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HUMAN COMPUTER INTERACTION

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Abstract

The concept of human-computer interaction is one of the most important fields of computer science. First of all, its importance consists in the fact that human-computer interaction has been developed to meet the needs in human life. This interaction in itself contains the physical, logical and conceptual interaction between man and the computer to achieve a certain goal. The greater involvement of this interaction has attracted the attention of the computer industry, but to reach this level it was necessary to simultaneously develop other aspects of technology. In the beginning computers were ready to be used only by professional people (their developers), while the rest had problems in using them. This has caused many complex calculations to be required to execute some simple commands. In this case, it has highlighted the problem that people have not had the knowledge to communicate with the computer properly. As the demands of the people increase, so does the focus of the technology industry on the greatest possible development of human-computer interaction, to enable people to communicate with technology and through it to gain support for the development of their human activities. The purpose of involving this interaction is to create technological equipment and systems which have a high degree of usability, security and functionality.

Keywords: Interaction, human, computer, design, HCI, HDI.

Human–computer interaction (HCI) is research in the design and the use of computer technology, which focuses on the interfaces between people (users) and computers. HCI researchers observe the ways humans interact with computers and design technologies that allow humans to interact with computers in novel ways. As a field of research, human–computer interaction is situated at the intersection of computer science, behavioral sciences, design, media studies, and several other fields of study. The term was popularized by Stuart K. Card, Allen Newell, and Thomas P. Moran in their 1983 book, The Psychology of Human–Computer Interaction, although the authors first used the term in 1980, and the first known use was in 1975. The term is intended to convey that, unlike other tools with specific and limited uses, computers have many uses which often involve an open-ended dialogue between the user and the computer. The notion of dialogue likens human–computer interaction to human-to-human interaction: an analogy that is crucial to theoretical considerations in the field.

Humans interact with computers in many ways, and the interface between the two is crucial to facilitating this interaction. HCI is also sometimes termed *human–machine interaction* (HMI), *man-machine interaction* (MMI) or *computer-human interaction* (CHI). Desktop applications, internet browsers, handheld computers, and computer kiosks make use of the prevalent graphical user interfaces (GUI) of today. Voice user interfaces (VUI) are used for speech recognition and synthesizing systems, and the emerging multi-modal and Graphical user interfaces (GUI) allow humans to engage with embodied character agents in a way that cannot be achieved with other interface paradigms. The growth in human–computer interaction field has led to an increase in the quality of interaction, and resulted in many new areas of research beyond. Instead of designing regular interfaces, the different research branches focus on the concepts of multimodality over unimodality, intelligent adaptive interfaces over command/action based ones, and active interfaces over passive interfaces.

The Association for Computing Machinery (ACM) defines human–computer interaction as "a discipline that is concerned with the design, evaluation, and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them". An important facet of HCI is user satisfaction (or End-User Computing Satisfaction). It goes on to say:

"Because human–computer interaction studies a human and a machine in communication, it draws from supporting knowledge on both the machine and the human side. On the machine side, techniques in computer graphics, operating systems, programming languages, and development environments are relevant. On the human side, communication theory, graphic and industrial design disciplines, linguistics, social sciences, cognitive psychology, social psychology, and human factors such as computer user satisfaction are relevant. And, of course, engineering and design methods are relevant." Due to the multidisciplinary nature of HCI, people with different backgrounds contribute to its success.

Poorly designed human-machine interfaces can lead to many unexpected problems. A classic example is the Three Mile Island accident, a nuclear meltdown accident, where investigations concluded that the design of the human-machine interface was at least partly responsible for the disaster. Similarly, accidents in aviation have resulted from manufacturers' decisions to use non-standard flight instruments or throttle quadrant layouts: even though the new designs were proposed to be superior in basic human-machine interaction, pilots had already ingrained the "standard" layout. Thus, the conceptually good idea had unintended results. The human–computer interface can be described as the point of communication between the human user and the computer. The flow of information between the human and computer is defined as the loop of interaction. The loop of interaction has several aspects to it, including:

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Visual Based: The visual-based human–computer interaction is probably the most widespread human–computer interaction (HCI) research area.

Audio Based: The audio-based interaction between a computer and a human is another important area of HCI systems. This area deals with information acquired by different audio signals.

Task environment: The conditions and goals set upon the user.

Machine environment: The computer's environment is connected to, e.g., a laptop in a college student's dorm room.

Areas of the interface: Non-overlapping areas involve processes of the human and computer, not about their interaction.

Meanwhile, the overlapping areas only concern themselves with the processes of their interaction.

Input flow: The flow of information begins in the task environment when the user has some task requiring using their computer.

Output: The flow of information that originates in the machine environment.

Feedback: Loops through the interface that evaluate, moderate, and confirm processes as they pass from the human through the interface to the computer and back.

Fit: This matches the computer design, the user, and the task to optimize the human resources needed to accomplish the task.

The following experimental design principles are considered, when evaluating a current user interface, or designing a new user interface:

- Early focus is placed on the user(s) and task(s): How many users are needed to perform the task(s) is established and who the appropriate users should be is determined (someone who has never used the interface, and will not use the interface in the future, is most likely not a valid user). In addition, the task(s) the users will be performing and how often the task(s) need to be performed is defined.

- Empirical measurement: the interface is tested with real users who come in contact with the interface daily. The results can vary with the performance level of the user and the typical human–computer interaction may not always be represented.
Quantitative usability specifics, such as the number of users performing the task(s), the time to complete the task(s), and the number of errors made during the task(s) are determined.

- Iterative design: After determining what users, tasks, and empirical measurements to include, the following iterative design steps are performed: Design

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the user interface; 2. Test; 3. Analyze results; 4. Repeat. The iterative design process is repeated until a sensible, user-friendly interface is created.

Methodologies

Various strategies delineating methods for human–PC interaction design have developed since the conception of the field during the 1980s. Most plan philosophies come from a model for how clients, originators, and specialized frameworks interface. Early techniques treated clients' psychological procedures as unsurprising and quantifiable and urged plan specialists to look at subjective science to establish zones, (for example, memory and consideration) when structuring UIs. Present-day models, in general, center around a steady input and discussion between clients, creators, and specialists and push for specialized frameworks to be folded with the sorts of encounters clients need to have, as opposed to wrapping user experience around a finished framework.

Activity theory: utilized in HCI to characterize and consider the setting where human cooperations with PCs occur. Action hypothesis gives a structure for reasoning about activities in these specific circumstances and illuminates the design of interactions from an action-driven perspective.

(UCD): a cutting-edge, broadly-rehearsed plan theory established on the possibility that clients must become the overwhelming focus in the plan of any PC framework. Clients, architects, and specialized experts cooperate to determine the requirements and restrictions of the client and make a framework to support these components.

Frequently, client-focused plans are informed by ethnographic investigations of situations in which clients will associate with the framework. This training is like participatory design, which underscores the likelihood for end-clients to contribute effectively through shared plan sessions and workshops.

Principles of UI design: these standards may be considered during the design of a client interface: resistance, effortlessness, permeability, affordance, consistency, structure, and feedback.

(VSD): a technique for building innovation that accounts for the individuals who utilize the design straightforwardly, and just as well for those who the design influences, either directly or indirectly. VSD utilizes an iterative plan process that includes three kinds of examinations: theoretical, exact, and specialized. Applied examinations target the understanding and articulation of the different parts of the design, and its qualities or any clashes that may emerge for the users of the design.

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Exact examinations are subjective or quantitative plans to explore things used to advise the creators' understanding regarding the clients' qualities, needs, and practices. Specialized examinations can include either investigation of how individuals use related advances or the framework plans. Although HCI emerged in the 1980s, it owes a lot to older disciplines. The most central of these is the field of *human factors*, or *ergonomics*. Indeed, the name of the preeminent annual conference in HCI—the Association for Computing Machinery Conference on Human Factors in Computing Systems (ACM SIGCHI)—uses that term. SIGCHI is the special interest group on computer-human interaction sponsored by the ACM.

Human factors is both a science and a field of engineering. It is concerned with human capabilities, limitations, and performance, and with the design of systems that are efficient, safe, comfortable, and even enjoyable for the humans who use them. It is also an art in the sense of respecting and promoting creative ways for practitioners to apply their skills in designing systems. One need only change *systems* in that statement to *computer systems* to make the leap from human factors to HCI. HCI, then, is human factors, but narrowly focused on human interaction with computing technology of some sort. That said, HCI itself does not feel "narrowly focused." On the contrary, HCI is tremendously broad in scope. It draws upon interests and expertise in disciplines such as psychology (particularly cognitive psychology and experimental psychology), sociology, anthropology, cognitive science, computer science, and linguistics.

HCI research

HCI research requires both rigorous methods and relevance. It is often tempting to lean more heavily towards one or the other. Some other fields of research do focus more on theoretical results than on relevance. However, HCI research must be practical and relevant to people, organizations, or design. The research needs to be able to influence interface design, development processes, user training, public policy, or something else. Partially due to the philosophies of the founders of the field, HCI has had a historic focus on practical results that improve the quality of life (Hochheiser and Lazar, 2007).

Is there a tension sometimes between researchers and practitioners? Absolutely. But all HCI research should at least consider the needs of both audiences. At the same time, the research methods used (regardless of the source discipline) must be rigorous and appropriate. It is not sufficient to develop a new computer interface without researching the need for the interface and without following up with user evaluations of that interface.

HCI researchers are often placed in a position of evangelism where they must go out and convince others of the need for a focus on human users in computing. The only way to back up statements on the importance of users and human-centered design is with solid, rigorous research. Due to this interdisciplinary focus and the historical development of the field, there are many different approaches to measurement and research currently used in the field of HCI. A group of researchers, all working on HCI-related topics, often disagree on what "real HCI research" means. There are major differences in how various leaders in the field perceive the existence of HCI.

Be aware that, as an HCI researcher, you may run into people who don't like your research methods, are not comfortable with them, or simply come from a different research background and are unfamiliar with them. And that's OK. Think of it as another opportunity to be an HCI evangelist. (Note: As far as we know, the term "interface evangelist" was first used to describe Bruce Tognazzini. But we really think that the term applies to all of us who do HCI-related work.)

In the early days of HCI research, measurement was based on standards for human performance from human factors and psychology. How fast could someone complete a task? How many tasks were completed successfully, and how many errors were made? These are still the basic foundations for measuring interface usability and are still relevant today. These metrics are very much based on a task-centered model, where specific tasks can be separated out, quantified, and measured. These metrics include task correctness, time performance, error rate, time to learn, retention over time, and user satisfaction (see Chapters 5 and 10 for more information on measuring user satisfaction with surveys). These types of metrics are adopted by industry and standards-related organizations, such as the National Institute of Standards and Technology (in the United States) and the International Organization for Standardization (ISO). While these metrics are still often used and well-accepted, they are appropriate only in situations where the usage of computers can be broken down into specific tasks which themselves can be measured in a quantitative and discrete way. Shneiderman has described the difference between micro-HCI and macro-HCI. The text in the previous paragraph, improving a user's experience using well-established metrics and techniques to improve task and time performance, could be considered micro-HCI (Shneiderman, 2011). However, many of the phenomena that interest researchers at a broader level, such as motivation, collaboration, social participation, trust, and empathy, perhaps having societal-level impacts, are not easy to measure using existing metrics or methods. Many of these phenomena cannot be measured in a laboratory setting using the human factors psychology model (Obrenovic, 2014; Shneiderman, 2008). And the classic metrics for performance may not be as appropriate when the usage of a new technology is discretionary and about enjoyment, rather than task performance in a controlled work setting (Grudin, 2006a).

After all, how do you measure enjoyment or emotional gain? How do you measure why individuals use computers when they don't have to? Job satisfaction? Feeling of community? Mission in life? Multimethod approaches, possibly involving case studies, observations, interviews, data logging, and other longitudinal techniques, may be most appropriate for understanding what makes these new socio-technical systems successful.

As an example, the research area of Computer-Supported Cooperative Work (CSCW) highlights the sociological perspectives of computer usage more than the psychological perspectives, with a focus more on observation in the field, rather than controlled lab studies (Bannon, 2011).

The old methods of research and measurement are comfortable: hypothesis testing, statistical tests, control groups, and so on. They come from a proud history of scientific research, and they are easily understood across many different academic, scientific, and research communities. However, they alone are not sufficient approaches to measure all of today's phenomena. The same applies to the "old standard" measures of task correctness and time performance. Those metrics may measure "how often?" or "how long?" but not "why?" However, they are still well-understood and well-accepted metrics, and they allow HCI researchers to communicate their results to other research communities where the cutting-edge tools and research methods may not be well-understood or well-accepted.

You may not be able to use experimental laboratory research to learn why people don't use technology. If you want to examine how people use portable or mobile technology such as smart phones and wearable computing, there are limitations to studying that in a controlled laboratory setting. If you want to study how people communicate with trusted partners, choose to perform business transactions with someone they don't know on another continent (as often happens with Ebay), or choose to collaborate, you need to find new ways of research and new forms of measurement. These are not research questions that can be answered with quantitative measurements in a short-term laboratory setting.

Philosophy of Computing and Information Technology

Human-Computer Interaction (HCI) is a subfield within computer science concerned with the study of the interaction between people (users) and computers and the design, evaluation and implementation of user interfaces for computer systems that are receptive to the user's needs and habits. It is a multidisciplinary field, which incorporates computer science, behavioral sciences, and design. A central objective of HCI is to make computer systems more user-friendly and more usable. Users interact with computer systems through a user interface, which consists of hard- and software that provides means of input, allowing users to manipulate the system, and output, allowing the system to provide information to the user. The design, implementation and evaluation of interfaces is therefore a central focus of HCI.

It is recognized in HCI that good interface design presupposes a good theory or model of human-computer interaction, and that such a theory should be based in large part on a theory of human cognition to model the cognitive processes of users interacting with computer systems [Peschl and Stary, 1998].

Such theories of human cognition are usually derived from cognitive psychology or the multi-disciplinary field of cognitive science. Whereas philosophers have rarely studied human-computer interaction specifically, they have contributed significantly to theorizing about cognition, including the relation between cognition and the external environment, and this is where philosophy relates to HCI. Research in HCI has initially relied extensively on classical conceptions of cognition as developed in cognitive psychology and cognitive science. Classical conceptions, alternatively called *cognitivism* or the *information-processing approach*, hold that cognition is an internal mental process that can be analyzed largely independently of the body of the environment, and which involves the manipulation of discrete, internal states (representations or symbols) that are manipulated according to rules or algorithms [Haugeland, 1978].

These internal representations are intended to correspond to structures in the external world, which is conceived of as an objective reality fully independent of the mind. Cognitivism has been influenced by the rationalist tradition in philosophy, from Descartes to Jerry Fodor, which construes the mind as an entity separate from both the body and the world, and cognition as an abstract rational, process. Critics have assailed cognitivism for these assumptions, and have argued that cognitivism cannot explain cognition as it actually takes place in real-life settings. In its place, they have developed *embodied* and *situated* approaches to cognition that conceive of cognition as a process that cannot be understood without intimate reference to the human body and to the interactions of humans with their physical and social environment [Anderson, 2003].

Many approaches in HCI now embrace an embodied and/or situated perspective on cognition. Embodied and situated approaches share many assumptions, and often no distinction is made between them. Embodied cognition approaches hold that cognition is a process that cannot be understood without reference to the perceptual and motor capacities of the body and the body's internal milieu, and that many cognitive processes arise out of real-time goal-directed interactions of our bodies with the environment. Situated cognition approaches hold that cognitive processes are co-determined by the local situations in which agents find themselves.

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Knowledge is constructed out of direct interaction with the environment rather than derived from prior rules and representations in the mind. Cognition and knowledge are therefore radically context-dependent and can only be understood by considering the environment in which cognition takes place and the agent's interactions with this environment. Embodied and situated approaches have been strongly influenced by phenomenology, especially Heidegger, Merleau-Ponty and the contemporary work of Hubert Dreyfus (e.g., [Winograd and Flores, 1987; Dourish, 2001; Suchman, 1987]).

Philosophers Andy Clark and David Chalmers have developed an influential embodied/situated theory of cognition, *active externalism*, according to which cognition is not a property of individual agents but of agent-environment pairings. They argue that external objects play a significant role in aiding cognitive processes, and that therefore cognitive processes extend to both mind and environment. This implies, they argue, that mind and environment together constitute a cognitive system, and the mind can be conceived of as extending beyond the skull [Clark and Chalmers, 1998; Clark, 1997]. Clark uses the terms “wideware” and “cognitive technology” to denote structures in the environment that are used to extend cognitive processes, and he argues that because we have always extended our minds using cognitive technologies, we have always been cyborgs [Clark, 2003]. Active externalism has been inspired by, and inspires, *distributed cognition* approaches to cognition [Hutchins, 1995], according to which cognitive processes may be distributed over agents and external environmental structures, as well as over the members of social groups. Distributed cognition approaches have been applied to HCI [Hollan, Hutchins and Kirsh, 2000], and have been especially influential in the area of Computer Supported Cooperative Work (CSCW). Brey [2005] has invoked cognitive externalist and distributed cognition approaches to analyze how computer systems extend human cognition in humancomputer interaction. He claims that humans have always used dedicated artifacts to support cognition, artifacts like calendars and calculators, which HCI researcher Donald Norman [1993] has called *cognitive artifacts*. Computer systems are extremely versatile and powerful cognitive artifacts that can support almost any cognitive task. They are capable of engaging in a unique symbiotic relationship with humans to create hybrid cognitive systems in which a human and an artificial processor process information in tandem. However, Brey argues, not all uses of computer systems are cognitive. With the emergence of graphical user interfaces, multimedia and virtual environments, the computer is now often used to simulate environments to support communication, play, creative expression, and social interaction. Brey argues that while such activities may involve distributed cognition, they are not primarily cognitive themselves. Interface design has to take into account whether the primary aim of applications is cognitive or simulational, and different design criteria exist for both.

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Conclusion

Human–computer interaction (HCI) is the study of how people use technological artifacts, and their design. Unified cognitive architectures such as GOMS and Soar, derived from artificial intelligence, have proven useful theoretically, but too detailed for general application in design. The recognition that design flaws had to be identified early in the design process has lead to the idea of user-centered design, with techniques such as QOC supporting the design process, and the development of evaluation methods, such as cognitive walkthroughs and codifications of practical advice in the form of guidelines. To help designers understand why usability problems might have arisen, cognitive psychology theories are being couched as supportive evaluation methods. One such approach, ICS, is an example of a trend away from the dyadic, turn-taking relationship between a single user and a single computer, towards a more complex view of computers as part of our everyday environment. This trend is increasing the involvement of social and organizational theorists. From another perspective, computer scientists see systems as built up from 'interactors' and argue that the user's cognitive processes can be modeled as just another set of interactors. Syndetic models examine the overall system of human and computer interactors. In general, HCI is focusing less on the individual, has a great deal to gain from other social sciences, and has the potential to provide insight into human behavior in return.

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