucial to perform your job? Why?

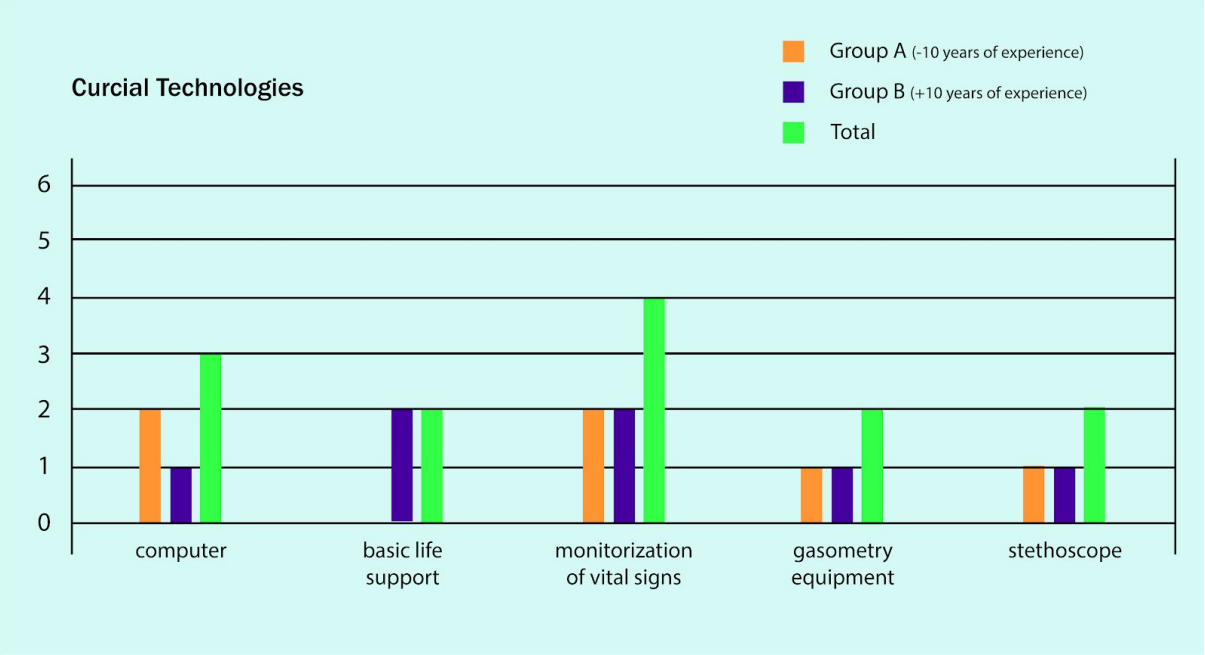


Image. 12 - Crucial technologies to perform their work, according to the participants

The goal of this question was to understand what, according to them, was the least they needed to accomplish their tasks. Both individuals from **group A** who mentioned the computer considered that having access to the patient's information, mainly their medical precedents, was the most essential as they can access information such as "emergency episodes (...) consultation (...)[3] the doctors that follow them, that have seen them," among others. The most referred technology overall was the monitorization of the vital signs - 2 individuals from each group talked about it. Gasometry equipment and the stethoscope were mentioned equally within the two groups (1 mention each) and we also have, once again, the basic life support mentioned only by participants from **group B**.

Q.3.1 Have you ever thought about alteration that you could do to these technologies?

Although there was a relatively wide range of responses to this question, we can identify some similarities between the participants. In **group A**, two of the most common issues mentioned were related to the computer information systems used in hospital's computers and to the hardware of some machines. When it comes to the computer information systems, it was referred that they were that "Often the [computer] program is too slow, what delays, for instance, consultation (...) we cannot proceed with the appointment, everything is stuck,"[4] until the program starts again; participant nr. 6 also mentioned that "it would be necessary to create a [computer] system that didn't fail so often"[5]. In **group B,** when it comes to the hardware of some devices used in the hospital, there was a general consensus when it comes to its size and portability, as we can see by comments such as "One problem of our devices is still often its size"[6]; "if the readers would be more portable and didn't need so many cables, as the cables make space management more difficult"[7] Besides these, the participant nr. 3 also considered that it would be useful "that they would given yet more information (...) more information in the least number of devices possible"[8], "the possibility of the same devices being compatible in all the patient's circuit (...) this is a problem related to equipment purchase and uniformization"[9], along with wireless equipment, something that is also mentioned by participant nr. 2 in other parts of the interview. Two of the participants, one of each group, could not point out any alterations they would like to see implemented.

b) Future Technology

Q.1 Do you think that there is space for you, as a medical professional, to suggest those alterations?

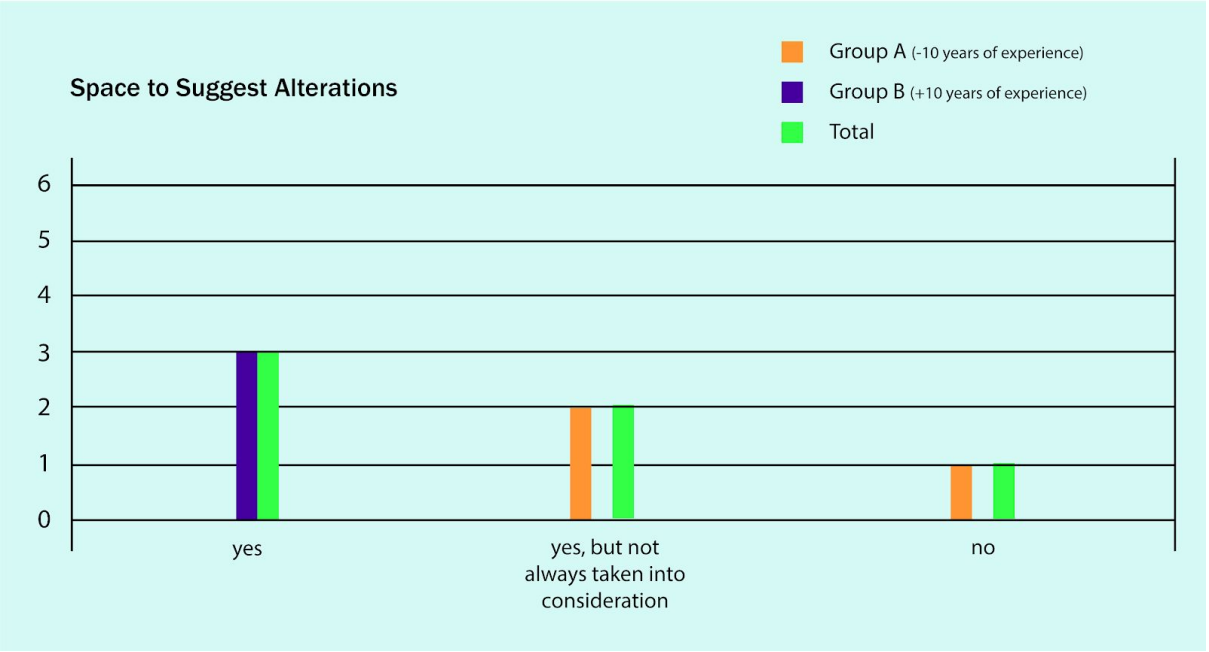


Image. 13 - Participants opinions regarding the space they have to suggest alterations in their workspace

In the answer to this question we have a clear contrast between the two groups. In **group B**, the participants all considered that they have a space within the medical community to give their opinion regarding changes they think could be made. Some of them even commented that companies developing medical technology are the ones making the effort to involve them in the process and ask for their opinion ("they are always looking for that (...) they often have a medical team"[10]). However, in a different part of the interview, participant nr. 3 commented "we could be much more consulted to understand if what is being developed makes sense for the patients' day-to-day"[11] In **group A**, the participants are less confident about this matter, saying that they can give an opinion, but it probably would not be taken seriously or even taken into consideration "We have space now… if they are going to do something about that… I am not sure"[12]. One of the interviewees even claims that she does not feel that they have space to opine. One of the participants from this group also considered that "despite there being a will to change

the system, people end up accomodating to it”[13] which makes people more reluctant to criticise it.

Q.2 What are some technologies you think would facilitate your work but do not exist at the moment?

Belonging to **group A**, interviewee nr. 5 mentioned that a “a national system (...) that has all the patient’s information"[14] would be very helpful to understand the patient's background, as well as more access to teleMedicine to both patients living in remote locations and to speak with specialists that the hospital does not have. Whereas participant nr. 6 suggested a machine to “scan the person and tell you what organs are failing (...) or are being affected”, as well as one that “intubated the patient independently”[15]. There was once again an interviewee that did not mention any technologies. In this instance it was the participant nr. 2, **group B**, that referred wireless equipment, claiming “the more, the marrier”[16], while participant nr. 3 mentioned “an iPad for each patient” with “all the necessary clinical information, their history, records…”[17], “technology associated to training and education”[18], as well as more efficient methods of sterilization for both the rooms (“if there was a shower or pulverizer, on the ceiling, on the walls, on the floor, that enabled a more speed and efficiency”)[19] and the transportation of the patient between them (“disinfection of the materials and the transportation to and from the operating room”[18]). Participant nr. 4 referred the necessity to create a national-level computer information system that could be compatible among all health units in Portugal: “there should be the possibility for the various computer information systems that exist (...) to be compatible, in order to know the whole information of each patient”[20], giving the suggestion of the creation of a “card” with all the patient’s information, including exam results; participant nr. 4 mentioned that it would be useful if an AI system could “ give information and give suggestions to the actual doctor (...) artificial intelligence is the future (...) and can be very important on the helping doctors”[21].

Q.3 From the technologies that you mentioned, do you think they could appear in the near future?

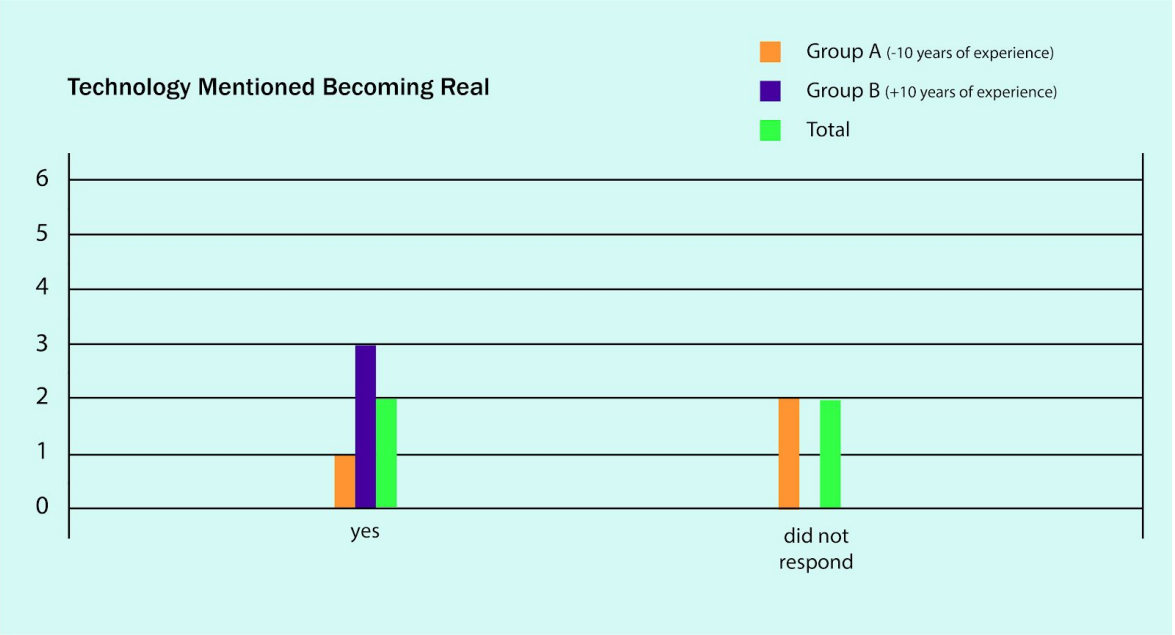


Image. 14 - Possibility of the technologies mentioned in the interview becoming a reality according to the participants

As we can see in above (Image. 14), two elements from **group A** could not or chose not to answer this question. The rest of the participants considered that the technologies that were mentioned in their interview (at this point) could appear in the near future. These technologies, however, were particular for each interview, although some were coincidental, as we have seen in question **2**.

4 I will now mention some emerging technologies that are somehow related to your profession, I would like for you to comment on those who capture your attention:

Group A commented the following technologies:

- **Instant Diagnosis**

Participant nr. 5 commented that she thinks “that is interesting, however (...) always with the interpretation of a doctor”[22], while one interview nr. 6 it was mentioned that it could

"eliminate human error" and that "besides being great because you'd save a lot of money in health, it is more objective"[23].

- **Brain Implants and Touchless Control Systems**

Participant nr. 5 commented saying she thinks that there will be some "difficulty implementing those [technologies]"[24], adding that she believes that "at the moment, with the doctor you have (...) it will be difficult". Interviewee nr. 6 considered that it would be good for younger people, like a friend of hers, that lose some kind ability, commenting that brain implants can be a facilitator for these young people to adjust to their new reality.

- **Medical Micro-robots**

Participant nr. 1 talks about the daVinci robot, with which she came into contact with during an Erasmus program. She adds "They used that robot a lot in Italy (...) I didn't even know such a thing existed before"[25]. Participant nr. 6 also commented, saying that it would be useful for localized oncologic treatment.

Group B made the following comments:

- **Instant Diagnosis**

Interviewee nr. 3 referred that doctors "will never be totally replaced by a machine" but that it "would be a great help"[26].

- **Constant Monitorization Devices**

Participant nr. 3 commented that there could be "even a call to an alarm system to the doctor or nurse (...) instead of waiting for somebody to find them unconscious hours later", and spoke about a cane for people with Parkinson disease that "detects the difficulty and emites and song that helps them" walk"[27]. In interview nr. 4 this artifact was also commented, mentioning "Shirts that, basically, have sensors in which the athletes (...) control their heartbeat, etc."[27].

- **Automatic Systems for Biological Regularization**

Participant nr. 4 considered these an "almost certain future"[28].

- **Medical Micro-robots**

Interviewee nr. 4 affirmed that "this is also the future (...) they are more precise that the Man's hand"[29].

c) Science Fiction

Q.1 Are you aware of any link between an artifact that you use daily in your professional life that was based on a concept from Science Fiction? After the response, if it is negative - I would like to give you the example of Mary Shelley's *Frankenstein*, which speaks of the use of electricity to awaken a "human body", a few decades before the first defibrillator was produced.

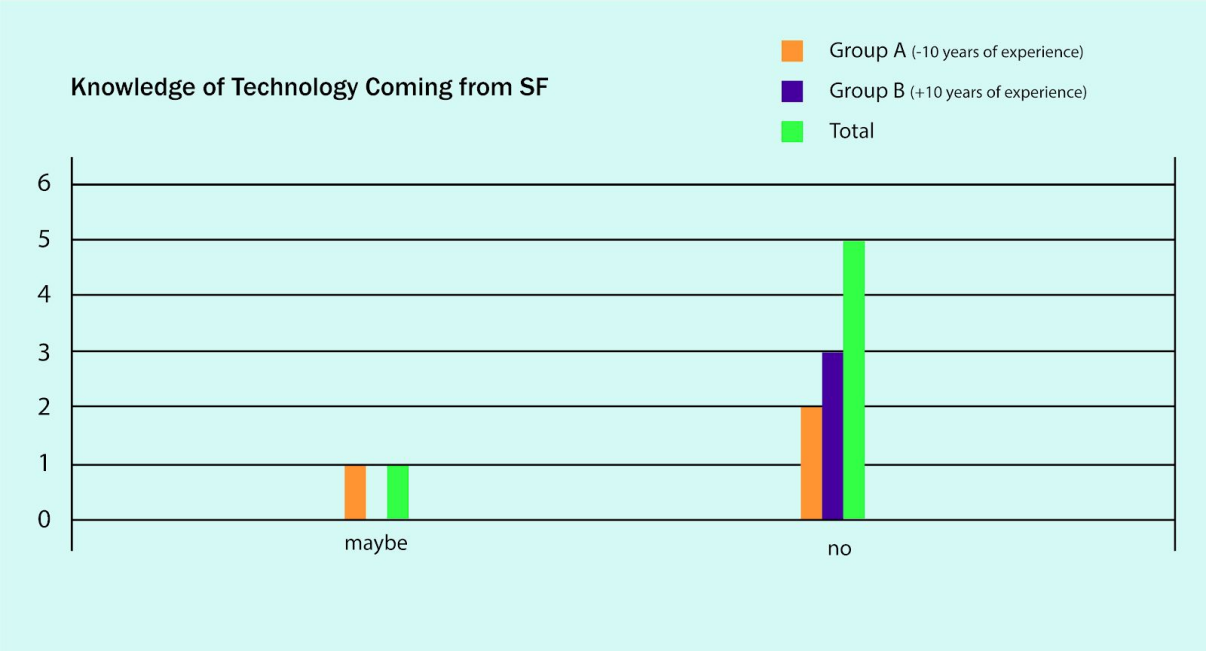


Image. 15 - Knowledge the participants have of technologies they used which have come from Science Fiction

With the exception of one of the interviewees from **group A**, everyone affirmed not to have knowledge of any Medical Artifact having been drawn out of Science Fiction, and even this participant only commented that some devices sound a bit "extraterrestrial"[30].

Q.2 Many of the referred artifacts seem to have been somehow influenced by Science Fiction. What are your thoughts on the use of Science Fiction as a source of inspiration for the development of Medical Artifacts?

When it comes to **group A**, Interviewee nr. 1 was of the opinion that Science Fiction is "a good source of inspiration"[31] and that it could be used to create more useful devices that facilitate tasks. Participant nr. 5 considered that it is worth trying ways of making the

work of medical professionals more efficient. Lastly, in the interview nr. 6 it was commented that it could be a way to run from the dogmas that are normally associated with Medicine ("creativity and imagination are needed to contradict [pre-established ideals]"[32]).

In **group B**, interview nr. 2, the participant commented that although they think Science Fiction is not created with the intention of innovation, that "Often people's imagination ends up being similar. That is, the doctor and the writer will perhaps envision similar futures and want to resolve the same issues"[33]. He also claimed that even though there is a clear difference between Science Fiction and reality, it can be a way for teams to get inspired. The interviewee nr. 3 reckoned that humbleness and creativity were key to make this transposition from Science Fiction to reality and highlights the importance of having a multidisciplinary team. On interview nr. 4, it is said that "Science Fiction is anticipating. That means that it is thinking about things that we would like to happen or that it would be important, but that are inaccessible at the moment"[34].

d) Framework

Q.1 Design Fiction is a branch of speculative design that uses the creation of stories, in various formats, to test the introduction of a product in a certain context. This can be useful to predict functioning errors, the public's reaction and even if it really is necessary - all of this without any costs associated with building a prototype.

Q.1.1 What do you think about a method like this to aid the development of Medical Artifacts?

Participant nr. 1, **group A,** considered that this would be a good methodology to use, adding that it could be helpful to reduce costs associated with testing Medical Artifacts. Participant nr. 5 also mentioned this aspect, and reckons that a methodology such as this one "it should be applied henceforth"[35], giving the example of a hospital that was built, only for them to realise that the stretchers did not fit into the doors. Interviewee nr. 6, however, believes this would not be very useful, considering that it would be one more (and unnecessary) step and that it would be very difficult to predict the reaction of the public. Nonetheless, they reckon that it would be important to have "less skeptical" people working in the area of Medicine.

In **group B**, interviewee nr. 2 affirms that by using a methodology like this, we could "think ahead" and that Intensive Medicine could benefit from it. Participant nr. 3 comments: "Perhaps we need that a lot, including to develop technologies that are directed for what we need, not wasting money, time, resources in research that goes to the trash because it does not make sense"[36]. She also warns not to forget about the ethical issues. Participant nr. 4 simply responds that it would be " a good exercise".

Q.2 Would you be comfortable in using artifacts mentioned before, if they were to appear in the near future?

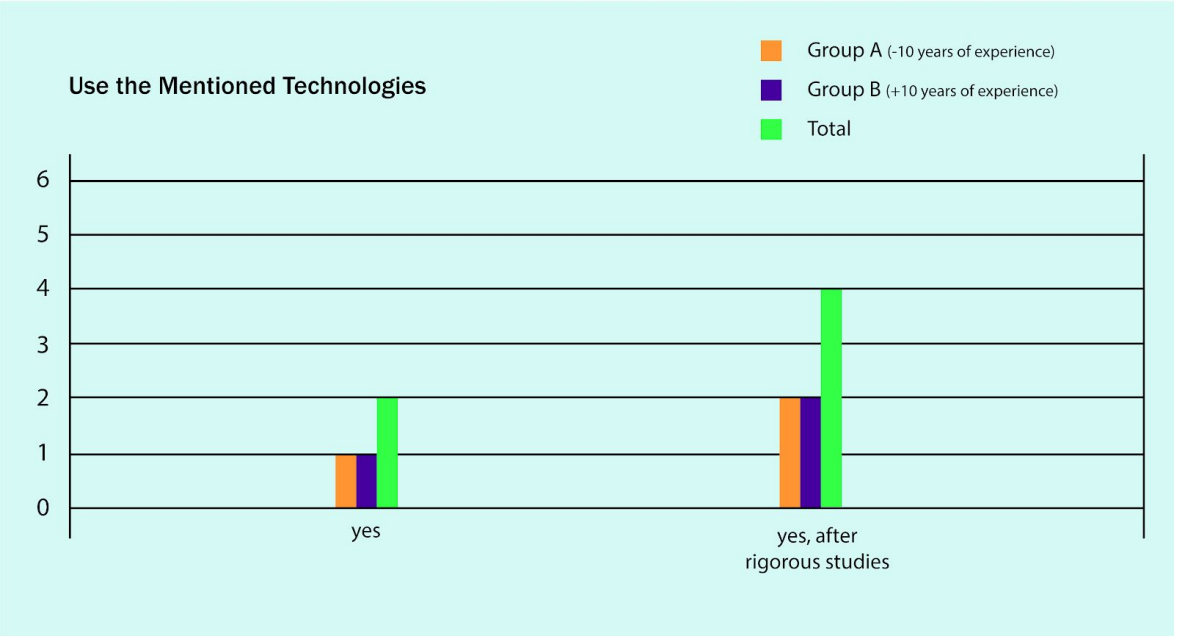


Image. 16 - Willingness of the participants to use the artifacts mentioned during the interview

Generally, we can say that all the interviewees consider they would be comfortable with using the technologies that I had mentioned, in case they were to appear in the near future. However, two participants of each group appeared to be a bit hesitant about the idea, making comments such as "as long as that doesn't replace the medical attitude, clinical thinking, ethics and above all doesn't interfere with the doctor-patient relationship" (int. 3, group B[37]) or that they have to be certain that what they are "doing to the patient is better than doing nothing and that it is better than other available treatments"[38].

Q.3 Have you ever worked with an investigation or development team on Medical Artifacts? What did you think of the experience (if yes)? Would you be interested in doing so (if no)?

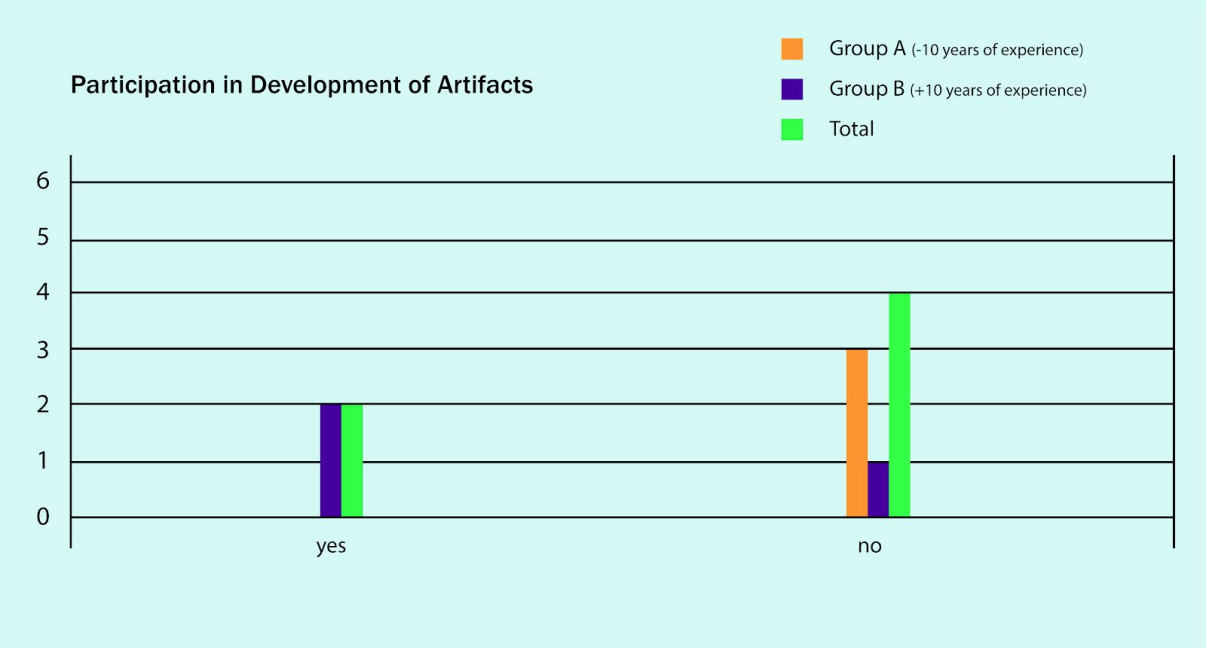


Image. 17 - Willinges of the participants to participant on the development of a Medical Artifact

From the six people that form the sample, four of them had never participated in any kind of study, but every single one says they would be happy to do it in the future. From the two that did participate, one of them was consulted regarding an instrument to help doctors in training, so that they could "provide support to education"[39] (Interview 3, group B), and the other was in a team working on a monitorization device for elders, more specifically "devices for domestic monitorization"(int.4, group B[40]).

4 The goal of this dissertation is to devise a sort of guide that will have the objective of helping the teams that are developing Medical Artifacts taking advantage of Science Fiction to make more informed decisions in the process. This guide will take into account not only existing methodologies - such as Design Fiction - but also other concerns that appear in related articles, as well as in these interviews.

Q.4.1 Would you be comfortable using a technology developed through a guide such as this?

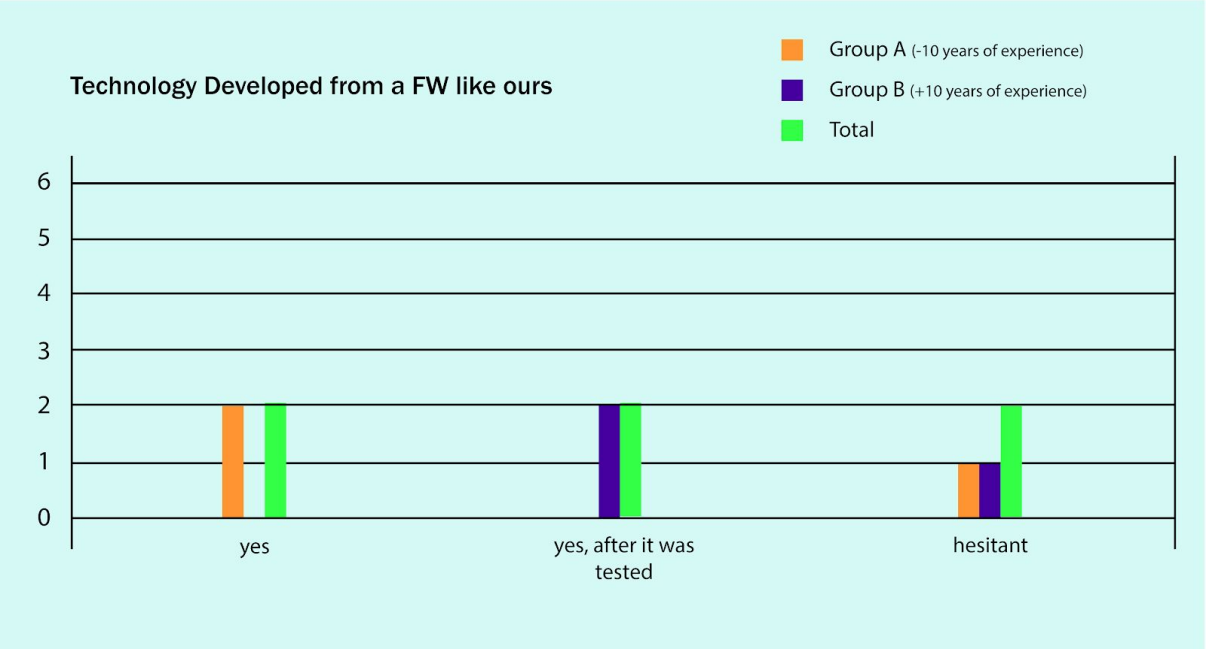


Image. 18 - Willingness of the participants to use a framework like to one being devised

Two participants from **group A** considered that they would use this technology right away, whereas two from **group B** claimed that they would, if these technologies had been properly tested beforehand. None of the interviewees responded with a “hard no”, however, one participant from each group appeared to be hesitant, commenting that these technologies would have to be “reasonable realistic”[41] and that they were not sure about ‘predicting’ the reaction of the public, saying “you can’t evaluate the true impact of it (...) nor the reaction of the people until you actually build it”[42].

Closing question: In general, what are your perspectives for Medical Artifacts for the next 20 years?

In **group A,** interviewee nr. 1 considered that 20 years seems too little time for the technologies that we mentioned in the interview to become a reality, although she thinks that from those, the first to appear will be Constant Monitorization Devices and Touchless Control Systems, and the last will be Instant Diagnosis. Participant nr. 5 considered that some of the technologies that will appear will be: a national computer

information system with the patient's whole information, a system that will enable the patients to be more involved in the process (such as the example of the "kioks" where they could "self-triage") and that improves the communication with them and the information they receive. In interview nr. 6, the intern said that their overall idea was that they will "be replaced by machines"[43] that will diagnose the patients and provide them medication. While in **group B** participant nr. 2 reckons that in 20 years time there will be: artificial organs or inter-species transplantation, an "pocket-sonograph" to replace the stethoscope and confesses to be afraid that the doctor-patient relationship can be affected if doctors "grab to much on technology and don't pay as much attention to the patient", which "already happens nowadays". He also brings up that it would be helpful to have "oral registration that quickly and automatically turned into writing"[44]. In interview nr. 3, the following technologies are referred to: easy-access algorithms for clinical decision, more portable and less invasive devices, as well as the discovery of markers for the prediction of diagnosis of diseases to which they were not identified yet. Lastly, interviewee nr. 4 mentioned that it will be a great development in the field of Artificial Intelligence, that people will be more independent of their healthcare and more literate on health in general, and that there will be more technology to aid the elders.

7. Interpretation of Results

Before proceeding, it is important to reinforce that, as the interviews were made with the intent of having a better understanding of how the framework should be, therefore the framework was not at all developed by the time these interviews were carried out. Besides, it is also important to note that these are our interpretations of the results and should be taken with a grain of salt, especially considering that these are mostly qualitative data.

7.1 Interpreting the Interviews

7.1.1 The Context of Technology Today

The fact that the interns referred more low-risks tasks than **group B** in the **Warm Up Question**, may come from the fact that they have not yet come into contact with extreme cases that often, or have not so far been that much into contact with those types of patient, since these participants only have 1-2 years of experience in Internal Medicine. It is important to have this in mind when commenting the following questions

from the interview, since experience can be a crucial factor on a person's point of view about their profession and how it evolves through time.

The same dynamic happens in question **a)1**, where we can see that participants from **group A** mention technologies associated with the patient's record and exams that are more commonly performed such as gamoetries and paracentesis and less complex artifacts, such as the stethoscope. Participant nr. 5 also mentioned two apps: *UpToDate* - which enables quick "access to clinical content and recommendations based on the best available evidence"[1]; and *Calculate* - a "next-generation medical calculator and decision support tool"[2]. In **group B**, however, we encounter technologies that are more associated with patients in life-threatening situations, as well as the ecography, which some of these interns affirmed not to be able to use at the moment. Besides these differences, we have some things in common: computer, monitorization devices and gasometry equipment, which both groups agreed on their relevance to their job.

In question **a)2**, all of the people interviewed affirmed being prepared to deal with the technology that they use presently. However we can see a difference between the two groups that is key to understand the evolution of Medical Artifacts through time: whilst some participants from **group B** affirmed that some technologies they use today did not even exist when they were studying, one of the interns comments that some of it is now obsolete and can bother more than help. As I have mentioned in **Medical Artifacts and Science Fiction**, Colombo et al. (2018) speak about the difficulty to break the canon when it comes to the progression of technology in Health. By understanding the changes we have been through in the last 30-50 years, we can have a stronger, more informed perspective on what the next 30-50 years will bring us.

In question **a)3**, we have once again the two opposites between **group A**, which considers the computer and the information that one can access on it to be essential to perform their job; and **group B**, which mentioned basic life support equipment. This is, in my understanding, the contraposition of knowing the long-term information of the patient and using it to decide what is the next step for their recovery; and constantly monitoring the patient's vital signs, in real time, in order to act quickly in case anything goes wrong. It can be seen as a passive response - where the information is gathered through the years, and active - where it is given in real time. Nonetheless, we have once again an agreement when it comes to monitorization of the vital signs, which, I would say, fit into

[1] www.uptodate.com/home
[2] Calculate by QxMD - Apps on Google Play

the “active” type of gathering information about the patient in order to know what to do next.

The interns interviewed mainly mentioned (in question **a)3.1**) flaws in the systems, such as slow software and usability and system errors, which can be explained by these being younger people, which probably came into contact with very responsive programs much earlier in life than the participants from the other group. The two groups coincided on the fact that some equipment could be smaller, being easier to transport from room to room. **Group B** also gave a particular importance to wireless devices, which were said to be easier to keep sanitized and, yet again, to be easier to move between places but also around the device itself. This might be one of the tendencies in the next few years, as we have seen before in works from Poon (2003) and Barraca et al. (2015). The problem of standardization between devices from different devices is certainly not a problem only witnessed in Medicine, since, for instance, some brands of smartphones have been making an effort in the last few years to have universal ports. It seems not to be a problem of having the right technology yet, but of disagreement between the brands producing the equipment.

7.1.2 Future Uses for Technology

In question **b)1**, we clearly have two different standpoints regarding the medical professional’s contribution to make the changes they feel necessary in their fields: **group A** seems to be more skeptical about their comments being taken seriously, while **group B** appears to be rather satisfied with the participation of medical professionals on the development of Medical Artifacts. By the confidence that the participants from **group B** showed, it seems that although some elements of **group A** affirm the contrary, the fact they are interns at the moment might be influencing their responde, not because others are more capable of suggesting changes, but perhaps because they are not integrated enough in the system to feel their voice is being heard. Nonetheless, we must take into account that most comments from **group B** referred to independent companies and investigations, that is, not related to official institutions such as Portuguese Medical Association (Ordem dos Médicos).

There were two main issues on which both groups focused on in question **b)2**, which was interesting given that the interviewee with more experience out of the 6 ended up talking about the same issues as the participants from **group A**, showing that these are timeless issues that might be worth trying to solve. One of these issues was the

necessity for the creation of a computer information system that would give any doctor access to all the information gathered about the patient throughout the years, no matter the hospital they had been before. It was mentioned in various interviews that the patient's background can be key to identify previous symptoms or even hereditary factors. The comment of participant nr. 3 about having a tablet for every patient is also associated with constantly having or annotating information about them on the spot, without having to wait until getting back to the office to have access/register said information. The common aspect about the responses of the two groups were the mention of technologies that would help the doctor make the diagnosis. This would bring together a technology that could, for instance, pair the symptoms of the patient with possible conditions, which together with the experience of the doctor would make up a much faster and arguably more accurate diagnosis. A technology like this one contrasts what we have seen before in works such as Colombo's et al. (2018), where there is mention of a similar system that instead of giving this information to the doctor, sends it directly to the patient.

7.1.3 Future Perspectives on Technology

In **b)3**, the majority of the participants seemed fairly optimistic in relation to the technologies that were discussed in each interview. Surprisingly, the only ones that were not sure about it were interns, that is, people who witnessed first-hand the rapid development of technology in the 21st century. For their comments during the interview, this might come from the fear of being replaced by machines and the opinion that they could never perform a job as well as a human doctor, despite the fact that there would be no need for them. However, it can also come from the fact that these people are younger, and therefore their notion of time is different: while interviewee nr. 1 said that 20 years was very little time for these technologies to take over, participant nr. 4 commented during their interview that technology evolves extremely rapidly nowadays.

Regarding question **b)4**, **group A** was a little concerned with such technologies like the ones mentioned taking the place of the doctors in the near future, which also appears to be an overall concern in different instances throughout the interviews. Something else that was mentioned was the idea that people today would not accept some of the technologies mentioned here, which was discussed before, for instance with *Threshold* (Richard Pearce, 1981). There is also an intern who mentions a technology similar to the one I have discussed, the daVinci Medical Robot (Image. 19), confessing

not to have known about it before leaving for erasmus. DaVinci is a surgical robot with small precise tools that aids surgeons in difficult procedures. It has a console, where the surgeon sits and controls the robot, which is "installed" in the patient manually. The doctor has a 3D screen where he can see the patient, one control for each hand and a set of micro and speakers on either side of his face, so that he can communicate with the rest of the team[3].

Image. 19 - DaVinci Medical Robot, retrieved from *A History of Robots: from science fiction to surgical robotics* (Hockstein et al., 2007)

On the other hand, in most interviews of **group B**, the participant brings up similar existing technologies, which seems to show that interns are not highly aware of technological advances in their field. This could be because more experienced doctors have more interest in researching advances in this field or just because they come into contact with these technologies more often. One of the technologies mentioned is a smart cane, that was developed at Instituto Politécnico de Coimbra and that helps people with Parkinson's Disease walking by creating a rhythm[4]. Overall, and contrary to what had been expected, participants from **group B** seemed to be more confident in the appearance of these technologies in the near future, while the ones from **group A** claimed that it would be a long time before they came true.

When asked "**In general, what are your perspectives for Medical Artifacts for the next 20 years?"**, there was no apparent consensus when it comes to the visions for Medical Artifacts in the next 20 years between the participants of this interview. However,

[3] *Google Takes on the Challenge of Making Robot Surgery Safer* (Tim Moy, 2015), in Wired.com
[4] *Politécnico de Coimbra desenvolve bengala inteligente para doentes de Parkinson* in sol.sapo.pt

group A seemed to consider 20 years a very short period of time, in the sense that very little could be changed, contradicting the other group, that seemed very optimistic in relation to what can be accomplished in that time-frame.

7.1.4 References to Science Fiction

It was expected for the interviewees not to be aware of the influence that Science Fiction may have on some of the artifacts they use today(question **c)1)**. However, after giving the example of the possible link between Mary Shelly's *Frankenstein* and the appearance of the defibrillator - which I did in every single interview, despite not being in the script - most of them recognise that there could be some kind of link between the two fields.

Although **group A** seemed to be more skeptical about the mentioned technologies appearing for a short amount of time, in the case of question **c)2**, it was the participants from **group B** that were more hesitant about bringing artifacts from Science Fiction to real-life, drawing attention to the importance of distinguishing between fiction and reality. However, there was also commenting about the possibility of transforming now only the dreams of the professionals, but also of the public, into reality. There was a comment regarding Science Fiction as a lense through which we can leave the dogmas associated with Medicine behind. This agrees with what has been discussed in some instances of chapter **5.** about how people's mentalities need to change in order to introduce more "visionary" technology to society.

7.1.5 Framework

Both groups were in agreement that reducing the costs of developing new medical equipment is an important factor that could be affected by using a framework that is being devised (**d)1.1**). This is particularly relevant since health is one of the most affected areas everytime there are financial issues in Portugal[5]. **Group B** also brought attention to ethical issues, which was on the themes fairly discussed in the articles from A Meta-Study and Content Analysis of Science Fiction in Computer Science Research (Jordan, 2019), and will not be taken lightly once the framework starts to be devised. Another important comment was made by an intern which showed some concern of a framework like this being an "extra-step" on the process, which might take more time

[5] *Marta Temido sublinha que Portugal deve reforçar investimento na Saúde,* in sabado.pt

than it would otherwise. It is crucial for this framework to be devised in a way in which it only saves time, instead of wasting it, or it will not be fulfilling its purpose.

The big issue with question **d)2**, once again, has to do with ethical and legal issues. Before going to the market, there are clinical tests that need to be made to the product, and ethical points that need to be taken into consideration. When devising the framework, it might be wise to include steps regarding these issues. In **d)3**, however, it is good to see that companies are already integrating doctors in the development of medical equipment. Nonetheless, they seemed to be more involved on the testing of the prototype or the future use of it (once it is ready), than on the actual process of thinking it through and coming up with the prototype.

When it comes to question **d)4.1**, although none of the participants answered with a straight up "no", we can see that there was some hesitance regarding using a methodology like this, despite all the benefits that they had mentioned before. Most of this, I suppose, might come from the fact that, at this point (as mentioned before) the framework was not fully developed, which can make it more difficult to fully understand its functionality. Nonetheless, it can also be because of the previous concerns that were mentioned: difficulty between what can and cannot be done in "real life", the ethical issues that might arise, or the simple fact that it is impossible to know for sure what the future holds. Therefore, it is important, if this framework ends up becoming a methodology, to have a consistent, solid explanation of how it works and of its purpose, so that it is clear, for instance, that clinical tests will be taken into account.

7.2 Similarities Between the Texts and the Interviews

When it comes to the future of technology in Medicine, there were some similarities between what was expected on the documents from Jordan (2019) and what was mentioned during the interviews. As we can see on the table 4, one of the things in which the two coincide is the incorporation of Artificial Intelligence on the health system, including to help on the communication between the medical professional and the patient's body, as in the case of "real-time biofeedback", which consists in automatic measurements of the patient's vital signs (or other indicator that might be of interest) and sending them to a medical professional that can make sense of them. There is also an agreement when it comes to AI helping the doctors, not replacing them, by making the diagnosis faster and more efficient by giving suggestions of diagnosis to the doctor,

based on the patients symptoms, as well as being more precise in identifying diseases or affected parts of the body and treating them, as we have already seen in **Medical Science Fiction Artifacts** where it is mentioned by Greene (2019). One of the more specific technologies mentioned - similar to the one operating in IPO Oporto (Instituto Português de Oncologia do Porto - Portuguese Oncology Institute) - is a kiosk that is a large screen - where any patient can go and have access to their exams, appointments and other information. If applied properly, as mentioned in said interview, it could help enhance some administrative procedures, by transferring the action to the patient - it would be them taking care of the appointments, writing down their symptoms, etc. It would be even more ideal if the machine could understand their facial expressions (as mentioned in some articles) or even some visual symptoms.

Interviews	**Documents**
AI giving suggestions to the doctor in real-time (interview nr. 4)	Personal assistants for medical care (*Ethics in Robotics Research*, 2017)
Scanner to detect affected organs (interview nr. 6)	Real-time biofeedback (*Writing the Future*, 2000)
AI aid for diagnosis (interview nr. 4 and 6)	Diagnosing diseases earlier ad targeting therapies more precisely (*Microbots on a Fantastic Voyage* , 2015)
Kiosks for “self-triage” (interview nr. 5)	Technology will be able to understand emotions (*Ethics in Robotics Research*, 2017)

Table 4 - Similarities between text and interviews regarding Artificial Intelligence

Advances in organ transplantation was another common expectation appearing both in the interviews and in the articles. In the interviews the focus laid on human organs being replaced by artificial versions of them, but also taking organs from other species, that are similar to ours, and making them work in our bodies. In the articles they went a bit further, there was a lot of talk about the possibilities of brain transplants, as well as full body parts - as in the case of prosthetics. Nonetheless, when it comes to organs, the one that had more display was the skin, especially when it comes to 3D printing skin.

Interviews	Documents
Artificial and interspecies organ transplant (interview nr. 2)	Various body parts, organs and brain implants (*Ethics and Brain Implants in the Military*, 2017)
	Stronger printed skin (*Healing the Burn*, 2016)

Table 5 - Similarities between text and interviews regarding organ transplantation

As technology for Medicine improves, also the technology for homecare develops. It was mentioned in more than one interview that the patient has become, and will be even more in the future, more independent from the doctors and informed than ever before. The articles in Jordan's thesis talk about helping disabled people being able to move independently, for instance using exoskeletons, as well as artificial systems that are integrated in the patient's body and helps them to control their conditions without going to the hospital. Also in the interviews it was mentioned that constant monitorization out of the hospital could be a reality in some years. There was also reference to the normalization of teleMedicine and an overall tendency to believe that there will be technology to help the patient out of the hospital.

Interviews	Documents
TeleMedicine to everyone (interview nr. 5)	Independent movement for disabled people (*A Clinical Roadmap for Brain-Neural Machine Interfaces*, 2013)
Constant monitorization (out of the hospital) (interview nr. 4)	Constant monitorization (out of the hospital) (*Wearable Devices in Medical Internet of Things*, 2017)
Technology to help the patient outside the hospital (interview nr. 4 and 5)	Exoskeletons (*Stepping Forward with Exoskeletons*, 2018)
	Implants inside biological cells will enable in vivo biosensing and cancer monitoring (*Future Implantable Systems* , 2011)
	Automatic systems for biological regulation (*Ethics in Robotics Research*, 2017)

Table 6 - Similarities between text and interviews regarding new formats for healthcare

Although it is more focused on surgery, there was mention of some type of touchless control in both the interviews and the articles. However, it can also be helpful to Internal Medicine, especially when it comes to infectious diseases. It was revealed more than once during the interviews that most of the contamination that happens in the hospital comes from the medical staff that deal with many different patients during their shifts. Touchless control devices, by reducing the frequency of times they touch surfaces, could help reduce the contamination between patients in different beds or rooms.

Interviews	**Documents**
Touchless control (interview nr. 1)	Input based on hand gestures (*Finger-Based Gesture Control of a Collaborative Online Workspace* , 2012)

Table 7 - Similarities between text and interviews regarding touchless interfaces

The role of Science Fiction in the development of Medical Artifacts was commented by the interviewees as something that may help people to disconnect from their fixed ideals and think beyond what is possible in the present moment. The articles are in agreement to this, with statements like “it turns out that many science fiction authors have envisioned the future as accurately as historians have chronicled the past" (Vos Post and Kroeker, 2000) and by the fact that some people, such as Robert A. Heilein, can be both a writer of Science Fiction and an inventor of objects that we still use today - in this case, the waterbed (Vos Post and Kroeker, 2000). Additionally, in most interviews, especially in those with the interns, it was referred that many technologies that we used today still seem like Science Fiction - for instance, in interview 5, the intern gave the example of the CAT - or of some that are not in use yet, but it is already being tested or even in use in other countries. However, in general, there was not that much optimism regarding the swiftness of these devices coming to mainstream use, especially when it comes to Portugal.

Finally, when it comes to the notes I have taken to apply to the Framework we are devising, there were also some common themes worth discussing. First, there is the concern with distinguishing what is fiction and what can become reality. Simpkins and Simpkins (2014) write "The authors lay out how they (...) resolved various real-life design problems such as weather, safety, and mobility", therefore showing the importance of

thinking through the environment where the technology will be applied and be prepared for how the two factors may interact. We also have to be prepared to deal with ethical and social issues that are always present when the lives of people are at risk. This too was written about by many authors of the articles analysed - such as Alexei et al. (2017) - as well as the Science Fiction works they referred to, as this is a topic fairly discussed in this genre. Besides ethical evaluation, in both parts of research there arose the question of social evaluation, that is, preparing for the social impact of the technology created. Nonetheless, the most recurrent thing that was common throughout both articles and interviews was the necessity of having a multidisciplinary team, which includes in it the all stakeholders of the projects: including medical professionals and even patients, if there is a need for them to interact with the device as well.

To develop a better understanding of how the information gathered in the interviews is related to the one gathered in the documents from Jordan (2019), it was organized in the same categories (except for the first one - 7.1.1, which contextualizes the roles of the participants).

8. MADIS: Medical Artifact Design Inspired by Science Fiction Framework

This framework was inspired by two other frameworks and then rearranged in order to address its purpose. Jensen and Vistisen (2017) showcase the table similar to Image. 21. In this essay, the authors discuss how Design Fiction can be used to address certain ethical issues and develop a framework to create and analyse Design Fictions with this purpose. The authors explain the need to “understand the near-future possibilities and challenges inherent in the artifact and its consequences for society” and apply this perception into the development of the artifact, which was the main goal of this framework. The highlighted elements were the ones inspiring the framework.

	Design Fiction		
storytelling	logos + pathos	pathos + minor ethical issues and character development	pathos + minor ethical + major ethical issues and character development
world building	storyworld, prototype, discourse consistency (logos)	storyworld, prototype, discourse help (pathos)	storyworld, prototype, discourse responsability (ethos)
	ontology This is the world	**epistemology** This is how we act in the world	**questioning ontology and epistemology** How should we act? What would we want?
ethical stances	**apathy** system over user	**sympathy** giving the user what they want	**empathy** giving the user what they need

Image. 20 - Design Fiction table adapted from *Ethical Design Fiction* (Jensen and Vistisen, 2017)

The other method that inspired my framework came from Sanders and Stappers (2014). Images 22 and 23 showcase adapted versions of their tables. The first one consists of a description of different phases of research. They mention the purpose of the artifact, including the problem it is trying to solve and the main goal of the artifact. Then, Sanders and Stappers tell us to “understand people’s experiences in the context of their lives: past, present and future”, which will reflect on the interaction between the artifact and the public. The authors also call attention to the future scenario in which we have to put our artifact in, to the context in which it will be used and all the implications of it. The “identification of problems” is also one of the main key-aspects of the framework. The very last item on the table is evaluating the “present and near future”, reminding us which aligned to the necessity of looking at the State of the Art and the evolution of the technology in the area we are developing an artifact in.

Design research	Pre design and post design	Generative	Evaluative
Purpose	To understand people's experiences in the context of their lives: past, present and future dreams	To produce ideas, insights and concepts that may then be designed and developed	To assess, formatively or summatively, the effect or the effectiveness of products, spaces, systems or services
	To prepare people to participate in codesigning	What will be useful? Usable? Desirable?	Is it useful? Usable? Desirable?
Results	Empathy with people	Opportunities for future scenarios of use	Identification of problems
	Creative codesigners	Exploration of the design space	Measurement of effectiveness
Orientation	Past, present and future	Future	Present and near future

Image. 21 - "The research phases compared", adapted from *Probes, Toolkits and Prototypes (Sanders and Stappers, 2014)*

In the second table, Sanders and Stappers (2014) divide the process into time frames, namely. This inspired the organization of our framework into time frames as well, although there is the need to add "Past", since there is a need to look at works of Science Fiction, among other aspects that will be discussed further on. Besides this, this table also mentioned some relevant authors and methodologies related to Design Fiction, which were sure to be present in the framework.

	Probes	Toolkits	Prototypes
The world as it is	Cultural probes (Gaver, Dunne, and Pacenti 1999)	Toolkits for understanding experience: a day-in-the-life exercise	Usability of an incrementally improved redesign
	Design probes (Mattelmäki 2005)		
The near future	Design Noir (Dunne and Raby 2001)	Toolkits for exploring future experience: my-ideal-future-product exercise	Usability/field testing of a radical new product
The speculative future	Design prototypes (Kirby 2011)	Toolkits for experimenting with experience: make-believe role-playing with co-constructed artefacts	Research through Design prototypes (Keller et al. 2009)
	Artefacts from the future (WIRED magazine)		

Image. 22 - ”The three approaches to making are expanding across different time frames”, adapted from *Probes, Toolkits and Prototypes (Sanders and Stappers,2014)*

The Medical Artifact Design Inspired by Science Fiction framework, or MADIS for short, is divided into three steps - Past, Present and Future - and two transitions between the steps, as we can see below (Image. 20). It was devised with the purpose of shortening the path between a possible Medical Artifact that might be inspired by Science Fiction and that has not been built yet, and its use, which will probably be possible in the near future.

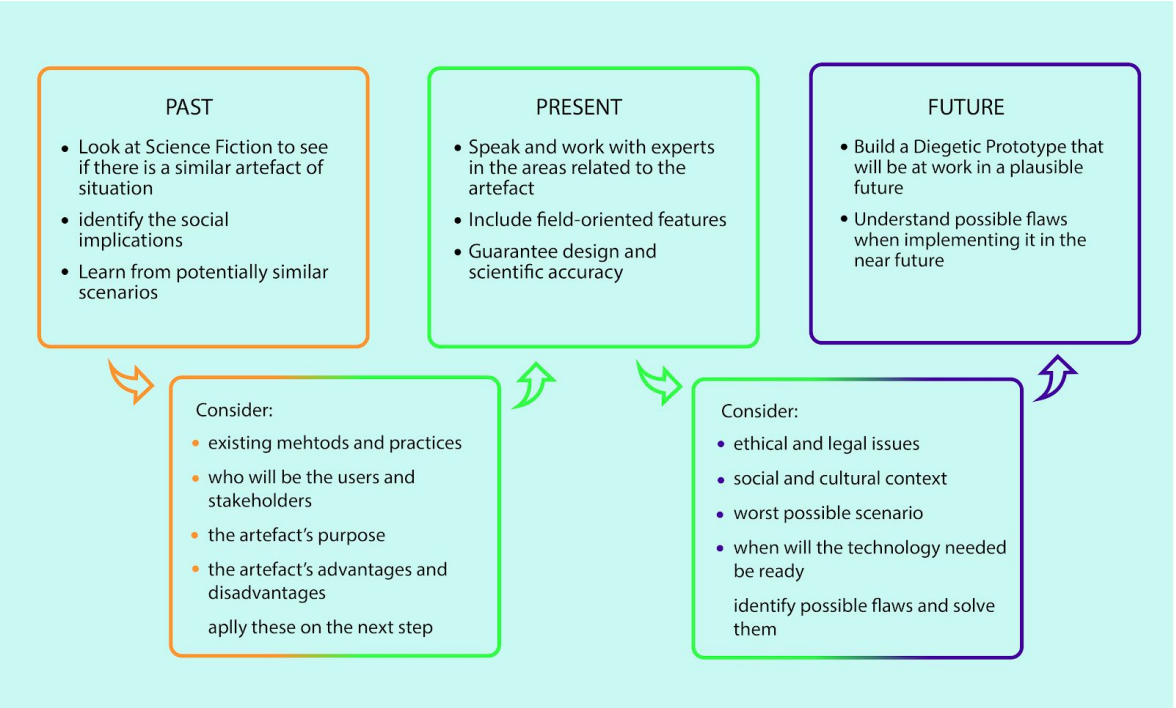


Image. 23 - MADIS - Medical Artifact Design Inspired by Science Fiction

The first step on this framework is to look at the past, in order to understand two main key points: if something similar to the work we are trying to develop has already been discussed in a work of Science Fiction. If so, the team is advised to, leveraging that knowledge, reflect on the general social implications and/or problems that might arise from introducing it into society.

Image. 24 - Past

The first point is rather important, for if the team did not take inspiration from Science Fiction nor has something similar been referenced in it, this might not be a suitable framework to use in the project. Let's take the common example of a time-machine: if we

were to build a time machine, we could look at works as The Time Machine by H. G. Wells or Back to the Future and try to identify some social issues that might arise, the reaction of the people to such an invention and, above all, the repercussions of the use of said artifact. This way, we could take advantage of the thought that was already put into the hypothetical invention of a time-machine and could make informed decisions such as i) who would have access to it, ii) how would the communication of this accomplishment be communicated to the general public, iii) what laws would revolve around it and even if it was worthy to build it at all. This is also a perfect time to look into the State of the Art and combine all this information in order to make the best decisions possible.

Image. 25 - First transition

When transitioning from the first to the second step, that is from the past into the present, we have to take into account some other aspects. One of them is the existing methods and practices already in use, for as Mackay explains in Is paper safer? The role of paper flight strips in air traffic control (1999), a radical change can "fail to account for all the embedded, intangible safety factors and are likely to result in dangerous, perhaps fatal, situations" (Xiao, 2005). We should also consider the target audience and stakeholders, which can later be consulted about their opinion or expertise; the artifact's purpose, as in to make sure that it is giving response to a necessity and is, therefore, useful; and the advantages and disadvantages of having an artifact as the one we intend to create. The goal of this step is, in the words of Sanders and Stappers (2014), to make sense of the future." With this in mind, we can then proceed into the next step.

Image. 26 - Present

In the “Present” section of this framework we will be focusing on the more objective part of the artifact development. For this, and taking into consideration what was mentioned before, on the first transition, we should seek to gather a multidisciplinary team, ideally bringing together all the areas that are relevant for the development of the artifact. Say we are building a medical robot: it is essential that we have programmers, electronic engineers and designers to build the actual device, but we should make sure that the also integrates health professionals that will have contact with the robot once it hits the market, and perhaps even patients and/or sociologists to help us understand how the general public feels about being treated directly by a robot. Having a multidisciplinary team will also help to correct certain details from the size of the arms of the robot to the dosage of drugs it administrates.

Image. 27 - Second transition

At this point of the development, the general draft of the artifact should be quite concise and the team should be able to think beyond the practical implications and move to the

socio-cultural aspect of it. Before completing the last step, there are some points to take into consideration. First, we have to look into the social and cultural context in which this artifact will primarily be introduced, since different cultures might be more or less open to the idea, for instance, of a medical robot, and accordingly identify ethical and legal issues that might interfere with the establishment of the artifact. In the words of Sanders and Stappers (2014), the goal is to make "sense of the future ways of living before we actually get there." The team should aim to understand how people would interact with the artifact being created, once it becomes common, mundane. As Timmermans and Berg (2003) say, "[technologies] are tools that generate interactions or social meaning but do not act", becoming important to understand the implication the artifact might have in the community it is introduced. Then, we should imagine the worst possible scenario, that is, the less ideal conditions possible that someone might come across when interacting with our artifact and design solutions that would work in it. Timmermans and Berg (2003) explain that "Healthcare work is often non-routine, so it is difficult to pre-schedule events and activities", so we have to be prepared for the unexpected. Lastly, it is important to understand if we have (or do not) the technology today to do this, in order to make an estimation of when would this product be ready to go on the market. Naturally, some of these details might not be possible to solve in this transition stage, depending on the artifact, but even if then it is crucial that we identify these issues and have them in mind before executing the last step of this framework.

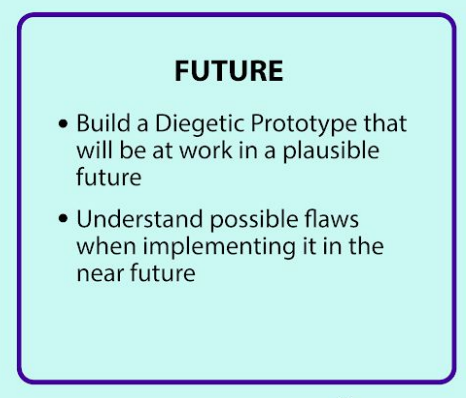
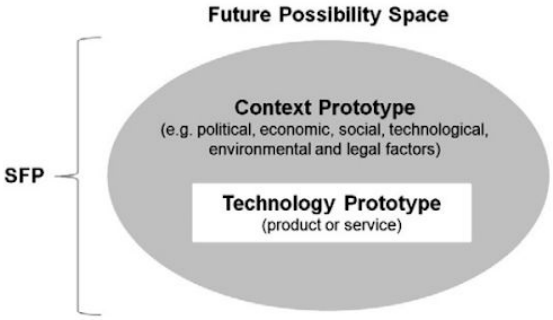


Image. 28 - Future

The last stage is looking into the future, and we will do this by creating a Diegetic Prototype. As mentioned in **Concepts and Context**, a Diegetic Prototype is the application of the conceptualized prototype (that is, before being physically built) to a

hypothetical scenario. This scenario can either be an existing one, for instance a scene of an existing narrative (fims, books, etc), or a newly created one, as long as it is a plausible future scenario. It is important to note that, most of the time, Diegetic Prototypes are used in conjunction with a Design Fiction, which would imply the creation or use of existing characters and narrative, alongside an action that is sometimes presented to an audience who gives feedback. Notwithstanding, I believe that to meet the purposes of this Framework, there is no need to use a narrative. The creation of a plausible, researched backed scenario will suffice, as considered in **Why is it important to study the influence of Science Fiction on Medicine?**, to understand possible pitfalls of the developing artifacts. Jensen and Vistisen affirm (2017) that "This intention [showing how the prototype would interact with the world] can be shown by solely depicting the artifacts and how it works with minimal characterisation of the users," hence not being crucial to place the prototype inside a narrative, unless the team working on it believes it would be useful. By placing the prototype in this scenario and mimicking how the situation would evolve, arguably it will be possible to identify possible flaws that were not already taken into consideration and have a better understanding of how it would be best to implement it in the future. This might also be a good time to consider other details such as those related with clinical testing. In Methodologies for the Development of Artifacts, there are several different methodologies that one can follow to come up with a Diegetic Prototype. Science Fiction prototyping is an option, since it always takes a small Science Fiction narrative - that can even be one used as an example in PAST - as a starting point to conceptualize a future world. However, Design Fiction might be a more appropriate option, since it focuses on creating "what if" plausible scenarios, that is exactly what we need in order to be able to insert our prototype in a context. The two following images illustrate these methodologies, discussed furtherly in **Methods for the Development of Artifacts**.



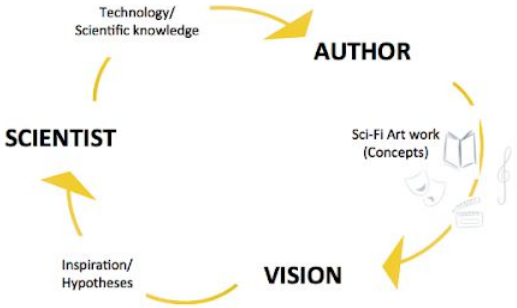


Image. 29 - retrieved from *The Role of Context in Science Fiction Prototyping* by Potstada and Zybura (right)

Image. 30 - retrieved from *Towards an Agenda for Sci-Fi Inspired HCI Research* bt Mubin et al. (2016)

It is important to disclaim that this framework is designed to be applied before building the prototype, more specifically between the design of the prototype and its construction. The whole point, as mentioned before, of a framework like this one is to optimize time and resources when building medical prototypes by pinpointing as many flaws as one can before building an actual physical prototype. It needs to be kept in mind, also, that after this process is completed and the team proceeds to the creation of the physical prototype, it is still mandatory to go through all the clinical tests and legal issues associated with introducing an artifact that will interact with patients and in the context of the hospital. Moreover, it is also crucial to mention that this framework can be used alongside other methods already in use by the teams and/or institutions working on an artifact.

9. Discussion and Future Work

9.1 Value of the Research

People were writing about life on Mars years before we landed on the moon (1969) - in works like Garrett Putnam Serviss's Edison 's *Conquest of Mars* (1898) and *Edgar Rice Burroughs's A Princess of Mars* (1917) - agreeing with the direction society of the time expected technology to evolve in. H. G. Wells was not predicting the moon

landing when he wrote *The First Men in the Moon* in 1901, it was evident at the time that we would eventually get there, and so he wondered how it would play out. As technology evolves, it is only natural that visionaries will ponder on the possibilities that it will bring and their consequences, as it is also natural for some of them to become real. A tool like MADIS can help turn these visions into reality, by being more informed about the future, in order to create more useful artifacts for the man of tomorrow. It is, overall, a way to anticipate the unknown, weighing different plausible scenarios that we will have to deal with and prepare for the challenges we will be facing as a species. Fiction inspires reality and vice-versa, in an endless creative cycle that can foreshadow what is to come, if we know how to look at it - ideas evolve, they do not appear out of thin air. Teams who are informed and aware of future obstacles can put aside the fear of moving forward and build from their creativity up.

Among the challenges we are most certainly facing in the future are diseases that are reaching new territories as a result of Global Warming, as well as microbes that used to be frozen in icebergs but are now being released into the environment once more as the ice melts. John M. Last (1993) discusses some data regarding climate change and its consequences. When discussing “Overall Impact of Global Warming on Human Health”, the author writes “I believe the situation is serious and that public health specialists would be justified in preparing to deal with the predictable health consequences”, reflecting the importance of thinking ahead when it comes to public health. We could look at numerous examples of possible scenarios that we can find in Science Fiction to answer social-aspect questions such as how would the population react or how would daily life change, and to data about the movements of the air and the tides and how it would affect of the diseases would travel and what countries they would reach. With the knowledge regarding the advances of these diseases, and by studying the effect they would have in animals and humans that have not dealt with them in centuries, if ever, it is possible to prepare for this inconvenient truth. More recently, in a 2020 article for *The Journal of Clinical Investigation* by Rexford S. Ahima, it is discussed how there are some diseases that get worse in warmer climates, especially when it comes to children, elders and people who already have other conditions. The author also explains that this is especially true in regions with what Ahima (2020) calls “undeserved conditions”, and that dehydration is also a factor causing worse symptoms. This is concerning, since there will be an even clearer contrast between rich - and healthy - countries and poor - therefore

unhealthy - countries, which are also often ones with warmer weather and more impactful drought even today.

Nonetheless, we must not only prepare for challenging scenarios, but also adapting to other changes that will happen as technology in all areas of society evolves. There was mentioned a few times throughout this dissertation the fact that people are becoming more and more responsible for their own care, not only in terms of health education and awareness, but also in legal and ethical terms. Stead et al. (2018) explains how the "designer-maker culture" is calling out to people to me more involved in the products that they use, and healthcare is no exception. People want to be more involved in what they wear and more aware of its influence on their lives, even more so if it deals with their health. One of the participants in our interviews also seems to be in agreement (participant nr. 4), since he claims that patients are becoming more and more informed about their health conditions and, therefore, capable of taking an active part in their treatment. The fact that we are living longer and healthier lives, together with the ability to be responsible for our own healthcare will probably change the picture of healthcare services nowadays. It is possible that changes will have to be made in order to adapt to the new social and demographic paradigm, something that can also benefit from a framework like MADIS, that could help understand what type of changes should be made and how. Of course these are just hypothetical examples of how MADIS can be useful in different scenarios and areas. Having that said, it can be constructive to look at a real event and how it could have gained from looking at it from the perspective this framework suggests.

9.2 COVID-19 and the Importance of Learning from the Past

During the writing of this thesis, the world experienced the COVID-19 pandemic, a variation of the Influenza coronavirus that originated in China in mid december 2019 (Guo et. al, 2020) and spread around the globe in a matter of months and killed over 401 thousand (as of June 6th) people. This can be taken as an example to illustrate how important it would have been to look at fictional depictions of similar events and take notes of what to do and not to do in such a situation. There are some Science Fictions that illustrate the situation of a plague tormenting humanity, from novels like *The Plague* by Albert Camus (1947), *A Journal of the Plague Year* by Daniel Dafoe (1722) and *Love in the Time of Cholera* by Gabriel García Marquez (1985); and films like *Outbreak* (1995), *Contagion* (2011) and all the undead franchises that have been thriving in the last two

decades, such as *Resident Evil* (2002). There are various approaches to how the creators of these considered the people would react when facing a new, unknown disease. So how can we know which of them corresponds to our current reality? Which issues could we predict and prepare for?

The answer to this comes from the cultural, political and social context of the time we are living in. Once a new "plague" is identified, it is wise to look at these and analyse how, in that time and place, people in power, civilians and even the medical community would react and how to avoid making uninformed mistakes that could cost hundreds, if not millions, of lives. To illustrate some "lessons" we could have taken from Science Fiction and applied as a reaction to the COVID-19 outbreak, I will take the first two examples: *The Plague* (1947) and *Outbreak* (1995). Lindley (2020) discusses Camus's work and compared it to some of the events experienced in this pandemic, from how empty the streets looked when people were sent home, to the coagulation of phone lines because people could not socialize in person - replaced by video call platforms in 2020. We see in *The Plague* that people are not keen to stay home, which also happens in *Outbreak*, as well as in real life. In the news article *Praias cheias de gente em tempo de quarentena* (beaches full of people in times of quarantine), Maria Leite Ferreira writes how portuguese beaches filled with people days after schools and workplaces were closed to the COVID-19 pandemic.

Some other similarities between the two works, and that are also related to what happened beyond the screen, are the lack of vaccine and the initial denial of the need for urgency and/or the lack of preparation on the part of some governments. There is a lot of controversy surrounding the creation of a COVID-19 vaccine. As Thanh Le (2020) elaborates on the development of a vaccine for the novel coronavirus, saying that "The global vaccine R&D effort in response to the COVID-19 pandemic is unprecedented in terms of scale and speed" and that they " could be available under emergency use or similar protocols by early 2021," which is a considerably shorter process than the usual. Nonetheless, until then, there must be other forms of containing the virus, such as social distancing and similar measures. There is also still to be discovered if this outbreak will be a one-of-a-kind event or if the virus will come back on a new wave, or even become seasonal disease, such as the flu.

In *Outbreak*, some of the characteristics of the deceased are similar to COVID-19, from the fact that it has flu-like symptoms and that it has mutated during its spread, to the fact that the original host was a wild animal. However, most importantly, the impact

of the virus in the film could have warned us that it was possible, for images of overcrowded hospitals and military in the streets and depicted - images that have also appeared in news all over the world. Moreover, Kirby (2011) refers to a comment from two medical consultants working in *Outbreak* that claim, according to Kirby, that they "clearly felt that their advice kept Outbreak enough within the ring of truth for the film to be used as an effective public relations device."

So, we can argue that by taking into consideration certain Science Fiction works, we could have been one step ahead of this disease. Nonetheless, that does not mean that this crisis did not have interesting "side effects" when it comes to the evolution of the technology regarding COVID-19. According to Srinivasan et al. (2020), "The greatest cause of COVID-19 patients is the development of respiratory failure due to acute respiratory distress syndrome," and it has been observed a lack of equipment in comparison with the number of people in need of it. As a response, there was a rush to create new ventiladores, with different systems and ways of use, especially focused on being non-invasive. Besides the more straightforward approach, that being finding ways to build low cost ventilators with cheaper materials, other different options have been studied, for instance the ones developed in the University of Oporto (Universidade do Porto)[6].

One of them was suggested by Paulo Roberto, a doctorate in University of Aveiro and anesthesiologist at the hospital of Gaia. This new ventilator uses parts of other equipment, common in healthcare units, that is assembled to work without intubating the patient - a more invasive technique - when traditional ventilators are not available.

[6] *Covid-19: concentrador de oxigénio da U.Porto pode servir de apoio ou alternativa a ventiladores* (Covid-19: oxygen concentrator from U. Porto can aid or be an alternative to ventilators)

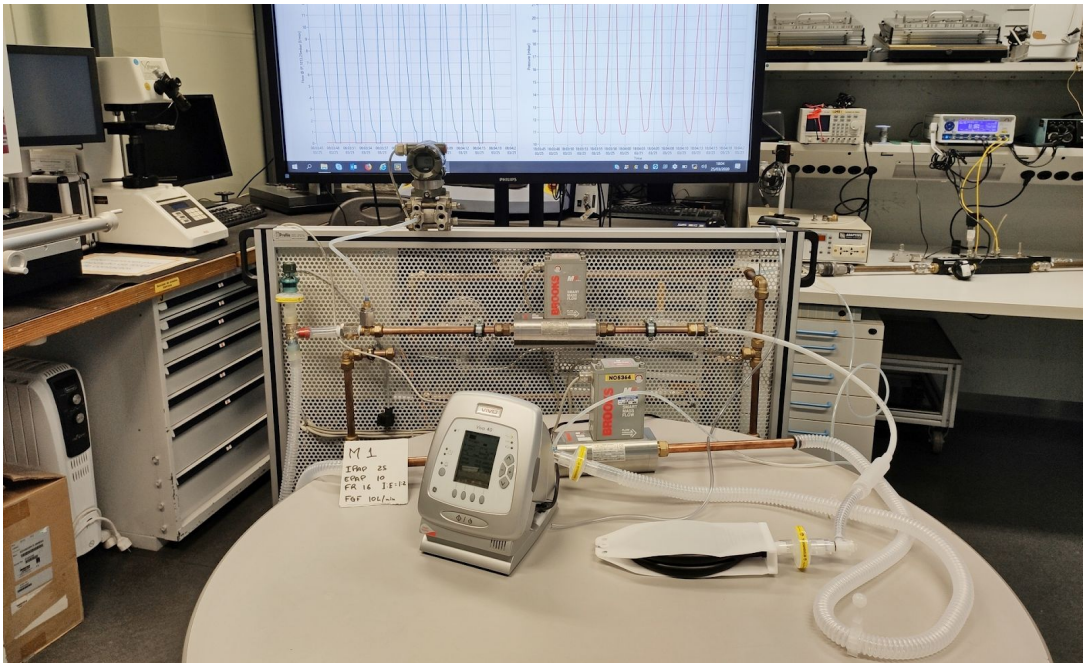


Image. 31 - Retrieved from www.ua.pt/pt/noticias

In the University of Sao Paulo, Brazil, they tested another alternative, which uses “anesthesia machines as ventilators for COVID patients admitted to intensive care” (Torres et al., 2020). This would work by adapting the substances entering the respiratory system of the patient to the needs of a person with respiratory failure caused by COVID-19. Although it has some downsides, the team affirms finding solutions for some of them. Overall, the authors claim that this would be an option for taking some of the pressure off the health system, and of the professionals responsible for deciding who gets to be treated and who does not. As Srinivasan (2020) explained, the lack of this type of equipment leads to very difficult decisions when it comes to triaging the patients infected with the novel coronavirus. We must also remember that ventilators are not solely needed for patients of COVID-19.

Srinivasan et al. (2020) present yet another alternative for the equipment shortage, consisting of using a single ventilator for two patients. The major challenges identified at the beginning, were mainly due to the fact that the two patients must not contaminate, nor become co-dependent of, one another. Focusing on surpassing these, they created the Individualized System for Augmenting Ventilator Efficacy (iSAVE) that “enables independent control of volume and pressure for each patient and incorporates safety measures to accommodate sudden patient deterioration and cross contamination.” The team created individual channels for each patient, as well as an alarm system that

notices if any of them is having problems (even if the other one is not), using materials easily found in hospitals or hardware stores. Despite not having been tried on human patients yet and the possible difficulty of adapting this system to the different ventilators available in the hospitals, they aim to double the potential for saving lives during this crisis.

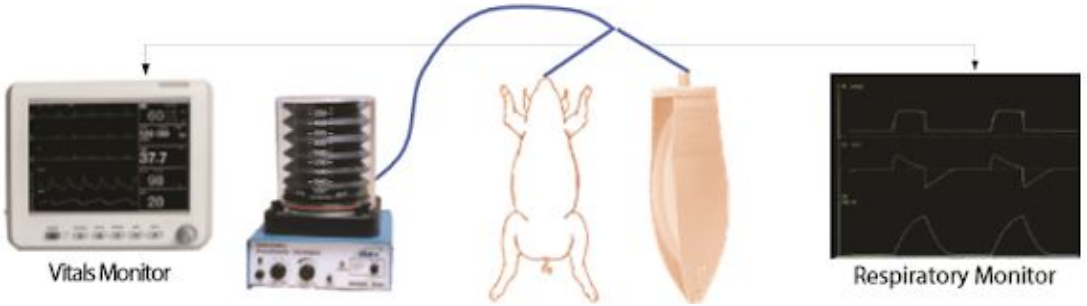


Image. 32 - retrieved from *Individualized System for Augmenting Ventilator Efficacy (iSAVE)* (Srinivasan et al., 2020)

9.3 Concerns Regarding Medicine and Technology

The first thing to comment regards the interviews. It might be worth noticing that there were multiple mentions of the inequality of access to equipment in different regions of Portugal, especially from the Interns, as well as this country compared to others. The question about inequality in access to technology has also been discussed on a socio-economic level in the documents analysed by Jordan (2019). Even though technology is advancing at an incredible rate, it does not reach every place nor every person at the same time, nor in the same conditions. York et al. (2019) comment “For responsible innovation to occur, the voices of many stakeholders must be represented in the conversation to prevent the inequality of access that many participants recognized as the most likely future.” This issue is also commented by Fielder (2003), stating about genetic modification technology that “it will be available mostly to the affluent and educated, deepening the advantage they have and the social inequality it produces and reinforces,” although it is true for other technologies as well. This is especially essential to discuss when it comes to health, as inequality in access to new technology is becoming each day more synonymous to inequality in access to healthcare.

It is extremely important to discuss new and different ways to go about developing technology for Medicine and healthcare, as it is one of the most important areas in our lives. Often money and resources are spent on the military forces, on space exploration and on fueling the industries of the countries, and sometimes it is done in

detriment of areas like education and healthcare. This is one of the reasons why it is so important to understand ways to make the evolution of the medical sciences use less time and resources - so that it can level up with other areas, even thought there might not be the same amount of investment in them. The other reason is that, while the world's population in general is aging, it is not always in the best conditions. It is crucial that we find ways for older people to have healthier and fulfilling lives, besides long ones. Hopefully the framework we have devised can help understanding these issues and solving them.

When working with Medicine, we must not forget that we are dealing with life and death, consent, and changes that might affect people's life forever. Therefore, ethical issues must always be brought to the table, raising the necessity for an expert to be on every team working on a Medical Artifact. Ethics are always raised when it comes to Medicine and technology, from legal concerns, interaction between humans and robots, leakage of personal data, among others. We have seen this throughout this dissertation, both on research and on the interviews made. There seems to be a particular concern regarding the body enhancement of healthy people and the influence that it can have in society overall. The main reason for this concern is the wealth gap and the "digital divide" that we experience nowadays. That is, the unequal access to cellphones, internet and other technologies throughout different layers of society and even different countries. Design Fiction and other methods as such can be a great help in the sense that it can give us an idea of the influence that these enhancements might have on the ones getting them, as well as the others and the difference between the two groups and their interactions. Especially when it has already been explored in some Science Fiction works, for instance of William Gibson. With Design Fiction we are not trying to predict the technologies that will be available in the future, not solely. We are, overall, trying to predict how they will interact with the environment and how it will (or not) be accepted, especially when it comes to public opinion. The most we can take out of a framework like the one we are devising is looking at works of Science Fiction and understanding what plausible scenarios were already played out for us, so that we can predict the future insertion of new technologies in society.

One of the things that stood out while reading some of these texts, namely those regarding Asimov's Laws of Robotics is that the stories from *I, Robot* (Asimov,1950) might be considered Design Fiction, for they insert a certain element on a plausible future and wonder about the influences it could have. There was one quote in particular that

struck as interesting to think about in one of these texts, when Wigan cites the Nietzche: "He who fights monsters should be careful lest he thereby become a monster". Most scientific scenarios in Science Fiction tend to be either Utopian or Dystopian, and the latter is one that we particularly enjoy, but also fear. Perhaps one of the most imminent fears of robots with Artificial Intelligence is that there will be a chance that they will become more intelligent than us, ending up overpowering the human race. However, this battle between intelligent species, between the natural and the unnatural, evokes what the human species has done to our planet so far. The role of technology - in the hands of humans, the intelligent species - strikes me as humans overpowering our origins - nature - the same way we fear Intelligent Robots will do to us. In this sense, this phrase really caught my attention, for history repeats itself. Will we witness the thing we created destroying its creator as we did to the planet which provided life to us in the first place? Are we already a monster, similar to the one we believe we ought to combat?

9.4 Limitations and Future Work

As mentioned at the beginning of this study, there is a clear lack of research when it comes to Science Fiction and Medicine. Although we were capable of exploring how the genre can be helpful to technological development in the area, there is a lot more left to explore. We were only able to interview a small group of doctors, however it would be interesting to take it to the next level, through a mass study on the influence of Science Fiction in Medicine and if/how professionals in the area are aware of it. On a more extensive study, it would be possible to cover various areas of Medicine, besides internal and intensive Medicine. It could also include other professionals and stakeholders related to the field, including actual teams working on Medical Artifacts. In a study like this, it would also be possible to make more direct questions, such as “did you use Science Fiction as an inspiration” for instance, in order to objectively answer the central issue regarding this theme: do developers of Medical Artifacts use Science Fiction as an inspiration for their creations? By directly asking the teams working on new Medical Artifacts if they are looking or have looked to Science Fiction as an inspiration to their work, we would have more objective data, leading to clearer results.

There are some things that we were not able to accomplish due to the fact that this is a master’s dissertation, which means a limited amount of time and resources. In the interviews, it was only possible to carry them in Portugal and with a very small sample, but that is not all. Ideally, it would have been remarkable to create a whole

methodology, instead of a framework, to draw Science Fiction concepts and artifacts into reality, which we knew from the beginning that it would have to be a future project. However, by creating the base for that work, through MADIS as well as the theoretical research made at the beginning, we have foundation to work upon.

Regarding the framework created, there are also steps yet to be taken. There is the need to validate it among professionals and teams working in Medical Artifacts in order to conclude its efficiency in practical terms. One way to do this could be contacting teams already working on an artifact, willing to integrate the framework in their work. Besides this, it would also be beneficial to compare our frameworks to others already in use, not only in terms of efficiency, but also in terms of speed, clarity and its influence on teamwork. Ultimately, it would be valuable if there was the possibility of following a team using this framework from the beginning of their project until its conclusion and evaluating the results of the integration of the artifact in society.

9.5 Researcher Bias

As mentioned before, it is relevant to keep in mind that the study made must not be taken as an absolute truth, for the small group interviewed cannot speak on the behalf of the medical community. It is possible that the mostly positive feedback given by these doctors regarding the use of Science Fiction as an inspiration or a tool for Medical Artifact development can differ in different areas of Medicine, other countries or even just another group of medical professionals.

The data researched and analysed during this dissertation is composed of qualitative data, and therefore subjected to interpretation. The author's background as a culture student might also create a bias for the interpretation of these data, as the perception of how society or social groups work in general terms can create generalized concepts. The interpretations of the interview results can, therefore, be subconsciously affected by these generalized concepts.

FInally, the author's personal likes and opinions regarding Science Fiction and its influence on real life can also have bleed through in certain moments of the study, namely during the interviews. Although all efforts were made to make this process as objective as it could - given the nature of the data - one has to take into account these factors.

10. Conclusion

Ever since its origins, science Fiction, has always been a way for people to express their fears, worries and expectations about the future. It is far from reality, at least from the reality the authors experiences, however is not really fantasy either, for most of the futuristic visions that these authors portray in their stories are actually plausible. Instead of seeing Science Fiction as “fake science”, we could begin to look at it as a draft of what our future could look like. Then, we can take that draft and tailor it to our capabilities and necessities and come up with a final version that fits our context, without being limited to it. By using Science Fiction as a guide to create or enhance Medical Artifacts, we can open the gateways for more informed decisions and visionary concepts when developing them.

10.1 - H1: Science Fiction helps developers of Medical Artifacts develop a better understanding of how their inventions can help doctors or healthcare providers.

After the research done during the theoretical context for this dissertation, we can conclude that Science Fiction can have a positive influence on the understanding of the impact an artifact can have when placed on a certain environment, even if it is in the future. Many authors, like Mubin et al. (2016) consider that this genre, more than others, can be beneficial for, in this case, HCI developers and that it has even compelled some scientists to draw its concepts into reality. Moreover, the fact that methodologies like Design Fiction and Science Fiction Prototyping exist, show that teams are already using Science Fiction to be more aware of what the future holds and make more informed decisions about it when it comes to developing artifacts. Clark (1995) mentioned how it would be crucial, for instance, for us to anticipate what diseases we will come across in the future. Additionally, we have also seen that sometimes, the narratives created when using methods like Science Fiction Prototyping can be used to prepare the audience for something that is already being developed, as is the case of *Threshold* (1981) and the artificial heart.

10.2 - H2: A framework will help developers of Medical Artifacts taking advantage of Science Fiction to make more informed decisions when it comes to the artifacts they are developing.

As we have seen previously, there are already some methodologies that help developers and researchers take advantage of Science Fiction, as some have already been used in the contexto of Medicine and Healthcare. Although one could argue that it has not been used that much in areas like Medicine and Healthcare, we did find some examples of it, showing that there have been some steps taken in the direction of using Science Fiction as a tool to create future Medical Artifacts. In studies such as Stead (2018), this method has also been used in the context of healthcare, proving, once more, that this serious and crucial area of our life as a society can also take advantage of Science Fiction to design for the future. Furthermore, in the interviews that were carried out, most participants considered that it could be a helpful method to incorporate into the development of Medical Artifacts.

10.3 - H3: Medical professionals with different levels of work experience will have similar opinions when it comes to the influence of a framework to help the development of Medical Artifacts.

The third hypothesis was confirmed by the interview. We can see by the answers of sections c) and d) (Design Fiction and Framework) that despite their levels of experiences, the general opinion was that a framework such as this one could be helpful to the field, if properly used and designed, never forgetting the social, legal and ethical issues that might arise from each artifact that is being developed. However, it is worth noting that, when making the bridge with what is discussed in Medical Science Fiction Artifacts, the participant number 4 was the one who came closest to the State of the Art on technology for Medicine. In his interview, he mentioned smart clothing, Artificial Intelligence and the fact that the patients are becoming more informed and involved in their own treatment. We can, therefore, conclude that, from all the professionals interviewed, participant number 4 - the one with more experience - seems to be the most aware of the state of technology in Medicine today and the near future.

10.4 - RQ: Could Science Fiction allow for a more informed creation of future artifacts used in Medicine?

After all the research done,our research indicates that a Science Fiction could allow for a more informed creation of Medical Artifacts, especially when it comes to diseases which movement - as well as the factors that influence that movement - we can predict through data analysis. This is, as mentioned before, the case with ones that will be affected by climate change, which will arguably be quite extreme in the future. Besides, there is also the socio-cultural aspect, since Science Fiction can help predict and prepare for the reaction of society to the introduction of a new, possibly disruptive, new artifact. This might be done by understanding the way in which history repeats itself, which may give us hints of how society as a group will evolve in the near future. Similarly to artistic movement in which each one contradicts the previous one and is contradicted by the following, also communities have padroized reactions to the evolutions of the world around them, one just has to apply that knowledge in the context of developing Medical Artifacts. Finally, it can be added that situations such as the COVID crisis experienced in 2020, if not avoided, will be less impactful in the future, if we only take measures to prepare for it. In the Netflix documentary *Explain: The Next Pandemic*, that aired in November of 2019, Bill Gates claims that the event of a next pandemic is not a question of “if”, but of “when” - which was confirmed a month later when the outbreak started in a small town in China. If we knew this was an imminent danger, why were we not prepared for it? Will we be prepared for the next one?

10.5 Final Remarks

The main goal of this dissertation was to understand how Science Fiction as a genre could help developers of Medical Artifacts to make more informed decisions regarding their work. We looked at how Science Fiction has evolved and about what it means to write about a plausible future, as well as the fears, hopes and expectations we have about it. We also looked into the state of the art of Medical Artifacts and, through interviews with medical professionals tried to pinpoint some of the adjustments and additions to those technologies that could be made. Those interviews, alongside an analysis of a database of scientific articles that refer to Science Fiction, we have devised a framework - MADIS - that will hopefully help teams working on Medical Artifacts to take concepts, advices and expectations from Science Fiction works and turn them into a reality in the medical field. Overall, this was a study about the way in which we can

prepare for a future where people are healthier; in which medical technology is more accessible, has a faster developing process and is well received by the public; and in which we know how to prepare for future threats to our well-being.

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12. Annexes

Annex 1 - Documents analysed, from *A Meta-Study and Content Analysis of Science Fiction in Computer Science Research* (Jordan, 2019)

TITLE	AUTHOR	YEAR
A Clinical Roadmap for Brain-Neural Machine Interfaces? perspectives on the 2013 international workshop	Liew, Sook Lei et al.	2013
Assistive Technologies that are Meant to Integrate Brain and Computer: Accepted or Rejected by Society?	Monteiro, Genari Celso et al.	2013
Beyond Asimov: The Three Laws of Responsible Robotics	Murphy, Robin R. Woods, David D.	2009
Bridging Present and Future of Brain Computer Interfaces: an assessment of impacts	Velloso, Gabriel Teykal	2012

Ethics and Brain Implants in the Military	Wigan, Marcus	2017
Ethics in Robotics Research	Grinbaum, By Alexei et al.	2017
Finger-Based Gesture Control of a Collaborative Online Workspace	Gadea, Cristian et al.	2012
Future Implantable Systems	Poon, Ada S.Y.	2011
Getting the Best from Nanotechnology: Approaching social and ethical implications openly and proactively	Mills, Kirsty Fleddermann, Charles	2005
Healing the Burn: Advances in Burn Treatment Technology Aim to Save Lives, Lessen Pain and Scarring	Allen, Summer E.	2016
The Ethics of Creating Designer Children	Fielder, John	2007
Microbots on a Fantastic Voyage	Courtland, Rachel	2015
Rescue Robotics	Simpkins, Annellen M. Simpkins, C. Alexander	2014
Safe Product Design, Forensic Engineering, and Asimov's Laws of Robotics	Bilancia, Louis F.	2014
Silent Communication: Toward Using Brain Signals	Pei, Xiaomei Hill, Jeremy Schalk, Gerwin	2014
Sound Technologies, Sound Bodies: Medical Implants with Ultrasonic Links	Arbabian, Amin et al.	2016
Stepping Forward with Exoskeletons	Griffin, Robert	2018
Influence of Science Fiction Films on the Development of Biomedical Instrumentation	Boutillette, Michael et al.	2015
The Internet of Things in the Context of the Philosophy of Technique: The Transformation of Being	Yury, Shaev	2017
Towards a Novel Safely Norm for Domestic Robotics	Wassink, Martin Stramigioli, Stefano	2007
Writing the Future	Vos Post, Jonathan Kroeker, Kirk L.	2000

Annex 2 - Future uses of technologies observed in the documents

independent movement for disabled people	safety bots for static pressure injuries, shock injuries and skin injuries	communication devices for locked in patients
magnetic controlled technologies	prosthetics/chairs controlled by neurotics/brain electrical signals	various body parts, organs and brain implants
affecting computing	personal assistants for medical care	automatic systems for biological regulation
infrared cameras	medical studies	voice synthesizers
exoskeletons	input based on hand gestures	extracellular sensing
nanotechnology	3D printed skin	pulsed electric field treatment
epidermal electronics	microrobots	microgrippers
micro scallops	epilepsy monitoring	electroceuticals
microwave radar	acoustic probes	real-time biofeedback
fire-resistant safety vehicles		

Annex 3 - Future visions and expectations observed in the documents

Adapt medical technologies for home use	Focus the design on the user, which often times is the practitioner
By 2030 civilians will be enhanced by technology	Adapt medical technologies for mainstream consumption: price, quality, esthetics-design, and availability of the product
Trust, capabilities, limits, and the relationship with the user will be concerns about robots	People will be more afraid of robots
There will be efforts made to inform people about technology	technology will be able to understand emotions
Enhancements to the human body will be removed without causing harm to the user	small and versatile implants will “support extracellular and intracellular level distributed biosensing and localized operations"
implantable systems will enable minimally invasive diagnosis and and enhance the success rate of complicated surgery	implants inside biological cells will enable in vivo biosensing and cancer monitoring
Sense electrical activity and share the data through wirelessly to a subcutaneous implantable cardioverter defibrillator	Stronger printed skin
Flexible electronics that deliver Pulsed Electric Fields	Small untethered instruments
Diagnosing diseases earlier and targeting therapies more precisely"	be able to track the technological artifacts we put inside our bodies
find a way to power these artifacts	Apply Medicines in a more targeted manner, reducing doses and side effects
allow humans to communicate silently	
Smart implants for minimally invasive surgical procedures without sacrificing function and performance	IMDs network, working to prevent, diagnose, and treat diseases
Small devices with complex sensing, stimulation, and communication	Provide ways of disabled people to move with the ease of an able-bodied person
Advances in medical IoT network	

Annex 4 - Tips for the Framework

Include a multidisciplinary team	Understand the consequences and impacts
Try to avoid later on costly changes to the product	Understand the marketability and longevity of the product on the long run
Choose the time limit accordingly to your product and emerging technologies	Involve future users and stakeholders in your studies
"roadmapping"	Who? Where? Why? When?
Take into account the education/skills of the future users	Apply regular rules of medical ethics
take into consideration the worst possible medical scenario	Take into account legal Issues
Weather Safety → environmental aspects Mobility	Know the space where the product will be placed and how the two will interact
Make flexible an intelligible rules for usage	Balance the feedback of future users with the knowledge of experts and the design/engineering team

Annex 5 - Science Fiction as inspiration

Sometimes the fears portrayed in Science Fiction regarding the advances of technology become real fear among society	Diffusion of advances on technology in the area of health and Medicine are taken to the public by mainstream mass media, such as programmes and even films.
Asimov's *, I, Robot* pretend to show the impact of emerging technologies	What we thought as Science Fiction a few years ago, is now on the market
People are more willing to try more non-invasive enhancement procedures → not noticeable at first glance, not making them look artificial	Computer interface that is entirely controlled by gestures - Minority Report (2012)
(1966) Fantastic Voyage → microrobots	Choosing characteristics of embryos → we can choose the sex of the baby now
Fears regarding nanotechnology has been portrayed in works such as *Spiderman, Agent Cody Banks* and *The Stepford Wives*	Science Fiction show us some of the worst, more extreme scenarios for things that are already possible
Science Fiction has showed us safety bots, which are being studied right now	Science Fiction works help to wonder about the future
Karel Capek's *R.U.R* shows organic robots → beginning of 2020 discovered possible organic material for nanorobots	*Firefox* and *Avatar*, *Metropolis* → person's thoughts being read directly from his/her brain/transferring it to other bodies
Exoskeletons and prosthetics have been commonly portrayed in Science Fiction and are becoming more and more common (ex. Star Wars)	Dr. Jekyl and Mr. Hyde (based on The Strange Case of Dr. Jekyl and Mr. Hyde) → issues related to bipolar disorder and being able to (or not to) control it
Science Fiction can help people prepare for technological realities that might be true in the future	Andromeda Strain (based on the book), Star Trek's Medical Tricorder a scanner that diagnoses diseases = MedCom and programs that already exist
Some Science Fiction writers were also inventors (such as Robert A. Heinlein)	Small device attached to the belt tells the astronaut the oxygen in his/her blood (ex. Iron Man)
In 1958, Isaac Asimov → handheld programmable calculator that became true 20 years later	Even the name of technology come from Science Fiction (cyberspace → W. Gibson, robot → Karel Capek, robotics → Isaac Asimov)
Dr. Caligari → make men wake from coma	

Annex 6 - Interviews

Questão de abertura: O que costuma fazer no seu dia-a-dia profissional?

a) Tecnologia Hoje

Q.1 Que tecnologia utiliza no seu dia-a-dia como profissional médico?

Q.2 Sente-se confortável com a utilização dessas tecnologias?

Q.3 Das tecnologias que utiliza no seu trabalho, quais considera essenciais para o seu trabalho? Em que medida?

Q.3.1 Alguma vez pensou em alterações que se pudessem fazer a essas tecnologias?

b) Tecnologia no Futuro

Q.1 Considera que há espaço para, como profissional médico, sugerir essas alterações? Estaria interessado em fazê-lo?

Q.2 Quais são algumas tecnologias que pensa que facilitariam o seu trabalho, mas ainda não existem?

Q.3 Das tecnologias que mencionou, considera que alguma delas poderá aparecer num futuro próximo?

Q.4 De seguida irei enunciar algumas tecnologias emergentes que de alguma forma estão relacionadas com a sua profissão, gostaria que comentasse aquelas que mais captam a sua atenção:

- Diagnóstico instantâneo
- Aparelhos de monitorização constante
- Implantes cerebrais
- Sistemas de controlo sem toque
- Sistemas automáticos de regularização biológica
- Microrobôs médicos

c) Ficção Científica

Q.1 Tem conhecimento da ligação de algum artefacto que use diariamente na sua vida profissional que tenha por base um conceito de Ficção Científica? Após a Resposta, se for negativa - Gostaria de lhe dar o exemplo de *Frankenstein*, de Mary Shelley, que fala da utilização de eletricidade para restaurar a vida de um “corpo humano” poucas décadas antes de aparecer o primeiro desfibrilador.

Q.2 Muitos dos artefactos que referi parecem ter sido de alguma foram influenciados pela Ficção Científica. O que pensa acerca da Ficção Científica como fonte de inspiração para o desenvolvimento de artefactos médicos?

d) Guia

Q.1 Design Fiction é um tipo de design especulativo, que utiliza a criação de histórias, em vários formatos, para testar introdução de um produto num determinado contexto. Isto pode ser útil para prever erros no funcionamento do produto, a reação do público ao mesmo e até se ele será mesmo necessário - tudo isto sem o custo de produção de um protótipo.

Q.1.1 O que acha da utilização de um método como este para auxiliar o desenvolvimento de artefactos para a medicina?

Q.2 Considera que se sentiria confortável a utilizar alguns dos instrumentos referidos, caso eles aparecessem num futuro próximo?

Q.3 Já trabalhou com alguma equipa na investigação ou desenvolvimento de um artefacto médico? O que achou da experiência?/Estaria interessado em fazê-lo?

4 O Objetivo desta dissertação é construir uma espécie de guião, que terá o objetivo de ajudar as equipas que desenvolvem artefactos médicos a tirar o máximo partido da Ficção Científica para tomarem decisões mais informadas nesse processo. Este guia, terá em conta não só metodologias já existentes - como o Design Fiction - mas também outras preocupações que vão aparecendo em textos científicos, bem como nestas mesmas entrevistas.

Q.4.1 Considera que sentiria confiante a utilizar uma tecnologia construída a partir de um modelo deste género?

Questão final: No geral, quais são as suas prespetivas para o futuro dos artefactos médicos nos próximos 20 anos?

Annex 7 - MADIS support documents

Medical Artifact Design Inspired by Science-fiction

PAST

Project

What are you working on?
eg. Artificial Heart

Developers

Who are the elements of your team?
eg. John Smith, University of Aveiro

Purpose

What moves you to work on this project?
eg. Enable a longer life to patients with heart issues

Similar Artifacts Seen in Science Fiction

Where have you seen a simillar technology on Science Fiction?

eg. Threshold (1981)

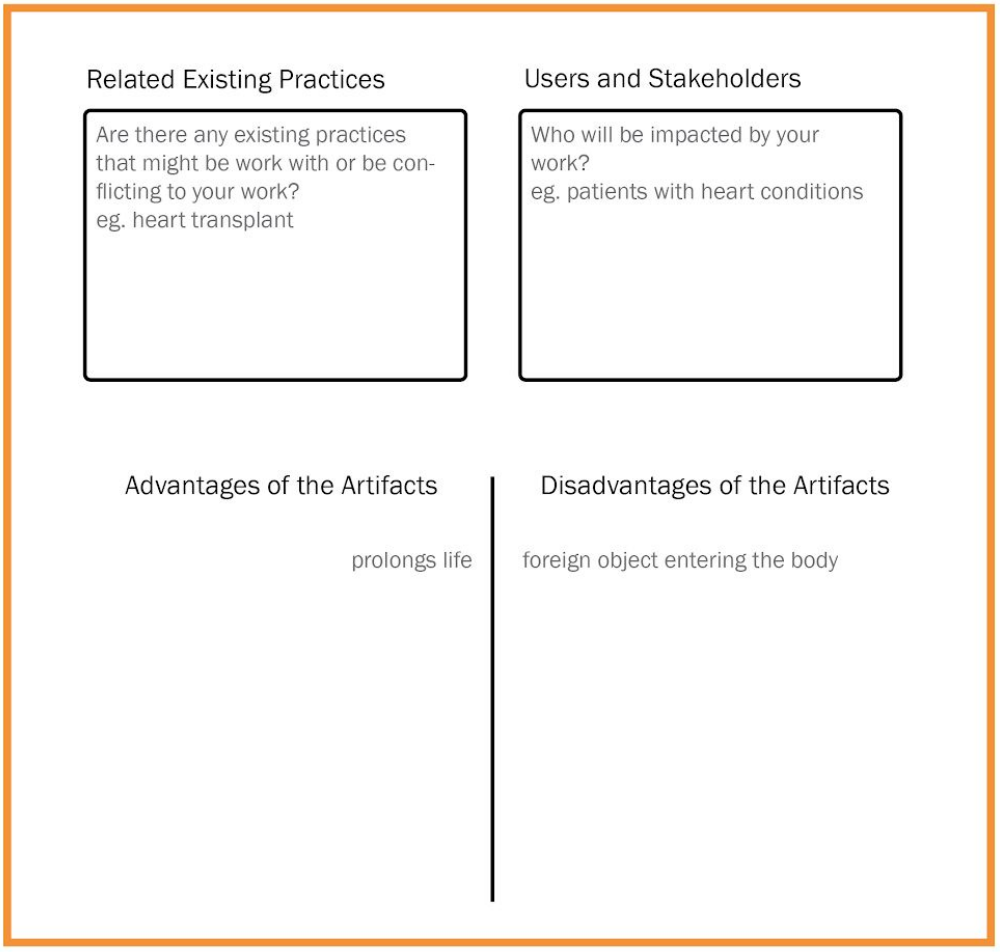
Possible Social Implications of the Artifact on Society

How do you think people will react to this technology?
eg. Lack of acceptance of an artificial heart

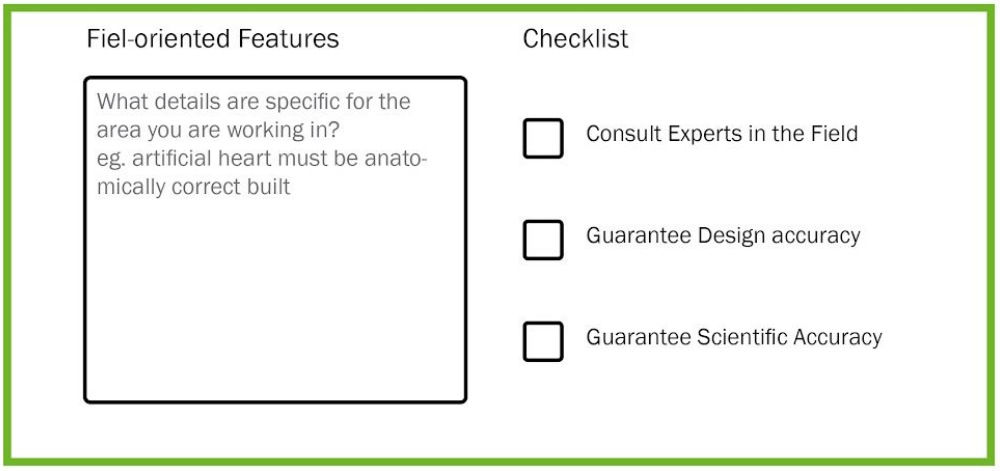
↓

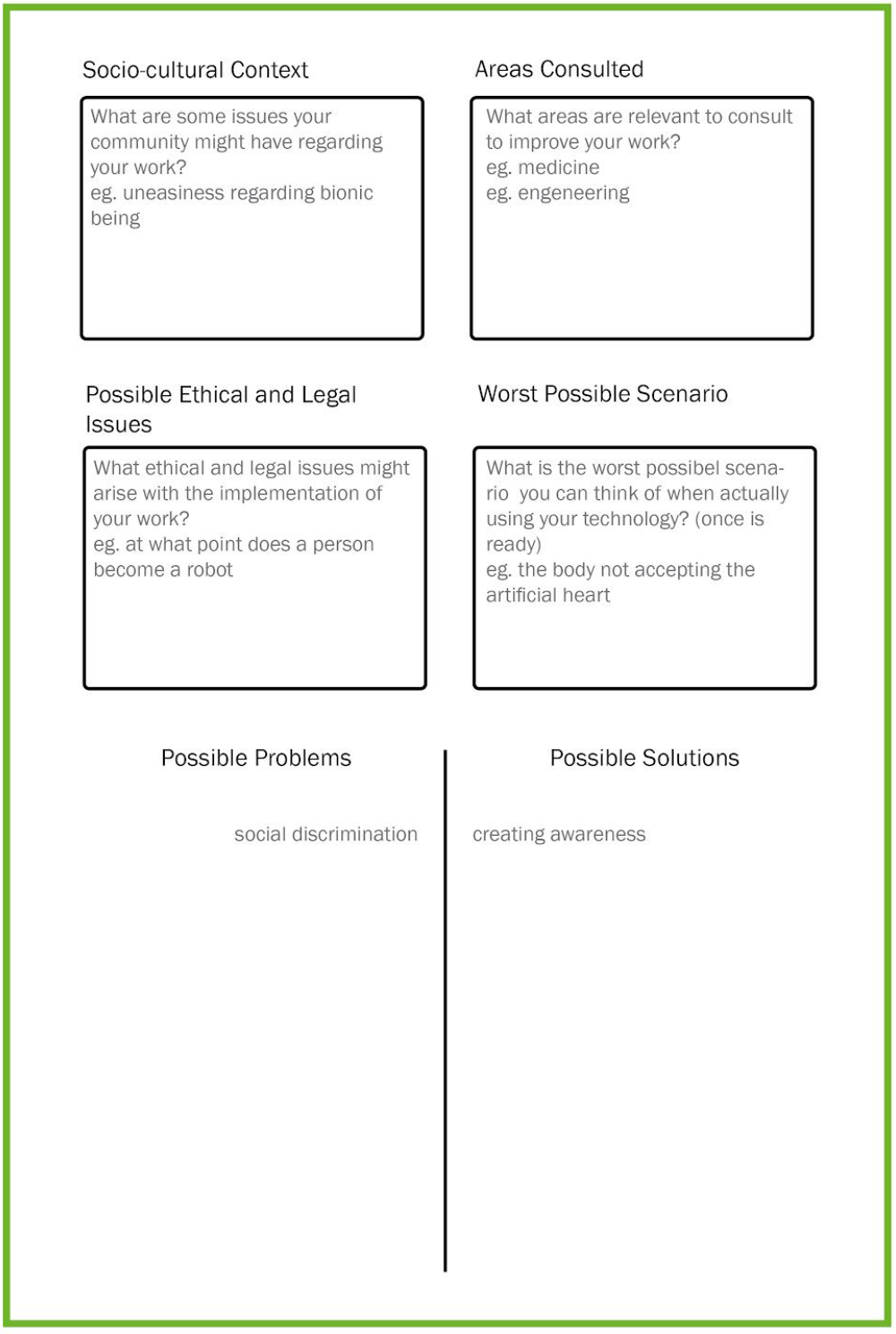
What can we learn from them

What have you learn from these works of Science Fiction that can be applied to your work?
eg. We need to ensure the patient and the public the heart does not change the person


Related Existing Practices
Are there any existing practices that might be work with or be conflicting to your work?
eg. heart transplant
Users and Stakeholders
Who will be impacted by your work?
eg. patients with heart conditions
Advantages of the Artifacts
prolongs life
Disadvantages of the Artifacts
foreign object entering the body

PRESENT


Fiel-oriented Features
What details are specific for the area you are working in?
eg. artificial heart must be anatomically correct built
Checklist
Consult Experts in the Field
Guarantee Design accuracy
Guarantee Scientific Accuracy


Socio-cultural Context
What are some issues your community might have regarding your work?
eg. uneasiness regarding bionic being
Areas Consulted
What areas are relevant to consult to improve your work?
eg. medicine
eg. engeneering
Possible Ethical and Legal Issues
What ethical and legal issues might arise with the implementation of your work?
eg. at what point does a person become a robot
Worst Possible Scenario
What is the worst possibel scenario you can think of when actually using your technology? (once is ready)
eg. the body not accepting the artificial heart
Possible Problems
social discrimination
Possible Solutions
creating awareness

FUTURE

General Idea of the Artifact

here you can write or draw your ideas

Possible Flaws	Possible Solutions
incompatibility with the body	use different materials

13. Endnotes

14.1 Interview excerpts from group A

Interview nr. 1

[4]"Muitas vezes o programa está muito lento, o que atrasa, por exemplo, a nível de consultas (...) não conseguimos prosseguir com a consulta, fica tudo parado" (interview 1, group A)
[12] "Espaço temos, agora… se vão fazer alguma coisa em relação a isso… não sei"
[25] "Em Itália usavam muito esse robô (...) nem sabia que existia tal coisa"
[31] "uma boa fonte de inspiração"

Interview nr. 5

[13] "com o passar dos anos, e por muito que exista a vontade de mudar o sistema, as pessoas acabam por se acomodar"
[14] "Acho que seria importante, por exemplo haver um sistema, a nível nacional (...) que tenha todas as informações de um doente"
[22] "Acho que isso é interessante, mas acho que, mais uma vez, sempre com a interpretação de um médico"
[24] "Eu acho que vais ter uma certa dificuldade em implementar [essas tecnologias](...) acho que neste momento, com os médicos que tu tens (...) vai haver dificuldade em implementar isso"
[30] "os aparelhos da TAC e das ressonâncias e todos os aparelhos de imagiografia para mim são um bocado extraterrestres"
[2] "para mim é uma barreira por exemplo uma impressora que não imprime uma nota de alta, ou uma etiqueta que não sai"
[35] "Isso é tão fundamental, que deve ser efetivamente desde já aplicado"

Interview nr. 6

[3] "No computador nós temos os registos de tudo e mais alguma coisa (...) em cada doente, tens os episódios de urgência, todos, que ele foi. Tens as consultas que o doente é seguido, por isso consegues ver quais são os médicos que o seguem, que já o viram."
[5] "Acho que era preciso criar um sistema que não falhasse tantas vezes"
[15] "Era fixe ter uma máquina que entubasse os doentes sozinha"; "Era fixe uma máquina que pudesse 'scanear' a pessoa e dizer quais são os órgãos que estão a falhar (...) ou que estão afetados"
[23] "É uma maneira de tu eliminares erro humano (...) além de ser ótimo porque poupas imenso dinheiro com a saúde, é muito mais objetivo" (interview 6, group A)
[32] " é preciso ter criatividade e imaginação para contrariar [ideias pré-estabelecidas]"
[42] "Tu não consegues avaliar o verdadeiro impacto dele (...) nem a reação das pessoas até o construíres mesmo"
[43] "Acho que nós vamos ser substituídos por máquinas"

14.2 Interview excerpts from group B

Interview nr. 2

[6] "Um dos problemas dos nossos dispositivos é, muitas vezes, o tamanho"
[10] "passa muito pelas empresas, que acabam por fazer os produtos" (...) " estão continuamente a procurar isso" (...) "muitas vezes as empresas têm uma equipa médica"
[16] "Wireless, quanto mais melhor" → principalmente no transporte de doentes.
[44] "tenho receio que os médicos do futuro se agarrem demasiado às tecnologias e não prestem tanta atenção ao doente"(...)"já se passa um bocadinho isso hoje em dia"; "registo oral, que rapidamente passasse automaticamente para linguagem escrita era uma coisa ótima para nós"
[1] "Muita da tecnologia que existe hoje não existia quando eu fiz a minha formação nesta área"

[33] “Muitas vezes a imaginação das pessoas acaba por ser semelhante. Ou seja, o médico e o escritor se calhar imaginam futuros semelhantes e querem resolver as coisas rapidamente” 41 “realismo seja razoável”
[44] "tenho receio que os médicos do futuro se agarrem demasiado às tecnologias e não prestem tanta atenção ao doente"(...)"já se passa um bocadinho isso hoje em dia"; "registo oral, que rapidamente passasse automaticamente para linguagem escrita era uma coisa ótima para nós"

Interview nr. 3

[7] "que os leitores fossem mais portáteis e que não precisassem de tantos cabos, porque os cabos dificultam-nos muito a gestão do espaço”
[8] “Que nos dessem mais informação ainda (...) máximo de informação em menos dispositivos possíveis”
[9] "a possibilidade de os mesmos dispositivo serem compatíveis em todos o circuito do doente"; "isto é um problema até mais na compra dos equipamentos e na uniformização dos equipamentos do que propriamente o equipamento não existir"
[11] "nós podíamos muito mais ser consultados para perceber se aquilo que está em desenvolvimento faz sentido ou não no dia-a-dia dos doentes"
[17] “Um iPad para cada doente(...)"no sentido de ter à cabeceira da cama do doente toda a informação clínica necessária, o seu historial, os registos....”
[18] "muita tecnologia associada à formação e ao ensino"
[19] "limpeza e desinfecção dos materiais das salas operatórias"(...)"se houvesse um chuveiro ou pulverizador, no tecto, nas paredes, no chão, que permitisse rapidez e eficácia" "uma câmara de pressão (...) desinfecção dos materiais e do transporte para dentro e fora do bloco operatório"
[26] "nunca será substituído na totalidade por uma máquina" mas seria "uma grande ajuda"
[27] haver até ligação a algum sistema de alarme ao médico ou ao enfermeiro que perante um doente que mora não sei a onde, que tem um nível de glicémia baixíssimo, o INEM vai a caminho, em vez de esperarem umas horas para serem encontrados inconscientes e alguém chamar o inem. isso se calhar salvaria muitas vidas (...)a bengala deteta a dificuldade e imprime uma música que ajuda"
[36] “Se calhar nós precisamos muito disso. Até para ajudar a que o desenvolvimento das tecnologias seja mesmo direcionado àquilo que nós precisamos, sem desperdício de dinheiro, de tempo, de recursos numa investigação que depois vai para o lixo porque não faz sentido nenhum”
[37] "sim, desde que isso não substitua a atitude médica, o raciocínio clínico, a ética e acima de tudo que não interfira com a relação médico-doente"
[39] “ dar apoio à formação.”

Interview nr. 4

[20] “deveria haver a possibilidade dos vários sistemas informáticos que existem, programas, etc, poderem ser compatíveis, de modo a ser possível, para cada doente, haver informação global”
[21] "dar informações e fazerem sugestões ao próprio médico" "a inteligência artificial é o futuro (...) e pode ser muito importante na ajuda que dá aos médicos"
[28] “Futuro quase seguro”; "umas camisolas, no fundo, que têm sensores, em que os desportistas (...) controlam a frequência cardíaca, etc."
[29] "também é o futuro" (...) "mais precisão do que a mão do Homem"
[34] “A ficção científica é antecipar. Quer dizer que é, pensar em coisas que nós achávamos que gostaríamos que acontecessem ou que seriam importantes, mas que no momento são inacessíveis, e por isso é ficção”
[38] "o que eu lhe vou fazer é seguramente melhor do que não fazer nada e é melhor do que outros tratamentos que estarão disponíveis"
[40] "aparelhos de monitorização do domicílio"