CMPE 233: Human Factors

Introduction, History

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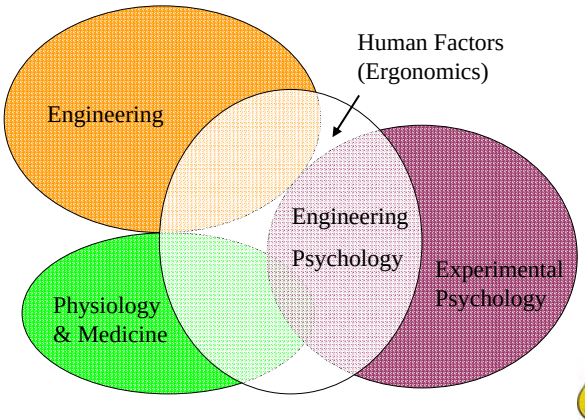
Human Factors

- Design systems that accommodate the limits of the human user
- "The study of how humans accomplish work related tasks in the context of human-machine system operation, and how behavioral and nonbehavioral variables affect that accomplishment". (Meister p.2)
  - "behavioral" = psychological constraints - how do humans process information?
  - "non-behavioral" = physical constraints - can a human physically operate system?
- Goals: making human interaction with systems one that
  - Reduce errors
  - Increase production
  - Enhance safety and comfort

Where are Human Factors situated?



Related Definitions

- Experimental Psychology
  - The scientific study of mind, brain, and behavior
  - *Why humans think and behave the way they do*
  - EP is concerned with underlying principles of behavior (why?), while human factors is more concerned with design (how?)
- Ergonomics (from Greek ergon 'work' + nomics) is the application of scientific information concerning humans to the design of objects, systems and environment for work use.
- Human-Computer Interaction (HCI)
  - the design, evaluation and implementation
  - of interactive computing systems for human use and
  - the study of major phenomena surrounding them

Human Factors course

- Aims of the class: to identify
  - Human constraints and needs (physical and cognitive) when interacting with systems
  - Approaches for improving productivity, health and safety
  - Methods for assessing a product or systems' effectiveness
- Varying application domains
  - Space mission planners should be able to control the Mars Rover in terms that make sense to them
  - Doctors should be able to comfortably hold surgical tools without risk of dropping it or excessive hand fatigue
  - Nuclear power plants operators should be able to easily read warnings + power plant indicators (3-mile island)
  - Aviation pilots should be able to quickly find the information they need and intuitively understand it

Course Logistics

- Class meetings
  - Tue/Thu 4:00-5:45 PM, Porter Acad 250
  - Standard lectures, movies, demonstrations
- Assessment
  - Mid-term exam (W1-5 material): 30%
  - Group Project: 40%
  - Homework (around 3): 30%
- Suggested readings (buy used on froogle):
  - C.D.Wickens, J.D.Lee, Y.Liu, S.Gordon-Becker "Introduction to Human Factors Engineering"
  - M.S. Sanders, E.J.McCormick "Human Factors in Engineering and Design"
  - Norman, D. "Design of Everyday Things"
  - Krug, S. "Don't Make Me Think"
  - Johnson, J. "GUI Bloopers"

Tentative timetable

- W1: Historical foundations. Biological basis of psychology and sensation. Human Information Processing
- W2: Visual system: sensation vs. perception (depth perception, motion perception, and pattern recognition), color vision, visual search, perceptual speed, perceptual organization, visual display
- W3: Auditory and tactile systems: Signal Detection Theory, audition and touch, RSI, designing for hearing and touch, haptic/tactile interfaces
- W4: Memory and attention: theories of attention, selective/divided attention, Multiple Resource Theory, reasoning, decision making, designing for memory
- W5: Performance measurement: Psychometric tests (Simple/Choice Reaction Time tests, digit/word span, visuospatial test), Fitts' Law, Hicks' Law, other cognitive tests, quantitative and qualitative methods

Tentative timetable

- W6: Midterm exam.
  Individual differences: novice vs. expert, personality trait, effect of practice, transfer of training
- W7: Workload management: mental workload, NASA-TLX (subjective measure of mental workload), stress, fatigue and coping
- W8: Human error and reliability: system concept and human error, Human Reliability Analysis
- W9: Socio-technical systems approach to safety.
- W10: Ergonomics science in a glance: introduction to anthropometry, work physiology and biomechanics. Project presentation

Project: *developing a GUI blooper and observing how much effort users need to take to become skilled at using it*

History

- Before the industrial revolution people did not explicitly worry that much about HF
- The roots of HF as a science begin in the late 19th century
- Industrialization increased
- Markets expanded from local to national and global levels aided by inventions:
  - Telegraph, telephone, train, steam ships
- Three significant figures
  - Fredrick Taylor (started in 1881)
  - Frank & Lillian Gilbreth (early 1900)

Taylor, 1881, Midvale Steel, Philadelphia

- Founder of modern *time study*
- Came up with system of managing work to make it more efficient:
  - Managers plan work 1 day in advance
  - Workers get written instructions on tasks and how to accomplish them
  - Each job has a "standard time" determined by a time study made by experts
  - Advocated breaking tasks into "elements"
- No one took much notice until 1903 published in ASME : 'Shop Management'
- But in recent days there is backlash against efficiency movement

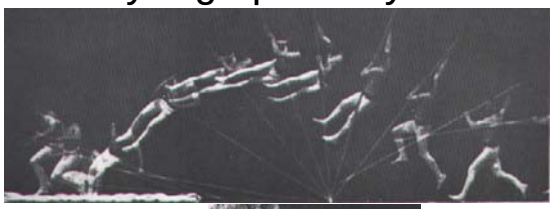
Taylor's studies

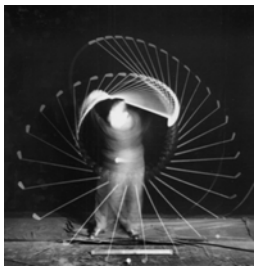
- Pig Iron Study (1898) – Bethlehem Steel Co.
  - Established methods for carrying 92 lb. "pigs" of iron up ramp to freight car
  - Provided financial incentives
  - Greatly increased productivity from 12.5 tons/day/worker to 48 tons (4 fold increase)
- Shoveling Experiment
  - Redesigned shovels (were same size for all jobs):
  - Short handle for heavy iron
  - Long handled scoop for light rice coal
  - Productivity increased
  - Material handling costs decreased

The Gilbreths – early 1900s

- Founders of modern *motion study* techniques
  - Study of body motions used in performing tasks
  - Simplifying motions
  - Establishing most favorable motion sequences
  - As they were in brick laying trade, increased performance from 120 bricks/hr to 350
- Photographed and filmed motions to study them
  - Cyclographic analysis: put light on workers' finger, and photograph the path.
  - Chrono-cyclographic analysis: Put strobe on finger – get dotted lines on photo; Spacing indicates speed
  - Divide motion into elements "therbligs"

Cyclograph Analysis



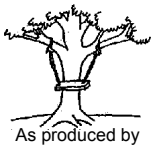


What happens in engineering design

As proposed by the project sponsor

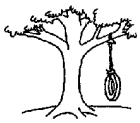
As specified in the project request

As designed by the senior analyst



As produced by the programmers

As installed at the user's site



What the user wanted

Human (or User-) Centered Design

- A design philosophy, or methodological principle, that centers the design process around the user.
- Three important attributes:
  1. Focus on the roles of humans in complex systems
  2. Design objectives are elaborated in terms of roles of humans
  3. Specific design issues follow from these objectives
- Four general approaches to HCD/UCD:
  1. Understand users, their tasks and their environment early
  2. Observations and measurements to gather user requirements and limitations
  3. Iterative design using prototypes, where rapid changes are made to the design
  4. Participatory design where users are directly involved as part of the design team

Human-Centered Design: Background

- Systems have increased in size, scale, and complexity to increase performance
- People will increasingly become like “cogs of machines.”
- However, machines can never be legally, ethically, and socially responsible for their actions
- Hence, regardless of systems’ scale and sophistication, humans will always have the ultimate responsibility of their operation. Therefore humans must
  1. perceive the nature of these responsibilities, and
  2. have appropriate levels of authority and knowledge to fulfill them.

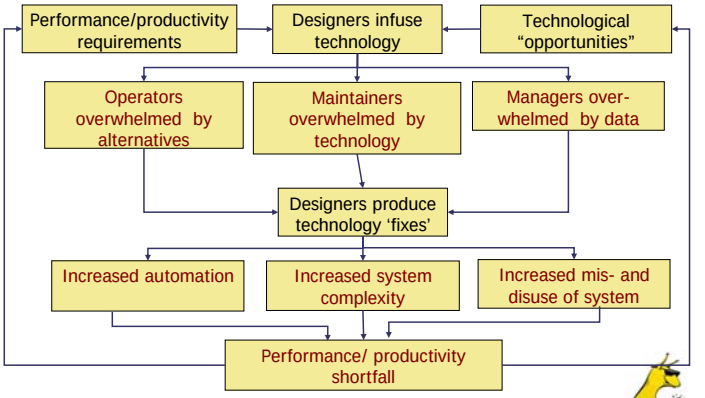
Human-Centered Design Objectives

- Design objectives should be to support humans to achieve the operational objectives for which they are responsible
- In HC aviation, it is
  - not the main aim to train the pilot to fly the airplane that takes people from point A to point B;
  - instead, it is important to design an airplane that supports the pilot, whose responsibility is to take people from A to B.
- In HC engineering, it is
  - not the main aim to train the engineer to operate a machine that is designed to achieve some engineering goals;
  - instead, it is important to design a machine that supports the engineers who are responsible for achieving engineering goals.

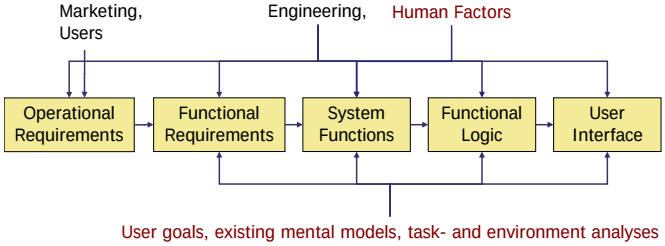
Human-Centered Design

- Human centered design should…
  1. enhance human abilities
  2. help overcome human limitations
  3. foster user acceptance
- Design Issues:
  1. Formulate the right problem -- make sure that system objectives and requirements are right
  2. Design an appropriate solution -- excellence in engineering is necessary but not sufficient to assure that system design is successful
  3. Develop the solution to perform well -- operability, maintainability, supportability
  4. Assure user satisfaction

Technology-Driven Design



Human Factors in System Development



System Development Lifecycle

- Stage 1: Front-End Analysis
  - User Analysis
  - Preliminary Task Analysis
  - Environment Analysis
  - Identification of User Preferences and Requirements
  - Input for System Specifications
  - Make sure objectives and functions match user requirements
  - Provide success criteria
- Stage 2: Conceptual Design
  - Function Allocation
  - Support for the Conceptual Design Process

System Development Lifecycle

- Stage 3: Iterative Design and Testing
  - Task Analysis
  - Interface Design
  - Prototype Development
  - Heuristic Evaluation
  - Cost-Benefit Analyses
  - Trade-off Analyses
  - Workload Analysis
  - Simulations and Modeling
  - Safety Analysis
  - Usability Testing
- Stage 4: Design of Support Materials
  - Develop and provide input for support materials
- Stage 5: System Production
- Stage 6: Implementation and Evaluation
  - Evaluate system in the field
- Stage 7: System Operation and Maintenance
  - Monitor System Performance Over Time
- Stage 8: System Disposal

Role of HF in System Engineering

- Both SE and HF are vested in system success
- Focus of SE: integration of ALL systems to insure
  - system success
  - stakeholder satisfaction
- Focus of HF: integration of the *needs of the human* into ALL systems to insure
  - optimal performance
  - Safety
- Including HF throughout process can decrease total cost of ownership
  - Incorporating HF early in design cycle may impact initial cost and schedule but will reduce long-term costs (e.g., training, maintenance, staffing, safety)
  - It is 10x more costly to fix it during development, and 100x more costly to fix it after the product is released (Pressman, 1992)

Psychopathology of Everyday Things

- From Norman's "Design of Everyday Things"
- We are surrounded by many everyday things that have poor *usability*
  - Programming a VCR
  - Telephone features we can't remember how to use
    - How to change the remote access code?
  - Photocopiers and fax machines
    - Face down or face up?
- Many of these things can be difficult to interpret and frustrating to use if they provide no clues or false clues as to how they operate

Why is usability important?

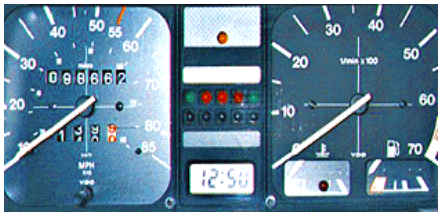
- Defined in ISO 9241
  - a measure of the **effectiveness**, **efficiency** and **satisfaction** with which specified users can achieve specified goals in a particular environment.
- Poor usability results in
  - anger and frustration
  - decreased productivity in the workplace
  - higher error rates
  - physical and emotional injury
  - equipment damage
  - loss of customer loyalty
  - costs money

Examples of Poor Design

- Door handles
  - Trapped between doors!
  - Handles **afford** pulling
  - Using a flat plate would **constrain** the user to push
- Wireless Powerpoint slide controller
  - Short press to go forward
  - Long press to go backward
- Refrigerator temperature control
  - Two compartments and two controls
  - One cooling unit

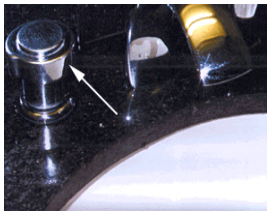
Norman's Principles of Design

- Make things visible
  - The correct parts must be visible and they must convey the correct message
  - Natural signals are naturally interpreted
  - Visibility problems occur when clues are lacking or exist in excess
  - Just by looking the user should know the **state of the system** and **possible actions**
  - Don't violate these principles to make something "look good"!
- Provide a good conceptual model
  - A good conceptual model allows us to predict the effects of our actions
  - Without a good model we operate blindly
    - Simply follow rules without understanding a reason
    - No understanding of cause or effect
    - No recourse when something breaks



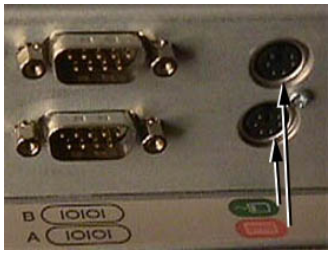
Affordance

- The physical property that gives a way what can be done with an object

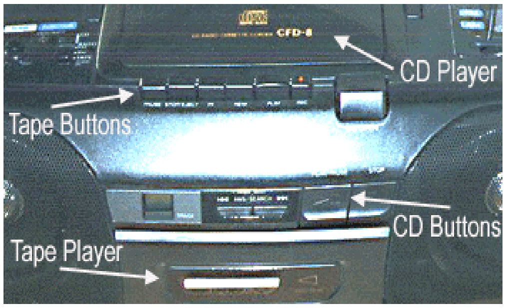


Mapping

- Controls and displays should exploit natural mapping
- Natural mapping takes advantage of physical analogies and cultural standards
  - Physical: Steering wheel
  - Cultural: red means stop, green means go



How do you operate these?



Constraints

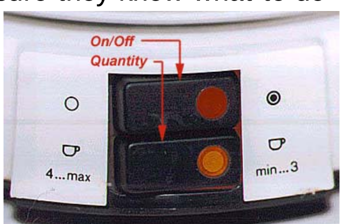
- Constraints limit the ways in which something can be used
- Constraints can be
  - Physical
  - Semantic
  - Cultural
  - Logical

Paper scissors

Barber scisssors

Feedback

- Feedback is sending back to the user information about what action has actually been done
- Visibility of the effects of the operation tell you if something worked correctly
- Systems should be designed to provide adequate feedback to the users to ensure they know what to do next in their tasks
- Examples
  - Telephone button press tone
  - Rice cooker goes "bing!"
  - Clicker on your turn signal
  - Animated icon while waiting for a web page to load



Norman's Principles in Software

- Affordance
  - If it looks like a button it can be pressed, if it is a underlined it can be clicked (web)
- Mapping
  - Clicking on a particular interface element produces expected effect (under F)ile should be O)pen)
- Constraints
  - Constraining search criteria, graying out menu items that don't apply in a particular context
- Feedback
  - Providing clear and immediate feedback for each user action
- Visibility
  - Visibility of the tasks the interface supports
  - Communication of system state / mode

Larson's Dog effect

Thank you for registering! We appreciate your business. To activate your software, you will be sent an email key. After you have received the key then you will be able to click here and you can then proceed with the activation process.

Blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah click here blah blah blah blah blah blah blah blah blah blah blah

Coffee machines