Human Computer Interaction

UNIT-6
Lecture 1:
Cognitive Architecture

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Cognitive Architecture
Lecture 1: Introduction

Objective

- There are three components in HCI - **H**uman, **C**omputer and **I**nteraction
- Among them, human is the most important (consideration of human in design differentiates HCI from other fields)
- Design should take into account human (which resulted in user centred/participatory design approaches)

Objective

- In the previous lectures, we have learned about the model-based approaches (to reduce design time and effort) [Unit- II]
  - In those lectures, we have already seen how individual models of human factors are taken into account (Fitts' law etc.)
  - Also learned about GOMS – a simple model of human behavior

Objective

- However, human behavior is very complex
  - We need more complex approaches, taking into account different components of human behavior
  - Such complexities are sought to be captured in integrated cognitive architectures (CA), which are found to be very useful in HCI
- In this lecture, we shall learn about the CA and its application in HCI

Human/User

- A user can be viewed as an information processing system
- Information i/o …
  - Input: visual, auditory, haptic
  - Output: movement/motor action
  - Processor: Cognitive, Perceptual, Motor
- Information stored in memory (Sensory, Short-term, Long-term)

Human/User

- The information taken as input and stored are processed and applied in various ways
  - Reasoning
  - Problem solving
  - Skill
  - Error
- Also, emotion influences human capabilities

Message

- We want to model these activities of human information processor (HIP)
- Such (HIP) model can
  - Validate understanding of ourselves
  - Inform the design of better user interfaces
  - Develop robust automated design approaches

HIP Models

- **There are broadly two approaches to model HIP**
  - **Computational –** HIP modeled using computer metaphors
  - **Connectionist –** Biological metaphor to model HIP; HIP as a neural network

HIP Models

- **Our focus –** computational approaches
- **Computational HIP models can be of two types**
  - **Production systems:** the information processing behavior is implemented as a set of production (IF-THEN-ELSE) rules
  - **Non-production systems**

Cognitive Architectures (CA)

- **CA -** a broad theory of human cognition based on a wide selection of human experimental data, and implemented as a running computer simulation program

- Essentially, CAs are computational HIP models taking into account all the components of cognition

Cognitive Architectures (CA)

- There are many CAs developed, most of them are production systems with few non-production systems
- **Examples of CAs developed as production systems:**
  - Model Human Processor, Soar, EPIC, ACT-R/PM
- **Example of non-production CAs** – Integrated Cognitive Subsystems

CA and HCI

- **CAs are relevant to usability**
  - They can provide an engineering perspective to usability analysis
  - Can be used to develop HCI-related applications
  - Can serve an important role in HCI as a theoretical science

CA as Usability Engineering Tool

- Engineering requires quantitative predictions
  - Helps compare alternative designs and identify design problems
- Qualitative/quantitative guidelines may not be sufficient to compare two “nearly equally good” designs
  - Need some theory/model to “compute” certain “parameters” of the designs to compare them

CA as Usability Engineering Tool

- Usability engineering involves similar situation
- Every design must be subjected to usability test
  - UE experts mostly rely on intuition/experience/guidelines to do so

CA as Usability Engineering Tool

- Ex: intuition may say interface X is faster than Y, but how much? 10%. 20%
  - Such quantitative data is required, as small savings in execution time may result in large financial savings
- Requires quantitative prediction theories

CA as Usability Engineering Tool

- Computational models based on CAs can provide such quantitative answers
- The models can predict many useful quantities such as
  - Execution time
  - Error rate
  - Transfer of knowledge

CA as Usability Engineering Tool

- The models can predict many useful quantities such as
  - Learning rates
  - Memory load
  - Many more performance measures
  - Results may not be accurate but sufficient for comparison

CA as Usability Engineering Tool

- Models based on CA can be employed for evaluations in situations where traditional usability evaluation may be very costly or even impossible
  - For example, evaluation involving fighter pilots or astronauts
- GOMS/cognitive walkthroughs etc. can also provide quantitative predictions
  - They are abstracted from some underlying architectures
  - CA based models can predict much more

CA Applications

- **By definition, CAs are executables, making them suitable for several HCI-relevant applications**
  - Intelligent Tutoring Systems
    - The Lisp tutoring system
  - Populating simulated worlds/situations
    - Training fighter pilots
    - Multi-party game
    - Virtual reality

CA - Issues

- **Many aspects of human behavior are yet to be accounted for**
  - Error behavior
    - It is difficult to mimic such behavior, which sometimes is required to evaluate usability
  - Emotion
    - Recently some promising works are being done

CA - Issues

- Simulated agents usually interact with an interface using a specification of the system

  -An active research area is to enable simulated agents access interfaces in ways that approximate the richness and limitation of human perceptual-motor capabilities

- At present, understanding and implementing CAs requires specialization

  – Usability of CA specification languages needs improvements