Human – Computer Interaction

Presented By:

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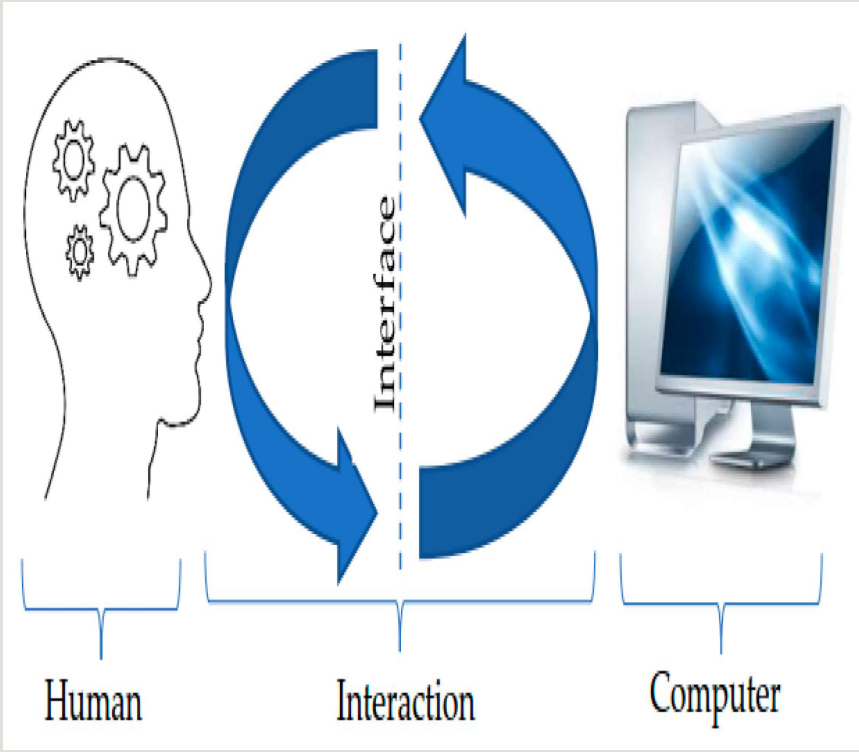
Human Computer Interaction

Human-Computer Interaction is a multidisciplinary field that focuses on designing and evaluating computer systems and technologies that people interact with.



Source: Simplilearn

Components of HCI

1. Psychology
2. Cognitive Science
3. Ergonomics
4. Sociology
5. Computer Science
6. Business
7. Graphics design

Importance of Human-Computer Interaction (HCI) in Modern Engineering

1. Enhancing User Experience

- User-Centered Design: HCI emphasizes designing systems that cater to the needs, abilities, and limitations of users, leading to more intuitive and accessible products.
- Satisfaction and Engagement: By focusing on user experience (UX), HCI ensures that products are not only functional but also enjoyable to use, increasing user satisfaction and engagement.

2. Improving Usability

- Ease of Use: HCI principles help engineers design interfaces that are easy to navigate, reducing the learning curve for new users.
- Error Reduction: Well-designed interfaces minimize user errors, improving the overall safety and reliability of the system.
- **3. Ensuring Accessibility**
- Inclusive Design: HCI promotes the creation of products that are accessible to people with disabilities, ensuring that technology can be used by a diverse population.
- Regulatory Compliance: Following HCI guidelines helps engineers meet accessibility standards and regulations, avoiding legal issues and ensuring broader market reach.

4. Adapting to Future Trends

- Responsive and Adaptive Systems: HCI helps in designing systems that can adapt to changing user needs and contexts, such as mobile interfaces that work seamlessly across different devices.
- Human-Robot Interaction: As robotics becomes more integrated into daily life, HCI ensures that interactions between humans and robots are safe, intuitive, and effective.

Components of Human-Computer Interaction

HCI is primarily composed of four essential elements:

1. The User

An individual or a group of individuals who work together on a project is referred to as the user component. HCI researches the needs, objectives, and interaction styles of users.

2. The Goal-Oriented Task

When using a computer, a user always has a purpose or aim in mind. To achieve this, the computer presents a digital representation of things.

Source: Simplilearn

3. The Interface

An essential HCI element that can improve the quality of user interaction is the interface. Many interface-related factors need to be taken into account, including the type of interaction, screen resolution, display size, and even color contrast.

4. The Context

HCI is not only about providing better communication between users and computers but also about factoring in the context and environment in which the system is accessed.

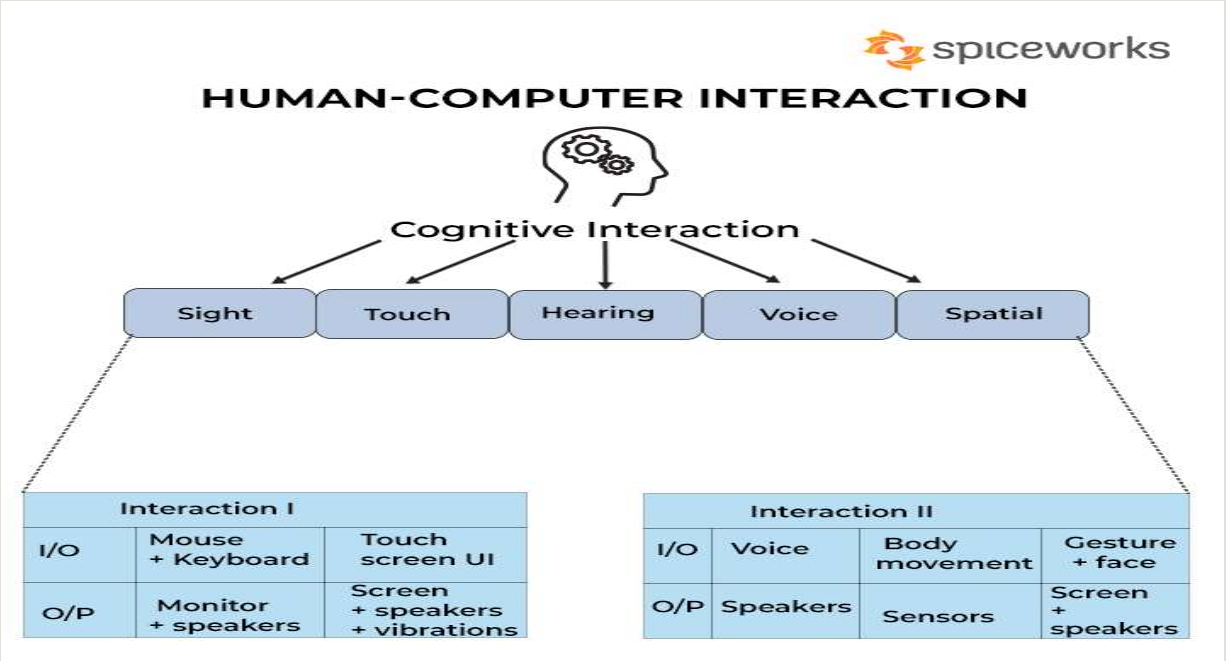
Human Input Output Channels

Input

1. Sight
2. Hear
3. Touching

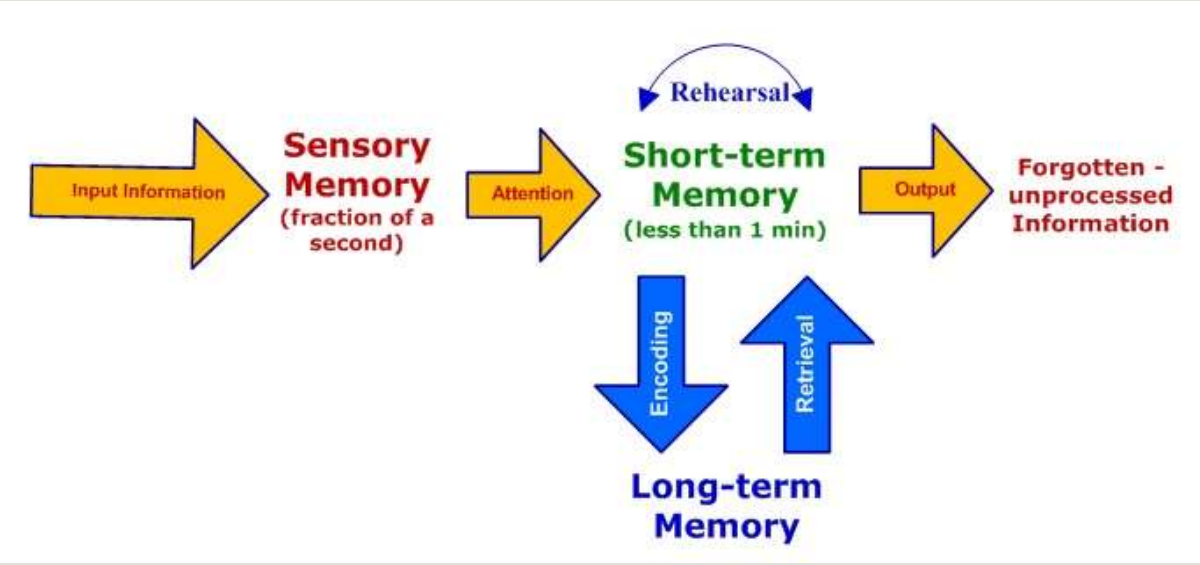
Output/Effectors

1. Limbs
2. Fingers
3. Body position/head
4. Voice



Human Memory

1. Sensory memory
2. Short term memory
3. Long term memory



Key Concepts in Human-Computer Interaction (HCI)

1. **Interaction Models**

Interaction models in HCI describe how users interact with computers and how these interactions are structured. They serve as frameworks for understanding and designing user interfaces.

- Direct Manipulation
- Menu-Driven Interaction
- Command-Line Interfaces (CLI)
- Natural Language Interaction
- Hybrid Interaction Models

2. Human-Centered Design (HCD)

Human-Centered Design is a design philosophy that places the user at the center of the design process, ensuring that products are tailored to meet the needs, capabilities, and limitations of the end users.

- Empathy and Understanding Users
- Iterative Design Process
- Involving Users in the Design Process
- Focus on Usability and Accessibility

3. Usability

Usability in HCI refers to how effectively, efficiently, and satisfactorily a user can interact with a product or system. It's a core concept that ensures that technology is user-friendly and meets the intended purpose.

- Effectiveness
- Efficiency
- Satisfaction
- Learnability
- Memorability
- Accessibility

Theories of HCI

1. Norman's Seven Principles
2. Shneiderman's Eight Golden Rules

Norman's model of interaction

1. Establishing the goal
2. Forming the intention
3. Specify the action sequence
4. Execute the action
5. Perceive the system state
6. Interpreting the system state
7. Evaluating the system state

2. Shneiderman's Eight Golden Rules

1. Strive for Consistency
2. Seek Universal Usability
3. Offer Informative Feedback
4. Design Dialogue to Yield Closure
5. Prevent Errors
6. Permit Easy Reversal of Actions
7. Keep the User in Control
8. Reduce Short-term Memory Load

Interaction Styles

Command Line : It is one of the oldest interaction style present today. But it is not user friendly because user needs to learn so many commands. Each task or work have it's own command, you have to be expert or proficient in writing these commands.

Graphic user interface : It is one of the popular interaction style available today. Operating systems like Windows and macOS are the best style of GUI, where user can provide input with the help of mouse and keyboard.

Natural Language : It is one step ahead of GUI. We can interact with system by the help of languages that we are using in our day to day life. **Alexa**, **Siri**, **Google voice** are the best example of voice assistant that uses natural language.

Q/A (Question and Answer) : The best example of this interaction style are chatbots. Every application whether it is web or mobile application has chatbot now a days.

Applications based on HCI

1. Smartphones

- Example: Apple iPhone
- HCI Features:
  - Touchscreen Interface: Users interact directly with the screen, using multi-touch gestures like swiping, pinching, and tapping.
  - Voice Assistants: Siri allows users to interact with their phone using natural language, making tasks like setting reminders or sending messages hands-free.
  - Facial Recognition: Face ID enhances security by allowing users to unlock their phone just by looking at it.

  Impact: Smartphones have revolutionized communication, entertainment, and daily tasks, making advanced computing power accessible to the masses.

2. Smart Home Devices

- **Example**: Amazon Echo (Alexa)

- **HCI Features**:
  - **Voice Commands**: Users can control home appliances, play music, and get information using voice commands.
  - **Natural Language Processing**: Alexa can understand and respond to complex commands and questions in natural language.
  - **Smart Home Integration:** Echo devices can be connected to various smart home products like lights, thermostats, and security systems, providing centralized control through voice interaction.

  Impact: Smart home devices simplify daily routines, enhance home security, and improve energy efficiency through easy-to-use interfaces.

3. Automotive Interfaces

- Example: Tesla Model 3
- HCI Features:
  - Touchscreen Dashboard: The central control is managed through a large touchscreen, replacing most physical buttons and dials.
  - Voice Control: Drivers can use voice commands to adjust settings, navigate, or make calls without taking their hands off the wheel.
  - Autopilot and Advanced Driver Assistance Systems (ADAS): Semi-autonomous driving features interact with drivers to provide assistance, such as lane-keeping and adaptive cruise control.
- Impact: Modern automotive interfaces enhance safety, comfort, and driving efficiency by providing intuitive controls and advanced assistance systems.

4. Healthcare Applications

- **Example**: Electronic Health Records (EHR) Systems

- **HCI Features**:
  - **User-Friendly Interfaces**: EHR systems like Epic and Cerner provide healthcare professionals with intuitive interfaces for managing patient data.
  - **Decision Support Systems**: These systems assist doctors by providing recommendations based on patient data and medical guidelines.
  - **Mobile Integration**: Mobile apps allow doctors and patients to access medical records, schedule appointments, and communicate with each other remotely.

Impact: HCI in healthcare improves patient care by making it easier for healthcare providers to manage and share patient information, and for patients to access their health data.

5. Gaming Consoles

- **Example**: PlayStation 5

- **HCI Features**:
  - **Haptic Feedback**: The DualSense controller provides tactile sensations that correspond to in-game actions, enhancing immersion.
  - **Adaptive Triggers**: These offer varying levels of resistance, simulating real-life actions like pulling a bowstring.
  - **Voice Commands**: Gamers can use voice commands to navigate menus, start games, or communicate with other players.

Impact: Gaming consoles have evolved to provide highly immersive experiences through innovative HCI, blurring the line between the virtual and physical worlds.

6. Virtual and Augmented Reality

- **Example**: Oculus Quest 2 (VR) and Microsoft HoloLens (AR)
- **HCI Features**:
  - **Immersive Environments**: VR systems like Oculus Quest 2 allow users to interact within fully immersive 3D environments, using hand controllers or even just their hands.
  - **Gesture Control**: AR devices like HoloLens enable users to interact with digital content overlaid on the real world using gestures.
  - Spatial Audio and Haptics: These technologies enhance the realism and interactivity of virtual environments by providing audio cues and tactile feedback.

  Impact: VR and AR are transforming industries like gaming, education, healthcare, and design by providing new ways to experience and interact with digital content.

7. Wearable Technology

- **Example**: Apple Watch

- **HCI Features**:
  - **Touchscreen and Digital Crown**: Users interact through a combination of touchscreen gestures and the digital crown, which allows for precise control.
  - **Health Monitoring**: The watch tracks various health metrics, like heart rate, sleep, and exercise, providing real-time feedback and recommendations.
  - **Notifications and Apps**: The watch interfaces with a smartphone to display notifications, messages, and apps, all accessible on the wrist.

Impact: Wearable technology enhances personal health management and keeps users connected, integrating seamlessly into daily life.

Trends in the User Experience Industry driven by Human-Computer Interaction?

1. **Voice Guided User Interface**

Voice-guided UI is a new trend in the market, where users can interact with the technology using only their voice. We can command and instruct these Voice Guided devices to perform tasks like playing music, controlling electronic devices, or set reminders, etc with the help of IoT & AI.

2. Gesture Guided User Interface

We are already using the gesture-guided interface on our mobile phones or touch screen devices for navigation through swipes, taps, or pinches.

Tech companies are constantly imbibing these techniques to enhance the interaction on wearable devices too.

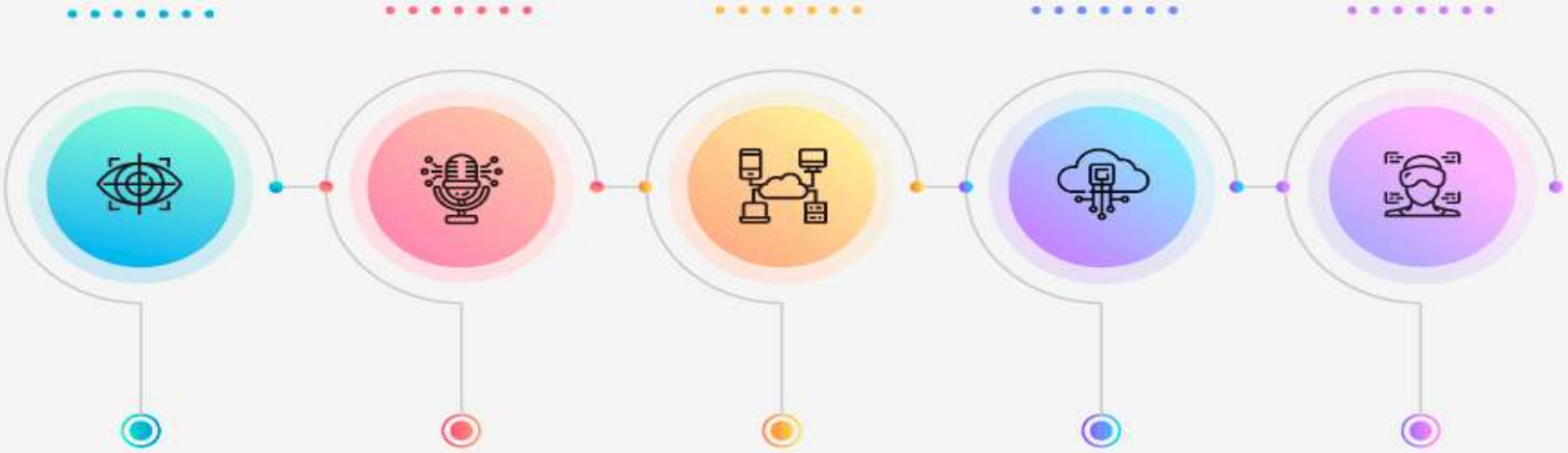
3. Virtual/Augmented Reality

Virtual reality headsets allow us to engage in truly immersive experiences. As technology evolves, we may perform more of our daily tasks using a headset instead of a laptop and keyboard. Augmented reality lets us experience the world while administered by technology.

4. Wearable Technology

Wearable technology has started enhancing the user interface for smart watches and fitness monitors that allow us to track our vital signs and keep a check on our health with just a few taps.

Technologies that facilitate human-computer interaction



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HCI and AI

Techniques used in HCI

1. Gaze estimation

Gaze estimation is the process of determining where a person is looking based on their eye movements and facial features. It is a technique that is used in a variety of applications, including human-computer interaction, virtual and augmented reality, psychology, and neuroscience research.

Gaze estimation can be performed using a variety of different approaches, including computer vision algorithms, machine learning techniques, and specialized hardware such as eye tracking cameras. It typically involves analyzing the position and movement of the eyes and other facial features to estimate the direction of the person's gaze.

Gaze Estimation Models and Algorithms

1. Feature-Based Gaze Estimation

Feature-based methods use specific features of the human eye, including cornea reflection and pupil contour, to estimate gaze. Compared to other facial features, these are less sensitive to changes in lighting and viewpoint. Still, traditional feature-based gaze estimation methods were not reliable for gaze detection outdoors or when ambient light is strong.

A solution to this problem is to combine head pose and eye location information. One such vector is the PC-EC vector proposed by Sesma (2012). Another approach, known as behavior-informed validation, uses supervised learning algorithms, which learn eye gaze via user interaction cues provided by human testers.

2. Cross-Ratio-Based Gaze Estimation

Cross-ratio methods use several infrared (IR) or near-infrared light sources, and their reflection in the cornea, to detect gaze. For example, IR light-emitting diodes (LED) can be placed on the corners of a computer monitor, highlighting the center of the user's pupil and creating a polygon. These methods use learning-based methods to simultaneously reduce errors from spatial variance and head pose.

Cross-ratio gaze detection makes it possible to identify the center of the pupil without calculating geometric relations of the eye and camera position, and often without requiring calibration.

3. Appearance-Based Gaze Estimation

Appearance-based methods directly analyze an eye image and attempt to determine the point of gaze. They are more effective than other approaches when only low-resolution eye images are available.

Modern appearance-based gaze estimation relies on convolutional neural networks (CNN). For example, VGG16, AlexNet, ResNet18 and ResNet 50 have been used to achieve gaze estimation in the wild without dependence on person and head pose. Other approaches use multi-modal training, combining elements like head pose, full-face images, and face-grid data. For a full review of deep learning appearance based methods, see Cheng et. al (2021).

Datasets for Gaze Estimation

1. MPIIGaze
2. GazeCapture
3. The Provo Corpus
4. Gaze-in-the-Wild
5. SynthesEyes
6. VQA-MHUG

Gesture recognition

Gesture recognition is the ability of a computer or device to detect and interpret human gestures as input. Such gestures include hand movements and even finger-written symbols.

The technology behind gesture recognition involves using cameras or other sensors to capture the gestures, and then using machine learning algorithms to analyze and interpret the captured data.

Gesture recognition has a variety of uses, including:

Human-computer interaction: Gesture recognition can be used to control computers, smartphones, and other devices through gestures, such as swiping, tapping, and pinching.

Gesture Recognition and Detection Datasets

MlGesture dataset

EgoGesture

HAnd Gesture Recognition Image Dataset (HaGRID)

Vision for Intelligent Vehicles and Applications

Objectively Recognizing Eating Behavior and Associated Intake (OREBA)

HCI with AI

- AI-powered Human-Computer Interaction (HCI) refers to the use of artificial intelligence techniques to enhance interactions between humans and computers.
- Traditional HCI primarily focuses on designing systems and interfaces that allow humans to interact with computers efficiently.
- When combined with AI, these systems become more intuitive, adaptive, and intelligent, making interactions smoother, more responsive, and personalized.

Technologies used

- Machine Learning: Improves system responsiveness by learning from user data.
- Natural Language Processing: Allows interaction using spoken or written language.
- Computer Vision: Tracks gestures, gaze, and body movements for interaction.
- Gesture and Speech Recognition

1. Eye Tracking based Interaction

Eye tracking involves detecting the position of the eyes in real-time video and interpreting this data to recognize gestures or control input.

Libraries which can be used

Open CV: image processing

Dlib/Mediapipe: facial and eye landmark detection

Working

1. Video Capture
2. MediaPipe Face Mesh
3. Eye Tracking
4. Control Gesture (Blinking, looking left or right to interact with the system)

2. Gaze-Based Interaction Model

Tracks eye movements to control elements on the screen.

- Uses computer vision to detect gaze direction and trigger actions.
- Example: Move the cursor or select items by looking at them

3. Gesture-Based Interaction Model

Uses computer vision to detect hand gestures or body movements.

- Example: Kinect for Xbox, touchless interaction in smart environments.
- AI analyzes gesture data to trigger appropriate responses

Case Study: Hand Gesture Recognition for Contactless Human-Computer Interaction

Data set 20BN-Jester dataset (Kaggle)

Can be built with using: KERAS, OPEN CV

Steps :

1. Data Exploration
2. Data Extraction
3. Hyper parameter training
4. Model Training
5. Classification

4. Voice-Based Interaction Model

Uses NLP to understand and respond to spoken commands.

- Example: Virtual assistants like Siri, Google Assistant.
- Recognizes speech and provides output based on commands.

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THANK YOU !