



Understanding the importance of animation in human-computer interfaces and its relation to user experience

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ABSTRACT

Animation is increasingly used in multimedia user interfaces (UI). Ever more applications are including animation to improve their UI and user experience (UX). Animation seems to play a key role to develop user-friendly, easy-to-use and easy-to-understand apps that achieve a satisfactory UX. This work attempts to explain animation performance in multimedia UI and how this affects the UX. We found that: (1) animation is a key element of multimedia UI that strongly affects UX and can improve it, if applied correctly; (2) animation enhances: reduced perceived waiting time, explanatory and cognitive support, efficient feedback and increased user attention; (3) animation's major properties lie in adapting its intensity, function, time and aesthetics to the context of action. Additionally, we identified two categories of animation aspects in multimedia UI: internal aspects and external features. Furthermore, this study demonstrates that the design of animated multimedia interfaces does not have a standardised methodology. Animation is incorporated ad-hoc, under the individual empirical experience of the creators, and without any a priori guarantee of usefulness or success. Therefore, our future work aims to generate an integral model where the variables related to animation in multimedia UI that modulate UX are analysed, and thus improve human-computer interfaces.

CCS CONCEPTS

• **Human-centered computing** → Human computer interaction (HCI); Interaction paradigms; Graphical user interfaces; • **Computing methodologies** → Computer graphics; Animation.

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1 INTRODUCTION

Human-computer interfaces are the artefact by which users interact with computer systems. These human-computer interfaces, also called user interfaces (UI), have evolved over the years with the purpose of improving their usability and acceptance. To achieve this, it has been necessary to analyse the factors and elements to be taken into account in order to develop successful human-computer interfaces. One factor that has become visible as important to build a good UI is user experience (UX). This is obvious when considering that all software applications are developed with the aim of being interacted with by an end-user through an interface. The way such interaction occurs is the UX, thus, in order to develop a good UI, it is essential to consider the UX.

Also, one component of interfaces whose implementation has increased over the years is animation. This growth has been helped by the acceptance of animation by users, who increasingly interact with it by default in very basic computer system activities, such as sending multimedia messages [1]. Animation brings several advantages to both human-computer interface and UX. For example, animation can optimise space on the interface and simultaneously facilitate the user's understanding of the system through timely feedback. Nowadays, animation is present in all computer systems, from administrative systems to video and image processing systems. However, its implementation has become especially popular in multimedia systems (see e.g., [2], [3]). In fact, there are multimedia graphical interfaces where animation is a mandatory element,

such as in video games (see e.g., [4], [5]) and virtual reality environments (see e.g., [6], [7]). Nevertheless, it has been found that animation is sometimes wrongly or unjustifiably used in the UI, which affects the UX. Consequently, it is important to study the use of animation in interfaces to enhance the UX they cause and subsequently implement UI improvements.

Therefore, over the last two decades, the subject of user experience has become popular in the field of human-computer interaction (HCI) and interaction design. The topic's momentum has been linked to the emergence of countless interactive products whose success can be largely explained by their ease of use and efficiency. User experience (UX) is now regarded as an essential requirement within the traditional domain of HCI because UX opens up new possibilities and brings about a novel perspective [8].

The terms UX and UI (user interface) are often used interchangeably due to their similar meaning. It is worth noting, however, that UX focuses on end users and their needs, while UI centred on content and its visualisation. As far as design is concerned, UX is associated with low-fidelity prototyping and UI with high-fidelity prototypes. The design process should consider end-user needs so as not to limit itself to merely producing good visual aesthetics. The user interface allows end users and the system or device to interact, and user experience derives from this very interaction. These paradigms and associated research have flourished, driven by the popularised use of mobile interfaces (smartphones and tablets) and web services [9]. In the same way, UX is playing an increasingly key role in UI design [10].

According to CEO Deborah J. Mayhew [11] five web interface characteristics directly affect user experience: utility, that is, how useful the content of the interface is for the user; the integrity of functionality, i.e., whether the interface fulfils the expected operation; usability, i.e., ease of use of the interface; persuasion, referring to the way in which the interface itself directs the user towards certain behaviours; and, lastly, the graphic design, to the extent that the interface aesthetics can provoke positive or negative emotions. Though these factors refer to web UI, they are of a general nature and can apply to any type of multimedia interface. Along the same lines, Baxley proposed a universal UI model which included UX in its design [12]. It supports certain aspects identified by Mayhew. However, Baxley structured the UI characteristics into three groups. The first is the structure, that is, the internal part of the interface that is invisible to the user. Usability, utility and integrity are located in this structure and are based on the organisational model, the workflow and the conceptual model. The second characteristic is behaviour. Behaviour is associated with usability, persuasion and integrity, the functions of the interface, including user assistance, editing and manipulation, together with viewing and navigation. The last characteristic is presentation, which is related to persuasion and graphic design and encompasses all the interface's aesthetics.

Animations in multimedia UI such as mobile and web interfaces aimed at improving the UI and UX are increasingly common. The reason is that animations can help end users to understand the multimedia UI, thus generating a better UX. However, we have also seen how an incorrect application can increase loading time or distract users [3], and thus trigger the opposite effect. Animation therefore also has detractors [13].

The present article is structured as follows. In Section 2, we explain the context of the study, as well as basic UX/UI design concepts, the role that animation plays in multimedia user interfaces and its relationship with UX. In Section 3, we describe the systematic research methodology followed in the present work. The section falls into two sub-sections: the planning phase and the search strategy. Section 4 presents the results and their links with the research questions. And finally, in Section 5, we draw conclusions from the research findings, specifying the questions left unanswered and that need to be pursued in future work.

2 RELATED WORK

Despite countless studies on UX, difficulties remain regarding the determination of a standardised approach and its dissemination. This is due to the numerous current outlooks that are based on a range of achievements in various disciplines. According to the International Organisation for Standardisation (ISO), UX encompasses end user perceptions and responses resulting from their interactions with a product, service or system [14]. UX embraces different end user factors, their range of emotions, preferences, beliefs, behaviours, physical and psychological reactions taking place at different moments in the user's interaction with the system, service or product. UX thus covers the moments before and after the experience, as well as the time during the experience itself [15]. This is why many studies specify that the subject of UX is much more extensive than the traditional field of usability [8].

According to Forlizzi and Battarbee, UX depends on the following factors: end user disposition, or mood (expectations, mental paradigms, needs and predispositions, among others); the specificities of the product, service or system (interface, functionality, usability, etc.); and the environment in which the interaction takes place (social context, organisation, type of activity, among others). Therefore, UX design can be understood as a multidisciplinary concept [16].

Moreover, after conducting a survey on 275 people in the field of user experience, E. Law found that UX is variable, relative and depends on its context of development. The survey results also suggested that UX should not be socially defined, i.e., regarded as stemming from the user's interaction with a system or product. UX should, on the contrary, be considered as a personal emergence, an individual experience resulting from the interaction [14].

A variety of disciplines, from the social sciences to engineering, have given rise to a range of UX theoretical perspectives and models. There is thus no single way of studying UX. Forlizzi and Battarbee, however, grouped these approaches into three categories: product-centric, user-centred, and interaction-focused perspectives. The product-centric model focuses on identifying the key factors allowing to achieve a pleasant user experience when creating a product or service, from the design phase to its evaluation. The user-centred model helps designers and developers understand end users. This model collects the different disciplinary viewpoints that allow grasping the actions of individuals, as well as the significant aspects relating to the end user's experience of the product or service. Lastly, the interaction-focused model aims at analysing how products or services develop according to the user's actions [16].

Basri's research has also contributed to the conceptualisation of UX. This author grouped three ways of studying UX. The first is

by addressing UX as a phenomenon, covering what UX is, what types of UX exist, and the circumstances in which UX may unfold, as well as defining potential consequences. The second way of studying UX is to consider it as a subject of study and thus analyse the specific experiences entailed, how to create systems capable of creating given user experiences and methods of development and evaluation of UX. The third way is to regard UX as a practice, i.e. approaching it as an integral part of design practices, representing it with prototypes, evaluating it and creating designs that allow elaborating concrete user experiences [17].

With respect to UX improvement, several authors have pointed out that movement – as a component of multimedia interface design – can contribute to improving user experience. Doyun Park, for example, stressed the importance of measuring movement quality to improve user experience, and considered that the affective qualities produced by animation influenced emotions [10]. Likewise, according to Kraft and Hurtienne, light animations can be an efficient way of providing cognitive support without adding to the user’s mental load, helping the user to understand the functioning of the multimedia UI. Light animations have also been found to be very useful to improve gesture-based interactions [3]. Moreover, Jia Yang Ma’s study indicated that micro-interactions (subtle animations that convey the state of the multimedia UI element) can be applied to improve the users’ emotions during their interactions with the UI. They can also strengthen the emotional link between humans and computers [18]. In addition, Chevalier’s work, which covers various perspectives, from academia to industry, led to the conclusion that animation can meet various multimedia UI objectives, including the improvement of UX due to its ability to enrich usability and visual aesthetics. Animation can also fulfil user-support functions as can preserve the context, facilitate the understanding of the UI’s visual messages, provide timely explanations and increase information coding, thus also contributing to improving the UX [19],[20]. Regarding the above, the experiment by Wu, Ziming, et al. links the importance of animation as part of the UX related to user engagement. Animation modifies aesthetic appeal, focused attention, perceived usability and reward, which are elements that are associated to the positive aspects of interaction that seek to increase the engagement [21].

Therefore, analysing user experience is key in different domains and especially in the design of multimedia human-computer interfaces. Indeed, it allows to better understand users’ perceptions of the interface they are interacting with. With the increasing incorporation of animation into multimedia user interfaces, it has become essential to explore in depth how these implementations are being executed and to understand the role of animation in users’ interactions with the multimedia UI as well as their relationship with UX. It is necessary to analyse how the animation design is perceived in the multimedia user interface and to identify its characteristics. This will allow to build an understanding of the type of experience an individual may have, and why, ultimately making it easier to provide people with an enjoyable and meaningful experience [16], [22].

The context of our research is therefore contained within the user experience domain, and focuses on the multimedia interfaces of human/computer interactions. Our study focused on how animation

is being used in these multimedia interfaces and which general design characteristics lead towards a positive user experience.

3 SYSTEMATIC RESEARCH METHODOLOGY

The objective was to conduct a systematic study of the impact of animation within the UX through the multimedia UI. To do this, the search process was divided into two phases: the planning phase, in which we detailed the research objectives together with the search criteria and filters, and the execution phase, in which the results were detailed.

3.1 The planning phase

In this phase, the research objectives were defined together with the questions to be answered in this work and the search strategy adopted.

3.1.1 Research objectives. As seen in the contextualisation section, while different approaches are followed to generate UIs with an adequate UX, it is increasingly common to include animation in multimedia interfaces. The main objective of this study was to understand the role of animation in the design of multimedia user interfaces to achieve a satisfactory user experience, and to discover which essential design features allow a correct implementation. To this end, we raised a number of questions which we sought to answer using the latest research.

3.1.2 Research questions. To meet the planned objectives, three questions were defined, around which a systematic search would later be performed.

- Q1. How does UI influence UX?
- Q2. Is animation one of the important aspects of the multimedia UI to generate a good UX?
- Q3. What considerations need to be addressed to properly implement the animation in the multimedia UI to improve the UX?

3.1.3 Research strategy. We searched the Web of Science (WoS) database to identify the existing literature on the topic. The search was limited to Open Access reading material and we focused on publications in scientific journals or conference proceedings, mainly in English and secondarily in Spanish. The search period was 2015 to 2022. The selected keywords were extracted from the theoretical framework, i.e., (including the keywords in Spanish):

1. User experience, UX, experiencia de usuario
2. User interface, UI, interfaz de usuario
3. Human-computer interaction, HCI, interacción humano computadora, IHC
4. Animation, animación, motion,
5. Design, diseño
6. Multimedia

According to the research context, the following base structure for the search was defined: (1) and (2 or 3) and (4) and (5) and (6). The search was initially performed using titles only. However, given the very limited number of results obtained, we chose to perform the search by topic to obtain a larger range of results. The final search string was as follows:

Table 1: List of selected articles and number of citations collected according to WoS and Google Scholar.

Ref	Pub. year	Pub. type	Ref. WoS	Ref. GS
[23]	2019	Journal Q1, JCR JIF 7.2	27	39
[24]	2015	Journal Q1, JCR JIF 4.4	19	42
[7]	2017	Journal Q2, JCR JIF 2.1	13	26
[6]	2019	Journal Q1, JCR JCI 0.7	1	4
[27]	2017	Conference	1	3
[28]	2020	Conference	0	2
[5]	2019	Conference	0	0
[25]	2018	Conference	0	2
[29]	2018	Conference	0	0
[26]	2015	Conference	0	0

(TS=(User experience) OR TS=(UX) OR TS=(experiencia de usuario)) AND ((TS=(User interface) OR TS=(UI) OR TS=(Interfaz de usuario)) OR (TS=(Human-computer interaction) OR TS=(HCI) OR TS=(interacción humano computadora) OR TS=(IHC))) AND (TS=(animation) OR TS=(animación) OR TS=(motion)) AND (TS=(design) OR TS=(diseño)) AND (TS=(multimedia))

3.2 Execution

The search chain produced 758 articles, which were subsequently subjected to 3 stages of filtering.

In the first stage, the articles that did not belong to the computer science domain were excluded, as the present study focuses on the design of animation in the multimedia UI to improve the UX from a computer science perspective. In this phase, after discarding 105 articles, a total of 653 articles were obtained.

In the second stage, a total of 145 Open Access (OA) articles remained after excluding the articles that were not OA, i.e., 508 articles. The justification of such a decision lies in the fact that OA articles are more extensively disseminated because their consultation is not restricted by a subscription or payment system. They thus gain a wider readership and have a greater impact on the scientific community. In addition, articles that are only published in specific proceedings or that not available even online are very difficult to obtain. It would not make sense to include them in this study since they could not be reviewed.

In the third and final stage, an inclusion criterion was applied when reviewing the article titles and abstracts with respect to the research questions. In this way, we identified whether the content of the articles could provide information to solve the problem raised. After excluding 135 articles, a total of 10 constituted the study's final selection.

Most articles in phase 1 moved on to the next stage, i.e., 87% (653) of the initial total. However, in phase 2, only 19% (145) of the original articles passed the selection process. This was the stage in the which the largest number of articles were excluded. Finally, in phase 3, only 1.3% (10) of the initial set were included in the final selection. The articles finally selected are described in Table 1, in which we include: article title, author, year of publication, type of publication together with relevance, number of citations in WoS and Google Scholar (GS).

4 RESULTS

With respect to the article sample, Figure 1 presents a quantitative analysis showing that the upward trend in the study of animation in relation to multimedia UI and UX has been intermittent. The largest numbers of publications corresponded to the years 2015, 2018 and 2019. One can also see the growing impact of these articles, as articles published in 2019 were cited more than those in previous years. Clearly, articles published in journals had a much greater visibility than articles published in conference proceedings. This affects the number of citations, placing the emphasis on the years in which articles were published in journals

Figure 2 shows that 60% of the selected articles were conference proceedings and 40% were published in a JCR journal (Journal Citation Record). Of these, 75% were indexed by the JIF (Journal Impact Factor) and the remaining 25% by the JCI (Journal Citation Indicator) as they were part of a JCR indexed journal within the last 3 years. If we analyse the citation data, we can again observe that journals indexed in JCR produced a greater impact as they obtained a greater number of citations.

Regarding the percentages indicated in Figure 2, the number of publications per year was not very high. They were, however, considered to be of quality because they were published in the WoS and are OA. In the same way, the publications with the highest number of citations presented an impact factor that was well above that of their respective journals (Table 1). They thus have a notable scientific impact and are relevant to the present study.

We will now explain how our research questions were addressed through the findings presented in the selected articles.

4.1 Q1. How does UI influence UX?

We can see in [23] the importance of reaching a balance between the visual elements in the UI to provide a good UX. They pointed out that an excess of striking visual elements in the UI could result in a low-quality UX and lead to a loss of users due to feelings of harassment. On the other hand, an insufficient amount of visual elements could cause users to feel lost when interacting with the UI, negatively affecting UX. On this subject [6] mentioned that even when a UI visual element fails to significantly improve the system's performance, it can improve the user experience and therefore its use is justified. In [24] was found that the cognitive support provided by a good interface design could improve UX by increasing

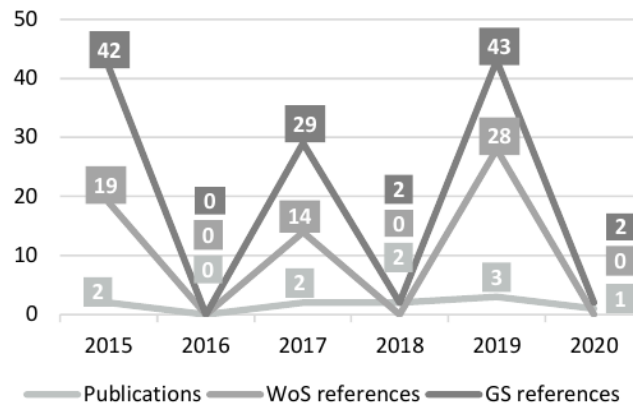


Figure 1: List of publications and citations per year.

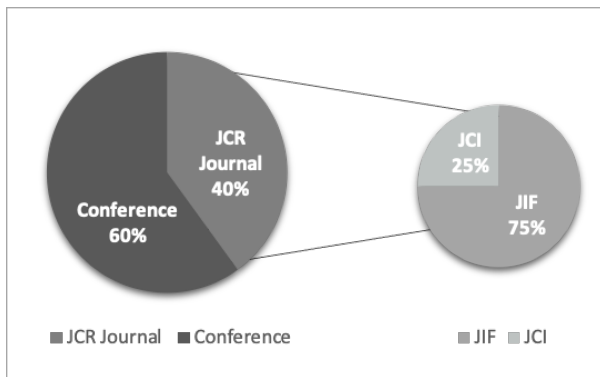


Figure 2: Comparison of publications in journals and conferences.

performance, as well as by building a sense of security and trust in the end user. In the same line, [25] agreed that an intuitive UI positively affected interactive systems such as multimedia ones and could contribute to creating a better UX. In the same way as on mobile platforms, [5] identified and demonstrated through an experiment that by ameliorating the UI design, it was possible to improve user experience and performance in mobile entertainment applications.

In [7] was demonstrated via an experiment the importance of an adequate UI design in a virtual reality (VR) environment for mobile applications. They showed that it was a significant factor to obtain a good user experience and to decrease the potentially negative psychological effects of this immersive experience, such as dizziness due to VR, fatigue and control difficulties. Moreover, [26] adjusted the fundamentals of UI design and study in immersive VR systems in order to meet the new interaction paradigms emerging as a result of these types of experiences and that directly influence UX.

UI has even been found to affect the UX regardless of the end user’s age. Mohammed & Husni [27] noted that user interface design plays an important role in children’s user experience. Their experiment on educational reading applications demonstrated that

by correctly designing the UI, it was possible to increase the children’s engagement with the application and stimulate the child’s interest in reading.

Finally, waiting time plays a notable role for all users. In [28] was highlighted that UI design can influence how users perceive browsing time on websites, which in turn has a substantial effect that is often measured in UX evaluations. Following the same approach, [29] also reached this conclusion, this time in the context of mobile applications.

To summarise, all the studies found that the user interface was a significant factor that affected user experience. Depending on the interface design, alterations could produce negative or positive effects. In addition, this influence could be observed across different multimedia user interfaces: whether on web, mobile or virtual reality platforms. The influence of UI on UX was also independent of the field of knowledge addressed by the systems, such as education, medicine or entertainment. A UI can positively influence the UX even when problems occur in the system’s operation or performance through the use of elements that motivate the user to pursue their mission.

4.2 Q2 Is animation one of the important aspects of the multimedia UI to generate a good UX?

Jankowski et al. [23] found that animation was part of the visual elements that could have an impact on user experience. The study showed how levels of visual intensity affected user responses during the interaction depending on the multimedia UI design and components. In the same way, in [5], animation was considered as a key point in the design and development of a new multimedia user interface to improve a mobile video game’s UX.

As we can see, [24] compared the performance of a multimedia UI with animations and a UI without animations. The results indicated that the UI with animations reduced the reconciliation time, number of clicks and scrolls to perform certain actions in the interface. In addition, it received more positive evaluations from end users, suggesting that its UX was better. On the subject of animation as an instrument to better understand a multimedia UI, [27] proposed

that the use of animation in educational multimedia UIs could significantly improve children's user experience. The results of the experiment indicated that integrating animation into the UI could lead to a more immersive reading experience compared to other static methods, as well as facilitate learning. Likewise, [25] pointed out the need to support users' understanding of certain UI processes and that this was feasible by adding animation in the multimedia UI using a plugin.

Pibernik et al. [6] for their part, showed the advantages of float action buttons (FAB) animation. According to these authors, FAB is an attractive and desirable multimedia UI feature, which, when used correctly, can improve the quality of the UX. They even warned against omitting them in the interface design of applications multimedia, not only in web and mobile environments but also in virtual ones. In the same line, [7] presented a multimedia UI in which the pointer was managed by the user's gaze in virtual reality interfaces on mobile platforms. The objective was to understand whether this type of multimedia interface improved user experience. For the design of its UI, 4 types of multimedia interfaces were considered, including the feedback system, where animation is commonly used in virtual reality environments to indicate to the user that certain actions are being performed on the platform. For example, an animated 2D circular slider is commonly used to indicate the passage of time, and animated buttons are used to confirm decisions. Relating to this, [26] pointed out that animation can be more effective when it is used to reinforce a single idea, providing users with greater clarity and a better UX.

In [28] was studied the perception of the initial page load time (PLT) in relation to the visualisation of website above the fold (ATF) with and without animated content. The aim was to analyse its influence on the quality of the UX. The authors found that animation made it possible to prolong the loading time and at the same time, reduce the user's perception of this time. However, they also signalled that animation in banners and ads could negatively affect attention. In the same way, [29] suggested that the implementation of animation in multimedia UIs could be a practical and useful method to obtain better user experience by improving waiting time perceptions.

Therefore, animation is regarded as an important aspect in the multimedia UI that can affect the UX positively (or negatively). Indeed, the results of the studies above agreed that animation fulfils significant functions such as: facilitating users' understanding of the UI, improving waiting time perceptions, and providing system-user feedback. In relation to this, animation is clearly a key component in multimedia interfaces, particularly in interactive ones, such as virtual reality UI, video games, as well as educational UIs. In addition, there is a tendency to study animation as a UX improvement factor in different types of multimedia user interfaces, whether web, mobile or virtual reality interfaces.

4.3 Q3. What considerations need to be addressed to properly implement the animation in the multimedia UI to improve the UX?

In [23] was explained that the animation's intensity (quantity) influences the attention paid by users when interacting with the

multimedia UI and in turn, intervenes in their UX. The authors point out that the greater the animation intensity used, the easier it will be to attract the user's gaze to the required element, even towards elements that would not be of interest to them if they were static, such as banners. However, increasing animation intensity does not guarantee an increase in attention time, but rather the frequency with which users will direct their gaze towards the animated elements. Similarly, the article indicates that excessive animation intensity will negatively affect the UX and reduce interaction time and conversions.

Moreover, [24] found that to define how animation should be designed and implemented to positively affect UX, it was clearly essential to consider the type of user to whom the multimedia UI was directed and the function fulfilled by the animation. They observed that animation implemented in the user-UI reconciliation process was especially useful for beginner-users. As a result, their UX improved. On the other hand, the animation was not as valuable for advanced users, and their UX did not improve significantly. The reason is that the animation fulfilled the function of supporting beginner-users. Likewise, the animation's duration must also be taken into account. Indeed, during the experiment, some users attempted to begin before the animation had concluded, which can cause users to feel desperate and can negatively affect their UX. Similarly, [27] supported the previous study regarding the importance of defining the animation's targeted user in order to design and implement it properly in the multimedia UI and thus enrich the UX. Their experiment showed that it was not possible to follow the same animation guidelines for adults and children. In addition, [25] also showed that defining the animation's function in the multimedia UI and to whom it was addressed were essential considerations for an appropriate UI design in which animation improved UX. Also in [28] was found that the duration time of the multimedia UI's animated elements had a direct impact on the UX. Their experiment showed that an animation implemented in the multimedia UI for an appropriate period of time enabled to reduce waiting time perceptions and to achieve a more pleasant UX. According to the authors, the animation's speed and loading time were also factors to consider.

Relating to the above, [29] pointed out that the type of animation movement and design in the multimedia UI was associated with the perception of the graphic interface's loading time, the user's attention, and consequently with the UX. Therefore, it had to be taken into account when designing and implementing the animations in the multimedia UI. The study even indicated that the longer the loading time, the greater the impact the type of animation would have on its perception, and that different types of animation could be combined to reduce the time perceived. This finding also agrees with that of [26], regarding the key role of the type of animation movement. According to these latter authors, animated movements in realistic virtual reality environments must take natural human movements as a reference to achieve greater acceptance by the user, thus also leading to a better UX. Regarding VR UI, [6] pointed to the important role of the aesthetics of animated elements: they could lead to greater user acceptance as they make the multimedia UI more attractive and generate a more pleasant UX. In the same line as [24], [28] relating to a multimedia UI's design considerations in virtual reality environments, [7] agreed that it was fundamental

to define the role of the animations and their duration. In their study, the authors found that animation could be very useful in the user-UI feedback system, but that for this, it was necessary to define when and for what it would be used, as well as how long it would last. In their experiment, they exposed that if the animation lasted longer than expected or was not clear, it could be harmful in the UX.

In addition, [5] understood that it was necessary to consider the characteristics of the device for which the multimedia UI with the animation would be designed. Indeed, the type of device would also determine the number of animated elements that could be added to the UI without affecting its performance and consequently its UX.

Having analysed the different proposals, we were able to extract a range of common conditioning factors in the design and development of multimedia UI animation to improve UX. The reviewed works agreed that the considerations to take into account were both internal and external to the animation. The internal characteristics, i.e., belonging to the animation itself, were as follow: duration time, loading time, speed, type of movements, design and aesthetics. The external features depended on the environment of implementation of the animation: the type of interface, user and device to which it is directed, the animation's function and intensity (the amount of animation that would be added to the UI). The external dimension conditions the internal dimension, and it is this internal dimension that will produce the desired effects on the UX.

5 CONCLUSIONS AND FUTURE WORK

The main contribution of this article is to demonstrate the fact that animation in user interfaces is not arbitrary, indeed, it is particularly essential in human-computer interfaces in multimedia applications. Thus, its design and implementation must be handled carefully and thoughtfully in order to enhance user interface and to benefit user experience. Through this work, it was concluded that user interfaces must imperatively contain animation, being as important feature as the security design of a system, the definition of deployment infrastructures or data structures. In fact, some functionalities are impossible or difficult to implement without animated interfaces.

The present research focused on the collection and examination of articles from data sources following the criteria established in the systematic research methodology, ensuring that the selected articles were drawn from high impact sources. Although UX is a broad research domain, the number of reference works was greatly reduced as we focused on a very specific animation aspect, i.e., within HCI multimedia user interfaces. Of the initial number of articles found, only 1.3% focused on the specific topic addressed in the present work. Nevertheless, the questions set out in the study were ultimately addressed in the reviewed works.

The articles were selected according to the criteria of belonging to top scientific OA works, included in the WoS, and that served to answer specific research questions. Of note, a reduced number of articles were found that were directly related to the topic. Therefore, few articles were considered and although the selection was of high quality, several other interesting contributions had to be discarded. Nevertheless, by analysing the selected articles it was possible to answer the research questions and obtain valuable information

for the scientific study of animation, multimedia UI and UX. The conclusions of our study are the following:

- UI significantly influences UX during users' interactions with the system. The UI's design delimits whether this influence is positive or negative and is independent of the type of interface. Regardless of whether it is a web, mobile or virtual reality multimedia UI, animation will always influence user experience. This conclusion is of great interest in a range of disciplines other than IT, i.e., in the social, educational, medical and recreational domains for example.
- Analysis of the articles confirmed that animation is in fact an essential aspect of UX. Animation is indeed highly powerful, and when used correctly, it can positively impact UX. In domains where animation is key, its implementation in the multimedia UI is so common that it is taken for granted, as in the case of virtual reality interfaces, video games or for recreational purposes, acting as a fundamental element in the multimedia interface-user feedback system. In addition to the above, the research pointed to a number of beneficial uses that animation can provide. Animation can be used to direct users' attention to a section of the interface, also providing cognitive support during navigation in the UI. It is even possible to attract the attention of advanced users who focus solely on looking for the information that is of interest to them in the multimedia interface. In addition, animation has the capacity to address one of the priority needs of today's applications, which is to modify the user's perception of waiting time. In this way, it decreases the generation of negative emotions that occur while the user waits for the system to load a process. Animation is frequently used to reduce the perception of waiting time, because it causes a better mental state in the user, which leads to a more pleasant UX. Moreover, animation can be highly instrumental for educational and explanatory objectives, for example, for beginner-users who need a guide to learn or reconcile a UI. In fact, animation helps to explain issues that can be confusing for any user, since a short animation is able to explain an issue much more clearly than a text. These types of aids can help users develop a sense of security and independence, as they can understand how to use the UI without asking for help. Therefore, animation manifestly has the ability to act on users' moods, on their perception and attention in the multimedia UI, as well as on their understanding process. We must remember, however, that animation only improves UX during UI interactions when it is correctly implemented in the UI.
- Regarding the implementation of animation, we observed a research trend focusing on the implementation and performance of animation in different types of multimedia UI, as well as on its impact on UX. Some works openly indicate the need to measure how animation affects UX, because animated elements are being increasingly added to multimedia UIs. It is thus ever more essential to identify how animation can be properly implemented. However, the works did not formalise the study of the essential animation characteristics in multimedia UI to improve UX nor was any homogeneity or

consensus found. The studies did, however, reflect a correlation between UI and UX. The articles also provided valuable information allowing to identify various desirable animation design characteristics. They fell into two categories: internal aspects (duration time, loading time, speed, type of movement, design and aesthetics) and external features (interface type, user type, device type, function to be performed and animation intensity).

It is important to mention that the depth of the article was limited by the strict application of filters in the research methodology, where priority was given to quality rather than quantity. Additionally, because this is a preliminary work in the research we are doing concerning animation quantification in human-computer interfaces. Nonetheless, the results of the work demonstrate that animation is a powerful and increasingly necessary tool for improving interfaces and UX.

For all the above, we detected the need to conduct additional research specifically focused on how to improve UX via the inclusion of animation in the multimedia UI. Such studies, however, should target the creation of a comprehensive model that specifies the variables (dimensions) that affect the result, thus establishing a correlation between these variables and the positive or negative impact on the UX. The model should also be conditioned by the context of interaction: indeed, great variations exist between a user's first contact or conciliation with an application and possible moments of crisis or abandonment, as well as among situations of stress and haste and moments of relaxation. This should lead to a conditional model where internal and external factors are based on a balance according to their values.

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