Interaction between humans and computers: key aspects and evolution

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Abstract:

Introduction/purpose: The research aimed to analyze the key aspects of human-computer interaction, studying the evolution of this field from its beginnings to contemporary trends. Focusing on different aspects of this interaction, it studied how methods, technologies and principles have evolved over time and shaped our experiences in the digital environment.

Methods: The research methodology was based on the analysis of relevant literature and research papers devoted to human-computer interaction. Systematic review and evaluation of sources identified the key information on the evolution of user interaction with computers. Through evaluation of available studies, changes in interface design methods, interaction technologies and understanding of user needs over time were identified.

Results: Based on data synthesis, the key aspects of human-computer interaction were identified. An analysis of the literature revealed changes in interface design methods, interaction technologies, and understanding of user needs over time. Specific results included information on the evolution of interaction aspects, including improvements in efficiency, intuitiveness and personalization of experiences.

Conclusion: The key conclusion of the research is that innovations and evolution of technology have significantly influenced the way users interact with computer systems. Improvements in interface design, recognition technologies, and personalization of experiences are key factors in creating better user experiences and optimizing human-computer interaction. The research points to the continuous development and changes in the field of

human-computer interaction, emphasizing the need for further research and innovation in this area.

Key words: human-computer interaction (HCI), graphical user interfaces (GUI), user experience (UX), internet revolution, mobile revolution.

Introduction

The interaction between humans and computers is becoming ubiquitous in today's society, defining the way we communicate, work, and entertain ourselves. This paper explores the key aspects of this interaction and examines how it has evolved over time.

The development of human-computer interaction represents an impressive journey through time, shaped by key technological milestones and societal changes. The pioneering period in the history of computers, spanning from 1940 to 1950, marks the onset of the computer era and the development of the first digital computers. This period is characterized by experiments, pioneering work, and radical innovations in the field of computer technologies (Rojas, 2002).

The transition to programming (1950-1960) signifies the second phase in the history of computers, bringing significant changes in the approach to programming and computer usage. During this period, computers became prevalent in scientific and business communities, and programming evolved from low-level machine language to the use of high-level programming languages (Campbell-Kelly, 2007).

Starting from the early computers, interaction took place through command lines, leading to the development of graphical user interfaces (GUI) that facilitated interaction. The evolution also includes the development of mobile devices, virtual reality, and other interfaces.

The era of graphical user interfaces from 1980 to 1990 marks a period in which computers shifted from textual interfaces to visually richer user interfaces, significantly changing how people interacted with computers (Engelbart, 1962).

The Internet revolution (1990-2000) signifies a period of rapid growth, development, and commercialization of the Internet. During this decade-long period, the Internet transformed from an academic and military network into a global phenomenon that changed the way people communicate, work, and access information (Berners-Lee, 1989).

The mobile revolution (2000-2010) represents a period of significant development in mobile technology, bringing numerous innovations such as smartphones, mobile applications, broadband Internet access, and changing the way people communicate and use mobile devices (Jobs, 2007).

The era of artificial intelligence (AI) and virtual reality (VR) from 2010 to the present day is marked by accelerated progress in the field of artificial intelligence, machine learning, deep learning, as well as the development of VR and augmented reality (AR) technologies (Goodfellow et al, 2016).

Historical context of human-computer interaction

The evolution of human-computer interaction represents an impressive journey marked by constant technological innovation. This chapter highlights the key moments in the history of this relationship and provides insight into how technological breakthroughs shaped our ability to communicate with computers.

Early computer systems (1940-1950)

In the early decades of the computer era, interaction with computers was limited to physical connections and programming via punched cards. ENIAC, constructed at the University of Pennsylvania, was the first general-purpose digital computer.

ENIAC was one of the earliest large-scale computers, where communication with the machine was rudimentary and required direct manipulation (Rojas, 2002). Physically, ENIAC was immense by contemporary computer standards, aimed at performing mathematical operations faster than humans.

It comprised 17,468 vacuum tubes, 7,200 crystal diodes, 1,500 relays, 70,000 resistors, 10,000 capacitors, and around 5 million hand-soldered joints. It weighed about 27 tons, measured 2.4 m by 0.9 m by 30 m, occupying 167 m2 and consuming 150 kW of power. It was capable of conducting a wide range of numerical computations. Interaction with ENIAC during this period was quite limited. Programming involved physical connections and system configuration using switches and cables. Each program was literally constructed manually, often requiring significant effort.

Mark I, built at Harvard University, was one of the first electromechanical computers. It resulted from the collaboration between Harvard University, IBM, and the U.S. Navy. It used electromechanical components, including electric motors, switches, and electromagnetic circuits. It was designed to solve mathematical problems and generate ballistic tables. Interaction with Mark I was similar to ENIAC, where operators had to set up and configure physical components for each computed operation.

During the pioneering period, programming occurred at a low level, directly manipulating machine language. Programmers needed a deep understanding of hardware specifics. Programs were often written on paper and then manually translated into machine code. This phase demanded precision and patience from programmers. The pioneering period laid the groundwork for computer technology. ENIAC and Mark I represented the initial steps toward the digital age, opening doors to unprecedented computing capabilities. Experiences during this period served as the foundation for the development of subsequent generations of computers, gradually improving performance, size, and accessibility.

The pioneering period marked pioneering efforts in the field of computing, laying the groundwork for later developments that would define modern information technologies. Interaction with computers during this period was raw and physically demanding but set the stage for the technological revolution that would follow.

Development of programming languages (1950-1960)

The introduction of programming languages like Fortran and COBOL marked a key phase of abstraction. Programmers could now communicate with computers in a language more akin to human language, laying the foundation for the development of modern programming methods (Campbell-Kelly, 2007). Here is a more detailed overview of this period:

1) Development of programming languages: In the earlier pioneering period, programming relied on machine language, direct hardware control. Assembler was the first step toward abstraction, enabling programmers to use mnemonic labels instead of binary instructions. In the mid-1950s, the first high-level programming languages were developed. Fortran (Formula Translation) was aimed at scientific computations, while COBOL (Common Business-Oriented Language) was designed for business applications. These languages allowed programmers to write code at a higher level of abstraction.
2) Commercial use of computers: During this era, IBM introduced the System/360, the first family of compatible computers of varying capacities. This allowed companies to scale their computing resources more easily. The development of input and output peripheral devices was significant during this period. Computers acquired keyboards, screens, and other devices that facilitated user-machine communication.
3) Operating systems: Early versions of operating systems dealt with batch processing, where tasks were predefined and executed in groups. This improved data processing efficiency. The first operating

systems like IBM's OS/360 introduced concepts such as multitasking, virtual memory, and resource management, enhancing computer usage efficiency.

4) University influence: Universities became key players in computer science development. Educators and students contributed to the development of new technologies, and research became a fundamental component of the academic world. This period also saw the development of theoretical foundations of computer science, including work on algorithms, complexity theory, and formal languages.
5) Increased accessibility: The development of miniaturized computers during this period allowed smaller organizations and institutions to access computer technology. Commercial use and increased availability of computers contributed to the development of the computer products and services market.
6) Transition to programming: The development of high-level programming languages and operating systems made programming more efficient, allowing programmers to focus on application logic rather than hardware details. The development of academic computer science during this period laid the groundwork for further research and innovation in the field of computing. The transition to programming meant the expansion of computer technology into various societal sectors, from business to the academic community.

The transition to programming from 1950 to 1960 was pivotal in shaping modern computing, introducing high-level programming languages, operating systems, and expanding the use of computers into various fields. These changes laid the groundwork for further developments in information technology.

Appearance of graphical user interfaces (1980-1990)

Entering the eighties, the development of Graphical User Interfaces (GUIs) brought a revolution in human-computer interaction. Xerox PARC pioneered in this field, while Apple, with its Macintosh computer, introduced GUIs to the broader audience, making interaction visually rich and intuitive (Engelbart, 1962). Here is a detailed overview of this era:

1) Development of graphical user interfaces: The development of GUIs began at Xerox Palo Alto Research Center (PARC) in the 1970s. Concepts like the mouse, icons, and windows were developed in this environment. Apple commercialized GUIs for the first time with the Apple Lisa computer in 1983, followed by the more popular Macintosh

computer in 1984. These computers featured user interfaces with icons, a mouse, and drag-and-drop functionalities.

2) Operating systems with graphical interfaces: Microsoft started developing the Windows operating system, with its first release (Windows 1.0) in 1985. The evolution of Windows led to broader acceptance of graphical interfaces on personal computers. Apple's Macintosh System Software continued to evolve, enhancing its user interfaces and introducing new features.
3) Graphic design and user experience: This era witnessed the development of Desktop Publishing software, enabling users to create professional documents, brochures, and other graphic-rich materials. Launched in 1988, Adobe Photoshop became the standard in image processing and graphic design, setting the foundation for digital image manipulation.
4) Internet and WWW: The development of graphical web browsers like Mosaic (1993) and Netscape Navigator (1994) significantly facilitated users' access to the World Wide Web. Incorporating images, graphics, and other graphical elements into web pages added a visual dimension to the online experience.
5) Multimedia and video games: Computers became increasingly capable of reproducing sound, video content, and interactive multimedia applications. GUIs became crucial for the development of video games, and the popularity of gaming grew with computers' advanced graphic capabilities.
6) Significance for user experience: Graphical User Interfaces made computer usage more accessible to a wider audience, enabling quicker and easier interactions. Visual elements like icons and windows allowed users to interact with software more efficiently.

Features like drag-and-drop functionality, contextual menus, and other innovations changed the way users interacted with software. The era of Graphical User Interfaces marked the transition from text-based to visually oriented interfaces, allowing for a more intuitive and accessible interaction with computers. This period had long-term effects on how we use and perceive computers today.

Development of personal computers and the Internet (1990-2000)

The widespread adoption of personal computers and the expansion of the Internet transformed how people communicate and work. Web browsers, email, and other online platforms became an integral part of

everyday life (Berners-Lee, 1989). A detailed overview of the Internet Revolution from 1990 to 2000 is provided further below:

1) Development of the World Wide Web (WWW): Tim Berners-Lee, working at CERN, introduced the concept of the World Wide Web in 1990, using HTTP (Hypertext Transfer Protocol) and HTML (Hypertext Markup Language) to create interconnected pages on the Internet. The development of the first web browsers like Mosaic (1993) and Netscape Navigator (1994) enabled easier access and browsing of web pages.
2) Commercialization of the Internet: Advancements in secure online transactions and the creation of SSL (Secure Sockets Layer) facilitated the emergence of e-commerce. Amazon was founded in 1994, and eBay in 1995. The Dot-com boom, the expansion of Internet companies in the late 1990s, led to significant investments in Internet startups, often without actual profits.
3) Global expansion of the Internet: The development of commercial Internet Service Providers (ISPs) allowed widespread access to the Internet for individuals and businesses. The Internet became a global network, and technologies like email, chat, and video conferencing enhanced communication among people worldwide.
4) Development of technologies and standards: Internet Protocols (IP) became the standard, and IPv6 (Internet Protocol version 6) began to be introduced to overcome the IP address shortage. The proliferation of high-speed Internet access through broadband connections improved the speed and quality of Internet connections.
5) Multimedia development and web applications: The development of streaming technologies allowed users to consume audio and video content directly over the Internet. The development of web applications, along with JavaScript and other technologies, enabled dynamic and interactive functionalities on web pages.
6) Cultural influence: The first social networking sites like Six Degrees (1997) and Friendster (2002) emerged, enhancing online social interaction. The Internet became a key platform for sharing information, arts, and cultural content, leading to the formation of digital culture.
7) Challenges and issues: The expansion of Internet companies culminated in the Dot-com bust in 2000, leading to the collapse of many dot-com businesses. Increased online activity resulted in heightened security challenges, including cyber-attacks, identity theft, and other threats.

The Internet revolution from 1990 to 2000 transformed the way we live and work, opening doors to global communication, a digital economy, and new forms of cultural interaction. This period marked the transition of the Internet from an academic and military network to a universally accepted and indispensable part of everyday life.

Mobile revolution (2000-2010)

Entering the 21st century, smartphones and tablets became indispensable. Touchscreens, sensors, and mobile applications became crucial for everyday interaction, enabling people to communicate with computers anywhere, anytime (Jobs, 2007). Here is a detailed overview of this period:

1) Emergence of smartphones: Apple launched the iPhone in 2007, introducing the concept of a smartphone with an intuitive graphical user interface. The iOS operating system allowed third-party applications. Google responded by launching the Android platform, an open operating system for smartphones, leading to device and application diversity.
2) Rise of mobile applications: The Apple App Store was launched in 2008, followed soon after by Google Play (then Android Market). These platforms facilitated the proliferation of mobile applications. Mobile devices became pivotal for accessing social networks, with Facebook, Twitter, and others adapting to the mobile environment.
3) Development of mobile networks: The introduction of 3G (third generation) and later 4G (fourth generation) mobile networks improved data transmission speed and enabled high-quality multimedia content. The expansion of Wi-Fi and Bluetooth technologies allowed faster and more flexible connections of mobile devices to the Internet and other devices.
4) Mobile multimedia: Smartphones became equipped with increasingly better cameras, changing how people capture moments and share photos. The development of music and video streaming services allowed users to access rich content directly from their mobile devices.
5) Navigation and location: Built-in GPS sensors in smartphones enabled precise navigation and the creation of location-based services like Google Maps. Location-based apps became crucial, including services like geocaching, local guides, and social networks.
6) Social and business mobility: Mobile applications enabled remote work and access to business tools such as email and video conferencing. Social interactions shifted to mobile platforms, allowing constant connectivity and real-time sharing of moments.

7) Sustainable growth in the mobile device market: Increased sales of mobile devices: Mobile devices became ubiquitous, and sales rapidly grew worldwide.
8) Innovations in design: Mobile device design became the focus of innovation, including touch-sensitive screens, thinner profiles, and advanced features.
9) The mobile revolution from 2000 to 2010 transformed the way people communicate, work, entertain, and use technology.

This period marks key milestones in mobile technology that laid the groundwork for further smart device development.

The era of artificial intelligence and virtual reality (2010-present)

In the past decade, the focus shifted towards interacting with artificial intelligence. Voice commands, facial recognition, and gestures have become ubiquitous, while the development of virtual reality opens new dimensions of interaction (Goodfellow et al, 2016). Here is a detailed overview of this period:

1) Advances in artificial intelligence: The development of deep learning became a key component of AI, enabling systems to learn complex patterns from large datasets. The application of machine learning expanded across various industries, including healthcare, finance, manufacturing, and marketing. The development of cloud computing provided access to powerful computing resources needed for training and implementing AI models.
2) Development of virtual reality and augmented reality: The development of consumer VR and AR devices, like Oculus Rift, HTC Vive, Microsoft HoloLens, among others, allowed a wider audience to experience these technologies. VR and AR were used in education, medicine, engineering, as well as in business scenarios like virtual meetings and employee training. The development of virtual worlds allowed users to fully immerse themselves in digital environments, contributing to the gaming industry and simulations.
3) Autonomous vehicles and AI in traffic: AI and machine learning play a crucial role in the development of autonomous vehicles, representing a revolution in transportation. Integrating artificial intelligence into infrastructure systems contributes to the development of smart cities with improved efficiency and safety.
4) Growth of ethical issues and regulations: The increased use of AI has raised important ethical issues, including privacy, discrimination, and

responsibility. The development of regulatory frameworks and guidelines attempts to regulate the use of artificial intelligence in various sectors.

5) AI in healthcare: The development of AI enabled personalized medicine with tailored therapies and diagnoses. AI is used to analyze large datasets in the healthcare sector, identify patterns, and enhance diagnostic procedures.
6) Development of quantum computing: Although still in the experimental phase, the development of quantum computing promises a revolution in computing capacity and speed.
7) Artificial intelligence in networking and security: AI is used for detecting and preventing cyber-attacks, providing an additional layer of security. Artificial intelligence helps optimize network performance and resource management.

The era of artificial intelligence and virtual reality from 2010 until now has been marked by rapid technological advancements, creating new possibilities and challenges for society. This period continues to shape the way we use technology and interact with the digital world.

The path to intuitive interaction

The history of human-computer interaction testifies to a continual quest for more intuitive modes of communication and more efficient methods of using technology, aimed at enhancing user experience and facilitating interaction between humans and machines.

This detailed retrospective demonstrates how the steps in human-computer interaction have been marked by technological innovations often intertwined with societal changes. Each phase has brought new challenges and possibilities, shaping the modern paradigm of interaction that we know today.

Intuitive interaction refers to the mode of communication between users and technological systems that is natural, easy to understand, and requires minimal effort. This is often achieved through user interface design and technology that mimics natural human abilities and behavioral patterns.

Below, several key aspects of intuitive interaction will be presented:

1) Ease of use: Intuitive interaction demands minimal learning and training for users to effectively utilize the system. It is designed to provide users with quick access to functions and tools. It employs recognizable symbols, icons, and behavioral patterns familiar to users

from everyday life, thereby reducing the need for additional explanations. The work of Norman (2002) discusses how the design of objects around us impacts our daily experience, focusing on design concepts that facilitate or hinder the use of objects and technology in everyday life. In the book by Preece, Rogers, and Sharp (Preece et al, 2015), the design of interactions between humans and computer systems is explored, covering a wide range of interface design topics, including principles, techniques, and processes for creating efficient interactive systems.

2) Response to user actions: Intuitive systems respond quickly and consistently to user actions, providing a sense of immediacy and control. They offer clear feedback to users about what is happening in the system after their actions. This can include visual indicators, sound signals, or other forms of notification. The book by Shneiderman et al. (2016) provides strategies for effectively designing interfaces between people and computer systems, covering the basics of user interface design and focusing on strategies to enhance interaction. Furthermore, the book by Cooper et al. (2007) is a guide to essential principles of interaction design, highlighting key concepts of interaction between people and technology to achieve a better user experience.
3) Natural interactions: Implementation of voice recognition technology allows users to communicate with the system through verbal commands. Touch-sensitive screens and technologies like gestures enable users to interact with the device in a manner similar to real-world communication. The book by Dix et al. (2004) provides a broad overview of interaction between humans and computer systems, covering topics such as interface design, evaluation of user experience, and theories underlying human-computer interaction.
4) Personalization and contextual awareness: Intuitive systems can adapt to user preferences and behavior, offering a personalized experience. Through context analysis, systems can better understand user needs and provide relevant information or functionalities at a given moment (Norman, 2002; Cooper et al, 2007).
5) Use of visual metaphors: Employing visual metaphors helps users understand system functionalities more quickly. Examples include icons representing real objects or operations. Intuitive interaction often involves elements that resemble real objects or processes to facilitate understanding (Shneiderman et al, 2016).

Intuitive interaction plays a crucial role in enhancing user experience, especially in an era where technology is becoming ubiquitous. This

approach not only facilitates system usage but also increases the adoption of new technologies among different users.

Principles of user experience design

User Experience (UX) design has become crucial for the success of human-computer interaction and is a key factor in creating innovative and efficient digital products.

This section of the work will analyze the fundamental principles of user experience design, emphasizing their importance in creating positive interactions between users and technology. Principles such as ease of use, consistency, and intuitiveness play a crucial role in creating a positive user experience.

1) Clarity and simplicity principle
   The central principle of UX design is clarity and simplicity. Designers should create interfaces that are intuitive, easily understandable, and unburdened by unnecessary information. This principle helps users quickly understand how to use a product without unnecessary difficulties. One of the fundamental principles of UX design is clarity and simplicity, as evident in Krug's book "Don't Make Me Think" (Krug, 2014). Krug argues that interfaces should be intuitive and reduce the user's mental effort, making them clear and simple.
2) Consistency principle
   Don Norman, in his work "The Design of Everyday Things" (Norman, 2002), emphasizes the importance of consistency in design, arguing that users should recognize patterns and expect consistency in interfaces for better understanding. Consistency is crucial for maintaining user trust. Elements such as icons, colors, and layout should be consistent throughout the product. Consistency aids users in recognition and expectation, creating a unified experience.
3) User contribution
   Principle Good UX design should ensure that the product contributes to users, helping them achieve their goals. A user-centered approach involves understanding user needs and adapting the design to meet these needs. Jeff Gothelf and Josh Seiden in the book "Lean UX" (Gothelf & Seiden, 2013) advocate an approach oriented towards users and creating value for them. This principle connects design with real user needs, creating products that contribute to their goals.
4) Trust and security principle
   Kim Goodwin, in the book "Designing for the Digital Age" (Goodwin, 2009), explores aspects of trust and security in UX design. Goodwin

highlights the importance of creating designs that instill user confidence in the digital environment. Security is a critical component of UX design, especially in a digital environment where user data is frequently processed. Designers must ensure that users have confidence in the product and a clear understanding of security measures.

5) User-centric principle
This principle emphasizes the importance of placing users at the center of design. Designers should conduct user research to gain a deep understanding of their needs, behaviors, and goals. This allows for the creation of personalized and relevant experiences. Jakob Nielsen, in the book "Usability Engineering" (Nielsen, 1993), lays out the basic guidelines for user research and an approach focused on their needs to create a usable product.
6) Accessibility principle
Good UX design should be accessible to everyone, including individuals with different abilities. Designers should consider proper contrast, font size, navigation, and other aspects to enable access to the product for all users. "Inclusive Design Patterns" (Pickering, 2016) by Heydon Pickering provides guidelines on creating accessible digital products that offer equal accessibility to users with different abilities.
7) Innovation and adaptability principle
While consistency and clarity are important, UX design also requires innovation and adaptability. Designers should explore new technologies, trends, and interaction methods to improve the user experience and remain relevant. Tom and David Kelley in the book "Creative Confidence" (Kelley & Kelley, 2013) present innovation and adaptability as a key principle for maintaining relevance in UX design.

The combination of these principles forms the basis for creating UX design that not only meets but exceeds user expectations. Proper implementation of these principles creates lasting relationships between users and products, enabling them to have a positive experience and achieve design goals.

Types of interaction

There are several different types of interaction, each with its own specifics and applications in various contexts. Here is a detailed overview of some classical types of interaction:

1) Physical interaction

Physical interaction refers to the direct physical manipulation of objects or systems. The study by Wensveen, Djajadiningrat & Overbeeke (Wensveen et al, 2004) explores the ways physical interactions can be linked to functionalities through feedback. It focuses on developing frameworks that allow aligning user actions with functions through feedback and previous information. Examples of physical interaction include touching the screen on a smartphone or tablet, using a keyboard, mouse, or other devices on a computer, or manipulating physical objects in a virtual space using VR controllers.

2) Visual interaction
   Visual interaction focuses on the perception and reaction to visual elements. This encompasses elements such as icons, colors, graphics, and visual information. Ware's book (Ware, 2012) deals with perception in information design. It analyzes how people perceive visual information and how that understanding can be applied to the design of interactive systems. Examples of visual interaction include clicking on desktop icons, browsing and clicking elements on web pages, or using visual elements for navigation in a VR environment.
3) Voice interaction
   The development of voice assistants and speech recognition technologies has enabled verbal communication (Young et al, 2006). Voice interaction uses verbal communication between users and systems. The system can interpret and respond to voice commands. Examples of voice interaction include using virtual assistants like Siri, Google Assistant, or Amazon Alexa, voice commands in smart devices such as smart TVs or smart bulbs.
4) Gesture interaction
   Gesture interaction uses movements and gestures as a means of communicating with the system. This can involve hand, body movements, or other body parts (O'Conaill et al, 1993). Examples include using gestures on smartphones for zooming, rotating images, or opening applications or controlling video games through body movements, such as Kinect sensors.
5) Cognitive interaction
   Cognitive interaction relates to communication between users and systems through cognitive abilities, such as recognizing emotions, understanding intentions, or interpreting brain signals. Norman explores the design of everyday objects and how that design impacts our interactions (Norman, 2002). It focuses on design principles that facilitate or hinder the use of objects and technology. Examples of cognitive interaction include using devices that interpret brain signals

to control computers or devices, as well as systems that analyze user emotions for personalized user experiences.

6) Haptic interaction
   Haptic interaction uses tactile feedback to enhance interaction by giving users a sense of touch or pressure. This may involve vibrations, pressure, or other tactile feedback (Sears & Shneiderman, 1991). Examples include smartphone vibration as feedback for touching the screen, using vibrations in gaming controllers to simulate touch or impact.
7) Immersive interaction
   In a contemporary context, the term "immersive" describes an experience that fully engages the senses, creating a sense of complete immersion in a particular environment, situation, or activity. Immersive experiences typically involve intense user engagement, often through advanced technologies, to achieve a sense of reality or presence in a digital or real space. Bowman et al.'s book (2005) explores the theory and practice of interfaces in 3D space, focusing on the development and application of interactive systems using three-dimensional interfaces.

Applications of immersion can be seen in various contexts, including:

1) Virtual Reality (VR): VR technology provides an immersive experience by creating a digital world that users perceive as real. Users typically use VR headsets and headphones to fully immerse themselves in a virtual environment. Sherman & Craig's book (Sherman & Craig, 2002) deals with concepts and applications of virtual reality, exploring interfaces, applications, and design related to virtual reality.
2) Augmented Reality (AR): AR integrates digital elements into the real world, providing users with an immersive experience by combining real and virtual elements. Examples include smart glasses that project real-time information onto the real world.
3) Gaming: Immersive video games provide players with an intense experience through high-quality graphics, realistic sound, and technologies such as 3D effects.
4) Education: Immersive technologies are used in education to provide students with a realistic experience, such as virtual tours, simulations, and interactive lessons.
5) Film and television: The use of advanced technologies in movie and series production can create an immersive experience for viewers, including 3D effects, high-quality sound, and more.

6) Training and simulations: Immersion is often used in professional training and simulations, creating realistic environments to practice specific skills or situations.

Immersive experience creates an intense sense of presence and engagement, often enhancing the emotional and cognitive response of users. This concept often finds wide application in various industries and fields, especially where creating an authentic and profound experience is desired.

Immersive interaction refers to the user's interaction with digital environments or content in a way that provides an intense and immersed experience. This type of interaction is often associated with augmented reality, virtual reality, and other advanced technologies that enable users to experience the digital world in a deep and exciting way.

The key elements of immersive interaction include:

1) Virtual Reality: VR technology uses devices like VR headsets and headphones to provide users with a completely immersed experience in a digital world. Examples: Playing VR games, virtual tours through digitally reconstructed spaces, or educational simulations and training in a virtual environment.
2) Augmented Reality: AR integrates digital elements into the real world, providing users with a combined experience of the real and virtual. Examples: Using smart glasses that project real-time information onto the real world, applications that add digital layers of information to real objects or scenes.
3) Haptic feedback: Haptic feedback involves tactile feedback that allows users to feel touch, pressure, or vibrations during an immersive experience. Examples: Vibrations in controllers during VR gaming and haptic feedback when touching virtual objects in a VR environment.
4) Interaction with 3D content: Immersive interaction allows users to interact with three-dimensional objects and scenes, providing a deeper level of involvement. Examples: Rotating, moving, and manipulating 3D objects in a VR space or interacting with digital elements appearing in the real world via AR applications.
5) Contextual adaptation: Immersive interaction often involves adapting the user experience based on context, such as movement, location, or focus of vision. Examples: Changes in a virtual environment in response to user movements or information that automatically appears in the real world via AR based on the user's location.
6) Real-time and quick response: Immersive interaction requires real-time and fast responses to maintain a sense of reality during the user's

experience. Examples: Quick responses to head or body movements in a VR space or immediate changes in the real world recognizable through AR applications.

7) Combination of technologies: Immersive interaction often combines multiple technologies to achieve the most efficient and exciting experience. Examples: Using AR and VR in combination to explore real and virtual elements or integrating gestures, speech, and haptic feedback into a unified immersive experience.

Each of these types of interactions has its advantages and limitations, often used in combination to provide a richer and more efficient user experience. The diversity of these approaches allows users to choose the most suitable way of interaction depending on the context and preferences.

The impact of technology on society

The impact of technology on society has profound and complex consequences across various levels, including the economy, education, culture, social relationships, and other aspects of social life. Here is a more detailed overview:

1) Economic impact: Technology, including automation and artificial intelligence, can enhance efficiency and productivity but also raises questions regarding job losses (Brynjolfsson & McAfee, 2014). The development of online commerce and digital platforms is transforming how people buy and sell products (Laudon & Traver, 2019).
2) Educational changes: Digital technologies enable access to education via the Internet, bringing changes to teaching and learning methods. The COVID-19 pandemic further highlighted the role of technology in supporting remote learning (Hodges et al, 2020).
3) Social changes: The impact of social networks on communication, communities, and shaping public opinion (Boyd & Ellison, 2007). The emergence of digital divides between those with access to technology and those without can deepen social inequalities (Warschauer, 2003).
4) Cultural dynamics: Technological advancements support the development of digital art, introducing new forms of expression and distribution (Greene, 2004). The integration of technology into literary creativity, including interactive stories and e-books (Hayles, 2008).
5) Privacy and security: Growing concerns about data privacy protection in the digital environment (Solove, 2006). Challenges and threats of

cybersecurity in an increasingly connected digital world (Clarke & Knake, 2010).

6) Politics and activism: Technology significantly influences the organization and mobilization of social movements and activism (Earl & Kimport, 2011). The application of technology in political engagement and democratic processes (Coleman, 2012).

This extensive impact of technology on society represents a dynamic process with numerous aspects. Studying these impacts enables a better understanding of how technological advancements shape our society and raises questions that require careful consideration and regulation.

Ethical aspects of human-computer interaction

With the growing integration of technology into people's lives, issues of privacy, data security, and ethical technology use become increasingly important.

Ethical aspects of human-computer interaction play a crucial role in the design, development, and use of technology. These aspects encompass questions of fairness, privacy, transparency, security, and many other dimensions aimed at ensuring a positive impact of technology on society.

Here is a more detailed overview of some key ethical issues related to human-computer interaction:

1) Privacy:
   Questions: How does technology collect, store, and use users' personal data? How is transparency and control over this data ensured?
   Principles: Respect for privacy, implementation of security measures, informing users about data collection.
   Issues of privacy in technology have been explored in many works which discuss the challenges of digital privacy. Principles concerning privacy and data security are highlighted in the work of Craig and Ludloff (2011), which explores the relationship between privacy and big data.
2) Fairness and discrimination:
   Questions: Does technology promote injustice or discrimination, for instance, through algorithmic systems that may exhibit bias?
   Principles: Universal access, respect for diversity, fairness in algorithms.

Fairness issues in algorithms have been explored in works like (O'Neil, 2016), emphasizing how algorithms can contribute to inequality. Principles of universal access to technology are presented in the work of (Noble, 2018), addressing discrimination and search algorithms.

3) Transparency:
   Questions: How informed are users about how technology operates and what data is collected?
   Principles: Providing clear information about system operations, openness in design and decision-making.
   The book edited by Sorin Adam Matei, Martha Russell and Elisa Bertino (Matei et al, 2015) delves into the topic of transparency in social media, particularly examining how technology operates and what data is collected in the context of online interactions. This book explores tools, methods, and algorithms used for mediating online interactions, focusing on transparency in the functioning of social media systems. The authors investigate ways to provide clear information to users about how technology works, what information is collected, and how it is used in an online environment. The book promotes the idea of openness in design and decision-making, emphasizing the importance of transparency for social media users.
4) Security:
   Questions: How is technology protected from misuse and cyber-attacks? How is data and system integrity ensured?
   Principles: Implementation of strong security measures, regular system updates, responding to security threats.
   In the book (Singer & Friedman, 2014), the authors explore topics related to cyber-security and cyber-warfare. Focusing on a broad audience, the book addresses issues related to Internet security, cyber threats, strategies for protection against cyber-attacks, and the implications of cyber warfare on society. Authors examine the role of technology in the global cyber space, providing fundamental knowledge and guidelines on Internet security and cyber threats.
   Author Bruce Schneier, in the book (Schneier, 2016), investigates issues related to data privacy and the use of personal information. Schneier explores how data is collected, stored, and used in today's digital age, highlighting the issues associated with mass data collection by companies and government institutions. The book analyzes the impact of data collection on individual privacy and society, emphasizing dilemmas related to controlling personal information and protecting privacy in the digital world.
5) Accountability and oversight:

Questions: Who is responsible for the harm that may arise from the use of technology? How can adequate oversight and regulation be ensured?
Principles: Establishing responsibility, ethical conduct in technology development, regulations that protect users.
The book (De George, 2003) presents ethical aspects of information technology and business. The author explores moral and ethical dilemmas arising from the use of information technology in the context of business. It focuses on issues such as data privacy, information security, responsibility towards users, ethical dilemmas in managing information systems, and legal aspects of information technology. The book provides a theoretical framework for understanding ethical challenges in these areas.
The author addresses broader ethical and social issues in the information age in his book (Kizza, 2013). Through the analysis of ethical dilemmas in the information era, the author discusses issues such as data privacy, freedom of speech on the Internet, fairness in accessing information, ethical implications of artificial intelligence, and the implications of technological development on society. The book explores questions arising from the use of information technology, providing an analysis of its impact on society and individuals from ethical and social perspectives.

6) Dependency and social impact:
Questions: How does technology impact social relationships, mental health, and the overall well-being of society? Is there excessive dependence on technology?
Principles: Comprehensive approach to technology development, assessment of social impacts, promotion of healthy digital habits.
Adam Alter, in his book (Alter, 2017), explores the impact of technology on our behavior, focusing on how digital technologies have become irresistible and how the industry strives to keep us "hooked" to them. The author investigates psychological mechanisms and strategies that technology companies use to create products that are attractive and addictive. This book analyzes how digital technology shapes our habits, behavior, and society as a whole, providing insights into our interactions with technology.
Nicholas Carr, in his book (Carr, 2010), explores the impact of the Internet on the human brain. He analyzes how constant use of the Internet, searching, and consuming information through digital devices shape our ability to concentrate, think, and process information. Carr explores how technological tools shape our cognitive ability,

highlighting their influence on our thinking and how we absorb and process information.

7) Environmental aspects:
   Questions: How does technology affect the environment? Is technology development guided by sustainable practices?
   Principles: Development of environmentally sustainable technologies, reducing negative environmental impacts.
   In the book (O'Toole, 2013), authors focus on the environmental aspects of technology and web design. They explore how technology, particularly web technologies, affects the environment and which practices in designing web ecosystems can contribute to sustainability. This book analyzes how digital technologies can be developed while reducing negative impacts on the environment. It examines how optimization, resource efficiency, and the development of sustainable technologies can contribute to creating more environmentally friendly web systems. The book explores principles of sustainable design for web ecosystems, providing guidelines for reducing the ecological burden caused by technological development.

These ethical aspects often require reflection and responsible actions from all stakeholders involved in the process of technology development and implementation. An ethical framework helps ensure that technology serves the well-being of people and society, minimizing potential negative consequences.

The future of human-computer interaction

The rapid development of artificial intelligence, augmented reality, the Internet of Things, and other technologies promises an even more intriguing future for human-computer interaction. Here are several key aspects that could shape the future of this interaction:

1) Artificial Intelligence and Machine Learning: AI will enable systems to better understand and adapt to individual user needs, making interactions more intuitive and efficient. The development of smart assistants using deep learning to provide more complex and personalized services.
2) Augmented Reality and Virtual Reality: Integrating digital elements into the real world through AR devices, such as smart glasses, will create richer and contextually enriched interactions. Advancements in VR technology will offer even more realistic and immersive experiences in digital environments.

3) Advanced Interfaces: Technologies allowing precise system control through gestures, enhancing flexibility and natural interaction. The use of haptic feedback technology to provide users with a sense of touch or sensations during interaction.
4) Voice Interaction: Advanced assistants with voice intelligence: Developing voice assistants that use natural language, recognize speech nuances, and better understand context. Integrating voice interfaces into business applications to enhance productivity.
5) Ethical Aspects: Focus on developing and applying ethical guidelines regarding AI to avoid injustices, discrimination, and other negative impacts. Strengthening measures for data privacy protection and security in the face of increasing connectivity and interaction.
6) Quantum Computing: New computing possibilities: The development of quantum computers will enable solving problems currently unachievable for classical computers. Adapting algorithms to leverage the specific characteristics of quantum computers.
7) Social Interaction and Artificial Emotion: Technology development capable of recognizing and simulating emotions to create more emotional and intuitive interactions. Progress in robotics allowing the creation of social robots capable of emotionally based interactions with humans.
8) Education and Training: Development of virtual classrooms and training will enable students and employees to acquire skills and knowledge in realistic digital environments.

These are just some of the potential developments in the future of human-computer interaction. The fast-paced progress of technology promises exciting innovations but also poses challenges in terms of ethics, security, and accessibility. Continuous study and consideration of these aspects are crucial to shape a positive and responsible technological development.

Conclusion

Human-computer interaction is not merely a technical concept but a pivotal element shaping our everyday lives. Understanding its evolution, principles of user experience design, and ethical implications is essential for building a positive and sustainable technological future.

The principles of user experience design form the foundation of successful digital products. Their application allows for the creation of user-friendly, functional, and efficient interfaces, ensuring that technology

serves users in the best possible way. By considering these principles, designers can shape experiences that exceed expectations and build lasting relationships with users.

Human-computer interaction significantly impacts society. From changes in communication to the transformation of work processes, technological progress shapes our everyday lives.

With the growing integration of technology into people's lives, questions of privacy, data security, and ethical technology use become increasingly important.

The rapid development of artificial intelligence, augmented reality, the Internet of Things, and other technologies promises an even more intriguing future for human-computer interaction. This interaction is not just a technical concept but a crucial element shaping our everyday lives. Understanding its development, principles of user experience design, and ethical implications is essential for building a positive and sustainable technological future.

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Interacción entre humanos y computadoras: aspectos clave y evolución

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CAMPO: tecnología de la información
TIPO DE ARTÍCULO: artículo de revisión

Resumen:

Introducción/objetivo: La investigación tuvo como objetivo analizar los aspectos clave de la interacción persona-computadora, estudiando la evolución de este campo desde sus inicios hasta las tendencias contemporáneas. Centrándose en diferentes aspectos de esta interacción,

estudió cómo los métodos, tecnologías y principios han evolucionado con el tiempo y han dado forma a nuestras experiencias en el entorno digital.

Métodos: La metodología de investigación se basó en el análisis de bibliografía relevante y artículos de investigación dedicados a la interacción persona-computadora. La revisión y evaluación sistemática de las fuentes identificó la información clave sobre la evolución de la interacción de los usuarios con las computadoras. A través de la evaluación de los estudios disponibles, se identificaron cambios en los métodos de diseño de interfaces, tecnologías de interacción y comprensión de las necesidades de los usuarios a lo largo del tiempo.

Resultados: A partir de la síntesis de datos, se identificaron los aspectos clave de la interacción persona-computadora. Un análisis de la bibliografá reveló cambios en los métodos de diseño de interfaces, tecnologías de interacción y comprensión de las necesidades de los usuarios a lo largo del tiempo. Los resultados específicos incluyeron información sobre la evolución de los aspectos de interacción, incluidas mejoras en la eficiencia, la intuición y la personalización de las experiencias.

Conclusión: La conclusión clave de la investigación es que las innovaciones y la evolución de la tecnología han influido significativamente en la forma en que los usuarios interactúan con los sistemas informáticos. Las mejoras en el diseño de la interfaz, las tecnologías de reconocimiento y la personalización de las experiencias son factores clave para crear mejores experiencias de usuario y optimizar la interacción persona-computadora. La investigación apunta al continuo desarrollo y cambios en el campo de la interacción persona-computadora, enfatizando la necesidad de más investigación e innovación en esta área.

Palabras claves: *interacción persona-computadora (HCI), interfaces gráficas de usuario (GUI), experiencia de usuario (UX), revolución de Internet, revolución móvil.*

Взаимодействие человека и компьютера: ключевые аспекты и эволюция

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РУБРИКА ГРНТИ: 50.41.29 Пользовательский интерфейс программного обеспечения

ВИД СТАТЬИ: обзорная статья

Резюме:

Введение/цель: Цель данной статьи – проанализировать ключевые аспекты взаимодействия человека и компьютера, изучить эволюцию этой области от истоков до современных тенденций. В исследовании внимание сосредоточено на различных аспектах взаимодействия и было изучено, как методы, технологии и принципы развивались с течением времени и формировали наш опыт в цифровой среде.

Методы: Методология исследования была основана на анализе релевантной литературы и исследовательских работ, посвященных взаимодействию человека и компьютера. Систематический обзор и оценка источников выявили ключевую информацию об эволюции взаимодействия пользователя с компьютерами. Благодаря оценке доступных исследований были выявлены изменения в методах разработки интерфейсов, технологиях взаимодействия и понимании потребностей пользователей, с учетом аспекта времени.

Результаты: Синтез данных выявил ключевые аспекты взаимодействия человека и компьютера. А анализ литературы указывает на изменения в методах разработки интерфейсов, технологиях взаимодействия и понимании потребностей пользователей с учетом аспекта времени. На основании конкретных результатов была освещена информация об эволюции аспектов взаимодействия, включая улучшения в эффективности, интуитивности и персонализации опыта.

Выводы: Ключевой вывод исследования заключается в том, что инновации и эволюция технологий существенно повлияли на то, как пользователи взаимодействуют с компьютерными системами. Улучшения в дизайне интерфейсов, технологиях распознавания и персонализации опыта являются ключевыми факторами в создании более удобной пользовательской среды и оптимизации взаимодействия человека с компьютером. Исследование указывает на постоянное развитие и изменения в области взаимодействия человека и компьютера, подчеркивая необходимость дальнейших исследований и инноваций в этой области.

Ключевые слова: взаимодействие человека с компьютером (HCI), графические пользовательские интерфейсы (GUI), пользовательский опыт (UX), интернет революция, мобильная революция.

Интеракција између човека и рачунара: кључни аспекти и еволуција

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ОБЛАСТ: информационе технологије
КАТЕГОРИЈА (ТИП) ЧЛАНКА: прегледни рад

Сажетак:

Увод/циљ: Циљ истраживања била је анализа кључних аспеката интеракције човека и рачунара; проучавана је еволуција овог поља од почетака до савремених трендова. Фокусирајући се на различите аспекте интеракције, истраживано је како су се методе, технологије и принципи развијали током времена и обликовали наша искуства у дигиталном окружењу.

Методе: Методологија истраживања заснивала се на анализи релевантне литературе и истраживачких радова посвећених интеракцији човека и рачунара. Систематским прегледавањем и евалуацијом извора идентификоване су кључне информације о еволуцији ове интеракције. Кроз вредновање доступних студија идентификоване су промене у методама дизајна интерфејса, технологијама интеракције и разумевању потреба корисника током времена.

Резултати: Синтетизацијом података идентификовани су кључни аспекти интеракције човека и рачунара. Анализом литературе откривене су промене у методама дизајна интерфејса, технологијама интеракције и разумевању потреба корисника током времена. Конкретни резултати обухватили су информације о еволуцији аспеката интеракције, укључујући побољшања у ефикасности, интуитивности и персонализацији искустава.

Закључак: Иновације и еволуција технологије значајно су утицали на начин интеракције корисника с рачунарским системима. Побољшања у дизајну интерфејса, технологијама препознавања и персонализацији искустава представљају кључне факторе у креирању све бољег корисничког доживљаја и оптимизацији интеракције човека и рачунара. Истраживање указује на континуирани развој и промене у домену ове интеракције , наглашавајући потребу за даљим истраживањем и иновацијама у овој области.

Кључне речи: интеракција човек-рачунар (HCI), графички кориснички интерфејси (GUI), корисничко искуство (UX), интернет револуција, мобилна револуција.

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