NOTEBOOK

Human-Computer Interaction

Accessibility

HCI course notes about accessibility, interfaces, and devices

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Summary

Preface

This book is a collection of notes, providing a concise introduction to the human factors that influence human-computer interaction. It is designed for university students studying human-computer interaction, user experience design and does not have the goal to address a full accurate discussion on the topic.

The content focuses on core concepts and fundamental topics that explain how human perception, memory, thinking processes, and cognitive biases affect the way people interact with technology. By understanding these human elements, designers can create interfaces that work with—rather than against—human capabilities and limitations.

Each chapter presents essential principles with clear explanations and practical implications for interface design. The concepts covered in this textbook are drawn from cognitive psychology, neuroscience, and human factors research, applied specifically to the context of human-computer interaction.

This condensed edition emphasizes definitions, key concepts, and direct applications to interface design, providing a solid foundation for further study in the field.

The updated version of this content can be downloaded

CHAPTER 1.
Introduction to Accessibility in Human-Computer Interaction

1.1. Definition of Accessibility

Accessibility in human-computer interaction refers to the design of products, devices, services, or environments that enables people with disabilities to access and use them effectively. The World Wide Web Consortium (W3C) Web Accessibility Initiative (WAI) defines web accessibility as "People with disabilities can use the Web" [1]. This encompasses the ability to perceive, understand, navigate, interact with, and contribute to digital systems.

The Italian legislation, known as the "Legge Stanca" (Law 9 January 2004, n. 4, art. 2), provides a comprehensive definition: "The ability of computer systems, within the forms and limits allowed by technological knowledge, to provide services and information that can be used without discrimination, even by those who, due to disabilities, need assistive technologies or special configurations" [2].

1.2. Accessibility as a Social Issue

Accessibility is fundamentally a social issue because it directly impacts the ability of individuals to participate fully in society. In our increasingly digital world, access to information and services through technology has become essential for education, employment, healthcare, civic participation, and social connection.

According to ISTAT (the Italian National Institute of Statistics), approximately 3,150,000 people in Italy live with disabilities, representing about 5.2% of the population [3]. Globally, the World Health Organization estimates that over one billion people, or about 15% of the world's population, live with some form of disability [4].

When digital technologies are not accessible, they create barriers that exclude these individuals from essential services and opportunities. This exclusion constitutes a form of discrimination and contributes

to social inequality. The COVID-19 pandemic demonstrated how accessibility directly impacts public health outcomes when many government services moved online.

1.3. The Importance of Accessibility in Modern Computing

Accessibility in modern computing provides several key benefits:

Universal Usability: Accessible design often leads to improved usability for all users. Features originally designed for people with disabilities, such as keyboard shortcuts, voice recognition, and high-contrast modes, frequently benefit users in various situations.

Expanded Market Reach: Implementing accessibility expands the potential user base of digital products and services. Research shows that accessible e-commerce platforms can see conversion rate increases of 8-17% [5].

Legal Compliance: Accessibility is increasingly becoming a legal requirement. The European Accessibility Act, effective June 28, 2025, requires companies with at least €2 million in revenue and/or 10 employees to ensure their products and services are accessible [6].

Corporate Social Responsibility: Accessibility aligns with broader principles of ethical computing and contributes to a more equitable society.

1.4. Overview of Human Factors in Computing

Human factors in computing, also known as ergonomics, studies how humans interact with computer systems and how these systems can be designed to match human capabilities and limitations. Several key factors are particularly relevant to accessibility:

Perceptual Factors: Humans perceive information through visual, auditory, and tactile channels. Disabilities may affect one or more of these channels, requiring alternative means of information presentation.

Cognitive Factors: These include memory, attention, problem-solving, and decision-making processes. Cognitive impairments may affect how users process and understand information.

Motor Factors: Physical abilities related to movement and manipulation of interface elements. Motor impairments may require alternative input methods or modified interface designs.

Contextual Factors: Environmental and situational factors that may temporarily affect user abilities, such as lighting conditions, noise levels, or device limitations.

CHAPTER 2.

Understanding Human Abilities and Limitations

2.1. Categories of Disabilities

Understanding different types of disabilities is crucial for designing accessible systems. Disabilities can be categorized into several main types:

Visual Impairments: These range from complete blindness to various degrees of low vision, including color blindness. Visual impairments affect approximately billion people worldwide [7]. Users may rely on screen readers, braille displays, or screen magnification software.

Hearing Impairments: These include deafness and various degrees of hearing loss. Hearing impairments affect how users perceive audio content and may require visual alternatives such as captions or sign language interpretation.

Motor Impairments: These affect physical movement and can range from temporary injuries to permanent conditions affecting limbs, coordination, or fine motor control. Users may require alternative input devices or modified interaction methods.

Cognitive Impairments: These affect mental processes such as memory, attention, language processing, and problem-solving. Examples include dyslexia, ADHD, autism spectrum disorders, and dementia.

2.2. Temporary Disabilities and Situational Limitations

Accessibility considerations extend beyond permanent disabilities to include temporary conditions and situational limitations:

Temporary Disabilities: Broken arms, eye infections, or temporary hearing loss can create short-term accessibility needs that benefit from the same design considerations as permanent disabilities.

Situational Limitations: Environmental factors such as bright sunlight making screens difficult to read, noisy environments affecting audio perception, or using devices while multitasking can create temporary accessibility challenges.

2.3. Aging and Progressive Limitations

Age-related changes affect various human capabilities and represent a growing concern as populations age globally:

Vision Changes: Presbyopia, reduced contrast sensitivity, and increased susceptibility to glare are common age-related vision changes that affect interface usability.

Hearing Changes: Age-related hearing loss, particularly in higher frequencies, affects the perception of audio interfaces and alerts.

Motor Changes: Reduced dexterity, slower movement, and decreased precision affect interaction with small interface elements and complex gestures.

Cognitive Changes: Changes in working memory, processing speed, and attention may affect how older users interact with complex interfaces.

CHAPTER 3.

Assistive Technologies

3.1. Definition and Purpose

Assistive technologies are tools, devices, or software applications that help people with disabilities perform tasks that might otherwise be difficult or impossible. In the context of human-computer interaction, assistive technologies serve as intermediaries between users and digital systems, translating inaccessible content into accessible formats.

3.2. Technologies for Visual Impairments

Screen Readers: Software applications that convert text and interface elements into speech or braille output. Popular screen readers include JAWS (Job Access With Speech), NVDA (NonVisual Desktop Access), and VoiceOver (built into Apple devices). Screen readers rely on proper semantic markup and alternative text to provide meaningful information to users.

Braille Devices: Hardware devices that convert digital text into tactile braille characters. These include refreshable braille displays that connect to computers and mobile devices, allowing users to read content through touch.

Screen Magnifiers: Software that enlarges portions of the screen for users with low vision. These tools often include features such as color inversion, contrast enhancement, and cursor tracking to improve visibility.

3.3. Technologies for Motor Impairments

Alternative Input Devices: These include specialized keyboards, joysticks, switches, and sip-and-puff devices that allow users with limited mobility to control computers through alternative means.

Eye-tracking Systems: Technology that allows users to control computers using eye movements and blinks. Modern eye-tracking systems can provide precise cursor control and text input capabilities.

Voice Recognition: Software that converts spoken words into text input or system commands. Advanced voice recognition systems can provide comprehensive computer control through speech.

3.4. Technologies for Hearing and Cognitive Impairments

Hearing Technologies: Include visual alert systems, vibrating notifications, and real-time captioning services that provide visual alternatives to audio information.

Cognitive Support Technologies: Include text-to-speech software, word prediction tools, and simplified interfaces that help users with cognitive impairments process and interact with digital content.

Augmentative and Alternative Communication (AAC): Devices and software that help users with communication difficulties express themselves through symbols, text, or synthesized speech.

3.5. Future Trends in Assistive Technologies

Artificial Intelligence Integration: AI-powered assistive technologies are becoming more sophisticated, offering features such as automatic image description, intelligent content summarization, and predictive text input.

Brain-Computer Interfaces: Emerging technologies that allow direct neural control of computer systems, potentially providing new interaction methods for users with severe motor impairments.

Mainstream Integration: Assistive technologies are increasingly being integrated into mainstream devices and operating systems, making them more accessible and reducing stigma.

CHAPTER 4.

Accessibility Guidelines and Standards

4.1. Web Content Accessibility Guidelines (WCAG)

The Web Content Accessibility Guidelines (WCAG) 2.1, developed by the W3C, provide the international standard for web accessibility. WCAG is organized around four fundamental principles, known by the acronym POUR:

Perceivable: Information and user interface components must be presentable to users in ways they can perceive. This includes providing text alternatives for images, captions for videos, and sufficient color contrast.

Operable: User interface components and navigation must be operable. This includes making all functionality available via keyboard, providing users enough time to read content, and avoiding content that causes seizures.

Understandable: Information and the operation of user interface must be understandable. This includes making text readable and understandable, making content appear and operate in predictable ways, and helping users avoid and correct mistakes.

Robust: Content must be robust enough to be interpreted reliably by a wide variety of user agents, including assistive technologies. This includes using valid, semantic markup and ensuring compatibility with current and future assistive technologies.

4.2. WCAG Conformance Levels

WCAG defines three levels of conformance:

Level A: The minimum level of accessibility. Addresses major barriers but may not provide comprehensive accessibility.

Level AA: The standard level recommended for most websites and applications. Addresses significant barriers and is often required by legislation.

Level AAA: The highest level of accessibility. Provides comprehensive accessibility but may not be practical for all content types.

4.3. WAI-ARIA (Accessible Rich Internet Applications)

WAI-ARIA provides semantic information about elements to assistive technologies, particularly for dynamic content and complex UI components. ARIA includes:

Roles: Define what an element is or does (e.g., button, navigation, alert).

Properties: Define properties of elements (e.g., aria-label, aria-describedby).

States: Define current conditions of elements (e.g., aria-expanded, aria-checked).

4.4. Regional and National Standards

Section 508 (USA): Requires federal agencies to make their electronic and information technology accessible to people with disabilities.

European Accessibility Act: Requires accessibility for various products and services across EU member states, effective June 2025.

EN 301 549: European standard that defines accessibility requirements for ICT products and services.

CHAPTER 5.

Design for Accessibility

5.1. Principles of Accessible Design

Universal Design: The design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation. The seven principles of universal design provide a framework for creating inclusive solutions.

Inclusive Design: A design methodology that considers the full range of human diversity with respect to ability, language, culture, gender, age, and other forms of human difference.

Design for All: A European approach emphasizing the design of mainstream products and services that are accessible and usable by as many people as reasonably possible without the need for specialized adaptations.

5.2. Semantic HTML and Proper Markup

Proper HTML structure is fundamental to accessibility:

Semantic Elements: Using HTML elements according to their intended meaning (e.g., headings for structure, lists for grouped items, buttons for actions).

Heading Structure: Creating logical heading hierarchies (h1-h6) that provide clear document structure for screen reader users.

Form Labels: Associating form controls with descriptive labels using the `<label>` element or aria-labelledby attribute.

Alternative Text: Providing meaningful alternative text for images that conveys the same information or function as the image.

5.3. Color and Contrast Considerations

Color Contrast: Ensuring sufficient contrast between text and background colors. WCAG requires a contrast ratio of at least 4.5:1 for normal text and 3:1 for large text at Level AA.

Color Independence: Not relying solely on color to convey information. Important information should also be indicated through text, icons, or other visual cues.

Color Blindness: Considering how content appears to users with various types of color vision deficiencies, which affect approximately 8% of men and 0.5% of women.

5.4. Keyboard Accessibility

Keyboard Navigation: Ensuring all interactive elements can be accessed and operated using only a keyboard. This includes providing visible focus indicators and logical tab order.

Skip Links: Providing mechanisms for keyboard users to skip repetitive content and navigate directly to main content areas.

Keyboard Shortcuts: Implementing consistent and discoverable keyboard shortcuts for frequently used functions.

5.5. Responsive and Adaptive Design

Flexible Layouts: Creating layouts that adapt to different screen sizes and orientations while maintaining accessibility.

Touch Targets: Ensuring interactive elements are large enough for users with motor impairments (minimum 44x44 pixels recommended).

Zoom Support: Ensuring content remains functional and readable when zoomed to 200% magnification.

CHAPTER 6.

Testing and Evaluation

6.1. Automated Testing Tools

Automated testing tools can identify many accessibility issues quickly and consistently:

axe-core: A popular accessibility testing engine that can be integrated into development workflows and testing frameworks.

WAVE (Web Accessibility Evaluation Tool): A browser extension and online tool that provides visual feedback about accessibility issues.

Lighthouse: Google's automated testing tool that includes accessibility audits as part of its performance and quality assessments.

Pa11y: A command-line tool for automated accessibility testing that can be integrated into continuous integration pipelines.

6.2. Manual Testing Techniques

While automated tools are valuable, manual testing is essential for comprehensive accessibility evaluation:

Keyboard Testing: Navigating through the entire interface using only a keyboard to identify navigation issues and missing focus indicators.

Screen Reader Testing: Using screen readers to experience how content is presented to users with visual impairments.

Color and Contrast Testing: Manually checking color combinations and testing how content appears to users with color vision deficiencies.

Cognitive Load Assessment: Evaluating whether interfaces are clear, predictable, and not overwhelming for users with cognitive impairments.

6.3. User Testing with People with Disabilities

The most valuable accessibility testing involves actual users with disabilities:

Recruitment: Working with disability organizations and accessibility communities to recruit diverse participants.

Testing Environment: Ensuring testing environments accommodate participants' assistive technologies and preferences.

Methodology: Using appropriate testing methods that account for different communication styles and interaction patterns.

Feedback Integration: Systematically incorporating user feedback into design and development processes.

6.4. Accessibility Audits and Compliance Testing

Conformance Evaluation: Systematic evaluation against WCAG guidelines to determine compliance levels.

Expert Review: Having accessibility experts review interfaces for potential issues and improvement opportunities.

Legal Compliance: Ensuring interfaces meet relevant legal requirements in target jurisdictions.

CHAPTER 7.

Legal and Ethical Considerations

7.1. International Legal Framework

UN Convention on the Rights of Persons with Disabilities: Establishes the international legal framework for disability rights, including access to information and communication technologies.

European Accessibility Act: Requires accessibility for various products and services across EU member states, with significant penalties for non-compliance.

Americans with Disabilities Act (ADA): While not explicitly covering websites, has been interpreted by courts to apply to digital accessibility.

7.2. Business Case for Accessibility

Market Expansion: Accessible design expands potential user base to include people with disabilities, representing significant market opportunity.

Risk Mitigation: Proactive accessibility implementation reduces legal risks and potential litigation costs.

Innovation Driver: Accessibility constraints often drive innovative solutions that benefit all users.

Brand Reputation: Commitment to accessibility enhances brand reputation and demonstrates corporate social responsibility.

7.3. Ethical Considerations

Digital Rights: Access to digital information and services is increasingly recognized as a fundamental right in the digital age.

Social Justice: Accessible design contributes to social equity and inclusion, reducing digital divides.

Professional Responsibility: Designers and developers have professional and ethical obligations to create inclusive technologies.

CHAPTER 8.

Future Directions

8.1. Emerging Technologies and Accessibility

Artificial Intelligence: AI technologies offer new opportunities for accessibility, including automatic captioning, image description, and personalized interfaces.

Virtual and Augmented Reality: Immersive technologies present both opportunities and challenges for accessibility, requiring new interaction paradigms and guidelines.

Internet of Things (IoT): Connected devices need accessible interfaces and interaction methods to be usable by people with disabilities.

Voice Interfaces: Voice-controlled systems can provide accessible interaction methods but must also accommodate users who cannot use voice input.

8.2. Evolving Standards and Guidelines

WCAG 3.0: The next generation of accessibility guidelines aims to be more flexible, testable, and applicable to emerging technologies.

Mobile Accessibility: Increasing focus on accessibility for mobile devices and touch interfaces.

Cognitive Accessibility: Growing recognition of the need for guidelines addressing cognitive and learning disabilities.

8.3. Organizational Change

Accessibility Culture: Building organizational cultures that prioritize accessibility from the beginning of design and development processes.

Training and Education: Increasing accessibility knowledge and skills across design and development teams.

Policy Integration: Integrating accessibility requirements into organizational policies and procurement processes.

CHAPTER 9.

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