Accessibility in Human Computer Interaction and Human Robot Interaction: A brief review on definitions, developers guidelines, laws and regulations

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Abstract- This paper presents an exploratory study of accessibility in both Human Computer Interaction and Human Robot Interaction focusing on its intersection with interrelated concepts such as usability and inclusive design. It underscores the overreaching goal of these concepts in improving the user experience and provide equal access to all user interfaces, albeit with different targeted user groups. Furthermore, the study presents a short review on main accessibility laws and developers guidelines for both Human Computer Interaction and Human Robot Interaction. The review reveals a remarkable gap in accessibility laws and guidelines for Human Robot Interaction, hence, there is an urgent need to broader initiatives and efforts from authorities, researchers community, and industry stakeholders to formulate and create accessibility laws and developers guidelines pertaining to Human Robot Interaction products, where no such laws or guidelines were found in this study, except an individual initiative by the author, which includes a proposal dedicated to help developer in creating accessible interfaces for Socially Assistive Robots. This paper also discusses some practical challenges in implementing accessibility guidelines in HCI and HRI interfaces.

Keywords- Accessibility; Usability; Inclusive Design; Human Computer Interaction; Human Robot Interaction; Guidelines; Laws; User Experience; Socially Assistive Robots.

1.   Introduction

The International Organization for Standards (ISO) defines the accessibility term for the interactive system as "the usability of a product, service, environment, or facility by people with the widest range of capabilities" [1], which means all systems´ users should have an equivalent and less discriminatory experience during their interaction with the systems. Accessibility, Inclusive Design and Usability terms are terms that are commonly and widely used regardless of the differences between them and to indicate the same purpose. The three terms vary mainly in the targeted user types.

In Human Computer Interaction (HCI), the necessity to ensure accessibility to all users with different abilities and needs has emerged and thus many countries have laws and regulations to guarantee the accessibility issue. Additionally, accessibility requirements in HCI have been extensively investigated by researchers and industry, where many guidelines and standards were introduced to help designers and developers to create accessible products [2]. In Human Robot

Interaction (HRI), mainly Socially Assistive Robots (SARs), it is difficult to know the extent to which designers and developers of the currently available SARs have committed to implementing the needed accessibility requirements in their designs. It is difficult to give a confident answer comparing to the situation in HCI discipline, due to the absence of specific accessibility laws and guidelines for HRI [3]. Furthermore, none of HCI accessibility guidelines can be completely applied to robotics designing due to the differences in physical interaction components and context of use.

This paper presents a brief review of accessibility, focusing on its definition and a comparison with related concepts, that are usually used in the same context, such as usability and inclusive design. Understanding the distinctions and intersections among these three concepts is vital to enhance design practices among HCI and HRI developers, which will improve user experience consequently. Moreover, such comparisons may enrich the literature and inform policies and standards that aim to enhance digital interfaces. Additionally, this paper provides a succinct overview of existing accessibility laws and guidelines pertinent to HCI and HRI, to identify the main ones and any potential lack or gaps in this regard. The structure of this paper is as follows: Section 2 provides definitions and comparisons of accessibility, usability, and inclusive design concepts. Section 3 presents a short review of the main accessibility guidelines and laws for HCI and HRI. Section 4 discuss some practical challenges in implementing accessibility guidelines. Finally, Section 5 outlines the conclusions of this study.

2.   Accessibility, Usability, and Inclusive Design

In this section, we define and compare the concepts accessibility, usability, and inclusive design, which are commonly used in same context, despite their nuanced differences. The differences among these concepts primarily lie in the targeted type of users.

2.1.   Accessibility vs. Inclusive Design

According to the International Organization for Standardization (ISO) [4], accessibility refers to the "Extent to which products, systems, services, environments and facilities can be used by people from a population with the widest range of user needs". Hence, accessibility focuses on users' needs and abilities and how to guarantee equality in access to all users during their experience.

Another concept that is usually used in the same context of accessibility is Inclusive Design. Microsoft [5] terms Inclusive Design related to user centred design process (UCD) as "A methodology, born out of digital environments, that enables and draws on the full range of human diversity. Most importantly, this means including and learning from people with a range of perspectives". John Clarkson & Coleman [6] define Inclusive Design as "a general approach to designing, in which designers ensure that their products and services address the needs of the widest possible audience, irrespective of age or ability".

Inclusive Design considers more issues than accessibility, for instance, culture, economic situation, and geographic location. Sometimes the terms Universal Design and Design for All are used for the same contextual meaning [7]. The concept of Inclusive Design is more comprehensive than the accessibility concept, (Figure 1).
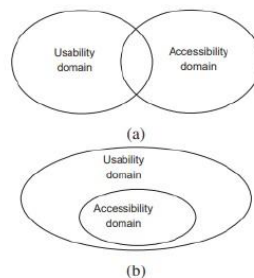
Figure 1. Accessibility compared to inclusive design [8].

in the following subsection the differences between accessibility and usability are highlighted.

2.2.   Accessibility vs. Usability

ISO defines Usability as the "extent to which a system, product or service can be used by specified users to achieve specific goals with effectiveness, efficiency and satisfaction in a specified context of use" [9]. Another definition for usability was set by the Institute of Electrical and Electronics Engineers (IEEE), which defines usability as "The ease with which a user can learn to operate, prepare inputs for, and interpret outputs of a system or component" [10]. Bevan & Petrie [11] have pointed out that there is lack of consensus about accessibility, where Web Accessibility Initiative WAI [7] proposed accessibility as a subset of usability, justifying that accessibility is considered only for a subset of users who are elderly or have disabilities. ISO [9] proposed that usability as a subset of accessibility, justifying that accessibility considers issues for the largest possible range of users, including older and disabled people [11]. Aizpurua et al. [12] have explained that the scope and extent of the relationship between accessibility and usability is difficult to define, since usability and accessibility are two qualities that interact with each other. For websites, if accessibility and usability are not incorporated, then web sites can be either accessible but hardly usable, or usable but hardly accessible. The association between usability and accessibility has been presented by Casare et al. [13] from two different points of view. The first is the complementary concepts which agrees with Aizpurua et al.'s perspective [12], considering usability and accessibility as integrated concepts. The second point of view is to present accessibility as a sub-class of usability which agrees with Web Accessibility Initiative WAI perspective [7]; Figure 2 shows the association between usability and accessibility according to Casare et al. [13].

Figure 2. Accessibility compared to usability: (a) as complementary concepts; (b) accessibility as a sub-class [13].

The next two sections provide a short review on main accessibility laws and developers guidelines for both HCI and HRI.

3. Accessibility Guidelines and Laws

The scope of this short review is outlined to focus on existing accessibility guidelines and laws related to HCI and HRI, covering software and hardware interaction component. The Google search engine, as well as the databases IEEE xplore, ACM Digital Library, and Google Scholar, were utilised in this search. While numerous accessibility guidelines and laws were found for HCI, no such guidelines or laws were identified for HRI.

2.3. Accessibility Laws and Regulations for HCI and HRI

Information Technology has played a major role in the daily activities of humans, therefore, the necessity to ensure accessibility to all users with different abilities and needs has emerged and many countries and organizations issued laws and decisions to guarantee the accessibility issue. In this search, main accessibility laws, regulations, and acts in different countries and international or regional organizations were reviewed. The search was limited to a maximum of two accessibility laws, regulations or acts for each country or organization. The search is also limited to the laws, regulations and acts that explicitly provide accessibility in HCI. Many laws have articles that could be explained and used implicitly for accessibility in HCI.

At countries level. For HCI, the United States of American (USA) has the Section 508 law [14], which is a regulation that expects all federal agencies to guarantee access to all federal agencies' information and communication technology (ICT) such as computers, websites, copiers machines, printers, etc. for people with disabilities [15]. Another accessibility law in the USA is Section 255 of the Telecommunications Act, which is dedicated to the telecommunication industry, such as all types of telephones including mobile phones, faxes, computers with modems, etc. [16].

Further, In United Kingdom (UK), the Equality Act 2010 [17] requires website accessibility for people with disabilities, while The Public Sector Bodies (Websites and Mobile Applications) (No. 2) Accessibility Regulations 2018 [18] maintains mobile applications and websites accessibility. Likewise, UNE 139803:2012 [19] is a Spanish regulation that aims to guarantee the accessibility of web content. Additionally, the German Act on Equal Opportunities for Persons with Disabilities (BGG) [20] and Barrier-Free Information Technology (BITV) [21] are digital accessibility laws in Germany. While China has the Law on the Protection of Persons with Disabilities 1990 [22], which provides for the development and implementation of equipment that eases the difficulties facing people with disabilities.

In Portugal, Decree-Law No. 83/2018 [23] is a national directive that requires web accessibility and mobile applications for all users. As well, the 2010/2012 Jodhan decision [24] and Policy on

Communications and Federal Identity [25] are policies in Canada that require web accessibility. Correspondingly, India has the National Policy on Universal Electronic Accessibility [26], which covers the accessibility issues of electronics and ICT products. France has a law for accessibility of all online public communication services in the country which is Law N° 2005-102 Article 47 [27]. At regional and international level. The European Union (EU) has the European Parliament approved directive 2016/2102 [28], which is a directive that mainly covers accessibility for websites and mobile applications. Moreover, the United Nations (UN) implemented The United Nations Convention on the Rights of Persons with Disabilities [29]. The convention is concerned with protecting the rights of people with disabilities in several areas, including access to information. Table 1 shows the main accessibility laws, regulations, and acts for HCI found in this search.

Table 1. Main accessibility laws, regulations, and acts for HCI.

#	Accessibility laws/ regulations/ acts	Scope	Country/ owner
1	Section 508 law	ICT e.g. computers, websites, copiers machines, printers.	USA
2	Section 255 of the Telecommunications Act	Telecommunication industry, e.g. All types of telephones, faxes, computers with modems.	
3	Equality Act 2010	Websites accessibility.	UK
4	The Public Sector Bodies (Websites and	Mobile applications and websites.	
5	UNE 139803:2012	Web content.	Spain
6	German Act on Equal Opportunities for	Digital Accessibility	Germany
7	Barrier-Free Information Technology	Digital Accessibility	Germany
8	Law on the Protection of Persons with	Development and implementation of	China
9	Decree-Law No. 83/2018	Web and mobile applications.	Portugal
10	The 2010/2012 Jodhan decision	Web accessibility.	Canada
11	Policy on Communications and Federal Identity		
12	National Policy on Universal Electronic	Electronics and ICTs products.	India
13	Law N° 2005-102 Article 47	Online public communication	France
14	European Parliament approved directive	websites and mobile applications	EU
15	The United Nations Convention on the	Access to information.	UN

In this short review, no accessibility laws, regulations or acts for HRI were found, neither at the countries level nor at the international level.

2.4. Accessibility Guidelines and Standards for HCI and HRI

In this section, the main accessibility guidelines and standards for HCI and HRI were reviewed. The focus was on well-known companies and accessibility organizations' guidelines or standards, where it was noticed that many countries have policies to comply with such guidelines and standards. For example, in the UK the BS 8878 [30] standards for web

accessibility were replaced with ISO 30071-1 [31].

For instance, the World Wide Web Consortium (W3C) developed accessibility guidelines, such as the Web Content Accessibility Guideline (WCAG 2.2) [32] for web, non-web content and ICT; the User Agent Accessibility Guidelines (UAAG 2.0) [33] for user agents which render the web content such as browsers, media players, etc.; the Authoring Tool Accessibility Guidelines (ATAG 2.0) [34]; and the Web Accessibility Initiative-Accessible Rich Internet Applications (WAI-ARIA 1.2) [35]. These guidelines help authors specify the proper semantic meaning of web content, hence, allowing Assistive Technologies (AT) to provide user interface behaviours and structural information to the user. W3C accessibility guidelines are comprehensive as they consider several web components such as web content, user agents, authoring tools and assistive technologies. These guidelines are presented for those interested among different types of supporting documents, like success criteria which work as a quick checklist, techniques, best practices and examples that explain how to achieve accessibility. And documents for more understanding and additional guidance for both success criteria and techniques. In addition, the guidelines have a conformance level model which starts with "A" the basic level for accessibility, "AA" the medium level for accessibility and ends with "AAA" the higher level for accessibility.

Funka Nu guidelines [36] which are accessibility guidelines for mobile interfaces by the Swedish consultancy for accessibility and user experience. The guidelines are presented in one document with a brief description for each guideline. IBM accessibility checklists [37] address accessibility issues from software and hardware perspectives such as web, non-web software, documentation and designing accessible hardware like personal computers, servers, printers, etc.

Further, Apple introduced their accessibility guidelines [38] for designing and implementing accessible applications that run on their platforms too. Apple accessibility guidelines are supported with resources and documentation which include a description for each guideline with additional learning sources, coding and graphical examples too. Correspondingly, Android developers [39] present their accessibility guidelines for android applications. The guidelines are presented along with coding and graphical examples, and additional resources (links) to provide more explanations.

The European Telecommunications Standards Institute (ETSI), European Committee for Standardization (CEN) and European Committee for Electrotechnical Standardization (CENELEC) implemented EN 301 549 [40], which is a group of accessibility guidelines for ICT products and services. These guidelines are explained in a document along with their test procedures and evaluation methodology. Moreover, the latest version of these guidelines adopted WCAG 2.1 [41]. A few graphical examples are attached to the guidelines, besides referencing technical reports, ISO and WCAG 2.1 as support documents that could help in implementing the accessibility guidelines. Also, ISO implemented **ISO/IEC 30071-1** [31]

standards for establishing organizational accessibility for ICT systems, such as mobile interfaces, websites, social media, wearable applications, etc. by adopting accessibility policies, and embedding accessibility decisions in ICT systems' lifetime starting from implementing, procuring and installing processes and ending with maintenance process. Table 2 shows main accessibility guidelines or standards found in this search.

Table 2. Main accessibility guidelines and standards for HCI.

#	Accessibility laws/ regulations/ acts	Scope	Country/ owner
1	WCAG 2.2	Web content, non-web content and ICT. E.g. desktops, tablets, laptops, and mobiles.	W3C
2	UAAG 2.0	User agents. E.g. web browsers, media players, and readers.	
3	ATAG 2.0	Authoring tools for developers and users. E.g. web page and multimedia authoring tools.	
4	WAI-ARIA 1.2	Semantic meaning of web content.	
5	Funka Nu	Mobile interfaces and applications.	Swedish consultancy for accessibility and user experience.
6	IBM	- Software. E.g. web, non-web software, documentation. - Hardware. E.g. personal computers, servers, and printers.	IBM
7	Apple's accessibility guidelines for their applications	For all apple's applications (software) which run on different apple's platforms.	Apple
8	Android developers accessibility guidelines	Android applications (software).	Android developer/ Google
9	EN 301 549	ICT product and services. E.g. for web and mobile applications, hardware, etc.	ETSI, CEN and CENELEC
10	ISO/IEC 30071-1:2019	ICT products and services	ISO

Researchers and industry have extensively explored accessibility requirements in HCI. Where many guidelines and standards were presented to support designers and developers to code and create accessible interfaces. However, the applicability of these guidelines to robotic interfaces design is limited due to the disparities in physical components and context of use. In this short review, no accessibility guidelines, standards, or recommendations for HRI were found, despite the work presented by the author herself, where she proposed accessibility guidelines for HRI, mainly focus on SARs [3].

The following section discusses several practical challenges that may obstruct the implementation of accessibility guidelines.

4.   Practical Challenges in Implementing Accessibility Guidelines

Implementing existing accessibility guidelines encompasses several challenges. Technically, designers and developers may face difficulty in understanding some long and extensive accessibility guidelines documents. Moreover, integrating accessibility features into existing digital systems and devices that were initially developed without considering accessibility principals can be challenging. Besides, developing accessible interfaces for users with diverse abilities and needs can increase system complexity and potentially slow down the performance.

In addition to the technical challenges, there is the cost implications. Adopting accessibility in HCI and HRI interfaces implementation requires specialised persons and tools in any team to design, develop and test these interfaces, which can increase the required time and cost for development. Accessibility evaluation tools might be free and open sources weather it is automated tool such as WAVE [42], or for example the use of Large Language Models (LLM) as in [43].

A lack of awareness about the importance of accessibility among developers, combined with insufficient training are other challenges that can affect accessible interfaces development process. Furthermore, the absence or lack of laws and legalisations in some countries creates barriers to ensuring accessibility standards are met during development process of digital products [44], where developers or organisations may deprioritise the implementation of accessibility features.

5.   Conclusion

The brief review presented in this paper explore accessibility in HCI and HRI regarding, comparative analysis of related concepts, existing designers and developers guidelines and laws. Accessibility, usability, and inclusive design are interrelated concepts, which usually used to refer to the same context. It is true that these concepts share the overreaching goal of improving user experience in general in addition to provide equal access to user interfaces, however the differences among these concepts primarily lie in the targeted type of users. Accessibility laws, regulations and acts at countries level and international levels were briefly reviewed in this study. Fifteen accessibility laws, regulations and acts were identified, in addition to the scope of each one. The laws varied in terms of the aspects they considered, both software and hardware interaction component. No accessibility laws, regulations or acts pertaining to HRI were identified during this brief review. Ten HCI accessibility guidelines and standards were identified along with the scope and owner of each one. While No accessibility guidelines, standards, or recommendations for HRI were found, despite the work proposed by the author.

This situation highlights the urgent need to broader efforts and initiatives from authorities, academia, and industry to establish more comprehensive accessibility laws and guidelines,

especially for HRI. Additionally, it is crucial to raise awareness among all stakeholders about the significant impact of accessibility and provide training to designers and developers and allocate the needed resources to encourage accessibility practices in any project.

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