On The Limitations of Assistive Human-Computer Interaction Technologies: Why Should We Have Them and How To Determine Them?

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The advancement of technology today led to an enormous amount of development in different fields. Also, as technology progresses, the relationship between different disciplines increases. In that context, Human-Computer Interaction (HCI) also started to extend to other disciplines like robotics, statistics, etc. As a result of this involvement, different technology systems like assistive systems emerged as new products. In that sense, it is crucial to investigate how these assistive systems affect our lives, and what are their positive or negative impacts for general users. In this paper, we argue that assistive systems might have unpleasant effects depending on their development purposes and usage areas, therefore there should be certain limits to control research and development processes related to these products even before they are started to being developed. However, we also hold the opinion that the development of these products might be helpful for cumulative technological knowledge and progress, even though they might have unpleasant effects in the areas like military applications. Hence, we should not ban the development of these technologies totally. To state clear boundaries regarding what we should ban or not, we draw certain lines regarding limitations. Related to that, we state that the product should not be harmful to ordinary people and should not provide superiority to its users among other people so that its users can interfere with the freedom of other people. As the discussion pursues, we try to give HCI-related assistive systems examples related to our discussion.

Additional Keywords and Phrases: Human-Computer Interaction, Assistive Systems, Research Limitations, Military Applications, Civilian Use

1 INTRODUCTION

With today's advancement in technology in general, and in Human-Computer Interaction products, more disciplines are getting involved with each other. To give an overview, as robotics gets involved with HCI, this collaborative work leads to more advanced products that which satisfy general user needs. However, it should not be forgotten that research and developments in different specific fields might have usage areas for more general purposes and users. Inevitably, these products will have unpleasant effects for general-purpose usage since their very existence reason is different. Therefore, this paper overviews these unpleasant effects, the boundaries to prevent these effects, and the line that humanity should draw to determine the limits. The paper is going to mention how these unwanted effects occur, why they are inevitable, and what community of scientists and engineers can do to decrease these effects as much as possible. This topic may be of interest to the scientific community because we draw attention to developing HCI technologies in a way that they do not adversely affect.

To make a detailed analysis one by one, we separated the research topic into three parts. In the first part, the question of whether we should have boundaries while developing HCI technologies is discussed by giving examples from military

applications in order to clarify the topic better. In that context, as a second part of the discussion, the possible positive impact of these technologies on technological advancement is discussed with examples of ongoing HCI research. Following these arguments, we then determined limits and boundaries for the HCI technologies in the third part of our discussion. In the literature, a lot of work discussed the advancement of HCI research, and HCI's different applications in robotics, programming, etc. The possible effects of these technologies on people, their advantages, and disadvantages are also thoroughly discussed, even several questions are raised in the literature regarding where to stop while developing these technologies. However, there is a gap in the literature since no or very little amount of work discussed the topic of limits regarding the development of technological products in general and HCI-related applications in specific. Similarly, we did not come across many works that discussed the limits of these technologies by giving examples of HCI applications and we also did not find significant work that draw a certain line related to boundaries. In addition, our goal with this paper is straightforward regarding why we should have limits. First, we aim to provide reasonable grounds for why we should have boundaries while developing HCI-related products. Second, we aim to draw the line that is going to determine the limit based on certain requirements. Without doubt, this paper cannot possibly contain all the discussion regarding the technological limits of HCI products since it is a huge and somewhat "arguable" topic. We limited our paper to having reasonable grounds based on technological advancements that are being developed today. We try to find a way how to adapt "some mechanism" to change the course of action of these technologies to have some boundaries that are going to prevent any harm to humans. The discussion regarding the ethics of developing products such as warfare products were left out of the discussion since it may contain too many subjective comments. In addition, we avoided unrealistic suggestions such as "all military products should be banned".

This study is relevant to HCI theory and ideas such as assistive systems and wearable devices and has taken up research around this topic. The main message of this paper is to suggest that technologies in general, and specifically HCI-related technologies should have some limitations in their development processes. In addition, these technologies should be developed under the limitations that are mentioned in the third part of the discussion. Firstly, we started to discuss the topic by mentioning our opinion about why technological developments should have certain limits in order to prevent unpleasant effects. Then, our opinions related to the characteristics of these limits and boundaries are discussed. Since our topic is complicated, the discussion requires a comparison of general user needs and specific needs. Also, we found very few sources to mention that topic directly. So, we investigated the topic by finding specific papers that are written related to different separate parts of our discussion, or different examples that we mentioned. Then, our method was to combine the ideas from the papers that mention different topics. In the end, we aim to have a full and fluent conclusion related to our research question. To make a summary, Section 2 contains the summary of previous work that we used throughout the paper, Section 3 contains our main motivation to write this work, the main discussion is made in Section 4, and Section 5 has the concluding remarks.

2 PREVIOUS WORK

In order to make a reasonable discussion regarding assistive HCI systems, their applications, unpleasant effects, and limits, a certain flow of topics tried to be followed in this work. To achieve that, previous work that is related to unpleasant and unintended effects of technologies, in general, will be mentioned. Firstly, it is important to mention that as can be seen from the movie "Edge of Tomorrow" [1] and Pacific Rim [2], advanced assistive HCI technologies are generally used in military or warfare applications. Related to this topic, a variety of articles can be found in the literature. In [3], Winterberg discussed how effective Einstein is in his time, and changed our vision deeply related to how we see and understand the universe. However, it is mentioned in the paper that Einstein later regretted his contribution to the development of the

atomic bomb due to its negative effects on humanity. The same topic is also discussed in [4]. In addition, several works like Gill argues about the unpleasant effect of technologies like Artificial Intelligence and raise questions related to the interaction of humanity with advanced AI systems [5]. Similarly, Radanliev et al. [6] discuss concerns and assumptions about the existence of "super-intelligence" that is smarter than humankind. To give an example from robotics research, Hadwick [7] draws attention to the fact that 4-legged robots were started to be developed with funding by defense and military organizations. Also, the statement [8] that is published by Boston Dynamics showed that there are similar concerns related to their products.

In addition to the negative effects of some technological products, several works in the literature argue that they are crucial for technological development. Related to that, Bellais et al. mention that research and development related to military products might have a positive impact on growth and contribute to the cumulative knowledge related to the technology [9]. In addition, they suggested that interaction between military technology and civilian investments might be beneficial. Also, in [10], it is stated that defense investments might positively affect civilian technology innovation. Related to that topic, it is also discussed that the Internet was actually a United States Department of Defense project and then how evolved to a daily use tool [11]. In different work, Morris et al. states that some developments might have undesired results, however, this contributes to the progress [12].

Defense organizations that fund assistive systems can contribute to the development of human safe HCI research. Kumar measured the bullet impact detection of a vest they called the Teleintimation Garment, which could track the health of soldiers [13]. It was emphasized that this project was funded by the Defense Research Development Organization (DRDO) and that it is possible to monitor the health status of soldiers thanks to wearable technology. Also, Vermatten et al. showed that it is possible to treat soldiers and veterans with VR [14]. The Military Mental Health Care of the Dutch Armed Forces aims to increase the level of relaxation of patients over time in an immersive environment where patients convey their war and personal experiences with VR.

One of the studies on assistive systems for the benefit of society aims to facilitate the nonverbal communication process of deaf and disabled people with gesture recognition [15]. Hand gesture recognition is a tool used as assistive system in their project, and Chattoraj et al. has achieved higher performance in HCI technologies with an algorithm that will reduce the delay time. Another area where gesture recognition is used is battlefields. Li et al. has presented a fast method that is tolerant to vibrations and enables gesture recognition in low light, and can work at a distance, by combining it with deep learning [16]. Their multi-stream mechanism used in gesture recognition is robust to noise or blurs in the images from battle.

There are studies that should be considered when determining the boundaries to be drawn in HCI research. As a basis of most of the work related to this topic, Asimov in his work [17], stated three different laws of robotics, which prevent robots to harm humans. The research [12] raise questions about wearable biomimetic implants that can lead a group of people who uses it to a way of transhumanism by providing them more life expectancy. In order to show the effect of creating an environment in which people's freedoms are restricted, the Stanford Prison Experiment is taken into account [18]. They showed that giving a slight superiority to a group of people among another group of people leads to complete disorder and abuse of power.

3 MOTIVATION

In this work, the development of assistive system technologies is generally discussed in the context of how extending these technologies to different fields might cause unintended consequences. Also, arguments that are related to why HCI technologies should have limitations for different reasons are discussed, and the question of how we should determine

these limits tried to be answered via different examples that are inspired by the movies “Edge of Tomorrow”, “Pacific Rim”, and “The Matrix” [1,2,19].

The motivation of this study is to discuss about boundaries of HCI research and possible outcomes of assistive systems in the perspective of general user. The first topic that we want to discuss is to explain how the development of technology, in general, might have negative effects based on the works [3, 4, 5, 6, 7]. However, based on our opinions, we do not aim to completely base our work on limitations because of possible unpleasant effects of high-tech technology products. Therefore, our second aim is to discuss how these products might have contributed to the overall scientific development and knowledge [9, 12], and how they even affect the development of HCI-related products based on the [10, 13, 14]. Hence, our goal is to discuss the idea of we should have limits while developing assistive technologies that might have unpleasant effects, however, we should not cause the limitation of the advancement of humanity by doing so.

As a final opinion of this paper, we want to draw lines related to the limits of developing assistive technologies. Related to that idea, we determined that harm to humanity, providing superiority, and interfering with people's freedom are our main limitations while developing HCI-related assistive technologies. We base our "harming people" idea on the work [17]. Related to providing "superiority" opinion we are inspired by [18] and [12] because these works show that how superiority is closely related to the interference of freedom.

Therefore, starting from the idea of why we should have limits, we pursue the question "Yes, we should have limits, but should we limit them all?". Then, saying no to this question leads us to the question "What should be the basis for limitations?". In the end, we aim to provide a whole discussion related to the usage and limitations of the assistive system as can be observed from the movies.

4 DISCUSSION

As technological development rapidly increases, different HCI technologies that have usability for different fields emerge. While sometimes we may use these technologies in our daily lives to make our lives better, sometimes they are developed to achieve a specific purpose in fields that necessarily do not have everyday applications for people's use. At that point, it becomes a crucial point to determine whether it is acceptable to develop technologies that may have unpleasant impact for people or not. We think that as well as other technological research of any kind, HCI research also should have boundaries in research and development processes. For that statement, several arguments can be given to explain our reasoning behind this idea.

4.1 Why should we have boundaries?

Throughout the history of science, each effort made by scientists led to the technology we have today. As we experience and interact with these technologies in our daily lives, we can argue that some of these technologies are good for us in terms of making our lives easier. However, we can also identify some of the technological advancements as "bad" technologies which have unpleasant effects like weapons, missiles, other military equipment, etc.

Regarding these kinds of technologies, we may not even notice that the technology that we are dealing with can have applications for other areas that have a bad impact on people. To give an example from the negative impact of scientific developments, as mentioned in [4], even Albert Einstein regretted his letter to the President of the United States regarding the development of the atomic bomb. Besides, AI and Machine Learning (ML) research gained great importance for their implementation in various fields of study in recent years. Radanliev et al. discussed a scenario in which even the most intelligent human minds are less intelligent than "super-intelligence of AI" [6]. They conducted forecasts and provided solutions for problems regarding the risks like cybersecurity risks caused by AI. Consequently, the atomic bomb, and super

AI examples clearly show how technological advancement may have unpleasant effects in any kind. Therefore, certain limitations and precautions should be considered even before the foundations of these technologies are studied.

As seen in the movie Edge of Tomorrow [1], wearable technologies and assistive systems can enable us to have power in the future that we cannot have with human abilities. These wearable devices, which enable people to withstand the attacks of creatures, attack them with weapons and move quickly, can be dangerous in general use in a realistic environment. Therefore, although they are successful technologies for military purposes in the film, technologies that are not restricted in general use can cause unpleasant effects such as harming civilians.

To illustrate, the victory of the robots' named "Jaegers" under the control of two people against the invading and world-destroying creatures is depicted in the movie Pacific War [2]. Although this movie sheds light on the power of robots produced and controlled by humans to save the world, considering the attack power of robots, it may pose a danger to the future of the world. The use of human-controlled giant robots in the wars of competing countries can have devastating consequences for the whole world and the society, and developments in the field should be limited.

One of the technological developments that have been started for military purposes and has the potential to be used in many different fields is 4-legged robots. Defense Advanced Research Projects Agency (DARPA) was one of the first to fund the development of these dog-like robots for use in transport in the US military [7]. Boston Dynamics, which they funded, is a company that produces robots that can move very successfully on rough terrain today. These robots attract the attention of many sectors, especially logistics, to be used in fields such as supply chain and warehouse works. Considering the potential areas in which this research could be used, the fact that it was initiated for military purposes is not a serious problem. However, the potential implications of the military's potential use of these robots that are so capable and able to move quickly over rough terrain should also be discussed. Their ability to move like living creatures, and the possibility of combining them with dangerous equipment like weapons reveals the necessity of limits in the development of these robots that we can use in our daily lives. Even company itself made an announcement to state they will never use their robots as a potential threat to society. Therefore, it is clear that they admitted that their robots carry a potential threat [8].

To this point, we presented examples to support the argument of technologies in general and HCI technologies might have unpleasant effects regardless of they are developed for good purposes or not; so, we should have limits. However, technologies that we use today might be outcomes of various fields' research like military. In the following section, the benefits of extending research to various fields is discussed in the scope of assistive systems.

4.2 Why should extended HCI research not be banned totally?

While limiting HCI research in some fields, it must be discussed why research in these areas should not be completely banned. It should not be forgotten that some technologies might be developed with initially good intentions, but then might have bad consequences as mentioned above. In contrast, some technologies might have initially been developed for different purposes but have good results for people. In different ways, the internet might be considered one of the most impactful Human-Computer Interaction mediums of our century. However, as mentioned in [11], internet was a project that is developed by the United States Department of Defense. From a defense project, it now become a "toy" and the most interactive medium for everyone in the world. Thereupon, totally limiting and preventing the development of "unpleasant" technologies like defense and military technologies might not be such a good idea. As Bellais et al. stated, interpreting today's civilian technology and defense technology separately is counterproductive because of contribution of both to the cumulative knowledge [9]. Examples such as Radar and GPS developed for the military also show that some of the technologies we use today come from research in military.

The use of HCI developments in the military or the development of them by being financially supported by the military can also lead to the emergence of satisfactory and positive products. For example, vests produced with conductive fibers can detect bullets and provide information about the patient's health status to a remote center [13]. Monitoring the health of the soldier and detecting bullets in the vest is possible with that innovative technology which is supported by Defense Research Development Organization in India. Moreover, VR can be used in the rehabilitation processes of soldiers [14]. Head-mounted displays and body-tracking sensors are used, and patient's reactions are tracked against the changing simulations. Patients can discover her/his feelings in an immersive environment during therapy. The research which is collaborated with The Military Mental Health Care of the Dutch Armed Forces aims to increase the level of relaxation and personalization of therapies over the time. This research involving military organizations are harmless and contribute to the development of assistive systems.

There is no cause for concern in the continuation of non-harmful research, where assistive systems and HCI research are supported by the military. These studies can lead to the general use of assistive systems. Therefore, it is not realistic and correct to completely ban HCI research that has been expanded for different purposes, but there should be limits for possible disturbing effects.

4.3 What should be the limits?

In order to understand which technology is good for humanity and which technology should have limits, a certain threshold should be determined. Two main points should be discussed when determining threshold; potential harm to people and endangering freedom. A certain product or project should not be harmful to ordinary people. Also, it should not provide superiority to its users so that these users can use the power of these technologies to limit the freedom of other people. Similar thoughts are widely discussed throughout history. The most widely known example is Asimov's three laws of robotics in which the first rule states "A robot may not injure a human being, or, through inaction, allow a human being to come to harm." Also, the other two rules protect the first rule by additionally putting responsibilities on robots.

Today's rapidly increasing militarization has led to an enormous amount of research and development in military products. Also as mentioned in the second section of the discussion, the development of these products carries great importance for the advancement of technology, even for everyday use. These military products are not developed for "good purposes"; however, it should be noted that they are mostly used in warfare in which "armies" of the two opposing countries use each other. The aim of producing them is to use them against other countries' military personnel, not ordinary people. This might seem like a "way around" but limiting the development of warfare products will be unrealistic in every aspect. As mentioned in [12], every technological action has results that are not intentional, and this is what makes the progress.

The first part of our argument states that there should not be any harm to "ordinary people" due to the technologies developed for everyday use. Initial capabilities for the products that are designed for everyday use should be determined at the beginning. For example, gesture recognition is an interesting research topic for using assistive systems for different fields. Chattoraj et al. [15] proposed a real time hand gesture recognition which can be used by deaf people. Their research offers a positive solution to increase the communication of deaf people in society and need not be limited in this regard. On the other hand, Li et al. [16] recommends combining gesture recognition with deep learning to take advantage of HCI technologies on the battlefield. Their solution is effective in solving vibration and low light issues in the use of HCI in long range combat environment. Hence, the possibility of harming civilians by assistive systems such as gesture recognition, which is used for military purposes, should be considered as a limit for HCI research at the first stage.

Secondly, a product should not provide superiority to the user over other people. This topic is also discussed in [12] and they ask can human limits be extended via wearable devices to lead toward transhumanism. From a technological point

of view, they also give an example of a biomimetic implant that humans can wear as a part of their body and can have "more" life expectancy [12]. When we think about the possibility of "wearable body parts" that can give humans the ability to run faster than a train, the importance of the "superiority" topic is more clearly understood. Therefore, the importance of how this superiority will affect other people leads us to our other point, "freedom". Regarding this topic, as can be understood from the Stanford Prison Experiment, giving some group of people superiority among other groups of people, immediately results with superior groups to limit the freedom of other group [18]. Hence, some group of people having a superiority provided by their technological devices can lead these users to limit other people's freedom in different ways. Accordingly, this possibility should not be ignored to set the limits.

CONCLUSION

As we mentioned at the beginning, the limits of HCI research are discussed for the unpleasant effects that may arise from the development of assistive technologies in different fields. In general, assistive systems can meet the needs of general users in many areas and expanding research into different areas is not expected to have a negative impact in general. However, the threats that may be created by technologies developed for specific purposes and not appealing to the general user should be evaluated. As a result of this evaluation, an answer should be sought to the question of whether HCI research should have limits.

The motivation and aim of the study are to be enlightening about the limits of research by discussing the ongoing HCI research and the possible effects of open-to-use HCI products by expanding them to different fields. It has been emphasized that it is not realistic to completely ban research which does not aim for the benefit of the society and continues for a specific purpose as in the military. It is also one of the aims of this study to determine the limitations in the range between not setting limits on HCI research and completely banning some HCI studies.

To reiterate, HCI research that is developed for military purposes and has a high probability of having an unpleasant effect should not be completely banned because many of the products we use today were originally developed to meet military needs. On the other hand, the harmful effects of military to general use must be considered. The limits to be determined should be evaluated from two different perspectives to avoid these unpleasant effects and to prevent civilians from being exposed to this harmful effect: potential harm to people and endangering freedom. One of the unpleasant effects of using assistive systems developed for military purposes is the possibility of harming people. HCI research that is likely to harm civilians should have limits at this point. Furthermore, an HCI product should not have the possibility of establishing a superiority for a person or a group over other people. It is because this superiority, which may restrict people's freedom, can be a part of our lives with many everyday products such as wearable devices.

What makes this study significant is to ensure the continuity of HCI studies, while determining the possible negative effects of these research and drawing boundaries for them. If the limits set in the development of assistive systems are followed, the probability of general users being exposed to unpleasant effects will be significantly reduced. In conclusion, HCI research should have limits in designing technologies such as the assistive system, and these limits should consider the harm and freedom of society.

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