Software Visualization or How to See and Explore the Intangible

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Acknowledgement

- Omar Benomar
- Simon Bouvier
- Karim Dhambri
- Guillaume Langelier
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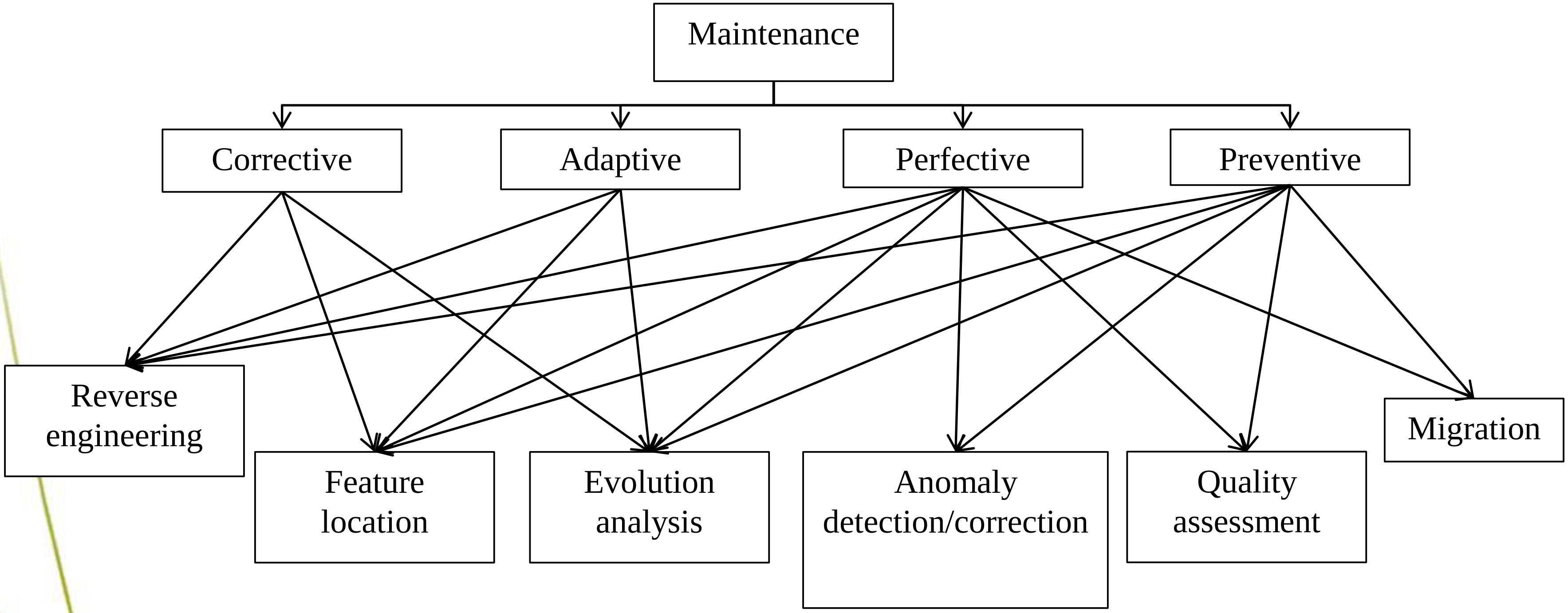
Maintenance Tasks

- Maintenance problems

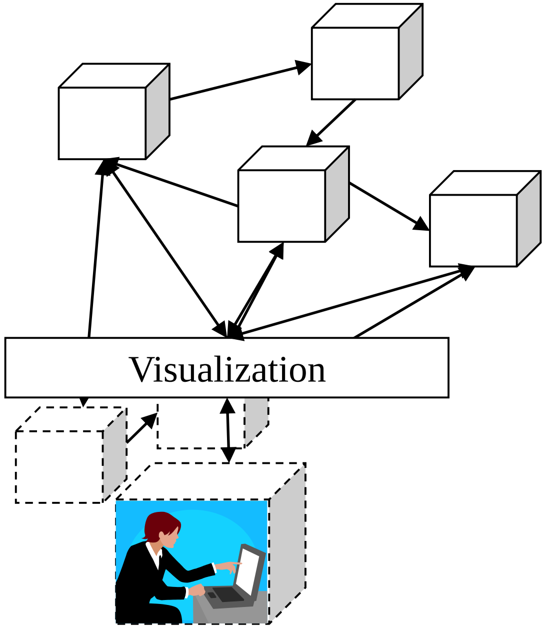


Maintenance Tasks

- Many maintenance tasks difficult to automate
  - Multi-criteria decision making
  - Difficulty to capture/encode contextual information
  - Complexity/scalability

Interactive Visualization

- Semi-automatic approach
- Maintenance task = Set of reasoning and calculation modules
  - Set of automated modules AMs (explicit knowledge)
  - Human analyst module HM
  - Interactive visualization = Interface between AMs and HM



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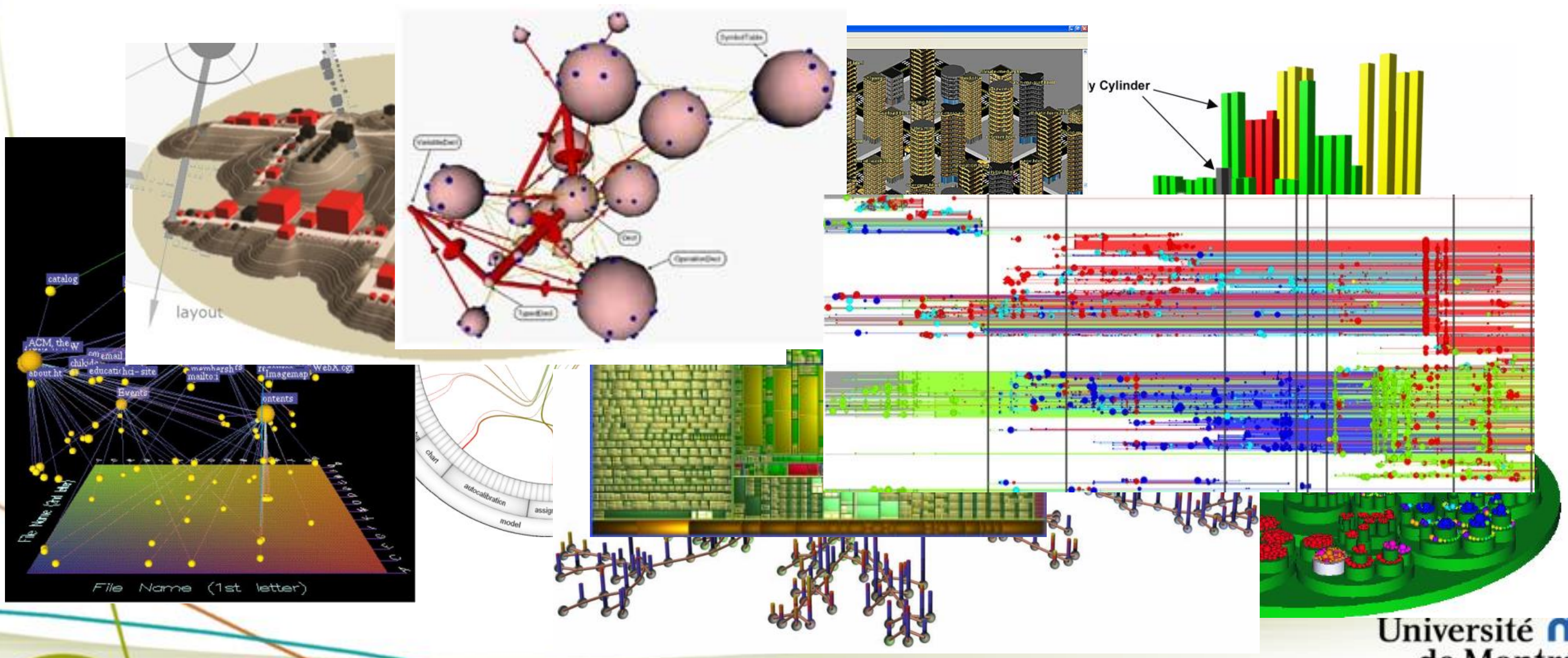
Visualization Tools for Maintenance

- Dozens of tools proposed each year in VLHCC, SOFTVIS, VISSOFT, SE journals, conferences and workshops, etc.



Visualization Tools for Maintenance

- Not used outside the community that developed them
- What's wrong?
  - Not tailored for specific tasks
  - Effort and efficiency
    - Intrinsic complexity
    - Suitability

Modeling Maintenance as Interactive Visualization

- Maintenance world
  - Maintenance task
    - Exploring data extracted from software artifacts
    - Modifying software artifacts
  - Data
    - *Entities* (at different levels) with *Properties,* having *Relationships* and *Structures*
    - Viewpoints
    - Time
  - Operations
    - Aggregation, clustering, identification, etc.

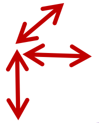
Modeling Maintenance as Interactive Visualization

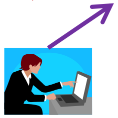
- Example : detecting anomalies
  - Example of anomaly definition
    - A Blob is a *controller* class, *abnormally large*, with *almost* no parents and no children. It *mainly uses* data classes, i.e. *very small* classes with *almost* no parents and no children.
  - Model
    - Entities: classes, methods
    - Properties: coupling, cohesion, complexity
    - Relationships: invocations, inheritance
    - Structure: architecture
    - Viewpoints: code, metrics
    - Time: multiple version
    - Operations: evaluate conditions, etc.

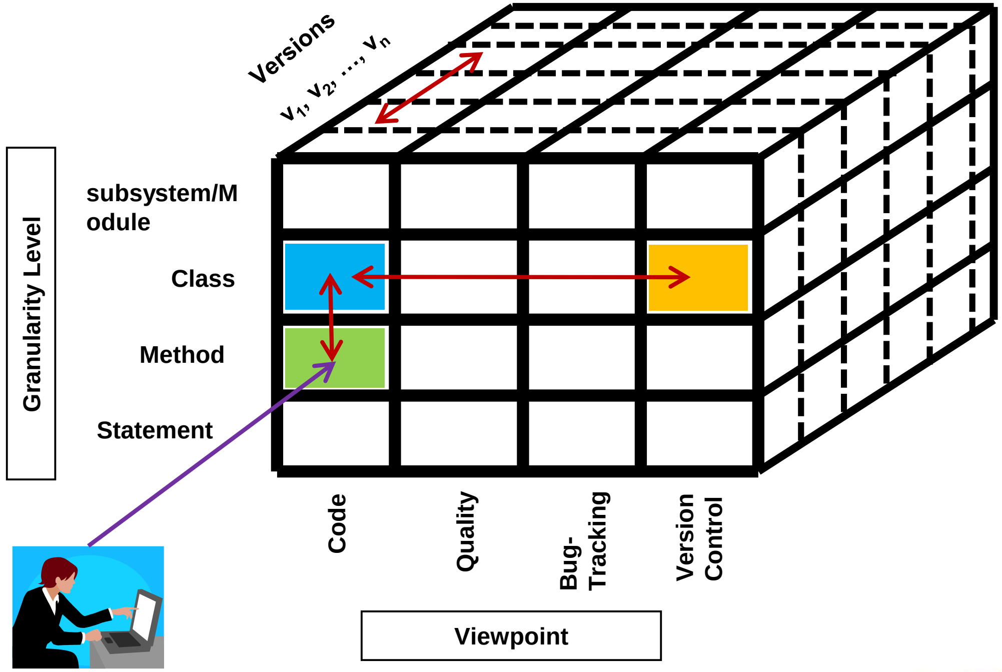
Modeling Maintenance as Interactive Visualization

- Visualization world


Views


Movements


Interactions



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Modeling Maintenance as Interactive Visualization

- Visualization world
  - Interactive visualization
    - Processing large sets of multidimensional data
    - Mainly a perception problem
  - Human brain hard-wired to perceive things in a certain way
  - Understanding human perception reduces complexity and increases efficiency

Defining Views

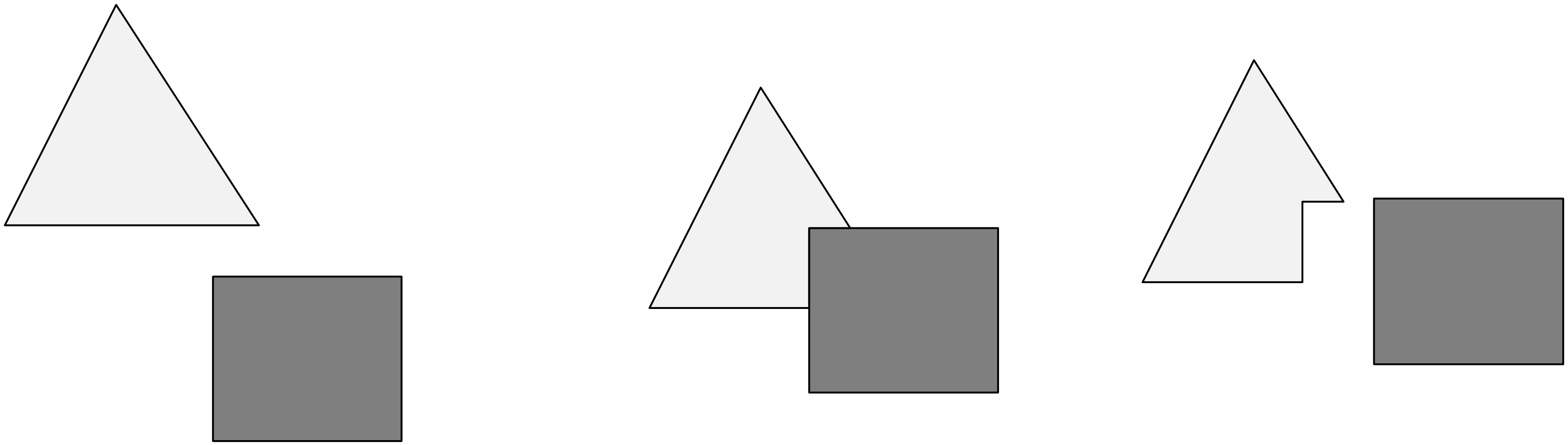
- Software is intangible
- Representations of
  - Entities by shapes
  - Properties by graphical attributes of shapes
  - Relationships by connecting shapes
  - Structures by spatially organizing shapes

Defining Views

- Representing entities (principles)
  - Gestalt Rules of Perception

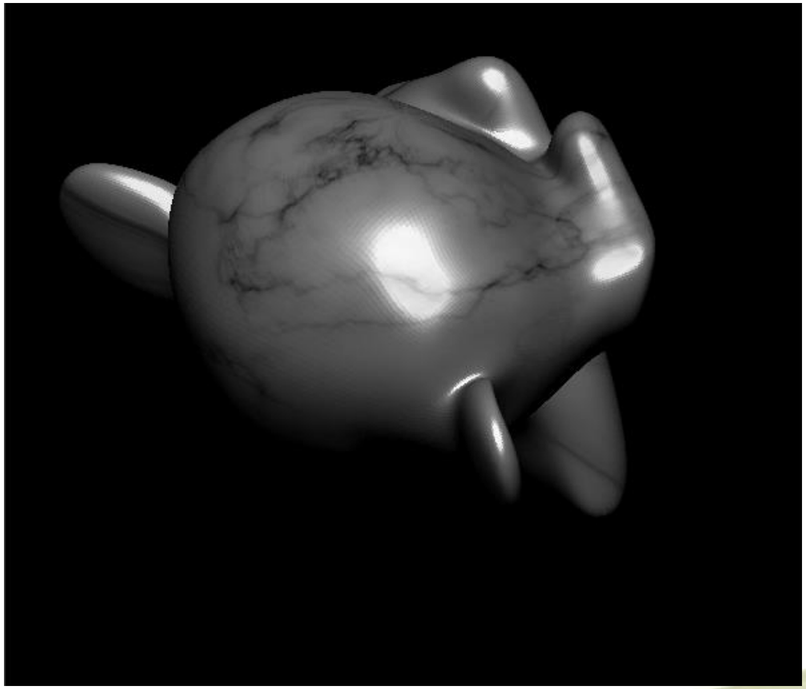
Defining Views

- Representing entities (principles)
  - Simplicity



Defining Views

- Representing entities (principles)
  - Continuity



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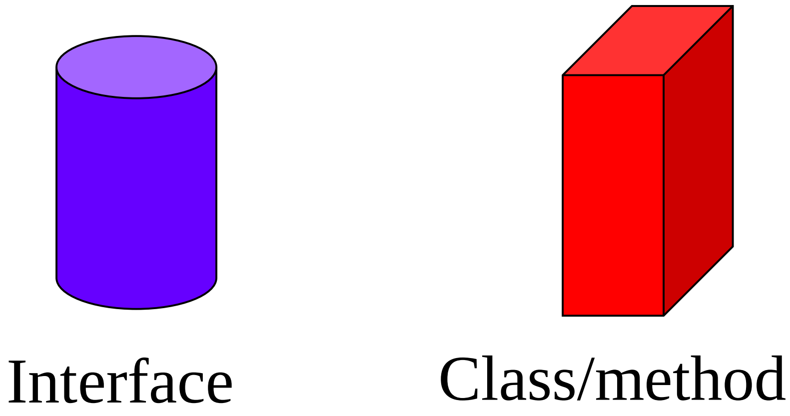
Defining Views

- Representing entities (principles)
  - Continuity

Defining Views

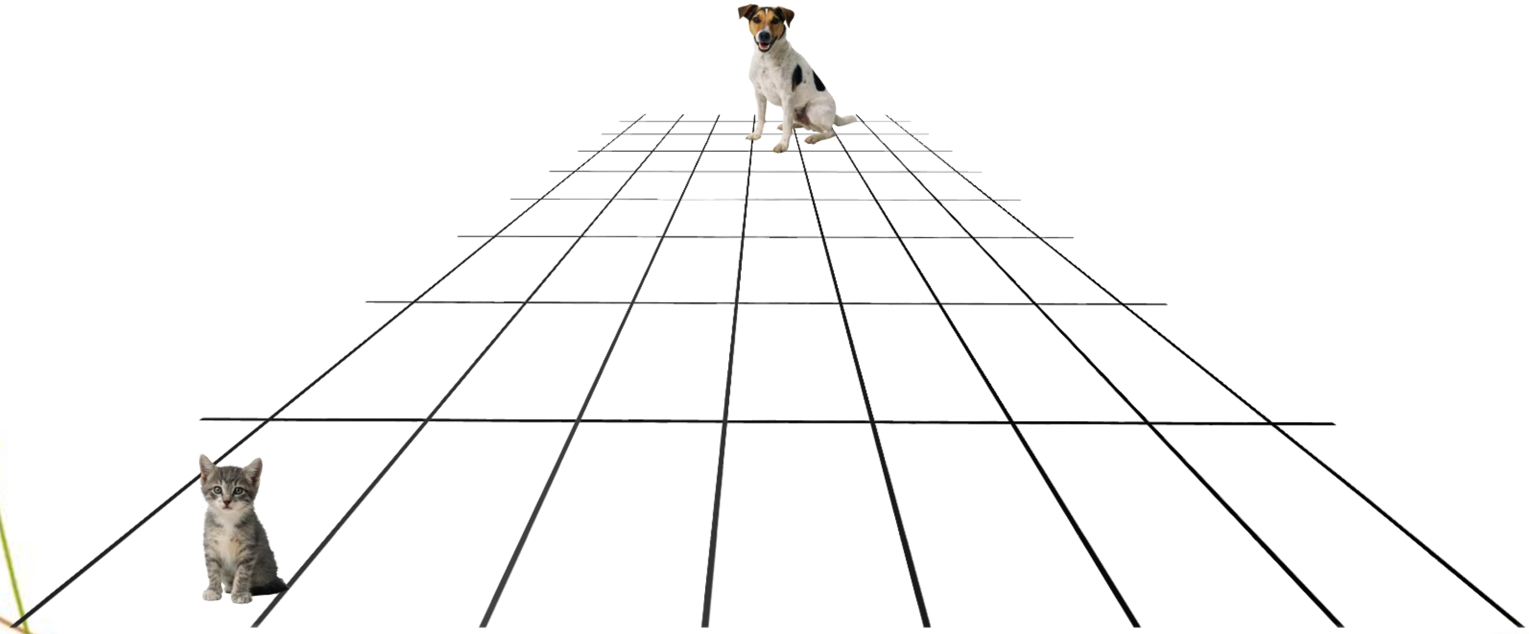
- Representing entities
  - Example of VERSO



Defining Views

- Representing properties (principles)
  - Interaction between visual properties

Size vs depth



Defining Views

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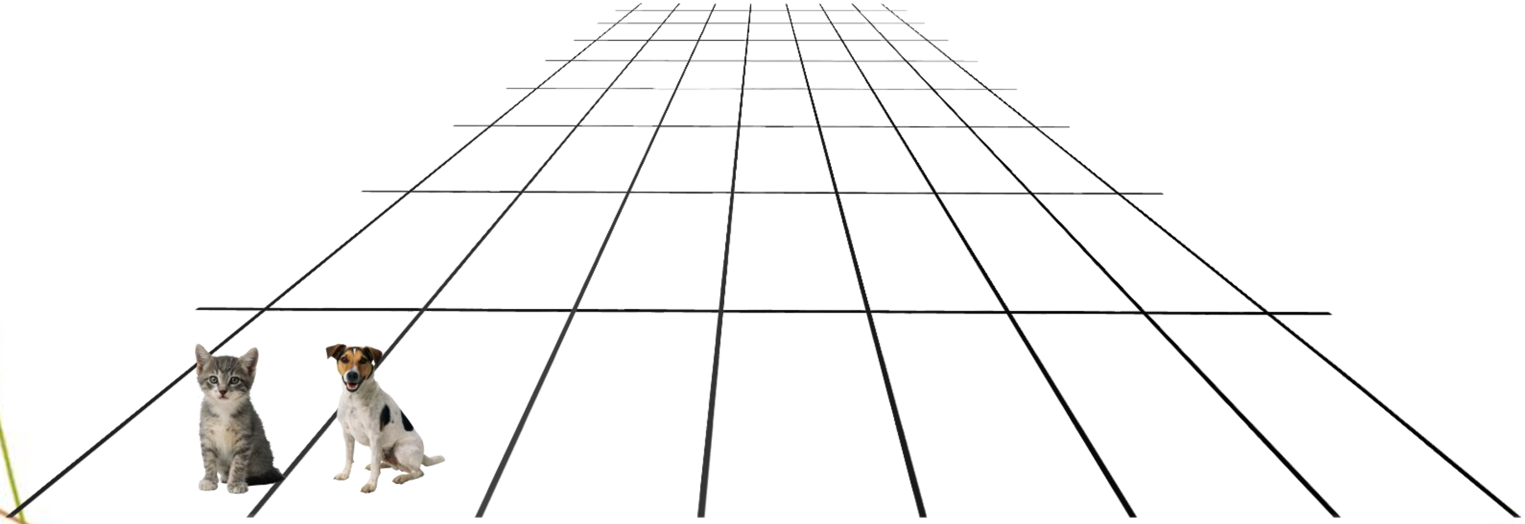

Defining Views

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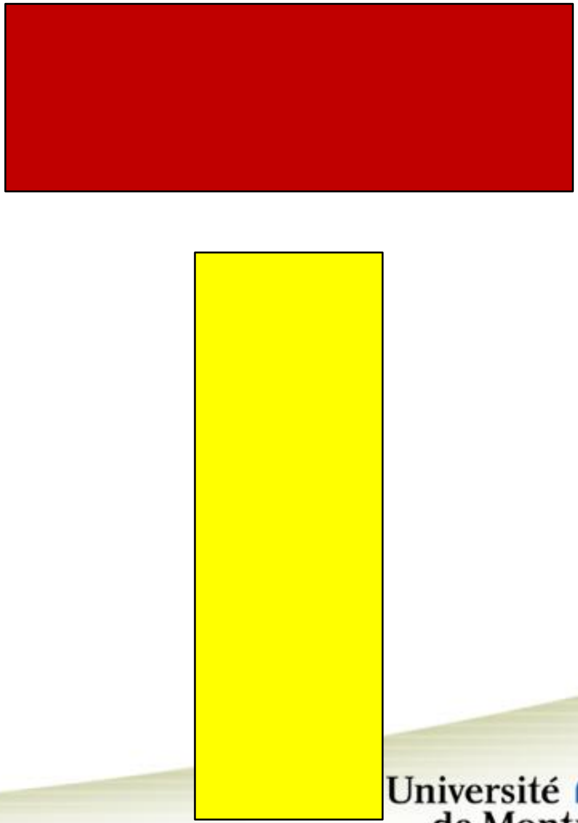
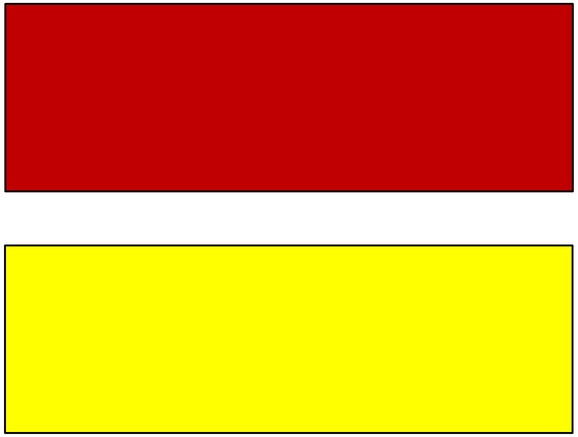


Size vs orientation

Defining Views

- Representing properties (principles)
  - Interaction between visual properties

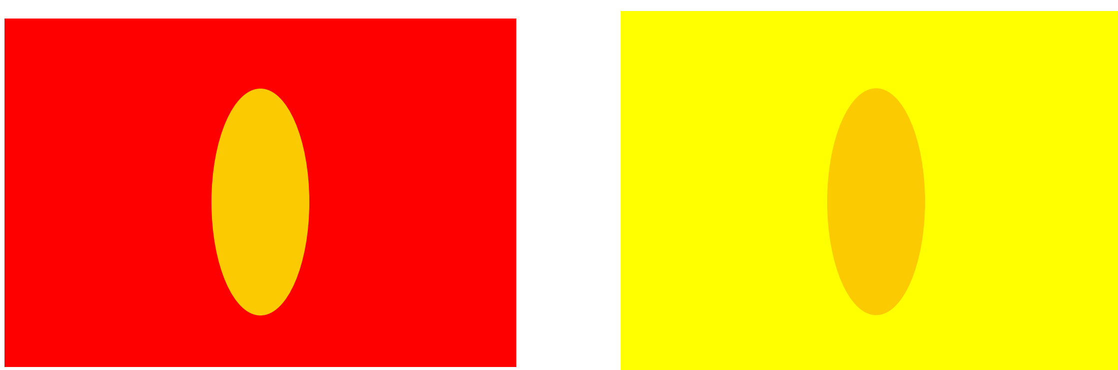
Size vs orientation



Defining Views

- Representing properties (principles)
  - Interaction between visual properties

Color & contrast



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Defining Views

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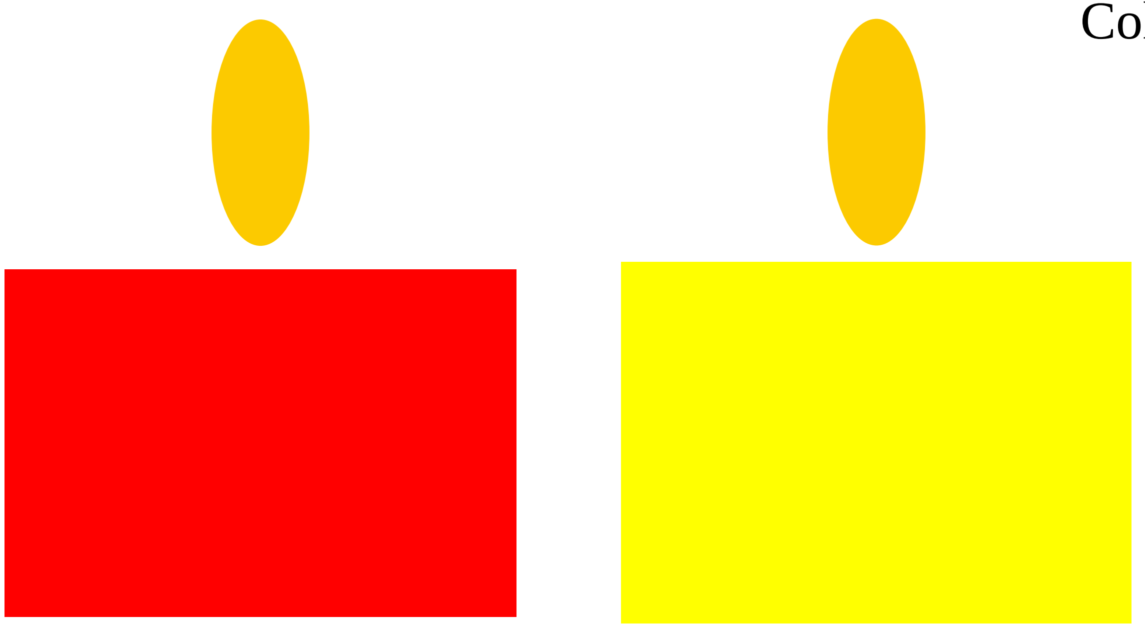
  - Interaction between visual properties

Color & contrast



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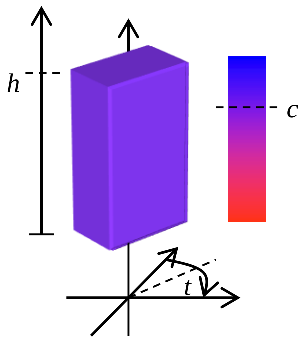
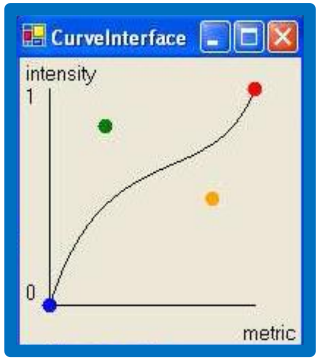
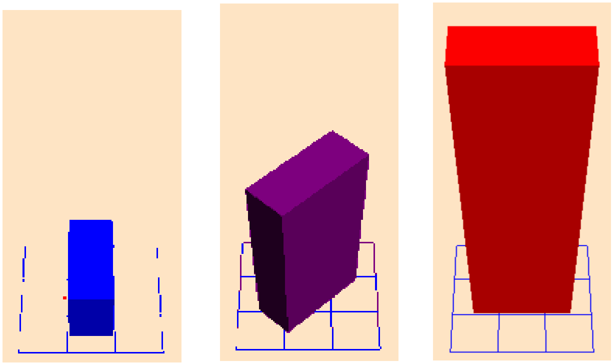
Defining Views

- Representing properties
  - Example of VERSO

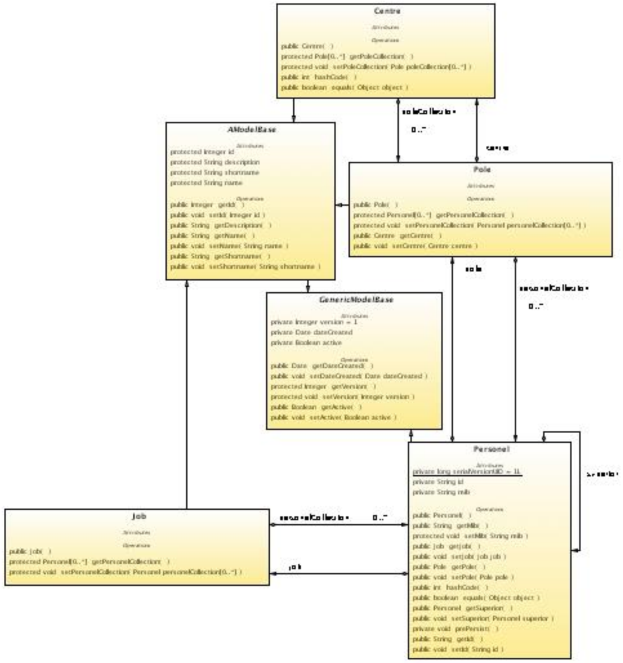






Defining Views

- Representing relationships (principles)
  - Explicit representation vs size



Defining Views

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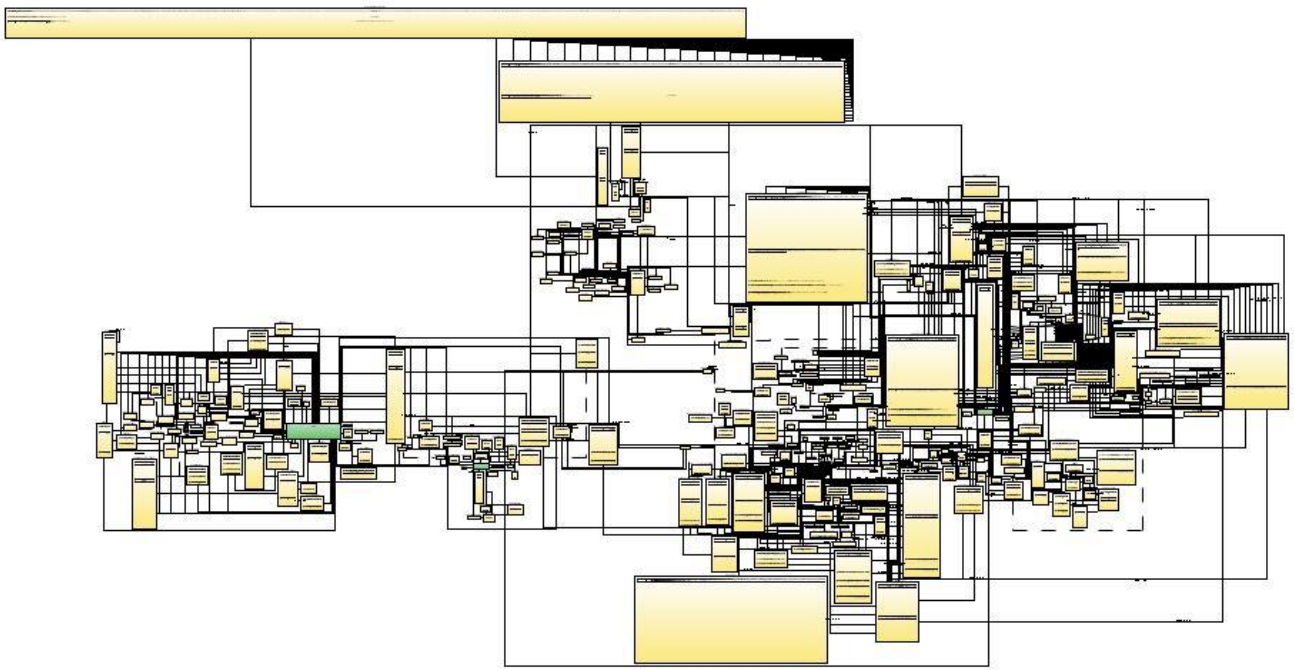
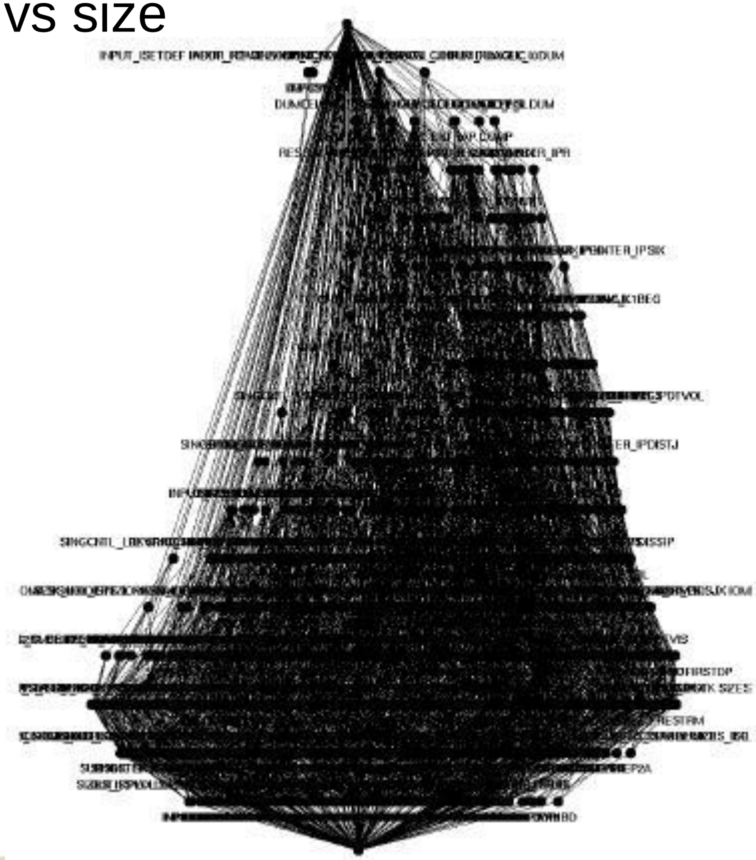


Defining Views

- Representing relationships (principles)
  – Explicit representation vs size



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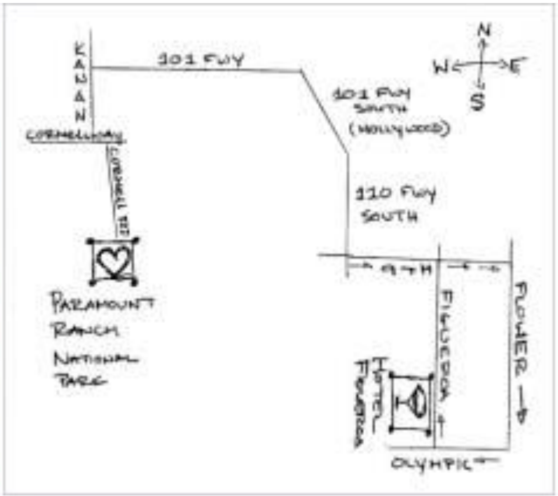
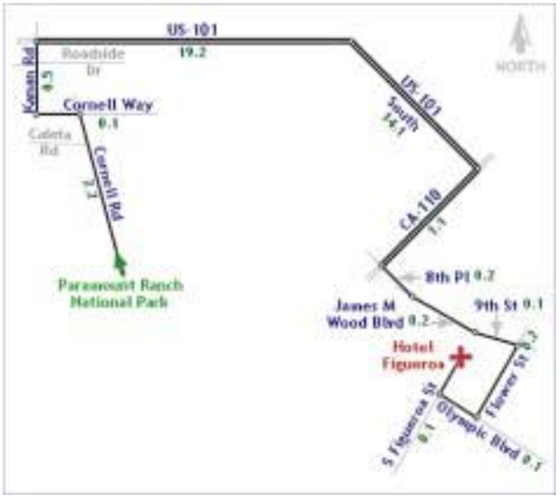
Defining Views

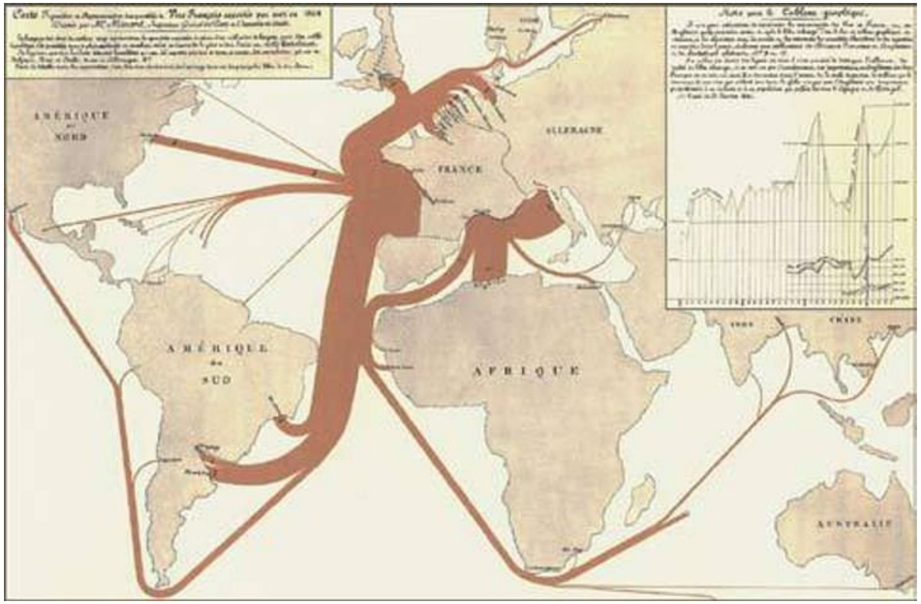
- Representing relationships (principles)
  - On-demand representation





Defining Views

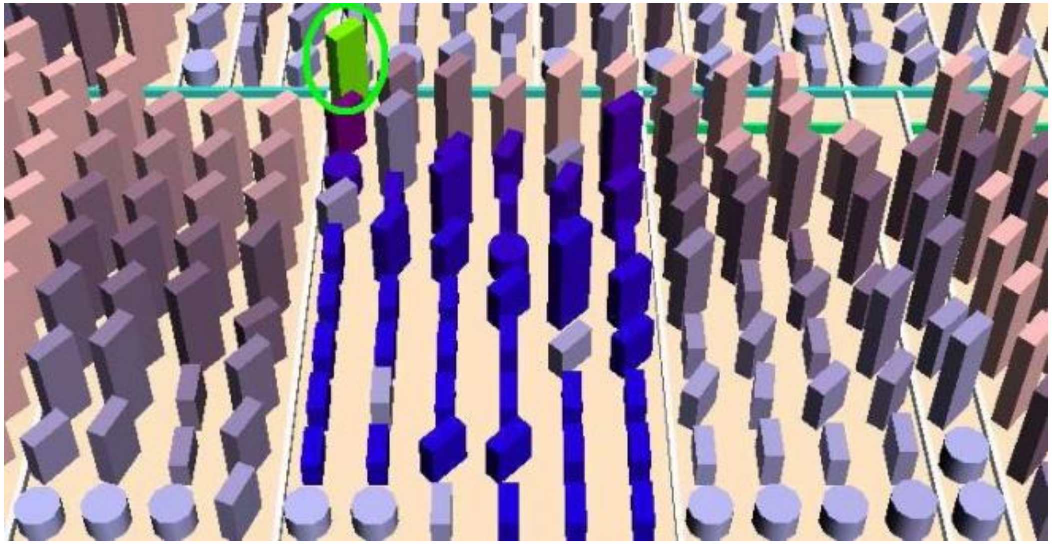
- Representing relationships (principles)
  - Flow maps



Minard, C. J. "Carte figurative et approximative des quantités de vin français exportés par mer en 1864".

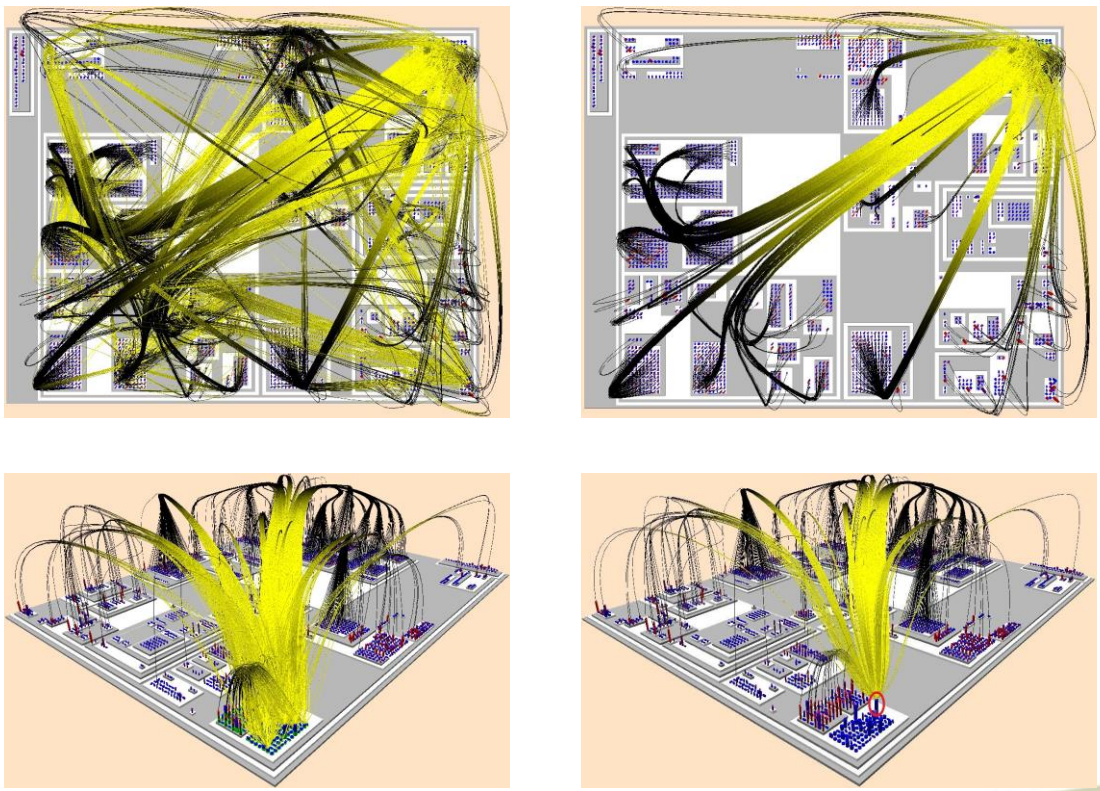
Defining Views

- Representing relationships
  - Example of VERSO (filters)



Defining Views

- Representing relationships
  - Example of VERSO (Edge bundles)



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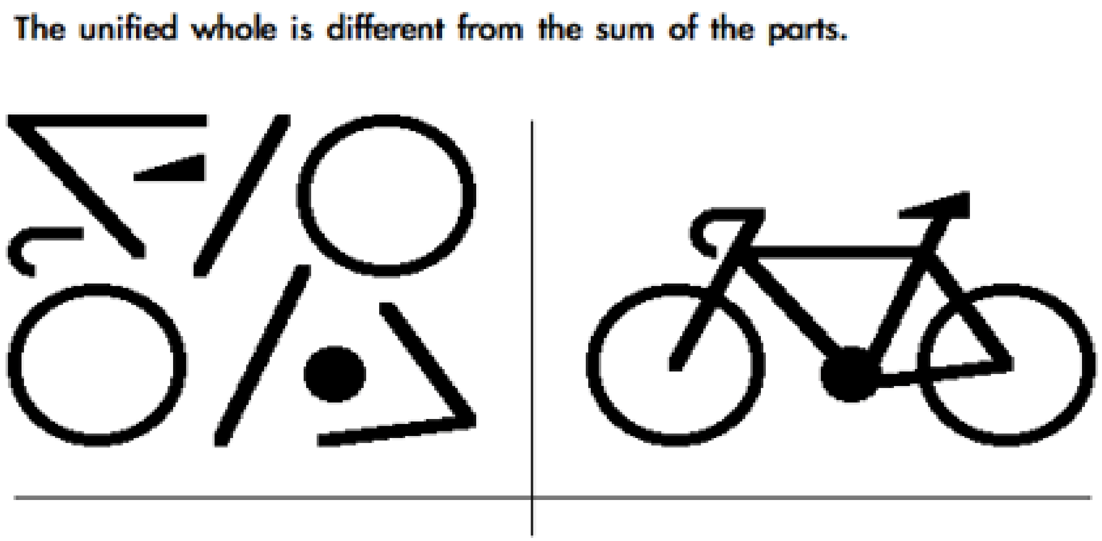
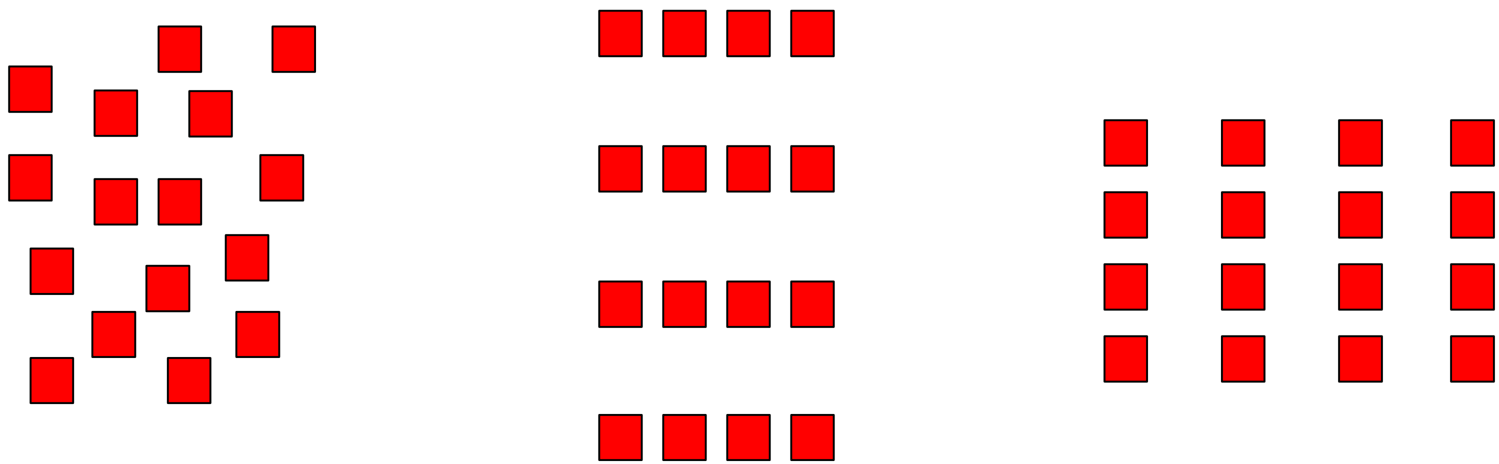
Defining Views

- Representing structure (principles)
  – Whole vs parts



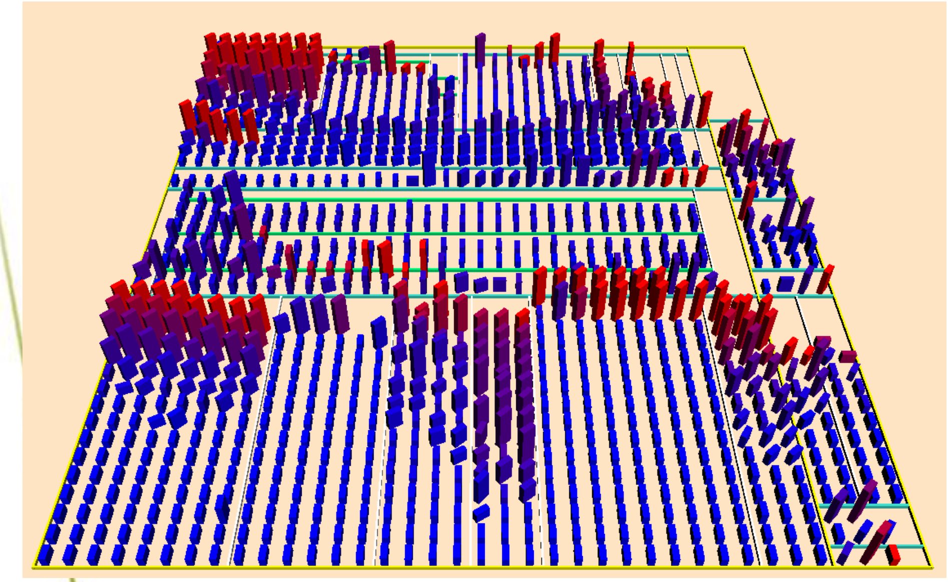
Defining Views

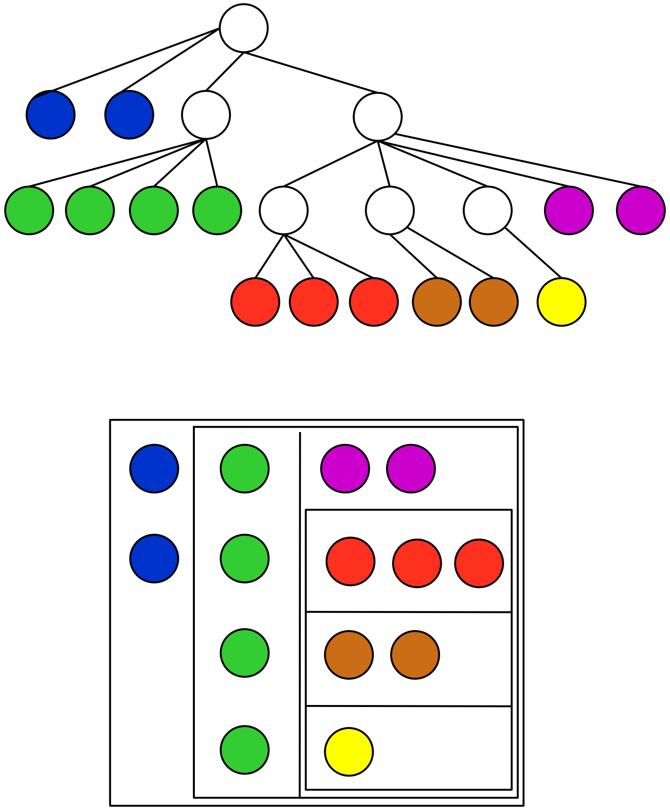
- Representing structure (principles)
  - Law of proximity



Defining Views

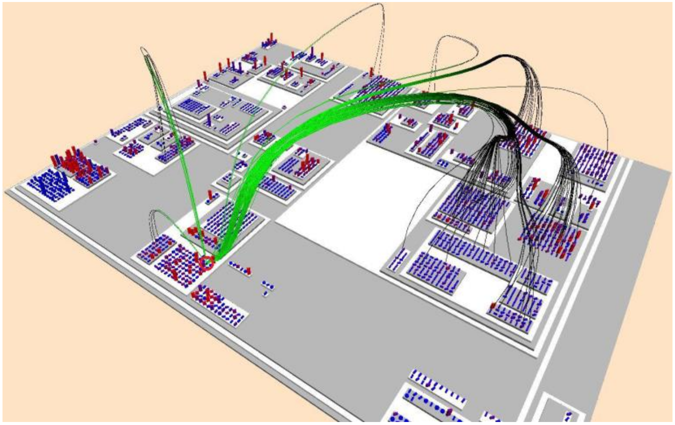
- Representing structure
  - Example of VERSO

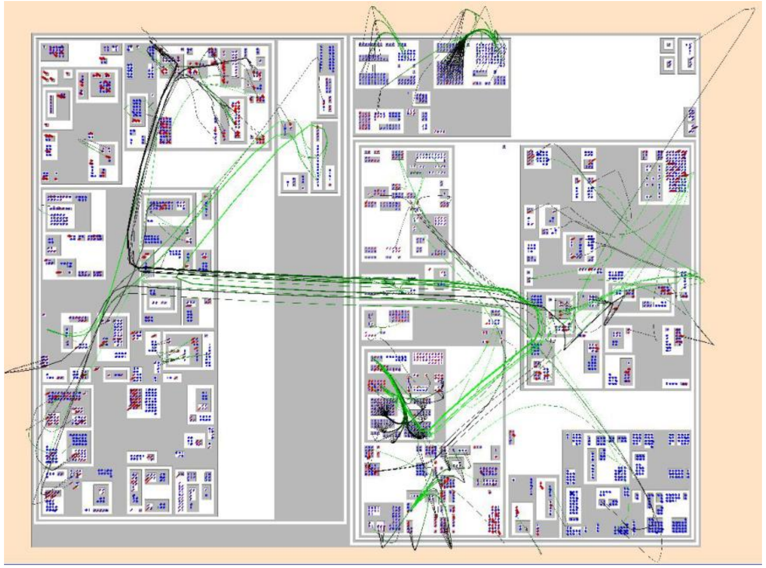




Defining Views

- Representing structure
  - Example of VERSO





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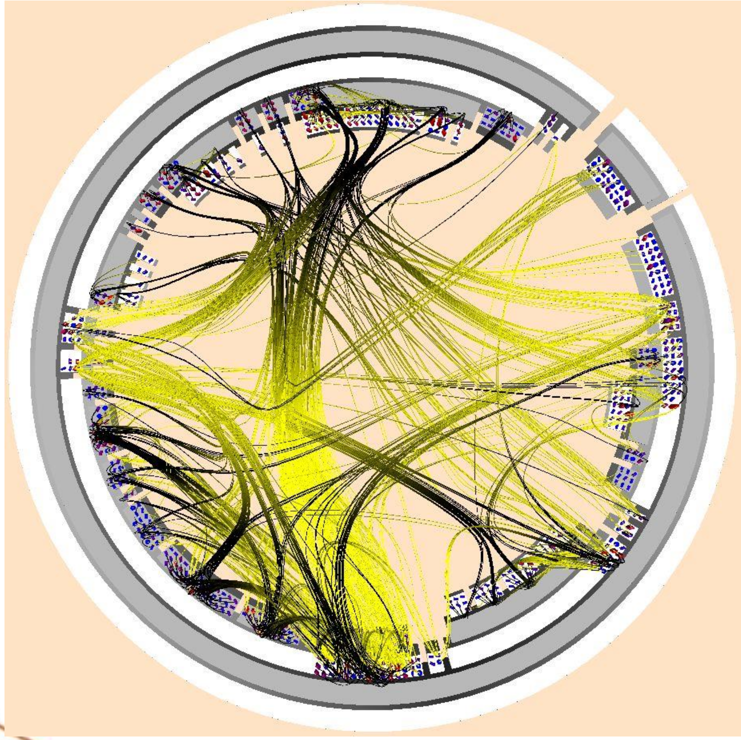
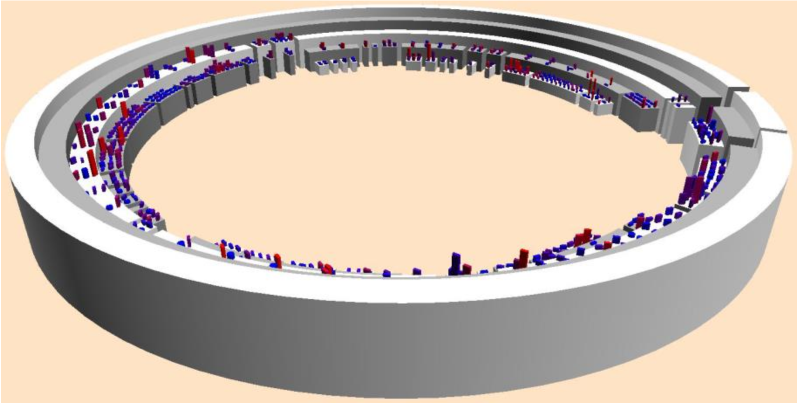
Defining Views

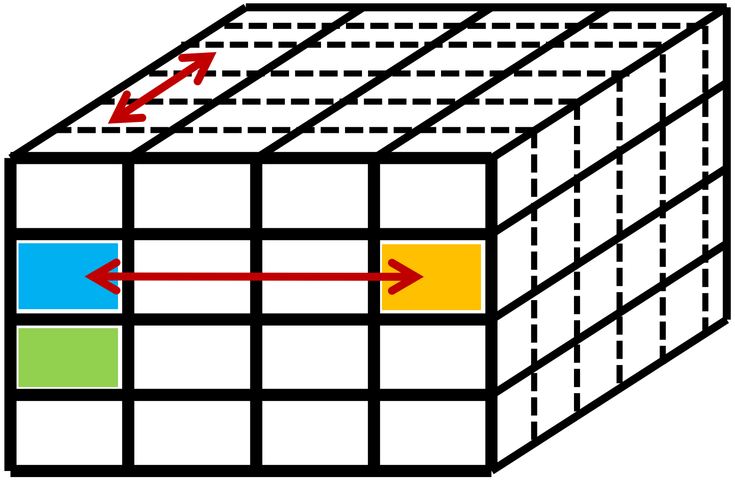
- Representing structure
  - Example of VERSO





Movements between Views

- Within the same level (principles)
  - Change detection mechanisms
    - Change vs difference
  - Multiple-viewpoints management
  - Visual coherence
    - Spatial coherence
    - Temporal coherence



Movements between Views

- Spatial coherence
  - Difference detection

Movements between Views

- Spatial coherence
  - Change detection

Movements between Views

- Spatial coherence
  - Change detection

Movements between Views

- Spatial coherence

Movements between Views

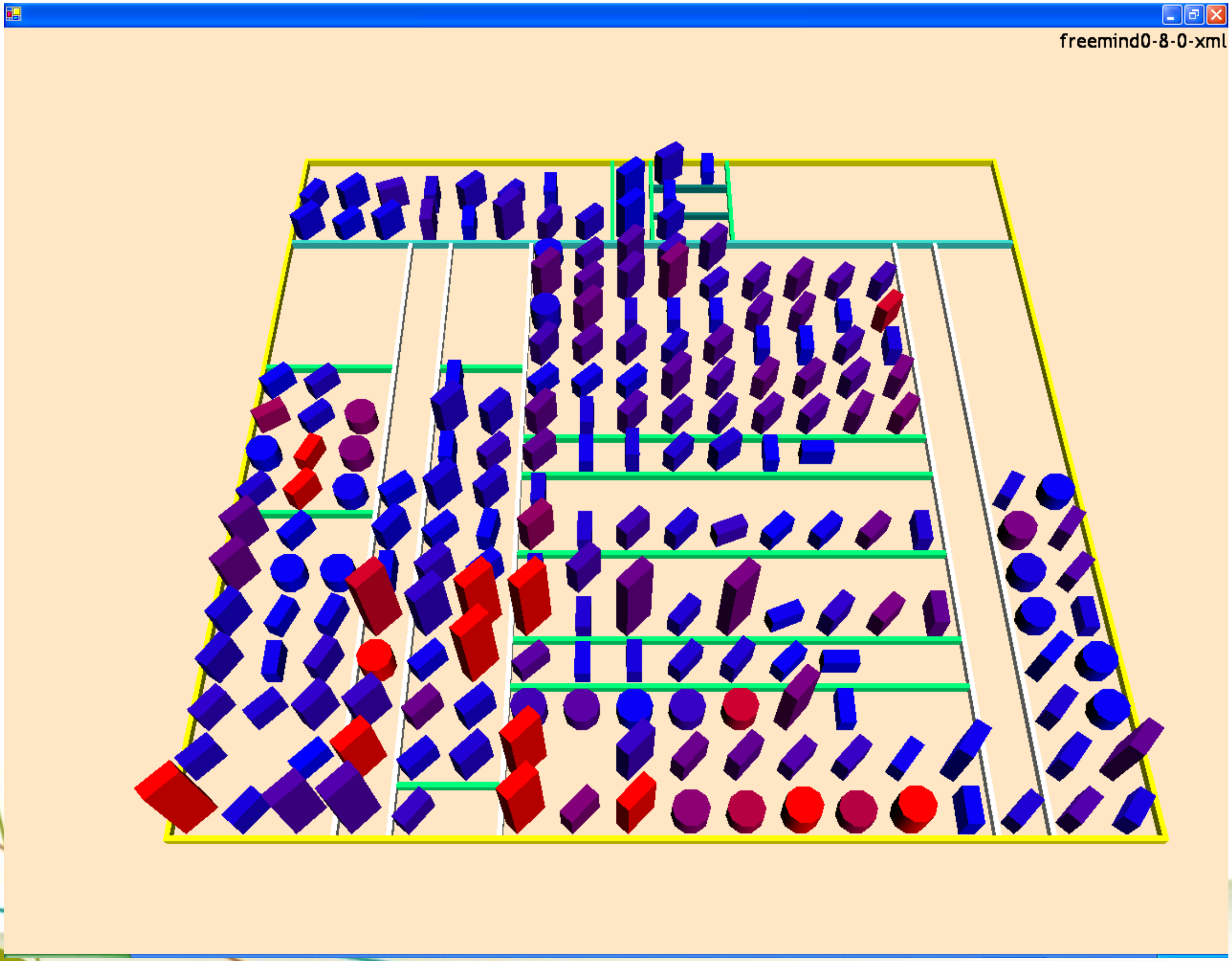
- Spatial coherence

Movements between Views

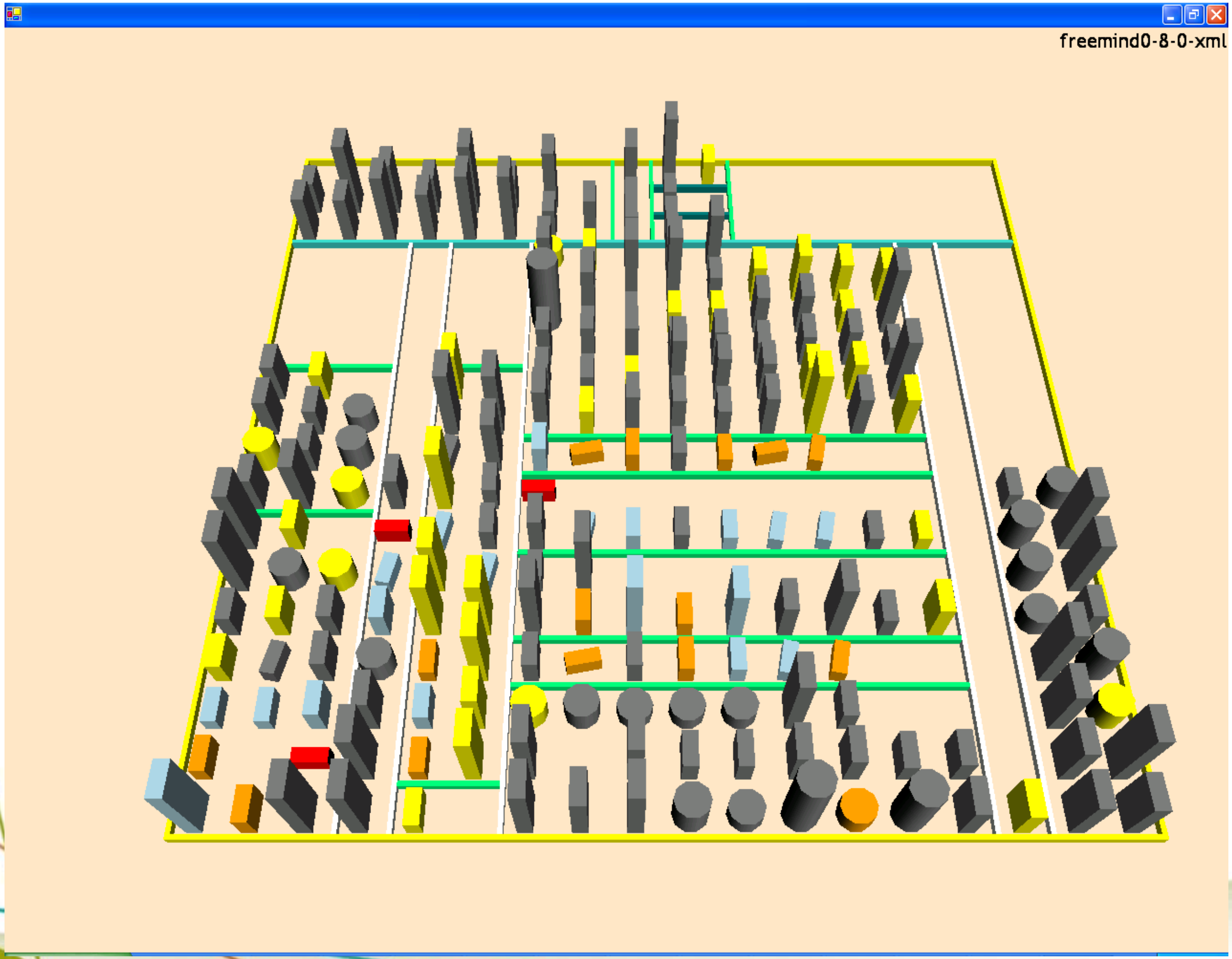
- Temporal coherence
  - Change Blindness

Rensink RA, O'Regan JK, and Clark JJ (1997). To See or Not to See: The Need for Attention to Perceive Changes in Scenes. Psychological Science, 8:368-373.

Movements between Views



Movements between Views



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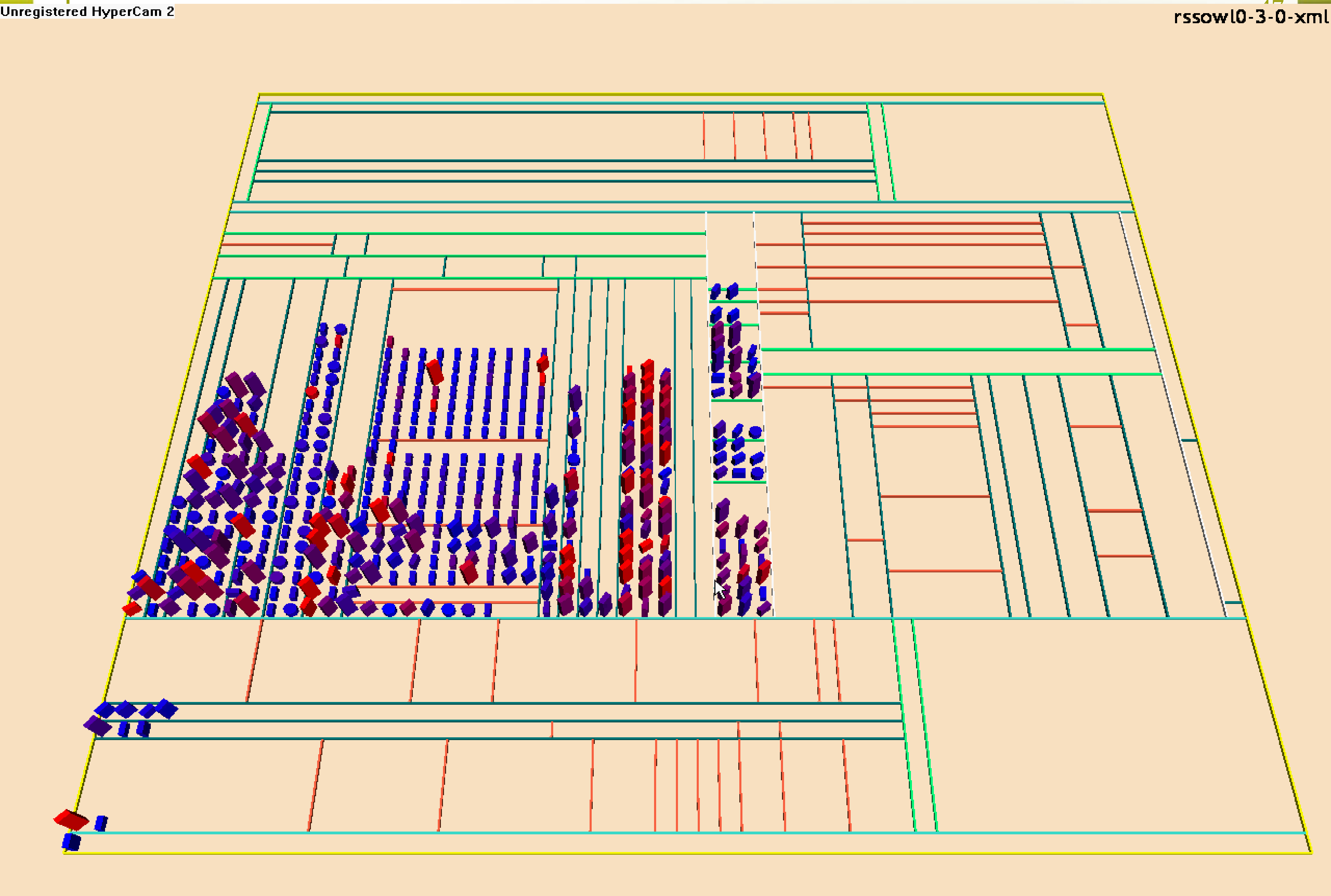
Movements between Views

- Within the same level
  - Example of VERSO for the evolution
    - Fixed positions
    - Relative positions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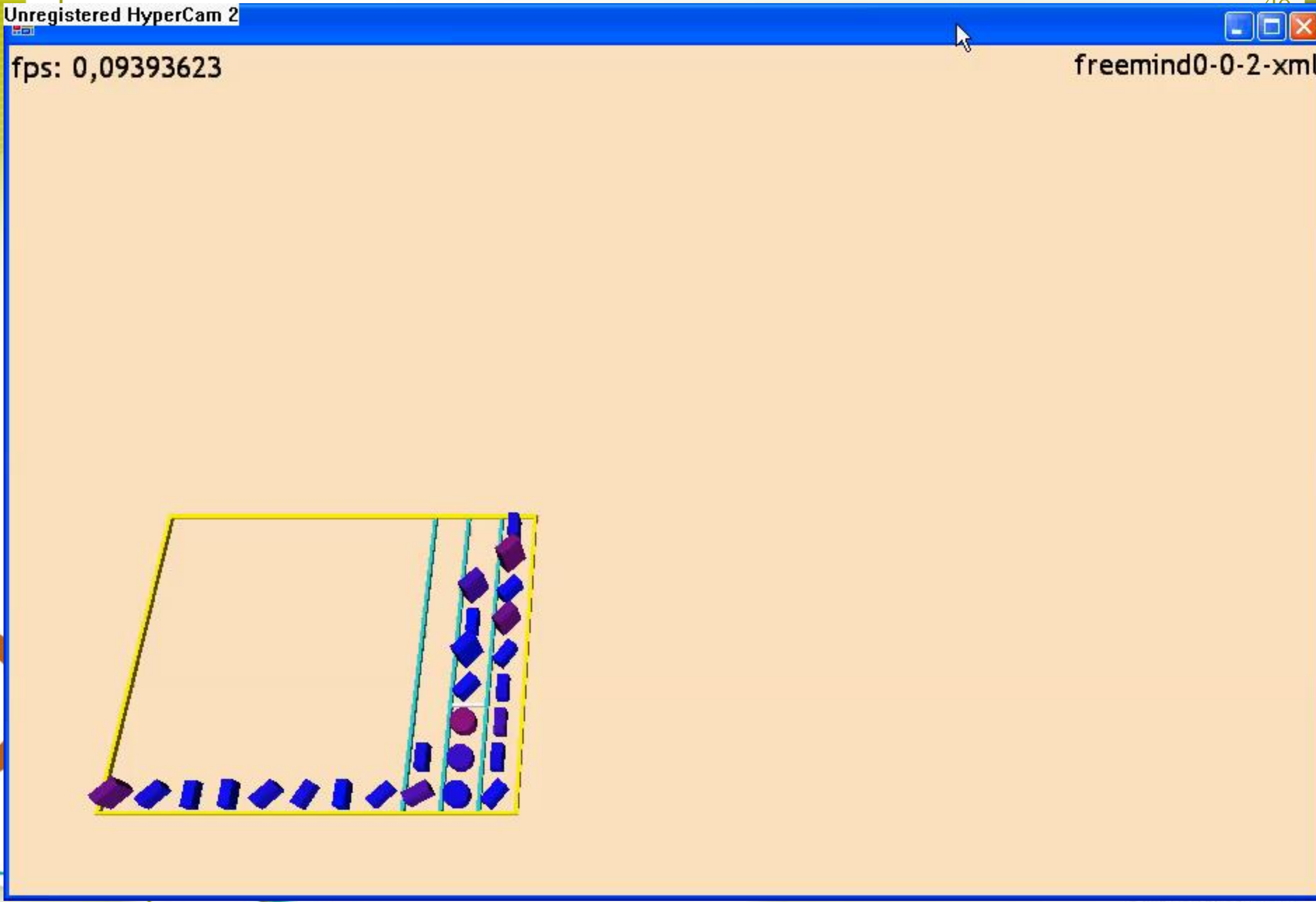
rssowl0-3-0-xml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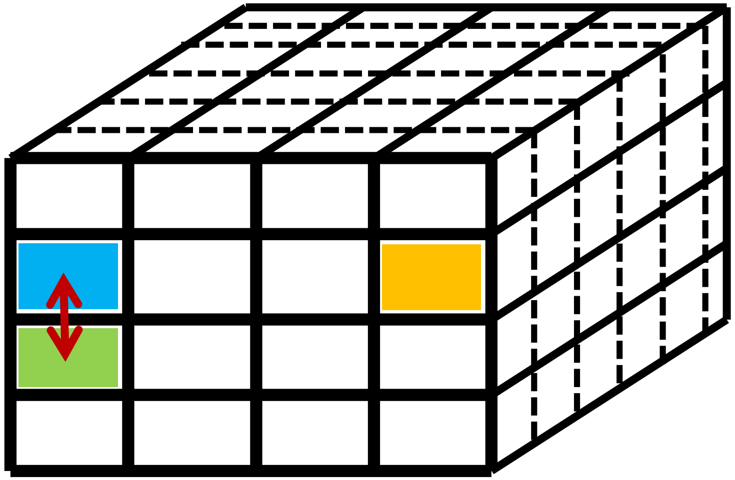
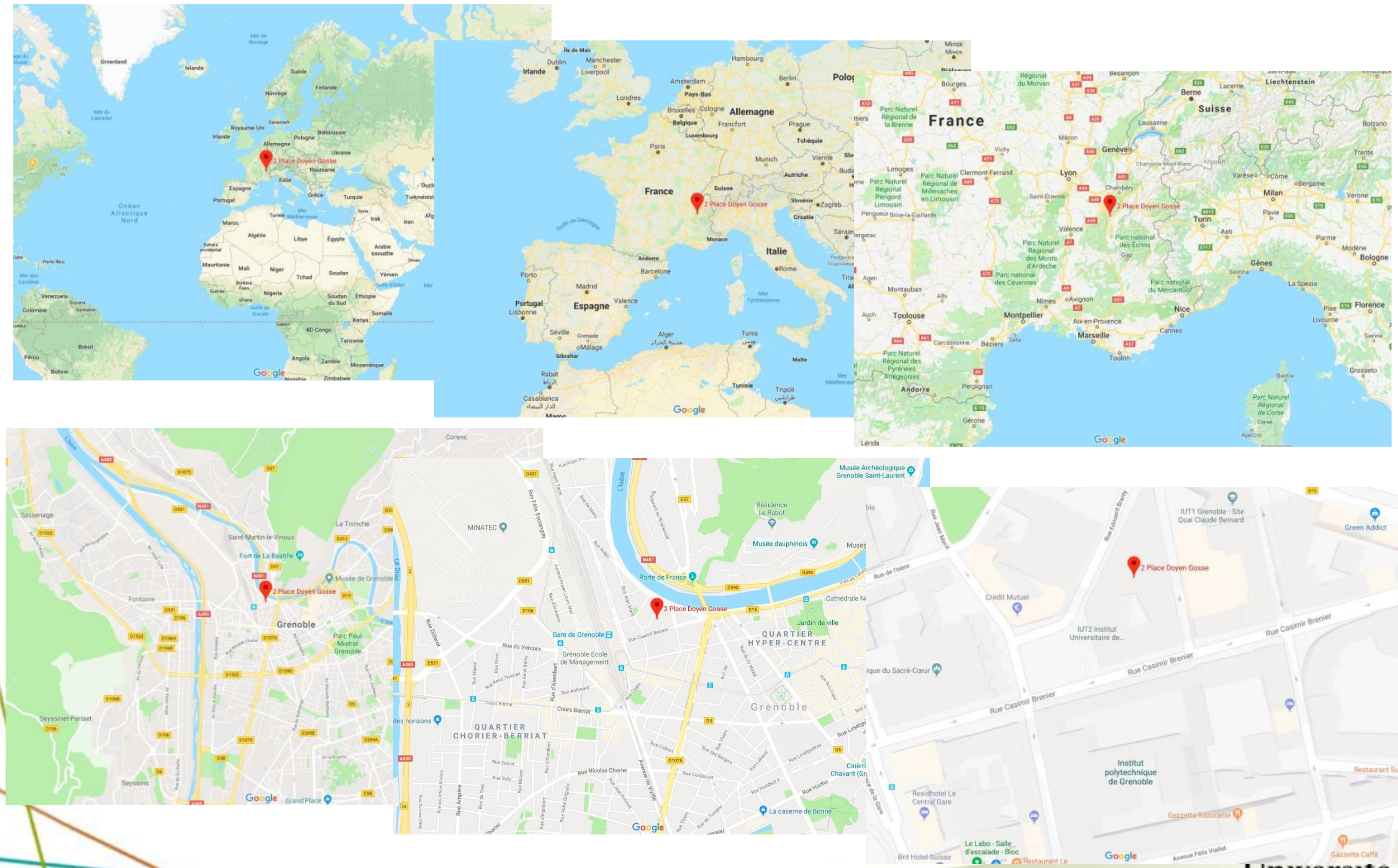
Movements between Views

- Between levels (principles)
  - Keeping track of the context
  - Semantic zoom



Movements between Views



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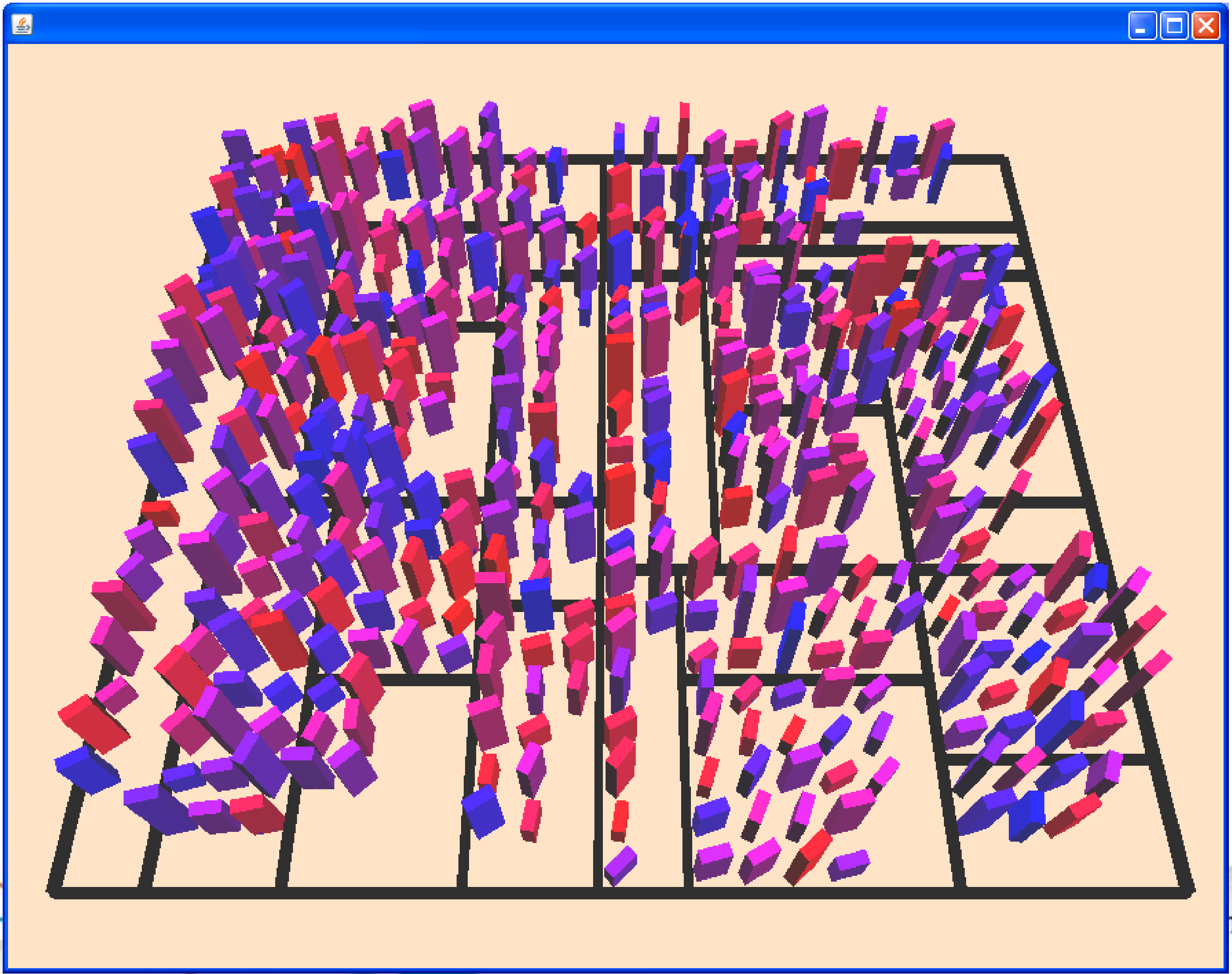
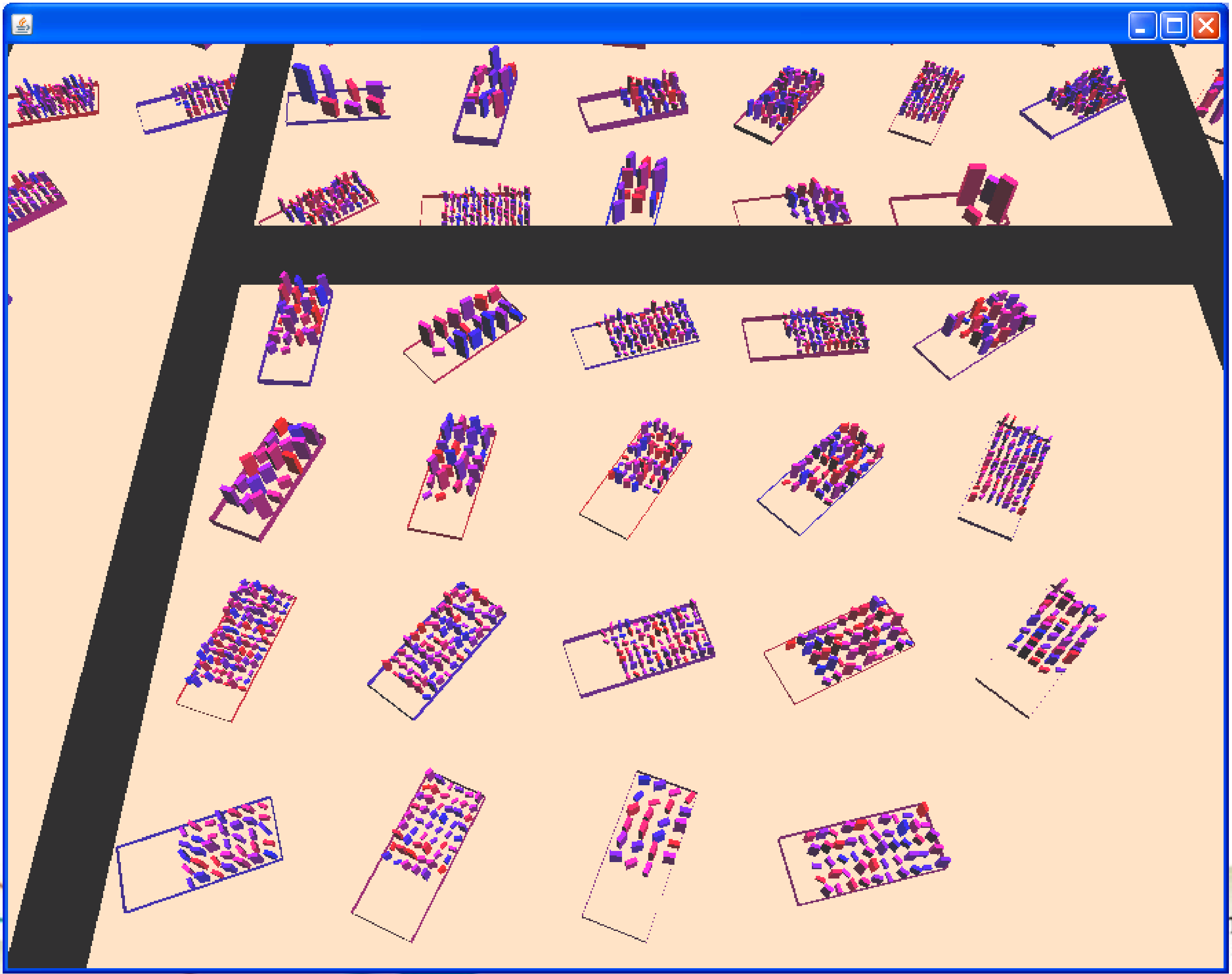
Movements between Views

- Between levels
  - Example of VERSO

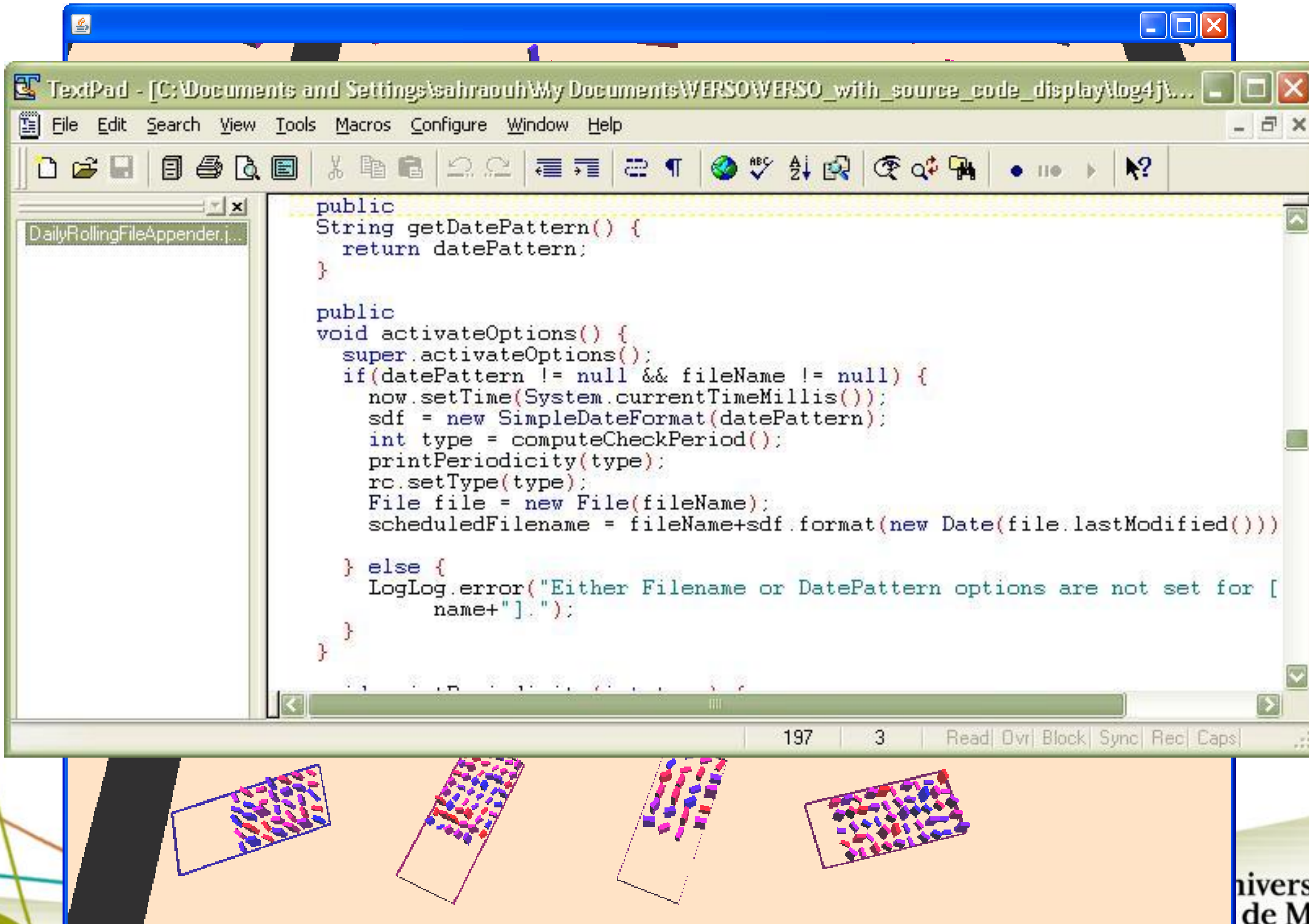
Keeping track of the context



Keeping track of the context

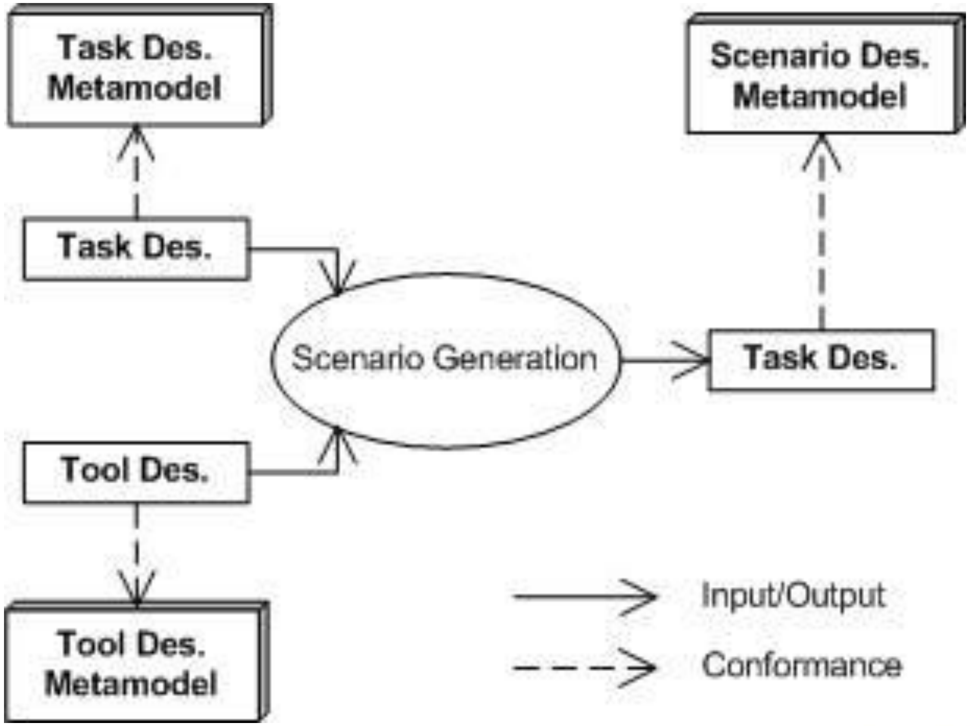


Keeping track of the context



Interactions

- From analysis tasks to interaction scenarios



Example

- Blob Detection
  - Task description

```
Goal(Blob_detection, BlobSet, System)
   {
      achieve(Controler_class_detect, CDD, System)
      achieve(Data_class_verif, BlobSet , CDD)
   }
Goal(Controler_class_detect, Cand, Scope)
   {
      Filter(Scope, Cand,
         ishigh WMC and
         ininterval LOW MEDIUM LCOM5 and
         islow DIT)
   }
Goal(Data_class_verif, Found, Cand)
   {
      for_each(c, Cand) {
         Filter(System, Rel, iscalled(c))
         Filter(Rel, RelData, islow WMC and islow DIT)
         Compute_derived_value(RelData, count, Num)
         if (ishigh Num) {
            operation (+, Found, Found, c)
            }
         }
   }
```

Example

- Blob Detection
  - Interaction scenario

```
Mapping

   Graphic representation
      3-D box >> Class
   Graphics attributes
      twist >> LCOM5
      height >> DIT
      color >> WMC
```

Example

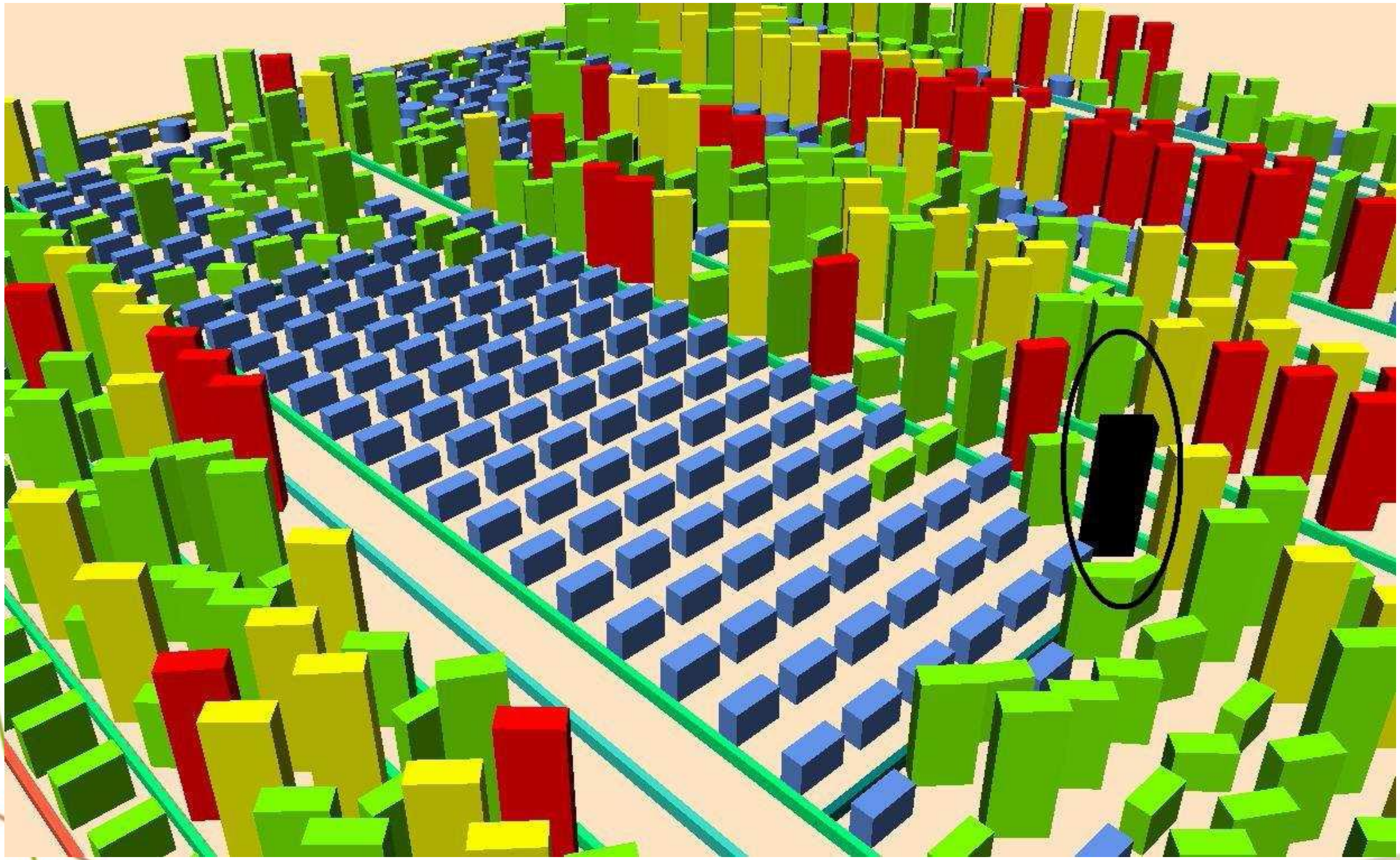
- Blob Detection
  - Interaction scenario

```
Scenario(Blob_detection)
   {
      Run_scenario(Controler_class_detect)
      Run_scenario(Data_class_verif)
   }
Scenario(Controler_class_detect)
   {
      Overview(Class)
      Block(Class){
         Check_if(Color:Red
            and Twist:0 to 45
            and Height: Medium To High)
         Select(Result)
         Tag(CC, Result)
      }
   }
```

```
Scenario(Data_class_verif)
   {
      for_each(c in CC){
         Overview(Class)
         Apply_automatic_filter(Class, iscalled(c))
         Tag(REL,Result)
         Overview(Class)
         Block(REL){
            Check_if(color:blue
               and height:low)
            Select(Result)
            Tag(RelData,Result)
            }
         Overview(RelData)
         Do_function(count, RelData, Num)
         Block{
            Check_if(Num,ishigh)
            Tag(Blob, c)
            }
         }
   }
```

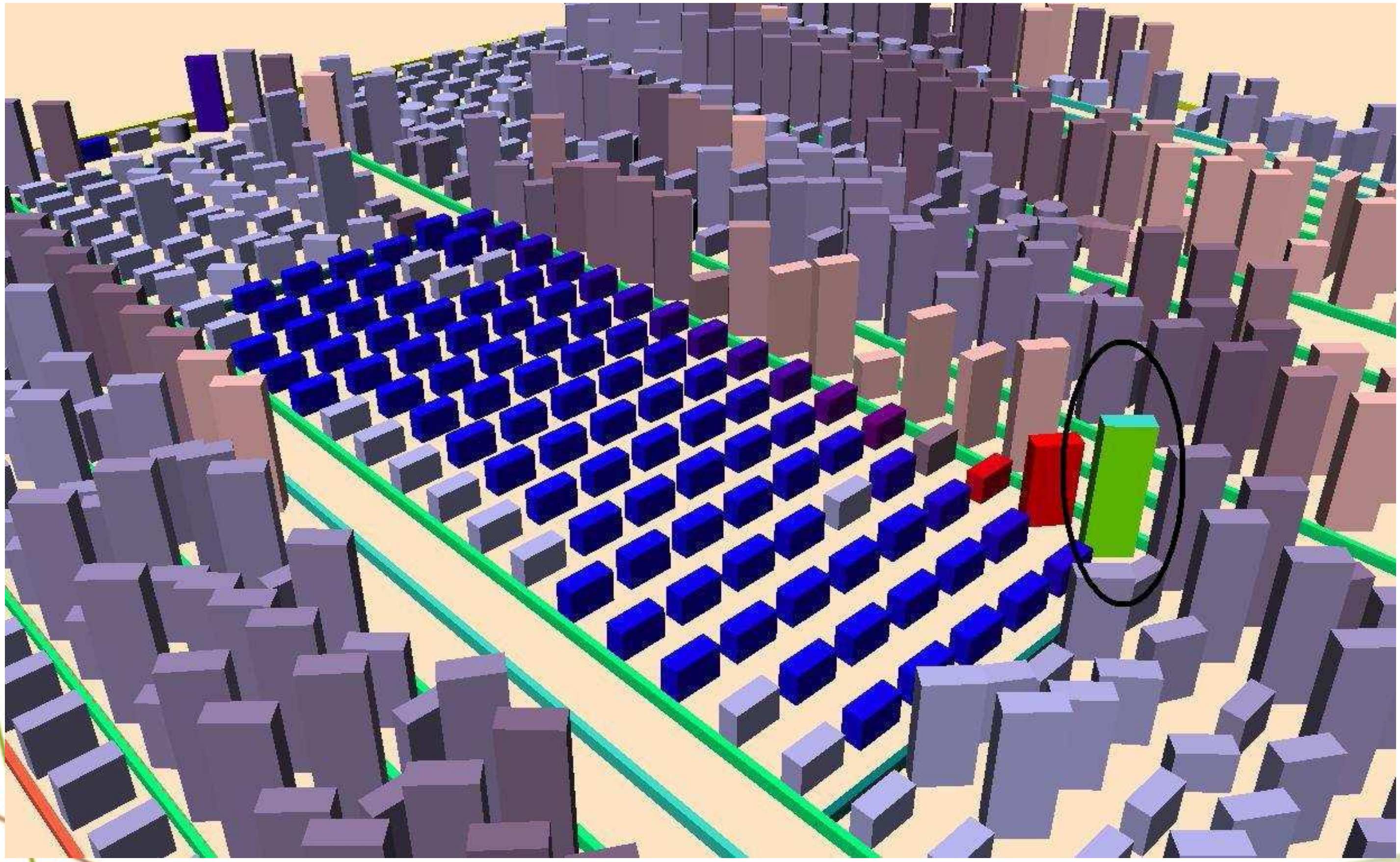
Example

- Blob Detection



Example

- Blob Detection



Increasing Tolerance to Complexity

- Problem
  - In the context of large-scale systems
    - Principles mentioned above reduce data exploration complexity
    - Complexity is still overwhelming
    - Much too difficult for a human analyst
  - How can we increase tolerance to complexity?

Increasing Tolerance to Complexity

- Principles
  - Flow state (Csikszentmihalyi)

    Mental state of operation in which the person is fully immersed in what he or she is doing, characterized by a feeling of energized focus, full involvement, and success in the process of the activity

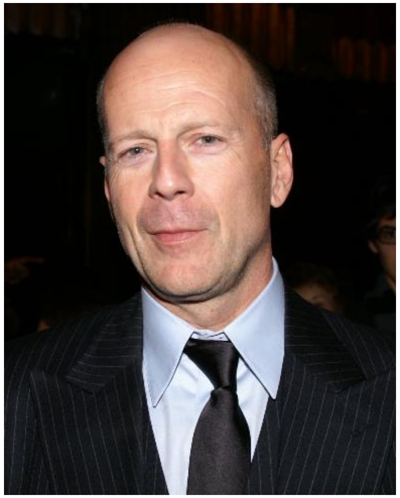
    - Characteristics
      - Clear goals, distorted sense of time, …
    - Applications
      - Education, (video) gaming, sport, …

Increasing Tolerance to Complexity

- Principles
  - Neurological theory of aesthetic experience (Ramachandran)
    - 10 universal laws of art:
      1. Peak shift
      2. Grouping
      3. Contrast
      4. Isolation
      5. Perception problem solving
      6. Symmetry
      7. Abhorrence of coincidence/generic viewpoint
      8. Repetition, rhythm and orderliness
      9. Balance
      10. Metaphor

Increasing tolerance to complexity

- Peak shift
  - Exaggerated versions of learned objects easier to interpret by the brain
  - Examples
    - Caricatures
    - Women in art
      - Forms
      - Positions

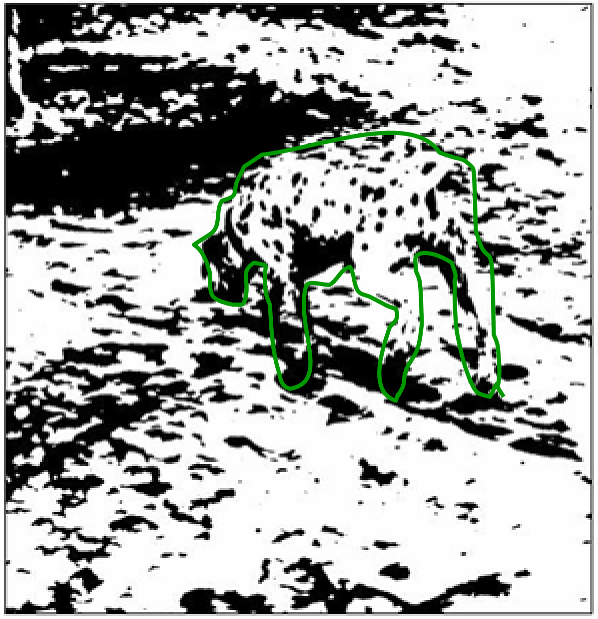


Increasing tolerance to complexity

- Peak shift
  - Exaggerated versions of learned objects easier to interpret by the brain
  - Examples
    - Caricatures
    - Women in art
      - Forms
      - Positions

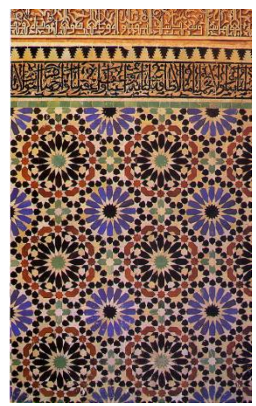
Increasing tolerance to complexity

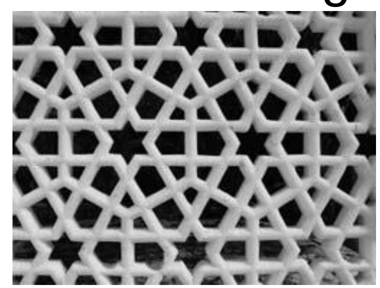
- Grouping & Perception problem solving
  - Human visual system is trained to detect regularities in a world of noise
  - Discovery of regularities is rewarding (AHA sensation)
  - Example

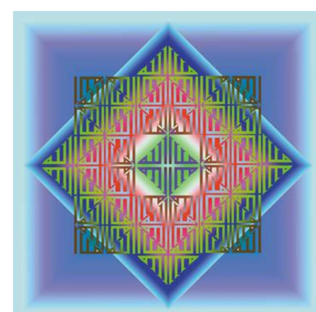


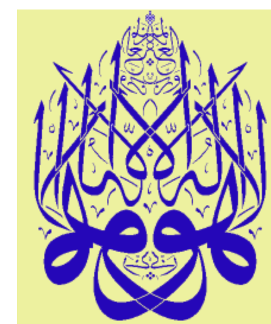
Increasing tolerance to complexity

- Symmetry & Repetition, rhythm and orderliness
  - Symmetry is attractive
  - Repetition, rhythm and orderliness are soothing
  - Example
    - Islamic art
    - Western painting



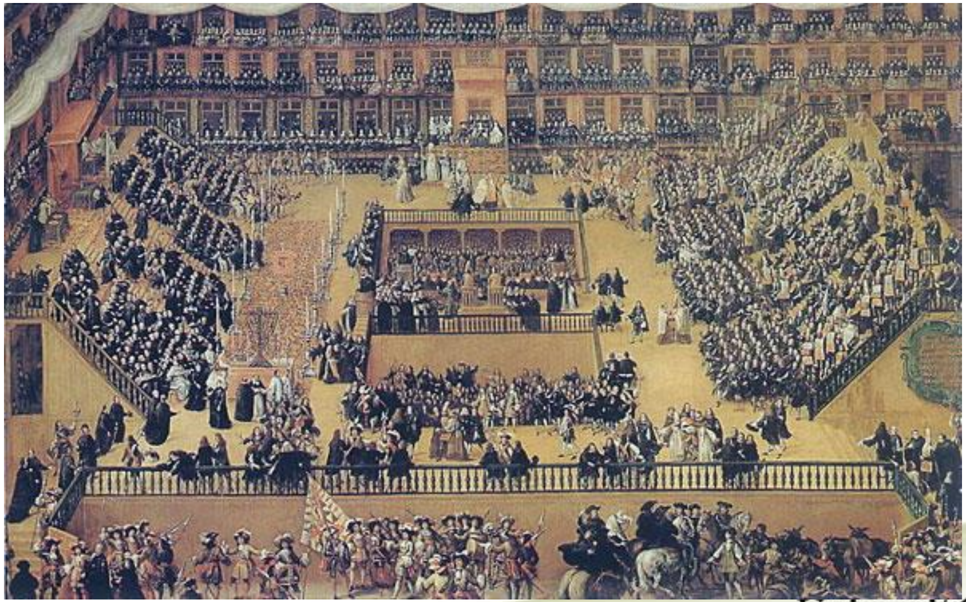






Increasing tolerance to complexity

- Symmetry & Repetition, rhythm and orderliness
  - Symmetry is attractive
  - Repetition, rhythm and orderliness are soothing
  - Example
    - Islamic art
    - Western painting



Increasing tolerance to complexity

- Metaphor
  - Generates emotional response even before we understand it
  - Examples
    - Indian art
    - Western painting

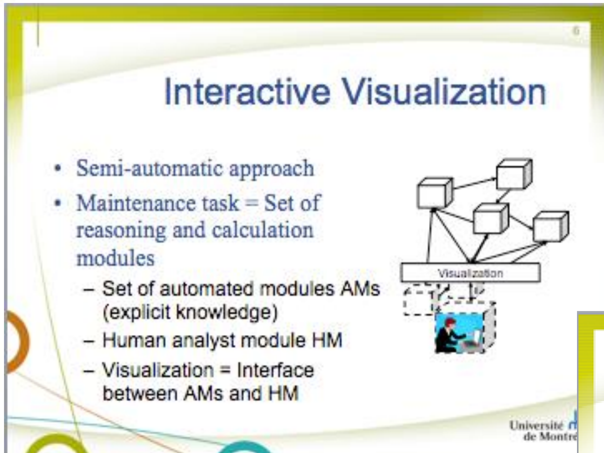
Increasing tolerance to complexity

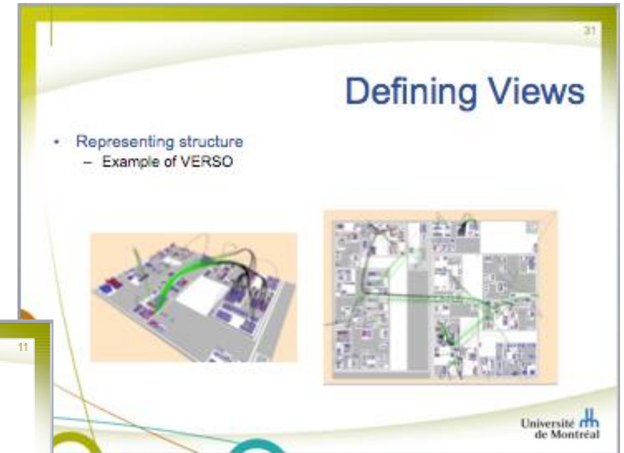
- Metaphor
  - Generates emotional response even before we understand it
  - Examples
    - Indian art
    - Western painting

Increasing Tolerance to Complexity

- Implementation example
  - Differences between entities can be visually amplified
  - City metaphor is used
  - Data exploration tasks are modeled as perceptual problem solving
  - Entities are positioned following a particular order
  - Entity groupings are meaningful
  - Each graphical configuration has a single meaning

Conclusion


Interactive Visualization
• Semi-automatic approach
• Maintenance task = Set of reasoning and calculation modules
– Set of automated modules AMs (explicit knowledge)
– Human analyst module HM
– Visualization = Interface between AMs and HM
Visualization


Defining Views
• Representing structure
– Example of VERSO
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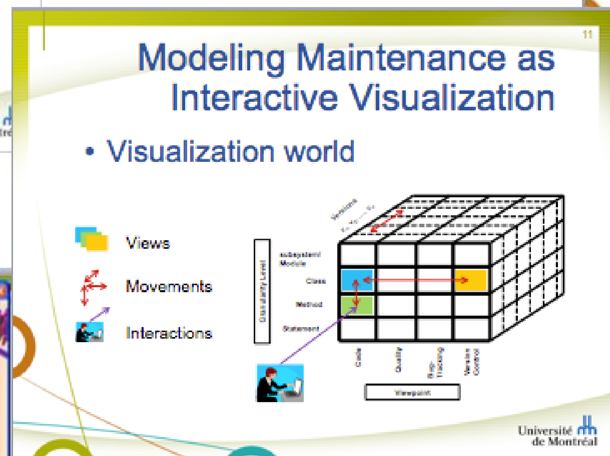
Modeling Maintenance as Interactive Visualization
• Visualization world
Views
Movements
Interactions
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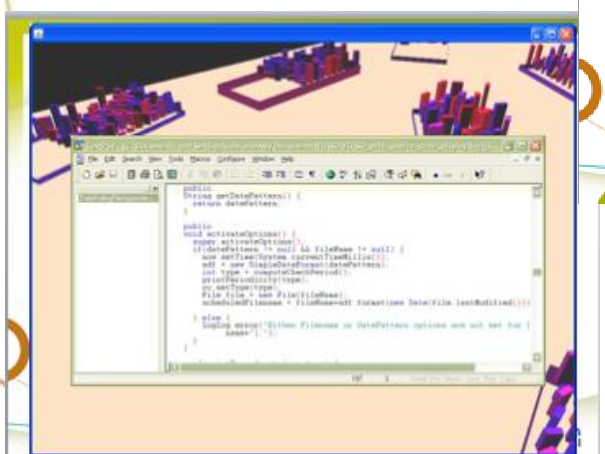

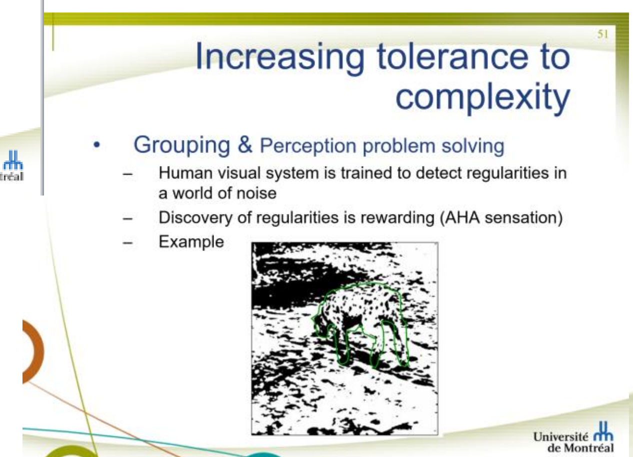
Increasing tolerance to complexity
• Grouping & Perception problem solving
– Human visual system is trained to detect regularities in a world of noise
– Discovery of regularities is rewarding (AHA sensation)
– Example
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