

Fundamentals of Human Computer Interaction (HCI)

PART ONE

Basics of HCI

- Modality of Interaction
- Interaction Models
- Architectures for Interactions

Modality of Interaction

Learning Objectives

- What are the types of Modality of Interaction from Multimedia's point of view?

Interaction

- Interaction with artificial objects (including both physical and virtual)
 - results of advances of Artificial Systems *i computer system*
 - Artificial System : a set of components, each of which interacts with each other in an ordered manner.
- Advances in Computing and Networking markedly changed our society and how we interact with artificial systems.

Purpose of Interaction

- Advancing Human Capabilities
- Advancing Human Communication
- Advancing Assistance Capability
- Improving Experience

Advancing Human Capabilities

- calculation (this is how it's started...)
- simple memorization
- associative memory
- language translation
- problem solving
- automatic proofing
- enhancing human cognitive capability (cognitive artificial systems)
- requires understanding of human activities.

Advancing Human Communication

- combined with advances of networking technologies
- provides new media for human - human communication (computer mediated communication)
- unlike a non-computer mediated communication, various services can be provided to enhance the communication.

Advancing Assistance Capability

- Many audio/visual products can be interconnected with networks
- Various white-goods now have micro-controller
- Mobile/Wearable computing allow us to access networked computers anytime
- Perceptual user interfaces allow computers to sense our activities in order to provide adaptive services.

(Matthew Turk and George Robertson: Perceptual User Interfaces, Communications of the ACM, Vol. 43, No. 3, 33-34, 2000)

Improving Experience

- computer assisted/mediated artificial systems
 - characterised not only by their functional capabilities
 - but also by how they can improve our physical/mental experiences

Types of Interactions

- Interactions occur between
 - human and human (HHI)
 - human and computer (HCI)
 - human and machine (HMI)
 - human and information (HII)
- HXI covers all “Human - X” Interactions

A solid orange vertical bar is positioned on the left side of the slide.

Multimedia Oriented Modality of Interactions

Modality of Interactions (Multimedia Oriented)

Many different methods are used to represent pieces of information used in interactions



Two basic representation media

language :
text, audio (voice)

non-language :
other media

Language Media



Natural Language

spoken / written language



Artificial Language -
convey the information in a
simple and accurate
manner

programming language



Suited for describing
complex information in an
orderly manner using
common grammar and
syntax.

Non-Language Media

Examples

- facial expression, body language
- pause during a conversation
- body movement

Purpose

- support/control language media
- convey information, which cannot be easily expressed in language

Vargas' Nine Types of Non- Language Media

- Action
- Peripheral language
- Silence
- Time
- Chroma
- Human body
- Body contact
- Eye
- Territorial Space

Action

- Expression by posture and movement of human body. ^{eg.} Facial expression also belong to this type.
- Actions might have different meanings depending on recipients' culture.

Peripheral Language

- Features associated with conversational language
 - Tempo
 - Volume
 - accent, etc.
- feeling, personality can be conveyed (subjective)

Silence

- pause in conversations
- intentionally ignore

Time

- Temporal factors, which have significant influence on communication.
- factors based on actions
 - timing of interruption in conversation
- factors based on biological rhythms
 - timing to induce sleepiness

Chroma

- Color in the environment
- Work on human perception
- Can be used to control communication and action

Eye

- Includes
 - eye contact
 - expression in eye
- Under Information provider's control

Eye contact & Facial Expressions

- Facial expressions represent many emotional states of users
- supported by gestures
- hard to control consciously
- differences in looking (active) and seeing (passive)
- looking in public space might be offensive

Eye contact & Facial Expressions (cont.)

- can be used to
 - control timing of speaker/listener change
 - monitor responses
 - display your opinion
 - display your emotion
 - express your attitude towards other participants

Human Body

≠ body language

- characteristics of human body expressed in its age, gender, physique, skin color, etc.
- Typically based on information recipients' cultural background.

Body contact

- Includes
 - real body contact
 - replacement of body contact, which is closely associated with the real body contact.

Body Language

- Linguistic body language
 - associated with an apparent message (sign language, common gestures)
- illustrative body language
 - assists the conveyance of messages (gesture to emphasize the point of messages)

Body Language (cont.)

- negotiation body language
 - gesture for invitation and patting on the shoulder
- ceremonial body language
 - hand-shaking and bowing

Body Language (cont.)

- body language to regulate verbal communication
 - nodding, touching your chin, arm crossing, etc.
- adapter body language
 - yawning, scratching, etc.
- Synchrony
 - unconsciously imitate the person's body language when you agree with that person

Territorial Space

- interaction distances between humans
- spatial arrangement of participants
- could be culturally biased

Territorial Space (cont.)

- In human communication, users are very sensitive to their own territorial space
- Territorial space can be violated by
 - territorial pollution (verbal, physical)
 - unsolicited space use
 - overtaking the territory
- Personal Space defines the comfortable interaction space for individual

Territorial Space (cont.)

- Stop-Distance method - measure the personal space
 - an experimenter getting close to the subject, and the subject will indicate when the experimenter reaches the uncomfortable distance
- Artificial systems could modify the personal space
 - use of mobile phone in the public space
 - kids' long phone call at home
 - online game

Territorial Space (cont.)

intimate distance : < 45cm

- all five senses will be involved
- very close relationship unless a participant is forced to be in the situation

individual distance : 45cm - 1.2m

- individually interested parties

social distance : 1.2 - 3.6m

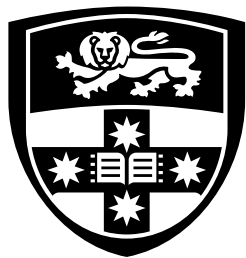
- cannot touch other parties nor see them in detail
- for non-individual conversation

public distance : > 3.6m

- public lecture, presentation
- you can escape

Summary

- Modality of Interaction from Multimedia' point of view
 - language vs. non-language
- Vargas's Nine non-language media
 - Gaze/Facial expression
 - Body Language
 - Territorial Space



THE UNIVERSITY OF
SYDNEY

Fundamentals of Human Computer Interaction (HCI)

PART TWO

Basics of HCI

- Modality of Interaction
- Interaction Models
- Architectures for Interactions

Human Information Processing Model

Learning Objectives

Understanding human cognitive action in Interaction

- Human Information Processing Model
- Ecological Model
- Social Interaction Model

Human Information Processing Model

- In cognitive psychology - the human is treated as an information processing unit
- cognitive process is modelled as a series of information processes on this IP unit
- understand human cognitive processes such as inference, problem solving, memory and learning
- S.K. Card, T.P. Moran and A. Newell : the Psychology of Human-Computer Interaction (Erlbaum, 1983)

Human as an information processing unit



Computer

Input
Central Processing Unit
Output



Human

Five sensory devices (input)
Brain : Memory & CPU
Body (including speech) (output)

Human Memory Unit

Sensory Register

- very short-time storage for five sensory devices

Working Memory

- temporary information storage mechanism
- limited capacity and function (magic number 7)

Long-term Memory

- Declaratory Memory
 - episode memory (for events)
 - semantic memory (for abstract concept)
- Procedural Memory

Pros/Cons of HIP model

Cons:

- very little biologically equivalent explanations

Pros:

- can be simulated
- can be used to evaluate functions and performances of human interaction

Simulation using HIP model – Example I

decide menu system

*① menu bar { many items
small # but click can expand.*

- Capacity limitation of the Working Memory
 - the number of items a user needs to remember should be small
- Example: the time it takes to reach the decision is proportional to the number of available choices (Hick-Hyman law)
- W.E. Hick, On the rate of gain of information, Quarterly Journal of Experimental Psychology, 4:11-26, 1952.
- R. Hyman. Stimulus information as a determinant of reaction time. Journal of Experimental Psychology, 45:188-196, 1953.
- a small number of menu windows with many selections will be effective than a large number of menu windows with small selections

Simulation using HIP model – Example II

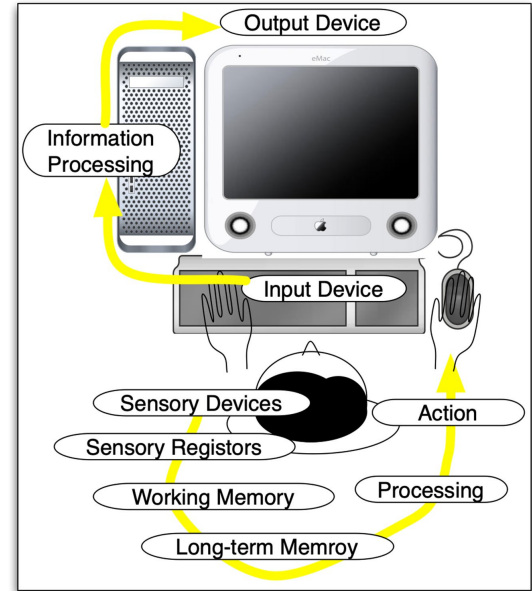
- Example: the time it takes to reach a target using a pointing device depends on the size of and distance to the target (Fitts' Law)
 - Provides a user interface design guideline: where to place the target objects on the screen

decide the size & location of the target.

HCI Modelling using HIP Model

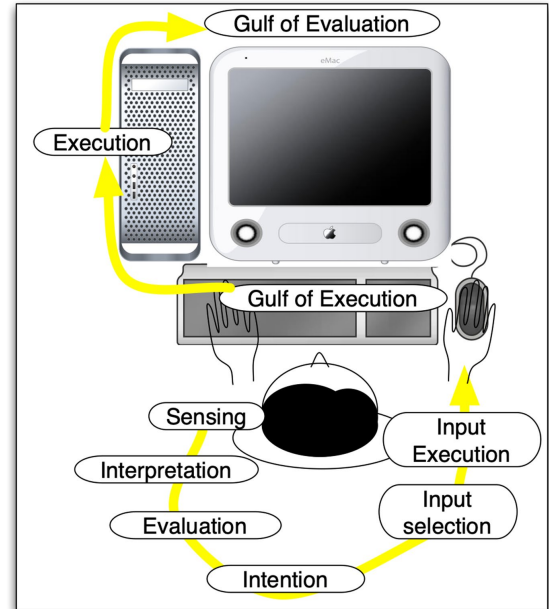
- Two Information Processing Units
- Two sides are connected by IOs

for human:
input : sensory Devices , eg. eyes.
out : Action eg. hand



Interaction Cycle in D. Norman's Gulf Model

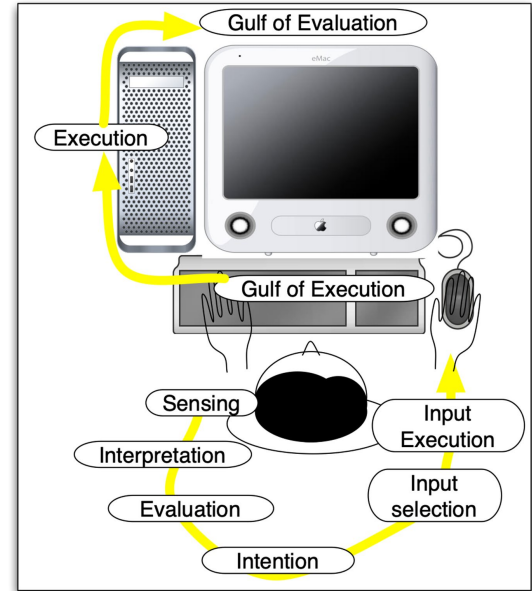
- Sensing State of an Artificial System
- Interpret the sensing results
- Evaluate the interpretation against its own intention
- (Re)-Set a new intention
- Select a new input
- Execute the new input
- Execution by the Artificial System



Breakdown in D. Norman's Gulf Model

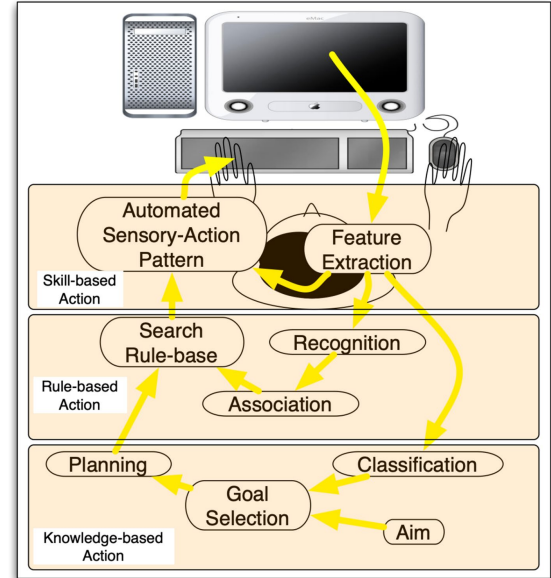
- This model is useful to analyse/explain various difficulties, ineffectiveness, failure and breakdown
- Gulf prevents a seamless coupling of two execution systems (computer and human)
- There are two gulfs
- **Execution** (from H to C)
- **Externalisation** (from C to H)

mismatch
① seeing & interpreting info
② put info back to computer



Rasmussen's Decision-Making Control Model

- Three levels of hierarchical control model
 1. Skill-based
 2. Rule-based
 3. Knowledge-based
- Similar to “Subsumption Architecture” (Brooks@MIT) often used in Robot-Control.
 - fast but low-quality low-level processing
 - slow but high-quality high-level processing



Minsky's Society of Mind : Agent-based Model

- Treat “Human Mind” as a group of inter-related agents
- It provides many interesting possibilities to build the model of mind but has not been applied to the practical models

Ecological Model

Ecological Model

- Closely related to Rasmussen's SRK-based decision making model
- Put its focus on the environment rather than the human as an information processing unit.
- Analyse how the environment offers relevant information to humans in order to assist any interaction

Ecological Model (cont.)

- It does not analyse (absolute) physical characteristics the environment has.
- It analyses
 - How relevant information can be generated based on humans' needs
 - How humans obtain such information
 - How humans apply such information to their actions
- Early works were founded upon research on human visual perception

Example of Ecological Model

- Imagine that you're visiting the powerhouse museum for the first time.
- How would you plan your action in order to achieve your primary objective?
 - to get in, it seems that you need a ticket
 - what sorts of exhibits?
 - how they are arranged?, etc.

Affordance

- A person will obtain pieces of information from the environment in order to assist its action plan.
- Affordance: the pieces of such information available in the environment (James J. Gibson: The Ecological Approach to visual Perception, Houghton Mufflin Co., 1979)

Affordance in a museum

- sign for the entrance
- queue for buying a ticket
- a map of the museum
- announcements
- etc.

Affordance Rich/non-Rich

- Many pieces of affordance are available in an familiar environment
- In an unfamiliar environment, available affordance is limited
- Affordance is defined by the relationship between the subject and its environment

Affordance in AFL

- If you're an experienced player, you can inference many pieces of information from
 - players' movements around you,
 - trajectory of the ball, etc.

Invariant in Affordance

- It is a pieces of information, which does not change depending on how the subject moves around the environment
- It allows the subject plan and achieve a stable action.
- In order to obtain such invariant, the subject is encourage to actively move around the environment.

Dynamic Touch

- An action that the subject actively apply to objects in the environment in order to obtain invariant
 - touching, shaking, hitting, etc.
- gentle to rough : Micro Activity/Action
 - accumulate micro activities lead to finding of invariant

Social Interaction Model

Social Interaction Model

- Human society consists of many small and large groups of people
- Such groups try to
 - achieve common goals,
 - solve common problems,
 - assure the trust
- These activities are carried out through various interactions within the groups

Group and Community

- A group, whose members have apparent roles to achieve a common goal.
- A community is a gathering of participants who joined based on their own will.
 - a circle, alumni, academic association, volunteer group
 - traditionally, it indicates geographic locality and association
 - Advances in network tech. introduced a new type of community (Network Community)

Network Community

Community of Interest

- increase the ground coverage through common interests.

Community of practice

- academic association, union - maintaining good human relationships

Online local communities

- conventional local communities enhanced through the use of networks.

Features of Group/Community

There is a clear boundary to identify member and non-member (some even have uniforms...boy/girl scouts)

Through background knowledge and interests, they build strong associations

There are formal and tacit rules and regulations

Common Factor in Group and Community

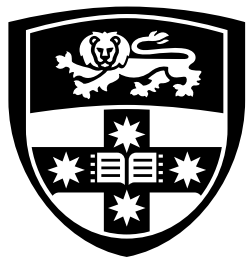
- The group and the community are usually formed based on different objectives
- However, both entities involves strong awareness of other members through background/tacit knowledge

Role of Awareness

- Awareness is closely associated with tacit knowledge along with various pieces of background information in the environment.
- Appropriate awareness will add positive information towards the successful completion of tasks in the group/community.
- Awareness-rich community will be highly likely to succeed.

Summary

- Understand Interaction through Cognitive Action Models
 1. Human Information Processing Model
 2. Ecological Model (Affordance)
 3. Social Interaction Model (Awareness)



THE UNIVERSITY OF
SYDNEY