December 7th, 2023

LECTURE 6, DESIGN & INFOVIS - RULES ABSTRACTIONS, PROTOTYPING

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SYSTEMS ANALYSIS FOR USER CENTERED DESIGN

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The PACT system

- **P**eople
  - Physical characteristics; Psychological differences
- **A**ctivities
  - Temporal aspects
  - Cooperative complexity
- **C**ontext
  - Physical, social, organizational
- **T**echnologies
  - What i/o devices for communication/content

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PACT

- Helps to understand the system
- From the design point of view

- Questions
  - What people will use a system — P
  - What activities people want to undertake — A
  - What is the context of these activities — C
  - What interactive technology — T
- Answers
  - Make a relation between Activity and Technology

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DESIGN, THE PROCESS OF DEVELOPING ARTEFACTS

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Interaction Design

= Designing interactive products to support people in their everyday activities.

- Design vs. software engineering?
  - architects vs. civil engineers
- Concerned with designing good interface/interaction (cf. chap .14)
  - what is "good"? take into account
    - what will it be used for?
    - where will it be used?
    - who will use it? (what are they good at, what do they do now, what do they want, use "tried" and tested techniques, etc.)
  - prototyping
  - evaluation: user centered!
  - usability testing

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Two Crucial Errors

- Assume all users are alike
  - User Centered means that we accept that people differ in cultural background, physical ability, etc …
- Assume all users are like the designer
  - Consider the discrepancy in engineering and designing

Therefore:

- User in center of development

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Design & Analysis

- Design
  - *process* of developing artefacts (lecture 11)
  - various *representations* of artefacts during design
  - achieving goals with constraints
- For design analysis is required
- Analysis (lecture 9, 12)
  - Bring about the key issues of artifact
  - User involvement
  - Use Personas, Scenarios, Storyboarding
  - Look broad: Stakeholders
- Design is a layered process.

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Design

- Conceptual Design
- Physical Design
  - Operational design
  - Representational design
  - Interaction design
- Envisionment (for Infovis: *Edward R. Tufte*)
  - Working out ideas
- Evaluation (typically the Star Model)
  - Testing out ideas
- Implementation

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Conceptual Design

- Considering Information and Functions
- Making abstractions
- **What** do we expect from the user
- Communication of Conceptualization =
  - Mental Model
  - Metaphoric concepts
- Modeling

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Physical Design

- **How** is it going to work
- Can lead to a detailed look and feel
- Structuring interaction
  - Logical sequences
  - Allocation of functions
  - Requirements for Software and Hardware
  - Tasking activities
- 3 sub components

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Physical Design Components

- Operational design
  - How everything works
  - How everything is structured/stored
- Representational design
  - Shapes, Icons, Colours; Style Aestatics
  - Information layout
- Interaction design
  - Allocation of function to Human/Technology
  - Structuring
- Relates to Envisionment

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INFOVIS INTERACTION

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Infovis & Design

- Interactive components
  - Dimensions
- Visual support components
  - Symbols, Glyphs, Colour
- Hardware
  - Display
  - Interaction, i.e. pointing device, gesture registration …
  - Computation, i.e. fast data transformations

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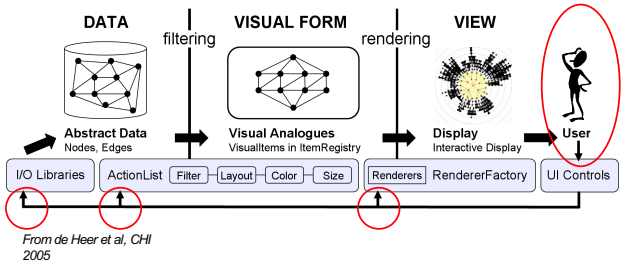
InfoVis, from Data to View/Interaction



From de Heer et al, CHI 2005

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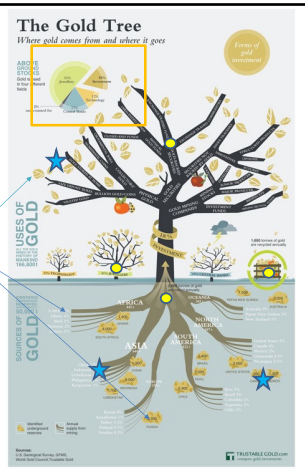
Metaphor

Colour coding

Glyph

Data transformation



Focus & Zoom	*No*
Details	*Yes*
Filtering	*No*

Understandable?
… difficult

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Information visualization requires knowledge on the data

DATA ABSTRACTION

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What is Information?

- Information is the concretization of data of any kind in order to gain understanding thereof.
- *Semantics* of data refers to its real world meaning; Creator provides exact semantics.
- *Type of data* refers to the mathematical interpretation
  - Data level
  - Data set level

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What is the nature of the data

- Goal: build an information display
- Method: Analyse an instance
  - e.g. with PACT, people, activities, context, technology
- Data Abstraction:
  - What part of the analysis pertains to the data
  - What is the nature of the data
  - How are these data represented
  - Data type influences how we visualize

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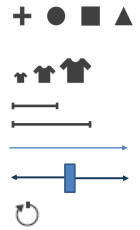
What about data ...

- Data can be
  - Categorical: represent categories, no ordering (fruits, names) sometimes hierarchy
  - Ordered:
    - Ordinal: well defined order, without arithmetic
    - Quantative: measurement, magnitude supports arithmetic
  - Sequential, diverging, cyclic
  - Static, Dynamic
    - Static: status quo (immmediate)
    - dynamic: Stream of data, Behaviour, Time-series (gradually)



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Data type characterization

- Attribute
  - Some specific property that is measured, observed, logged
  - aka variable, data dimension, dimension
- Item
  - Individual entity that is discrete
  - Row, node …

- Link
  - Relationship between items in a network
- Grid
  - Strategy for sampling continuous data
  - geometry, topology
- Position
  - Spatial data element (e.g. GPS)

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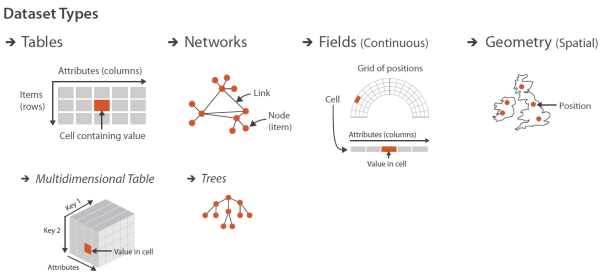
Dataset types (1)



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Dataset types (2)

Tables	Networks	Trees	Fields	Geometry	Clusters, Sets, Lists
Items	Items = nodes	Items = nodes	Grids	Items	Items
	Links	Links	Positions	Positions	
Attributes	Attributes	Attributes	Attributes		

Type refers to Structural or Mathematical interpretation

Combinations

- Data Set: collection of information
- 4 basic types of dataset
  - Tables
  - Networks
  - Fields
  - Geometry

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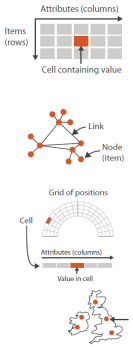
Dataset types (3)

- Table
  - Flat table, row = item; colum = attribute
  - Multi dimensional table
- Network
  - Relationship (link,edge) between items (node, vertex)
  - Tree, hierarchical structure – parent ~ child
- Field
  - Continuous, sampled to Grid
  - Geometry and Topology of Grid
- Geometry
  - Specification of shape with explicit spatial positions



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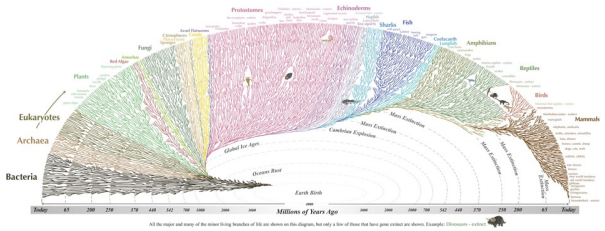
Example Tree - Hierarchy



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Semantics of the data

- In order to visualize, know the semantics
  - Creator knows the semantics
- Semantics
  - Meaning in the real world
  - Key Attribute in the data
    - Index for value attribute
    - aka independent attribute (dimension)
  - Value Attribute
    - aka dependent attribute (measure)
  - Also given by the meta-data
    - Data about the data, descriptive in nature

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Consider the information visualization in an abstract form

TASK ABSTRACTION

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Building an Information Display

- User domain ~ Designer domain
- Tasks User intends to perform with data
  - Why visualize!
- Abstract away from user task, and user terms!
  - Generalize
  - Produce tools
  - Produce support
- Task Abstraction:
  - generalize from domain specific to abstract form. Helps finding **similarities** in vis-applications

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Task Abstraction

- 3 levels of actions to define user goals
  - High level actions: Analyse
  - Mid level actions: Search
  - Low level actions: Query
- Actions → Verbs
- Targets → Nouns

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Taxonomy Interactive Visual Analytics

Category	Task type	
Data & View Specification	**Visualize**	data by choosing visual encodings.
[ANALYZE]	**Filter**	out data to focus on relevant items.
	Sort	items to expose patterns.
	Derive	values or models from source data.
View Manipulation	**Select**	items to highlight, filter, or manipulate them.
[SEARCH-QUERY]	**Navigate**	to examine high-level patterns / low-level detail.
	Coordinate	views for linked, multi-dimensional exploration.
	Organize	multiple windows and workspaces.
Process & Provenance	**Record**	analysis histories for revisitation /review /sharing.
[QUERY-SEARCH]	**Annotate**	patterns to document findings.
	Share	views and annotations to enable collaboration.
	Guide	users through analysis tasks or stories.

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Analyze Abstraction, actions

- Consume information
  - Discover, use InfoVis to find new knowledge
    - Hypothesis testing and generation
  - Present
    - Communication, storytelling
  - Enjoy
    - Casual (playfull) encounters with Infovis
- Produce information
  - Annotate, augment InfoVis with annotation (domain)
  - Record, saves/captures InfoVis elements
    - e.g. For Dashboards, Infographics
  - Derive, produce new data elements
    - derived attributes

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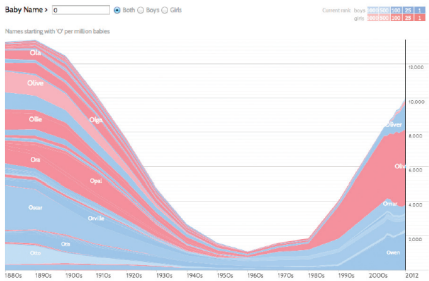
Example Enjoy, baby-names



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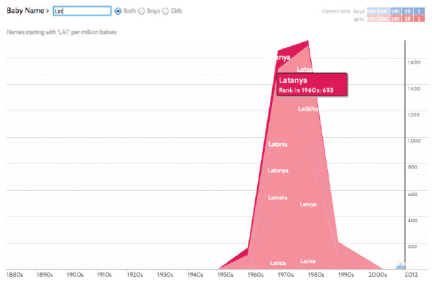
InfoVis Mantra, Focus & Zoom



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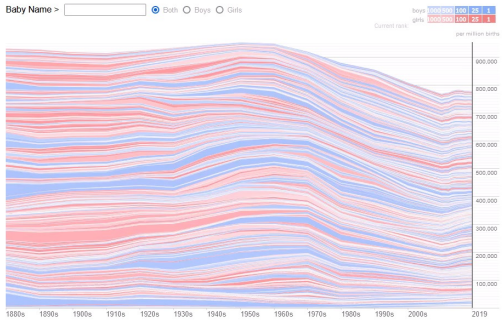
Interaction Enhances Experience



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Search Abstraction, actions

- Look-Up
  - Know where to look for
  - Using InfoVis as knowledge table
- Locate
  - Known target, at unknown location
  - Helps in understanding relations
- Browse
  - Unknown target, location is group of attributes
- Explore
  - Characteristics from parts of InfoVis
  - Typically Focus and Zoom, start from Overview

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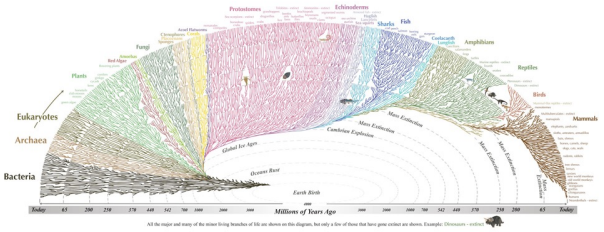
Example Tree - Hierarchy



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Query Abstraction, actions

- Identify
  - Query on a single target
  - Chararteristics identified from result
- Compare
  - Query on multiple targets
  - Possibillity to identify relations
- Summarize
  - Query all possible targets
  - Produce an overview
  - Starting point for exploration or comparison

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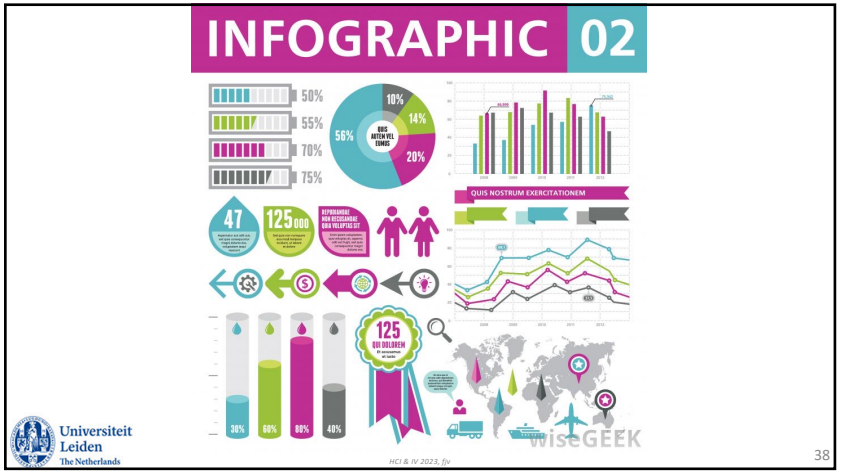

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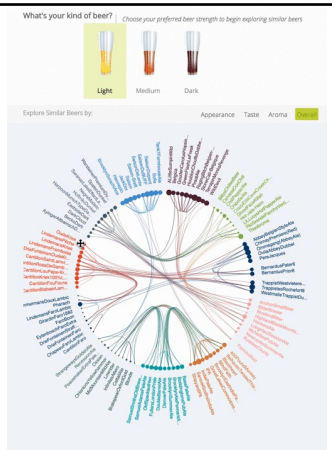
- Beer recommender system
- Choose a general style
- Show similar beers
- No focus/zoom?



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INFORMATION DISPLAYS

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How do we build Information Displays (1)

1. Decide what we want to visualize (paper design)
2. Determine the nature of the data
   - Data abstraction
   - Data type
3. What are the tasks that we need to support
   - Analyze, Produce
   - Search
   - Query
4. What kind of interaction is required
   - How the support Focus and Zoom

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How do we build Information Displays? (2)

5. Layout tools – wire-frame models.
6. Layout appropriate Symbols, Glyphs …
7. Connect interactivity to
   - Symbols
   - Glyphs
   - Graphical objects
8. Introduce widgets for support of queries
   - Upon necessity
9. Add your code
   - The "product" functionality
   - Design Pattern: Model View Controller

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Prototyping is common in almost every field of engineering design

In prototyping one has to plan to throw away

PROTOTYPING

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Prototyping the User-Interaction

- Purpose of prototyping
- Merits of prototyping
- Types of prototyping
- Prototyping and management
- Limitations of prototyping on its own

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Purpose of Prototyping

- Identifying user interface, interaction (and other) requirements:
  - almost impossible to specify in advance
- "It is not until users interact with something concrete that their rich expertise about their working environment will surface."

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Design is Developing of Artefacts

- Indeed, "Magritte" was right!

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Prototyping

- The prototyping approach provides continuous feedback on the current design situation
- For *Interaction* there will never be fully satisfactory design guidelines applicable in all circumstances
- Need not be computer based or have full functionality
- Supported by good software tools
  - Graphical editors, construction kits
  - User Interface Management Systems (UIMS)
  - Wireframes
- "Prototyping does *NOT* mean '*build in haste*'"

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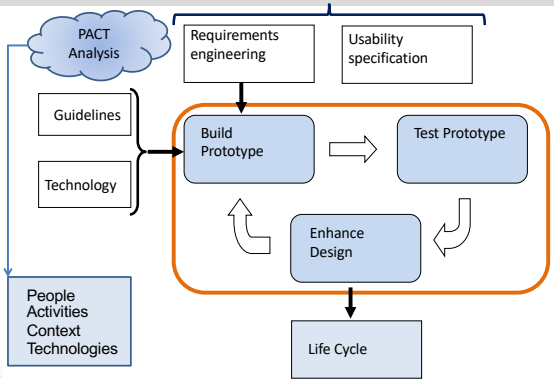
Prototyping an Interactive Product



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Prototype Fidelity

- Prototyping is concerned with the design process leading up to production of a final system
- Prototypes are not the final system, merely representations of that system: *Artifact*
- As the Prototyping refines, the Fidelity of the prototype increases.

low fidelity ⟷ high fidelity
start design ⟶ end design

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Merits of Prototyping

- Requirements capture
  - interaction and functional requirements
- Reveals problems / prevents gross mistakes
- Allows evaluation and discussion
  - Fostering innovative ideas (from designers and users)
- Users enjoy prototyping and feel involved
  - Participatory design
- Suggests level of user support
- Results in better usability
- Reduced deadline effect
- Fewer lines of code

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FIDELITY IN PROTOTYPING

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Fidelity in Prototyping

- Fidelity refers to the level of detail
- High fidelity:
  - A prototype that looks like the final product
- Low fidelity:
  - Artists renditions with many details missing

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Why Low-Fidelity Prototype ?

- Traditional methods take too long
  - sketches → *prototype* → evaluate → iterate
- Can simulate the prototype
  - sketches → evaluate → iterate
  - sketches act as prototypes
    - designer "plays computer"
    - other design team members observe & record
- Requires "Fröbel" implementation skills
  - allows non-programmers to participate

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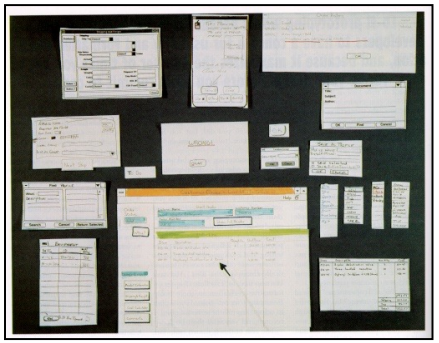
Construct Low-Fidelity Prototype



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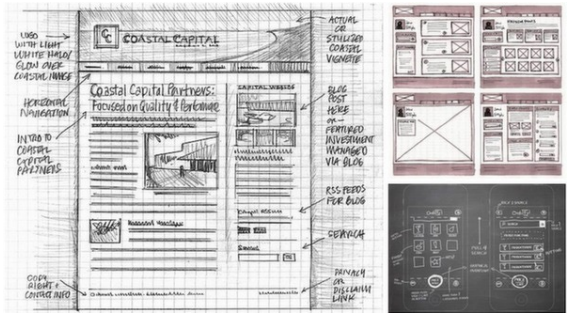
Sketched Paper Design



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Low-Fidelity Prototyping

- Takes only a few hours
  - no expensive equipment needed
- Can test multiple alternatives!!!
- Can change the design as you test
  - If users are trying to use the interface in a way you did not design/intend it
  - go with what they think! Adapt!
- Allows designers & users to work together

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Storyboards

- Series of sketches showing how a user might progress through a task using an interface
  - Film industry
  - Graphical snapshots
- Often used with scenarios, bringing more detail
  - Derived from the scenario
  - Focus on history of events (task-analysis)
  - Useful for InfoVis
- Help envisioning the progress of the interaction

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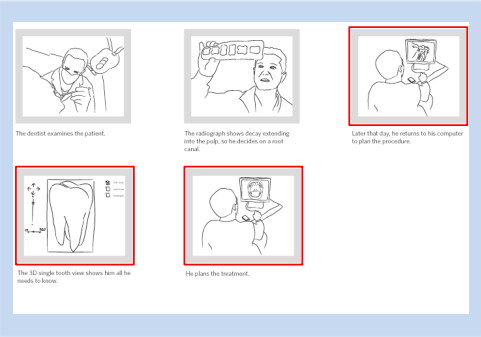
Example Story Board (scenario)



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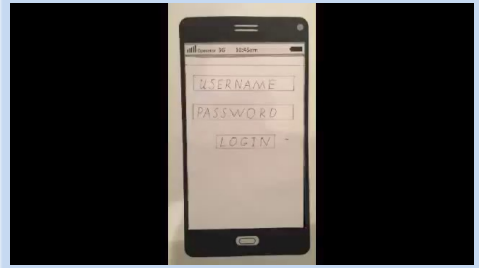
Example Lo-Fi Prototype



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Example Med-Fi Prototype

Includes a Scenario for use

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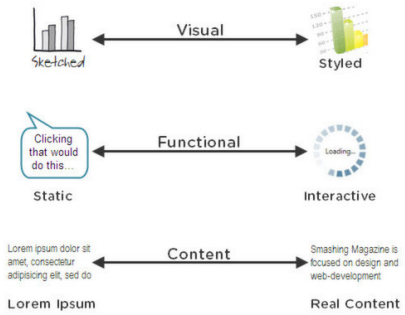
Prototyping – Increasing Fidelity



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PARTICIPATORY DESIGN

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Benefits of Participatory Design

"Computer-based systems that are poorly suited to how people actually work impose cost not only on the organisation in terms of low productivity but also on the people who work with them.

Studies of work in computer-intensive workplaces have pointed to a host of serious problems that can be caused by job design that is insensitive to the nature of the work being performed, or to the needs of human beings in an automated workplace."

Kuhn, S. in Bringing Design to Software, 1996

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Prototyping: Participatory Design

- Involving users as full partners in design.
  - Intention, Scandinavian origin (law)
- Two methods are frequently used:
  - CARD: Collaborative Analysis of Requirements & Design
    - Goal: design workflow
    - Higher level of abstraction
  - PICTIVE: Plastic Interface for Collaborative Technology Initiatives through Video Exploration
    - Goal: design screens
    - Find interaction
  - PICTIVE and CARD can be used together.

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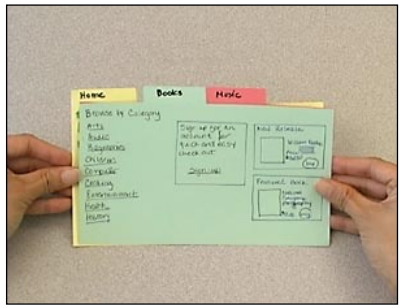
CARD



Collaborative Analysis of Requirements & Design

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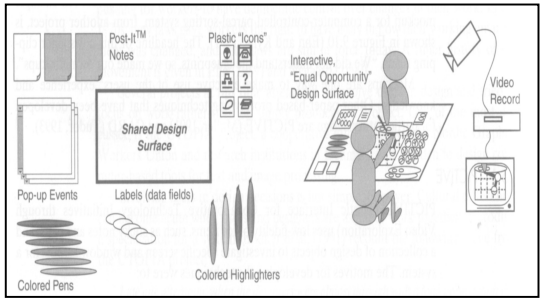
PICTIVE



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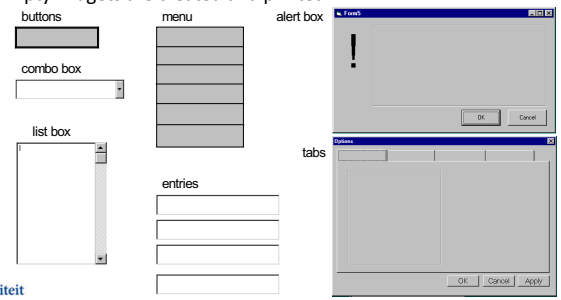
Low fidelity prototyping & PICTIVE

- Use pre-made interface components on paper
- Empty widgets are created and printed



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Working with PICTIVE

- A PICTIVE session has four parts:
  - Stakeholders all introduce themselves
  - Brief tutorials about areas represented in the session (optional)
  - Brainstorming of ideas for the design
  - Walkthrough of the design and summary of decisions made
  - Video capture of all interactions on the “table”

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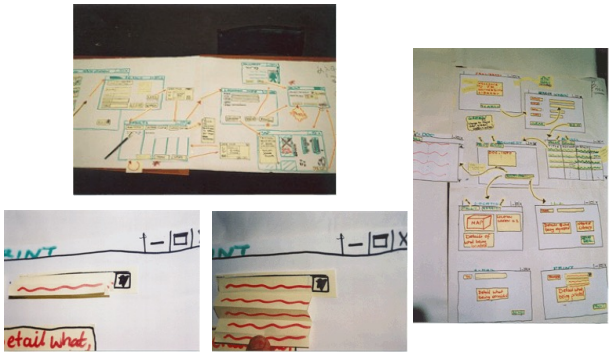
Example Results PICTIVE/Sketching



Collections of Sreens & Screen Interaction(s), *from Univ. of Manchester (2000)*

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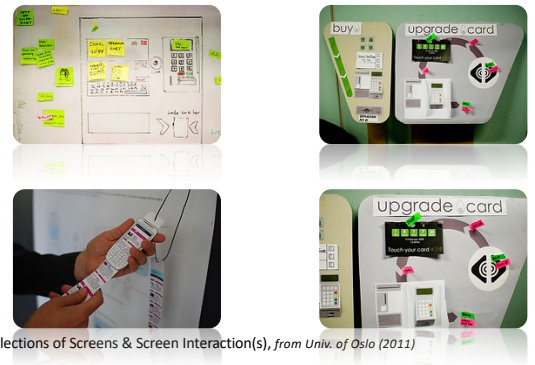
Example Results Paper Design (LoFi)



Collections of Screens & Screen Interaction(s), *from Univ. of Oslo (2011)*

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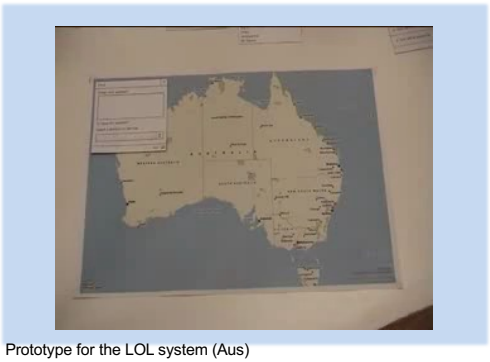
PICTIVE Session Example



Prototype for the LOL system (Aus)

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WIZARD OF OZ

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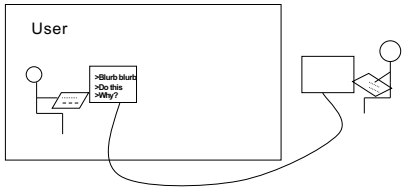
"Wizard of Oz" prototyping

- User thinks having interacting with a computer, but a developer is responding to output rather than the system.
- Usually done early in design to understand users' expectations (requirements)
- Aka, behavioral prototyping



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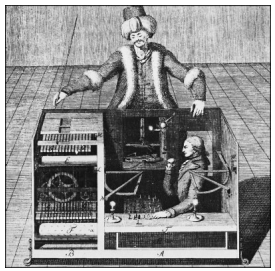
Early "Wizard of Oz"

- Chess machine built in Hungary (Kempelen)
- It worked remarkably well …



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Example Wizard of Oz

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TYPES OF PROTOYPING

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Types of Prototyping (1)

- Low-fidelity // High-fidelity
- Vertical
  - Focus on a specific element and simulate in depth
- Horizontal
  - Take a broad perspective but with reduced functionality at any point
- Full
  - Complete functionality, but less performance than final system

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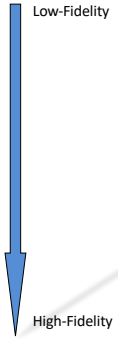
Granularity in Prototyping



- Paper-based Sketching
- Paper-based Storyboard a.k.a. PICTIVE
- Computer Aided Sketches / Storyboard
- Wizard of Oz / Slide Shows / Video
- Computer based Scenario Simulation
- Computer based Horizontal Simulation
- Computer based Vertical Simulation
- Computer based Full-Functional Simulation

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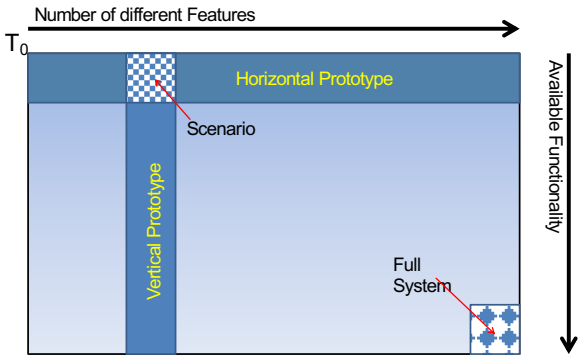
Types of Prototyping (2)



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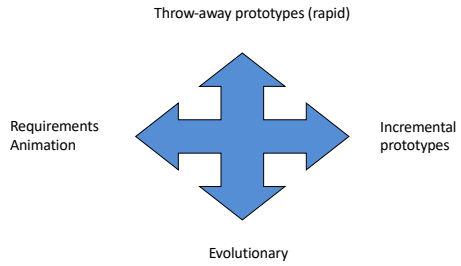
Prototyping Methods (1)



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Prototyping Methods (2)

- **Requirements Animation**
  - Functional requirements are demonstrated in prototype
  - Building a Mock-Up
  - Interaction is included in Mid-Fidelity renditions
- **Throw-away prototyping**
  - Similar to requirements animation
  - Prototype is not developed into the final product
  - Prepared to throw away
  - Presenting and developing ideas; try different ideas.

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Prototyping Methods (3)

- **Evolutionary prototyping**
  - Prototype is not discarded
  - Prototype used as the basis for next iteration of design
  - i.e. system "evolves" from prototype
- **Incremental prototyping**
  - Final product is build as separate components, one at a time
  - Allows large systems to be installed in phases to avoid delays between specification and product delivery.
  - Includes thorough testing for each phase
  - Typical with larger projects

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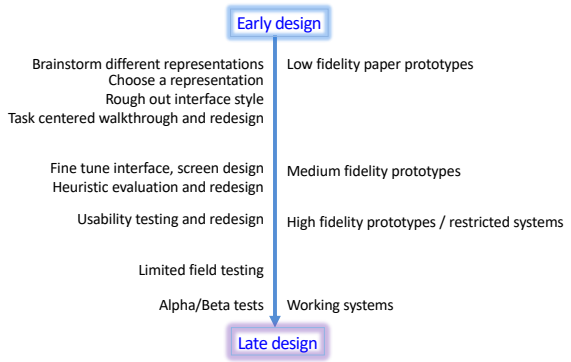
Prototyping



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Comparison of Techniques

Technique	Advantages	Disadvantages
Vertical	Realistic, In depth implementation Real user task	Limited part of UI/Interaction
Horizontal	Test entire UI/Interaction Fast implementation	Cannot perform real tasks
Scenario	Easy and cheap to construct	Cannot perform real tasks Limited part of UI/Interaction
Wizard-of Oz	Save programming time Renders understanding	Train people as computers Not always realistic
Animation (slides & video)	Simple System simulation	No real interaction Little flexibility

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Choosing a prototyping technique

- What developmental stage are you in?
- Proof-of-concept
- Navigation and flow
- Look-and-feel of product
- Cost and schedule constraints
- User-driven or Facilitator-driven
- Usability test
- Available facilitation (hardware) / programming skill (software)

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Performance of a technique

Suitable for:

- quick-and-easy application?
- providing controlled study?
- qualitative analysis?
- quantitative analysis?

} For evaluation!

Requirements for using:

- special equipment?
- specially trained personnel?

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Limitations on just Prototyping?

- Difficult for users: no coherent conceptual model
  - users' feel system has unpredictable components
- Uneven appreciation of various user groups
  - users involved with prototype development may not represent cross-section of users
  - not easy to learn or intuitive for newcomers
- Lack of task analysis
  - Lack of breadth of task support
- Lack of usability evaluation
- Lack of internal and external consistency
  - Failure to fully comply with a style guide

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USABILITY HEURISTICS

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10 criteria Usability Heuristics (1-5)

- Visibility of system status
  - *Appropriate feedback in reasonable time*
- Match between system and the real world
  - *Users language* (*information in natural order*)
- User control and freedom
  - *Marked emergency exit* (*mistakes*), Undo/Redo
- Consistency and standards
  - *Platform conventions, unambiguous*
- Error prevention
  - *Prevent errors, better then error management*

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10 criteria Usability Heuristics (6-10)

- Recognition rather than recall
  - *Visible objects/actions/options*
- Flexibility and efficiency of use
  - *Tailor frequent actions, provide shortcuts*
- Aesthetic and minimalist design
  - *Refrain from irrelevant information*
- Help users with errors
  - *recognize,*
  - *diagnose, and*
  - *recover*
- Help and documentation
  - *Focus on users' tasks* (*concrete steps*)

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Review #6b

- Data Abstraction
  - Data Set, datatypes
  - Attributes, Items and Nodes
  - Characterization of the data
  - Semantics of the data
- Task Abstraction
  - Generalize from the domain
  - Analyze
  - Search
  - Query

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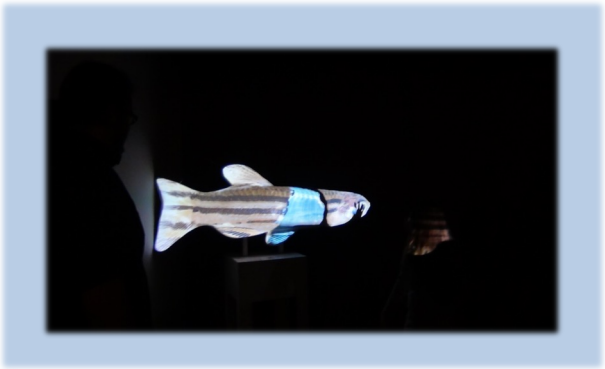
The Augmented Zebrafish (vs 2.0)



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