

Human–computer interaction

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Human–computer Interaction (HCI) involves the study, planning, and design of the interaction between people (users) and computers. It is often regarded as the intersection of computer science, behavioral sciences, design and several other fields of study. The term was coined by Card, Moran, and Newell in their germinal book, "The Psychology of Human-Computer Interaction." The term connotes that, unlike other tools with only limited uses (such as a hammer, useful for driving nails, but not much else), a computer has many affordances for use and this takes place in a sort of open-ended dialog between the user and the computer.

Interaction between users and computers occurs at the user interface (or simply *interface*), which includes both software and hardware; for example, characters or objects displayed by software on a personal computer's monitor, input received from users via hardware peripherals such as keyboards and mouses, and other user interactions with large-scale computerized systems such as aircraft and power plants. The Association for Computing Machinery defines human-computer interaction as "a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them."^[1] An often-sought facet of HCI is the securing of user satisfaction (see Computer user satisfaction), although user satisfaction is not the same thing as user performance by most meaningful metrics.

Because human-computer interaction studies a human and a machine in conjunction, 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, and human factors such as computer user satisfaction are relevant. Engineering and design methods are also relevant. Due to the multidisciplinary nature of HCI, people with different backgrounds contribute to its success. HCI is also sometimes referred to as **man–machine interaction (MMI)** or **computer–human interaction (CHI)**.

Attention to human-machine interaction is important, because poorly designed human-machine interfaces can lead to many unexpected problems. A classic example of this is the Three Mile Island accident where investigations concluded that the design of the human-machine interface was at least partially responsible for the disaster.^{[2][3][4]} Similarly, accidents in aviation have resulted from manufacturers' decisions to use non-standard flight instrument and/or throttle quadrant layouts: even though the new designs were proposed to be superior in regards to basic human-machine interaction, pilots had already ingrained the "standard" layout and thus the conceptually good idea actually had undesirable results.

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Goals

A basic goal of HCI is to improve the interactions between users and computers by making computers more usable and receptive to the user's needs. Specifically, HCI is concerned with:

- methodologies and processes for designing interfaces (i.e., given a task and a class of users, design the best possible interface within given constraints, optimizing for a desired property such as learnability or efficiency of use)
- methods for implementing interfaces (e.g. software toolkits and libraries; efficient algorithms)
- techniques for evaluating and comparing interfaces
- developing new interfaces and interaction techniques
- developing descriptive and predictive models and theories of interaction

A long term goal of HCI is to design systems that minimize the barrier between the human's cognitive model of what they want to accomplish and the computer's understanding of the user's task.

Professional practitioners in HCI are usually designers concerned with the practical application of design methodologies to real-world problems. Their work often revolves around designing graphical user interfaces and web interfaces.

Researchers in HCI are interested in developing new design methodologies, experimenting with new hardware devices, prototyping new software systems, exploring new paradigms for interaction, and developing models and theories of interaction.

Differences with related fields

HCI differs from **human factors** (or ergonomics) in that with HCI the focus is more on users working specifically with computers, rather than other kinds of machines or designed artifacts. There is also a focus in HCI on how to implement the computer software and hardware mechanisms to support human-computer interaction. Thus, human factors is a broader term; HCI could be described as the human factors of computers – although some experts try to differentiate these areas.

HCI also differs from human factors in that there is less of a focus on repetitive work-oriented tasks and procedures, and much less emphasis on physical stress and the physical form or industrial design of the user interface, such as keyboards and mouse devices.

Three areas of study have substantial overlap with HCI even as the focus of inquiry shifts. In the study of personal information management (PIM), human interactions with the computer are placed in a larger informational context – people may work with many forms of information, some computer-based, many not (e.g., whiteboards, notebooks, sticky notes, refrigerator magnets) in order to understand and effect desired changes in their world. In computer supported cooperative work (CSCW), emphasis is placed on the use of computing systems in support of the collaborative work of a group of people. The principles of human interaction management (HIM) extend the scope of CSCW to an organizational level and can be implemented without use of computer systems.

Design principles

When evaluating a current user interface, or designing a new user interface, it is important to keep in mind the following experimental design principles:

- **Early focus on user(s) and task(s):** Establish how many users are needed to perform the task(s) and determine who the appropriate users should be; 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, define the task(s) the users will be performing and how often the task(s) need to be performed.
- **Empirical measurement:** Test the interface early on with real users who come in contact with the interface on an everyday basis. Keep in mind that results may be altered if the performance level of the user is not an accurate depiction of the real human-computer interaction. Establish 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).
- **Iterative design:** After determining the users, tasks, and empirical measurements to include, perform the following iterative design steps:

1. Design the user interface
2. Test
3. Analyze results
4. Repeat

Repeat the iterative design process until a sensible, user-friendly interface is created.^[5]

Design methodologies

A number of diverse methodologies outlining techniques for human–computer interaction design have emerged since the rise of the field in the 1980s. Most design methodologies stem from a model for how users, designers, and technical systems interact. Early methodologies, for example, treated users' cognitive processes as predictable and quantifiable and encouraged design practitioners to look to cognitive science results in areas such as memory and attention when designing user interfaces. Modern models tend to focus on a constant feedback and conversation between users, designers, and engineers and push for technical systems to be wrapped around the types of experiences users want to have, rather than wrapping user experience around a completed system.

- **User-centered design:** user-centered design (UCD) is a modern, widely practiced design philosophy rooted in the idea that users must take center-stage in the design of any computer system. Users, designers and technical practitioners work together to articulate the wants, needs and limitations of the user and create a system that addresses these elements. Often, user-centered design projects are informed by ethnographic studies of the environments in which users will be interacting with the system. This practice is similar

but not identical to Participatory Design, which emphasizes the possibility for end-users to contribute actively through shared design sessions and workshops.

- **Principles of User Interface Design:** these are seven principles that may be considered at any time during the design of a user interface in any order, namely Tolerance, Simplicity, Visibility, Affordance, Consistency, Structure and Feedback.^[6]
- See List of human-computer interaction topics#Interface design methods for more

Display designs

Displays are human-made artifacts designed to support the perception of relevant system variables and to facilitate further processing of that information. Before a display is designed, the task that the display is intended to support must be defined (e.g. navigating, controlling, decision making, learning, entertaining, etc.). A user or operator must be able to process whatever information that a system generates and displays; therefore, the information must be displayed according to principles in a manner that will support perception, situation awareness, and understanding.

Thirteen principles of display design

Christopher Wickens et al. defined 13 principles of display design in their book *An Introduction to Human Factors Engineering*.^[7]

These principles of human perception and information processing can be utilized to create an effective display design. A reduction in errors, a reduction in required training time, an increase in efficiency, and an increase in user satisfaction are a few of the many potential benefits that can be achieved through utilization of these principles.

Certain principles may not be applicable to different displays or situations. Some principles may seem to be conflicting, and there is no simple solution to say that one principle is more important than another. The principles may be tailored to a specific design or situation. Striking a functional balance among the principles is critical for an effective design.^[8]

Perceptual principles

1. *Make displays legible (or audible).* A display's legibility is critical and necessary for designing a usable display. If the characters or objects being displayed cannot be discernible, then the operator cannot effectively make use of them.
2. *Avoid absolute judgment limits.* Do not ask the user to determine the level of a variable on the basis of a single sensory variable (e.g. color, size, loudness). These sensory variables can contain many possible levels.
3. *Top-down processing.* Signals are likely perceived and interpreted in accordance with what is expected based on a user's past experience. If a signal is presented contrary to the user's expectation, more physical evidence of that signal may need to be presented to assure that it is understood correctly.
4. *Redundancy gain.* If a signal is presented more than once, it is more likely that it will be understood correctly. This can be done by presenting the signal in alternative physical forms (e.g. color and shape, voice and print, etc.), as redundancy does not imply repetition. A traffic light is a good example of redundancy, as color and position are redundant.

5. *Similarity causes confusion: Use discriminable elements.* Signals that appear to be similar will likely be confused. The ratio of similar features to different features causes signals to be similar. For example, A423B9 is more similar to A423B8 than 92 is to 93. Unnecessary similar features should be removed and dissimilar features should be highlighted.

Mental model principles

6. *Principle of pictorial realism.* A display should look like the variable that it represents (e.g. high temperature on a thermometer shown as a higher vertical level). If there are multiple elements, they can be configured in a manner that looks like it would in the represented environment.

7. *Principle of the moving part.* Moving elements should move in a pattern and direction compatible with the user's mental model of how it actually moves in the system. For example, the moving element on an altimeter should move upward with increasing altitude.

Principles based on attention

8. *Minimizing information access cost.* When the user's attention is diverted from one location to another to access necessary information, there is an associated cost in time or effort. A display design should minimize this cost by allowing for frequently accessed sources to be located at the nearest possible position. However, adequate legibility should not be sacrificed to reduce this cost.

9. *Proximity compatibility principle.* Divided attention between two information sources may be necessary for the completion of one task. These sources must be mentally integrated and are defined to have close mental proximity. Information access costs should be low, which can be achieved in many ways (e.g. proximity, linkage by common colors, patterns, shapes, etc.). However, close display proximity can be harmful by causing too much clutter.

10. *Principle of multiple resources.* A user can more easily process information across different resources. For example, visual and auditory information can be presented simultaneously rather than presenting all visual or all auditory information.

Memory principles

11. *Replace memory with visual information: knowledge in the world.* A user should not need to retain important information solely in working memory or to retrieve it from long-term memory. A menu, checklist, or another display can aid the user by easing the use of their memory. However, the use of memory may sometimes benefit the user by eliminating the need to reference some type of knowledge in the world (e.g. an expert computer operator would rather use direct commands from memory than refer to a manual). The use of knowledge in a user's head and knowledge in the world must be balanced for an effective design.

12. *Principle of predictive aiding.* Proactive actions are usually more effective than reactive actions. A display should attempt to eliminate resource-demanding cognitive tasks and replace them with simpler perceptual tasks to reduce the use of the user's mental resources. This will allow the user to not only focus on current conditions, but also think about possible future conditions. An example of a predictive aid is a road sign displaying the distance from a certain destination.

13. *Principle of consistency.* Old habits from other displays will easily transfer to support processing of new displays if they are designed in a consistent manner. A user's long-term memory will trigger actions that are expected to be appropriate. A design must accept this fact and utilize consistency among different displays.

Human–computer interface

Main article: User interface

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:

- **Task Environment:** The conditions and goals set upon the user.
- **Machine Environment:** The environment that the computer is connected to, i.e. a laptop in a college student's dorm room.
- **Areas of the Interface:** Non-overlapping areas involve processes of the human and computer not pertaining to their interaction. Meanwhile, the overlapping areas only concern themselves with the processes pertaining to their interaction.
- **Input Flow:** The flow of information that begins in the task environment, when the user has some task that requires 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.

Current research

Hot topics in HCI include:

User customization

End-user development studies how ordinary users could routinely tailor applications to their own needs and use this power to invent new applications based on their understanding of their own domains. Users, with their deeper knowledge of their own knowledge domains, could increasingly be important sources of new applications at the expense of generic systems programmers (with systems expertise but low domain expertise).

Embedded computation

Computation is passing beyond desktop computers into every object for which uses can be found. Embedded systems make the environment alive with little computations and automated processes, from computerized cooking appliances to lighting and plumbing fixtures to window blinds to automobile braking systems to greeting cards. To some extent, this development is already taking place. The expected difference in the future is the addition of networked communications that will allow many of these embedded computations to coordinate with each other and with the user. Human interfaces to these embedded devices will in many cases be very different from those appropriate to workstations.

Augmented reality

A common staple of science fiction, augmented reality refers to the notion of layering relevant information into our vision of the world. Existing projects show real-time statistics to users performing difficult tasks, such as manufacturing. Future work might include augmenting our social interactions by providing additional information about those we converse with.

Factors of change

The means by which humans interact with computers continues to evolve rapidly. Human–computer interaction is affected by the forces shaping the nature of future computing. These forces include:

- Decreasing hardware costs leading to larger memory and faster systems
- Miniaturization of hardware leading to portability
- Reduction in power requirements leading to portability
- New display technologies leading to the packaging of computational devices in new forms
- Specialized hardware leading to new functions
- Increased development of network communication and distributed computing
- Increasingly widespread use of computers, especially by people who are outside of the computing profession
- Increasing innovation in input techniques (i.e., voice, gesture, pen), combined with lowering cost, leading to rapid computerization by people previously left out of the "computer revolution."
- Wider social concerns leading to improved access to computers by currently disadvantaged groups

The future for HCI, based on current promising research, is expected to include the following characteristics:

- **Ubiquitous communication.** Computers are expected to communicate through high speed local networks, nationally over wide-area networks, and portably via infrared, ultrasonic, cellular, and other technologies. Data and computational services will be portably accessible from many if not most locations to which a user travels.
- **High functionality systems.** Systems can have large numbers of functions associated with them. There are so many systems that most users, technical or non-technical, do not have time to learn them in the traditional way (e.g., through thick manuals).
- **Mass availability of computer graphics.** Computer graphics capabilities such as image processing, graphics transformations, rendering, and interactive animation are becoming widespread as inexpensive chips become available for inclusion in general workstations and mobile devices.
- **Mixed media.** Commercial systems can handle images, voice, sounds, video, text, formatted data. These are exchangeable over communication links among users. The separate worlds of consumer electronics (e.g., stereo sets, VCRs, televisions) and computers are partially merging. Computer and print worlds are expected to cross-assimilate each other.
- **High-bandwidth interaction.** The rate at which humans and machines interact is expected to increase substantially due to the changes in speed, computer graphics, new media, and new input/output devices. This can lead to some qualitatively different interfaces, such as virtual reality or computational video.
- **Large and thin displays.** New display technologies are finally maturing, enabling very large displays and displays that are thin, lightweight, and low in power consumption. This is having large effects on portability and will likely enable the development of paper-like, pen-based computer interaction systems very different in feel from desktop workstations of the present.
- **Information Utilities.** Public information utilities (such as home banking and shopping) and specialized industry services (e.g., weather for pilots) are expected to proliferate. The

rate of proliferation can accelerate with the introduction of high-bandwidth interaction and the improvement in quality of interfaces.

Academic conferences

One of the top academic conferences for new research in human-computer interaction, especially within computer science, is the annually held ACM's Conference on Human Factors in Computing Systems, usually referred to by its short name CHI (pronounced *kai*, or *khai*). CHI is organized by ACM SIGCHI Special Interest Group on Computer–Human Interaction. CHI is a large, highly competitive conference, with thousands of attendants, and is quite broad in scope.

There are also dozens of other smaller, regional or specialized HCI-related conferences held around the world each year, the most important of which include (see also [1] (<http://www.confsearch.org/confsearch/faces/pages/topic.jsp?topic=hci&sortMode=1&graphicView=true>)):

Special purpose

- ASSETS: ACM International Conference on Computers and Accessibility
- CSCW: ACM conference on Computer Supported Cooperative Work.
- DIS: ACM conference on Designing Interactive Systems.
- ECSCW: European Conference on Computer-Supported Cooperative Work. Every second year.
- GROUP: ACM conference on supporting Group work.
- HRI: ACM/IEEE International Conference on Human-robot interaction.
- ICMI: International Conference on Multimodal Interfaces.
- ITS: ACM conference on Interactive Tabletops and Surfaces.
- IUI: International Conference on Intelligent User Interfaces.
- MobileHCI: International Conference on Human-Computer Interaction with Mobile Devices and Services.
- NIME: International Conference on New Interfaces for Musical Expression.
- Ubicomp: International Conference on Ubiquitous computing
- UIST: ACM Symposium on User Interface Software and Technology.
- i-USER: International Conference on User Science and Engineering

See also

- Usability
- Human factors / Ergonomics
- Interaction design
- Physiological interaction
- Human Interface Device
- Human-Machine Interface (see also Human-machine interface in lower-case initials)
- Full list of HCI-related topics

Footnotes

1. ^ ACM SIGCHI Curricula for Human-Computer Interaction (http://old.sigchi.org/cdg/cdg2.html#2_1)
2. ^ Ergoweb. "What is Cognitive Ergonomics?" (<http://www.ergoweb.com/news/detail.cfm?id=352>) . Ergoweb.com. <http://www.ergoweb.com/news/detail.cfm?id=352>. Retrieved August 29, 2011.
3. ^ "NRC: Backgrounder on the Three Mile Island Accident" (<http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html>) . Nrc.gov. <http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html>. Retrieved August 29, 2011.

4. ^ <http://www.threemileisland.org/downloads/188.pdf>
5. ^ Green, Paul (2008). Iterative Design. Lecture presented in Industrial and Operations Engineering 436 (Human Factors in Computer Systems, University of Michigan, Ann Arbor, MI, February 4, 2008).
6. ^ Pattern Language (http://www.mit.edu/~jtidwell/common_ground_onefile.html)
7. ^ Wickens, Christopher D., John D. Lee, Yili Liu, and Sallie E. Gordon Becker. An Introduction to Human Factors Engineering. Second ed. Upper Saddle River, NJ: Pearson Prentice Hall, 2004. 185–193.
8. ^ Brown, C. Marlin. Human-Computer Interface Design Guidelines. Intellect Books, 1998. 2–3.

Further reading

- Academic overview of the field by many authors:
 - Andrew Sears and Julie A. Jacko (Eds.). (2007). Human-Computer Interaction Handbook (2nd Edition). CRC Press. ISBN 0-8058-5870-9
 - Julie A. Jacko and Andrew Sears (Eds.). (2003). Human-Computer Interaction Handbook. Mahwah: Lawrence Erlbaum & Associates. ISBN 0-8058-4468-6
- Historically important classic:
 - Stuart K. Card, Thomas P. Moran, Allen Newell (1983): *The Psychology of Human-Computer Interaction*. Erlbaum, Hillsdale 1983 ISBN 0-89859-243-7
- Overview of history of the field:
 - Jonathan Grudin: *A moving target: The evolution of human-computer interaction*. In Andrew Sears and Julie A. Jacko (Eds.). (2007). Human-Computer Interaction Handbook (2nd Edition). CRC Press. ISBN 0-8058-5870-9
 - Brad Myers: *A brief history of human-computer interaction technology*. Interactions 5(2):44–54, 1998, ISSN 1072–5520 ACM Press. <http://doi.acm.org/10.1145/274430.274436>
 - John M. Carroll: Human Computer Interaction: History and Status. (http://www.interaction-design.org/encyclopedia/human_computer_interaction_hci.html) Encyclopedia Entry at Interaction-Design.org
- Academic journals:
 - *ACM Transactions on Computer-Human Interaction*
 - *Behaviour & Information Technology* [2] (<http://www.informaworld.com/bit>)
 - *EMinds International Journal on Human-Computer Interaction*
 - *Interacting with Computers*
 - *International Journal of Human-Computer Interaction*
 - *International Journal of Human-Computer Studies*
 - *Human-Computer Interaction* [3] (<http://hci-journal.com/>) [4] (<http://www.tandf.co.uk/journals/titles/07370024.asp>)
- Collection of key papers:
 - Ronald M. Baecker, Jonathan Grudin, William A. S. Buxton, Saul Greenberg (Eds.) (1995): *Readings in human-computer interaction. Toward the Year 2000*. 2. ed. Morgan Kaufmann, San Francisco 1995 ISBN 1-558-60246-1
- Treatments by one or few authors, often aimed at a more general audience:
 - Jakob Nielsen: *Usability Engineering*. Academic Press, Boston 1993 ISBN 0-12-518405-0
 - Donald A. Norman: *The Psychology of Everyday Things*. Basic Books, New York 1988 ISBN 0-465-06709-3
 - Jef Raskin: *The humane interface. New directions for designing interactive systems*. Addison-Wesley, Boston 2000 ISBN 0-201-37937-6
 - Ben Shneiderman and Catherine Plaisant: *Designing the User Interface: Strategies for Effective Human-Computer Interaction*. 4th ed. Addison Wesley, 2004 ISBN 0-321-19786-0
 - Bruce Tognazzini: *Tog on Interface*. Addison-Wesley, Reading 1991 ISBN 0-201-60842-1

- Textbooks that could be used in a classroom:
 - Alan Dix, Janet Finlay, Gregory Abowd, and Russell Beale (2003): *Human–Computer Interaction*. 3rd Edition. Prentice Hall, 2003. <http://hcibook.com/e3/> ISBN 0-13046-109-1
 - Helen Sharp, Yvonne Rogers & Jenny Preece: *Interaction Design: Beyond Human–Computer Interaction, 2nd ed.* John Wiley & Sons Ltd., 2007 ISBN 0-470-01866-6
 - Matt Jones (interaction designer) and Gary Marsden (2006). *Mobile Interaction Design*, John Wiley and Sons Ltd.
- See also List of user interface literature
- See also readings on hcibib.org (<http://www.hcibib.org/readings.html>)

External links

- HCI Review (<http://www.hcireview.com/>)
- Bad Human Factors Designs (<http://www.baddesigns.com>)
- The HCI Wiki Bibliography (<http://www.interaction-design.org/references/>) with over 100,000 publications.
- The HCI Bibliography (<http://www.hcibib.org/>) Over 58,000 publications about HCI.
- Human-Centered Computing Education Digital Library (<http://hcc.cc.gatech.edu/>)
- Usability Views (<http://www.usabilityviews.com/>)
- HCI Webliography (<http://www.hcibib.org/hci-sites/ORGANIZATIONS.html>) with a list of about 100 HCI Organizations worldwide
- <http://cogscent.com/human-computer-interaction.html> Interactive computer use impacts cognition

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