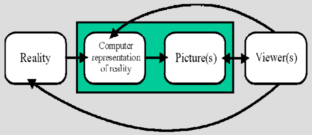
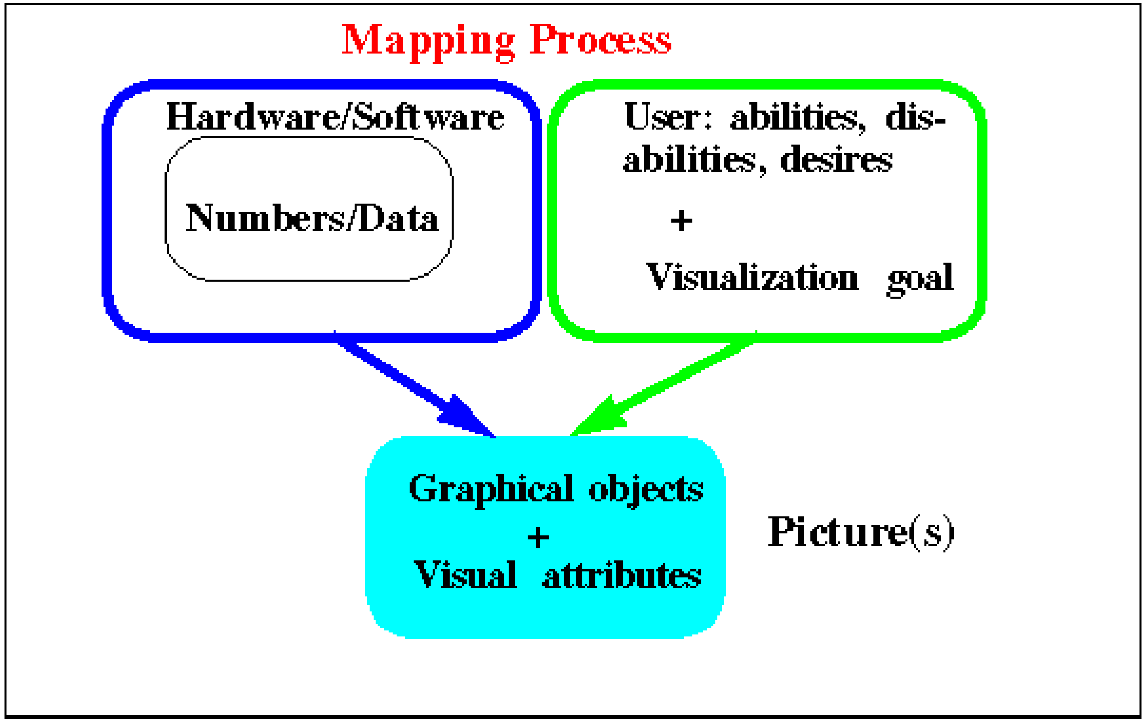


4.0 Mapping

- Need for systematic strategies (concepts, methodologies, intelligent visualization systems) to exploit data [ROB94]



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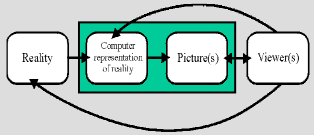
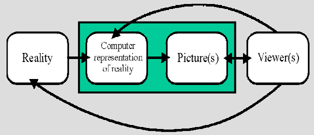


Mapping - Goals

Goals of this chapter:

- Explain concepts and strategies of Mapping Procedures
  - e.g. bottom-up versus top-down approaches
- Examples of systematic strategies, e.g. APT, SAGE
- Difficulties in the mapping process, e.g. approximations, artifacts



4.1 Models of Mapping Strategies

4.1.1 “Grand Tour of Visualizations” / Blind matching procedure

- separate data into data elements
- match data elements to visual primitives
- example: 4 data variables, 4 visual attributes available

e.g. data: (leaf length, leaf width, leaf type, leaf age)
vis. prim: (position x, position y, symbol type, symbol size)
offers 24 possibilities!

- General rule of thumb

n data characteristics, m visual attributes (n>m): n!/(n-m)!

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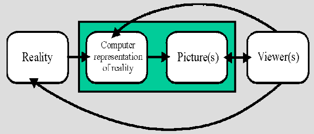


4.1.2 “Renaissance teams” (D. Cox, NCSA)

- bring together expert team
- domain experts + visualization experts determine visual representations
- costly!

Example created by Renaissance Team

[HAB90]

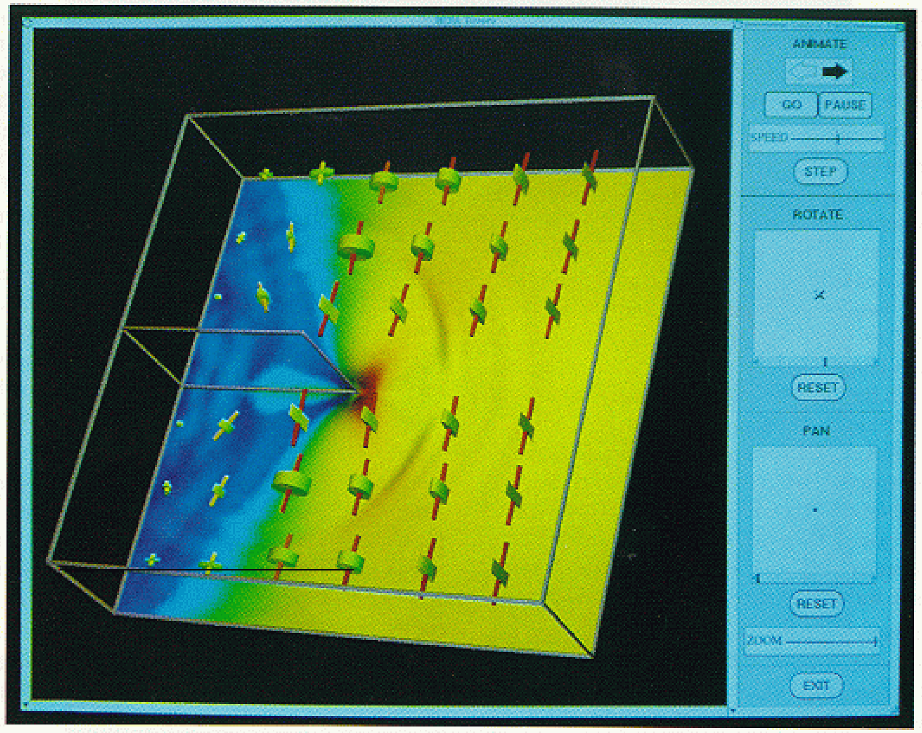
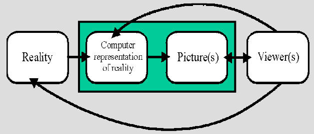


Figure 8. Tensor field visualization using the RIVERS polygon animation tool. From Chen Sheng, Hyun Koh, Hae Sung Lee, Creto Vidal, and Robert Haber, Departments of Theoretical & Applied Mechanics and Civil Engineering, University of Illinois at Urbana-Champaign; and Steve Chall, Ray Idaszak, and Polly Baker, NCSA.



Example created by Renaissance Team

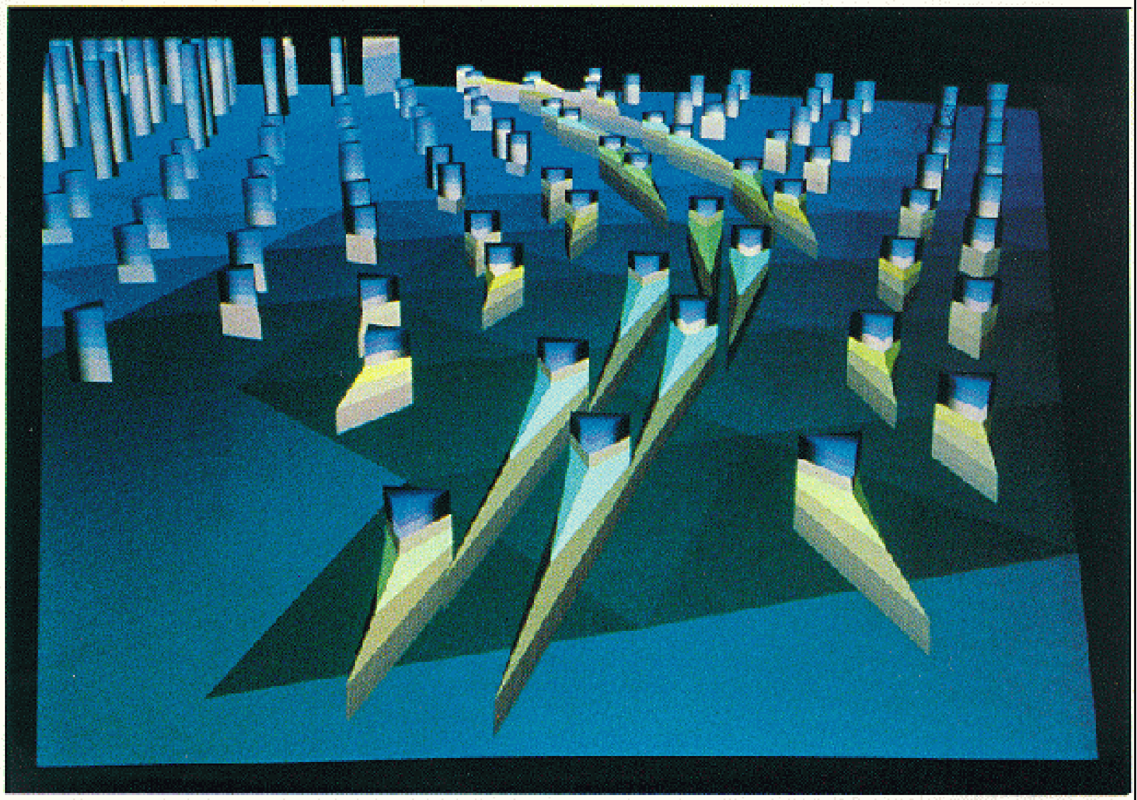
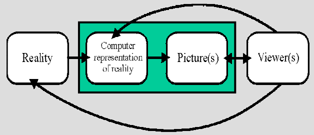


Figure 9. Visualization of plastic injection molding. From Rich Elson, Kodak Corp.; and Donna Cox, Department of Art and Design, University of Illinois at Urbana-Champaign; and Ray Idaszak, NCSA.

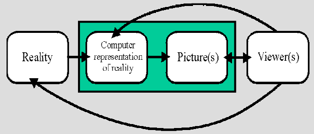
[HAB90]



4.1.3 Bottom-up versus top-down approaches

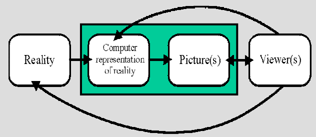
- **Bottom-up** approaches [MAC86], [SEN94]
  - generate pictures from visual primitives or graphical language
  - test pictures against **constraints**

- **Top-down** approaches [WEH90], [ROB91]
  - allow only coherent (complex) techniques
  - choose best fitting technique



Constraints in Bottom-Up may arise from:

- data (data characteristics)
- reality (problem domain)
- computer environment (available software and/or hardware), e.g.
  - output devices (e.g. b/w monitor)
  - input devices (e.g. mechanical/optical mouse, keyboard)
  - lack of computation/graphics power: e.g. real-time performance constraints
  - software available (e.g. volume visualization)
- viewer, e.g.
  - interpretation aims
  - abilities and desires of user
  - aesthetics, coherency



Other important constraints:

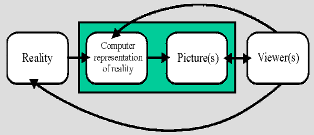
[MAC86]

effectiveness

– An effective graph presents all information clearly in view of visualization aims.

expressiveness

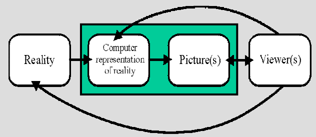
– An expressive graph encodes all relevant information and only that information.



4.1.4 Generate-and-test

Bottom-up methods are often used in generate-and-test procedures:

test visual representations against contraints after generating images from bottom-up [e.g. MAC86]



4.1.5 Code based reasoning

Top-down methods can be used in code based reasoning:

procedure to choose visual representation from data base of successful images [e.g.WEH90]

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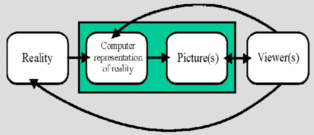

4.1.6 Examples of systematic strategies

4.1.6.1 Mackinlay (APT)

- A Presentation Tool [MAC86]
- Automatic 2-d discrete data presentation of relational information
  - graphics primitives: e.g. areas, lines, marks
  - visual attributes: e.g. color, size, saturation
  - primitive graphical languages and composition rules \xdf complete graphs
  - testing result: expressiveness and effectiveness criteria must hold (“generate-and-test”)

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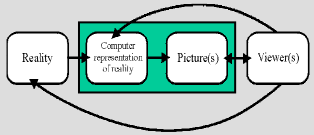
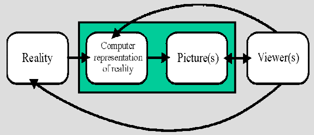


4.1.6.2 Roth and Mattis (SAGE) [ROT90]

- Knowledge-based system to create 2-d graphics automatically
- Elaborate characterization of data, semantics and relations
- total-costs = material - costs + labor-costs,

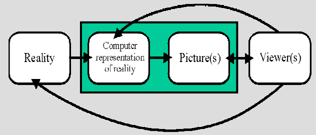
reflects composition in graph (e.g. two bar segments for each represented interval)

Includes components for constructive design of graphics (SageBrush) and retrieval of graphics (SageBook).



4.1.6.3 Casner (BOZ) [CAS91]

- Approach from task analysis
- Operating on relational database to produce 2-d graphics
  - first criteria is TASK: describe task through logical operators
  - map logical operators to perceptual operators (search operators/computation operators)
  - design graphs to satisfy visualization tasks
  - optimal graph has lowest cost for performing task



Example by Casner:

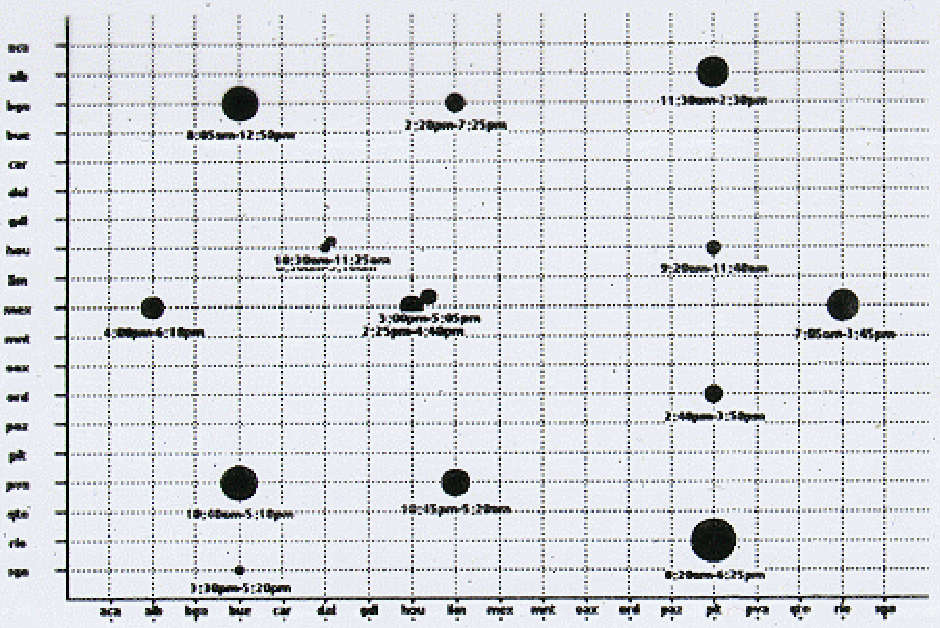


Fig. 2. Graphic for find cheapest flight task.

[CAS91]

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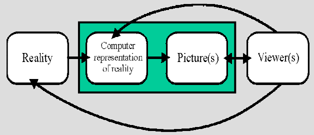
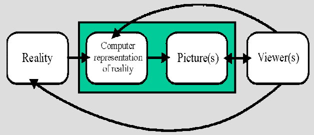


4.1.6.4 Senay and Ignatius (VISTA) [SEN94]

- VISualization Tool Assistant: extension to 3d visualizations
- Knowledge-based system to automatically design visualizations
  - primitive graphics techniques are composed to complex visualizations
  - extended composition rules for 3-d: transparency, occlusion, intersection extensive rules on effective mapping strategies
  - emphasize preattentive, if feature should attract viewer's attention
  - user may modify design



Example by VISTA:

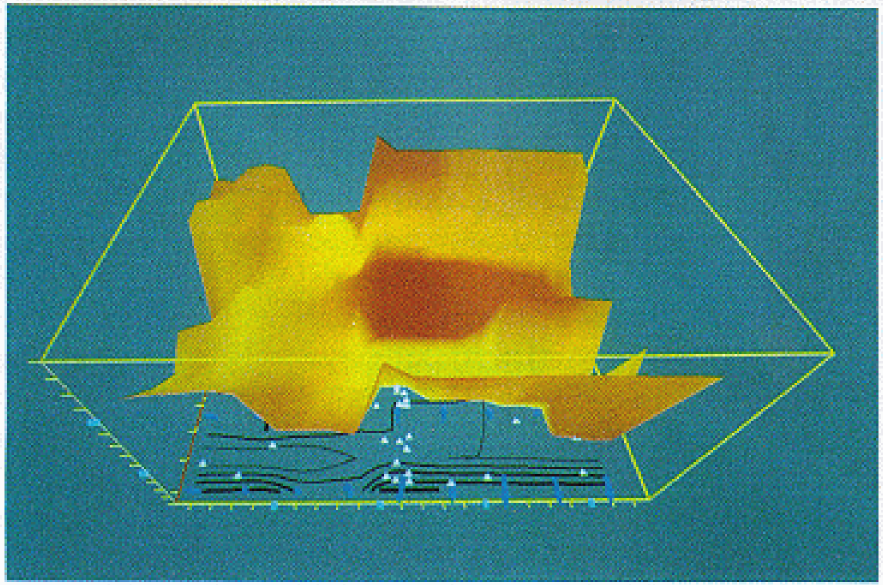
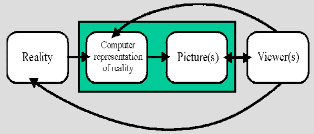


Figure 7.13. A second visualization of the same weather data, in which the supermposition operator has been replaced by what Senay calls union and Mackinlay calls double axis composition. The result is that the humidity contours, wind velocity vectors, and station locations are on the ground plane rather than on the rainfall surface, creating a less effective presentation because some of the information is obscured. (Courtesy H. Senay.)



4.1.6.5 Robertson (NSP)- Natural Scene Paradigm [ROB91]

- data elements are mapped onto features of natural scenes
  - e.g. mountains and valleys, showing patterns of density and color
- constraints
  - data characteristics:
    dimensionality, relationships, ordinal/nominal, discrete/continuous
  - interpretation aims:
    point/local/global importance; relative importance
  - display constraints (user directives)

assures coherency through top-down design of complex scenes

assures problem-free interpretation through perceptual skills of humans

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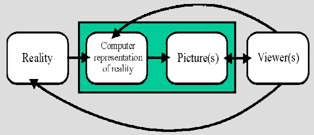
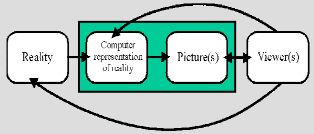


4.1.6.6 Wehrend and Lewis (Catalog of Visualizations)

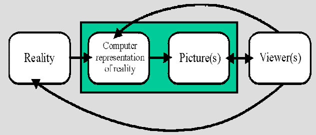
- Classification of simple and complex visualization techniques [WEH90]
- Categorize each visualization technique by:
  - what kind of data can be displayed ("attributes")
    attributes: [scalar, scalar field, nominal, direction, direction field, shape, position, spatially extended region or object, structure]
  - what operations act on these attributes ("operations/judgments").
    - operations: [identify, locate, distinguish, categorize, cluster, distribution, rank, compare within and between relations, associate, correlate]
- "Catalog of visualization techniques": large 2-d matrix to identify meaningful visualization techniques for a pair of (attribute/operation).



4.1.6.7 Beshers and Feiner (AutoVisual)

Rule-based design of interactive multivariate visualizations (n-Vision) [BES93]

- Specify visualization tasks
  - task operators: fundamental cognitive operations (exploration, directed search, comparison)
  - task selections: subset of relations, data items to display (constraints on available variables)
- Use rule-based visualization design principles
  - taking into account: visualization task, capabilities of hardware, characteristics of data
  - using interactive Worlds within Worlds techniques



4.1.6.7 Beshers and Feiner (AutoVisual) (cont)

- Termination conditions
  - **potential expressiveness**
    (visualization has potential, under user control, to display all its assigned information over time)
  - **potential effectiveness**
    ("visualization has potential, under user control, to display its assigned information sufficiently clearly over time``)

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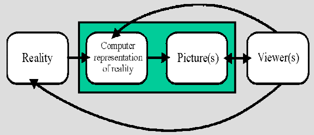

4.2 Difficulties in the mapping process

Computer-generated representations difficult to interpret due to

- approximations
  - e.g. smooth surface is approximated by polygons
- artifacts
  - e.g. surface color varies due to lightening model

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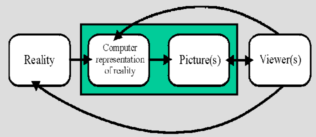

4.3 Visual context

- Design Issues, such as scale bars or annotations provide additional visual context outside the main mapping stage (see also Visual context / Necessary aids for the interpretation – The User and the Task)