

An Event-Based Approach to Visualization

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Outline

- Introduction and related work
- Model of Event-Based Visualization
 - Event specification
 - Event detection
 - Event visualization
- Event Visualization in VisAxes
- Conclusion and future work

Introduction and Related Work

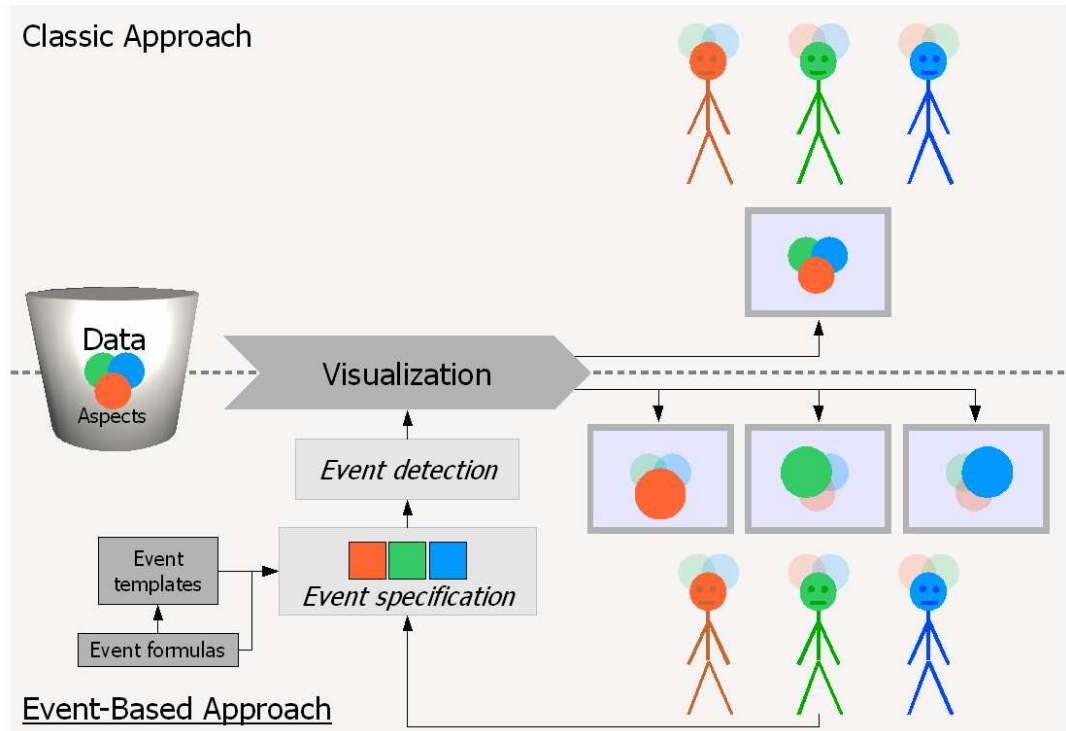
- Steadily growing amount of data to be visualized
 - Visualizations become increasingly complex and visually cluttered
 - Different users are interested in different data aspects
- However, most visualizations are specific to only one certain problem

Introduction and Related Work

Goals:

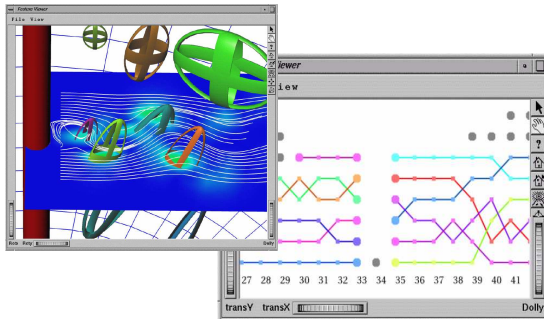
- *Increase flexibility: users specify their interests*
- *Increase expressiveness: emphasizing data portions users are interested in, declutter visualizations*

Approach:
*Visualize events
rather than data*

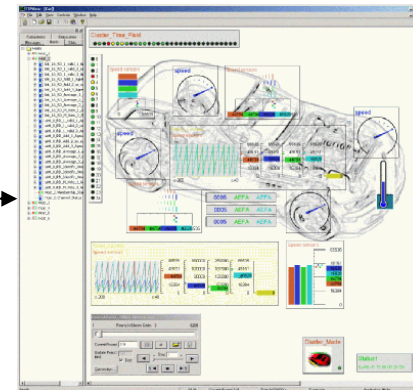


Introduction and Related Work

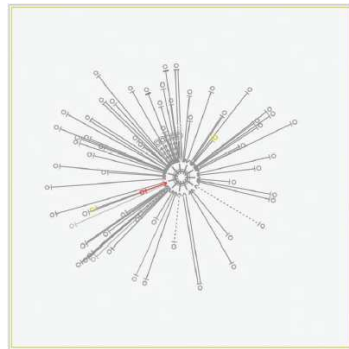
Variety of heterogeneous approaches



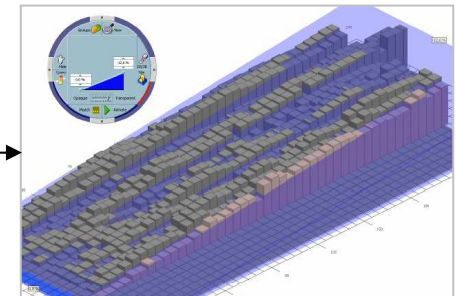
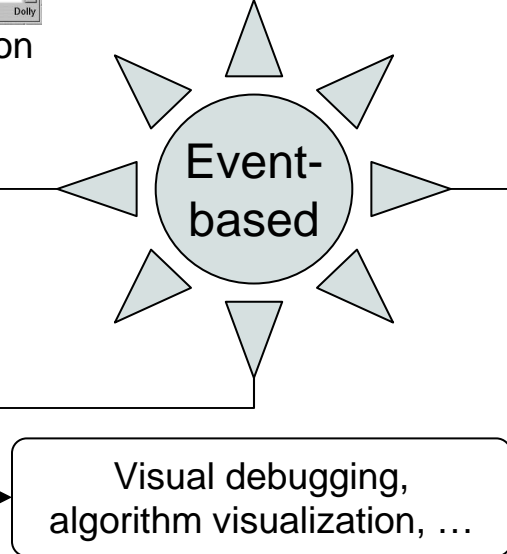
Feature-based flow visualization
(Reinders et al., 2001)



Process visualization
(Matkovic et al., 2002)



Intrusion detection
(Erbacher et al., 2002)

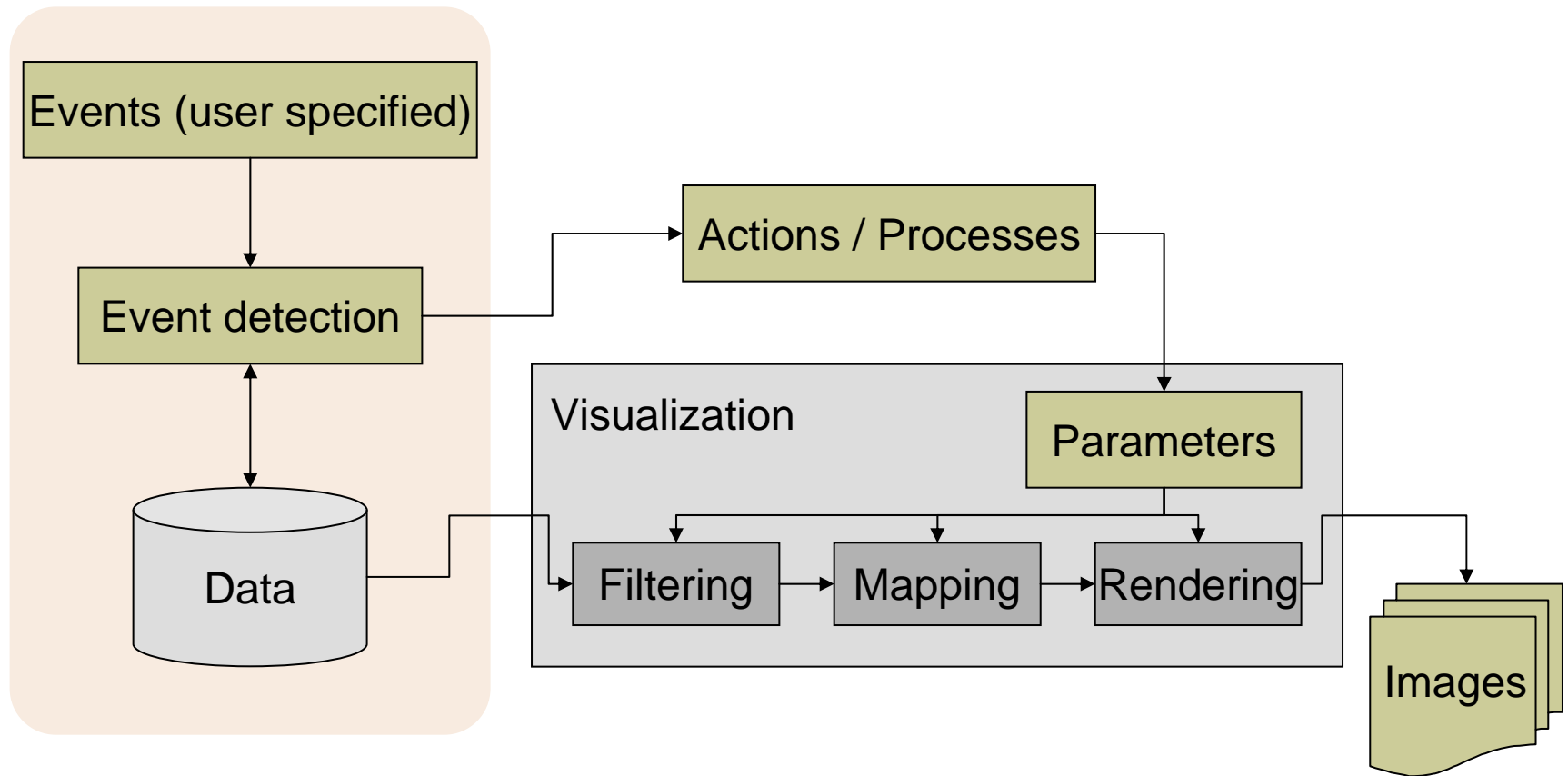


Visualization of clinical data
(Chittaro, 2003)

Model of Event-Based Visualization

- Our Aim:
 - Create a general event-based visualization model
 - Incorporate the classic visualization model in this approach
- Basic steps of the approach:
 - *Event specification*: Users specify data portions of interest by means of events
 - *Event detection*: On visualization and/or on alteration of the data perform event detection
 - *Event visualization*: Adapt the visualization regarding detected events; emphasize parts of the image; reduce irrelevant information

Model of Event-Based Visualization



Event Specification

Relational data model as basis for event definition:

Special portions of the data complying with certain conditions and constraints regarding data records and attributes.

Events

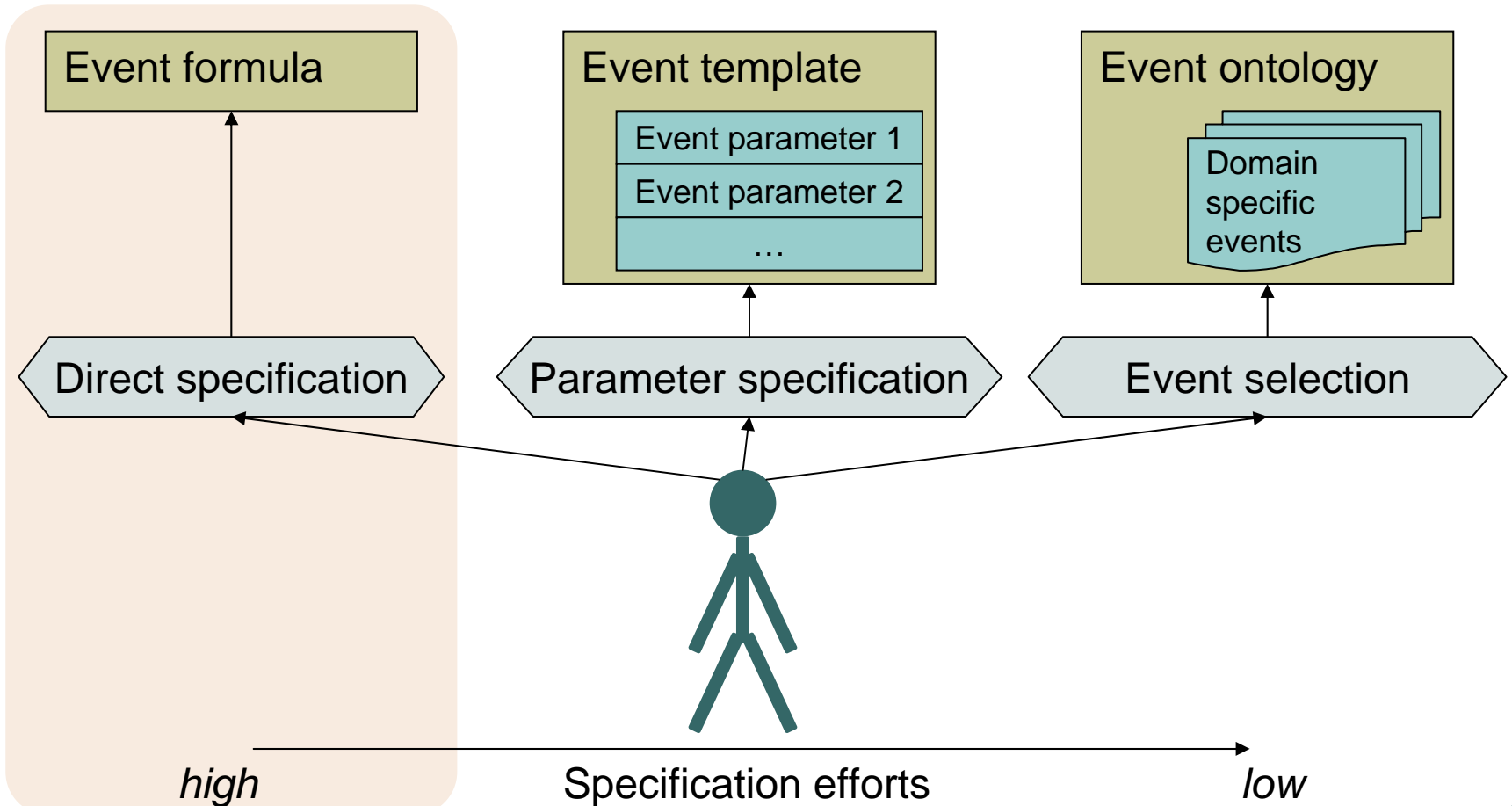
Event properties:

- Importance, attributes involved, relations to other events, ...
- Concrete values determined either by event detection or users

Example: “The number of cases of influenza exceeds 300.”

→ How to specify such or similar events?

Event Specification



Event Specification

- Basis: Relational data model
 - Relations, attributes, tuples
- Event formulas adapted from tuple calculus formulas (PL-I)
 - Tuple variables, functions (e.g. +, -, ...), aggregate functions (e.g. max, min, avg, ...) Atoms
 - Predicates (e.g. <, >, =, ...) Elementary formula
 - Event formulas (composed of elementary formulas, logical connectors $\neg, \wedge, \vee, \rightarrow$, quantifiers \exists, \forall) General event formula
- Event and event instance
 - Target (tuple variable) + event formula + variable substitution
Event Event instance
- Example: $\{\dot{x} \mid \dot{x}.influenza \geq 300 \wedge \dot{x}.region = "Rostock"\}$

Event Detection

→ *Determine what events evaluate to event instances regarding a certain data set*

- Realized by mapping event formulas to SQL queries
- Query results contain event instances
- Static data sets
 - Detection as preprocess
- Dynamic data sets
 - Detection on each change
 - Validity of event instances regarding the “current” visualization session

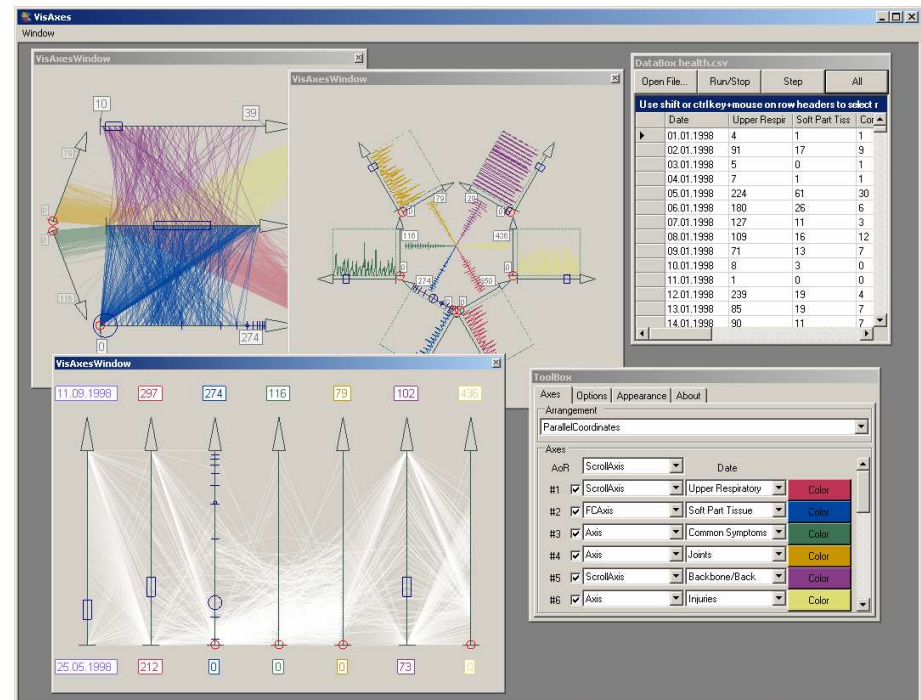
Event Visualization

- Event representation is key factor to success
 - Event occurrences must be highlighted
 - Visual differentiation of events
- Explicit event visualization
 - Events visualization separate from data visualization
 - E.g. visualize events rather than data, additional table view
- Implicit adaptation of visualization parameters
 - Find parameters suitable for adaptation
 - Instantaneous parameter changes defined as *actions*
 - Dynamic environments: parameter changes as *processes*

Event Visualization in VisAxes

Axes-based framework for visualization of relational data

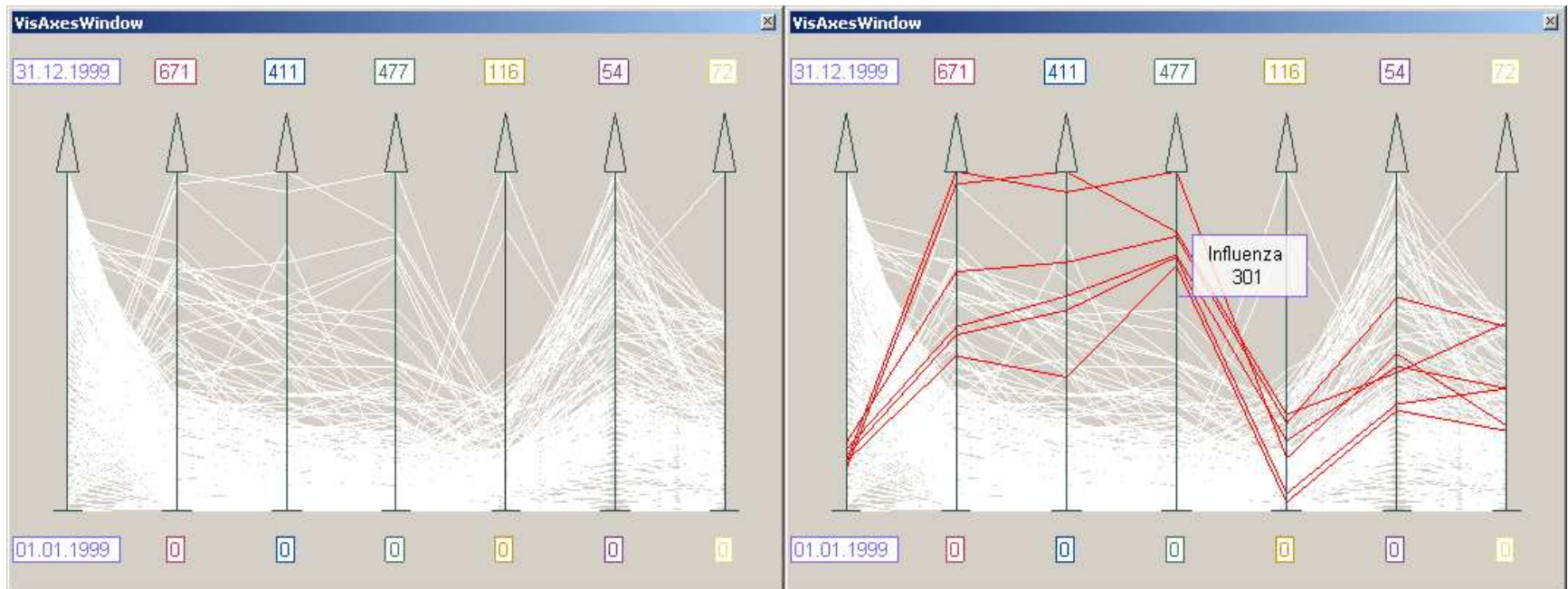
- Interactive axes
 - Scroll axis
 - Hierarchical axis
 - Focus+Context axis
- Several axes layouts
 - Parallel Coordinates
 - Coordinates Wheel
 - MultiComb



➔ Various parameters for adaptation on event occurrence

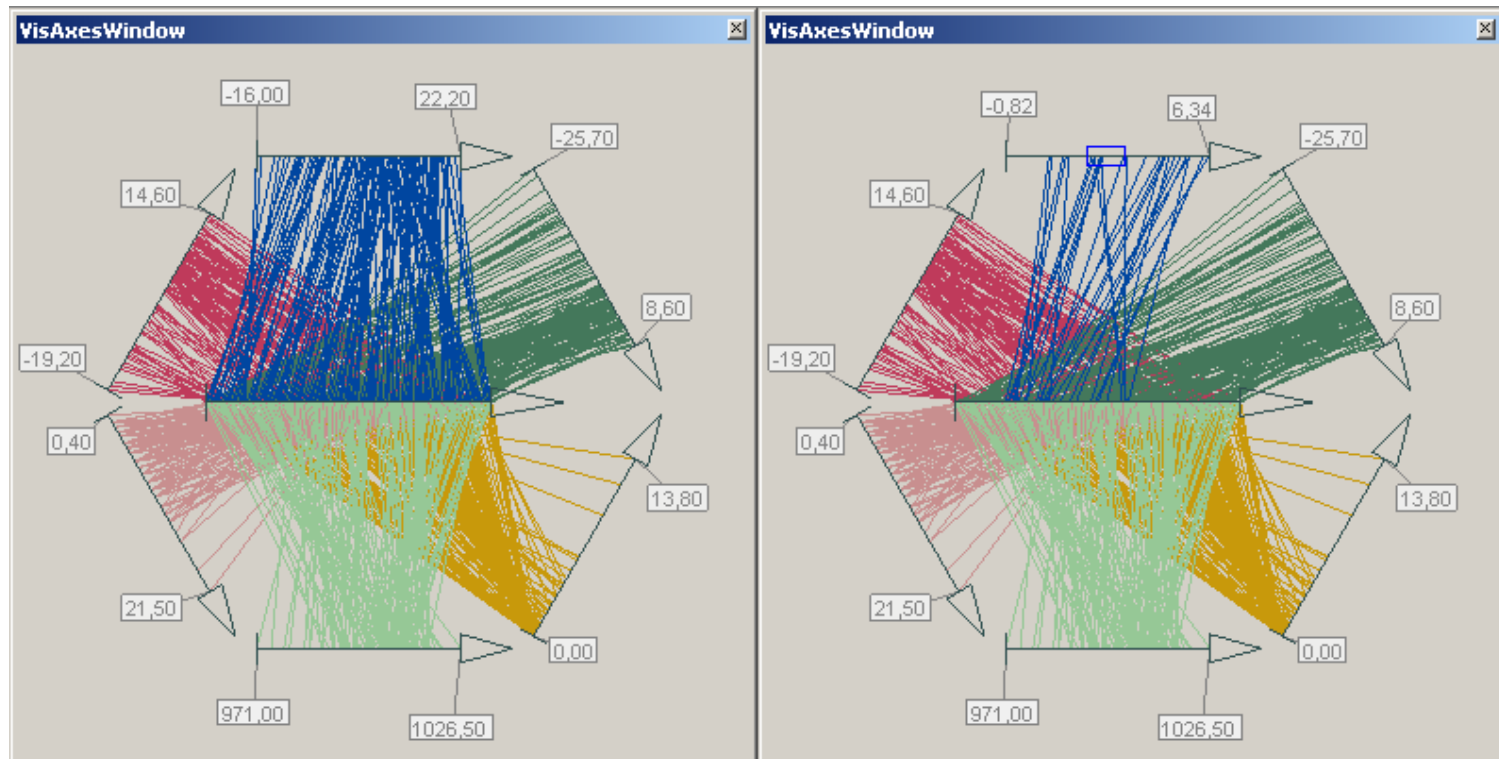
Event Visualization in VisAxes

- Representation of events by means of Brushing
- $\{x \mid x.influenza \geq 300\}$



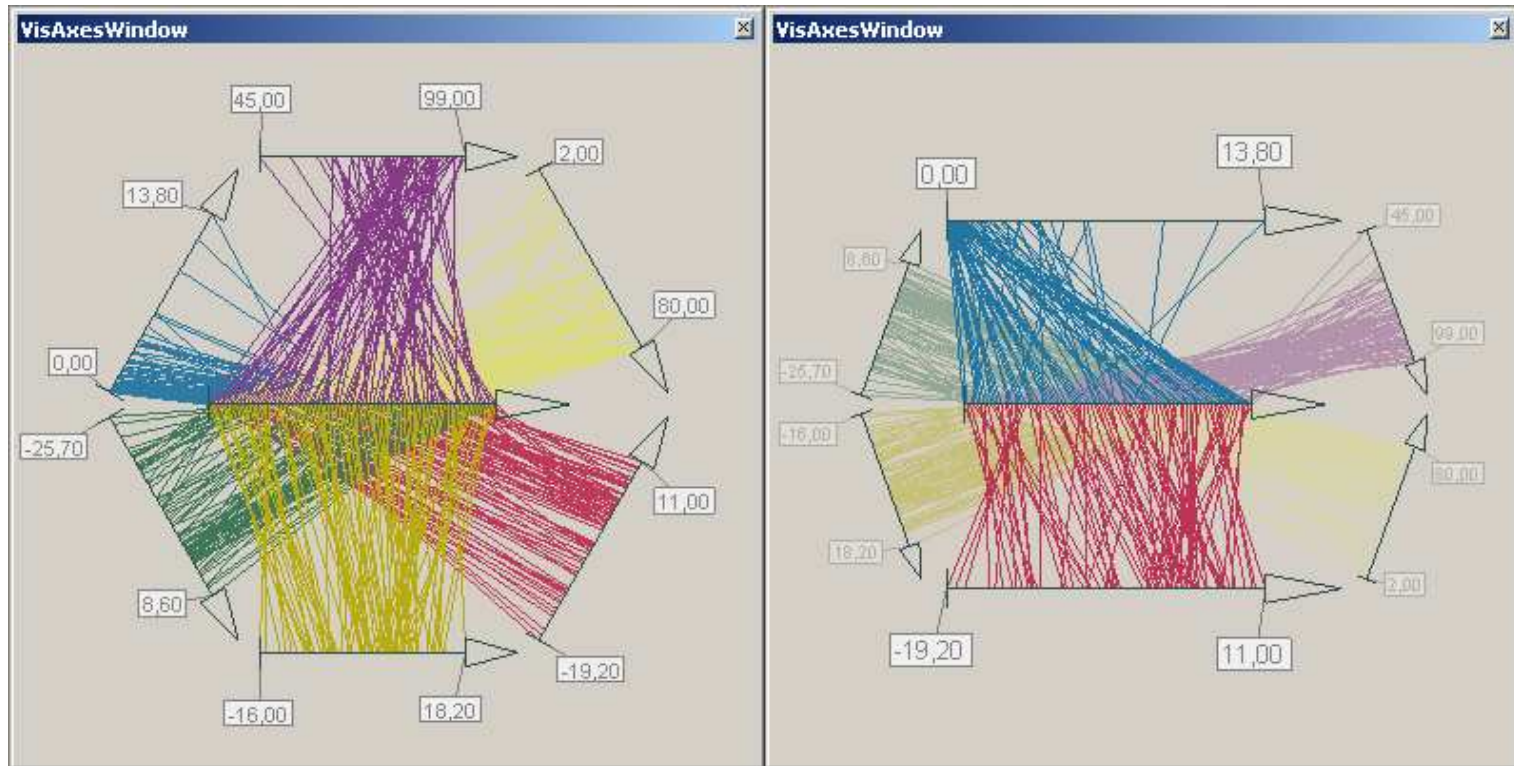
Event Visualization in VisAxes

- Adapting axes scales reduces irrelevant information
- $\{\dot{x} \mid \dot{x}.temp \geq -1 \wedge \dot{x}.temp \leq 7\}$



Event Visualization in VisAxes

- Adapting axes scales reduces irrelevant information
- $\{\dot{x} \mid \dot{x}.prec > outlier(prec)\}$ $outlier : \mathcal{A} \rightarrow \mathbf{R}$

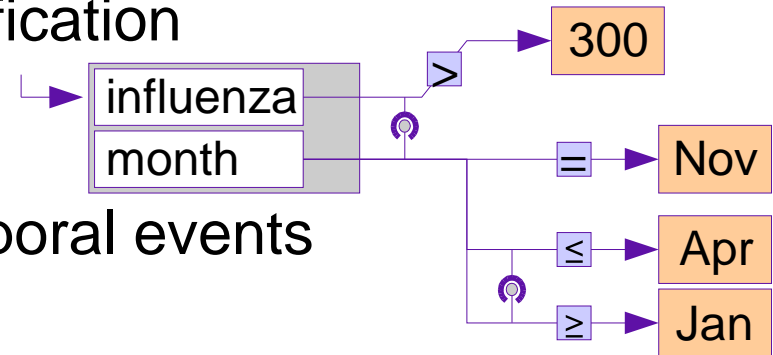


Preliminary Results and Conclusion

- First tests
 - Fixed set of visual adaptations
 - Simple events only
 - Positive feedback regarding visual adaptation
 - Event specification turned out to be difficult
- Conclusion
 - *Event-based visualization can help increasing expressiveness and flexibility of visualization*
 - *However, more work has to be done to fully reach these goals*

Future Work

- Visual editor for event specification



- Special event editor for temporal events

- Point vs. interval time
- Linear vs. cyclic time

- Find more and other visualizations and visualization parameters suitable for incorporation expressive event-based adaptations
- Handle concurrent actions / processes
- Finally, extensive evaluation to prove eligibility