The Visualization Pipeline

Content

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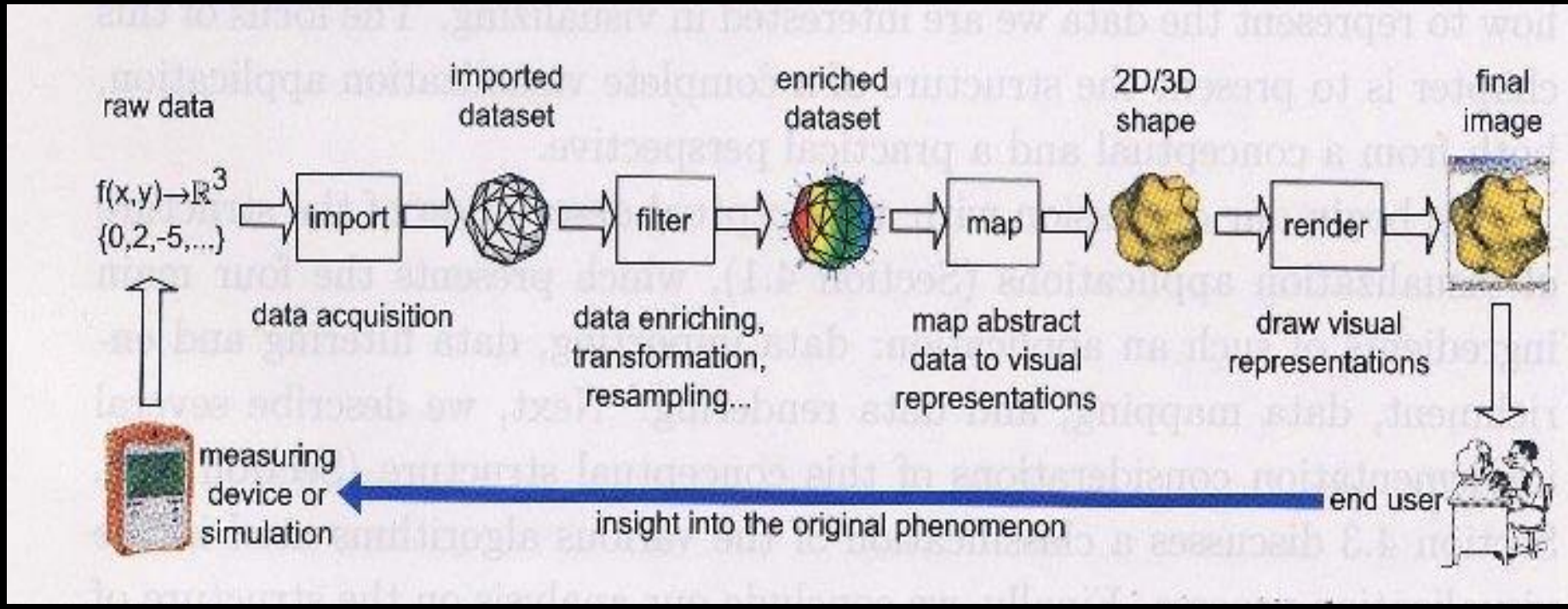
Algorithms used in the visualization
Structure of the visualization applications

The focus is on presenting the structure of a complete visualization application, both from a conceptual and a practical perspective.

Conceptual Perspective



The visualization pipeline

(***Computational Steering***: the cycle above in real time)

Conceptual Perspective

- **Four Visualization Stages**:

  data importing; data filtering and enrichment; data mapping; data rendering

- Function mapping: ***Vis***: ***Di*** --> ***Л***

Vis: function mapping

Di : the set of all possible types of raw input data

Л : the set of produced images

Reverse function mapping:

Insight: ***Л*** --> ***Di***

Conceptual Perspective

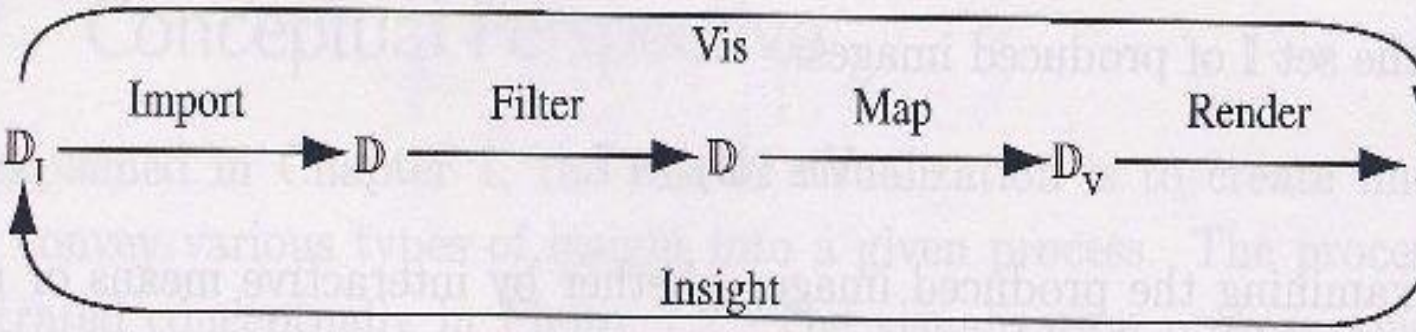


Fig 4.2 The visualization process seen as a composition of functions

Importing data

- Finding a representation of the original information

- D_I : the raw information
- D : the set of all supported datasets of a given visualization process
- In practice, data importing can imply translating between different data storage formats
- Or resampling the data from the continuous to the discrete domain
- The data importing step should try to preserve as much of the available input information as possible
- Make as few assumption as possible about what is important and what is not

Importing data

- Finding a representation of the original information

-- resampling the data from the continuous to the discrete domain

E.G. Petroleum seismic data

-- seismic reflection wave => digital sampling data

Data Filtering and Enrichment

- Decide important aspects or features
- We must somehow turn our raw dataset into more appropriate representations---enriched datasets
- Data filtering or data enriching, two tasks
  - Extract relevant information
  - Enriched with high-level information that supports a given task
- The input and output are datasets

Data Filtering and Enrichment

- Petroleum seismic data

  -- wave correction; denoising

- Medical data

  -- noise data removal; enhancement of certain material data, etc.

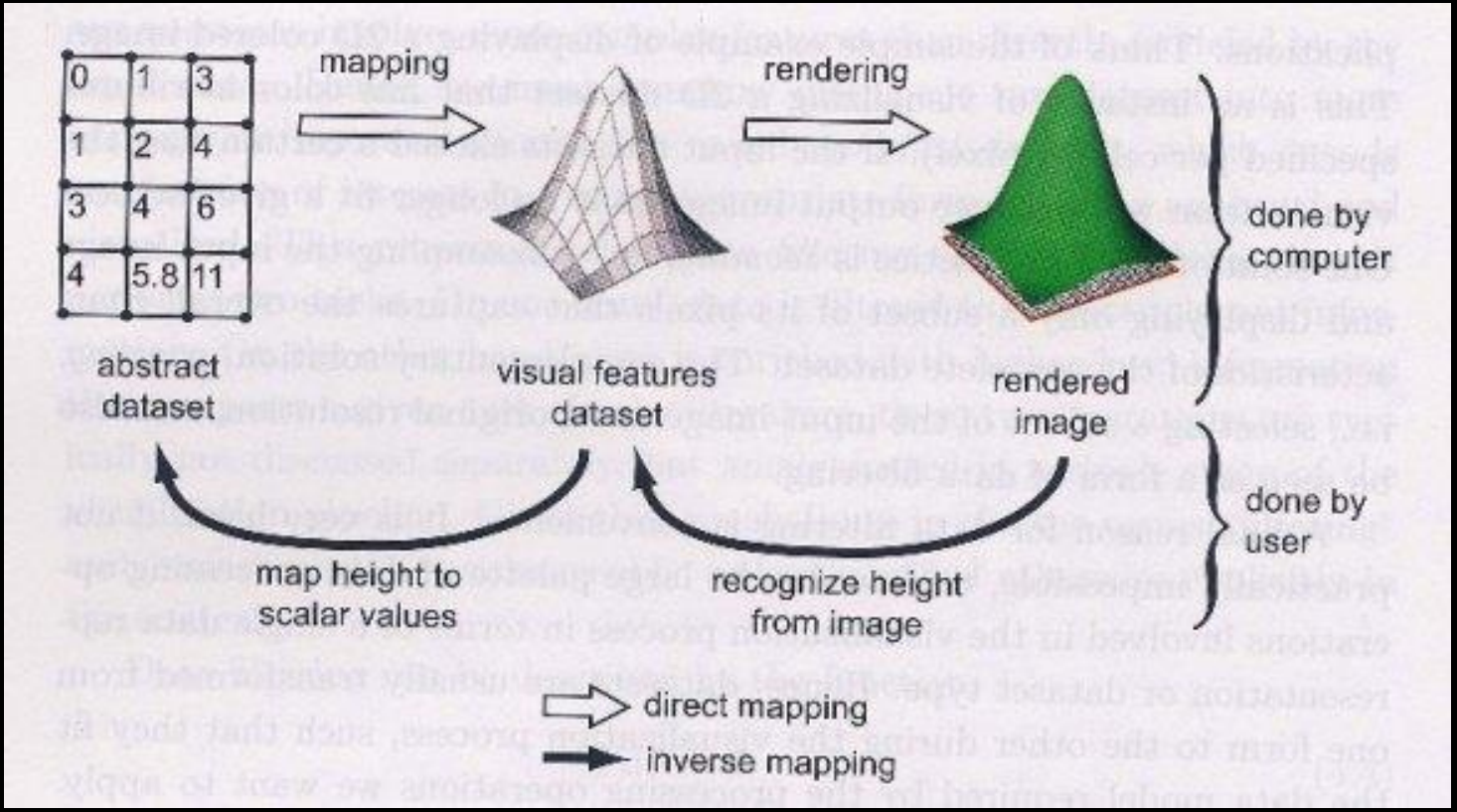
Mapping Data

- Once we have the needed data, we must map it to the visual domain.
- Mapping function $\text{Map} : D \rightarrow D_V$

  D: dataset

  Dv: dataset of visual features
- Comparison about mapping and rendering
  - Mapping: convert “invisible” to “visible” representations;
  - Rendering: simulates the physical process of lighting a “visible” 3D scene.

Mapping Data



Direct and inverse mapping in the visualization process

Rendering Data

- Final step of the visualization process.

$$\text{Render} : D_V \rightarrow II$$

- Tuning viewing parameters

Implementation Perspective

- The Visualization pipeline

$$Vis = F_1 \circ F_2 \circ \cdots \circ F_n \qquad where \;\; F_i : D \to D$$

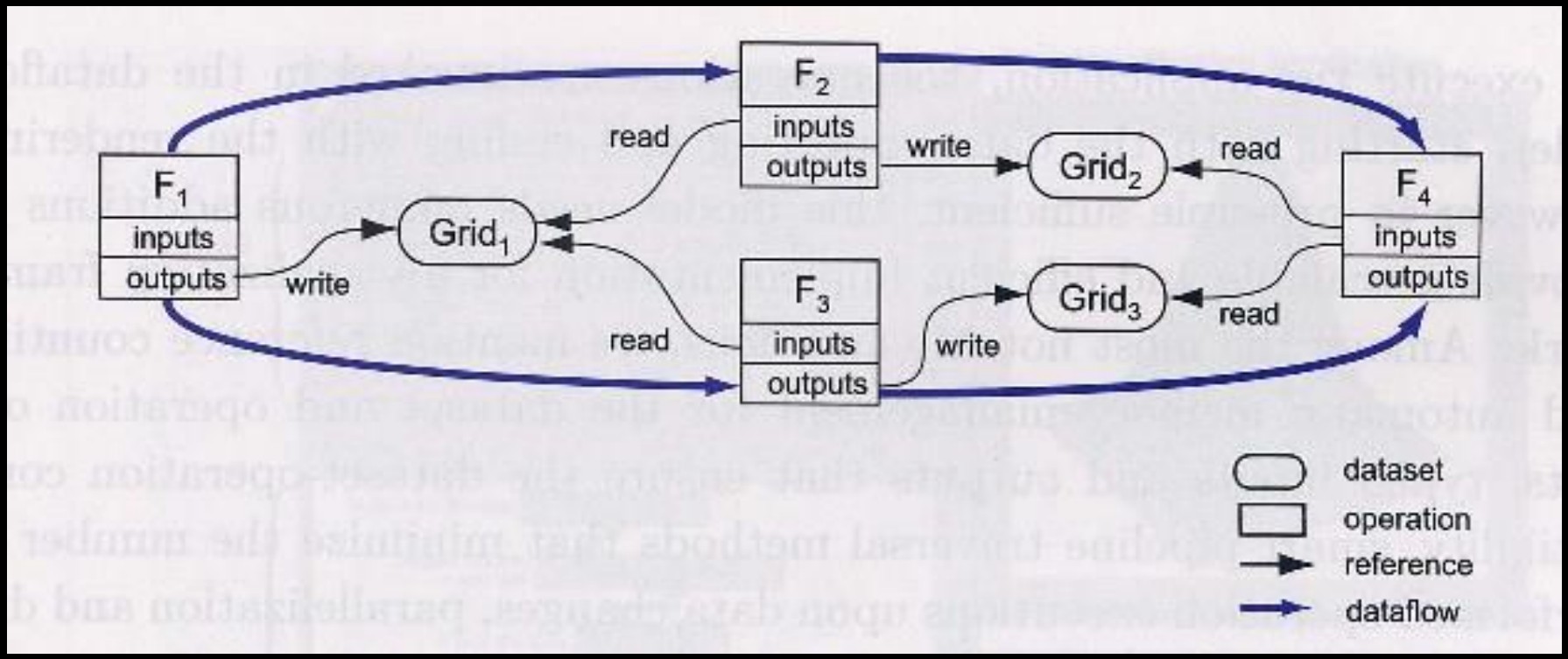
F_i perform the data importing, filtering, mapping, and rendering operations, in order.

- Input: raw data, output: the final image

```
class F
{
public:
    void          setInput(Grid*,int);
    Grid*         getOutput(Grid*,int);
    virtual void  execute() =0;
protected:
    vector<Grid*> inputs;
    vector<Grid*> outputs;
};
```

Listing 4.1. Visualization operation implementation.

Implementation Perspective

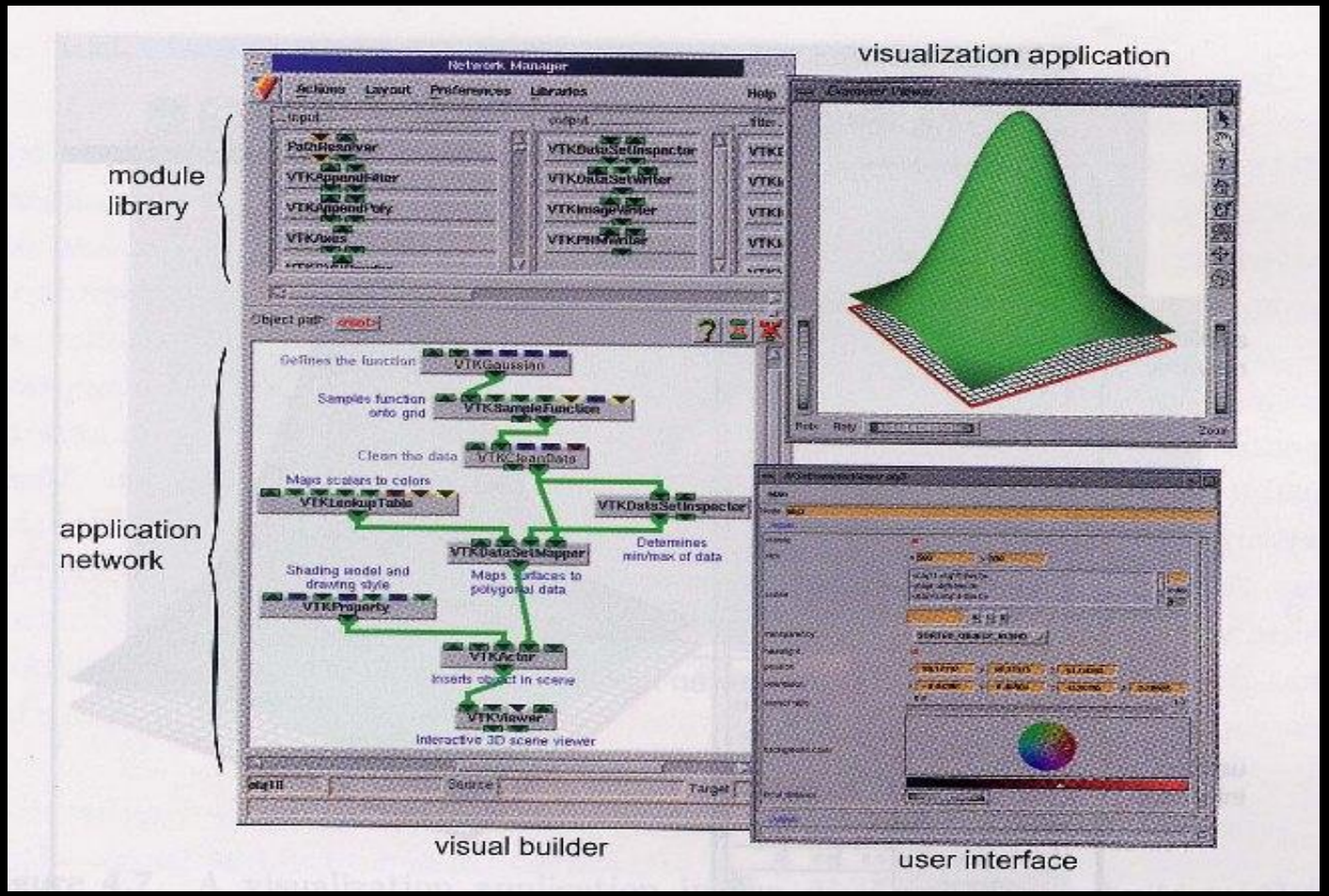


A visualization application as a network of objects

Implementation Perspective

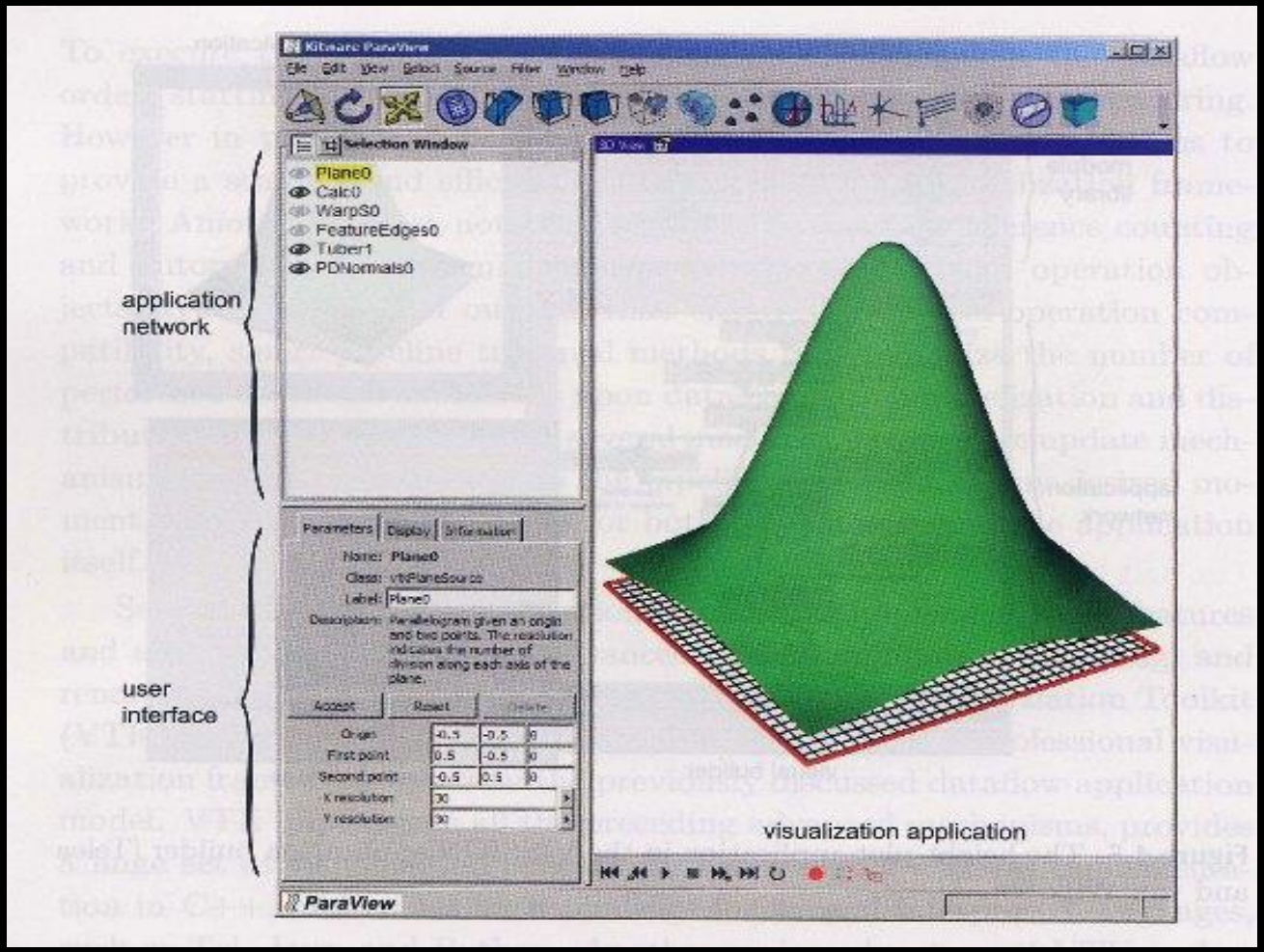
- Several professional visualization framework
  - VTK (Visualization Toolkit, Schroeder et al. 04)
  - C++
  - Open-source product

Implementation Perspective (AVS)



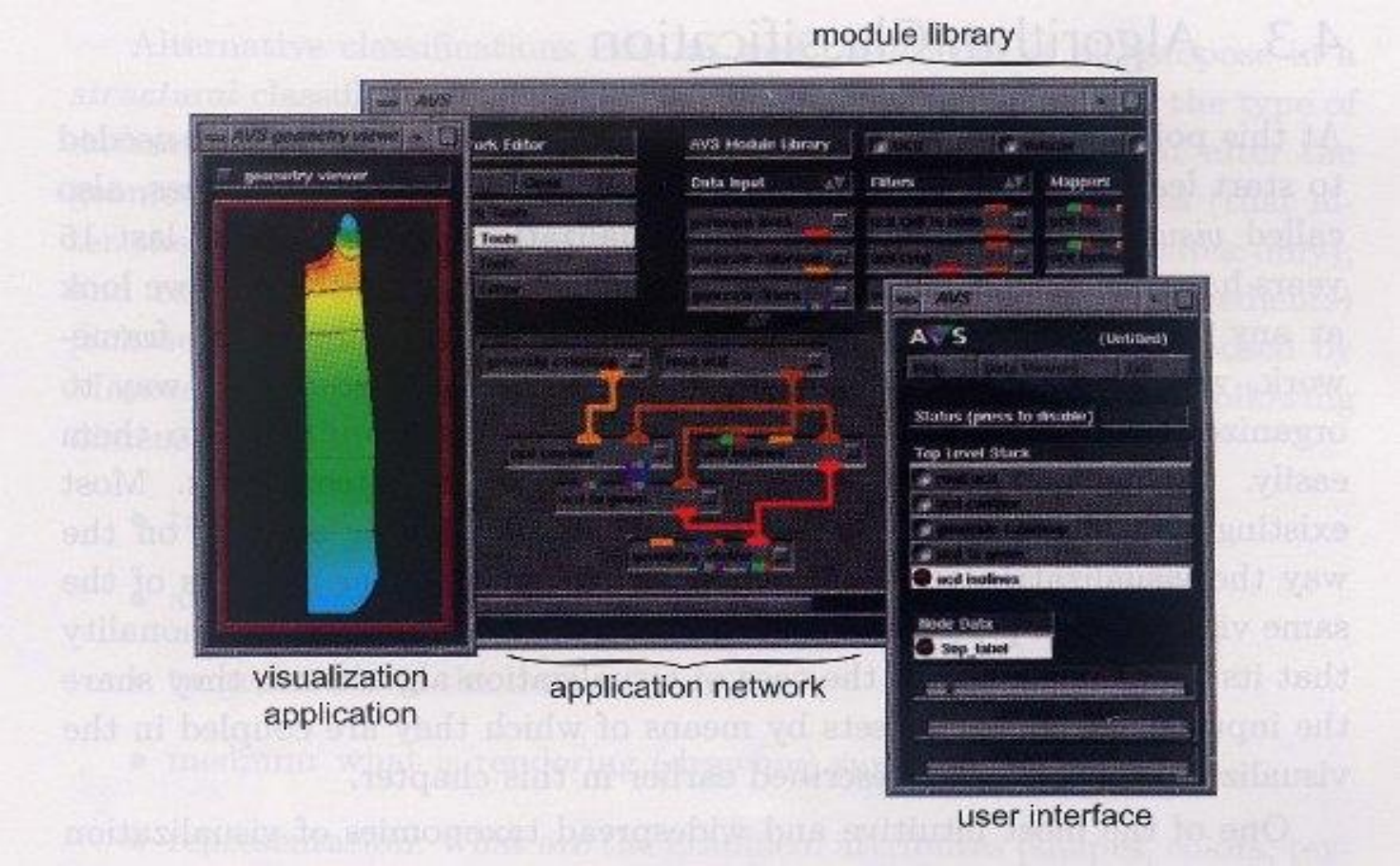
The height-plot application in the VISSION application builder [Telea and van Wijk 99]

Implementation Perspective



The height-plot application in the ParaView application builder [Henderson 04]

Implementation Perspective



A visualization application in the AVS app. builder [AVS, Inc. 06]

Algorithm Classification

- Large number of algorithms proposed
- One way of algorithm classification: based on the type of attributes these techniques work with
  - Scientific Visualization (Scientific parameters)
    - Scalar, vector, tensor
  - Information Visualization
    - Non-numeric attributes: text, graph, or general data table (abstract)
  - Color

Conclusion

- The structure of the visualization process, or visualization pipeline.
- There is no clear-cut separation of the visualization stages
  - The main separation point: the abstract data become “visible”
- Seleciton of mapping function is crucial
  - Combination of science & art