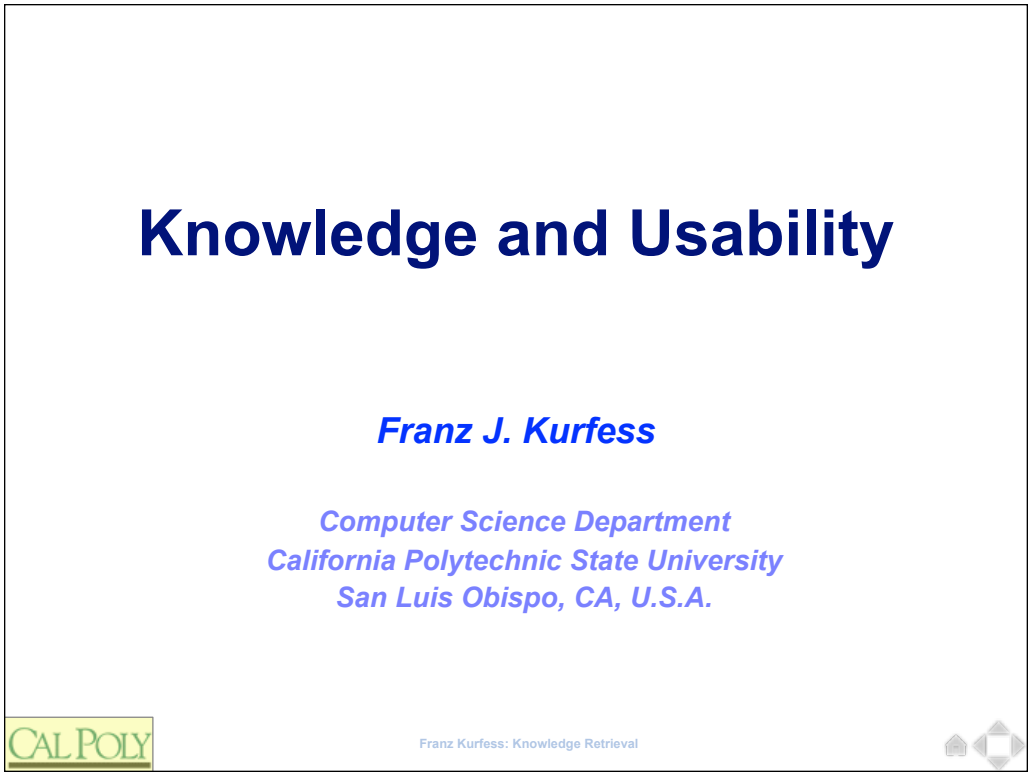

Paper: <link to a copy of the paper, URL>

address of the author

This paper discusses usability aspects of knowledge. It identifies different dimensions of usability, and examines ways of measuring usability along those dimensions. Aspects specific to usability of knowledge are examined by analyzing some commonly used usability evaluation methods, and by identifying the aspects that are relevant for knowledge-intensive tasks or contexts.

Acknowledgements

*Some of the material in these slides was developed for a lecture series sponsored by the **European Community** under the **BPD program** with **Vilnius University** as host institution*

Use and Distribution of these Slides

- These slides are primarily intended for the students in classes I teach. In some cases, I only make PDF versions publicly available. If you would like to get a copy of the originals (Apple KeyNote or Microsoft PowerPoint), please contact me via email at fkurfess@calpoly.edu. I hereby grant permission to use them in educational settings. If you do so, it would be nice to send me an email about it. If you're considering using them in a commercial environment, please contact me first.

Structure

- Introduction
- Dimensions of Knowledge Usability
- Metrics for Usability of Knowledge
- Knowledge-Intensive Activities
- Usability Evaluation Methods
- Problem Sources

typically reflects the structure of the paper

certain aspects of the knowledge are presented via graphical means, typically by associating graphical features (shape, color) with relevant knowledge aspects
in addition, visual primitives (spatial proximity, similarity, cohesion, ...) can be used to suggest similar relations among knowledge items

Is the way different parts of the system are used consistent within the system itself?

If the system is part of a family (e.g. the MS Office suite), do the different components work in a consistent manner?

Does the consistency reach across multiple applications or systems?

this is a collection of methods used in practice in various settings

"traditional" methods, without specific emphasis on knowledge aspects

Introduction

- Terminology
  - Data, Information, and Knowledge
- Using Knowledge
- Dimensions of Knowledge Usability

Using Knowledge

- What do we want when we look for information or knowledge?
  - answers, not documents!
- current retrieval systems identify documents that may or may not contain the answer
  - irrelevant documents
  - partial answers
  - multiple answers

Current Usage of Retrieval Systems

- tools to identify potentially relevant documents
- formulation of questions as unnatural queries
  - either simplistic sets of keywords, or complex expressions
- ranking of retrieved documents according to obscure criteria
  - re-formulation of queries to influence ranking
- mostly batch processing
  - submit query
  - wait
  - view result
- inconsistent, wrong context, …

Better Usage of Retrieval Systems

- provide answers to questions
- find the right information fast
- analyze information, combine it into easily digestible formats
- summarize longer documents, sets of related documents
- relate it to decisions to be made

Utilization and Usability

- utilization
  - dissemination, distribution
  - application of relevant knowledge
- usability
  - ease of use
  - convenience
  - effectiveness
  - efficiency

Usage Aspects

- collection and evaluation of usage information
  - single items vs. sets of items
  - individuals vs. groups
  - temporal relationships
  - info-space relationships
- examples
  - relevance feedback, user profiles, citation analysis, hypertext links, collaborative filtering
- problems
  - technical aspects, quantity of data
  - privacy

Knowledge Usage

- conceptual use
  - changes in levels of knowledge, understanding, or attitude
- instrumental use
  - changes in behavior and practice
- strategic use
  - manipulation of knowledge to attain specific goals
    - power, profit, political gain

[NCDDR 1996]

Knowledge Usage Metaphors

- "tabula rasa"
  - the learner's mind is an empty slate upon which people "in the know" impress knowledge
- learner as a sponge
  - soaking up knowledge, largely without filtering or processing
- brain as a computer
  - processes information in a systematic fashion as it is received from outside sources

Knowledge Use as Learning Process

- role of knowledge
  - dynamic set of understandings influenced by its originators and its users
- role of the learner
  - actively filters and shapes knowledge
    - integration into existing knowledge
  - constructs models of the the environment
    - explanations to make sense of the world
  - pre-existing (mis-)understandings may have to be changed
    - they result in discrepancies of the mental model

[NCDDR 1996]

Usability Evaluations

Usability Evaluations

- formative evaluation
  - done at different stages of development
  - influences the design of the system as it is being developed
  - relies on quick feedback from users
    - or other ways to obtain feedback
- summative evaluation
  - assesses the quality of a finished product
  - no influence during design and development
  - users can evaluate the actual product

Four evaluation paradigms

- ‘quick and dirty’
- usability testing
- field studies
- predictive evaluation

Quick and dirty

- 'quick & dirty' evaluation describes a common practice
  - designers informally get feedback from users or consultants to confirm that their ideas are in-line with users' needs and are liked.
- Quick & dirty evaluations can be done any time
- The emphasis is on fast input to the design process rather than carefully documented findings.

Usability Testing

- recording the performance of typical users
  - on typical tasks in controlled settings
  - field observations may also be used
- users are watched
  - recorded on video
  - their activities are logged
    - mouse movements, key presses
- evaluation
  - calculation of performance times
  - identification of errors
  - explanation why the users did what they did
- user satisfaction
  - questionnaires and interviews are used to elicit the opinions of users

Field Studies

- done in natural settings
- to understand what users do naturally and how technology impacts them
- in product design field studies can be used to
  - identify opportunities for new technology
  - determine design requirements
  - decide how best to introduce new technology
  - evaluate technology in use

Predictive Evaluation

- experts apply their knowledge of typical users to predict usability problems
  - often guided by heuristics
- another approach involves theoretical models
- users need not be present
- relatively quick & inexpensive

Nielsen's Ten Usability Heuristics

- Jakob Nielsen developed ten general principles for user interface design
  - frequently applied to Web pages, but also software systems in general

Nielsen's Heuristics - 1

- Visibility of system status
  - always keep users informed about what is going on
  - appropriate feedback within reasonable time
- Match between system and the real world
  - speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms.
  - follow real-world conventions, making information appear in a natural and logical order.
- User control and freedom
  - users often choose system functions by mistake
  - provide a clearly marked "emergency exit" to leave an unwanted state
  - support undo and redo
- Consistency and standards
  - different words, situations, or actions should not be used to mean the same thing
  - follow platform conventions
- Error prevention
  - careful design which prevents a problem from occurring in the first place.
  - eliminate error-prone conditions or check for them
  - present users with a confirmation option before they commit to the action

Nielsen's Heuristics - 2

- Recognition rather than recall
  - minimize the user's memory load by making objects, actions, and options visible
  - the user should not have to remember information from one part of the dialogue to another
  - instructions for use of the system should be visible or easily retrievable
- Flexibility and efficiency of use
  - accelerators (shortcuts) may often speed up the interaction for the expert user
    - the system can cater to both inexperienced and experienced users
  - allow users to tailor frequent actions.
- Aesthetic and minimalist design
  - dialogues should not contain irrelevant or rarely needed information
  - Every extra unit of information in a dialogue competes with the relevant units of information
    - diminishes their relative visibility
- Help users recognize, diagnose, and recover from errors
  - error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution
- Help and documentation
  - ideally, the system can be used without documentation
    - it may be necessary to provide help and documentation
  - help information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large

Dimensions of Knowledge Usability

- Functionality
- Task Completion
- User Satisfaction
- Consistency

Functionality

- feature-complete
  - provides all necessary features to complete the task under investigation
  - provides additional features that make it more convenient for the user
- feature overload
  - ratio of frequently used/unused features
  - ratio of relevant/irrelevant features for a given set of tasks

Task Completion

- time
  - completion
  - milestones
  - critical activities
- quality
  - final product
  - aspects of the final product
  - intermediate products

User Satisfaction

- satisfied with the outcome
- easy, pleasant to use
- need for training
- rate of abandon

Consistency

- internal
- in-family
- external

Metrics for Usability of Knowledge

- based on the dimensions of usability identified above

Direct Measurements

- registration of user interaction activities
  - mouse movements
  - mouse clicks
  - keys pressed
  - other activities can be registered, but may be problematic
    - use of Web cams or built-in cameras
      - may pose privacy problems
      - may influence the behavior of users

Practicality of Direct Measurements

- aspects like user satisfaction are highly subjective
- conditions under which measurements are performed are unrealistic
  - lab vs. work place
- participants in usability evaluations may not be representative for the intended user group
- not enough participants for statistically valid results
- voluntary participation skews the results
  - positive - mostly satisfied users
  - negative - mostly annoyed, unhappy users

Methods for Direct Measurements

- computer-supported event capturing
  - keystrokes, mouse-clicks, ...
- user observation
  - eye tracking, movements, ...
  - some observed activities may only be indirect measurements for something else
    - e.g. eye tracking for attention focus
- stream of consciousness protocols
- user feedback
  - typically yields subjective data
- often supported by video or audio taping

Indirect Measurements

- in principle less desirable
  - correlation between the observed behavior and the intended measurement can be questionable
    - other factors may influence the observed results
- often the only practical alternative

Methods for Indirect Usability Measurements

- questionnaires, interviews, focus groups, ...
  - usually done after the experiment
- stream of consciousness protocols
  - emphasis on implicit statements
- user observation
  - concentration, attention, comfort

Knowledge Usability Measurement Examples

- Internet advertising
  - significant efforts in measurements
  - knowledge aspects unclear

Internet advertising

- number of page views
- time spent on page
- click-through rates
  - emphasizes the last ad the viewer selected
  - neglects prior activities and interactions
- link trail analysis
- engagement mapping
  - attempts to take into account all the interactions with a company's marketing message and brand that may have lead up to a purchase or other user action
- social interactions
  - influence of other people close to the participant
- customer feedback
  - questionnaire about factors influencing purchasing decisions
- very important due to significant monetary interests
- soundness of the methods used may be questionable

Knowledge-Intensive Activities

- presentation
- retrieval
- identification
- manipulation
- acquisition
- creation of knowledge

listed in the order of decreasing relevance for usability:
knowledge presentation is “closer” to the user, and thus influences usability more directly

Presentation of Knowledge

- How is existing, identified, and retrieved knowledge presented to the user?
  - Methods
    - Visual
      - textual
      - graphic
      - visual metaphors
    - Non-Visual
      - sound, touch, smell, taste

Textual Knowledge Presentation

- natural language
  - complete sentences (prose)
- phrases
  - e.g. bullet points
- words
- numbers

Graphic Knowledge Presentation

- the main emphasis lies on visual primitives
  - shape, color, proximity, cohesion
- examples
  - image
  - sketch
  - diagram
  - graph
  - tree
- see http://www.many-eyes.com/
  - service for the general public to visualize data sets

Visual Metaphors

- visual displays of familiar objects or situations are used to present knowledge
  - "house" or "building" as a metaphor from architecture for the structure of computer-based systems
  - "funnel" as a selection process, filter
  - emphasis on the reduction of the input quantity
  - "scale" to "weigh" entities or properties
  - often used to point out advantages, disadvantages

Non-Visual

- sound
  - spoken language
  - music
  - soundscapes
- touch
- taste
- smell

Critical Aspects Knowledge Presentation

- user background
  - How familiar is the user with the domain, task, system, ...?
  - How wide is the range of users?
    - abilities, motivation,
- task
  - What is the (set of) task(s) to be performed by the user?
  - Will the same user perform the same task rarely, repeatedly, regularly?
  - Complexity of the task?
- context
  - What is the environment in which the task is to be performed?
    - multi-tasking
    - noise

Examples

- search results in search engines

Retrieval of Knowledge

- How is existing and identified knowledge accessed, encapsulated, and transported to the user?

The emphasis here is not on technical issues, but on aspects that affect the way the user can utilize the knowledge. Also, the question of how to present knowledge to the user is dealt with separately.

Retrieval Methods

- location (address)
- identity (unique name, identifier)
- properties
- context
  - vicinity
  - membership in a set
- association
  - an item is accessed by following (a chain of) associations with other items
- similarity
  - requires a metric or at least an operational characterization of similarity
  - does the user have to know this?

Critical Aspects of Knowledge Retrieval

- access time
- transmission time
- encoding and encapsulation
  - e.g. encryption, serialization, conversion between different representations
- Examples
  - search with search engines
    - text (keywords)
    - images
  - data base query

Identification of Knowledge

- How does the user distinguish wanted from unwanted knowledge entities?

Methods of Knowledge Identification

- browsing
- query
- similarity
- relevance feedback

Browsing

- the user follows an organizational structure of the collection
  - e.g. walking through the stacks of a library, scanning the table of contents in a magazine, following links on a Web page
  - the organizational structure often is related to the content of the documents
    - e.g. topics
  - can also be arranged according to other criteria
    - size
    - date of acquisition
    - external scheme
      - e.g. books by ISBN numbers

Query

- the user tries to describe relevant aspects of the items to be identified
  - presence of keywords, phrases, sentences
    - sometimes also more complex queries
      - e.g. Boolean operators
  - description of properties
    - ranges or values of important features

Relevance Feedback

- the user provides feedback on the suitability of the items presented
- very good basis for usability measurements

Similarity

- the user identifies entities that share important aspects of the one to be identified
- there also have to be some undetermined properties
  - otherwise the entity is already identified
- can be combined with
  - query - identification of distinguishing features
  - browsing - looking at a set of similar items
  - relevance feedback - selecting a better instance

Critical Aspects Knowledge Identification

- search for
  - specific instance
    - unique identification
    - distinguishing features of similar entities must be available
  - "exemplar"
    - entity that satisfies certain requirements
    - other features may be irrelevant
- identification and retrieval are often combined
  - "search"

Examples Knowledge Identification

- core activities of search engines
  - especially for search in “closed” systems
- data base queries

Modification of Knowledge

- Methods
- Critical Aspects
- Examples

Knowledge Modification Methods

- update
  - overall structure remains unchanged
  - values of some properties of entities are changed
- structural changes
  - relationships between entities are modified
- insertion/deletion
  - entities are added or removed
  - typcially results in structural changes

Critical Aspects Knowledge Modification

Examples Knowledge Modification

Acquisition of Knowledge

- explicit knowledge is converted into a representation suitable for storage on computers
  - often done by knowledge engineers to capture expertise
  - tacit knowledge has to be converted into explicit knowledge first
- Methods
- Critical Aspects
- Examples

Knowledge Acquisition Methods

- interview
- refinement
- observation

Creation of Knowledge

- knowledge is made explicit
  - conversion from the internal representation of the knowledge owner into one that can be shared with others
- Methods
- Critical Aspects
- Examples

Problems Knowledge Usability

- Semantic Gap
- Observability and Controllability
- Task Specificity
- Context and Environment

Semantic Gap

- in the knowledge-based systems domain, this refers to the difference between knowledge processing by humans and by computers
  - humans: emphasis on understanding (semantics)
  - computers: emphasis on symbol manipulation (syntax)
- here: gap between measurable and observable activities, and the achievement of the goal for a task
  - e.g. measuring that a user has "understood" the instructions for solving a computer setup problem

Observability

- technical term from control theory
  - counterpart of controllability
- internal states of a system can be inferred by knowledge of its external outputs
- it is possible to determine the behavior of a system from its outputs

Controllability

- technical term from control theory
  - counterpart of observability
- ability to move a system around in its entire configuration space using only certain admissible manipulations
  - typically inputs are manipulated
  - does not necessarily mean that the system can be kept in a certain state, only that it is possible to get to that state

Usability and Observability

- internal states of users are typically unknown
  - lack of a cognitive model
  - insufficient information about the user
- mental activities are difficult to observe and measure
  - technology such as fMRI exists, but is impractical for most situations
  - self-observation can be used, but is also problematic
    - subjective
    - probably has an impact on performance since it requires mental resources

Usability and Controllability

- usually it is impractical (and unnecessary) to cover the entire configuration space of a system
  - with exceptions, e.g. safety-critical systems, legal requirements
- user may have to be considered part of the entire system

Task Specificity

- goal criteria may be highly task-specific
  - difficult to generalize
  - usability metrics may depend on goal criteria

Context and Environment

- knowledge can be highly context-dependent
  - makes measurements difficult
- environment can have a significant influence on user performance
  - lab vs. work environment
- observation effect
  - the behavior of the user may be different when observed

Sources of Problems

- Conceptual Mismatch
- Labeling Mismatch
- Descriptive Mismatch
- Representational Mismatch

Conceptual Mismatch

- The concepts the user has in mind do not match those utilized by the developers of the knowledge representation, retrieval, or presentation system.

Labeling Mismatch

- The concepts used by the user and by the developer match reasonably well, but they use different labels (terms) for them. This may include ambiguities, homonyms, context (domains, everyday vs. technical terms) problems across languages

Descriptive Mismatch

- User and developer describe relevant aspects of entities in different ways.
  - A user saw a pretty red skirt with polka dots and ruffles in a fashion magazine, and has problems finding it on the Internet using the above keywords.

Representational Mismatch

- The internal structure of the representation of the knowledge is different from the one used by the user.
  - Example: A tall basketball player wants to buy a car, and needs one that can accommodate drivers larger than 2.00 meters. Most knowledge sources for cars (data bases, reviews, manufacturer information) will only contain related data that may give hints, but not the full answer to such a requirement.

References

- [Gil 2000] Yolanda Gil, Knowledge Mobility. Dagstuhl Workshop “Semantics for the Web”, March 2000.
- [NEEDS] National Engineering Digital Library, www.needs.org
- [Russell & Norvig 1995] Stuart Russell and Peter Norvig, Artificial Intelligence - A Modern Approach. Prentice Hall, 1995.